TM 11-1543

WAR DEPARTMENT TECHNICAL MANUAL

RADIO SET AN/MPN-1
SERVICE MANUAL

THEORY, TROUBLE SHOOTING, AND REPAIR

CONFIDENTIAL

WAR DEPARTMENT *20 SEPTEMBER, 1944*

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TM 11-1543 [redacted]

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WAR DEPARTMENT,
WASHINGTON 25, D. C., 20 SEP, 1944.

TM 11-1543, Service Manual for Radio Set AN/MPN-1, is published for the information and guidance of all concerned.

[A.G. 300.7 (28 February, 1944)]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

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(For explanation of symbols see FM 21-6.)

QUICK INDEX

WARNING
HIGH VOLTAGE

Voltages sufficient to cause
DEATH ON CONTACT
Are used in Radio Set AN/MPN-1

Extremely dangerous voltages exist especially in the following units:

1. ELEVATION INDICATOR ID-37/MPN-1
2. AZIMUTH INDICATOR ID-36/MPN-1
3. SEARCH INDICATOR ID-35/MPN-1
4. SYNCHROSCOPE TS-64/MPN-1
5. COMMUNICATIONS TRANSMITTER BC-625-A, BC-696-A, BC-457-A, BC-458-A
6. COMMUNICATIONS MODULATOR BC-456-B
7. MODULATOR MD-11/MPN-1
8. RADIO FREQUENCY UNIT RF-6/MPN-1
9. RADIO FREQUENCY UNIT RF-7/MPN-1
10. RECTIFIER POWER UNITS PP-22/MPN-1, PP-23/MPN-1, PP-24/MPN-1, PP-25/MPN-1, PP-26/MPN-1, PP-27/MPN-1, PP-28/MPN-1

HIGH VOLTAGE MAY BE FATAL IF CONTACTED BY THE OPERATING PERSONNEL. WHEN WORKING ON THE EQUIPMENT, AFTER THE POWER HAS BEEN TURNED OFF, ALWAYS GROUND ALL PARTS IN THE HIGH-VOLTAGE CIRCUITS BEFORE TOUCHING THEM.

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DESTRUCTION NOTICE

WHY . . . . To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN . . . . When ordered by your commander.

HOW . . . .

1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT . . . .

1. Smash—The magnetron tubes so that the construction and internal dimensions can no longer be discerned, smash the cathode structure separately, if possible. The antenna reflectors and external r-f plumbing. The antenna waveguides, angle capacitors, and angle coupling units. As much as possible of the internal waveguide installation, and all test equipment containing cavity resonators. All cathode-ray tubes, vacuum tubes and all meters on the operators' panels. As much as possible of the communication and the power supplies.
2. Cut—All dipoles off the antennas. As much of the wiring and electrical connections as possible. The r-f plumbing sections.
3. Burn—Using gasoline, sprinkle and ignite the operations trailer and power truck. If dynamite is available, place one charge in the indicator rack, one in the floor by the communications panel, and one in the radar transmitter rack. Open all rack and panel doors, wire the detonators, drench inside of trailer with gasoline, close the trailer doors and detonate.
4. Bury—Bury or scatter the chopped-off dipoles and r-f plumbing. If a body of water is accessible, throw in a scattering manner as many of the parts as possible. Throw the magnetron tubes into deep water or bury them in such a place and manner that their discovery will be most unlikely. If the situation does not warrant either of these, take the tubes with you and dispose of them in a like manner when the opportunity arises.

DESTROY EVERYTHING.

SAFETY NOTICE

Operation of this equipment involves the use of high voltages which are dangerous to life. Operating personnel must at all times observe all safety regulations. Do not service or adjust the equipment unless accompanied by a second person. It is strongly recommended that another person capable of rendering aid be available when adjustments are made within the racks.

Extreme caution must be exercised in the use of the cheater switches provided on the various units, for voltages as high as 15,000 volts will be encountered in the modulator, high-voltage power supply, and transmitter units when the equipment is in operation.

Care must be also taken to avoid contact with the 4-kv power supplies and the high-voltage supply circuits to the indicator tubes, as these circuits are charged to approximately 4,000 volts.

Do not attempt to operate the equipment without being thoroughly familiar with section III of chapter 2 and with chapter 3 of TM 11-1343, which cover preliminary adjustments and operation.

No attempt must be made to alter the adjustments on the communications equipment without first consulting the manuals covering those units.

FIRST AID TREATMENT FOR ELECTRIC SHOCK

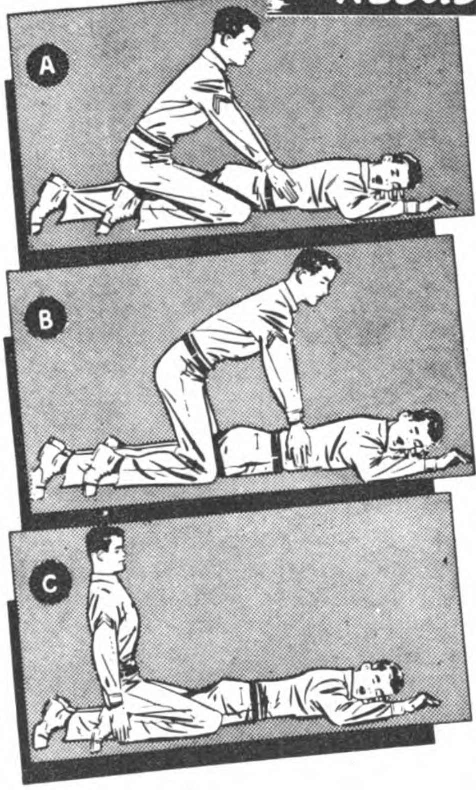
I. FREE THE VICTIM FROM THE CIRCUIT IMMEDIATELY.

Shut off the current. If this is not immediately possible, use a dry nonconductor (rubber gloves, rope, board) to move either the victim or the wire. Avoid contact with the victim. If necessary to cut a live wire, use an axe with a dry wooden handle. Beware of the resulting flash.

II. ATTEND INSTANTLY TO THE VICTIM'S BREATHING.

Begin resuscitation at once on the spot. Do not stop to loosen the victim's clothing. Every moment counts. Keep the patient warm. Wrap him in any covering available. Send for a doctor Remove false teeth or other obstructions from the victim's mouth.

RESUSCITATION



POSITION

1. Lay the victim on his belly, one **arm extended directly** overhead, the other arm bent **at the elbow, the face** turned outward and resting on h**and or forearm, so that** the nose and mouth are free for **breathing (fig. A).**

2. Straddle the patient's thighs, **or one leg, with your** knees placed far enough from his **hip bones to allow you** to assume the position shown in fi**gure A.**

3. Place your hands, with thum**bs and fingers in a** natural position, so that your pal**ms are on the small of** his back, and your little fingers **just touch his lowest** ribs (fig. A).

FIRST MOVEMENT

4. With arms held straight, swin**g forward slowly, so** that the weight of your body is gr**adually brought to bear** upon the victim. Your shoulders **should be directly over** the heels of your hands at the en**d of the forward swing** (fig. B). Do not bend your elbows. **The first movement** should take about 2 seconds.

SECOND MOVEMENT

5. Now immediately swing bac**kward, to remove the** pressure completely (fig. C)

6. After 2 seconds, swing forw**ard again. Repeat this** pressure-and-release cycle 12 to **15 times a minute. A** complete cycle should require 4 or **5 seconds.**

CONTINUED TREATMENT

7. Continue treatment until breathing is restored or until there is no hope of the victim's recovery Do not give up easily. Remember that at times the process must be kept up for hours.

8. During artificial respiration, have someone loosen the victim's clothing. Wrap the victim warmly; apply hot bricks, stones, etc. Do not give the victim liquids until he is fully conscious. If the victim must be moved, keep up treatment while he is being moved.

9. At the first sign of breathing, withhold artificial respiration. If natural breathing does not continue, immediately resume artificial respiration.

10. If operators must be changed, the relief operator kneels behind the person giving artificial respiration. The relief takes the operator's place as the original operator releases the pressure.

11. Do not allow the revived patient to sit or stand. Keep him quiet. Give hot coffee or tea, or other internal stimulants.

HOLD RESUSCITATION DRILLS REGULARLY

REFERENCE NOTICE

TM 11-1543, SERVICE MANUAL, is one of the three technical manuals on Radio Set AN/MPN-1. It is to be used in conjunction with TM 11-1343, TECHNICAL OPERATION MANUAL, and TM 11-1443, PREVENTIVE MAINTENANCE MANUAL. This manual, TM 11-1543, gives a complete theoretical discussion of the circuits used in Radio Set AN/MPN-1, together with data and instructions for locating and repairing troubles which may occur in these circuits. The manual also includes information on the operation, theory, and repair of all specialized test equipment included with the unit. The final chapter of the manual consists of a maintenance parts list which gives descriptions and procurement information on replaceable parts.

Additional information on various components of Radio Set AN/MPN-1 will be found in the following separate manuals:

Instruction Book for Power Equipment PE-127-A.

Instruction Book for Operation and Maintenance of Radio Set SCR-522-A (TO 08-10-105).

Operating and Maintenance Instructions for Rectifier Unit RA-62-B.

Instruction Book for Operation and Maintenance of Radio Set SCR-274 (TO 08-10-50).

Radio Receiver BC-342-N (TM 11-850).

Instruction Manual, Beacon Receiver BC-1206-C.

Trailer K-34-E (TM 11-2503).

Maintenance Manual for Truck V-8/MPN-1 (4 ton, 6x6), Models 96A, 968A, 969A, 970A, and 972 (TM 10-1533).

Maintenance Parts List for Truck V-8/MPN-1 (TM 10-1532).

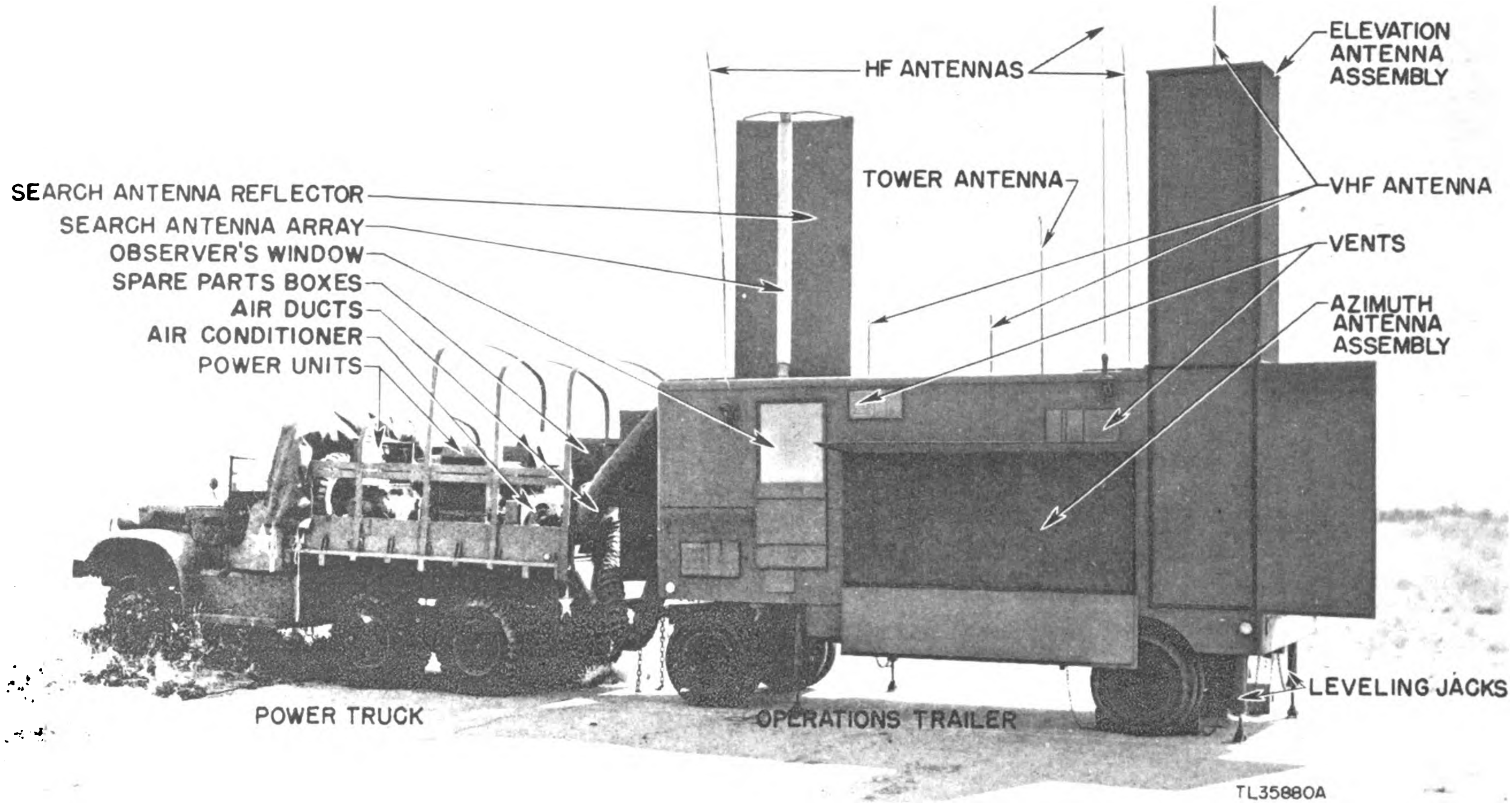


Figure 1. Radio Set AN/MPN-1.

CHAPTER 1

GENERAL THEORY

SECTION I

INTRODUCTION

1. PURPOSE OF MANUAL. This service manual presents the electrical and mechanical theory of Radio Set AN/MPN-1, and summarizes available information on the repair of the equipment. The first five chapters describe the equipment and give the theory of its operation. The next four chapters deal with trouble shooting and repair. Chapter 10 presents the maintenance parts list. TM 11-1543 is one of a series of three manuals on Radio Set AN/MPN-1. The other two are, TM 11-1343, Technical Operation Manual and TM 11-1443, Preventive Maintenance Manual.

2. DESCRIPTION OF EQUIPMENT. Radio Set AN/MPN-1 is a mobile ground radar unit consisting of a 6 x 6 Diamond-T truck which functions as a prime mover, and a four-wheel trailer which carries most of the operational equipment (fig. 1). Two gasoline-driven Power Units PE-127-A. mounted on the prime mover truck, supply 117-volt, 60-cycle single phase a-c power for the operation of all electrical equipment. An air conditioner, for trailer ventilation, and a spare parts box are also mounted on the truck chassis. The radar and communications equipment are rack-mounted in the operations trailer. Two complete radar systems are provided, a search system operating in the 10-centimeter or *S* band and a precision system operating in the 3-centimeter or *X* band. Two-way communication with landing aircraft, on 21 available channels of which three can be used simultaneously, is provided by the radio communication equipment. The trailer is equipped with a system of four hydraulic leveling jacks controlled by valves recessed in the trailer floor.

3. PURPOSES OF RADIO SET AN/MPN-1. Radio Set AN/MPN-1 provides facilities for directing the pilot of an aircraft in making a safe approach to an airdrome runway under poor visibility conditions. Accurate and continuous information regarding the location of incoming aircraft with respect to a predetermined glidepath is presented to the operators by the two radar systems. This information, interpreted as lateral and vertical deviations from the glidepath, enables the operators to direct the pilot in correcting his course. The search system presents a radar map on the plan position indicator (PPI) showing the positions of aircraft located within a radius of 30 miles and having an altitude of less than 4,000 feet. The PPI indicators of this system provide information used in "stacking up" aircraft within a specified region preparatory to turning them over to the precision system for landing. The precision system takes over when an airplane is ready to land. The precision system provides a magnified view of a relatively small sector. This sector is a region 20 degrees wide and 7 degrees high, having a 10-mile maximum radius.

SECTION II

FUNDAMENTALS OF RADAR

4. PULSE TRANSMISSION. Like most radar systems, Radio Set AN/MPN-1 utilizes pulse transmission. Instead of radiating continuously like the ordinary broadcasting transmitter, the radar transmitter concentrates its r-f energy into short bursts or pulses, each consisting of a relatively large number of oscillations. The resulting radio waves strike material bodies and are reflected or reradiated in all directions. Good electrical conductors give the best reflections; however, most materials that act as insulators at low frequencies will reflect high frequency radio waves. Part of the reflected energy is picked up by the radar receiver. If the energy were transmitted continuously there would be continuous reflections and the strong transmitter output would block the receiver, making the weak echo signals difficult to detect. Pulse transmission overcomes this difficulty since the transmitter is turned, off during the time echoes are received, and also provides a convenient means of measuring range. Usually, radar pulses have durations ranging from 0.5 to 10 microseconds (millionths of a second). They are separated by much longer time intervals, usually by several hundred microseconds. The length or duration of a pulse is commonly called the pulse width. The number of pulses per second is called the pulse recurrence frequency (prf). Radio Set AN/MPN-1 uses a pulse width of about 0.5 microseconds, and has a pulse recurrence frequency of about 2,000 pulses per second (pps).

5. DIRECTIONAL ANTENNAS. In order to find the direction of a target from a microwave radar set, an antenna system which provides an extremely narrow beam of radiation is used. Such an antenna does not radiate r-f energy equally in all directions but radiates more energy in one direction than in any other. If the radar antenna were not directional, echoes would be received, but there would be no simple way to determine target direction. The more directional an antenna, the more precisely can targets be located. The form of the beam is influenced largely by the type of reflector backing the antenna array. If the reflector is a paraboloid of revolution, or a parabolic "dish," as it is sometimes called, the beam of radiation is a narrow circular cone, whose diameter depends on the size of the reflector compared with the wavelength of radiation. This type of beam is generally referred to as a conical beam. In the common application of the conical beam, the entire antenna assembly is rotated much like a searchlight. A single antenna placed at the focus of a reflector, whose cross-section is a parabolic cylinder, produces a fan-shaped beam. This type of reflector, as used by Radio Set AN/MPN-1, is illustrated in figure 2. A number of antennas placed in a row or array along the focal line are fed consecutively from the same waveguide. The position of the directional antennas is adjusted in azimuth and elevation until the echoes bounced back from the target have maximum strength. The antennas are now pointing straight at the target and thus indicate the position of the target. An analogy will help to clarify the foregoing discussion. Assume that a searchlight is being pointed at an airplane. The airplane is most completely illuminated when it is in the center of the light beam. If the craft reflects light energy back to the searchlight, the amount of light received at the searchlight is greatest when the light beam is pointing straight at the airplane. If the searchlight beam were made very narrow, the only time the airplane would be illuminated at maximum intensity would be when the light was pointed directly at the airplane. In a similar way, the sharply focused radar pulses give precise information on the target position. The directivity of the radar antenna depends upon the positioning of the dipoles in the antenna array. Through proper placement of dipoles, side radiation is cancelled and forward radiation is reinforced. Whenever the directivity of the radar antenna system is increased, the area covered by the equipment is correspondingly decreased unless provision is made for turning the antenna in azimuth, tilting it in elevation, or both. In equipment that is to be used for searching a given area, the radiated beam must be narrow in the horizontal plane and yet provide complete coverage in the vertical plane. Under

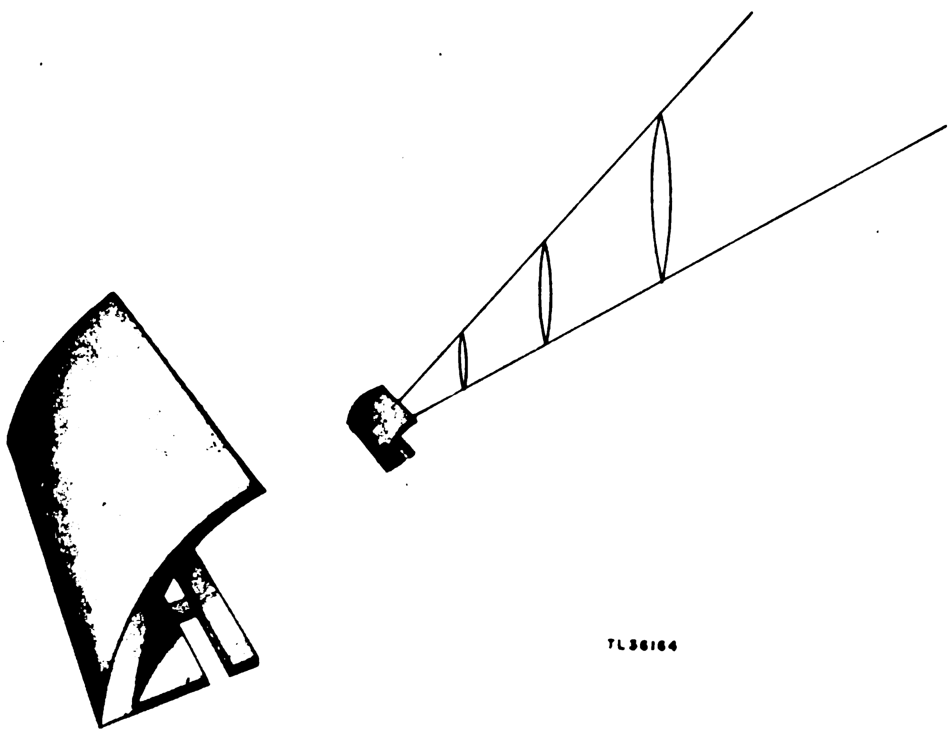


Figure 2. Fan beam and parabolic reflector.

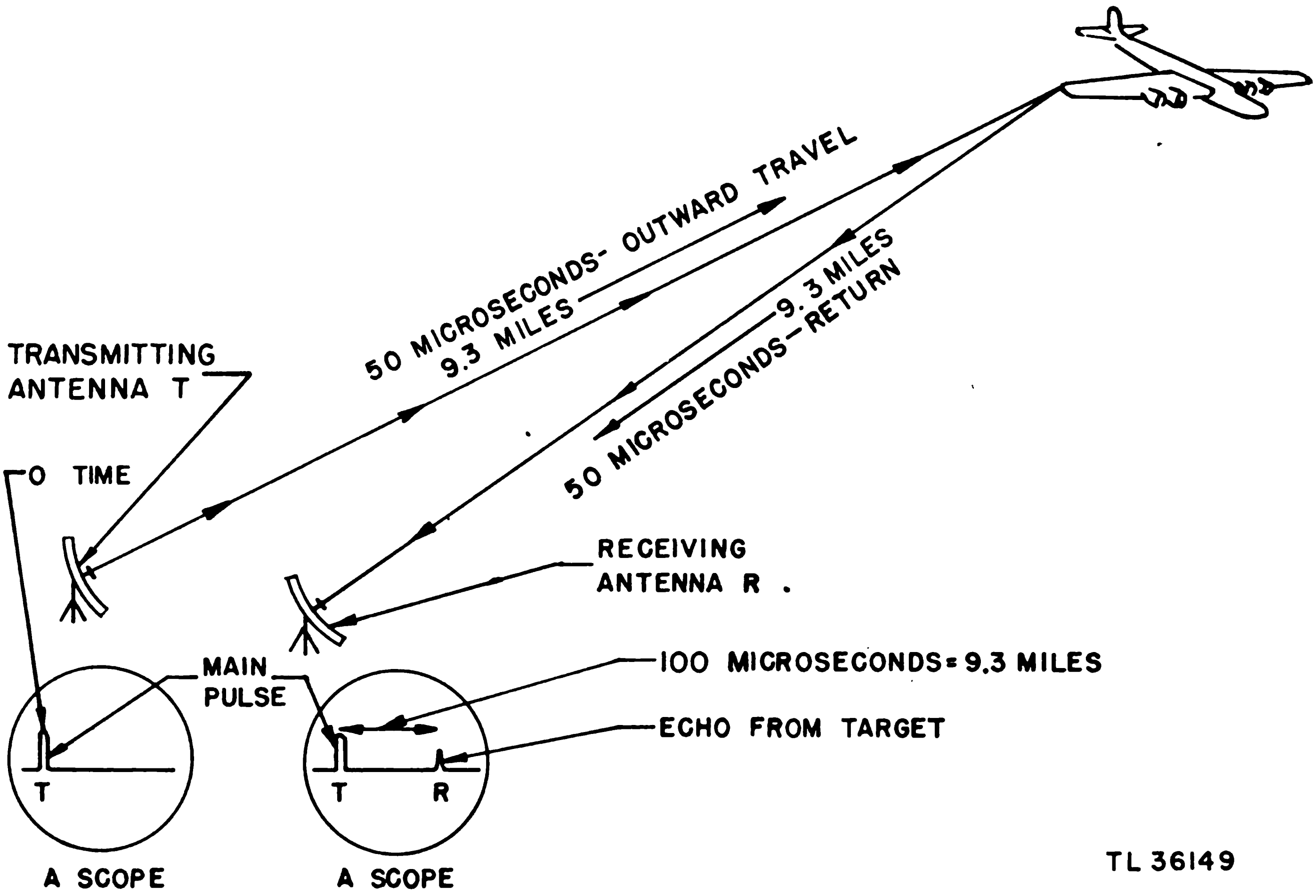


Figure 3. Range determination by radar.

such circumstances, the antenna must be rotated in azimuth but not necessarily tilted in elevation to get wide coverage. This method is used in the search system of Radio Set AN/MPN-1. If the radar equipment is required to cover only a narrow area in a given direction, the radar beam may be made to move back and forth over the necessary limits of coverage by electrical means. The precision system in Radio Set AN/MPN-1 covers only that region through which an airplane flies when making a safe approach to the airdrome runway. Therefore, the antennas of the precision system are not rotated when scanning but the beam is moved by electrical means.

6. RANGE DETERMINATION. Radar determination of range depends on the known fact that radio waves travel in straight lines with the speed of light. Pulses of electromagnetic energy, sent out by the radar transmitter, are partially reflected or reradiated when they strike an object. A small part of this reflected energy returns to the transmitter where it is picked up by a sensitive radio receiver. Measuring the time interval between the transmission of the pulse and the reception of its echo provides data from which the range of the object producing the reflection may be determined. This reflection of electromagnetic waves from objects is similar to the production of echoes by sound waves. Shouting toward a cliff or some other sound-reflecting surface, one hears his shout return from the direction of the reflecting surface. The time interval between the shout and its echo may be measured with a stop watch. This time interval increases with the distance of the observer from the object producing the reflection. Sound waves travel through air at approximately 1,100 feet per second. Thus if the observer stands 550 feet from the cliff, he hears the echo of his shout after a lapse of one second. If he is 2,200 feet away, he hears the echo after 4 seconds, and so on. The first half of the interval in each case is the time required for the sound waves to reach the reflecting surface; the second half of the interval is the time taken for the echo to return to the source. Radio waves travel with the speed of light, 186,300 miles per second. Thus if a radar pulse were to be sent out in the direction of a reflecting body 93,150 miles distant, its echo would return exactly one second after the pulse was transmitted. Obviously this distance is very large compared to the distances assumed in discussing the analogy with sound. It is also much greater than any distance measured in the practical application of radar. For this reason the time intervals involved in radar are measured in microseconds or millionths of a second. Since one microsecond is the time required for a radar pulse to travel approximately 0.186 miles, it is a unit of suitable size for expressing radar time intervals. The next requirement is a mechanism capable of measuring these short time intervals. Mechanical devices are unsuited because the inertia of their moving parts makes them incapable of the sudden movements necessary to show these extremely short radar time intervals. The radar timer must be capable of repeating its time cycle at a high speed. The cathode-ray tube is well suited to this service. Its electron stream, sharply focused, and driven by linear sweep voltages, is made to act as a weightless pointer. This pencil of electrons causes a bright spot which moves across the screen at a uniform speed. If the beam requires 100 microseconds to travel across the screen, half the traverse requires 50 microseconds, quarter traverse 25 microseconds, and so on. It could be calibrated to read in microseconds; however, it is equally easy to make it read directly in miles. Since radar waves travel at a constant velocity of 186,300 miles per second, or 0.1863 miles per microsecond, the 100-microsecond sweep assumed above corresponds to a total travel of 18.63 miles. This means that one traverse of the sweep provides sufficient time for a radar pulse to leave the transmitter and be reflected back from an object 9.315 miles away. The range represented by the sweep is therefore said to be 9.315 miles. If it were desired to have a maximum range of 30 miles the sweep time would be approximately 320 microseconds. The cathode-ray tube used in the manner just described is referred to in radar terminology as an indicator. In its simplest form the indicator reads range only. A simple range indicator or range scope would have its linear sweep trace running across the diameter of the circular screen, exactly like an ordinary test oscilloscope. This type of display is referred to as type A display, and the instrument is simply called an *A* scope. Figure 3 illustrates the use of an *A* scope in the determination of range. As the radar pulse leaves the antenna (T), the indicator begins its sweep. By direct pickup through the receiving system, the transmitter pulse appears on the scope at the beginning of the trace. The pulse travels out to the target and its echo returns to the transmitting position where it is picked up by the receiving antenna (R) and applied to the indicator. The echo appears on the trace as a pip displaced from the transmitter pulse by the distance traversed by the sweep in 100 microseconds. The time required for the round trip therefore is 100 microseconds. Since this is the time required for a radar pulse to travel 18.63 miles, the range of the target is half this distance or approximately 9.3 miles. Many other types of display are available. Radio Set AN/MPN-1 utilizes the PPI display in its search system. This type of indication is similar to type *A* so far as the method of determining range is concerned. It has the additional feature, however, of a timebase which rotates about the center point of the screen like the spoke of a wheel in synchronism with the rotation of a highly directional antenna. By this rotation the PPI presents azimuth as well as range. The indicators used in the precision system of Radio Set AN/MPN-1 are similar to the PPI except that instead of rotating through a complete circle they scan only a sector of a circle, and expand this sector to occupy most of the area on the tube screen. This display is of the type referred to as Expanded Partial Plan Position Indication (EPI). Both PPI and EPI are discussed at greater length in later chapters of this manual.

7. TYPICAL RADAR SET. The relationships between the elements of a simple radar system are given here to assist in applying the basic principles to the systems

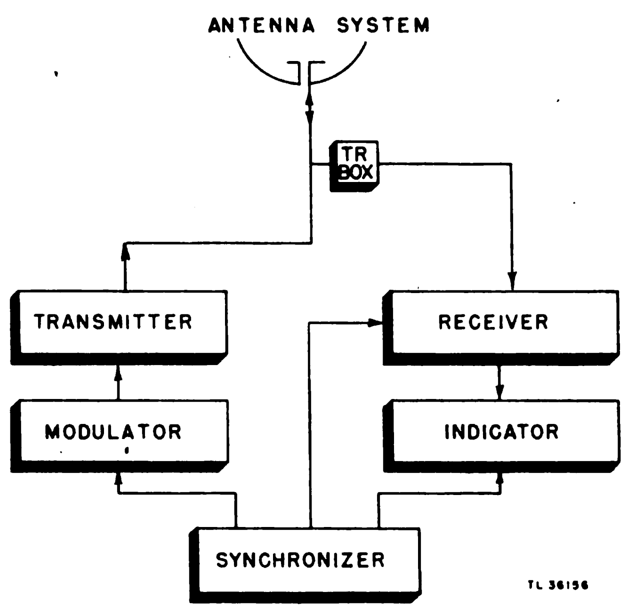


Figure 4. Block diagram of a typical radar set.

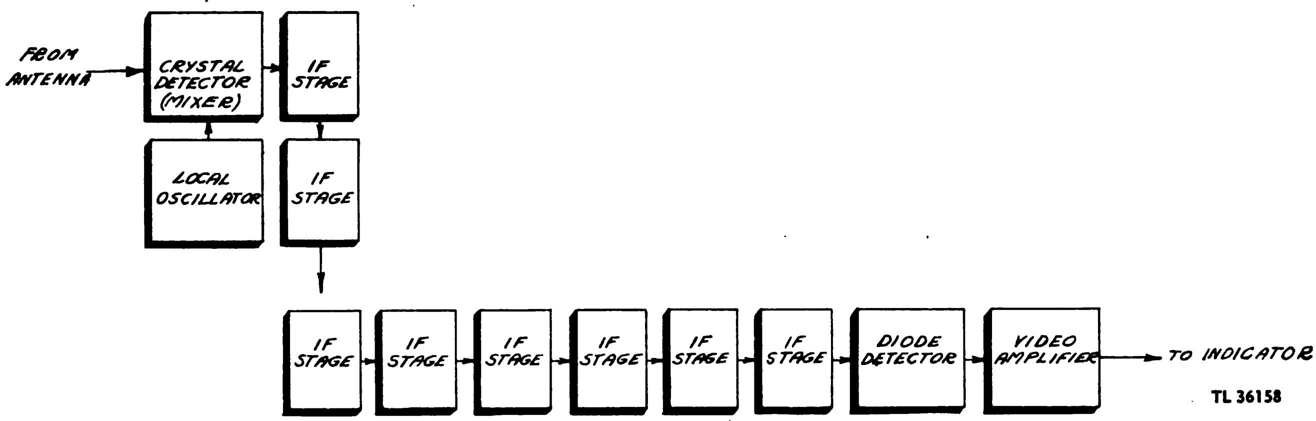


Figure 5. Radar receiver, block diagram.

involved in Radio Set AN/MPN-1. Basically, a radar set can be divided into seven components: a central timing and synchronizing unit, a modulator, a transmitting oscillator, an antenna system, a transmit-receive switch or T-R box, a receiver, and an electrical measuring device or indicator. Figure 4 shows the interconnection between these seven component parts used in a typical radar set.

a. Central Timing and Synchronizing Unit. This unit generates the pulse which keys the modulator and starts the electrical time measuring circuit of the indicators. Other voltage waveforms generated in the synchronizer are used for range calibration, gating, and blanking of the indicator between sweeps. The timing circuit in the indicator must be started at the same instant that the transmitter is pulsed so that the elapsed time between the outgoing transmitter pulse and the returning target echo can be measured accurately.

b. Modulator. The modulator receives a sharp trigger pulse from the synchronizer. This trigger pulse starts the action of a circuit in the modulator that has a precisely regulated period of operation. This stage is often referred to as the driver and its output is a square-wave pulse of short duration. The transmitting oscillator will oscillate only during the duration of the driver pulse. The output from the driver stage is not of sufficient amplitude to control the transmitter without additional amplification. The remainder of the modulator circuit steps up the driver pulse before applying it to the transmitter.

c. Transmitter. The transmitting oscillator tube is a magnetron. The high-voltage pulse from the modulator is applied to the magnetron circuit, causing a series of ultra-high frequency oscillations which are fed to the antenna system.

d. Antenna System. The radio energy from the transmitter may be fed to the antenna system through a coaxial transmission line, or at higher frequencies, through a hollow waveguide. The transmission line coupling and other connections are usually referred to as r-f plumbing. Since the transmitter uses the antenna system for only a small fraction of the total time, the same antenna system can also be used for the reception of the reflected pulses or echoes. For maximum power transfer, the transmission line must match the impedance of the transmitting tube on the input end and the impedance of the antenna on the output end. The antenna array, composed of dipoles or half-wave radiators, is set at the focus of a parabolic reflector designed to produce a narrow beam of radiation. This beam is made to scan the area to be covered in a definite pattern, either electrically or mechanically.

e. T-R Box. Because the same antenna system is used by both the transmitter and the receiver, some means of blocking the high-power transmitted pulse from the sensitive receiver components must be provided. If the transmitted pulse were allowed to enter the receiver it would result in damage to the input circuit. The T-R box functions as an electronic switching device to block the high power pulse from the receiver and allow the relatively weak echo signals to pass through to the receiver circuit and not be attenuated by part of the received signal going into the transmitter circuit.

f. Receiver. Radar receivers are usually of the superheterodyne type (fig. 5). The local oscillator produces an r-f signal which is mixed in a crystal detector with the incoming echo signals to produce an intermediate frequency signal which is the difference between the two r-f frequencies. The local oscillator, mixer, crystal detector, and first stages of i-f amplification are placed very close physically to the transmitter so that the weak echo signals are not attenuated by a transmission line to the receiver proper. From the preamplifier stages, the i-f signal goes to the receiver where it is amplified through a series of high gain tubes and passed on to a second detector. The output of the second detector is a video signal and is similar to the audio output of an ordinary radio receiver. The video signal is amplified and applied to the indicator system.

g. Indicators. Various types of cathode-ray tubes can be used very satisfactorily as radar indicators. In the cathode-ray tube a stream of electrons emitted by the cathode is formed into a beam and focused upon a screen of fluorescent material to form a spot of light. This electron beam can be swept across the face of the tube many times a second by the application of voltage or current waves to deflecting plates or coils. If the electron beam moves often enough over the same path, the eye sees it as an unbroken line. In the simplest case, the electron beam is swept horizontally across the face of the tube at a constant rate each time the transmitter is pulsed. The voltage applied to the horizontal deflecting plates to produce this timebase sweep has a saw-tooth waveform. Another set of plates, at right angles to the first, provide a vertical deflection of the electron beam at the same time that it is being deflected horizontally. When the echo detected by the receiver is applied to the vertical plates, a sharp pip or vertical mark appears, perpendicular to the trace, at a distance from the beginning of the trace proportional to the distance traveled by the transmitted pulse. The type of presentation described above is generally termed type *A* display. Thus the video signal amplitude modulates the trace. Certain other types of presentation provide more complete information on one indicator tube. In general, these types are intensity (or brilliance) modulated; that is, the control grid of the tube is biased to cutoff, allowing the trace to appear faintly, and the echo signal from the receiver is fed to the grid as a positive voltage. This increased voltage brightens the spot caused by the electron stream. The resulting increased flow of electrons causes a brighter dot to appear on the face of the tube. The PPI has a radial sweep beginning at the center and extending out to the edge of the screen. The angular position of the sweep at any instant represents the direction the r-f beam is pointing at that instant. The sweep is made to rotate uniformly about the center of the screen in synchronism with the rotating antenna, and the echo signals are displayed on the face of the tube as bright arcs of light. Thus, the PPI produces on the screen a circular radar map of the surrounding area, with its center point located at the antenna. Range is indicated by the distance of the echo signals from the center point; and bearing, by the angular position of the echo signals. Other types of indicators are used for special applications, varying mostly in the type of information shown on the screen. An important type used in Radio Set AN/MPN-1 is the expanded partial PPI, abbreviated as EPI. This type of indicator is used with a sector scanning antenna in the precision system to enlarge the scale of the radar map. PPI type presentation and a sector expanded by an EPI indicator is shown in figure 6.

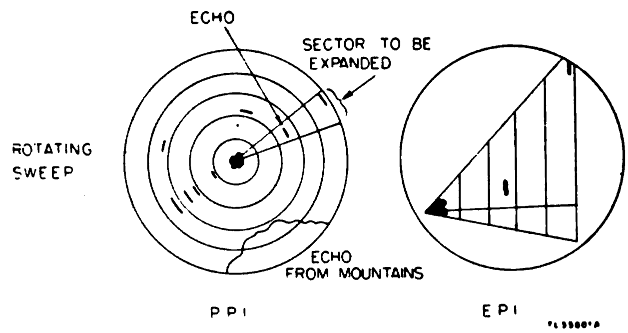


Figure 6. PPI and EPI presentation.

SECTION III

REFINEMENTS IN RADIO SET AN/MPN-1

8. GROUND-CONTROLLED APPROACH (GCA).

The radar and communications equipment included in Radio Set AN/MPN-1 has been designed to accomplish a definite mission, that of assisting the pilots of aircraft in making a safe landing under conditions of poor visibility. For this reason it contains many refinements not found in a typical radar set. Some of the outstanding features of Radio Set AN/MPN-1 are described below.

a. Narrow Pulse Width. The pulse transmitted by Radio Set AN/MPN-1 has a duration of 0.5 microseconds. The narrowness of this pulse insures good definition of echoes, and a maximum of resolving power at short ranges.

b. Highly Directional Antennas. The highly directional antennas used with Radio Set AN/MPN-1 minimize the error in determining position. The search antenna provides a beam approximately 7 degrees wide in azimuth. The precision elevation antenna beam is 0.4 degrees wide in elevation, and the precision azimuth beam is 0.6 degrees wide in azimuth. The narrowness of the elevation and azimuth beams reduces the error in estimating a landing airplane's deviation from the proper glidepath to approximately 5 feet, at ranges of a mile or less.

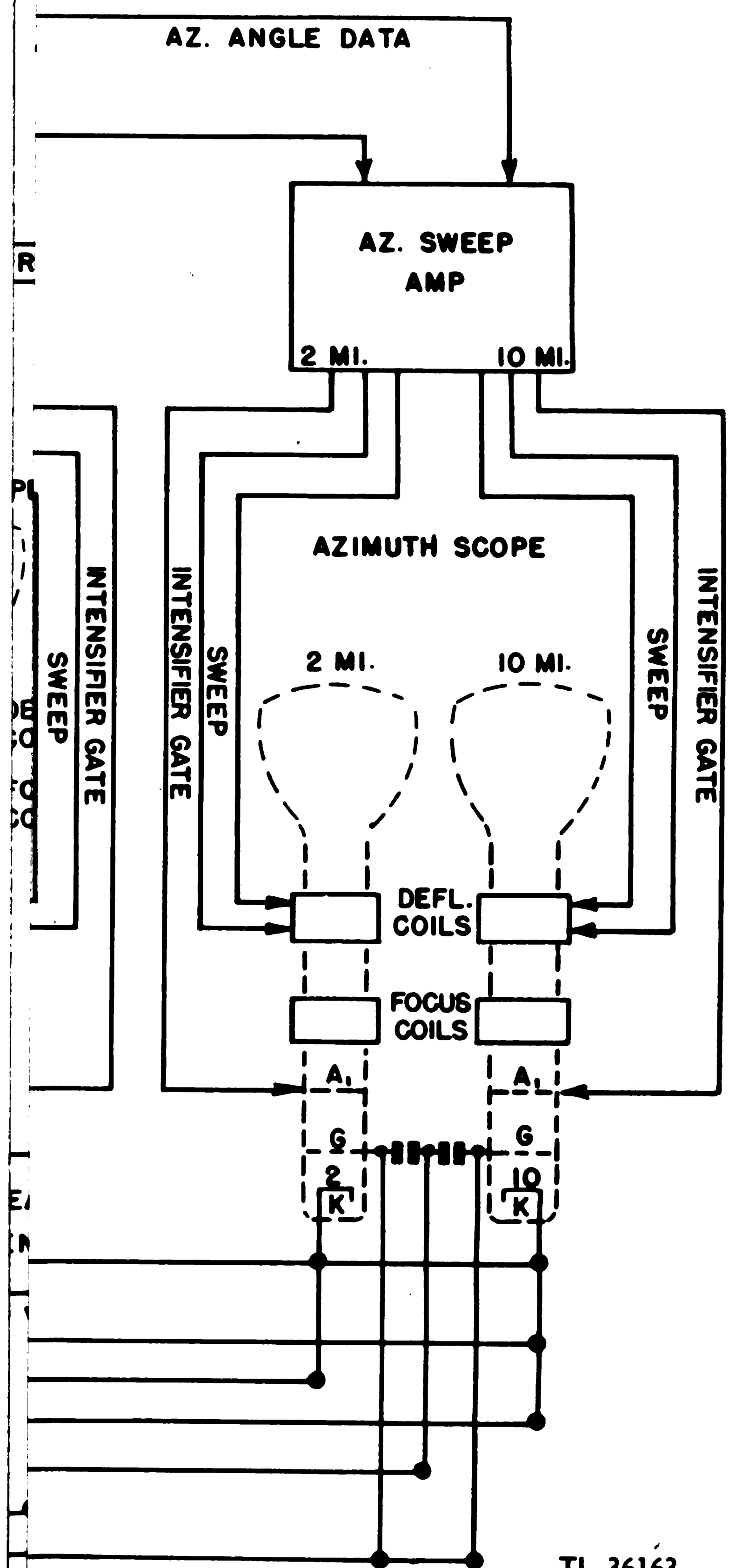


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Figure 7. Radio Set AN/MPN-1, simplified block diagram.

c. Two Systems of Operation. The inclusion of two systems of operation in Radio Set AN/MPN-1 permits equipment and operating personnel to work at maximum efficiency at all times. The search system provides a general coverage of the surrounding area and makes possible the control of traffic while aircraft await their turn to land. The precision system has been designed to provide maximum control during the actual landing operation when deviations of only a few feet from a prearranged glidepath must be detectable.

d. Provision of a Stand-by Channel. To minimize the possibility of interrupted operation due to a sudden failure of some part of the equipment, most of the units have been duplicated to provide two channels of operation. Provisions have been made for switching quickly from one channel to the other.

e. Communication System. The radio communication equipment included with Radio Set AN/MPN-1 provides for two-way contact with aircraft on 21 channels, three of which may be used simultaneously. Twelve of these channels are in the HF band and the other nine are in the VHF band. An additional receiver is used to monitor the control tower frequency.

9. FUNCTIONING OF RADIO SET AN/MPN-1. Figure 7 is a block diagram of one radar channel of Radio Set AN/MPN-1, showing both search and precision systems. A brief discussion of the equipment follows:

a. Search System. The search system of Radio Set AN/MPN-1 is a complete 10-centimeter, or S-band radar system. The continuously rotating antenna and duplicate PPI indicators provide general coverage of the area surrounding the station up to a maximum range of 30 miles. The search transmitter uses a magnetron oscillator driven by high-voltage pulses from a modulator unit. The modulator unit contains a common driver stage triggered by the synchronizer pulse, and two pairs of switch tubes. One pair of switch tubes applies the high-voltage pulse to the search magnetron and the other pair of switch tubes pulses the precision magnetron. The output of the S-band search magnetron is fed to a broadside array of 33 dipoles mounted along the wide side of a section of S-band waveguide, and backed by a cylindrical parabolic reflector. This array produces a fan-shaped radiation pattern 7 degrees wide in azimuth. Echoes are picked up by the rotating antenna, and fed via the T-R box to a mixer in the receiver where they beat with the frequency of the klystron local oscillator to give an intermediate frequency of 30 megacycles (mc). This 30-mc signal is amplified by a two stage preamplifier in the radio frequency unit and applied to the five stage i-f amplifier of the receiver. It is then detected by the second detector and the video signal is amplified by the video amplifier. The video output of the receiver is applied directly to the grid of the search indicator cathode-ray tube. Sweep and intensifying voltages, range markers, an identification strobe, and an auxiliary trigger pulse are generated by the circuits of the search centrals. The auxiliary trigger pulse is used for internal triggering when the precision system is not in operation. Ordinarily the search centrals are triggered by a negative-going pulse from the synchronizer unit. Each of the search indicators has its own search central, and its own low-voltage power supply.

b. Precision System. The precision system operates in the 3-centimeter or *X* band, and provides elevation and azimuth information on separate indicator systems. The output of the 3-centimeter magnetron oscillator is applied alternately to the azimuth and elevation antennas by a motor driven r-f switch. A blanker commutator mounted on the same shaft as the r-f switch causes the output of the receiver to appear alternately on the azimuth and elevation indicators. Thus each of the two indicator systems presents data during half the time required for the commutator shaft to make one revolution. The precision magnetron receives its high-voltage pulse from a switch tube circuit in the same modulator unit that actuates the search transmitter. A single receiving system serves both the azimuth and the elevation systems. Local oscillator, mixer, and preamplifier are located in the radio frequency unit along with the transmitting magnetron. The signal output of these circuits is applied at an i-f frequency of 30 megacycles to a receiver identical in design with that used in the search system. The video output of this receiver receives further amplification in the synchronizer unit and is then applied to the grids of the indicator cathode-ray tubes. Each of the precision indicators utilizes two cathode-ray tubes, one presenting a 10-mile range, and the other a 2-mile range. The indicator sweep and intensity voltages are supplied by the sweep amplifiers, which are triggered by a negative-going pulse from the synchronizer unit. The azimuth and elevation systems are each provided with two sweep amplifier units, one of which serves as a stand-by. Both azimuth and elevation antennas scan electrically, by means of a system which mechanically varies the width of the waveguide feeding the transmitting dipoles. This scanning mechanism is geared to the commutator shaft, and thus is synchronized with the operation of the r-f switch and blanking commutator. The elevation antenna array consists of 173 collinear dipoles mounted vertically along the wide side of a section of X-band waveguide. This waveguide is formed from two telescoping sections and thus has the long side of its cross-section variable (fig. 108). Varying the length of this cross-section of the guide varies the wavelength in the guide, and thus effects a progressive change in phase from one dipole to the next throughout the length of the array. Changing the phase of the dipoles with respect to each other changes the angle of the resultant beam. By continuously changing the width of the waveguide the elevation antenna beam scans through an angle of 7 degrees. The azimuth antenna is constructed similarly except that it has 121 collinear dipoles mounted horizontally, and its beam scans through 20 degrees. Both antennas are backed by reflectors whose cross-section is a half parabolic cylinder.

*c. **Synchronizer.*** The synchronizer generates and supplies the master trigger pulse which synchronizes the entire radar set. The positive-going pulse from this unit actuates the trigger circuit in the modulator, while the negative-going pulse synchronizes the precision sweep amplifiers and the master gating multivibrator in the search central. In addition, the synchronizer performs certain specialized functions in connection with the precision system. This unit includes the precision video amplifier, blanking voltage amplifiers, angle voltage circuits, and range mark circuits.

10. OPERATION OF GCA.

NOTE: The following discussion is not intended as tactical operation procedure. Some knowledge of the operational use of this equipment is required in order to give a clear understanding of the function and relationship between components of the set. The examples are presented with this thought in mind only.

*a. **Operating Personnel.*** (1) The OBSERVER is stationed at the observation window (fig. 8) during opera-

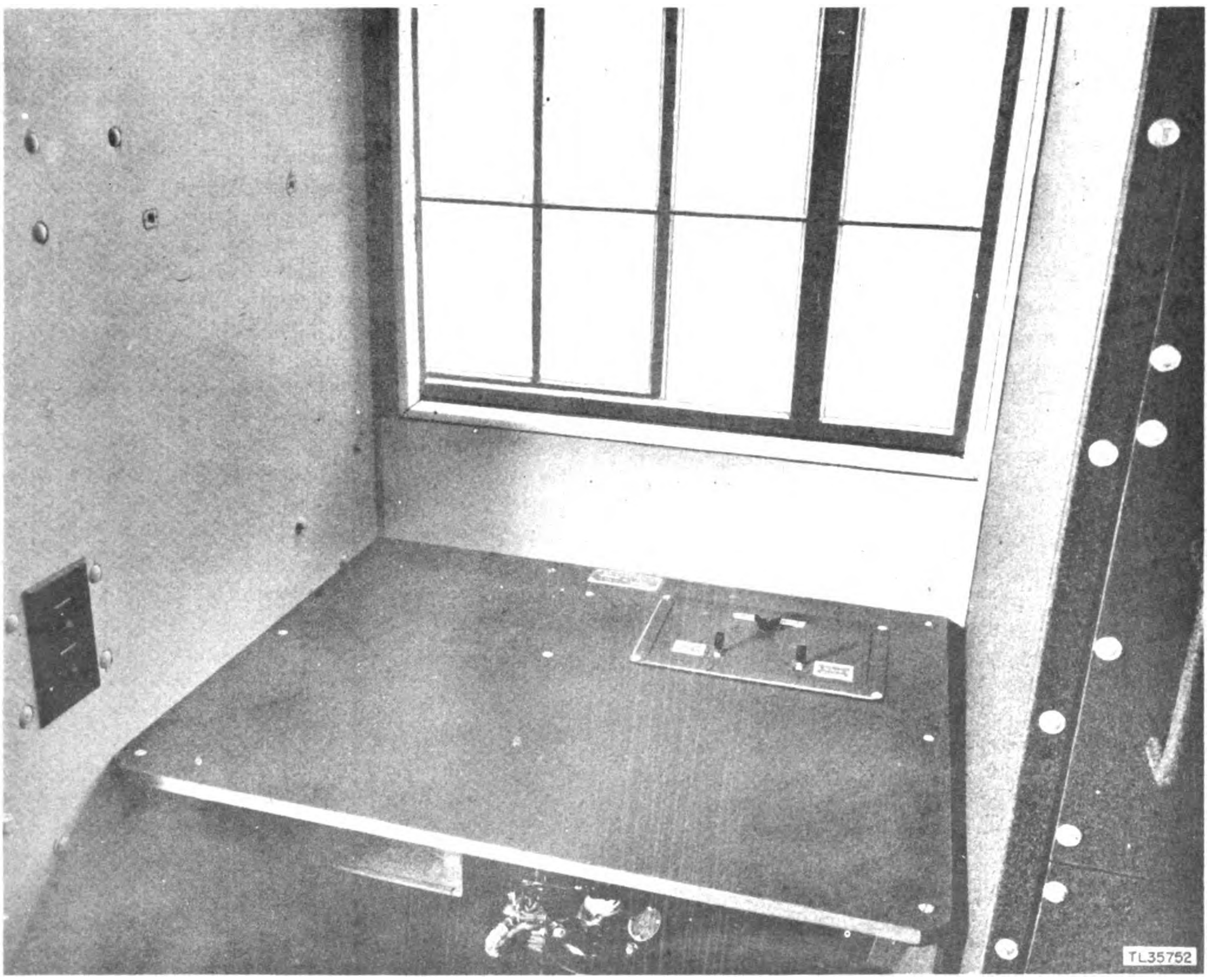

Figure 8. Observer's position.

tions, and monitors the controller to see that all necessary information is given the aircraft at the proper time. The observer's position also has facilities to monitor the airfield control tower so that control over aircraft may be coordinated. Any aircraft taxiing, taking off, or providing a hazard to the airplane making an approach can be seen through the observation window and reported to other operating personnel over the intercommunication system. The instant that the approaching aircraft breaks through the overcast it is reported over the intercommunication system. Should the observer see that the landing aircraft is in immediate danger he can instantly take over control from the controller.

(2) The TRAFFIC DIRECTOR is stationed at the No. 1 PPI position in bay 6 of the indicator rack (fig. 9) and is responsible for the initial pickup, identification, and initial directions to all aircraft landing on GCA. The push-to-talk transmit switch; illumination controls for the map, compass rose, clock; and the variable-range strobe control are within easy reach of the No. 1 PPI position. The compass rose must be set correctly before the start of each operational period and the navigating head is used during operations to give accurate compass readings. In the case of heavy clouds, the search receiver remote gain control in the center of the intercommunications panel is used to reduce heavy cloud signals until the aircraft can be seen through them. The map is used to mark the gate point and other turning points as well as areas into which it would be hazardous to direct aircraft.

(3) The PLANE SELECTOR is stationed at the No. 2 PPI position in bay 4 of the indicator rack. He accepts an aircraft from the traffic director, gives the pilot prelimin-

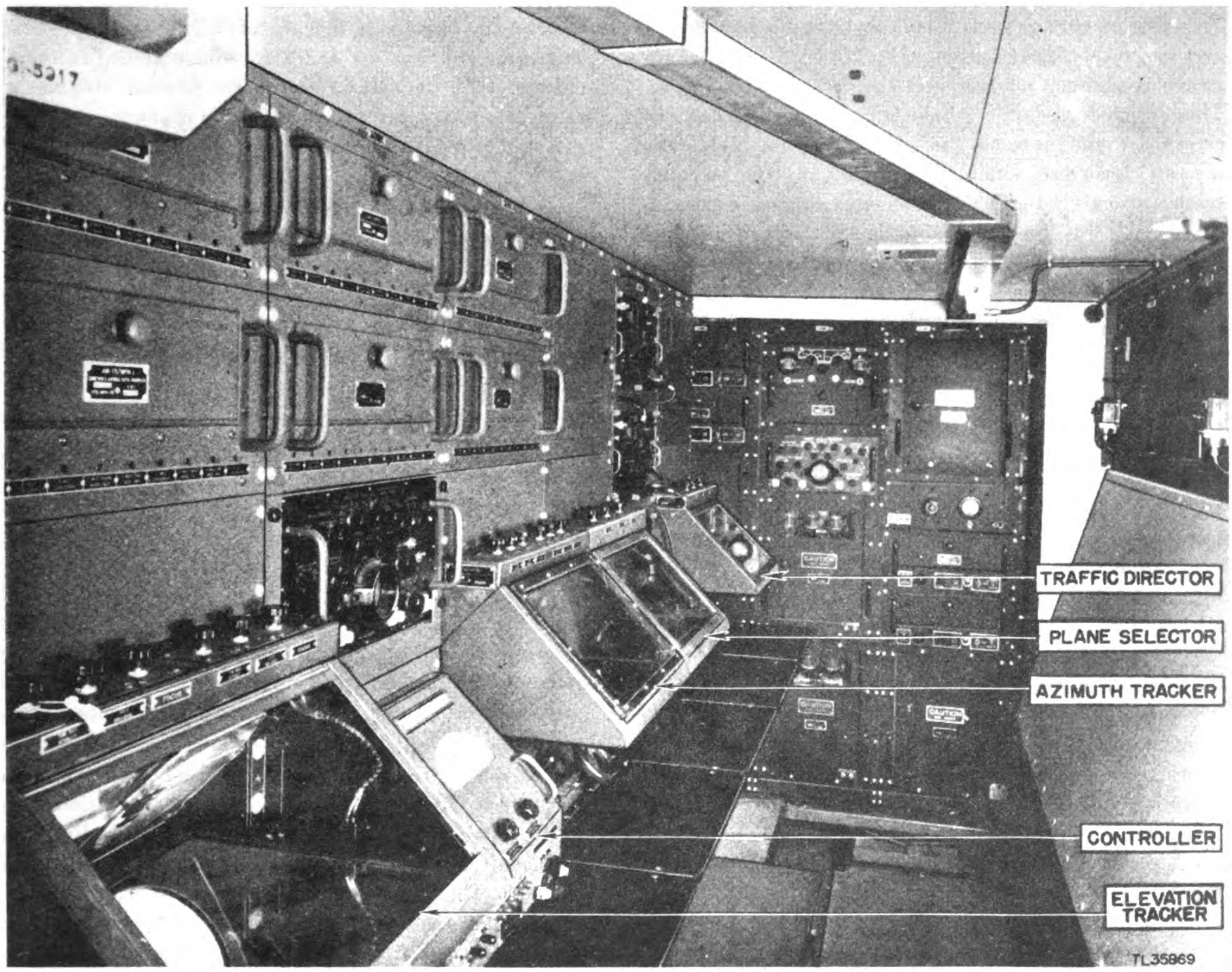

Figure 9. Operating positions.

ary instructions, including cockpit drills, and maneuvers the craft until it appears on the azimuth and elevation trackers' indicator scopes in a suitable position to start its approach. The No. 2 PPI position is identical with the No. 1 position, therefore, the plane selector has the same controls and instruments to use as the traffic director. In case of an emergency, when the precision system is inoperative, the plane selector may be required to direct the aircraft for the complete approach. In this case the search receiver remote gain control should be carefully adjusted for a sharp image on the CRT screens so that the information presented is as accurate as possible. An extension of the runway, out to 15 miles. is drawn on the plane selector's map to aid in directing aircraft.

(4) The AZIMUTH TRACKER is stationed at the precision azimuth indicators. He keeps the azimuth tracking cursors smoothly aligned on the approaching aircraft's signals by the use of the azimuth tracking handwheel. The tracking cursors control both the azimuth error meter and the aural signal output. The DATA GOOD toggle switch is snapped off whenever the data is questionable. This switch turns off the light illuminating the azimuth errormeter and prevents the controller from giving the aircraft incorrect azimuth information. The azimuth tracker also keeps the elevation antenna aligned in azimuth by moving his foot pedals until the aircraft echo is bracketed by the V-shaped servo cursor. A toggle switch changes the scanning rate of the precision antennas from one sweep per second to four sweeps per second. The azimuth tracker switches to high-speed scanning when the approaching aircraft is approximately 5 miles away. The video gain for the azimuth indicators is adjusted by means of the remote video gain control which is within easy reach of the operator.

(5) The ELEVATION TRACKER is stationed at the precision elevation indicators. He keeps the elevation tracking cursors smoothly aligned on the approaching aircraft's echo by means of the elevation tracking handwheel. This cursor controls the elevation errormeter and the red elevation warning light which indicates when the aircraft is more than 50 feet below the glidepath. The elevation tracker's DATA GOOD switch controls the light illuminating the elevation error meter thus preventing the controller from giving the aircraft incorrect elevation information. He also keeps the azimuth antenna aligned in elevation by moving the foot pedals until the aircraft's echo is bracketed by the V-shaped servo cursor. The elevation tracker tells the controller the range of the aircraft at prearranged intervals. The video gain for the elevation indicators is controlled by means of the remote video gain control within easy reach of the operator.

(6) The APPROACH CONTROLLER is stationed at the errormeter panel and is in charge of the operating crew. He interprets the meter readings and the display, and gives appropriate instructions to the pilot of the landing aircraft over the radio communications system. In the case of fighter planes, the controller will usually give the cockpit drill. The main controls used in this position are the transmit-receive switch, an aural signal switch, and a switch on the microphone cord which permits the controller to turn off his microphone independently of his transmitter carrier.

b. Typical Aircraft Landings. The following example for a typical approach assumes that a predetermined rendezvous point will be used. The rendezvous point is called the "gate" and may be a marker beacon. The maneuvering and spacing of aircraft before they reach this gate is a tactical problem and is not a function of Radio Set AN/MPN-1. Consider a group of aircraft desiring to land with the aid of GCA. Each airplane should have a receiver and a transmitter tuned to radio channel HF1 or VHF1. The traffic director also has a receiver and transmitter on the same channel.

(1) As each airplane passes over the gate, it will contact the traffic director. If the aircraft being landed is at least 2½ to 3 minutes behind its predecessor, the traffic director will direct it towards the start of the glidepath while keeping it at the proper elevation. If there is another airplane less than 2½ minutes ahead of this one, the traffic director delays the newcomer until he is at least 2½ minutes behind the airplane being landed at that time. The traffic director uses the push-to-contact switch which illuminates the lucite compass rose on the CRT head when selecting the heading or bearing given to the pilot. At about this point the director tells the pilot to check the gyro compass. When the craft is about 10½ miles from the field the traffic director switches the identification mark strobe on. He does this by throwing the IDEN. MK. switch to the No. 1 position and moving the VARIABLE STROBE control until the strobe coincides with the aircraft signal. In case operating personnel do not care to use the strobe, the same information can be conveyed by verbally announcing the range of the target.

(2) When the plane selector is ready he requests the next airplane from the traffic director. The selector also throws his IDEN. MK. switch to the No. 1 position, permitting him to see the director's strobe and aiding him in identifying the craft that the director is about to transfer. The director verbally gives the selector information on the landing airplane in the following manner: "Next plane, C Charlie, Liberator, range 10, elevation 2,500." The director then contacts the airplane on the radio communications system with instructions to shift

to radio channel 2. The director then shuts off his strobe and turns his attention to the next target.

(3) Using radio channel HF2 the selector directs the pilot until the airplane is about 6½ miles from the field, and at this point gives the pilot cockpit drill. The selector is now using the 7.5-mile range sweep and should be able to direct the pilot accurately enough to have him within plus or minus 500 feet from the center of the glidepath in azimuth and at 1,000 feet in elevation when the range of the airplane reaches 5.5 miles. The selector then places his strobe on the airplane by turning his IDENT. MK. switch to the No. 2 position, and also places his strobe on the precision indicators by placing his X SYSTEM switch on No. 2 position. He now tracks the craft in range using his VARIABLE STROBE control. When the approach controller is free to handle an airplane he requests "Next plane" from the selector. The selector replies, "Next plane, C Charlie, Liberator, 5.5 miles, 1,000 feet." The azimuth and elevation trackers use this information and strobe mark to locate the aircraft. As soon as they have located the airplane and have started to track it with both servo and errormeter cursors they turn on their DATA GOOD switch.

(4) The controller then turns to the selector and says, "Over to me." Selector then contacts the airplane on the communications system and request the airplane to switch its radio communications channel calling, "Over to channel 3, over." Selector then turns off his strobe mark, accepts the next following airplane from the director, permitting the director to start maneuvering a third ship into position for a landing. If airplane C Charlie is equipped with VHF it shifts both its transmitter and receiver to channel 3. If it is equipped with HF communications equipment it shifts only its receiver to channel 3 leaving its transmitter on channel 2. (A shift in channels at this point would be difficult with Radio Set SCR-274-N communications equipment.) Therefore, the controller's Radio Receiver BC-342-A is left on channel HF2 while the controller's transmitter is on channel HF3.

(5) As soon as radio contact has been established, the controller gives the pilot whatever azimuth or elevation correction may be necessary to keep him on the correct glidepath. At this range, azimuth information is given in the form of magnetic compass headings such as: "Take heading 275 degrees" and elevation information as rate of descent such as "Start to descend at 500 feet per minute." Meanwhile the azimuth tracker has turned on the rapid precision scan, thus providing the most accurate data possible.

(6) The elevation tracker is reporting ranges at 1-mile intervals. When the range is about 4 miles the controller turns on the aural signal unit, thus providing continuous azimuth information to the pilot. It is not absolutely necessary that the aural signal unit be turned on since azimuth information can be given verbally. However, use of the aural signal unit usually results in much smoother approaches. The controller can now stop giving magnetic compass headings and confine his remarks to elevation data except for an occasional "Left 4 degrees —Right 2 degrees" etc.

(7) When the range is about 2 miles, the elevation tracker begins to report range at ¼-mile intervals. The observer is on the alert at the observation window and should see the airplane break through the overcast. When the airplane does break through, and if it is in a position for safe landing, the pilot is instructed to take over.

(8) If the airplane reaches a point ¼ mile from the end of the runway and still has not been seen by the observer, the controller must decide instantly whether or not the craft is in a safe position to land. If it is, he tells the pilot in the following manner: "Range ¼ mile; your rate of descent OK; the center of the runway is 50 feet to your right; take over and pancake." If the airplane is not in a position where it could make a safe landing, the controller requests the pilot to "Pull up at once to 1,500 feet and return to radio channel 1."

(9) Throughout operations the plane selector, azimuth tracker, and observer must be constantly on the alert to report to the controller any other aircraft that might be a hazard to the ship on the glidepath. In case such a hazard develops, the controller should warn the pilot of the landing aircraft by requesting "Emergency sharp left (or right) turn." As soon as the controller has instructed the pilot to take over, the controller turns off the aural signal unit and his transmitter. He then requests the next ship from the selector and the routine is repeated.

SECTION IV

TECHNICAL CHARACTERISTICS AND LIST OF MAJOR COMPONENTS

11. CHARACTERISTICS. The principal technical features of Radio Set AN/MPN-1 are as follows:

Features	Search system	Precision system
Wavelength	10-cm band	3-cm band
Frequency	Approx 3,000 mc	Approx 10,000 mc
Peak power output	85 to 100 kw	15 to 20 kw
Pulse width	0.5 microseconds	0.5 microseconds
Pulse recurrence frequency	Approx 2,000 pps	Approx 2,000 pps
Maximum range	30 miles	10 miles
Scan	360°	Elevation 7° Azimuth 20°
Height limit	4,000 feet	
Range accuracy	7½-mi range ± ¼ mi 15-mi range ± ½ mi 30-mi range ± ¾ mi	2-mi tube no measurable error 10-mi tube ± 200 feet
Elevation accuracy		Error equals ± 50% of deviation from the glidepath in feet
Azimuth accuracy	Resolution of airplanes 700 ft apart at 4-mi range.	Resolution of airplanes 55 ft apart at 2,500-ft range on 2-m tube: 500 ft apart at 22,000-ft range on 10-mi tube.
Power requirements:		
When furnished by the PE-127-A units:	117-volt, 60-cycle, single-phase, 18-kva supply.	
When furnished by commercial power:	110-220-volt, 60-cycle, single-phase, 10-kva max load supply.	
Setting-up time	2½ hours for complete set up. Change of runway 40 minutes.	

12. LIST OF MAJOR COMPONENTS.

Descriptive name	Army-Navy nomenclature	
Air blower unit	Air Blower Unit	MX-35/MPN-1
Air conditioning unit	Air Conditioner	MX-31/MP
Altimeter unit	Altimeter Unit	ID-94/MPN-1
Angle capacitor unit	Angle Capacitor Unit	CU-15/MPN-1
Angle take off	Angle Coupling Unit	CU-14/MPN-1
Aural signal	Aural Signal Unit	O-8/MPN-1
Azimuth antenna	Azimuth Antenna Assembly	AS-40/MPN-1
Azimuth director	Azimuth Director Assembly	MX-32/MPN-1
Azimuth indicator	Azimuth Indicator	ID-36/MPN-1
Azimuth reflector	Azimuth Reflector	AT-20/MPN-1
Azimuth scanner or squeeze box	Azimuth Antenna Array	AS-41/MPN-1
Azimuth servo	Azimuth Antenna Follower Assembly	MX-47/MPN-1

Descriptive name	Army-Navy nomenclature	
Beacon receiver	Tower Receiver	BC-1206-C
Capacity divider	Voltage Divider	TS-222/MPN-1
Commercial power connector panel	Junction Box	J-29/MPN-1
Communications HF antenna (whip antenna)		
Communications VHF antenna (stub antenna)	Antenna	AT-22/MPN-1
Communications rack *A*	Communications Rack	MT-121/MPN-1
Communications rack *B*	Communications Rack	MT-120/MPN-1
Communications test equipment (SCR-274)	Test Equipment	RC-55-A
Communications test equipment (SCR-522)	Test Equipment	IE-19-A
Corner reflector	Reflector Target	MX-233/UP
Drive motor assembly	Motor Drive Unit	PU-38/MPN-1
Elevation antenna	Elevation Antenna Assembly	AS-42/MPN-1
Elevation director	Elevation Director Assembly	MX-33/MPN-1
Elevation indicator	Elevation Indicator	ID-37/MPN-1
Elevation reflector	Elevation Reflector	AT-21/MPN-1
Elevation scanner or squeeze box	Elevation Antenna Array	AS-43/MPN-1
Elevation servo	Elevation Antenna Follower Assembly	MX-48/MPN-1
Error meter	Approach Indicator	ID-38/MPN-1
Flux meter	Flux Meter	TS-15/AP
Headphone matching assembly	Headphone Matching Assembly	CU-46/MPN-1
HF communications equipment	Radio Set	SCR-274-N
Hydraulic leveling system	Hydraulic Leveling System	MX-34/MPN-1
Indicator rack	Indicator Rack	MT-118/MPN-1
Intercommunications panel	Intercommunications Panel	SB-2/MPN-1
Modulator	Modulator	MD-11/MPN-1
Mounting	Search Antenna Mount	MT-122/MPN-1
Negative power supply	Rectifier Power Unit	PP-25/MPN-1
Observer's control box	Observer's Control Box	C-139/MPN-1
Observer's desk	Observer's Desk	MX-204/MPN-1
Oscilloscope		
Photoelectric commutator	Commutator Unit	SA-40/MPN-1
Power distribution panel	Power Distribution Panel	SB-1/MPN-1
Power monitor	Power Monitor	TS-36/AP
Power monitor	Power Monitor	TS-125/AP
PPI central	Search Central	SN-6/MPN-1
PPI indicator	Search Indicator	ID-35/MPN-1
PPI power supply	Rectifier Power Supply	PP-27/MPN-1
Prime mover	Truck	V-8/MPN-1
Power extension cord	Junction Box	J-45/MPN-1
Power units	Power Unit	PE-127-A
Receiver	Radar Receiver	R-38/MPN-1
Reflector	Search Reflector	AT-19/MPN-1
Rotoflector	Search Antenna Assembly	AS-38/MPN-1
SCR-274 antenna relay	Antenna Relay Unit	BC-442-A
SCR-274 control box	Radio Control Box	BC-456-A
SCR-274 dynamotor	Dynamotor	DM-33-A
SCR-274 power supply	Rectifier Power Unit	PP-28/MPN-1
SCR-274 receiver	Receiver	BC-342-N

Descriptive name	Army-Navy nomenclature	
SCR-274 transmitter	Transmitters	BC-696-A, BC-457-A, BC-458-A
SCR-522 control box	Radio Control Box	BC-602-A
SCR-522 dynamotor	Dynamotor Unit	PE-94-A or PE-98-A
SCR-522 power supply	Rectifier Unit	RA-62
SCR-522 transmitter-receiver assembly		
S antenna	Search Antenna Array	AS-39/MPN-1
S echo box	Echo Box	TS-217/MPN-1
S field transmission line	Transmission Line	CG-30/MPN-1
S heterodyne converter and preamplifier		
S rotary transmission line	Transmission Line	CG-31/MPN-1
S test set	Test Set	TS-224/UP
S transmitter	Radio Frequency Unit	RF-7/MPN-1
Signal generator		
Sweep amplifier	Sweep Amplifier	AM-15/MPN-1
Switching unit	Switching Unit	SA-8/MPN-1
Synchronizer	Synchronizer	SN-5/MPN-1
Synchroscope	Synchroscope	TS-64/MPN-1
Test rack	Test Rack	MT-287/MPN-1
Tower receiver antenna mounting assembly	Antenna Bracket Assembly	AB-43/MPN-1
Tower receiver control panel	Tower Receiver Control Box	C-140/MPN-1
Tower receiver power supply	Rectifier Power Unit	PP-100/MPN-1
Trailer	Trailer	V-2/MPN-1
Trailer connector panel	Junction Box	J-30/MPN-1
Transmitter control box	Control Box	C-61/MPN-1
Transmitter h-v power supply	Rectifier Power Unit	PP-26/MPN-1
Transmitter rack	Transmitter Rack	MT-119/MPN-1
Truck connector panel	Junction Box	J-31/MPN-1
Truck telephone box	Telephone Box	TA-6/MPN-1
Tube tester		
VHF communications equipment	Radio Set	SCR-522-A
Voltage regulator	Voltage Regulator Unit	CN-3/MPN-1
Weston analyzer and multiplier		
X echo box	Test Set	TS-225/MPN-1
X heterodyne converter or preamplifier		
X test set	Test Set	TS-13/AP (modified) or TS-191/MPN-1
X transmitter	Radio Frequency Unit	RF-6/MPN-1
300-v power supply	Rectifier Power Unit	PP-22/MPN-1
4-kv power supply	Rectifier Power Unit	PP-23/MPN-1
4-kv relay assembly	Relay Assembly	RE-3/MPN-1
500-v power supply	Rectifier Power Unit	PP-24/MPN-1

CHAPTER 2

THEORY OF SEARCH SYSTEM

SECTION I

INTRODUCTION

13. PURPOSE AND DESCRIPTION. To assist aircraft in landing under conditions of poor visibility, Radio Set AN/MPN-1 must perform two distinct functions. First, it must provide information for stacking up the aircraft and for manuevering them into position for the approach to the runway. Second, it must provide a system which will accurately direct the airplane during the approach on a given runway. The first of these requirements is fulfilled by the search system of the radio set while the second requirement is handled by the precision system. The search system does not operate entirely independent from the precision system because some components such as power supplies, modulators, and timing circuits are shared between the two systems. Nevertheless, the search system may be thought of as a complete and independent radar set. The search system of Radio Set AN/MPN-1 operates in the 10-centimeter or *S* band of frequencies, and presents a radar map on the PPI showing the location of all aircraft within a radius of 30 miles and having an altitude of less than 4,000 feet. It uses a mechanically rotated antenna system which scans through 360 degrees in azimuth and presents data on two PPI display indicators. Information provided by this system enables the GCA operators to control traffic and to maneuver airplanes into a position where they may be turned over to the precision system for landing.

*a. **Dual Channel Design.*** The transmitting and receiving equipment of the search system, together with their associated power supplies, is in duplicate. The first set of equipment is designated channel A while the second is called channel B. The precision system has similar duplication. Radio Set AN/MPN-1 has been designed in this manner so that the failure of one component in the channel during landing operations will not render the set useless. The spare channel may be switched on and landing operations continued. The spare channel is maintained in a stand-by condition by the preheat circuit so that the channel switching time is held to a minimum.

*b. **Coverage.*** Each search indicator is provided with a range selector switch that may be set to 7½, 15, or 30 miles. Thus, the range of coverage on either search indicator may be selected independently. Normally the No. 1 PPI indicator is used by the traffic director who stacks up and gives preliminary instructions to aircraft awaiting their turn to land. The airplanes which he is following are usually at greater range than those handled by the plane selector on the No. 2 PPI indicator. Only two search indicators are provided in Radio Set AN/MPN-1 and both are in operation regardless of which channel is being used. In case of an emergency, one PPI indicator can be made to serve both the traffic director and the plane selector. The beam radiated by the search antenna in the vertical plane, is high enough to escape most ground objects which would give confusing reflections, and still detect aircraft at a minimum glide angle. The beam, while not giving complete overhead coverage, flattens out at approximately 4,000 feet in altitude so that during most of its range it is nearly flat-topped.

*c. **Location of Components.*** The physical grouping of components frequently does not conform to the logical functional grouping. For example, the crystal mixer which is part of the receiving system, is located in the transmitter compartment so that it may be physically close to the T-R box. The theoretical discussion to be given in the succeeding sections will take up the components in their functional order. It will be useful, however, to first give a brief description of the physical layout of components.

(1) RADIO FREQUENCY UNIT RF-7/MPN-1. This unit provides two complete r-f channels which are located side by side within the one compartment in bay 9 of the transmitter rack (fig. 10).

(2) MODULATOR MD-11/MPN-1. There are two identical modulator units both located in bay 8 of the transmitter rack. One is in the channel A circuit while the second is in the channel B circuit.

(3) RADAR RECEIVER R-38/MPN-1. Two identical radar receivers are used in the search system and they are in bay 7 of the transmitter rack. The channel A receiver

is located at the top of the rack just above the channel B receiver.

(4) RECTIFIER POWER UNIT PP-26/MPN-1. A separate high-voltage power supply is provided for each of the two modulators. They were both located in bay 7 of the transmitter rack.

(5) SEARCH INDICATOR ID-35/MPN-1. The No. 1 search indicator is in bay 6 of the indicator rack (fig. 11) and the No. 2 search indicator is in bay 4. These are respectively the operating positions of the traffic director and the plane selector.

(6) SEARCH CENTRAL SN-6/MPN-1. There are two identical search centrals that supply sweep and operating voltages to the search indicators. They are also in bays 4 and 6 of the indicator rack and are installed directly under their respective indicators.

(7) RECTIFIER POWER UNIT PP-27/MPN-1. These power supplies furnish operating voltages to each of the search centrals. They are located in bays 4 and 6 of the indicator rack behind the No. 1 and No. 2 search indicators. Therefore, they are not visible from the front of the rack and the search indicators must be removed in order to get at them.

(8) SEARCH ANTENNA ASSEMBLY AN-38/MPN-1. The search antenna assembly is located on the front right corner of the trailer roof (fig. 1). The search antenna drive assembly is below the rotating reflector and is accessible inside the trailer. The sine potentiometer is geared to the search antenna drive assembly and is used to produce varying voltages that synchronize the rotating sweep of the indicator tubes with the search antenna.

(9) RECTIFIER POWER UNIT PP-23/MPN-1. These two power supplies furnish the voltage applied to the final anode of both the search and precision system indicator tubes. They are located in bay 4 of the indicator rack.

14. BLOCK DIAGRAM. A block diagram of the search system is shown in figure 12. The components are in duplicate wherever two channels occur. Note that both the channel A and the channel B transmitter units are contained in the one compartment. The channel A modulator is normally triggered from the channel A synchronizer in the precision system while the channel B modulator receives its trigger pulse from the channel B synchronizer. Provision has also been made to trigger either modulator from the No. 1 or No. 2 search central by a selector switch on the intercommunications panel. Triggering by the search central is used if the search system is to be operated independently of the precision system. A separate receiver is supplied for each channel. At this point, duplicate channel equipment ceases and a relay switches the video output from either channel A or channel B receiver to both search indicators.

a. Transmitting Equipment. In the following discussion only the channel A equipment will be considered. The discussion applies equally as well to channel B. A positive trigger from the synchronizer starts the modulator action. The modulator produces two high-voltage pulses of 0.5 microseconds duration. One of these high-voltage pulses is applied to the channel A magnetron oscillator of the search transmitter unit. The second pulse is applied to the precision magnetron oscillator of the precision transmitter unit by means of a coaxial cable connection. Thus the two systems use a common modulator unit. The modulator unit has a self-contained power supply to furnish the plate voltage for the driver stage, negative grid bias voltages, screen grid voltages, and the negative keep-alive voltage for the gas tubes in the T-R boxes of both the search and precision transmitter units. The high-voltage for the final modulator stages is furnished by a separate high-voltage power supply (PP-26 on diagram) that delivers 15,000 volts dc to the modulator.

b. Search R-f System. The search r-f system includes the necessary plumbing and transmission line to connect the output of the magnetron oscillator to the antenna and to conduct the comparatively weak echo signals from the antenna to the receiving system. It also includes the r-f channel switch and T-R box, which permits the same antenna to be used for both the transmitter and receiver. Collectively the system functions to couple the high power r-f energy from the transmitting system to the antenna array where it is radiated into space, and to receive the reflected energy and apply the received echo signals to the receiving system. The antenna array is mounted vertically and it consists of 33 dipoles fed from a rectangular section of waveguide. The search antenna array is mechanically rotated in azimuth to give complete coverage of the surrounding space within the range of the set. The r-f output from the magnetron oscillator is fed through the motor-driven r-f channel switch to the search antenna. Echoes from the magnetron oscillator pulses are picked up by the same antenna and proceed through the T-R box to the heterodyne converter unit in the receiving system.

c. Receiving System. The S-band heterodyne unit converts the echo into an i-f frequency of 30 megacycles and amplifies it before sending it on to the receiver proper. The radar receiver has an additional five stages of i-f amplification, a second detector stage, and a video output stage. After passing through the receiver, the echoes are in the form of video pulses and may be connected directly to the grid of the PPI indicators. A built-in power supply in this receiver furnishes necessary voltages

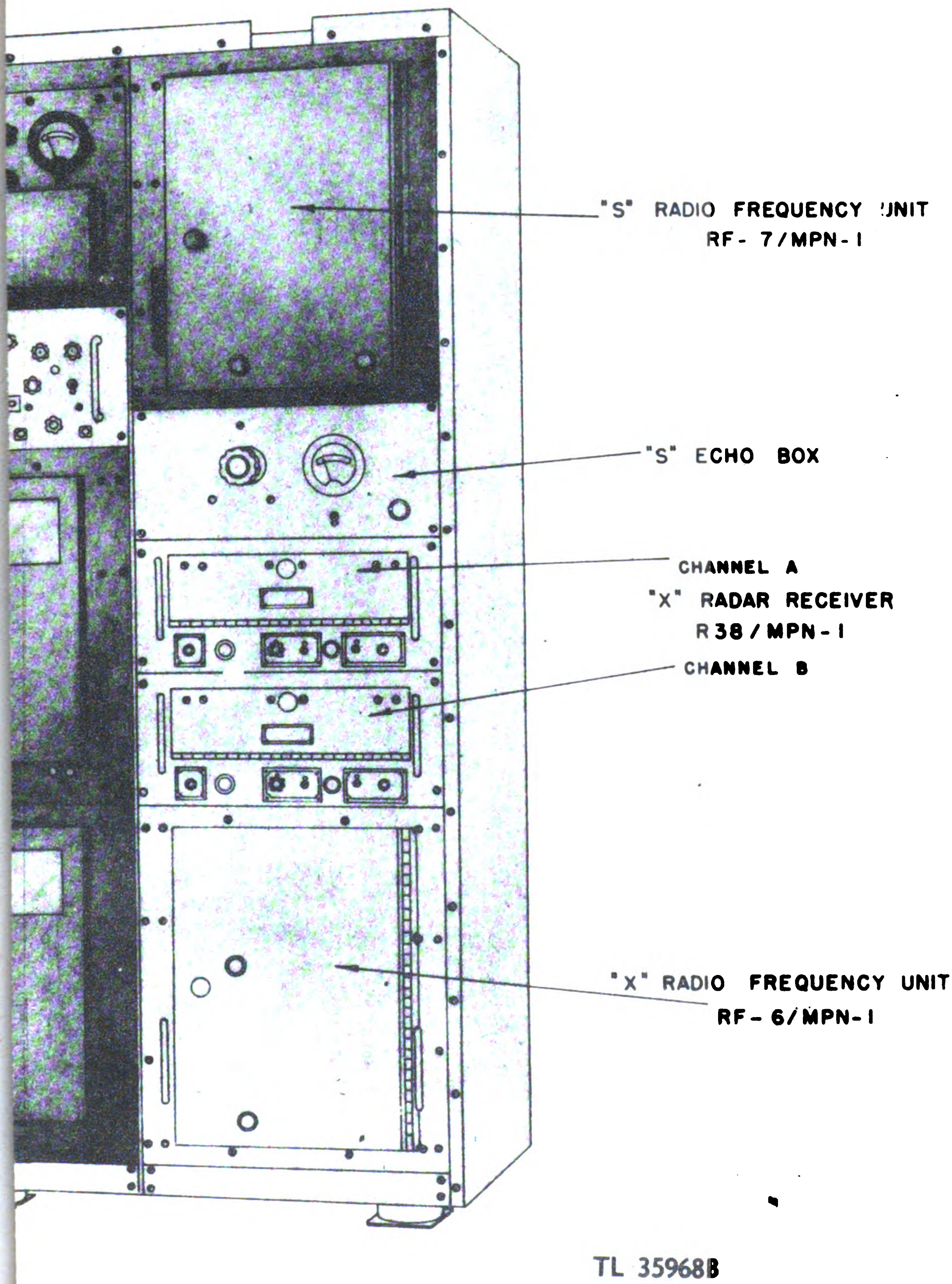

Figure 10. Transmitter Rack MT-119/MPN-1, search system components.

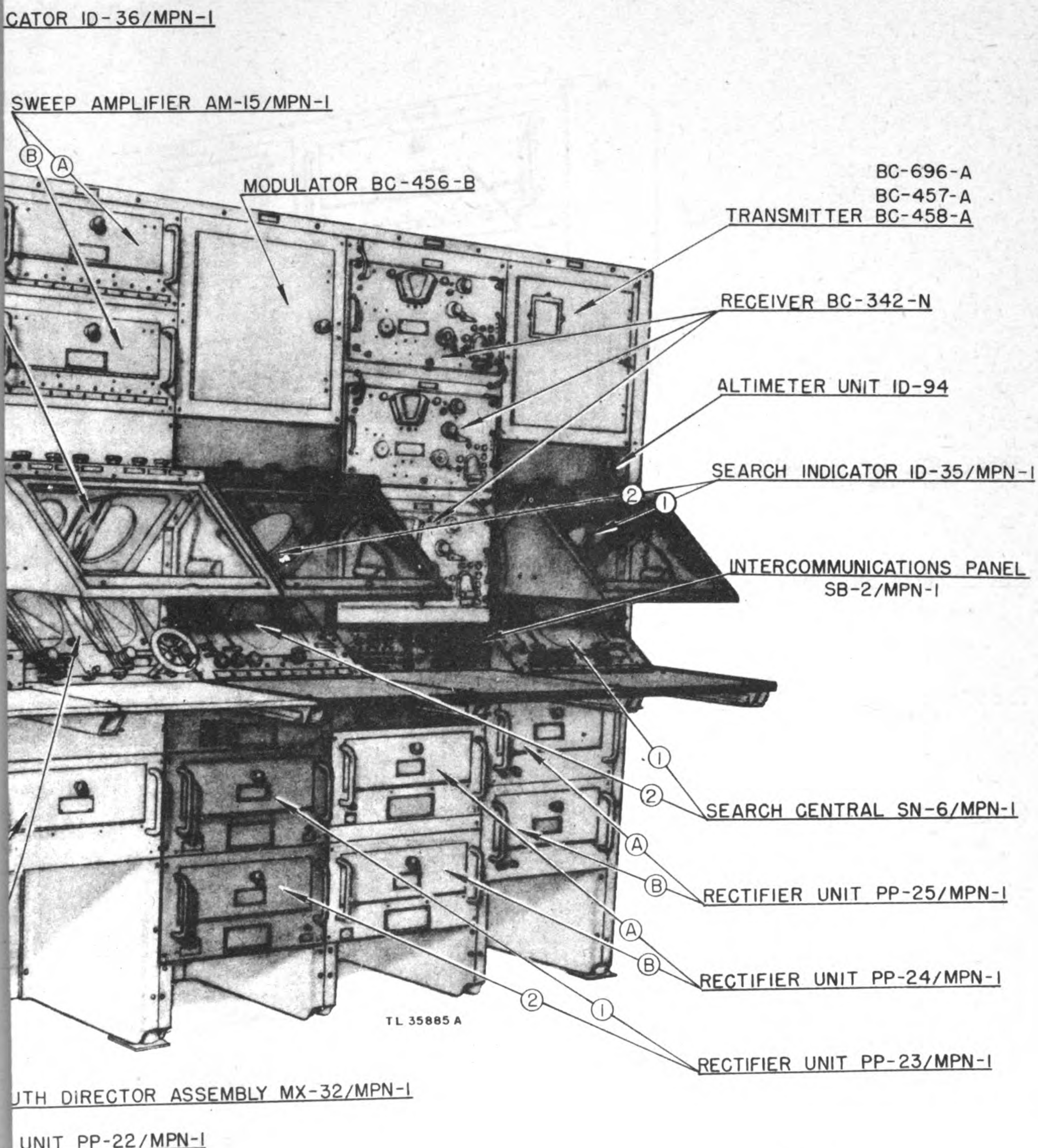

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Figure 11. Indicator Rack MT-118/MPN-1, search system components.

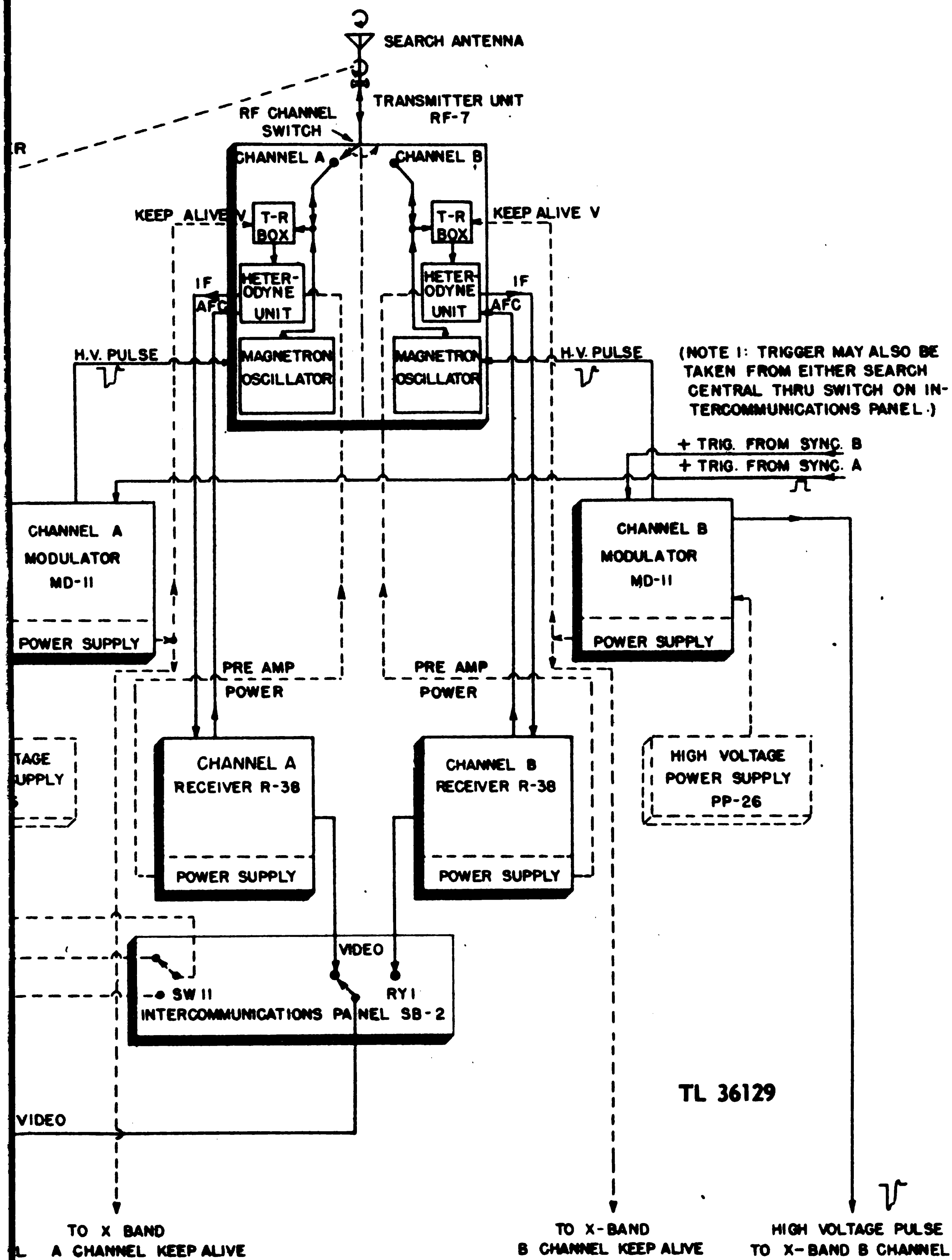


Figure 12. Search system, block diagram.

for the receiver unit itself and, in addition, it supplies power to the heterodyne converter unit located in the transmitter. The receiver AFC circuit feeds a voltage back to the heterodyne converter which controls the i-f frequency and keeps it constant at 30 megacycles. The video output from the receiver goes through relay 1 on the intercommunications panel. This relay is actuated by the channel switching circuit and connects the video output of either the chanel A or channel B radar receiver to the grid of both search indicators.

d. Indicating System. The search central is the heart of the indicating system. It provides a 360-degree rotating sweep, range markers, and adjustable identification strobe marks for the indicator tubes. Normally it is triggered by negative-going pulses out of the synchronizer, but a means of internal triggering is also provided. The search central panel mounts most of the controls needed at the two search operating positions. Both search indicators are in operation whenever the set is being used and they are not duplicated for channel A and channel B operation. The sine potentiometer, geared to the search antenna, provides voltages which synchronize the rotating sweep with the search antenna. This synchronizing voltage is applied to both search centrals where the timebase sweep for the indicators is generated by a circuit that causes the sweep to rotate on the indicator tubes. Each search central has its own power supply (PP-27 on diagram). Power for the sine potentiometer is obtained from either the No. 1 or the No. 2 search central through a switch on the intercommunications panel. The 4,000 volts supplied to the final anodes of the indicator tubes is applied from either of the two 4-kv power supplies. These power supplies also feed the final anode on the precision indicators. A 3-position switch, located on the front of the relay panel, makes it possible to select either of the two power supplies for final anode voltage. Either one, or both, of these power supplies can be used for both the search and precision system, or each system may be supplied separately.

SECTION II

TRANSMITTING SYSTEM

15. INTRODUCTION. The purpose of the transmitting equipment is to generate microwave radio frequency pulses. The following components make up the search transmitting system: Modulator MD-11/MPN-1, S-band Radio Frequency Unit RF-7/MPN-1, Rectifier Power Unit PP-26/MPN-1. Figure 13 is a simplified block diagram of the transmitting components and shows how the r-f pulses are produced. The trigger pulse which times the transmitter r-f pulse is supplied by the synchronizer unit. It is necessary to synchronize the circuits in the system in order to accurately measure the time interval between the production of the transmitted pulse and the reception of the echo reflected from the target. Provision also is made so that the transmitting system may be triggered from either of the two search centrals of the search system. Trigger pulse selection is controlled by a screwdriver-slotted switch on the intercommunications panel. In normal operation the trigger pulse is always supplied from the synchronizer, but the additional triggers from the search centrals are provided for test purposes and in case the search system should be used independently of the precision system. Each of the components shown in figure 13 will be described in detail later in this section. The search transmitting system is duplicated in two channels designated channel A and channel B. Only one channel is in use at a time, the second being held as stand-by.

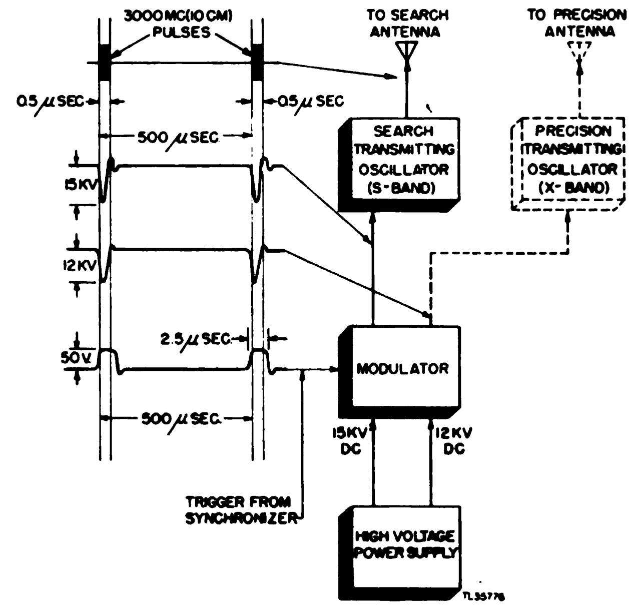


Figure 13. Transmitting system, simplified block diagram.

a. Location of Components. Figure 10 shows the front view of Transmitter Rack MT-119/MPN-1. Both channel A and channel B modulators are located in bay 8. The high-voltage power supplies for the modulators are in bay 7. The search radio frequency unit is located in bay 9 and houses duplicate r-f units for both channel A and channel B within the one compartment. The local oscillator, crystal mixer, and preamplifier unit for each channel are in the radio frequency unit. These components are part of the receiving system and are discussed in detail in section IV. Current and voltage readings for the search transmitting system are read on the *S* meter in Control Box C-61/MPN-1. The meter readings are helpful in determining whether the equipment is operating normally, and in locating the faulty component or circuits if trouble should develop.

b. Modulator MD-11/MPN-1. A single modulator unit for each channel supplies the high-voltage pulses to both S- and X-band transmitters. The sharp trigger pulse from the synchronizer is applied to the grid of the driver tube in the modulator which is a blocked oscillator. The output of the blocked oscillator is coupled through a special pulse transformer to the switch tubes and to the artificial line delay network through another winding. The delay network controls the oscillation period of the blocked oscillator which in turn determines the width of the transmitted pulse. There are four switching tubes used in each modulator, with one pair of tubes in parallel for the S-band transmitter and the other pair in parallel for the X-band transmitter. These are high vacuum, or hard, tubes and perform exclusively a switching function. A high-voltage capacitor is coupled to their plates and is charged to the potential of the high-voltage power supply. When the positive pulse from the blocked oscillator reaches the grids of the switching tubes, conduction is permitted, partially discharging the high-voltage capacitor through the magnetron. As the discharge time is short in comparison with the time constant of the circuit, a negative square wave pulse is generated. This voltage pulse is of 0.5 microsecond duration and the magnetron oscillates only when pulsed by the action of the switching tubes. The 0.5 microsecond pulses are applied to the magnetron 2,000 times per second which is the pulse recurrence frequency of the system.

c. Power Supplies. Rectifier Power Unit PP-26/-MPN-1 furnishes the high voltage used in the modulator. The total high-voltage output, 15 kv, is used as a plate supply for the two S-band switch tubes. The X-band switch tubes are supplied with about 12 kv through voltage dropping resistors in the high-voltage power supply. Rectifier Power Unit PP-26/MPN-1 is discussed in detail in chapter IV. The modulator unit contains an additional power supply that furnishes +1,200 volts dc and -750 volts dc. The positive voltage is used as a plate supply for the blocked oscillator and as the screen grid supply for all the modulator tubes. The negative voltage is used as a grid bias supply for the switching tubes and for the blocked oscillator. The negative voltage is also used for the keep-alive voltage in both the search and precision system T-R boxes. As this power supply is contained on the modulator chassis, it is discussed below with the modulator.

d. Radio Frequency Unit RF-7/MPN-1 (fig. 14). The radio frequency unit has two subchassis assemblies each mounting a magnetron oscillator and associated equipment (fig. 15). One magnetron oscillator is used with channel A while the second is used in channel B. The 15,000-volt negative pulse from the modulator unit of each channel is applied to the cathode of the transmitting oscillator. The magnetron receives filament power through a transformer which is insulated to withstand this high-voltage pulse. The output of the magnetron is coupled to the r-f plumbing system and is fed to the search antenna through a section of rectangular waveguide running along the trailer roof from the transmitter rack to the search antenna. The T-R box, channel switching mechanism, and the interconnecting plumbing are necessarily located in the transmitter unit but function as part of the r-f system and are therefore discussed in section III. As previously stated, the radio frequency unit also contains a local oscillator, a crystal mixer, and a preamplifier for each channel. These components, functionally part of the receiving system, are placed in the transmitter unit so that the weak signal may be converted to the i-f frequency and amplified sufficiently to overcome the attenuation of the transmission line to the receiver proper.

16. MODULATOR MD-11/MPN-1.

a. Description. The same modulator is used to key both the search and the precision transmitters simultaneously at a pulse recurrence frequency (prf) of 2,000 pulses per second. Two identical modulators (fig. 16) are included in Radio Set AN/MPN-1, one being used by the channel in operation and the other held ready for use in the spare channel. The complete schematic diagram for the modulator unit is shown in figure 25 and should be used in conjunction with the simplified circuit diagrams in the detailed discussion that follows. The trigger, or actuating pulse for the modulator is a positive pulse from the synchronizer unit. The first tube of the modulator is a double tetrode with its elements connected in parallel. This tube, the driver, consists of a blocked oscillator whose period of oscillation is controlled by an artificial delay line. The circuit constants of the artificial line are so chosen that the blocked oscillator produces a 0.5 microsecond pulse for operation of the two pairs of modulator switch tubes. One pair of switch tubes works into the S-band transmitter and the other pair into the X-band transmitter. These switch tubes together with the high-voltage RC circuit produce the extremely high-voltage negative pulses required for operation of the transmitting magnetron tubes. A block diagram of the modulator unit is shown in figure 17.

b. Driver (fig. 18). (1) A blocked oscillator may be used to produce a pulse of accurately controlled dura-

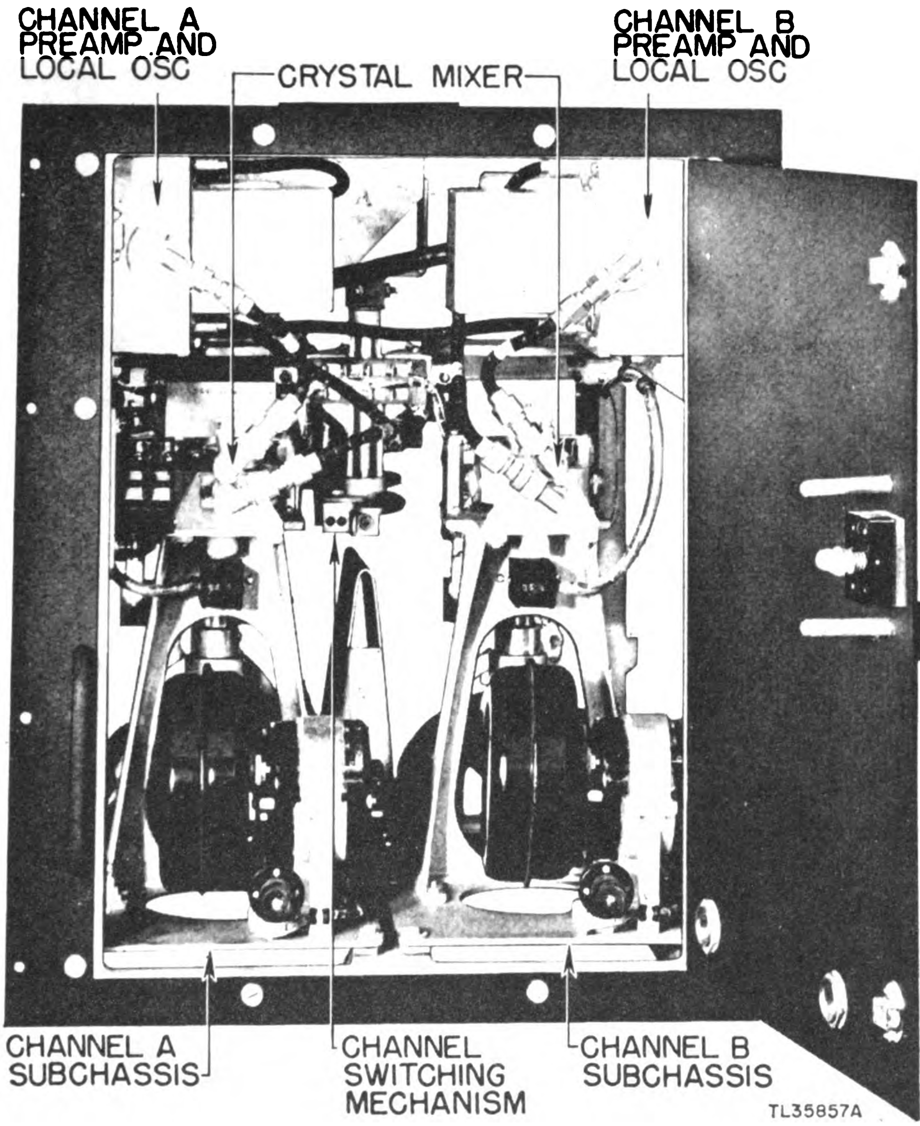


Figure 14. Radio Frequency Unit RF-7/MPN-1, front view.

tion for operating the modulator switching tubes. An artificial transmission line is used to control the duration of the pulse, since the blocked oscillator itself is unable to produce a very short square wave output of controlled duration. One advantage of this type of driver is that it requires only one tube, which makes the driver circuit and the associated power supply simple.

(2) A positive trigger of about 50-volt amplitude is applied from the synchronizer to the primary of transformer T1. The trigger pulse appears in the secondary of the transformer as a positive pulse of approximately 180-volt amplitude. This voltage step-up is necessary to compensate for the step-down transformer in the synchronizer unit.

(3) The blocked oscillator driver tube, V1, is normally cut off because its grids are connected through R5 to a minus 110-volt bias supply. The positive trigger pulse from transformer T1 is coupled across the capacitance of the artificial transmission line and through winding S1 on the pulse transformer to the grid of V1. Although the pulse is attenuated in passing through the network, it is of sufficient amplitude at the grid of V1 to start conduction in the blocked oscillator tube.

(4) The plate current of V1 flows through the transformer primaries, P1 and P2, and produces a voltage across these windings. A voltage in secondary S1 is induced that reinforces the trigger pulse, so that the grid is rapidly driven very positive as soon as conduction is

started. If 1,000 volts appear across P1, a voltage of 500 volts is induced in S1 because of the two-to-one turns ratio of the transformer. Current through inductance P1 will rise exponentially and will be almost linear for the 0.5 microsecond period that V1 conducts. Current will flow through P1 only during the conduction period of tube V1. A linear current rise in P1 will induce a relatively constant voltage in S1 which may be represented as a 500-volt source with polarity as indicated in figure 19.

(5) The artificial transmission line is normally charged to −110 volts from the bias supply for V1 through R5,

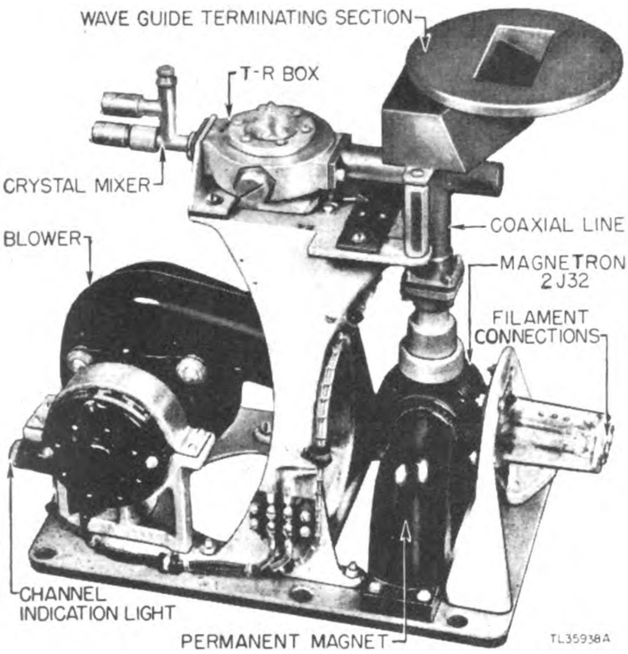


Figure 15. S-band transmitter, subchassis assembly.

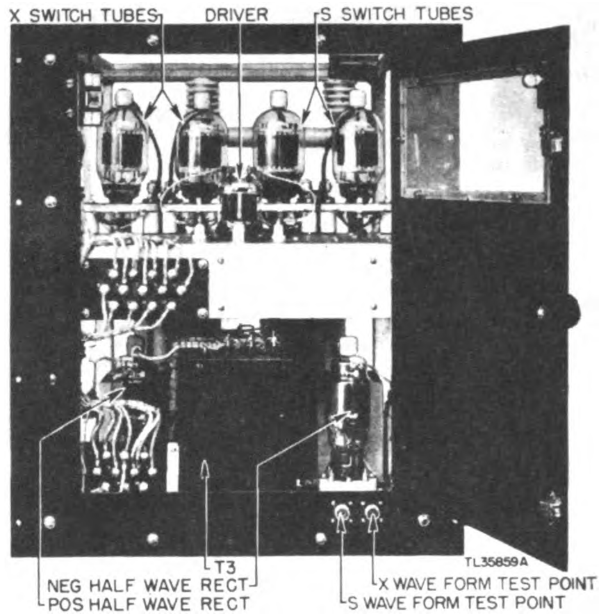


Figure 16. Modulator MD-11/MPN-1, front view.

S1, and T1. In the equivalent circuit, the line is shown as a resistor in series with a 110-volt battery. The voltage to which the line is charged is 110 volts and the voltage induced in winding S1 is 500 volts. Since these voltages oppose each other, only 390 volts (above the reference point) is effectively available in the grid circuit at that instant. The grid to cathode resistance of V1 will be low because the grid has been driven very positive and grid current will flow. The sum of the grid to cathode resistance of V1 and the output resistance of the secondary winding of T1 is approximately equal to the characteristic impedance of the artificial transmission line. Therefore, a current *i* flowing in the circuit divides the differ-

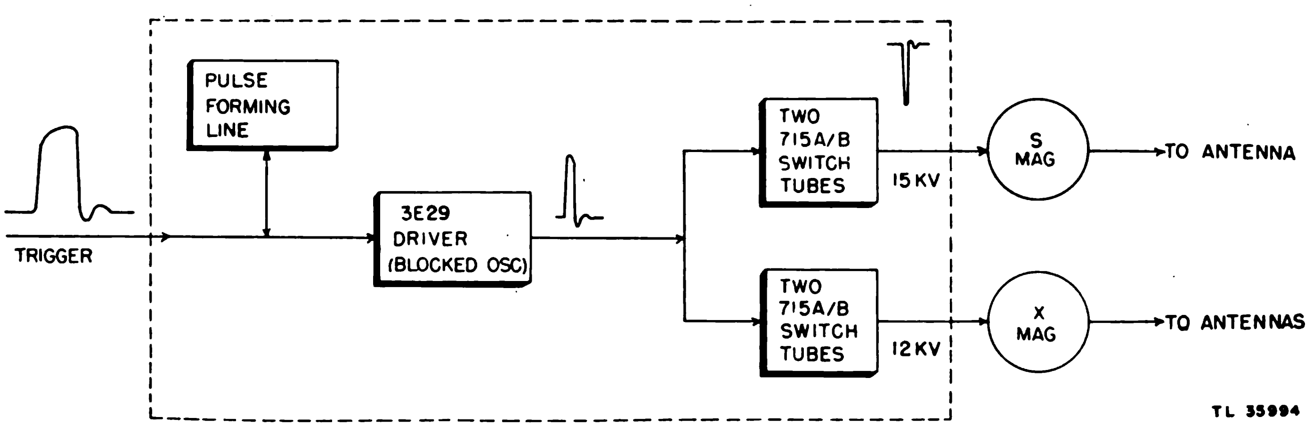


Figure 17. Modulator MD-11/MPN-1, functional block diagram.

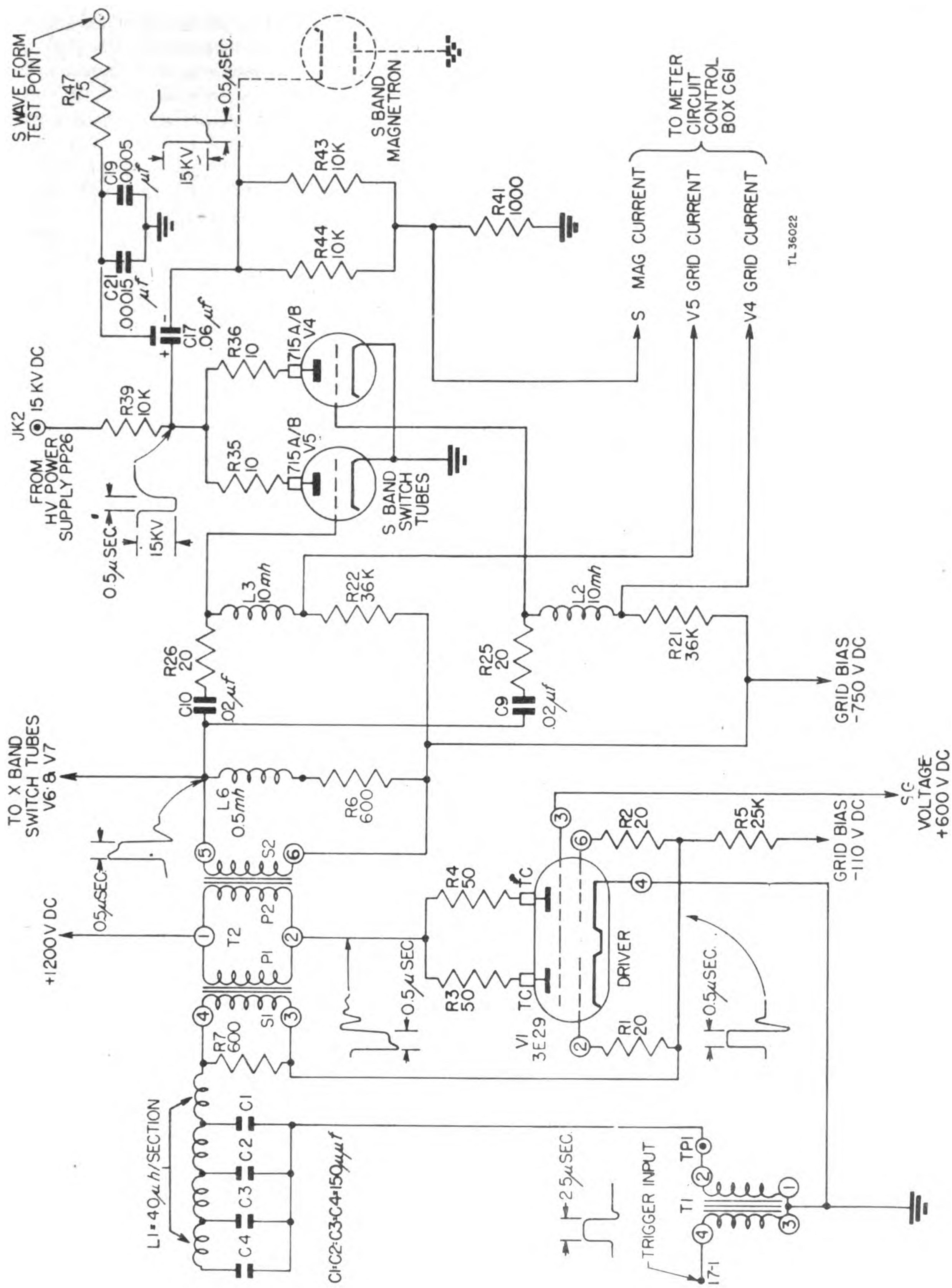


Figure 18. Modulator MD-11/MPN-1, simplified schematic diagram.

ence between the two opposing voltages (390 volts) approximately equal across the artificial line and R_{gk}. The polarity is indicated in figure 19. There will be approximately 195 volts across the line and 195 volts across R_{gk}. The voltage across T1 is small. As long as the current *i* continues to flow, the voltage developed across R_{gk} will keep V1 in full conduction.

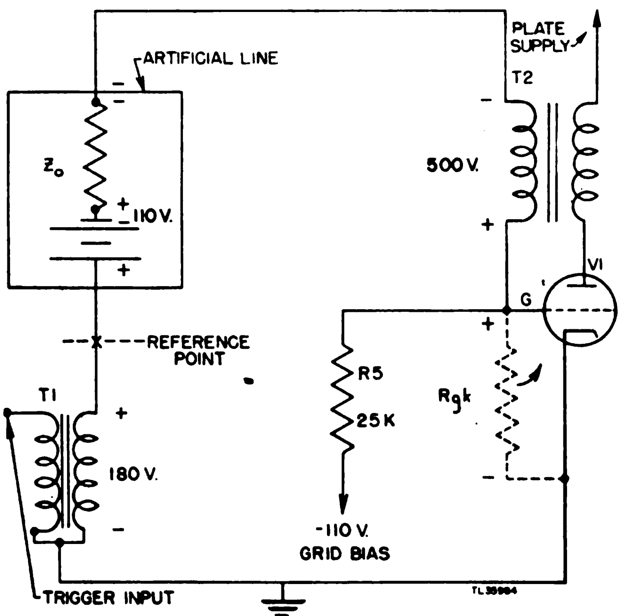


Figure 19. Equivalent circuit of line controlled blocked oscillator.

(6) The additional voltage impressed on the line by the flow of current *i* in the circuit is of the same polarity as the initial charge. A traveling voltage wave of –195 volts goes down the line, raising the voltage of the line to –305 volts above the reference point (fig. 19). When the wave strikes the open end of the line, it is reflected back without change of sign. The wave comes back towards the source, charging the line to –500 volts above the reference point as the wave progresses. When the reflected wave reaches the input terminals of the line, the current *i* drops, since the voltage across the transmission line equals the voltage induced at S1 (fig. 18). Although the timing pulse voltage may still exist across the secondary of T1, the potential of the grid of V1 drops sharply when the 500-volt source, S1, is neutralized by action of the artificial line, reducing the magnitude of the current flowing in the tube.

(7) As the current in the tube starts to fall off, the voltage induced in S1 drops, and the artificial line begins to discharge through R5 and the secondary winding of T1. Both of these effects combine to drive the grid sharply negative, which quickly cuts off the current in V1. The field set up by the primary winding collapses. In collapsing, a sharp negative surge of voltage is induced in S1 which drives the grid even further negative. The artificial line discharges through S1 and R5 to its steady state value of –110 volts. V1 is then held at cutoff by the –110-volt bias applied to its grid until the next trigger pulse from the synchronizer causes the cycle to be repeated. The duration of conduction in V1, which is equal to the output pulse length, is controlled by the artificial transmission line. Since the line is designed so that a $\frac{1}{4}$ microsecond is required for the wave to travel the length of the line, the output pulse is of $\frac{1}{2}$ microsecond duration.

(8) Resistor R7 is used to damp out the oscillations that are excited in the secondary by this negative surge. If no damping were provided, the positive swing of the oscillation might cause pulse triggering of the circuit. Resistor R6 and inductance L6 in the tertiary or output winding damp the output circuit and prevent parasitic oscillations. Resistors R1 and R2 in the grid circuit and R3 and R4 in the plate circuit are parasitic suppressors for the parallel sections of tube V1. The plate voltage for V1 is taken directly from the 1,200-volt output of the power supply contained in the modulator unit. The screen voltage is taken from a tap on the voltage divider across the rectifier output and is about 600 volts above ground. The grid bias voltage for V1 is obtained from the tap in the voltage divider across the negative power supply for the modulator unit. The $\frac{1}{2}$ microsecond positive output pulse from the tertiary winding of transformer T1 is applied directly to the grid of the modulator switching tubes through capacitors C9 and C10 for the S-band switch tubes and C11 and C12 for the X-band switch tubes. This waveform applied to the switching tube grids has a sharp negative transient at the trailing edge, a result of the back emf across the transformer winding. This does not affect operations of the modulator switching tubes, since it occurs at the end of the pulse and only tends to drive them further beyond cutoff.

c. Switching Tube Circuits (fig. 20). (1) There are two pairs of switch tubes used in the modulator unit, each pair consisting of two type 715A/B tetrodes paralleled through low value parasitic suppressor resistors. The parallel arrangement is used in order to secure sufficient current carrying capacity when the peak driving pulses strike the grid. One pair of tubes (V4 and V5) modulate the S-band transmitting magnetron while the other pair (V6 and V7) modulate the X-band magnetron. Both pairs of tubes are normally biased beyond cutoff, since the cathodes are grounded and the grids are returned to

–750 volts from the modulator power supply. The plate voltages for both pairs of tubes are supplied from Rectifier Power Unit PP-26/MPN-1 through load resistors R39 and R40. The plate voltage applied to V4 and V5 is about 15,000 volts and that applied to V6 and V7 is about 12,000 volts.

(2) The positive 0.5 microsecond pulse from the driver tube, V1, is applied through the tertiary winding of transformer T2 to the grid of both pairs of modulator tubes. Between pulses from the driver tube, when the modulator switch tubes are cut off, the high-voltage capacitors C17 and C18 will charge up to the plate voltage of their respective switching tubes. The charging path for C17 is from the positive 15-kv output of the high-voltage power supply through R39, and through the series parallel combination of R44, R43, and R41 to ground (fig. 18). Capacitor C18 charges in a similar manner from the 12-kv output of the high-voltage power supply through R40, and the series parallel resistor network R44, R45, and R42.

(3) Note that the time constant of charging for C17 and C18 is 960 microseconds. The pulse recurrence period of this system is 500 microseconds which would indicate that these capacitors never reach the full charge of the plate supply. However, this is not the case because capacitors C17 and C18 are not fully discharged when pulsing their respective magnetrons. Therefore, the high-voltage capacitors will reach the full charge of the plate power supply after several cycles of operation.

(4) When the positive pulse from the driver stage drives the grids of both pairs of switching tubes positive these tubes conduct very heavily. Effectively the plates of the switching tubes are placed at ground potential. Operation of the switching tubes connects the positive plate of the high-voltage capacitors to ground and completes the cir-

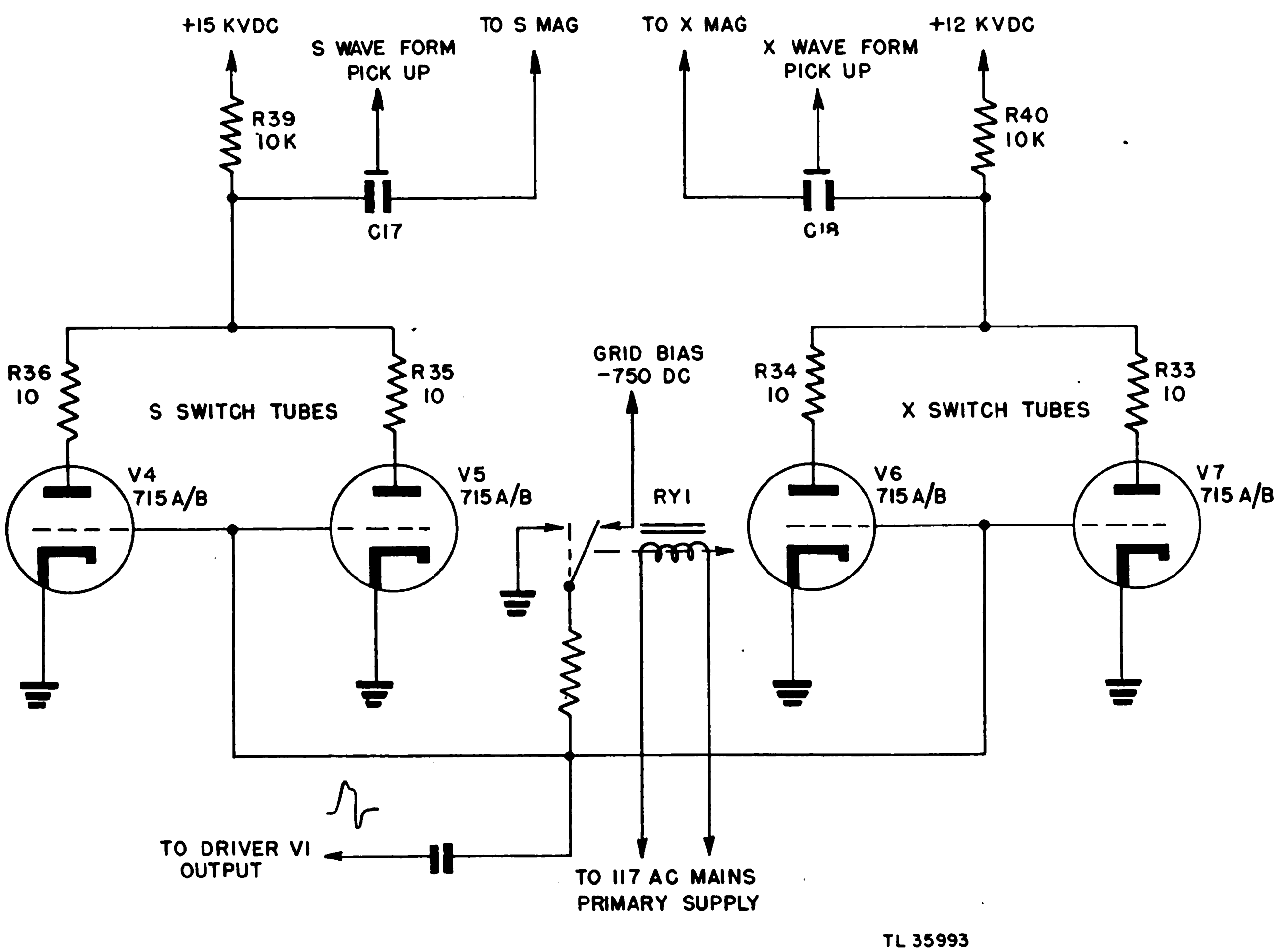


Figure 20. Modulator switch tubes, simplified schematic diagram.

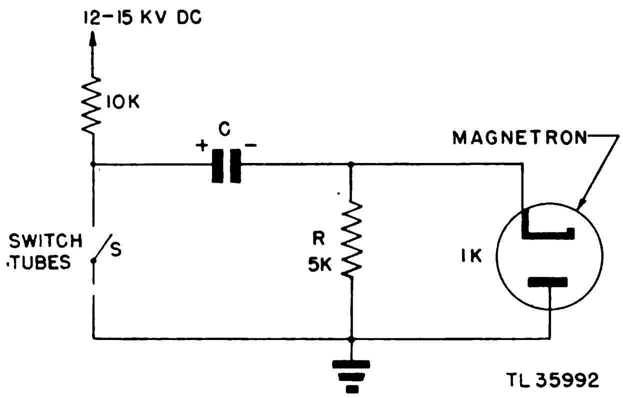


Figure 21. Capacitor discharge circuit.

cuit allowing the high-voltage capacitors to discharge through the magnetron tube as shown in figure 21. The magnetrons are shunted by a resistance network equivalent to about 5,000 ohms placed in parallel with the magnetron tube. During the period of conduction, the input resistance of the magnetron is approximately 1,000 ohms. Therefore, $5/6$ of the current flowing during discharge of the high voltage will go through the magnetron.

(5) The cases of the high-voltage capacitors C17 and C18 form one line connection, so the entire capacitor unit

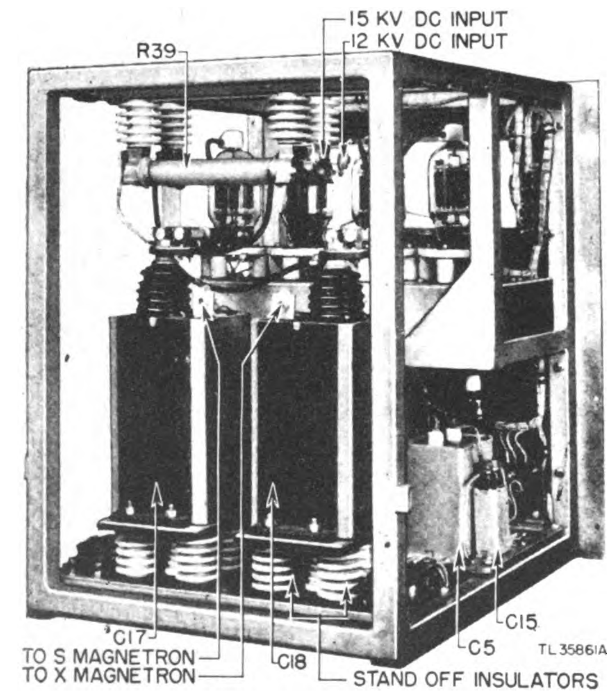


Figure 22. Modulator MD-11/MPN-1, rear view.

must be insulated from ground (fig. 22). Small insulated plates are mounted under C17 and C18 and by means of electrostatic coupling serve as testpoint for checking the high-voltage pulses to the S-band and X-band magnetrons. These leads are brought out to coaxial connectors on the front of the modulator compartment (fig. 16). The S- and X-output waveforms may be viewed on the test synchroscope by connecting to these coaxial output terminals.

d. Protective Relay. The function of relay RY1 (fig. 20) is to discharge the high-voltage capacitors C17 and C18 when the modulator unit is turned off and thus protect operating personnel from the high voltages present. The activating coil for the relay is connected across the 117-volt a-c supply to the modulator unit. Whenever power is applied to the primaries of the modulator filament and power supply transformers the relay will operate. When the relay is in an operated position it switches the −750-volt bias supply to the grids of the modulator switching tubes. This is the normal position when the modulator is operating. The instant that the 117-volt a-c primary power is turned off, the relay will release and, when in a non-operated position, will ground the grids of the modulator switching tubes. The cathodes of type 715A/B switching tubes will remain hot long enough to allow conduction for about 60 seconds at zero grid bias. Any charge on high-voltage capacitors C17 and C18 will automatically discharge through the switching tubes before the cathodes have cooled off.

e. Current Measurement. (1) Meters for current measurement of the tubes in the modulator unit are located in Control Box C-61/MPN-1 and are connected through interconnecting rack wiring to the connector strip on the modulator chassis. In measuring the modulator current output to each of the transmitting magnetron tubes, any meter inserted in series with the modulator output would have to pass the relatively high pulse current which is in the order of amperes. The mean current drawn by the magnetron is only a few milliamperes (ma) and a meter calibrated for this relatively small mean current would not pass the pulse current without damage. In order to avoid this condition, an indirect method of measurement is applied. To measure magnetron current in both the S- and X-band circuits the meter circuit is connected in shunt with a 1,000-ohm resistor which is part of the resistance network through which the high-voltage capacitors charge.

(2) A simplified schematic diagram of the meter circuit for measuring magnetron current on the S-band system is shown in figure 23. I_c is a charging current for the high-voltage capacitor C17. I_m is that portion of the

discharge current that flows through the meter circuit resistance network. I_t is that portion of the discharge current that flows through the magnetron tube. From Kirchoff's laws of current flowing around a closed loop:

$$I_c = I_m + I_t$$
$$I_t = I_c - I_m.$$

As shown in figure 23 the meter has two currents, I_c and I_m applied to it in opposite directions. Therefore, the d-c meter will read the difference of the two currents which is $I_c - I_m$ and is equal to I_t as shown above. I_t is the true magnetron mean current and is the value read on the meter scale.

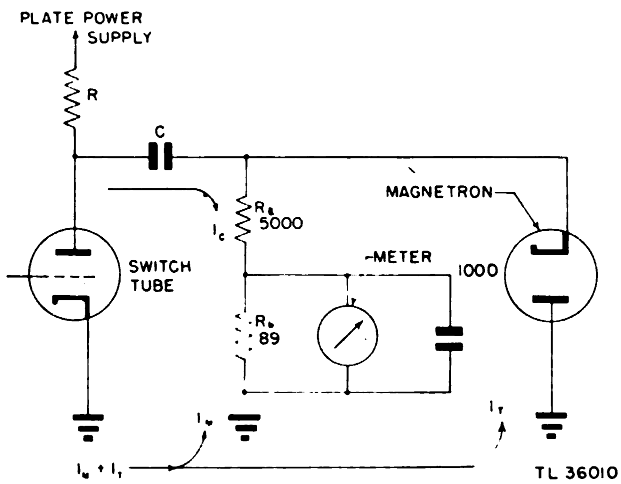


Figure 23. Magnetron current measuring circuit.

(3) For example, if the high-voltage capacitor C17 discharges about 10 amperes into the parallel combination for 0.5 microsecond and the pulse recurrence frequency is 2,000, the mean current is 10 ma. Of this total mean current approximately 1/6 or 1.6 ma flows through the meter and 8.4 ma flows through the transmitter tube. Between pulses, the transmitting magnetrons are nonconducting and the total charging current for capacitor C17 flows through the meter circuit in the opposite direction. The mean charging current must equal the mean discharge current or 10 ma even though the charging period is much longer than the discharge period. The difference between mean charging current of 10 ma, and the mean discharge current of 1.6 ma is 8.4 ma which is the mean current of the transmitting magnetron. These figures are approximations and should not be considered as the actual operating figures.

f. ***Power Supply Circuit.*** (1) All operating voltages for driver tube V1, as well as the grid bias voltage for the modulator switching tube are obtained from a power supply incorporated in the modulator unit. As shown in the simplified schematic diagram, figure 24, this power supply may be considered as two independent half-wave rectifier circuits fed from a single plate supply transformer T3. Using T3 in this manner eliminates the need for an additional transformer.

(2) Half-wave rectifier tube V2 is connected in series with the full secondary voltage output of transformer T3 with its plate wired to the upper secondary winding, terminal 1. It will pass current only during that part of the cycle when terminal 1 is positive with respect to ground. It delivers + 1,200 volts to the modulator unit. The necessary filtering is supplied by capacitor C5 and the voltage divider network, composed of resistors R8 to R16 inclusive.

(3) Negative voltage, with respect to ground, is supplied by rectifier tube V3 which has its cathode connected to terminal 2 on the plate-voltage supply transformer. The only time the current will flow through tube V3 is when terminal 2 becomes negative with respect to ground. The secondary winding of T3 is tapped at a point giving 550-volt rms potential difference between terminals 2 and 3. The output of the half-wave rectifier tube V3 is filtered in the same manner as the positive rectifier circuit above. The voltage divider network consists of resistors R17 to R20 inclusive and C6 serves as the filter capacitor. The resistance chain for the complete voltage divider network is shown on the detailed schematic diagram of the modulator unit, figure 25.

(4) Note that the d-c output of both the positive and negative rectifiers is greater than rms voltage rating for the secondary of transformer T3. Filter capacitors C5 and C6 will charge to the peak value of the voltage wave passed by their respective rectifier tubes. Because the current drain on the power supplies is not large, the d-c output will approach the peak value of the a-c voltage applied to the rectifiers.

(5) Transformer T1 applies the filament voltage to the modulator unit furnishing 27-volt ac for the filaments of the switch tubes and 6.3-volt ac for the filament of the driver or blocked oscillator tube. A common ground return is used in all filament circuits except that of the rectifier tubes themselves. Screen grid voltages are taken from the voltage divider network across the positive power supply with +1,000 volts going to the screen grids of the switching tubes and +600 volts to the screen grid of the driver. The grids of the switching tubes are returned to the -750-volt output of the negative power supply, while the grid of the driver stage is returned

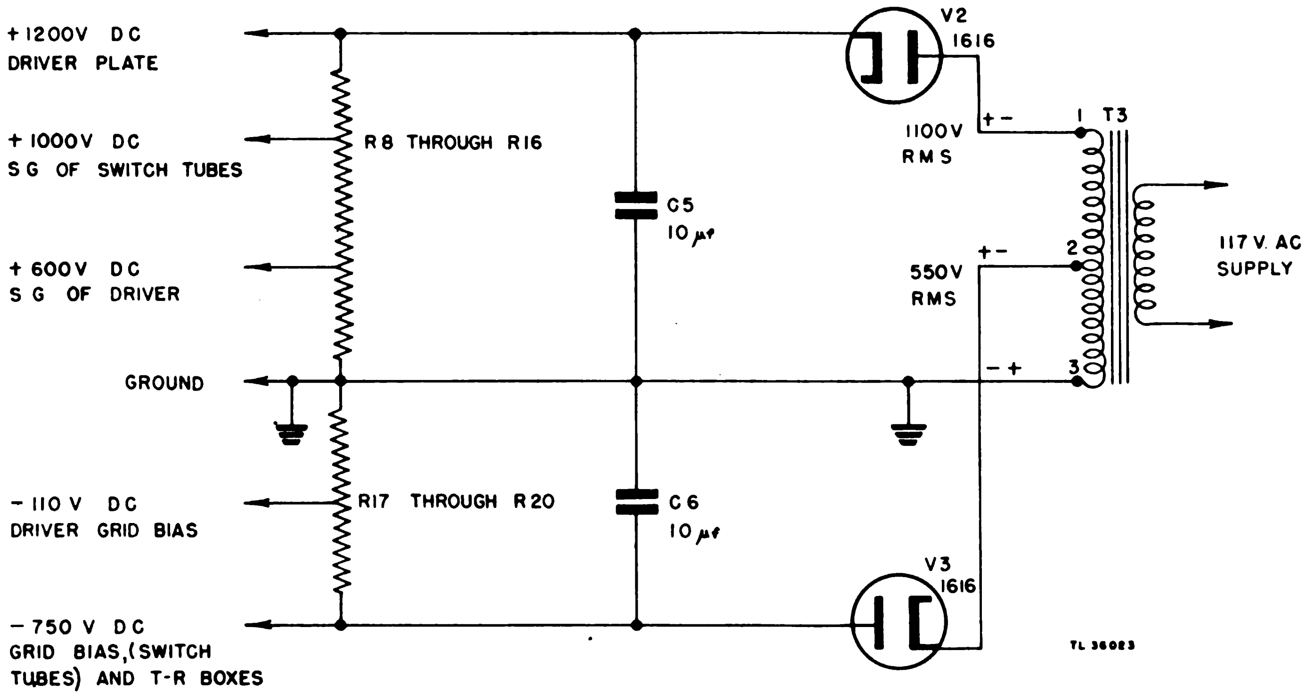


Figure 24. Modulator power supply, simplified schematic diagram.

to –110 volts. The keep-alive voltages for the T-R tubes located in the S-band and X-band transmitter units are supplied from the –750-volt supply in the modulator.

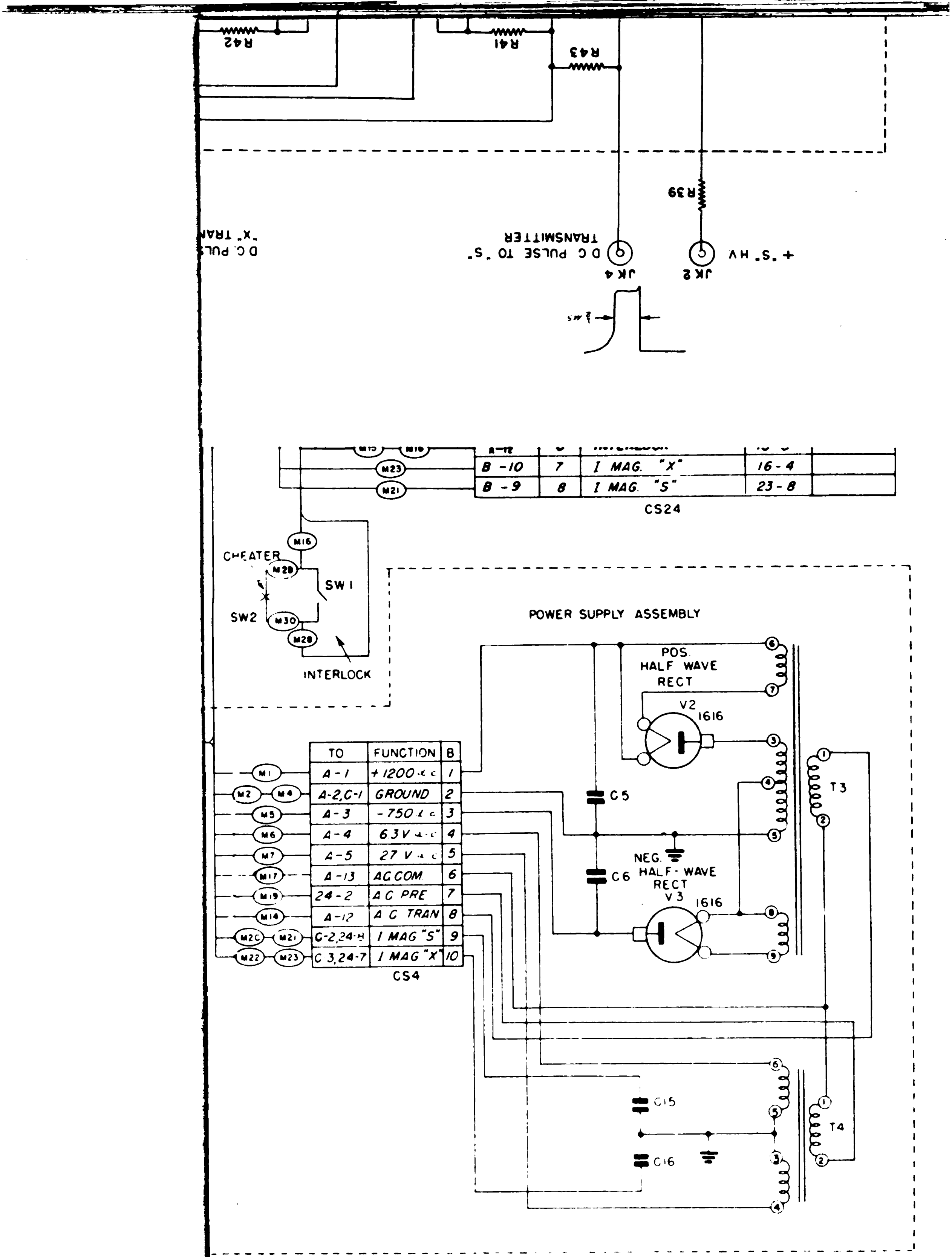
17. RADIO FREQUENCY UNIT RF-7/MPN-1.

a. Description. A single compartment houses the transmitting equipment for both the A and B channels. The high-voltage pulse output from both channel A and channel B modulators is connected to their respective magnetron oscillators through high-voltage insulated cables brought in to the back of the component. The transmit switch, on the power distribution panel, controls channel switching and through its associated circuits applies voltage to the terminal strips of either the channel A or channel B magnetron oscillator circuits. The preheat switches, also on the power distribution panel, apply power to the filament transformers and blower motors of the transmitting equipment before the high voltage is applied. The output of either the channel A or channel B magnetrons is fed to the waveguide running to the search antenna through an S-shaped section of rectangular waveguide that is free to rotate. A small back-geared motor rotates this section of waveguide over the appropriate magnetron output during channel switching. This arrangement is shown in figure 28. The r-f channel switch is functionally part of the r-f system and is discussed in detail in section III. The preamplifier and local oscillator, together with the crystal mixer, is also shown on a complete schematic diagram. Details of these components are discussed in the receiving system, section IV.

b. Magnetron Transmitting Tube. The transmitting equipment is built around the requirements of the magnetron tube which is the heart of the system. The conventional type of vacuum tube oscillator cannot be used to generate frequencies anywhere near the (approximately 3,000 megacycles) output of the magnetron used in the search system. The transit time, or time required for the electrons to travel between the electrodes, becomes an appreciable part of the cycle at high frequencies. The inductance and capacitance between electrodes is also a limiting factor in the maximum frequency at which an ordinary vacuum tube will oscillate. The magnetron tube was developed to overcome these difficulties and yet to have a high-peak power output. It is a diode-type tube and requires a strong external magnetic field perpendicular to the electric field existing between the cathode and plate. Because the tube requires a magnetic field for its operation it is called a magnetron.

c. Operation of Magnetron. The complete theory of operation of this tube is beyond the scope of this manual. Further details may be found in section XII of TM 11-466, Radar Electronic Fundamentals. The elementary facts, however, are as follows:

(1) When a magnetic field of the proper strength is



TL 36061A

Figure 25. Modulator MD-11/MPN-1, schematic diagram.

Description	
Rating	Tolerance
4	10%
4	10%
10	10%
10	10%
2	20%
2	20%
2	20%
8	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
2	10%
½	10%
½	10%
½	10%
½	10%
10	10%
10	10%
10	10%
10	10%
10	10%
10	10%
10	10%
10	10%
10	10%

Symbol Designation	Description		
	Value	Rating	Tolerance
R34	10	10	10%
R35	10	10	10%
R36	10	10	10%
R37	25,000	5	20%
R38	25,000	5	20%
R39	10,000	50	10%
R40	10,000	50	10%
R41	1,000	2	10%
R42	1,000	2	10%
R43	10,000	50	10%
R44	10,000	50	10%
R45	10,000	50	10%
R46	10,000	50	10%
R47	75	½	10%
R48	75	½	10%
RY1	SPDT 110 ac		
SW1	ML7460330-G4 G.E.		
SW2	8201 C.H.		
T1	GE 68G711 Trigger Transformer		
T2	GE 80G16 Pulse Transformer		
T3	15-3452 Pwr Transformer		
T4	15-3453 Fil Transformer		
V1		3E29	
V2	VT 266	1616	
V3	VT 266	1616	
V4		715 A/B	
V5		715 A/B	
V6		715 A/B	
V7		715 A/B	

supplied (the tube is mounted between the pole faces of a permanent magnet) and the cathode of the tube is made sufficiently negative with respect to the plate, which is at ground potential, the tube will oscillate.

(2) The frequency of oscillation depends on the internal construction of the tube. No externally tuned circuits are required. Note that making the cathodes negative permits electrons to flow between the cathode and plate.

(3) The magnetron is capable of operating in a number of different ways or modes. In order that the magnetron oscillates in an efficient, stable mode, the magnet air gap must be properly adjusted, the r-f system must be tuned so that the magnetron is properly loaded, and a peak pulse voltage of the required value must be applied by the modulator to the cathode of the magnetron.

d. Magnetron Characteristics. A type 2J32 magnetron oscillator is used in each channel of the search system. Each magnetron has a built-in coupling unit suitable for coupling to a 7/8-inch coaxial line. The magnetron is rigidly mounted in the field of a permanent magnet with a field strength of 1,200 to 1,325 gauss. The magnetic air gap has been carefully fixed at the factory and does not require adjustment. Under usual operating conditions, the tube is pulsed at a rate of 2,000 times per second and draws a mean current of approximately 15 milliamperes. The magnetron actually oscillates only 1/1000 part of the time. Therefore the peak current drawn during the 0.5 microsecond pulses is about 15 amperes. This gives a peak power input to the magnetron tube of about 225 kilowatts. Note the following essential features and associated circuits (fig. 26):

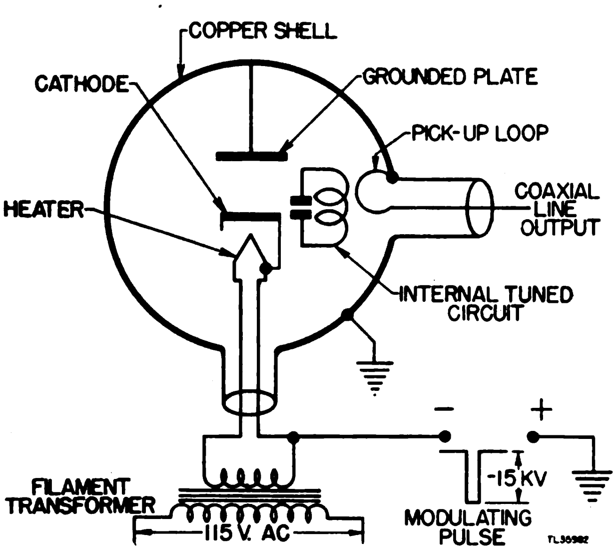


Figure 26. Magnetron equivalent diagram.

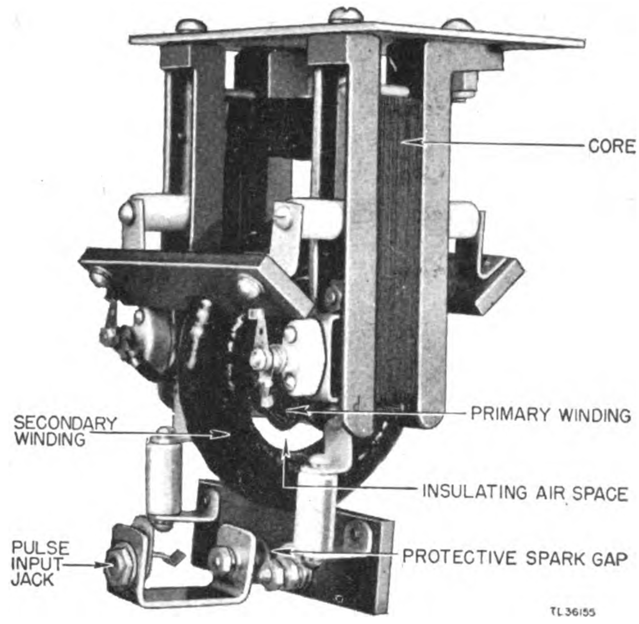


Figure 27. Magnetron filament transformer.

(1) The plate of the magnetron is connected to the copper shell which forms the outside of the tube and is at ground potential.

(2) The cathode of the tube is indirectly heated and connected to the heater.

(3) A built-in tuned circuit determines the frequency of oscillation. No adjustment is provided. To shift the frequency a new magnetron must be installed. The wavelength of the magnetrons used in the search system should lie between 10.60 and 10.80 centimeters. The magnetron for channel A and channel B should be chosen to have frequencies close to each other. Otherwise, trouble may result when switching channels due to a shift in the beam peak for the S-band search array caused by a difference in frequency of the two magnetrons.

(4) The r-f output is taken off through a pick-up loop which is coupled inductively to the tuned circuit inside the magnetron. The pick-up loop connects to the interconductor of a coaxial transmission line.

(5) The filament supply for the magnetron is fed from a special transformer which is highly insulated to withstand the peak modulator pulse voltage applied to the cathodes. Since the cathode and filament of the magnetrons are tied together, the secondary of the filament transformers, T1 and T2, are subjected to high pulse voltages applied to the cathode of the tube. Therefore, the transformer primary and secondary windings are well insulated from each other with a large air space between the windings of the filament transformer as shown in figure 27. The design prevents arc-over and keeps the

shunt capacitance from cathode to ground at a minimum to preserve the pulse amplitude and shape. A protective spark gap is provided across the secondary output of the transformer. It is adjustable by turning the eccentric disk. This type transformer is often referred to as an isolation transformer.

(6) Each magnetron has a blower (B1), wired into the 117-volt a-c preheat circuit, to dissipate the heat from the magnetron. The average heat dissipation is of the order of 335 watts. The blowers begin operation as soon as power is applied to the magnetron filaments and are driven by 117-volt a-c induction motors at 1,525 rpm.

SECTION III

R-F SYSTEM

18. INTRODUCTION. The search r-f system of Radio Set AN/MPN-1 is taken to include the r-f plumbing and waveguide transmission system, the T-R switch, and the search antenna array (fig. 29). The purpose of the r-f system is to couple the high-power r-f energy from the transmitting system to the antenna array where it is radiated into space in a directional pattern, and to receive the reflected energy and apply the received echo signals to the receiving system. Included in the r-f system is a sine potentiometer unit provided to generate the rotary timebase sweep used with the PPI (plan position indicator) display system.

a. R-f Plumbing. (1) The high-power r-f energy from the magnetron oscillator in the transmitting system is fed through a short length of coaxial cable into the waveguide channel switching system. The channel switching system consists of a section of waveguide pivoted about a point midway between the channel A and channel B r-f units in such a way that it can be rotated through 180 degrees to connect either channel to the common waveguide transmission system (fig. 29).

(2) From the r-f channel switch, energy is conducted to the search antenna array by a waveguide line mounted along the trailer ceiling. At the antenna mount the r-f energy is fed from the waveguide, through a length of coaxial cable with rotatable joints, to the antenna array.

b. T-R Switch. (1) Since the same antenna array is used both for transmitting the high-power r-f pulse and for receiving the comparatively weak echo signals, some means of blocking the strong transmitted pulse from the sensitive receiver circuits must be utilized. In the search system a single T-R tube is used in each channel as a transmit-receive switching device.

(2) Basically, a T-R switch is a spark gap which short-circuits the end of a length of transmission line upon being subjected to high power pulses. The T-R tube is placed at the end of a quarter-wavelength line which, when shorted, reflects a maximum impedance at the input, thereby blocking the r-f pulse from the receiver input circuits. When a weak pulse is applied, the spark does not form across the gap, and the line remains open for the energy to travel past the gap to the input of the receiving system.

(3) During reception of the received echo signals, the high impedance of the transmitter is reflected at the junction point with the branch coaxial cable. Thus very little received energy will be lost in the transmitting system, the majority of the received energy being conducted through to the receiving system.

c. Antenna Array. (1) The search antenna system (fig. 30) consists of a linear array of 33 horizontal slot-fed dipoles placed along the focal line of a shallow cylindrical reflector with a parabolic cross-section. The dipoles are mounted along a length of rectangular waveguide approximately 7 feet 6 inches long. For protection, the entire array and waveguide supports are enclosed in an opaque plexiglass cylinder. Energy is fed in from the top of the waveguide and the proportion not radiated by the dipoles is absorbed in a load at the lower end.

(2) The dipoles extract energy from the waveguide by means of small probes extending into it (fig. 31), and the feed to alternate dipoles is reversed in order that all dipoles may be fed in phase. In general, the dipoles are spaced along the supporting waveguide with a separation slightly less than half a wavelength in the guide. Near the feed end, however, the dipoles are spaced successively closer together in order to transmit more energy in an upward direction. Excitation of the closely spaced dipoles is made more intense than in the main part of the array, so that the required spread of energy may be obtained with a short length of array. This leaves a sufficient length of evenly spaced dipoles to produce a sharp drop in intensity on the lower side of the pattern.

(3) The antenna pattern produced by this scanning array approaches what is mathematically termed "cosecant-squared" radiation. The outline in the vertical plane of the beam radiated by this antenna has its principal maximum at 3 degrees above the horizontal, high enough to escape most ground objects which would give confusing reflections, and still detect an aircraft at a minimum glide angle. The beam, while not giving complete overhead coverage, has a maximum angle of 10 degrees from the horizontal, flattening out at an approximate altitude of 4,000 feet, so that over most of its range it is nearly flat-topped. A pictorial comparison of the two types of beams and the patterns seen on the corresponding PPI tubes is shown in figure 32.

Symbol Designatio

R1
R2

B1

V1
V2

NE1

T1
T2

SW1
SW2
SW3
SW4
SW5

SK1
SK2

PL1

Motor

SWM1

TR1

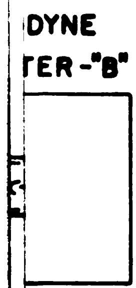
G1
G2
G3

JK1
JK2

CS1
CS1B
CS19A
CS19B
CS2

XTAL

Magne



CONNECTOR STRIP 19A & 19B CONNECTIONS

RMI-AL	FUNCTION	OUT TO	IN FROM
	A.C. COMMON		DIST. PANEL
2	A.C. PREHEAT		DIST. PANEL
3	TRANSMIT		20-5
4	N C		
5	INTERLOCK	24-3	
6	-750 V. FOR KEEP ALIVE		17-8
7	N C		
8	GROUND		GROUND BUS

TL 36067

Figure 28. Radio Frequency Unit RF-7/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	2 Megohm	½W	10%
R2	3 Megohm	½W	10%
B1	Blower, 1525RPM—115V A.C.		
V1	2J32		
V2	721A		
NE1	1/10 Watt G6 G.E.		
T1	UX 7022A Raytheon		
T2	UX 7022A Raytheon		
SW1	Interlock Switch		
SW2	Interlock Switch		
SW3	B-5A C.H.		
SW4	B-5A C.H.		
SW5	B-RL2 Micro Switch Corp.		
SK1	S2404 FHE Jones Socket		
SK2	S2404 FHE Jones Socket		
PL1	P2404SB Jones Plug		
Motor	Switch Motor 11RPM 115V A.C.		
SWM1	"S" Wave Crystal Mixer		
TR1	Transmit-Receive Cavity		
G1	Radio-Freq. Switch		
G2	R.F. Cross & Converter Assem.		
G3	Magnetron Coupler		
JK1	High Voltage Jack		
JK2	High Voltage Jack		
CS1	Connector Strip—Male		
CS1B	Connector Strip—Female		
CS19A	Connector Strip		
CS19B	Connector Strip		
CS2	Connector Strip #2-141 Jones		
XTAL 1	IN21A Crystal		
Magnet 1	Cinaudagraph #15A135		

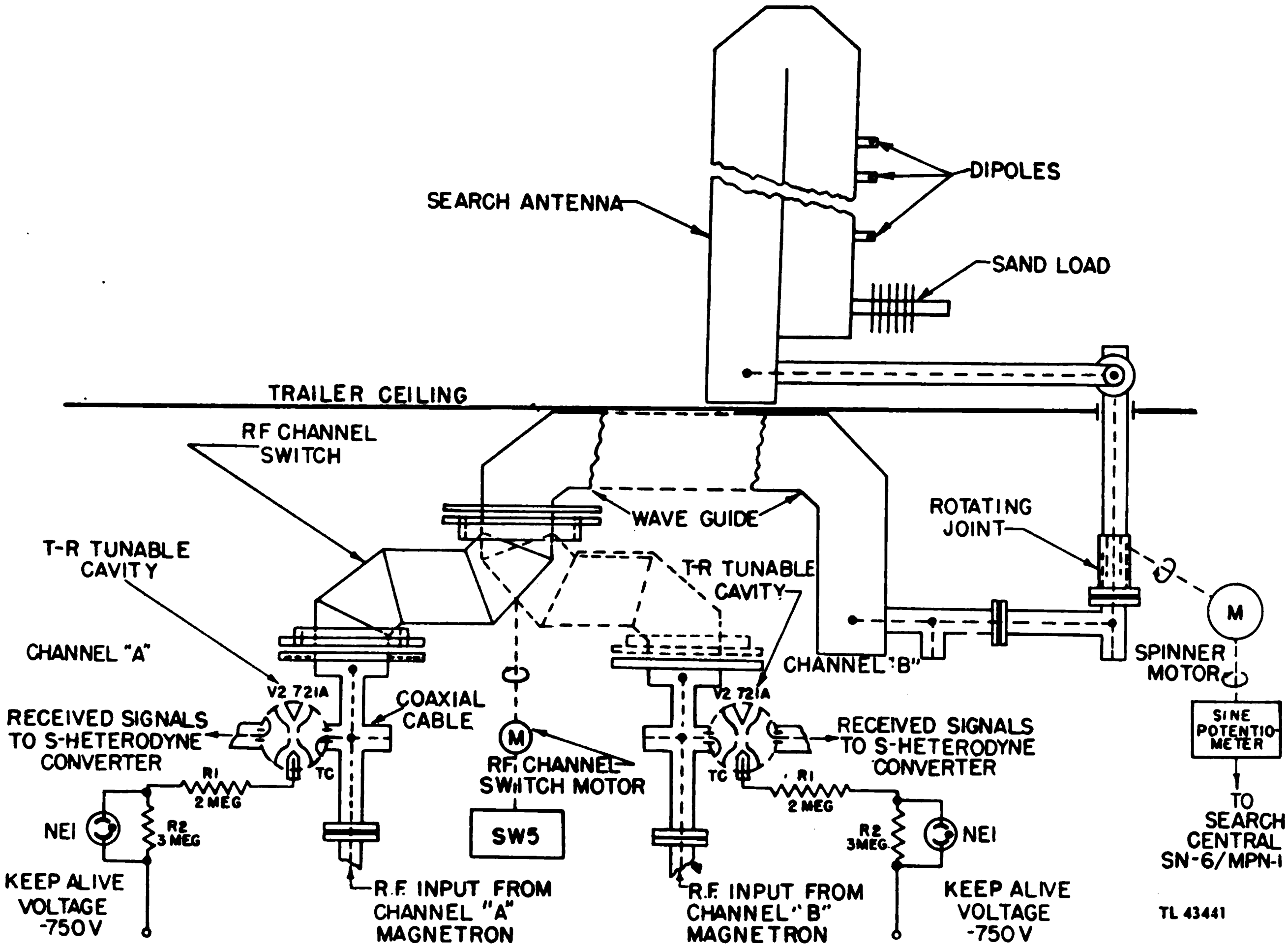


Figure 29. Search r-f system, simplified schematic diagram.

(4) The entire search antenna array and reflector are rotated in azimuth at 30 rpm by a $\frac{1}{4}$-horsepower spinner motor mounted within the antenna mount. A sine potentiometer is coupled to the antenna array and revolves in synchronism with the reflector and array thereby providing potentials for modulating the PPI timebase sweep developed in the search central chassis.

19. R-F PLUMBING.

a. General. (1) At the high radio frequencies used in the search system of Radio Set AN/MPN-1, standard types of two-wire transmission line cannot be used, because of the high power loss caused by the radiation resistance and capacitance effects between conductors and ground. Such a line acts as an antenna, radiating a large percentage of the transmitted power; therefore only a small part of the power goes on to the desired point of application. In the attempt to eliminate these losses, coaxial cable was developed. In this type of transmission line, one conductor is hollow and the other conductor is contained within it, the two being separated by insulators. At the search system frequencies, approximately 3,000 megacycles, excessive lengths of this type of conductor would produce considerable losses, however comparatively short lengths of coaxial cable are used in this system where space is limited and the more bulky waveguide system would be undesirable.

(2) To feed the r-f energy the length of the trailer, from the r-f unit to the search antenna, the more efficient waveguide system is used. In the use of waveguides, a hollow tube of conducting material such as copper, silver, or brass is the sole conductor. In this case, the theory of transmission lines does not entirely apply. What actually happens is much closer to the broadcasting of radio energy than to currents traveling through conductors.

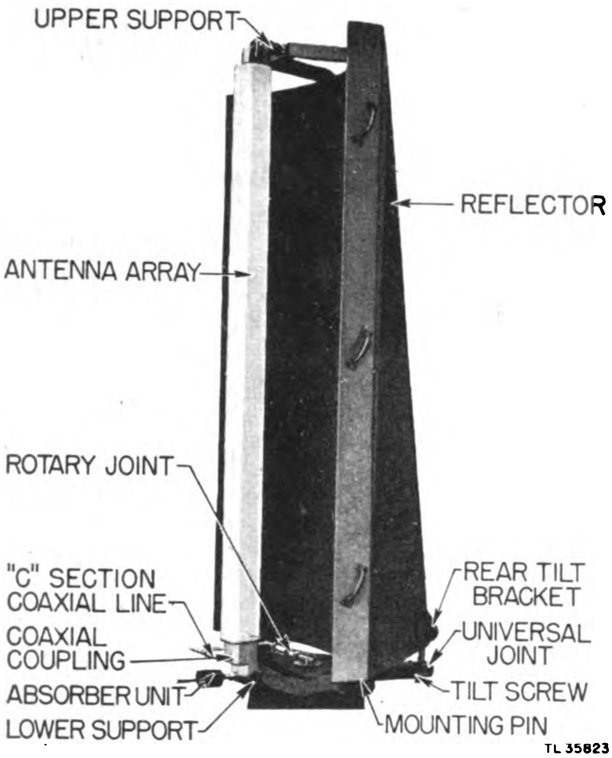


Figure 30. Search antenna array.

"Skin effect," the increased extent to which alternating currents travel on the surface of a conductor as frequency increases, reaches a point where the walls of the guide do not actually conduct more than a small amount of current and serve only to direct the path of the radiated energy.

b. Coaxial Line. (1) The majority of the search r-f transmission system is composed of 10-centimeter waveguide, however, at the transmitting end and at the rotating antenna end short lengths of coaxial cable are used. The cable consists of a 7/8-inch coaxial line of 46.25-ohm surge impedance. The line is constructed so that no insulating material is used to support the inner conductor. Instead, "metallic insulators," or quarter-wave stub lines are used for support, since the electrical characteristics of such lines produce an extremely high input impedance when the opposite end is shorted. For this reason, such stubs can be tapped onto the coaxial line at any point without adding to the line losses. This method of support is only effective at the frequency for which the stub is resonant; at other frequencies the stub will cause a serious impedance matching problem.

(2) The coaxial line used to couple the waveguide to the transmitting magnetron and to the T-R switch is shown in figure 33. Transmitted energy from the magnetron is conducted along the vertical section of line to a small antenna mounted in the waveguide section. Received energy is picked up by the waveguide antenna and conducted through the branch coaxial line to the T-R tube and hence to the S-heterodyne converter in the receiving system.

(3) At the antenna end, the transmitted energy is fed from the right-angled waveguide termination into Transmission Line CG-31/MPN-1 (fig. 34), also a coaxial line assembly. By means of this coaxial line assembly, energy is fed up inside the hollow bearing shaft of the search antenna mount to the search antenna array. Since the search antenna rotates continuously in azimuth, a rotary capacitance joint is provided at the lower end of the bearing shaft. By means of this joint, energy from the stationary line assembly is capacitively coupled through to the rotating coaxial line and hence to the antenna. A second rotary capacitance joint is mounted in a horizontal plane at the search antenna to allow the antenna to be tilted slightly from the vertical.

c. Waveguide Transmission. (1) Connecting the two r-f coaxial line assemblies mentioned above is a length of standard S-band waveguide mounted on the ceiling of the trailer (fig. 35). The waveguide is constructed of brass rectangular tubing, silver-plated for low surface resistance. From a small antenna, or exciting probe, r-f energy is introduced into this rectangular guide

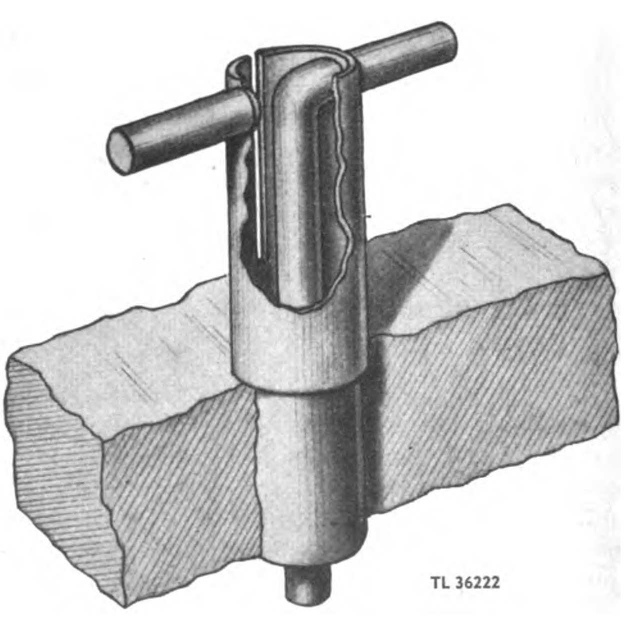


Figure 31. Dipole construction and insertion into waveguide.

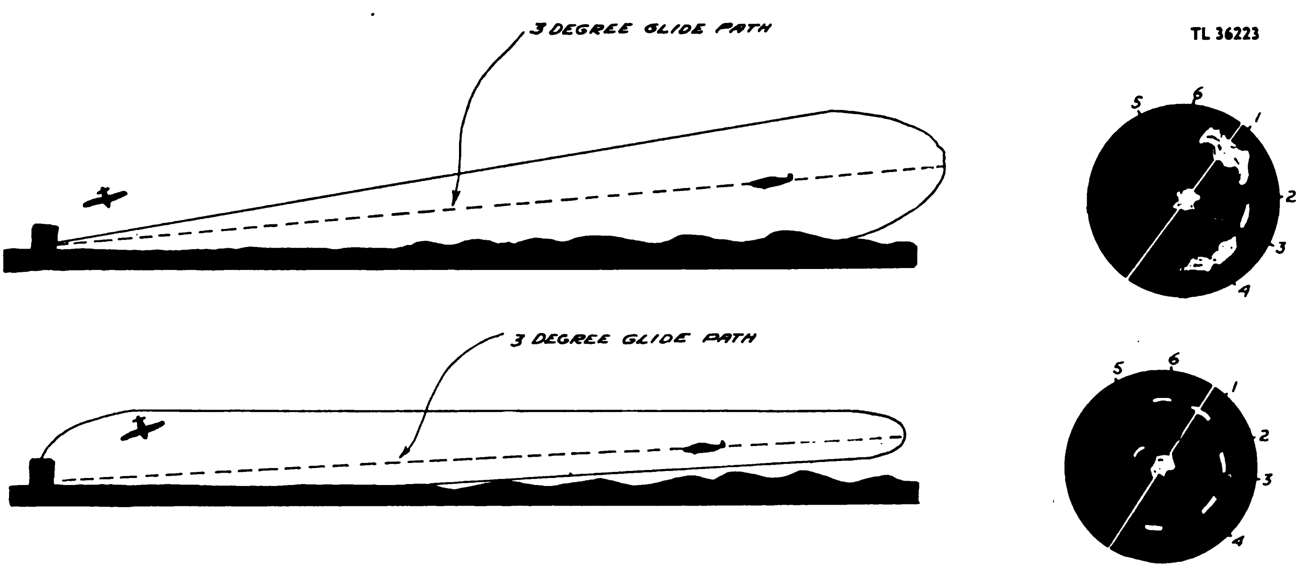


Figure 32. Comparison of standard with search system beam.

and is reflected back and forth between the walls. If the frequency of radiation is sufficiently high, there will be a phase difference between impinging and reflecting waves so that they do not cancel entirely, but add in some places and cancel at others to form wavefronts which travel down the length of the guide. At the S-band frequency, skin effect prevents any appreciable penetration of the wave into the guide wall and thus the efficiency of transmission is high. For complete theory of waveguide transmission, refer to section XI of TM 11-466, Radar Electronic Fundamentals.

(2) The wide sides of the guide are too close together to permit formation of interference waves from the reflections between them. However, between the narrow sides (along the wider dimension) there is room for the formation of one interference maximum midway between the walls. Hence, in the normal mode of operation at this frequency, the electric field is directed across the guide, the field intensity being perpendicular to the broad side (fig. 36) and varying in intensity from zero at the narrow side to a maximum at the center. The absence of the electric component at the narrow side is due to the shorting effect created by the conductivity of the walls in the process of reflection. This situation is somewhat similar to the disappearance of voltage across the shorted end of an open-wire transmission line.

(3) A wavelength in the guide is the distance between two consecutive similar points in the interference wave pattern. The wavelength measured across the guide, in general, is different from that measured along the guide. The measure used in a particular case depends upon the application. Varying the spacing between the narrow sides of the waveguide changes the longitudinal wavelength in the guide. As the guide width increases, the longitudinal wavelength becomes progressively smaller until it approaches the value in free space. This effect will be encountered later, since it is applied in the precision antenna scanning system and is an important feature of this set.

(4) Energy is coupled into the waveguide from the coaxial line at each end by a small antenna or exciting probe mounted in the waveguide. The exciting probe is connected to the center conductor of the coaxial line and is mounted in the guide perpendicular to the wide side so that it is parallel to the desired electric field.

*d. **Waveguide R-f Choke Joints.*** (1) Choke joints are used in both the S-band and X-band waveguides to connect two waveguide sections together and to form a low-loss section for the r-f switches. If the ends of the waveguide sections were merely butted together, considerable loss would occur due to the discontinuity in the

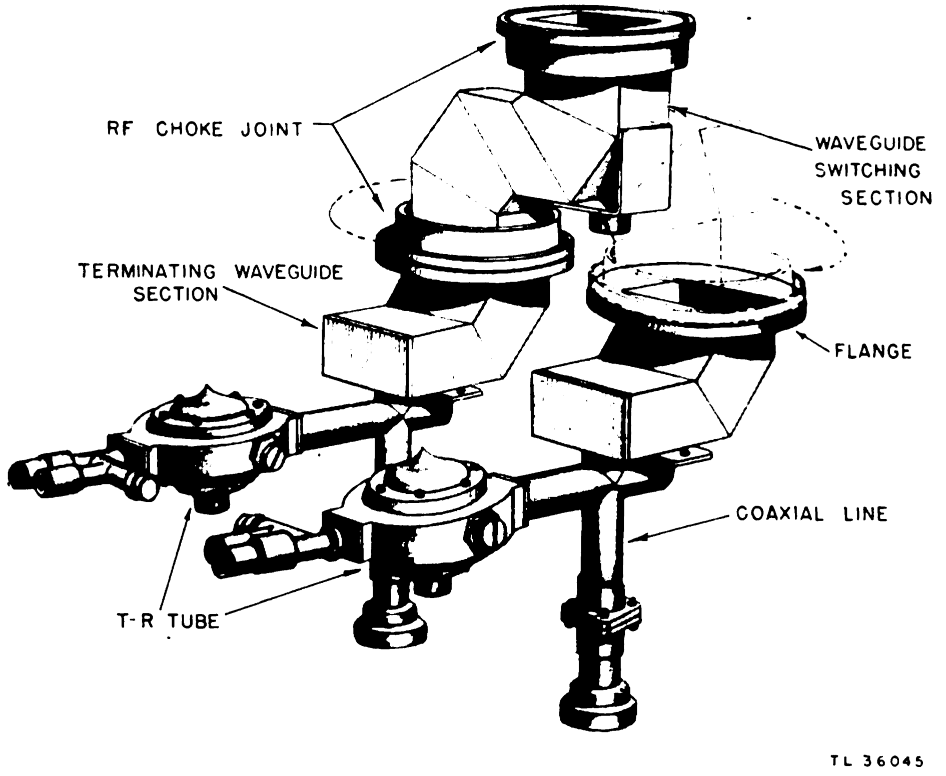


Figure 33. R-f channel switching assembly.

conductor. This loss can be minimized by constructing one of the flanges so that when butted together the two form an r-f choke joint. The construction of the flange involves forming a circular slot a quarter-wavelength deep in the face of the flange (fig. 37). Between the slot and the interior of the guide the surface of the flange is sunk so that a narrow gap will be formed when the two flanges are fitted together. The electrical short circuit at the bottom of the slot is reflected back through a half-wavelength and places a virtual short circuit at the junction of the inner edges of the sections of waveguide. Thus, to the wave going down the guide, the wall of the guide appears solid and the energy loss in the shorted section is extremely small.

(2) A circular slot is used whose diameter is such that its distance from the inside wall of the guide is approximately a quarter-wavelength at the middle of the wide side. Since this is the maximum point of electric field intensity, it is also the point of maximum loss. The circular groove deviates most from a quarter-wavelength spacing at the corners of the guide; here the field intensity and thus the loss are the least, even with no choke joint, so this dimension is not critical.

(3) Where it is desirable to prevent transmission of stress and vibration through a waveguide connection, the flange and adjacent surface of the choke can be separated, so that no mechanical connection exists, without causing an appreciably greater loss. If this spacing is increased excessively, losses tend to increase and another choke joint is used in place of the flat flange to form a double choke joint.

e. R-f Channel Switches. (1) In the search system, as in the precision system, two identical magnetron oscillators are utilized. One channel is used in the actual operation of the equipment while the other channel is maintained in a stand-by condition. To connect either channel to the common waveguide transmission system, a waveguide channel switch is used (fig. 33). The chan-

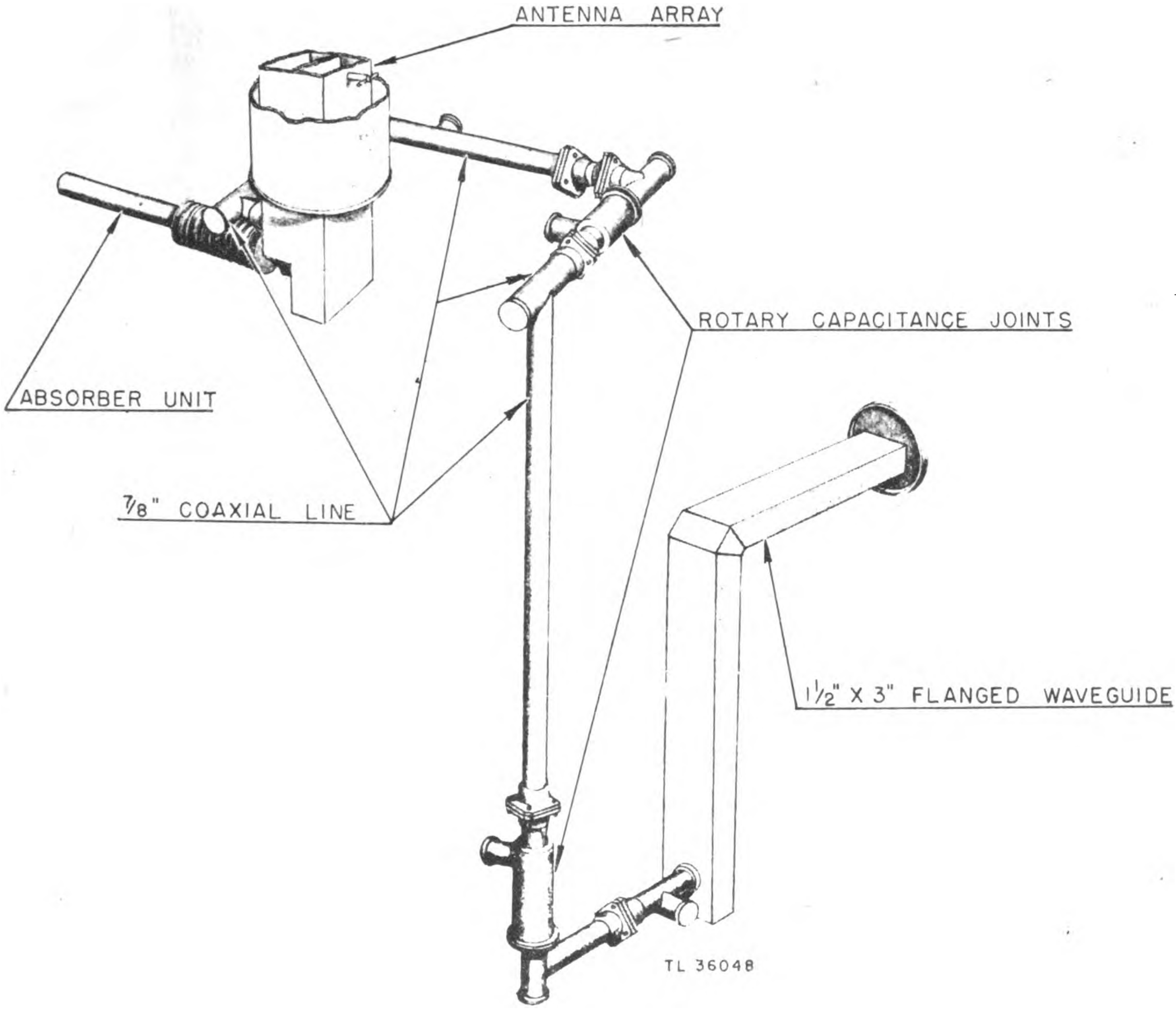


Figure 34. Transmission Line CG-31/MPN-1, search antenna feed.

nel switch consists of an S-shaped section of waveguide, pivoted about a point in line with the axis of the waveguide to which the r-f unit connects (fig. 29). Each end of the S-shaped waveguide section is terminated in an r-f choke joint, the upper choke joint being coincident with a circular flange on the waveguide transmission line, and the lower choke joint being coincident with a circular flange on a section of waveguide fed by the transmitting oscillator. Thus the transmitted energy from the oscillator is fed through the waveguide channel switch and

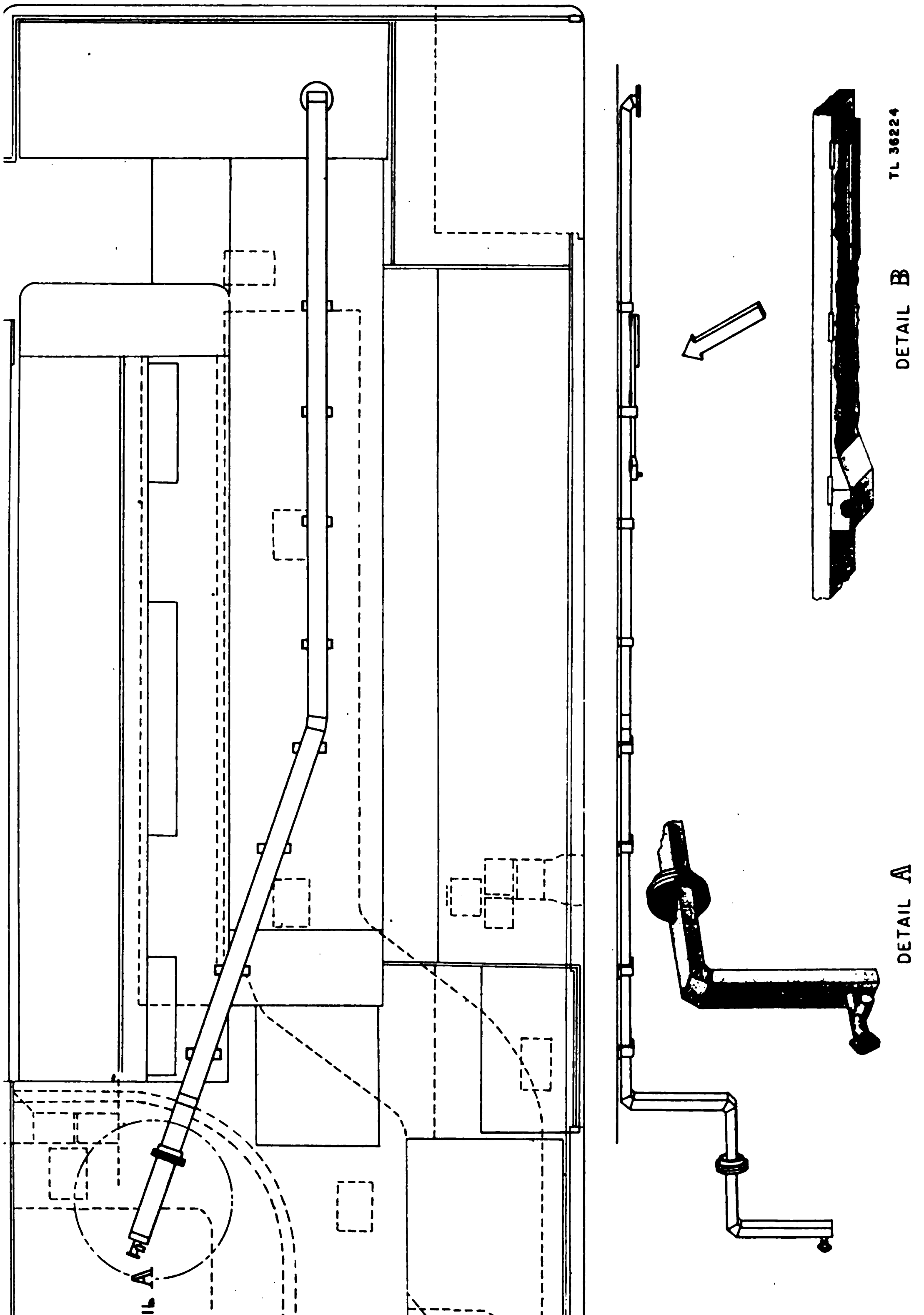


Figure 35. S-band transmission line.

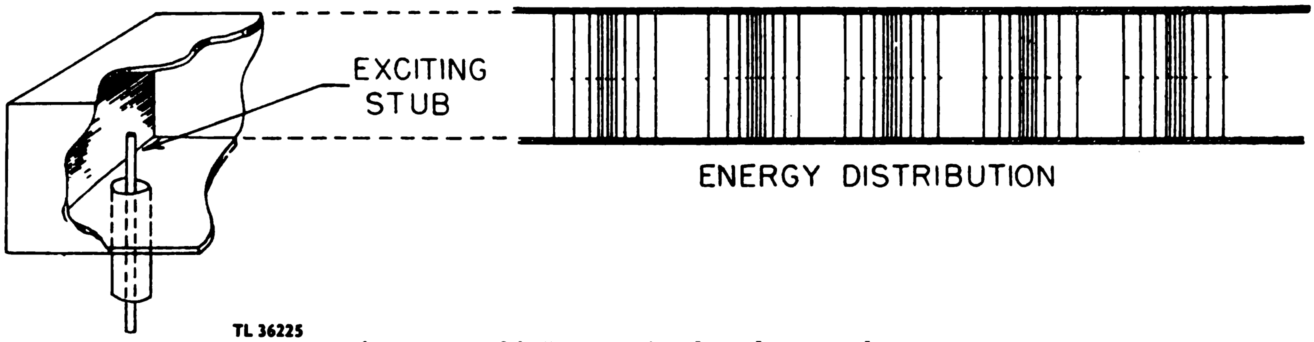


Figure 36. Transmission through waveguide.

waveguide transmission system to the search antenna. For reception from the other channel, the S-shaped waveguide arm is rotated about its axis until the waveguide section is over the terminating waveguide section in the line from the other magnetron.

(2) The waveguide arm is driven by a crank and connecting rod from a 180-degree cam which is driven by a small geared-down motor. Microswitch SW5 is also operated by the cam and stops the motor when the switching motion is completed. When channel A is operating the motor is connected to the lead of channel B. When channel B is selected, this line is energized and the motor rotates the cam through 180 degrees, at which point SW5 breaks that circuit and switches the motor to the channel A line, after which the motor stops.

f. ***Selector Line.*** (1) The selector line is a device for sampling a fixed portion of the transmitted power from the S-band r-f unit. It consists of a section of standard waveguide mounted in series with the transmitter output and the main transmission line to the search antenna. A power sampling section is built on to the bottom of the waveguide flush with the narrow sides of the main guide section (fig. 38). A slotted aperture, tapered at each end to reduce reflections, is cut through the wall separating the two sections to permit a small amount of r-f power leakage into the test section. The slot is made sufficiently long so that frequency changes will not affect the amount of energy leakage. The test section contains a pick-up probe set into the wide side of the guide and terminating in a standard coaxial connector. At the opposite end of the section is inserted a resistor strip absorber.

(2) R-f energy from the magnetron oscillator enters the waveguide section in the direction shown in figure 38. As the energy passes the slotted aperture, a portion leaks

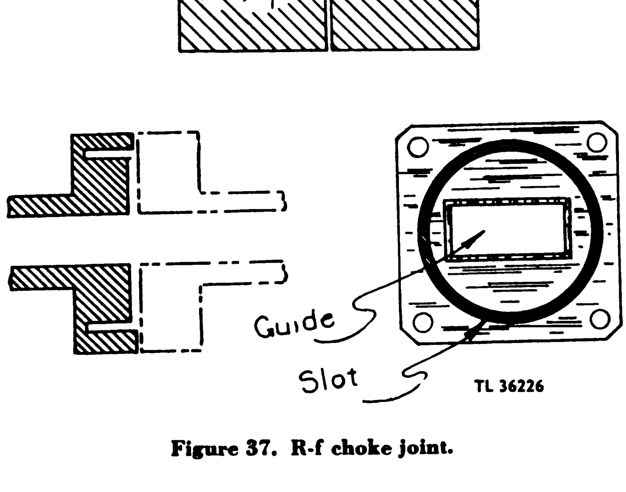


Figure 37. R-f choke joint.

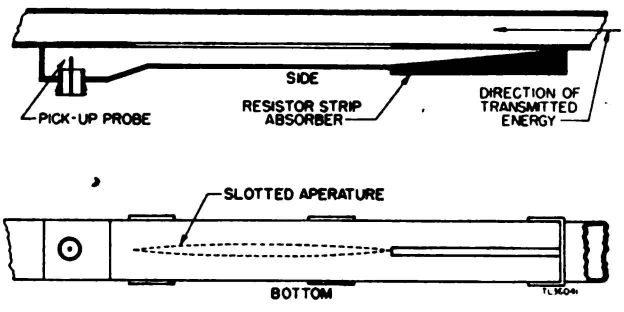


Figure 38. S-band selector line.

through into the test section and is conducted to the end containing the pick-up probe. The energy reflected from the end of the section travels back through the test section and is dissipated by the resistor strip absorber mounted at the opposite end. Thus a small portion of the transmitted energy is present in the waveguide test section where it is picked up by the test probe. The selector line is so designed that the insertion of the section in the transmission system causes negligible loss.

20. T-R SWITCH.

a. General. (1) The T-R switch, one of which is associated with each channel of the S-band r-f unit, functions to connect the search antenna to the transmitter for the duration of the transmitted pulse, and to the receiving system during the reception of the reflected echoes. In this manner, a single antenna may be used for both transmitting and receiving. The T-R box is located in the coaxial cable assembly leading to the S-heterodyne converter as shown in figure 33.

(2) The T-R box consists of a resonant cavity, the center of which is formed by a pair of copper disks surrounded by a glass envelope or tube (fig. 39). The copper disks, whose edges extend out through the wall of the glass tube, are drawn to points opposing each other and forming a small spark gap. The spark gap tube is gas-filled, the gas being maintained in a partially ionized state by the application of a –750 volts to one of the electrodes.

b. Transmission. (1) The T-R box is essentially a spark gap placed across the receiver input at a point a multiple of a quarter-wavelength from the junction point with the coaxial line from the transmitter (fig. 40). When the transmitter fires, the spark gap breaks down and produces a low impedance across the receiver line. At the input to the receiver line, a quarter-wavelength away, a high impedance is reflected, thereby blocking the receiver path to the high power transmitted pulse.

(2) The spark gap alone, however, is not adequate protection for the sensitive crystal mixer circuit in the receiving system input, since the voltage drop across the gap is still sufficiently high to damage the crystal detector. Also, a certain voltage is required before the spark will form, which would apply a surge of high power to the receiver at the moment the arc is struck. Therefore the spark gap is surrounded by a resonant chamber or cavity with the gaps located at the point of maximum electric field.

(3) A tuned cavity oscillating in its lowest mode is analagous to an ordinary parallel tuned circuit in which a small amount of applied current produces a large circulating current, or a small voltage injected across a portion of the coil builds up a large voltage across the entire coil. This is characteristic of all resonant circuits and the voltage or current multiplication is numerically equal to the Q of the circuit. Since the Q of a resonant cavity is inherently high, only a small signal need be applied to strike the spark gap. Further assistance in

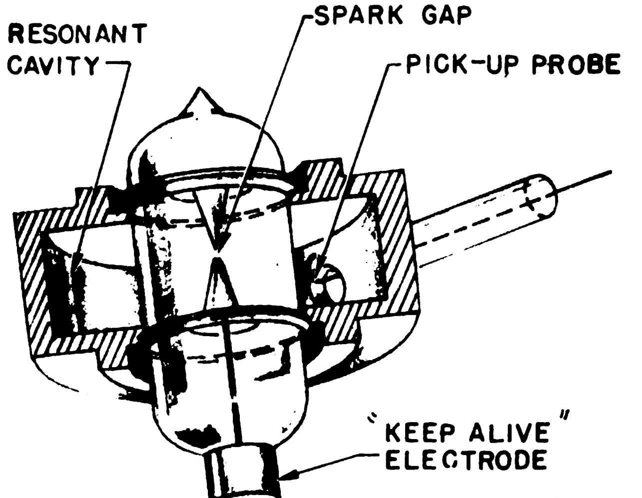


Figure 39. Cross-section of T-R switch.

striking the arc between the electrodes is furnished by keeping the gas in the tube surrounding the gap partially ionized through the use of a high negative voltage applied to a third or keep-alive electrode within the tube envelope. The voltage applied to the keep-alive electrode brings the stress on the spark gap almost to the sparking point and only a small amount of r-f input is required to strike it.

*c. **Reception.*** During the period when the transmitter is quiescent, the reflected echo signals will be conducted in a reverse direction through the waveguide channel switch and coaxial cable to the junction of the T-R branch line with the main coaxial line from the magnetron. At this point the received signal finds a large impedance in the direction of the magnetron tube since the high impedance of the cold magnetron placed a half-wavelength away is reflected as an equally high imped-

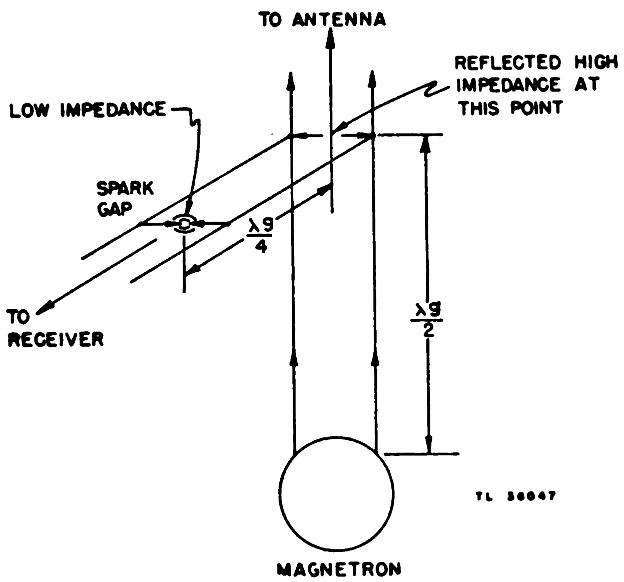


Figure 40. T-R switch transmitting, simplified schematic diagram.

ance at the junction point (fig. 41). Thus the echo signal will be conducted down the lower impedance path through the r-f switch. Since the received energy is too small to strike the arc in the T-R tube, the signal will pass through the tube to the crystal mixer section of the heterodyne converter.

21. SEARCH ANTENNA ASSEMBLY AS-38/MPN-1.

*a. **General.*** (1) The search antenna assembly consists of Search Reflector AT-19/MPN-1, Search Antenna Array AS-39/MPN-1, and Search Antenna Mount MT-122/MPN-1. The search antenna array is mounted along the focal line of the search reflector, a cylindrical paraboloid. The assembly of the array and reflector is vertically mounted on the search antenna mount, which pro-

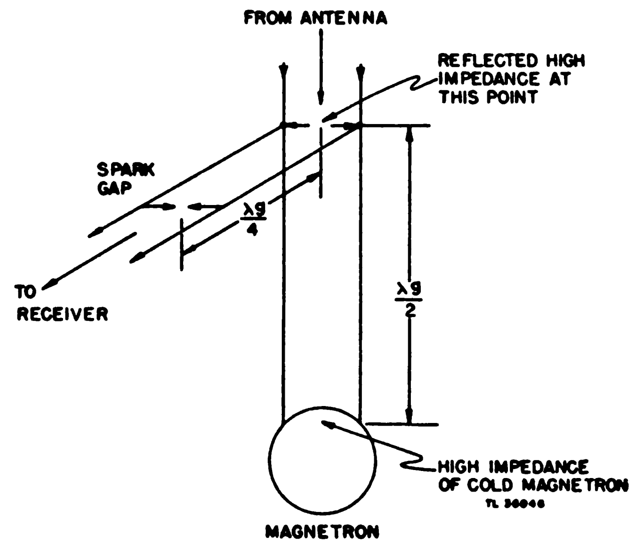


Figure 41. T-R switch receiving, simplified schematic diagram.

vides a rotating base for the 360-degree search system antenna scan.

(2) The reflector, a cylindrical parabola, has an aperture 8 feet high by 4 feet wide, with a focal length of 21.6 inches. It is constructed of aluminum and sprayed with olive drab paint. The reflector focuses the radiated beam to a half-power width of 6 degrees in the horizontal plane.

*b. **Antenna Array.*** (1) The vertically mounted search antenna array consist of an array of 33 alternately reversed dipoles, mounted horizontally in the wide side of a length of standard S-band waveguide, supplying both energy and support. British-type slotted dipoles are used as radiators in this array. The theory of the slotted dipole is complex and will not be explained in this text, however, a brief explanation of the operation of the

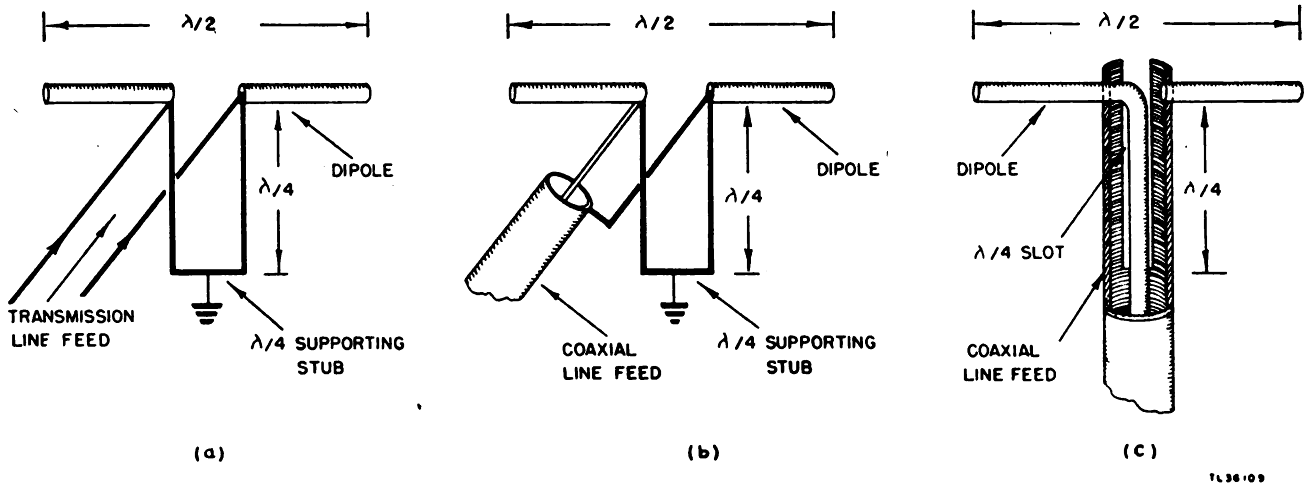


Figure 42. Development of the slotted dipole.

dipole will be given with the aid of the diagrams shown in figure 42. Diagram (a) is a standard center-fed dipole, energized by means of an open-wire transmission line. The quarter-wave supporting stub can be placed directly across the two halves of the dipole since the stub acts as a quarter-wave line, shorted at the far end, and reflects a high impedance at the junction point with the dipole. Thus this high impedance placed across the comparatively low center impedance of the dipole will have negligible effect on the electrical characteristics of the dipole.

Figure 43. Search antenna array, cutaway view.

(2) Now if the standard transmission line is replaced by a coaxial cable feed, diagram (b), the electrical feed will remain unchanged. A further modification of the simple dipole feed is shown in diagram (c). In this case the quarter-wave supporting stub is formed by the sheath of coaxial line while the central conductor still feeds the left-hand dipole half. The electrical characteristics of this feed system remain unchanged, the dipoles being supported by the shorted quarter-wave stub and the two dipole sections being fed by the two conductors of the coaxial cable. The dipole shown in diagram (c) is the slotted dipole used with the search antenna array.

(3) The center conductor of the coaxial line extends into the waveguide as a pick-up probe at the point of maximum electric field intensity. The probe depth, and consequently the amount of energy picked up by the individual dipoles, is varied over the length of the array to aid in developing the required radiation pattern. Since the average dipole spacing is of the order of a half-wavelength in the guide (7 centimeters), alternate dipoles must be reversed in order that all dipoles will be fed approximately in phase.

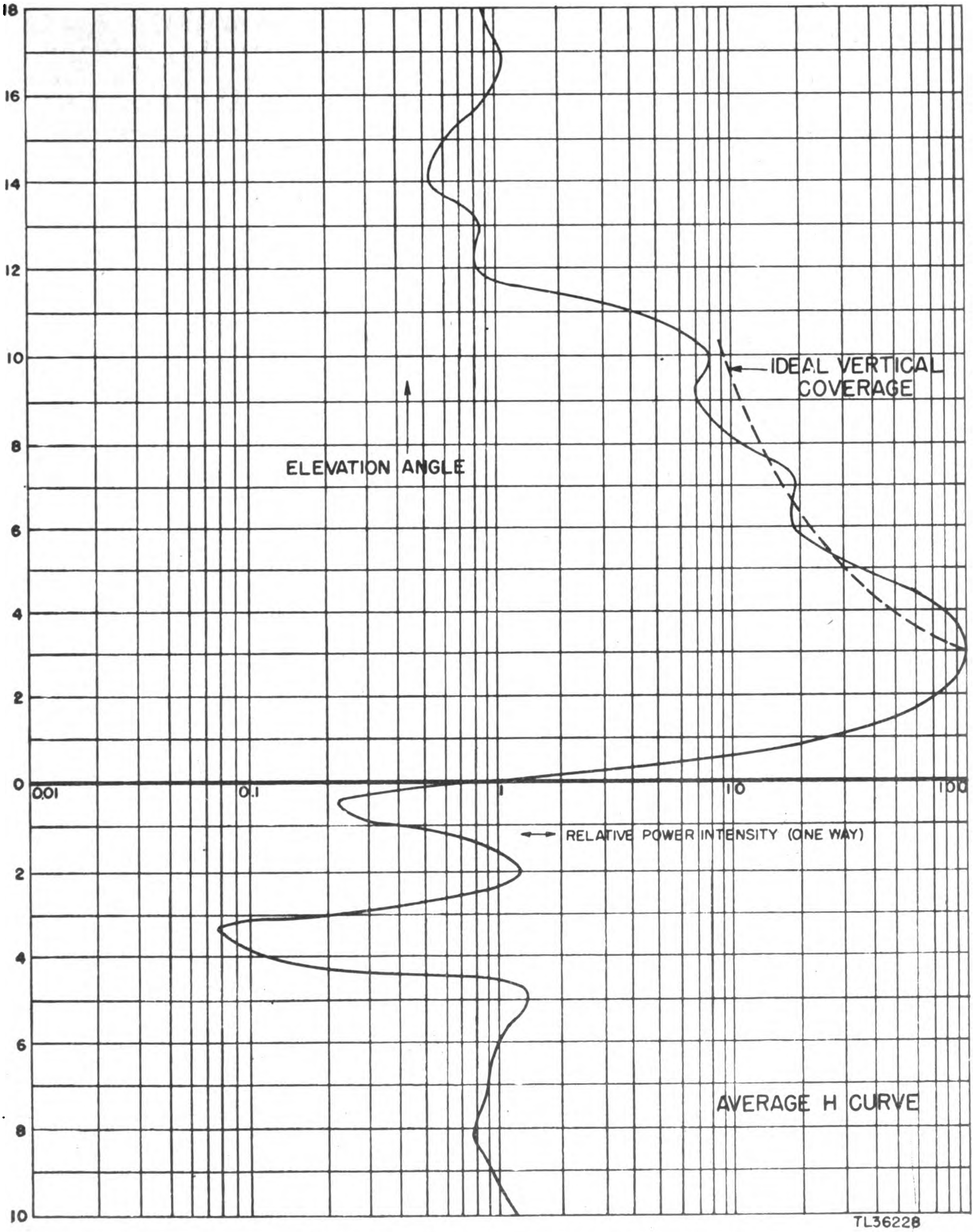


Figure 44. Search antenna, elevation field pattern.

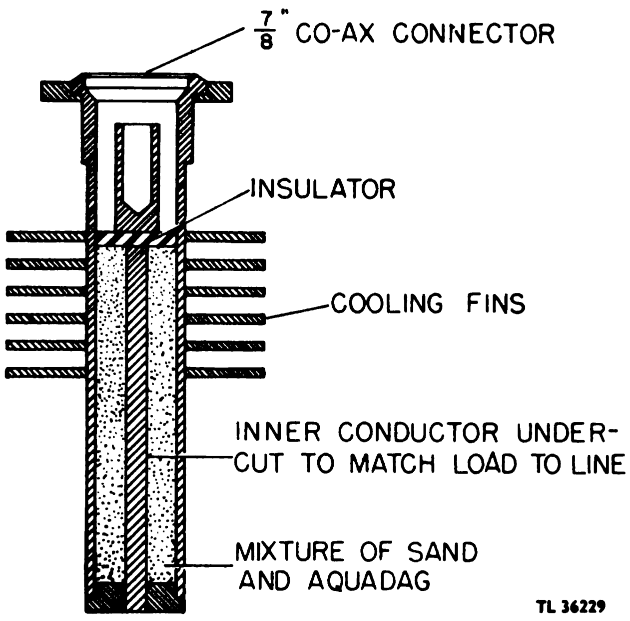


Figure 45. Absorber Unit CG-32/MPN-1, cutaway view.

(4) The first 20 dipoles, counting from the bottom, are spaced 7.3 centimeters apart, and from there the spacing decreases gradually to 6 centimeters at the top of the array. Together with the varying probe depth insertion, the variable dipole spacing provides the desired vertical field distribution pattern for the search system. It is necessary to feed energy to the array from the top in order to develop the proper energy distribution. To accomplish this, the supporting waveguide is backed by another length of waveguide opening into it at the top through several short-angled sections (fig. 43). Energy from the transmitter is introduced at the bottom of the backing waveguide and is conducted to the top of the array where it is fed to the waveguide section containing the dipoles.

(5) The antenna array is totally inclosed in a thin-walled hollow plastic cylinder, held in place by rubber mounts at the top and bottom. This cylinder seals the array, thus preventing moisture from entering the waveguide through the open slots in the dipole support. The plastic cover is sandblasted and sprayed with a thin coat of low-loss, lusterless, olive drab. Care must be taken, if the coating of paint needs touching up, not to daub the paint on too thickly as this results in increased r-f losses.

(6) The vertical radiation pattern produced by this array is designed for the most effective coverage of the scanned area. If uniform dipole spacing were used, the pattern would be of the usual form which would produce undesirably large ground echoes as well as inadequate coverage of aircraft at a high angle overhead (fig. 32). By decreasing the dipole spacing at the top of the array, the energy from these dipoles at the higher angles will not entirely cancel, thereby shifting the beam from these dipoles upwards at a greater angle. Thus, the top of the over-all vertical pattern is extended at short range, permitting a more complete coverage of the scanned area, and the bottom of the pattern is flattened, minimizing ground returns. The elevation field pattern of the search array is shown in figure 44.

(7) To prevent the remaining r-f energy at the lower end of the antenna array from being reflected and developing high standing waves within the guide, the energy is dissipated in Absorber Unit CG-32/MPN-1. This unit picks up the remaining r-f energy in the guide by a coaxial probe extending into the waveguide, and dissipates the energy in a load of sand and aquadag. Cooling fins are provided around the absorber unit to radiate the heat generated in the unit by the dissipated r-f energy (fig. 45).

*c. **Antenna Mount.*** (1) The antenna array and reflector are supported by a triangular shaped mounting plate (fig. 30) fastened to the upper end of a hollow shaft which passes through two large ball bearings. The outer shells of the bearings are connected to a 2-foot square metal plate set into the trailer roof. The reflector is mounted through two sleeve joints, fastened to two corners of the triangular mount, and is connected at the back by means of an adjustable brace. Tilting of the antenna and reflector is effected by adjustment of the screw connecting brace at the rear corner.

(2) The end of the vertical drive shaft which extends into the trailer is geared to a 1/4-horsepower motor and reduction gear box by means of a pinion and spur gear. By means of this gear arrangement, the motor speed is reduced from 1,725 rpm to the antenna scanning speed of approximately 32 rpm. A sinusoidal potentiometer is driven through a gear arrangement at a speed in synchronism with the antenna rotation by means of a second pinion gear. The sine potentiometer supplies synchronizing voltages to the search central to develop the circular sweep of the PPI timebase trace (ch. 2, sec. V).

SECTION IV

RECEIVING SYSTEM

22. INTRODUCTION. The function of the search receiving system is to detect and amplify the received echo signals. The receiving system (fig. 46) is basically of the superheterodyne type. Two identical receiving systems are used in the search system, one being used in channel A and the other being used in channel B of Radio Set AN/MPN-1. A brief description of the function of the receiving system is given below and should be read in connection with the block diagram (fig. 47).

a. S-band Heterodyne Converter. The S-band heterodyne converter is a part of the search system radio frequency unit assembly. This converter is mounted close to the associated transmitting magnetron in order to avoid the use of long lengths of transmission line or waveguide between the transmitting system and the receiver. It consists of the S-band local oscillator, crystal mixer, and the first two stages of i-f amplification. This assembly is duplicated in the radio frequency unit, one converter being used with the channel in operation and the other being held for stand-by. The r-f input to either heterodyne converter is through a metallic coaxial line coupled to the T-R box associated with the converter. R-f signal energy from the T-R box is applied to the crystal detector and mixer, together with r-f energy from the local oscillator. The resultant i-f signal is applied to the two preamplifier stages before application to the search system receiver for conversion to a video signal.

b. Local Oscillator. (1) Local oscillator V3 (707B), is a McNally reflex klystron with an external tunable cavity. In this type of ultra-high-frequency generator a single resonant cavity is used as the oscillatory circuit and the velocity-modulated electron stream traverses the cavity twice by the use of a repeller electrode, or reflector. Adjustable plugs inserted in the outer rim of the cavity permit tuning. The output coupling of the energy is accomplished by means of a magnetic coupling loop inserted into the cavity. The amount of output power can be adjusted by varying the position of the coupling loop in the cavity.

(2) The cavity is maintained at the same positive potential as the accelerating grid within the tube envelope. The cathode source of electrons within the tube is held at ground potential. The emitted electron stream must pass through the central aperture of the doughnut-shaped cavity.

(3) The oscillating frequency is a function of reflector voltage, the accelerating or cavity voltage being held constant. This type of electrical tuning keeps the local oscillator in operation at a frequency which, when beat against that of the transmitter, produces a 30-megacycle i-f frequency. The electrical tuning is accomplished by

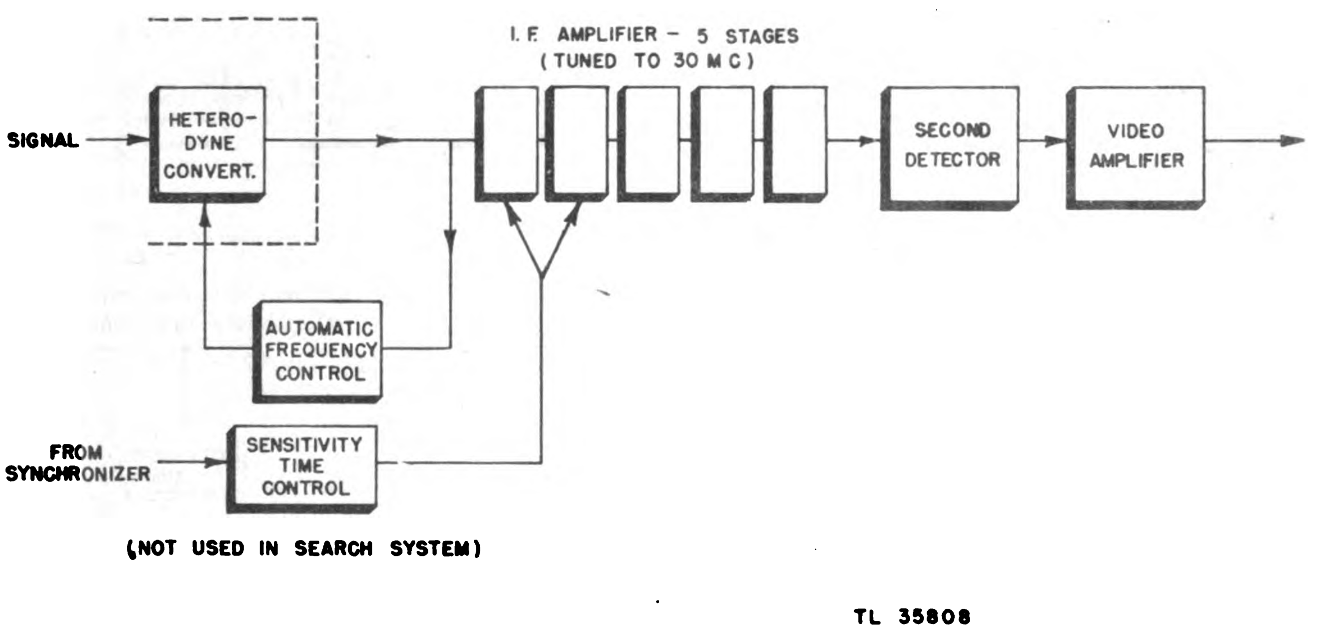


Figure 46. Receiver functions.

supplying the negative reflector voltage from the automatic frequency control (AFC) circuit in the receiver. The tuning slugs in the resonant cavity provide a further means for mechanically varying the oscillator frequency. (4) The coupling loop in the resonant cavity leads out to a coaxial cable fitting, from which the oscillator output is applied to the crystal mixer and detector. The entire local oscillator assembly is inclosed in a shielded box with the preamplifier unit.

c. Crystal Detector and Mixer. This unit receives the r-f echo signals from the search antenna and the r-f output of the local oscillator; mixing the two signals to produce an i-f signal for application to the preamplifier stages. In this coaxial mixer, the echo signal is coupled directly to the crystal detector input probe and the local oscillator output is coupled through a variable-capacitance arrangement, for adjustment of the local oscillator signal strength. The crystal output is applied to the preamplifier section through a short length of coaxial cable.

d. Preamplifier Unit. The weak i-f output from the crystal detector is put through two stages of i-f amplification before application to the receiver proper. The amplified output is brought out at the coaxial fitting and is carried through low-impedance coaxial cable to the input of the S-band receiver. Power for operation of the local oscillator and preamplifier stages is supplied through a five-conductor cable from the receiver.

e. Search Receiver. (1) Two Radar Receivers R-38/MPN-1 are used in the S-band search system. These receivers are identical in all respects, and interchangeable with the precision system receivers. To eaoh receiver is applied the i-f output from one of the heterodyne converter units in Radio Frequency Unit RF-7/MPN-1. Video output from either receiver is applied to both search indicators. Either the channel A or channel B receiver may be selected by a relay connected in the channel switching circuit.

(2) The sensitivity-time-control circuit (STC) is not used in the search system and STC switch SW2 (fig. 53) in the receiver is kept in the OFF position, therefore tubes V15 and V16 (fig. 47) of the STC circuit remain idle because the positive trigger from the synchronizer is not applied. The remote gain input to the receiver is supplied from a potentiometer mounted on the intercommunication panel. A dual potentiometer is provided to permit the use of a single control knob for both search receivers. The use of manual gain control rather than STC is necessitated by the different application of the system. Because the

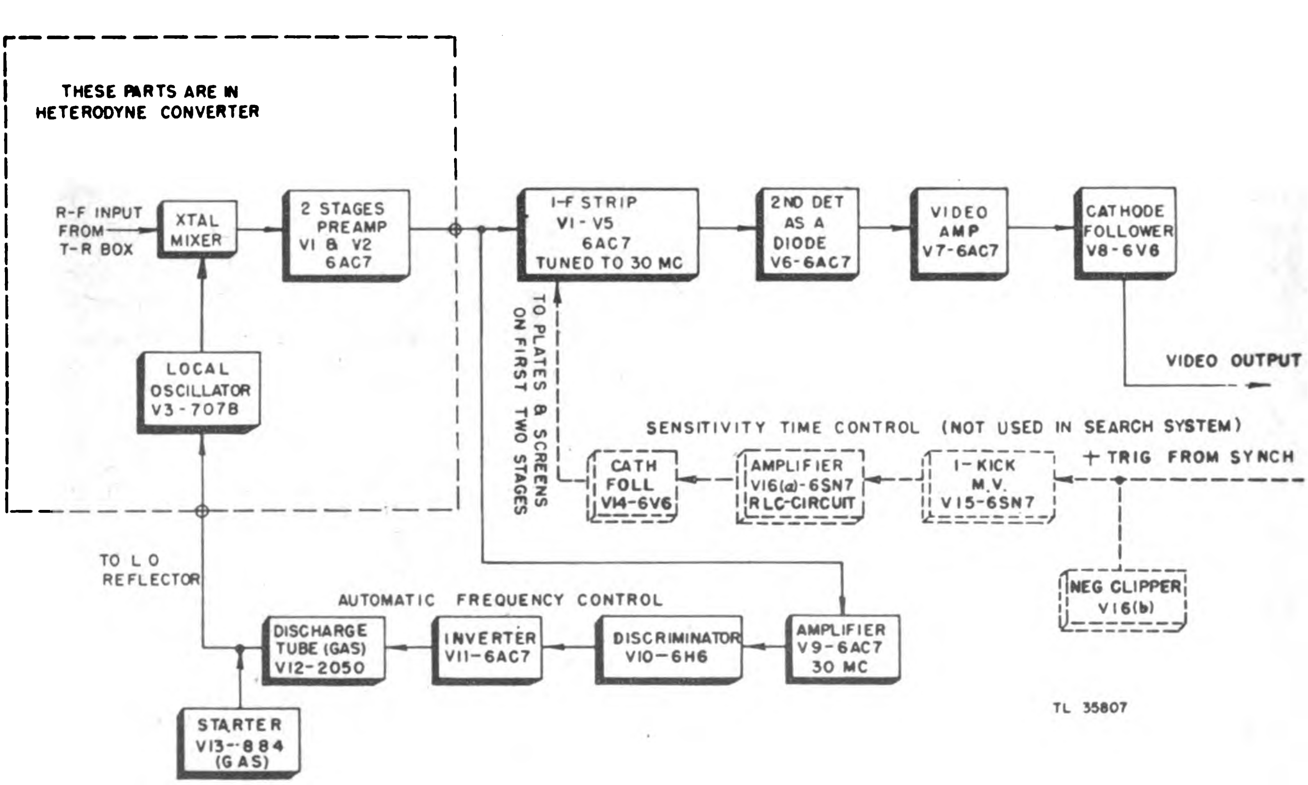


Figure 47. Block diagram of receiver.

search system covers a consistently greater range than the precision system, near-by ground returns are less critical.

23. LOCAL OSCILLATOR.

a. General. The local oscillator tube is a special kind of vacuum tube known as a reflex klystron. One oscillator tube is located on each preamplifier chassis in the search transmitter unit. This type tube is used because at the high frequency (approximately 3,000 mc) at which the local oscillator operates, an ordinary vacuum tube oscillator can not be used. A cross-section of the type 707B klystron is shown in figure 48. The voltages applied to the electrodes are indicated in the diagram. The output of the oscillator is taken through a coupling loop which projects into the cavity. Power for the klystron tube is obtained from the power supply of the respective Radar Receiver R-38/MPN-1 with which it is used. An interconnecting cable plugs into power input plug 1 (fig. 52).

b. Klystron Operation. The electrons emitted by the cathode of the klystron are formed into a beam in much the same way as in a cathode-ray tube. This beam of electrons passes through the two cavity grids and continues toward the reflector electrode. The negative voltage on the reflector electrode, however, repels the electrons and sends them back through the cavity grids on a return trip. The beam of electrons thus passes through the cavity grids twice. The oscillations in the cavity are

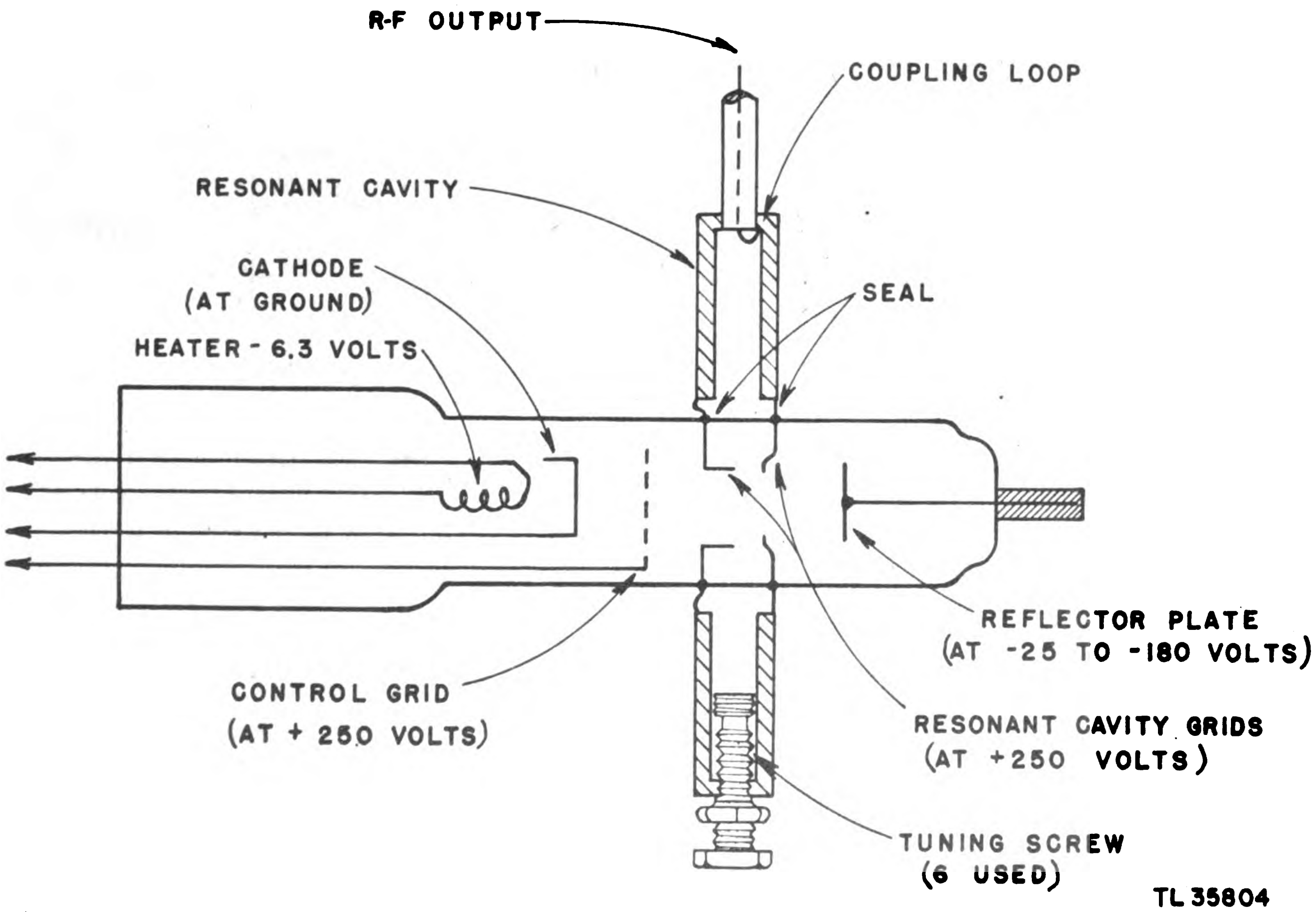


Figure 48. Reflex klystron tube.

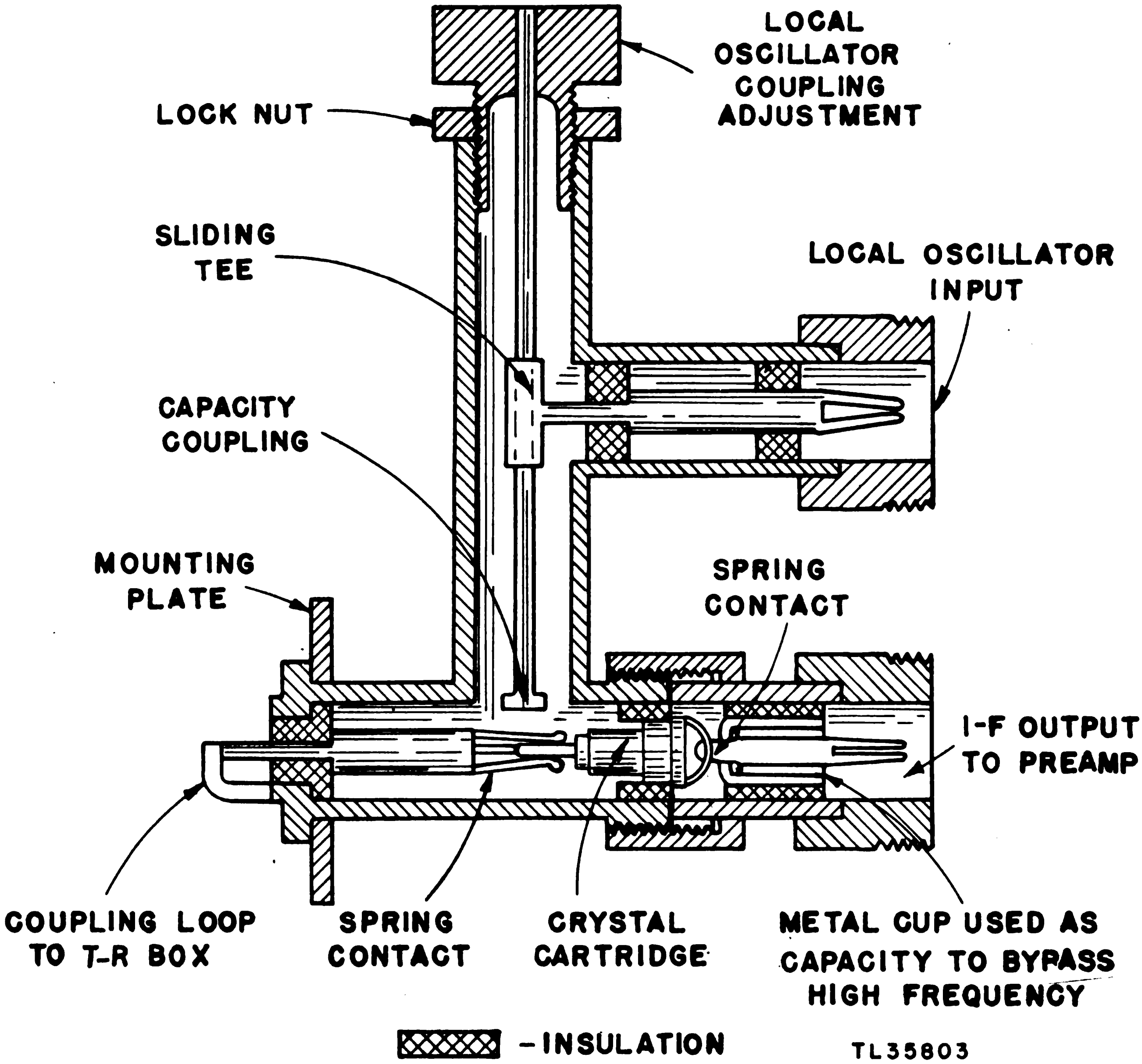


Figure 49. Crystal mixer, cross-sectional diagram.

produced as the result of electrons on the walls of the cavity surging back and forth approximately 3,000,000,000 times a second (3,000 mc). During these oscillations, the electrons on the walls of the cavity pile up first on one cavity grid and then on the other cavity grid, thus producing an electric field between the two grids of the cavity. This electric field alternately speeds up and slows down the beam of electrons as it passes through the cavity grids. This action results in a grouping or bunching of the electrons in the beam. The bunches of electrons are turned back by the reflector, and on their way back, the bunches arrive at the proper instant to reinforce the oscillations of the electrons in the cavity. Weak oscillation is started in the cavity by the approach of the first electrons in the beam. From this point on, the oscillations rapidly build up because the returning bunches of electrons reinforce the oscillation of the electrons on the walls of the cavity. Whether or not the oscillations are reinforced and maintained depends upon the tuning of the cavity, the spacing between the cavity grids, and the voltages applied to the various electrodes of the tube. The control grid voltage has an important effect on whether the tube will oscillate as it determines the speed of the electrons in the beam. The reflector voltage is also important because it determines how long the bunches of electrons take to return to the cavity grids where they give up their energy and support the oscillations only if they arrive at the proper instants.

c. Coupling and Tuning. A coupling loop, inserted in the cavity, inductively picks up the energy of the oscillations which is fed to the crystal mixer by a short section of flexible coaxial cable. The frequency of oscillation depends on the resonant frequency at which the cavity has been tuned. Coarse frequency adjustment is made by changing the size of the resonant cavity. This is done by turning the adjusting screws in (clockwise) to increase the frequency, and out (counterclockwise) to decrease the frequency. A fine adjustment of frequency is made electrically by the setting of the reflector plate voltage. This determines the instant that the reflected electrons return to the cavity grids and therefore affects the frequency of oscillation. Two potentiometers in series adjust the reflector voltage. P9 located on the front panel of Radar Receiver R-38/MPN-1 gives a vernier adjustment of reflector plate voltage while P2 located on the subpanel of the radar receiver provides a greater range of frequency adjustment. This circuit is shown in figure 62.

d. Indications of Oscillation. When the klystron goes into oscillation the crystal current rises sharply. The crystal current meter measures the rectified current produced by the local oscillator output flowing through the crystal detector. Therefore the crystal current reading is a convenient indication of whether or not the klystron is oscillating and of its relative output. The normal crystal current reading is about 0.6 milliampere. If the klystron should go out of oscillation it will be indicated by a sudden drop in crystal current.

e. Frequency Drift. Because of thermal expansion of the resonant cavity, resulting in a change in its physical dimensions, the klystron may drift in frequency by as much as several megacycles while warming up during the first 10 or 15 minutes of operation. After this time, under normal conditions, the tube should not drift in frequency by more than 0.01 percent.

24. CRYSTAL DETECTOR AND MIXER.

a. General. The function of the crystal mixer is to combine the received echo signals with the output of the local oscillator to produce an intermediate-frequency signal which can be amplified in the i-f amplifier circuits of the receiver. The frequency of the local oscillator is tuned to 30 megacycles above the frequency of the transmitting oscillator; and in the crystal mixer, the two frequencies are combined to produce a difference frequency of 30 megacycles. The crystal mixer contains a specially designed silicon crystal detector, and the output of this "first detector" of the complete receiving system is the i-f signal fed to the preamplifier. Figure 49 is a cross-section drawing of the mixer with the crystal cartridge in place, showing the interior details of construction. Figure 50 is a schematic diagram of the crystal mixer circuit. The entire unit is attached directly to the T-R box by means of the mounting plate; and the coupling loop projects into the T-R cavity and inductively picks up the energy of the received r-f signal. The input r-f voltage from the local oscillator enters the crystal mixer at the connection indicated, and the output 30-megacycle i-f signal from the crystal mixer is taken from the second coupling through a short length of flexible cable to the preamplifier.

b. Crystal Mixer Operation. The operation of the crystal mixer will be explained with the aid of figure 50. The input coupling loop to the T-R box is inserted into the T-R cavity at a point where the r-f signal inductively picked up by the loop is greatest. The signal enters a coaxial line made by the hollow shell of the mixer itself, with the coupling loop at the input end and the crystal at the output end. This line is designed so as to be resonant at the frequency (approximately 3,000 mc) of the input signal from the T-R cavity. The loop at the input end has a low impedance, while the output end of the mixer line is open except for the crystal load, and so presents a relatively high impedance. By making the mixer line three-quarters of a wavelength long, it will act as a step-up transformer and therefore will apply a high r-f voltage to the crystal. The local oscillator voltage from the klystron is capacitively coupled into the mixer line by means of the rod and disk coupling (fig. 50), through a sliding sleeve connection to the input line.

c. Mounting of Crystal. The crystal cartridge is clamped in place by means of an insulating washer. A short metal stub at one end of the cartridge is tightly gripped by spring fingers which make contact with the inner conductor of the coaxial resonant mixer line. The metal base of the cartridge makes contact with the inner conductor of the coaxial output line which carries the i-f output signal. The base contact on the cartridge connects to an insulated cylindrical metal cup in the output portion of the line, which offers a low impedance path for the 3,000-mc rf from the base of the crystal cartridge to the outer conductor of the output line, thus completing the 3,000-mc circuit to the crystal. This shunt impedance across the output line effectively keeps most of the "3,000-mc" signals out of that line, but it has such a high

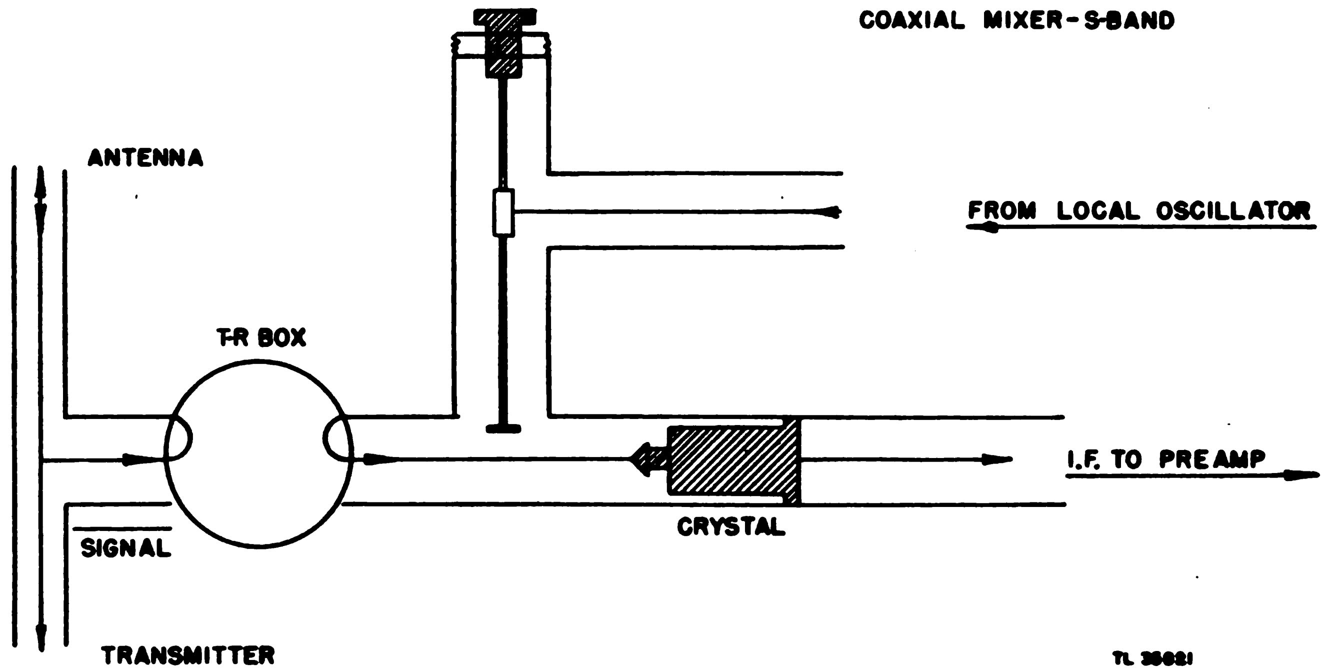


Figure 50. Mixer circuit.

impedance at 30 megacycles that it does not bypass the i-f signals appreciably.

d. Crystal Mixer Coupling. Since the input echo signal is always weak, the coupling of the crystal mixer to the T-R cavity is as tight as possible. On the other hand, since the output of the klystron is very much stronger, it is only loosely coupled to the crystal mixer. As a result of this loose coupling, only a very small part of the echo signal is lost in the oscillator coupling. To prevent overload and damage to the crystal, the disk coupling the output of the local oscillator into the crystal mixer cavity must be kept well out of the cavity initially, and then screwed in carefully until the normal current flows through the crystal. This is indicated by a reading of approximately 0.6 milliampere on the crystal current milliammeter, located in Control Box C-61/MPN-1. Adjustment of the coupling disk position may be made with all lines connected by loosening the locknut and turning the knurled head of the adjusting screw. This operation is recommended only when absolutely necessary.

e. Measurement of Crystal Current. A shorting-type jack, J1, connects one side of the crystal output to ground through resistors R1 and R2 and inductance L1 and L3, as shown in figure 52. Since capacitors C1 and C2 will bypass all r-f current to ground, a milliammeter plugged into J1 will indicate the d-c crystal current. This current should be between 0.5 and 0.6 ma for best operation of the crystal. It should not exceed 0.7 ma. A cord and plug is available inside the door on the search transmitter chassis that may be plugged into the crystal metering jack of either the A or the B channel as required. This cord leads to the meter circuit of Control Box C-61/-MPN-1 where the crystal current is read for both the

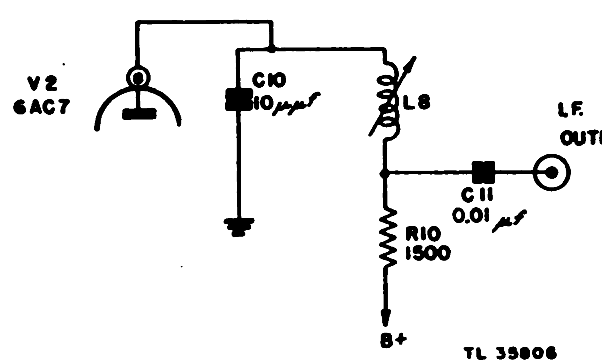
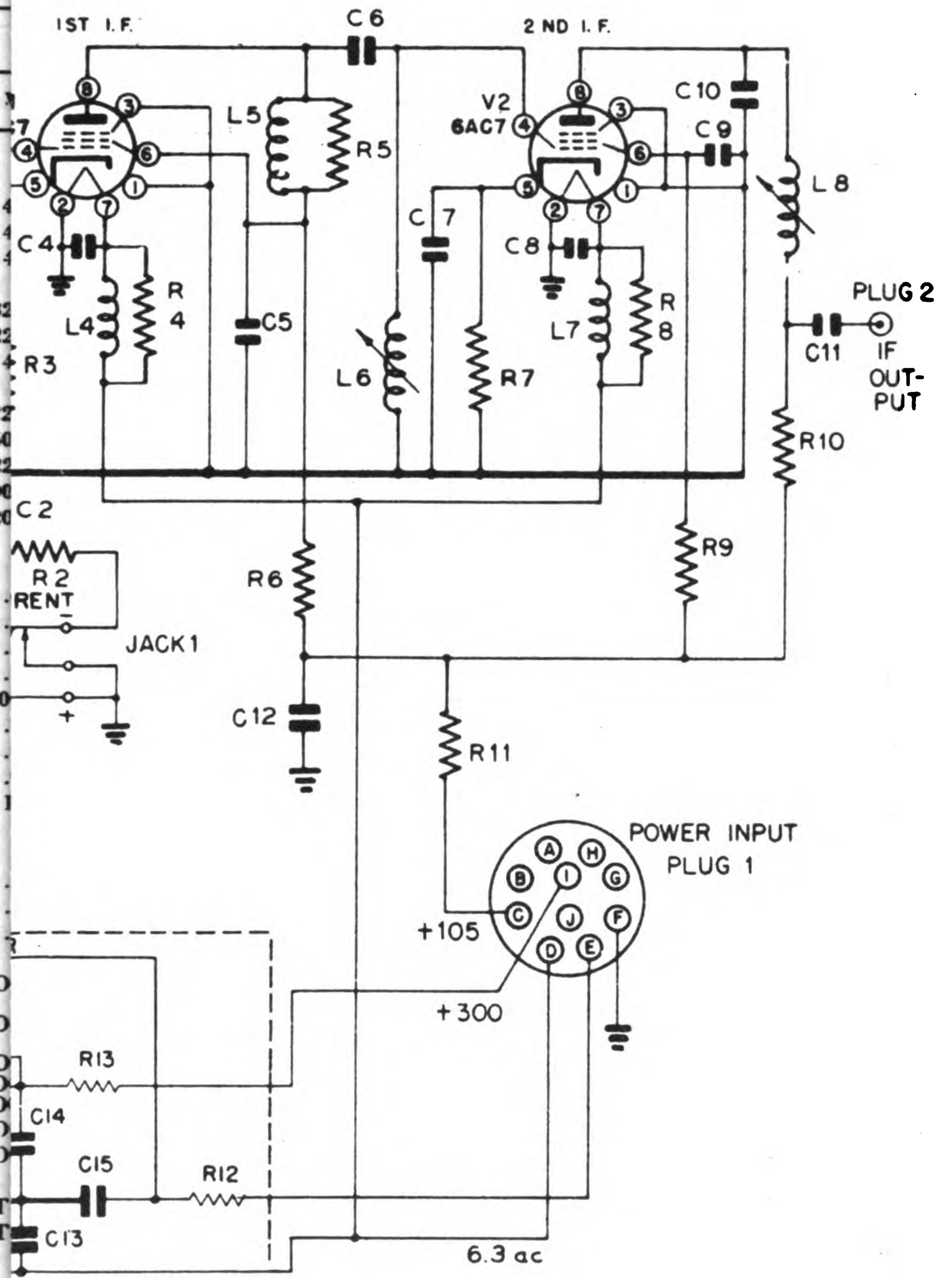


Figure 51. Preamplifier, output lead schematic.

Symbol Designation	
R1	4
R2	4
R3	4
R4	
R5	82
R6	22
R7	4
R8	
R9	22
R10	150
R11	22
R12	2200
R13	220
C1	
C2	
C3	
C4	
C5	
C6	.0
C7	
C8	
C9	
C10	1
C11	
C12	
C13	
C14	
C15	
L1	BO
L2, L3	BO
L4	AO
L5	AO
L6	BO
L7	AO
L8	BO
V1	VT
V2	VT
V3	
J1	A2
PL1	AN
PL2	AN
PL3	C1
PL4	BO



TL 36080A

Figure 52. S-band Preamplifier and heterodyne converter, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	47 Ohm	½W	10%
R2	47 Ohm	½W	10%
R3	47 Ohm	½W	10%
R4	1 Meg	½W	20%
R5	820 Ohm	½W	10%
R6	220 Ohm	½W	10%
R7	47 Ohm	½W	10%
R8	1 Meg	½W	20%
R9	220 Ohm	½W	10%
R10	1500 Ohm	1W	10%
R11	220 Ohm	½W	10%
R12	22000 Ohm	½W	10%
R13	2200 Ohm	5W	10%
C1	.01 mfd	300V	20%
C2	.001 mfd	300V	20%
C3	.001 mfd	300V	20%
C4	.001 mfd	300V	20%
C5	.001 mfd	300V	20%
C6	.0001 mfd	500V	10%
C7	.001 mfd	300V	20%
C8	.001 mfd	300V	20%
C9	.001 mfd	300V	20%
C10	10 mmfd	300V	20%
C11	.01 mfd	300V	20%
C12	.01 mfd	300V	20%
C13	.001 mfd	300V	20%
C14	.001 mfd	300V	20%
C15	.001 mfd	300V	20%
L1	BOO-4934-7		
L2, L3	BOO-4935		
L4	AOO-4417		
L5	AOO-4418		
L6	BOO-4934-3		
L7	AOO-4417		
L8	BOO-4934-3		
		Mfr. No.	
V1	VT-112	6AC7	
V2	VT-112	6AC7	
V3		707B	
J1	A2	MALLORY	
PL1	AN-3106-18-1P		
PL2	AN-3106-8S-1S		
PL3	CHU-49284	MENDELSOHN	
PL4	BOO-9954	GB	

search and precision system. The crystal current metering plug should be removed from the jack when not being used to measure crystal current. If it is left in place the signal-to-noise ratio of the receiver is changed sufficiently to interfere with operation of the set.

f. Care in Handling. The static discharge from an ungrounded piece of equipment or from the operator's person may burn out a crystal when it is being inserted in the mixer cavity. Avoid such discharges by holding the cartridge by the base and making electrical contact with the equipment through the hand before inserting the cartridge. Do not drop crystals, nor subject them to heat or to strong r-f electrical fields generated by this equipment.

CAUTION: The crystals used in this detector are extremely sensitive and will be damaged if not treated carefully and gently. Any of the following actions may burn out the crystal:
(1) Excessive local oscillator output.
(2) T-R failure.
(3) Static discharge.
(4) Mechanical shock.
(5) Strong magnetic fields resulting in induced currents in crystal leads.

25. PREAMPLIFIER UNIT.

a. General. Before application to the receiver, the i-f output of the crystal detector is applied to two stages of low-gain single-tuned amplification provided in a preamplifier unit, a part of each heterodyne converter. In this way the signal is sufficiently amplified before being fed through a 72-ohm coaxial line to the receiver.

b. Operation. (1) The 30-megacycle i-f output from the crystal detector is applied across the self-resonant inductance L1 and L3 (fig. 52). The signal input to the grid of V1 is developed across inductance L2 which is mutually coupled to L3 because the two coils are wound on the same form. Therefore the output of the crystal detector appears across L2 which, with the input capacitance of V1, forms a parallel resonant circuit. The inductance is variable through the adjustment of an inserted metal core. The coil is tuned to give the stage maximum amplification at 30 megacycles. The return to ground of rectified crystal current is through L1, L3, R1, R2, and J1. The combination of R1, R2, C1, and C2 provides filtering of the crystal current.

(2) Amplifiers V1 and V2 (6AC7) are metal-envelope, high-gain pentodes. In each tube the suppresser grid and shell are grounded. The heater circuits are connected in parallel, with one terminal of each heater grounded. In V1 the heater circuit is effectively isolated from r-f voltages by L4 and R4 (a combination r-f choke wound on a 1-megohm resistance) in series with the a-c heater lead. Across the heater, C4 provides an r-f bypass to ground for any high frequency components not blocked by the r-f choke. C8, L7, and R8 form a similar combination for V2.

(3) The screen and plate operate at essentially the same potential, being supplied from the +105-volt input through R11 and R6. C5 is the screen bypass capacitor and inductance L5 and resistance R5 serve as the plate load. C6 couples the output of the first stage to the grid of V2. The operation of L6 in the grid circuit of V2 is identical with that of L2. The cathode, heater, and suppresser grid connections are also identical with those in the first stage. Screen grid voltage is supplied through R9 with C9 as the bypass to ground. Plate voltage, supplied through R10 and L8 is lower than the screen voltage, giving V2 the characteristics of a constant current pentode, since R9 has a value of 240 ohms and R10 a value of 1,500 ohms (fig. 51).

(4) C11 couples to the i-f output plug 2 which connects the coaxial line to the receiver proper. The entire heterodyne converter assembly is carefully shielded from stray pick-up, each tube having an additional individual shield. Power plug 1, into which the power cord terminates from the receiver, is the input for the operating power used by the local oscillator and preamplifier tubes.

26. RADAR RECEIVER R-38/MPN-1.

a. General. Radio Set AN/MPN-1 utilizes four radar receivers. Two are in actual operation and two maintained for stand-by purposes. Of the two in operation, one is used in the precision system, the other in the search system. All are identical, but minor control adjustments are necessary when interchanged between the *X* and the *S* bands. A front view of the receiver chassis is shown in figure 53. The complete schematic diagram for Radar Receiver R-38/MPN-1 is shown in figure 56 and should be used with the discussion that follows.

b. I-f Amplifier Stages. (1) The i-f amplifier section within the receiver consists of five stages of amplification, V1 through V5, using 6AC7 type pentode amplifiers. The typical circuit is illustrated in figure 54. The output from the preceding stage is fed through a coupling capacitor to a tuned circuit in the grid circuit of the next stage. The tuned circuit consists of a variable inductance tuned to resonance at 30 megacycles with the input capacity of the tube. A band width of approximately 2 megacycles is provided. The circuit is essentially the same as that already discussed in the paragraph on the preamplifier unit.

(2) I-f amplifier tubes V1 and V2 differ from this standard arrangement in that their plates and screens are not

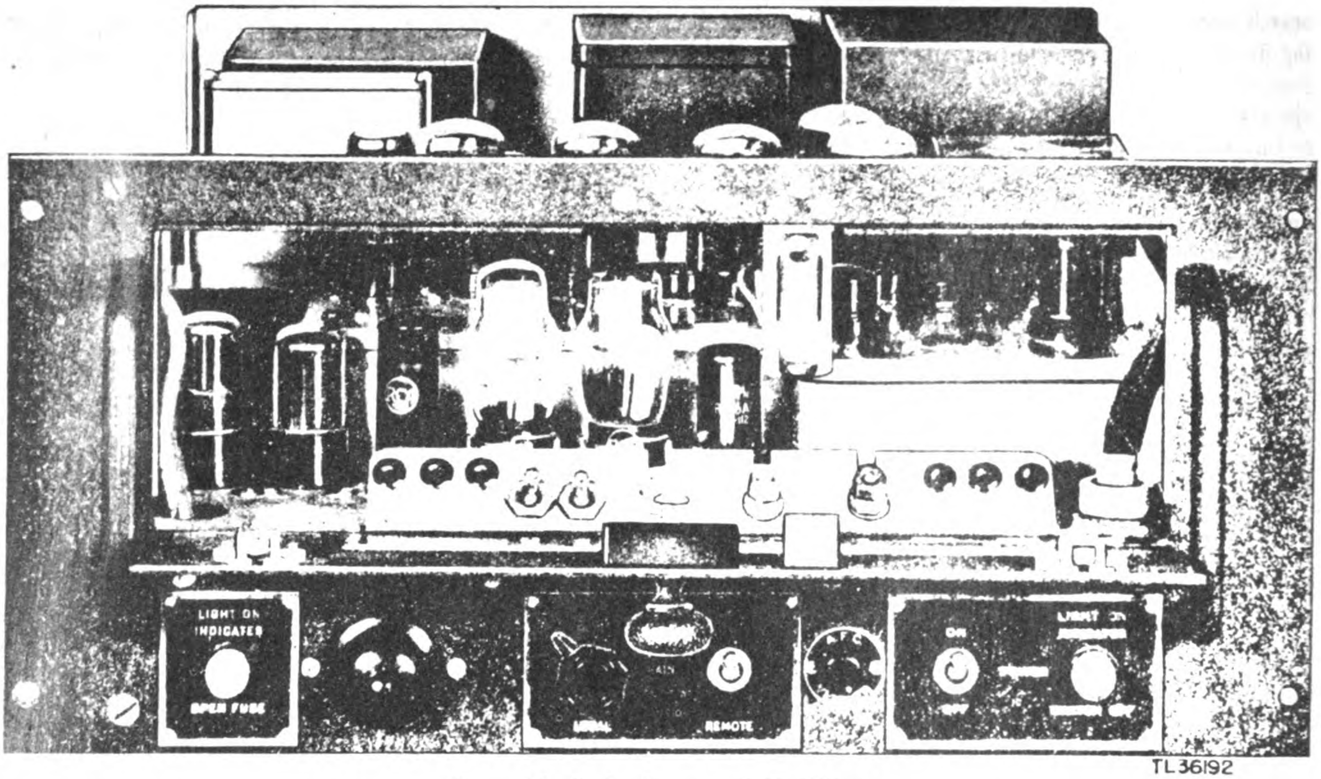


Figure 53. Radar Receiver R-38 MPN-1.

supplied from the 105-volt supply, but receive voltage from the output of the sensitivity-time-control (STC) circuit. A varying plate voltage is applied to these two tubes as the range of the echo signal increases in order to increase the receiver gain when the STC circuit is in operation. This circuit is used only in the precision system and is discussed in detail in chapter 3, section IV. When the search system is used the STC toggle switch, located on the subpanel of the receiver, is set to the OFF position and a d-c voltage, controlled only by the manual gain control, is fed to the first two i-f amplifier tubes in the normal manner. Figure 55 illustrates the method of gain control applied to the radar receiver as it is used in the search system when the STC switch is OFF. Setting SW3 to the REMOTE position transfers the radar receiver gain control to a similar potentiometer circuit located on the intercommunications panel in bay 5 of the indicator rack. This is done to bring the radar receiver gain control within easy reach of the search system operators. In order to have only one gain control knob for both channel A and channel B radar receivers, two potentiometers have been ganged on the same shaft and each remote gain control circuit serves its individual receiver. The intercommunications panel schematic diagram, figure 85, shows the remote gain control circuit.

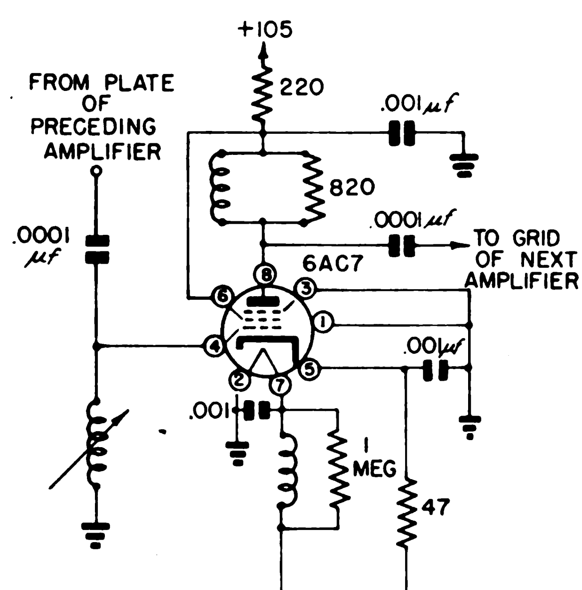


Figure 54. I-f amplifier stage schematic diagram.

(3) Instead of operating at 105 volts, the final i-f amplifier stage, V5, is supplied with a higher potential from the 220-volt source through resistors R21 and R22. This is to supply sufficient power output for the diode detector stage, V6.

c. Detector and Video Amplifier. The i-f output from V5 is coupled through C20 to the cathode of V6. A simplified schematic diagram of the detector and video amplifier stages is shown in figure 57. The three grids of tube V6 are connected to the plate so that it functions as a diode. The heater circuit of this tube, as well as of V7 and V8, is isolated from r-f voltages by a filter network identical to those used in the preceding i-f amplifier stages. L18 and C23 filter the high frequency component from the rectified output so that only video signals are applied to video amplifier stage V7. V7 is operated as a normal resistance-capacitance coupled amplifier with its screen voltage obtained from the 105-volt supply and plate voltage from the 220-volt supply. To prevent output distortion, a low value plate resistor R29 is used. V8, a cathode follower output stage, is used to match the impedance of the circuit to the video output coaxial line. Potentiometer P1 is a variable cathode load resistor to permit gain and impedance-matching adjustments. Both search system indicators are fed by one radar receiver at a time. By using a switching relay, provision is made so that either the channel A or channel B receiver will supply the video output to the indicators, depending on which channel is in operation. The video output from the receivers of both channels is wired through relay 1 located on the back of the intercommunications panel assembly. This relay and its associated circuit is shown in the intercommunications panel schematic diagram (fig. 85).

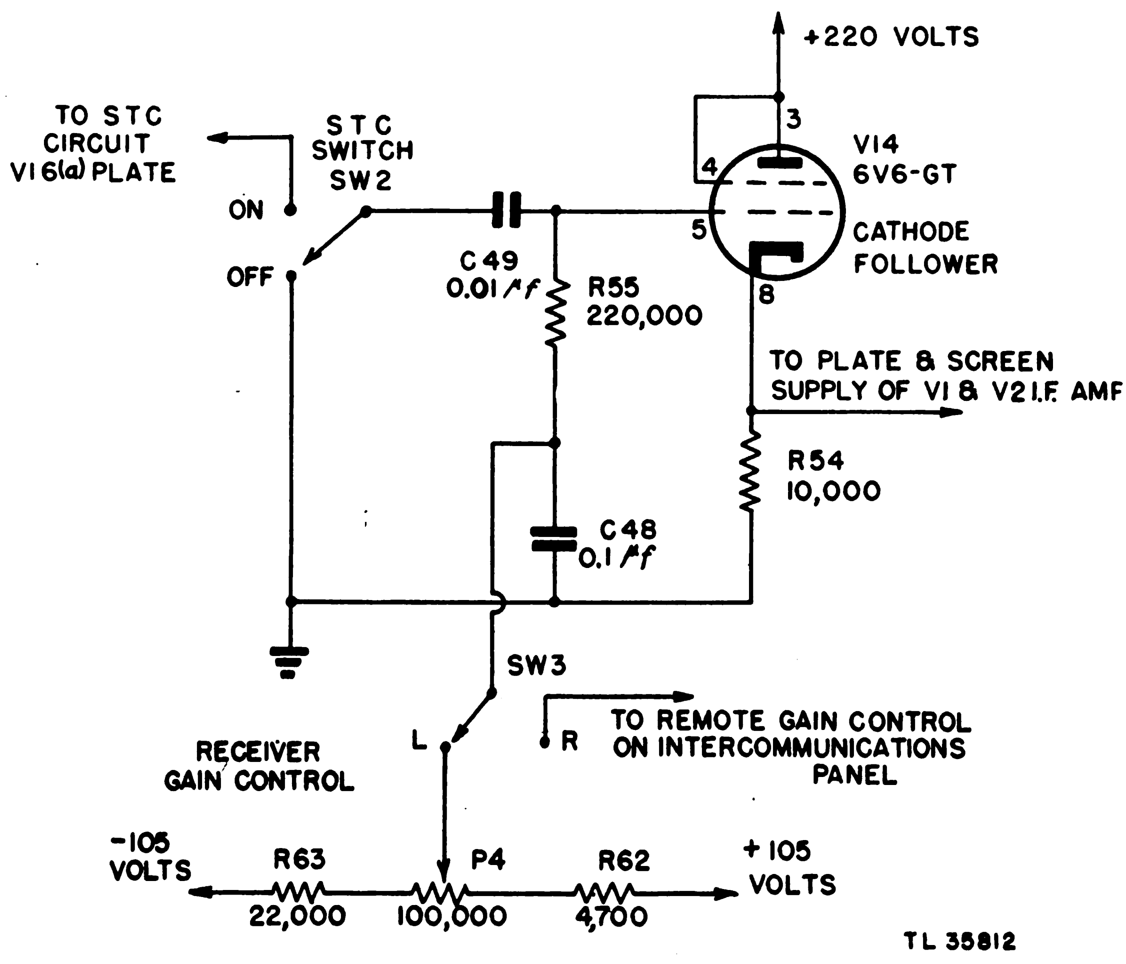


Figure 55. Receiver gain control circuit.

d. Automatic Frequency Control. To assure i-f stability, an automatic frequency control (AFC) circuit is incorporated in the receiver and serves to vary the frequency of the local oscillator, operating above the transmitter frequency in such a way that the intermediate frequency is held constant at 30 megacycles. The desired frequency variations in local oscillator output are accomplished by the AFC circuit which supplies a negative voltage to the reflector of the local oscillator tube, thereby controlling its frequency of oscillation and consequently the intermediate frequency as well. As the intermediate frequency tends to change, the negative voltage increases or decreases to assure 30-megacycle i-f stability. The functional block diagram for the AFC circuit is shown in figure 58.

(1) The i-f input voltage to the receiver is coupled to a single i-f amplifier stage V9 (fig. 59). The output circuit of this stage is composed of L22 and variable capacitor C34 in parallel and is tuned to resonate at 30 megacycles. This output tank circuit is coupled both inductively and capacitively to the input of the discriminator circuit. The discriminator circuit develops a voltage proportional to frequency (not amplitude) of the input signal.

(2) L23 and variable capacitor C36 form the input circuit of the discriminator, and are tuned to resonate at 30 megacycles. L22 and L23 are inductively coupled because they are wound on the same form and act as primary and secondary windings of the discriminator transformer. This inductive coupling is loose in order to avoid a shift in the resonant frequency. The two windings are also directly coupled through low-reactance capacitor C35 from the plate of V9 to the center tap of L23.

(3) Discriminator tube V10 (6H6) is a double-diode rectifier whose plates are connected to opposite ends of L23. The output voltage of the discriminator is the rectified voltage appearing across the two load resistors R37 and R38. This output is the rectified peak voltage due to the filtering action of capacitors C38 and C39.

(4) The coupling between the primary (L22) and the secondary (L23), and the tuning of the primary, are adjusted to give a voltage across the secondary that differs by 90 degrees in time phase with the primary voltage. The primary is connected to the center tap on the secondary by means of coupling capacitors C35. Figure 60 shows an equivalent circuit of the discriminator and the various voltage relations for frequencies above, below, and at resonance. Both the primary and secondary circuits are tuned to resonate at the 30 megacycle i-f frequency. As shown in the equivalent circuit, the voltage applied between the upper diode plate and the cathode of V10(a) is the drop developed across the resistor between A and D. This is the vector sum of the voltage across the upper half of the secondary A to B and the voltage of the primary B to D. Similarly, the voltage applied to the lower diode plate, V10(b), is that across the lower half of the secondary, C to B, plus the primary voltage, B to D. When the i-f signal is at its proper frequency (30 megacycles), the voltage across the secondary, A to C, is 90 degrees out of phase with the voltage across the primary, C to D (fig. 60-2). Thus E_{CB} leads E_{BD} by 90 degrees while E_{AB} lags E_{BD} by 90 degrees. Since the secondary is center-tapped to make E_{AB} equal to E_{CB}, the vector sums are equal in magnitude. Equal signals on the two diode plates produce equal currents in the cathodes, which in turn, produce d-c voltage drops across R37 and R38. These voltage drops are equal but of opposite polarity. The output of the discriminator circuit is therefore zero and no correction voltage is obtained when the proper frequency is being applied to the transformer.

(5) If the i-f signal changes in frequency, the secondary circuit is no longer tuned to resonance, and the voltage A to C no longer differs by 90 degrees. If the frequency decreases, a lag of more than 90 degrees is produced; if the frequency increases, a lag of less than 90 degrees occurs. In the former case the voltage applied to lower diode plate V10(b) is greater (fig. 60-3) and the output of the discriminator circuit is negative. In the latter case, conditions are reversed (fig. 60-4) and a positive output is produced. The net output from the discriminator circuit is a d-c pulse which is applied to the grid of V11 to be inverted and amplified for application as a correction voltage actuating the remainder of the circuit.

(6) Inverter-amplifier stage V11 has test point TP1 tapped off its plate load resistor R42 to provide a means of viewing the discriminator output with a test oscilloscope. The output from V11 is positive when the i-f frequency is below 30 megacycles and negative for i-f frequencies above 30 megacycles. The relationship between the output voltages of V10 and V11, plotted against frequency, is shown in figure 61.

(7) The negative voltage applied to the local oscillator reflector is developed across capacitors C44 and C46 and regulated by gas tubes V12 (2050) and V13 (884) as shown in figure 62. The "hunting" tube, V13, begins to operate as soon as the receiver is turned on. With its associated RC network, V13 is a saw-tooth oscillator sweeping the reflector voltage slowly through a wide range by charging C44 and C46 through R52 and R53, a combination having a long time constant. When the plate voltage of V13 becomes high enough to overcome the negative bias on its grid, the tube fires, discharging the

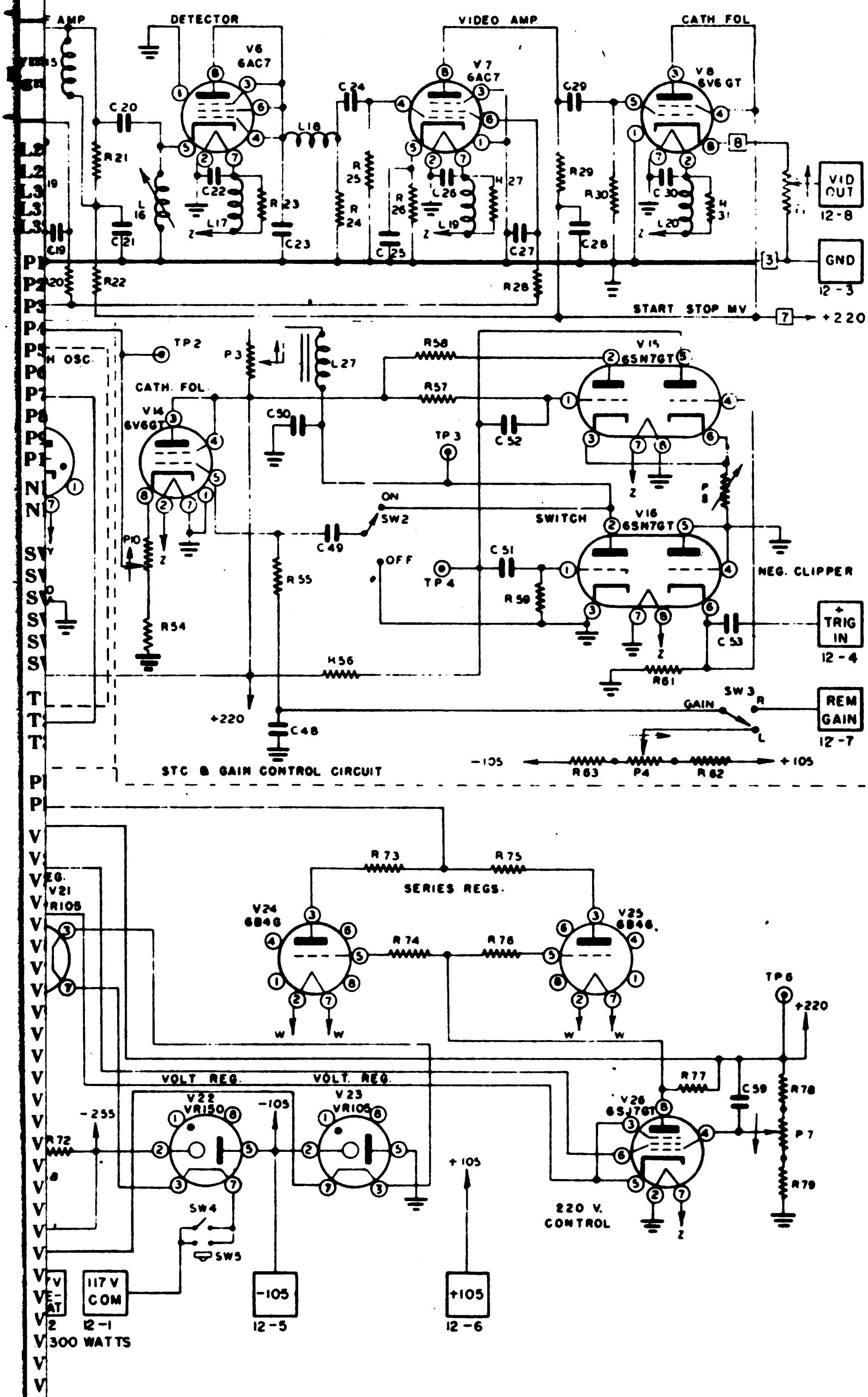


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Figure 56. Radar Receiver R-38/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
C35	25 mmf	300	20%
C36	3-13 mmf	500	
C37	.001 mfd	300	20%
C38	140 mmf	500	10%
C39	100 mmf	500	10%
C40	100 mmf	500	10%
C41	.01 mfd	400	20%
C42	.01 mfd	400	20%
C43	.01 mfd	400	20%
C44	.01 mfd	400	20%
C45	.01 mfd	400	20%
C46	.5 mfd	600	20%
C47	.25 mfd	600	20%
C48	.1 mfd	600	20%
C49	.01 mfd	400	20%
C50	.0068 mfd	500	10%
C51	.001 mfd	300	20%
C52	.0015 mfd	500	10%
C53	33 mmf	500	20%
C54	8 mfd	1000	20%
C55	.1 mfd	600	20%
C56	.5 mfd	600	20%
C57	.01 mfd	400	20%
C58	4 mfd	600	20%
C59	.1 mfd	600	20%
C60	Omitted		
C61	.1 Mfd	1000	20%
C62	.01 Mfd	400	20%
C63	.01 Mfd	400	20%
C64	.01 Mfd	400	20%
F1	5 amp	3AG	
L1	BOO-4934-1		
L2	AOO-4417		
L3	AOO-4418		
L4	BOO-4934-3		
L5	AOO-4417		
L6	AOO-4418		
L7	BOO-4934-3		
L8	AOO-4417		
L9	AOO-4418		
L10	BOO-4934-3		
L11	AOO-4417		
L12	AOO-4418		
L13	BOO-4934-3		
L14	AOO-4417		
L15	AOO-4418		
L16	BOO-4934-3		
L17	AOO-4417		
L18	AOO-4421		
L19	AOO-4417		
L20	AOO-4417		
L21	AOO-4417		
L22	MIT-C-5382-A		
L23			
L24	AOO-4417		
L25	AOO-4418-1		
L26	CH-844-18		
L27	15-2475		

Symbol Designation	Description		
	Value	Rating	Tolerance
L28	15-2474		
L29	15-2473		
L30	AOO-4417		
L31	AOO-4417		
L32	AOO-4417		
P1	500	4	20%
P2	500,000	2	10%
P3	100,000	2	10%
P4	100,000	2	10%
P5	100,000	2	10%
P6	2,000	25	
P7	100,000	2	10%
P8	2,000	2	10%
P9	50,000	2	10%
P10	5,000	2	10%
NE1	5122		
NE2	5122		
SW1	1GA4A1		
SW2	1GA3A1		
SW3	1GA3A1		
SW4	8201	C.H.	
SW5	ML 7460330G4	G.E.	
SW6	1GA1A1	G.E.	
T1	15-3426		
T2	15-3463		
T3	15-3425		
PL1	AN-3108-8S-1S		
PL2	AN-3108-18-1S		
V1	VT-112	6AC7	
V2	VT-112	6AC7	
V3	VT-112	6AC7	
V4	VT-112	6AC7	
V5	VT-112	6AC7	
V6	VT-112	6AC7	
V7	VT-112	6AC7	
V8	VT-107A	6V6GT	
V9	VT-112	6AC7	
V10	VT-90	6H6	
V11	VT-112	6AC7	
V12	VT-245	2050	
V13	VT-222	884	
V14	VT-107A	6V6GT	
V15	VT-231	6SN7GT	
V16	VT-231	6SN7GT	
V17		5R4GY	
V18		6B4G	
V19	VT-116A	6SJ7GT	
V20		5R4GY	
V21		VR105	
V22		VR150	
V23		VR105	
V24		6B4G	
V25		6B4G	
V26	VT-116A	6SJ7GT	

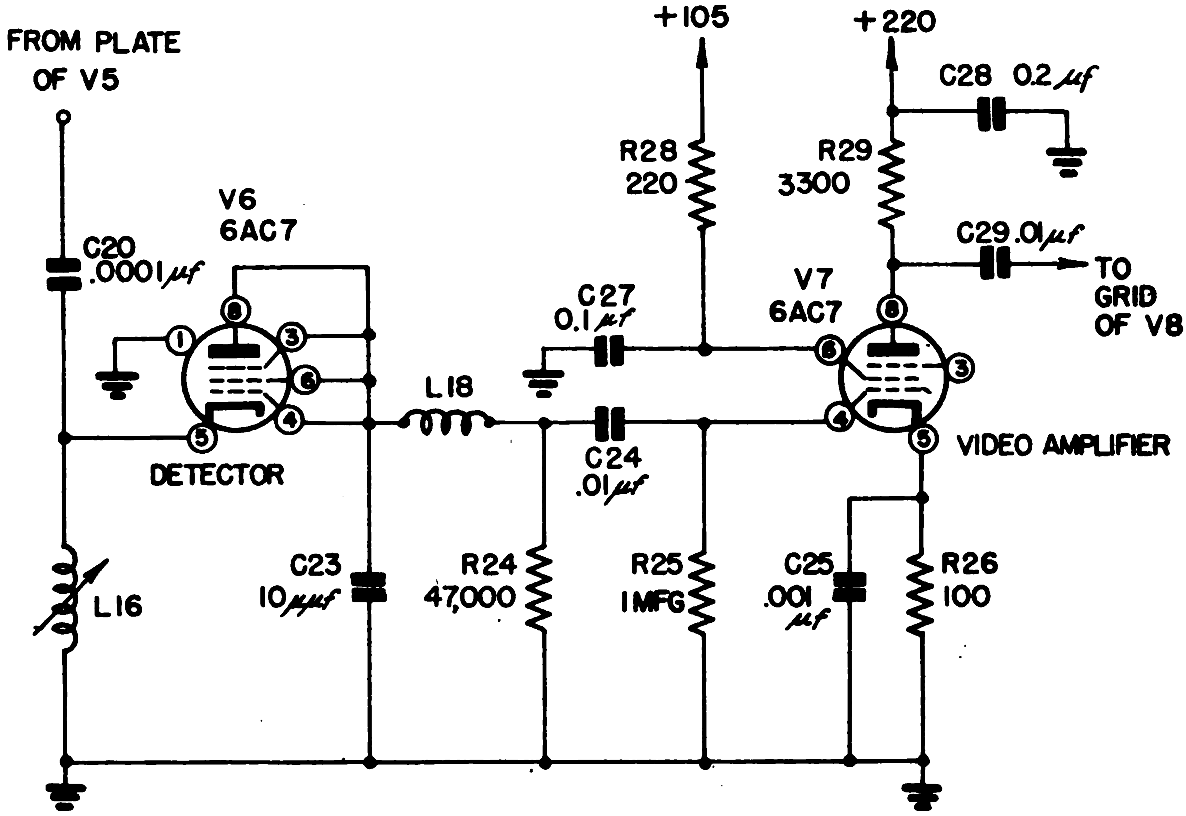

Figure 57. Detector and video amplifier schematic diagram.

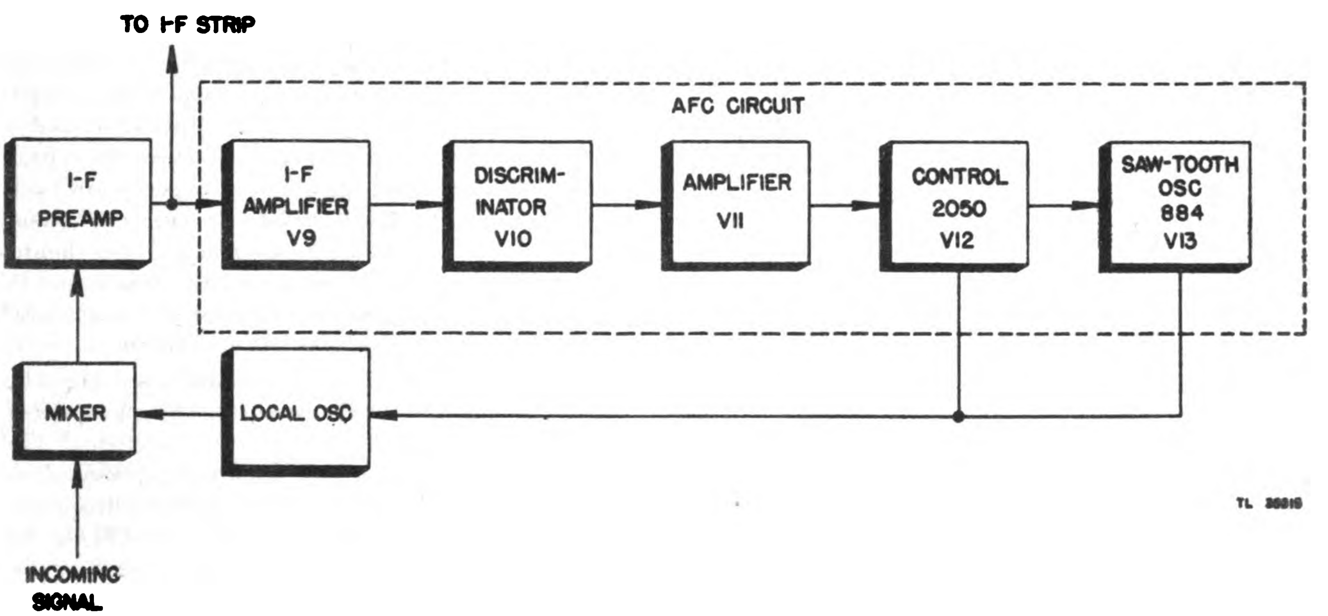

Figure 58. AFC circuit, functional block diagram.

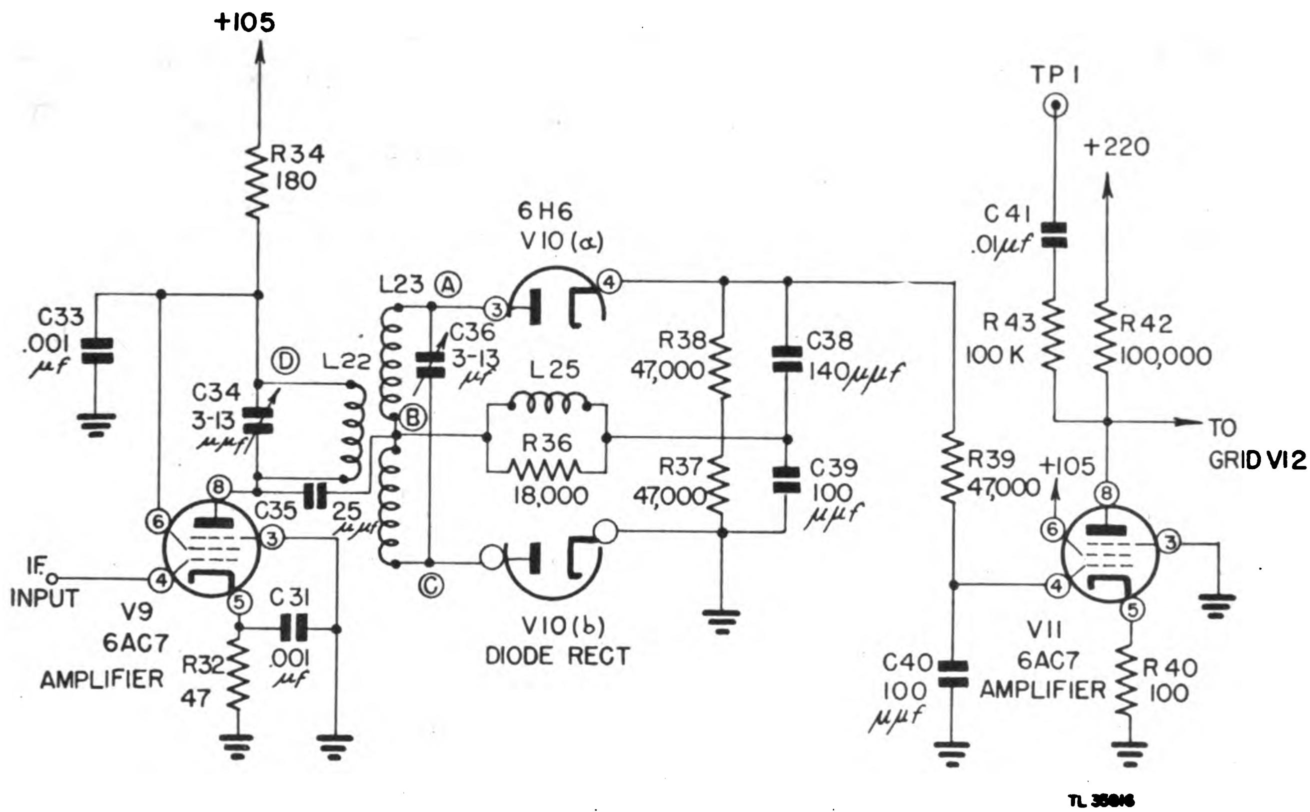

Figure 59. Discriminator, simplified schematic diagram.

capacitor and beginning again the slow hunting cycle, which is about ¾ second duration. The voltage across C46 is proportional to that applied to the reflector of the local oscillator.

(8) Once the local oscillator has struck a mode of oscillation, an i-f voltage is applied to discriminator V10. If above the desired frequency, the output of V11 forces the grid of V12 further negative, resulting in no further action of V12. The hunting cycle of V13 continues, making the reflector voltage less negative which decreases the intermediate frequency until the output of V11 becomes positive. The positive output applied to the grid of V12 permits it to fire and to produce a voltage drop across R53. Capacitors C44 and C46 are partially discharged, driving the reflector voltage further negatively, raising its frequency and increasing the intermediate frequency.

(9) Since the grid bias of V12 is affected by the discriminator output, V12 fires when the i-f goes below 30 megacycles, halting the hunting action of V13. When the i-f frequeney goes below 30 megacycles, V12 fires with each transmitter pulse. The capacitors C44 and C46 discharge progressively less and raise the i-f frequency slightly each time, so that when operation becomes stabilized V13 will not fire and V12 will operate around a delicate voltage-balance. If V12 is not active, the voltage applied to the reflector plate will be a long-cycle saw-tooth curve (fig. 63). The local oscillator frequency variations are represented by the lower curve in the same figure. These wide changes in frequency would be of no use in operation as they only serve to hunt for the proper local oscillator frequency when transmission is begun.

(10) Before V13 can complete its normal saw-tooth cycle, V12 comes into operation at some point M (fig. 63) and from that time controls the action of the circuit. The effect on the circuit when V12 conducts is represented on the diagram by MNOPQRS and local oscillator frequency variations are represented by M′N′O′P′Q′R′S′. If the local oscillator frequency is set correctly above the transmitter frequency, the AFC acts first to hunt for the desired intermediate frequency and then maintains that frequency within very narrow limits.

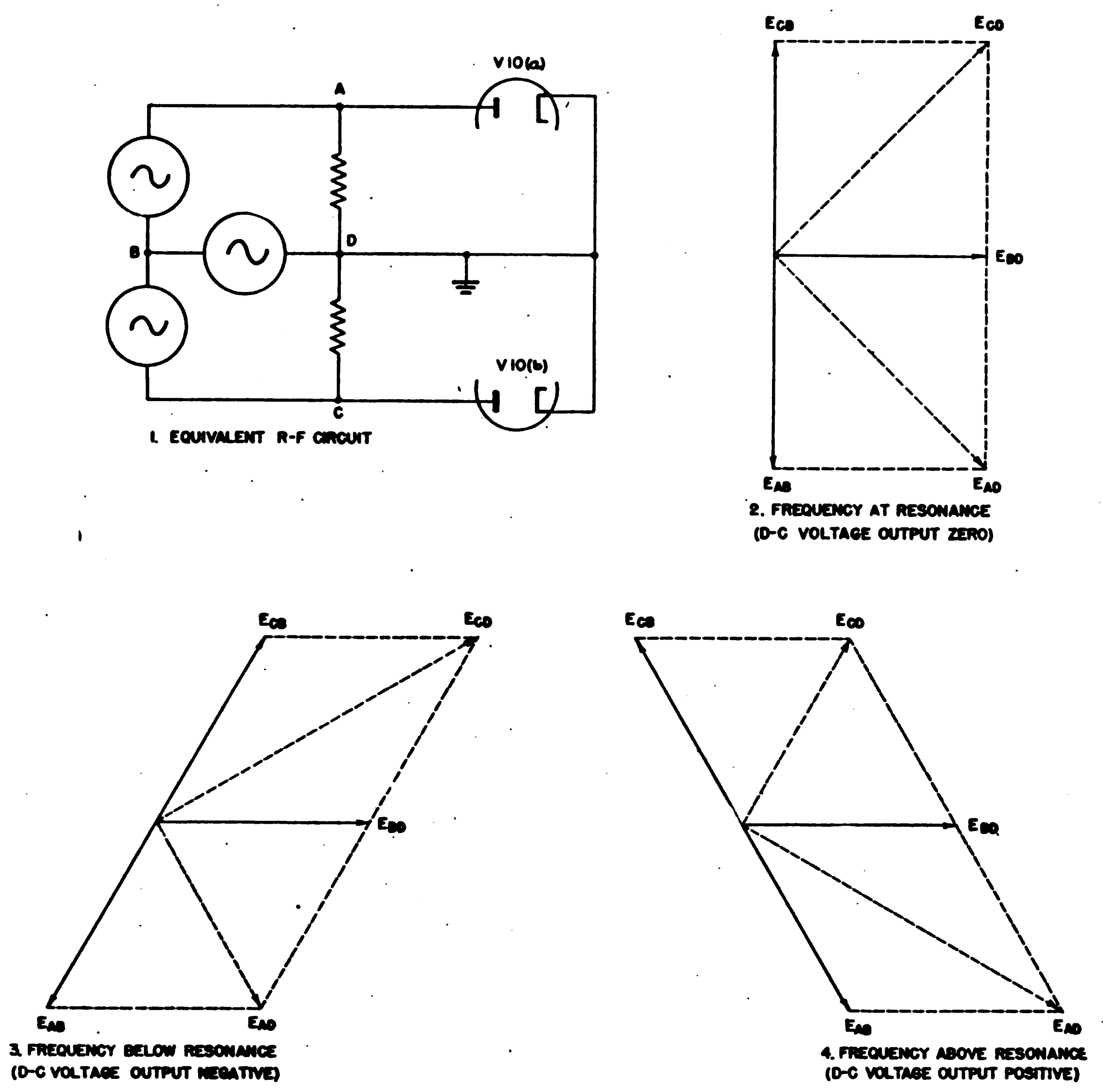

Figure 60. Equivalent circuit and vector diagram of discriminator circuit.

(11) Should the frequency of the transmitter change, the AFC circuit will correct the local oscillator frequency within the operational limits of the circuit, and keep the i-f frequency constant at 30 megacycles. For example, if the transmitter frequency should suddenly decrease, the i-f frequency would then be greater than 30 megacycles. The output of V11 for an i-f frequency greater than 30 megacycles is negative and therefore V12 will stop conducting. When V12 stops conducting the change on capacitors C44 and C46 becomes less negative because there is no longer a voltage drop through R53. This voltage drop is due to plate current taken by V12. The repeller plate voltage will also rise (point A, fig. 64) and will decrease the local oscillator frequency to point B where the i-f frequency is again 30 megacycles and the system reaches an equilibrium. Should the transmitter frequency decrease sufficiently, the discriminator circuit can no longer correct the local oscillator. Therefore a 30 megacycle i-f frequency will not be produced and the repeller plate voltage will continue to rise from point C to point D where V13 fires. The AFC circuit will then hunt until the transmitter frequency is returned to normal (point E) and the AFC circuit can again take control.

(12) When it is not desirable to use the AFC circuit, SW1 is turned off to eliminate the AFC and provide for manual control of the reflector voltage. With the switch on the

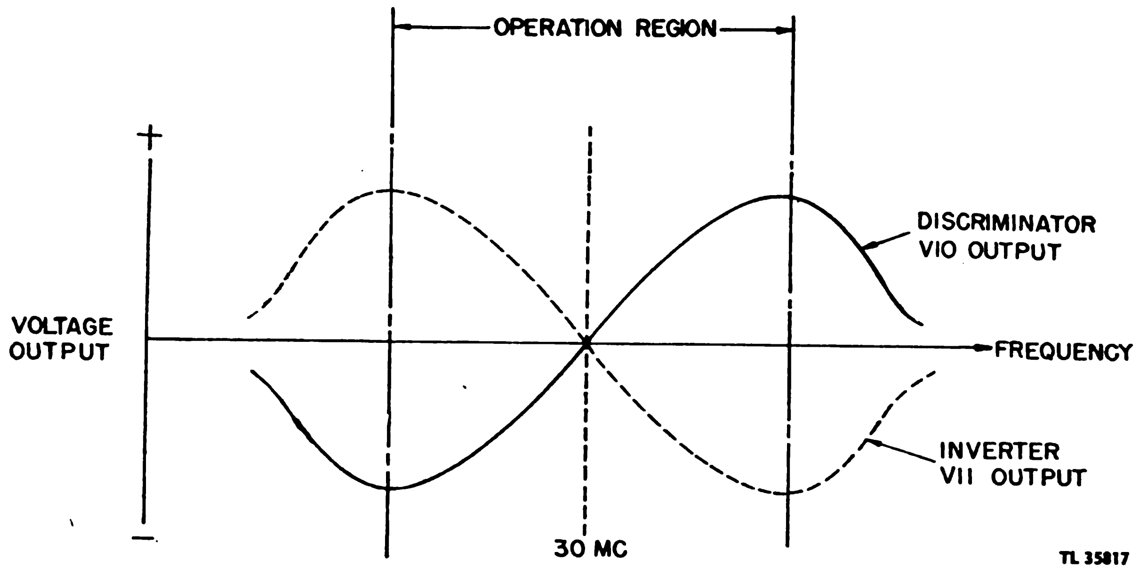

Figure 61. Discriminator output voltage versus i-f frequency characteristics.

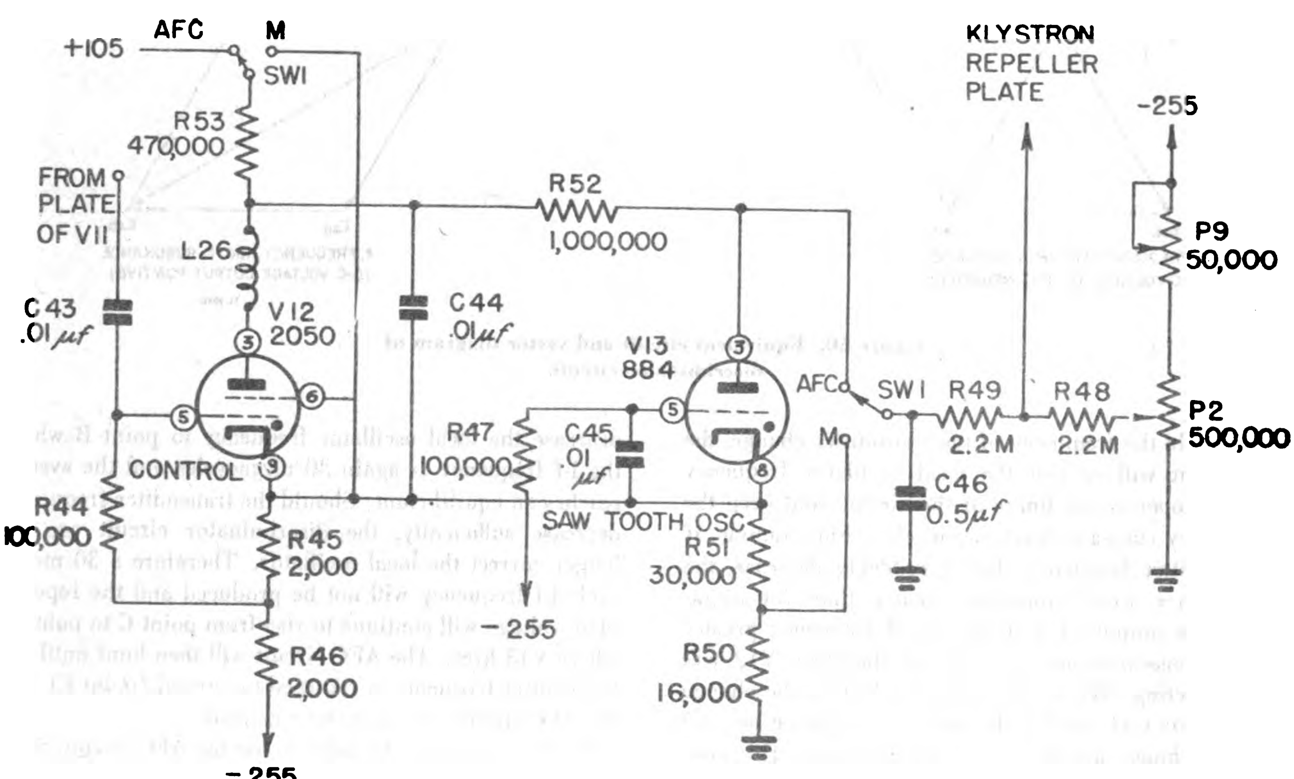

Figure 62. Reflector voltage control circuit.

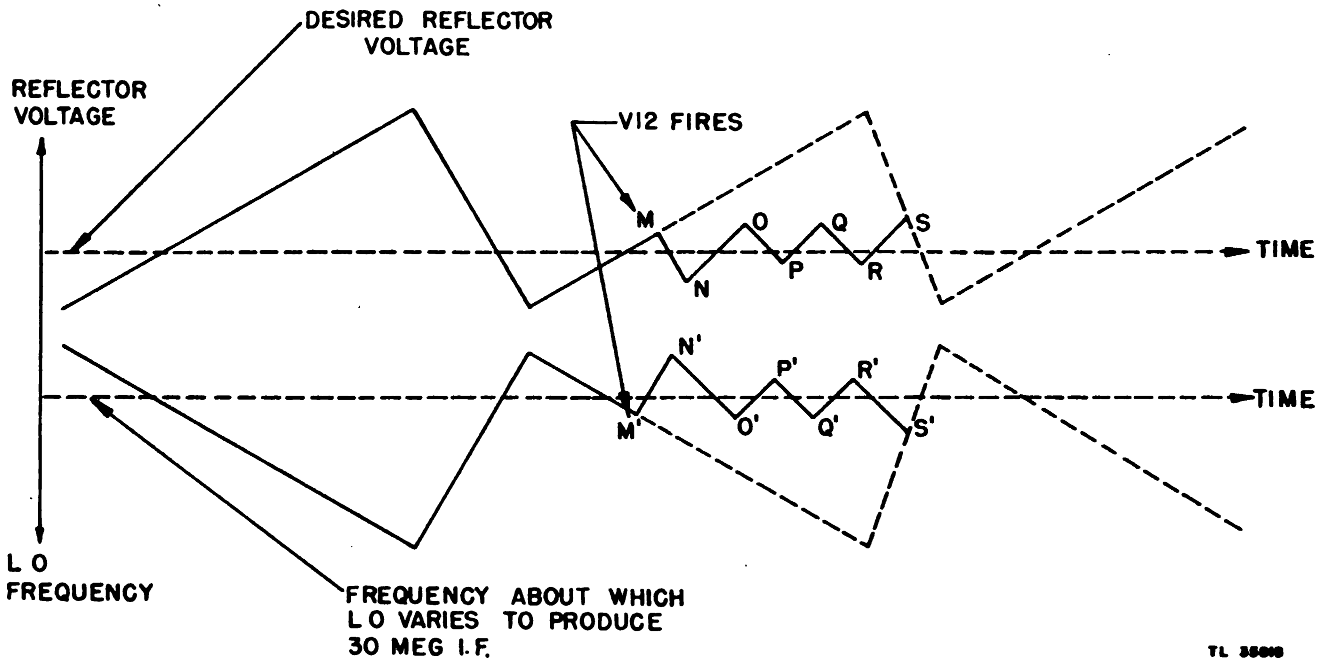

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Figure 63. Basic AFC operation.

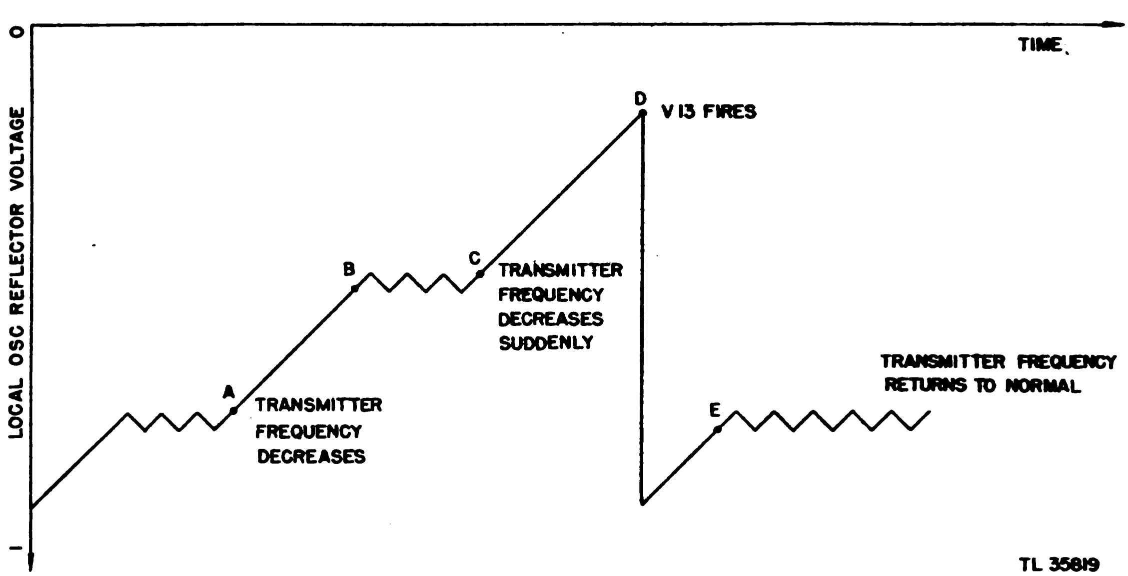

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Figure 64. AFC operation graph.

manual position the AFC circuit is not used. The negative reflector voltage for the local oscillator is taken directly from the voltage divider network (fig. 62) and adjusted by potentiometers P2 and P9 connected in series. P9 provides a fine adjustment of the klystron repeller plate voltage and is located on the front panel of the radar receiver. P2 gives a wider range of adjustment and is located on the subpanel of the radar receiver. It has a screwdriver slot for adjustment.

e. ***Receiver Power Supply.*** Two vacuum tube rectifiers, located inside the receiver, supply the rectified power for the receiver and preamplifier unit. A simplified schematic diagram of the radar receiver power supply is shown in figure 65. The full-wave, high-vacuum rectifier V17 delivers power to the 300-, 220-, and 105-volt regulating circuits. Primary filtering of V17 output is performed by a network composed of L28, R64, and C54. At this point the line branches into two separate circuits, one supplying 300 volts and the other supplying 220 and 105 volts.

(1) In the 300-volt circuit, V18, in series with the line acts as a variable resistor to control the output. Conduction through V18 is controlled by grid bias applied

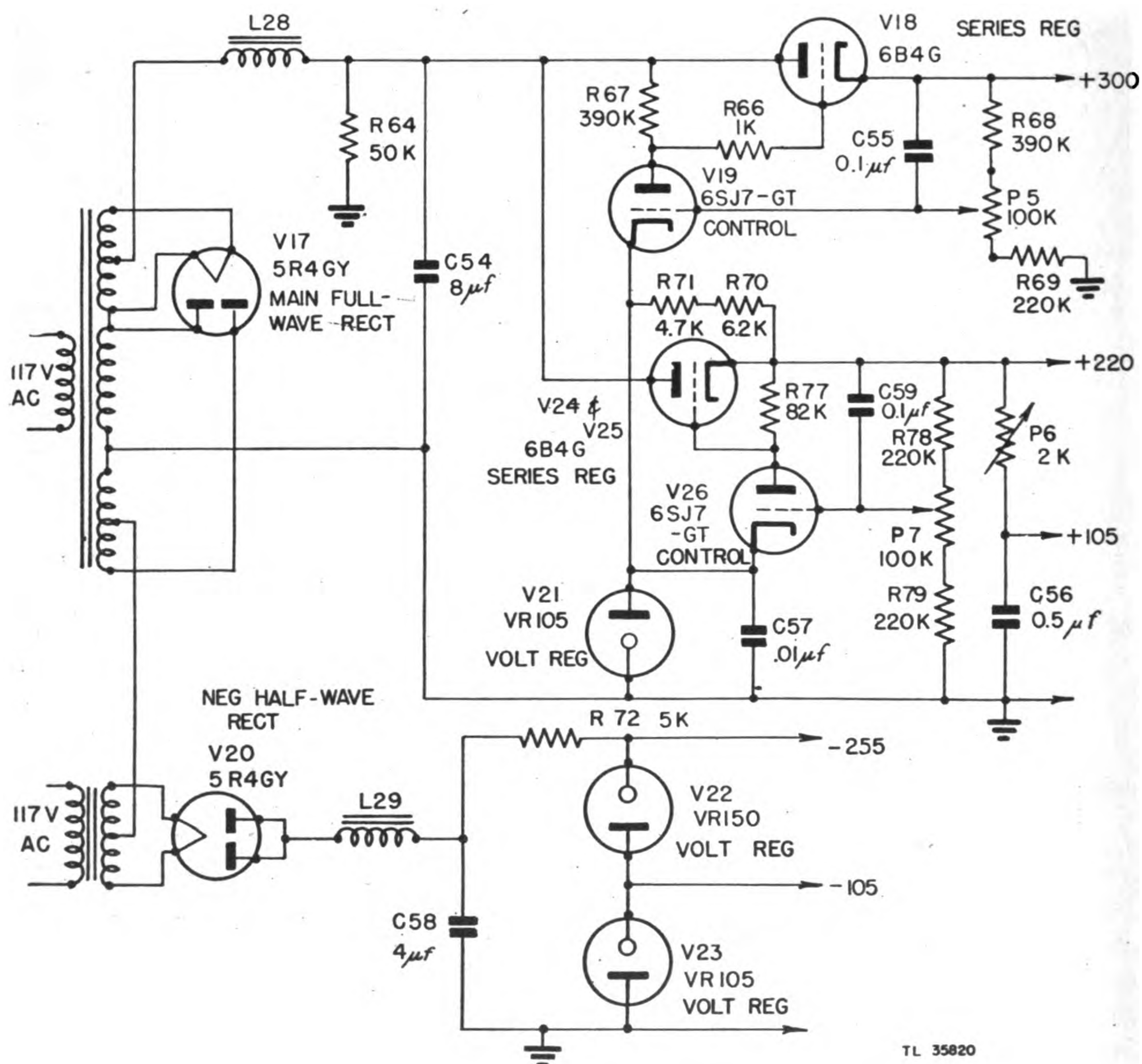

Figure 65. Receiver power supply, simplified schematic diagram.

through the action of V19 and V21. The arrangement of this circuit permits control of variations in the input from V17, as well as changes in the output load. The cathode of V19 (6SJ7-GT) is the fixed voltage reference point which is biased to a positive 105 volts by being returned to ground through V21 (VR105), a voltage regulator tube designed for a constant drop of 105 volts over a considerable current range. A voltage divider network, composed of R68, P5, and R69 to ground, provides a means of sampling or tapping off a portion of the 300-volt output voltage. The voltage sample taken off P5 is applied to the control grid of V19. Should the output load diminish and the voltage tend to rise above 300 volts, the current through the voltage divider network, which is in parallel with the load, would thus tend to rise, increasing the voltage applied to the grid of V19. This increase in grid voltage causes V19 to conduct heavier, lowering its plate potential because of the voltage drop through R67. Therefore the grid of V18, connected to the plate of V19 through R66, will drop in potential. This decreases the conductance of V18, thereby increasing the series resistance in the 300-volt output line, and lowers the output voltage. The setting of potentiometer P5 determines the point about which the system will operate in correcting the output load variation, and is used to set the output at 300 volts.

(2) In the 220-volt circuit, the output is regulated by V24 and V25 in parallel to allow for the greater current drain on this supply. Regulation is supplied with R78, P7, and R79 furnishing the sample voltage across P7 to apply to the grid of V26 (6SJ7-GT). The plate voltage of V26, dropped from the 220-volt value through its plate load resistor R77, is applied back to V24 and V25 as grid bias and determines the conductance of these tubes. Potentiometer P7 sets the point about which this circuit will regulate the output voltage.

(3) In the positive 105-volt circuit, the output is supplied from a series dropping resistor, P6, connected to the 220-volt output point. P6 is a variable potentiometer to permit adjustment to the exact voltage required. C56 acts as a bypass and filter capacitor.

(4) Negative voltages are supplied from a half-wave rectifier, V20 (5R4GY), a double diode with both plates tied together. L29 and C58 provide primary filtering. Two voltage-regulating gas tubes, V22 and V23, in shunt to ground, are used with series resistor R72 to provide regulation. V22 (VR150) and V23 (VR105), inherently constant voltage tubes, form a voltage divider across the rectifier output. The total voltage across the combination of tubes is the sum of the 150-volt drop across V22 and the 105-volt drop across V23, or 255 volts. The −105-volt supply is tapped between the two voltage regulator tubes. The low current drain from the negative power supply makes this type of voltage regulator circuit feasible.

SECTION V

INDICATING SYSTEM

27. INTRODUCTION. Chapter 1 discussed the principles of radar and explained how distances are determined by measuring the time interval between the transmission of a radio frequency pulse and the reception of its echo from some distant conducting body. The indicator system provides the means for measuring these extremely short intervals of time, converting them to distances, and presenting them on a graphic display (ch. 1, par. 6).

a. Plan Position Indicator (PPI). The duplicate search indicators of Radio Set AN/MPN-1 present plan position indicator or PPI displays, and thus provide both azimuth and range data on the screens of the cathode-ray tubes. The sweep trace of this type of indicator begins at the center of the screen and extends outward along a radius. At the same time, the entire trace rotates continuously about the center of the screen in synchronism with the scanning of the highly directional antenna. Echoes appear on the screen as crescent-shaped spots of light displaced from the center or origin of the system by a distance proportional to the range of the reflecting object. The azimuth of the body causing the reflection is given by the angular displacement of the lightspot from a fixed radius representing a known compass direction. The use of a long afterglow cathode-ray screen causes echoes to remain visible for several seconds after the sweep trace has rotated to a new position. Thus the search indicator presents a circular map upon which aircraft within a predetermined range appear in very nearly their true relative positions. Figure 66 is a sketch of the PPI display. The fixed spot at the center of the screen is the transmitter pulse or "main bang," as it is sometimes called. The equally spaced concentric circles are range markers, representing definite distances from the operating position. Range markers appear at 2-mile intervals when the 7.5-mile sweep is used, and at 5-mile intervals with the 15 or 30-mile sweeps. Figure 66 shows the 30-mile timebase in use. Echoes from airplanes or fixed conducting bodies appear at ranges of 17 and 21 miles. The clutter seen near the center of the screen is caused by reflections from fixed objects near the equipment.

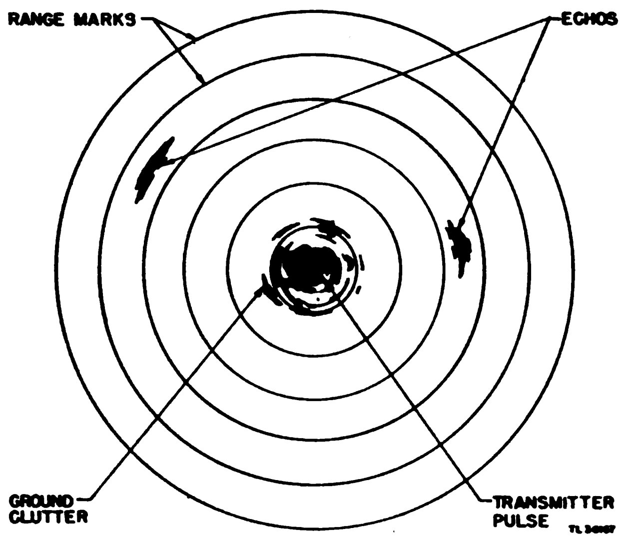

Figure 66. PPI display.

b. Duplication of Equipment. Radio Set AN/-MPN-1 contains two complete sets of search indicator equipment, each operating independently of the other. One of these duplicate systems is installed in bay 4 of the indicator rack, the other is in bay 6. The block diagram (fig. 67) shows the functional relationships existing among the components of one system only. Search Indicator ID-35/MPN-1 functions principally as a mounting for the 7-inch cathode-ray tube presenting the display. The circuits which provide sweep voltage, intensity voltage, range markers, and the strobe pulse to the indicators are contained in Search Central SN-6/MPN-1. All voltages except those supplied to the filaments of the search indicator, and the 4 kv supplied to the anode of the cathode-ray tube, are obtained from Rectifier Power Unit PP-27/MPN-1. Figure 67 also shows the inputs received from external sources. These include the negative-going trigger pulse from the synchronizer, the sinusoidal input of the sine potentiometer, and the video signal from the receiver.

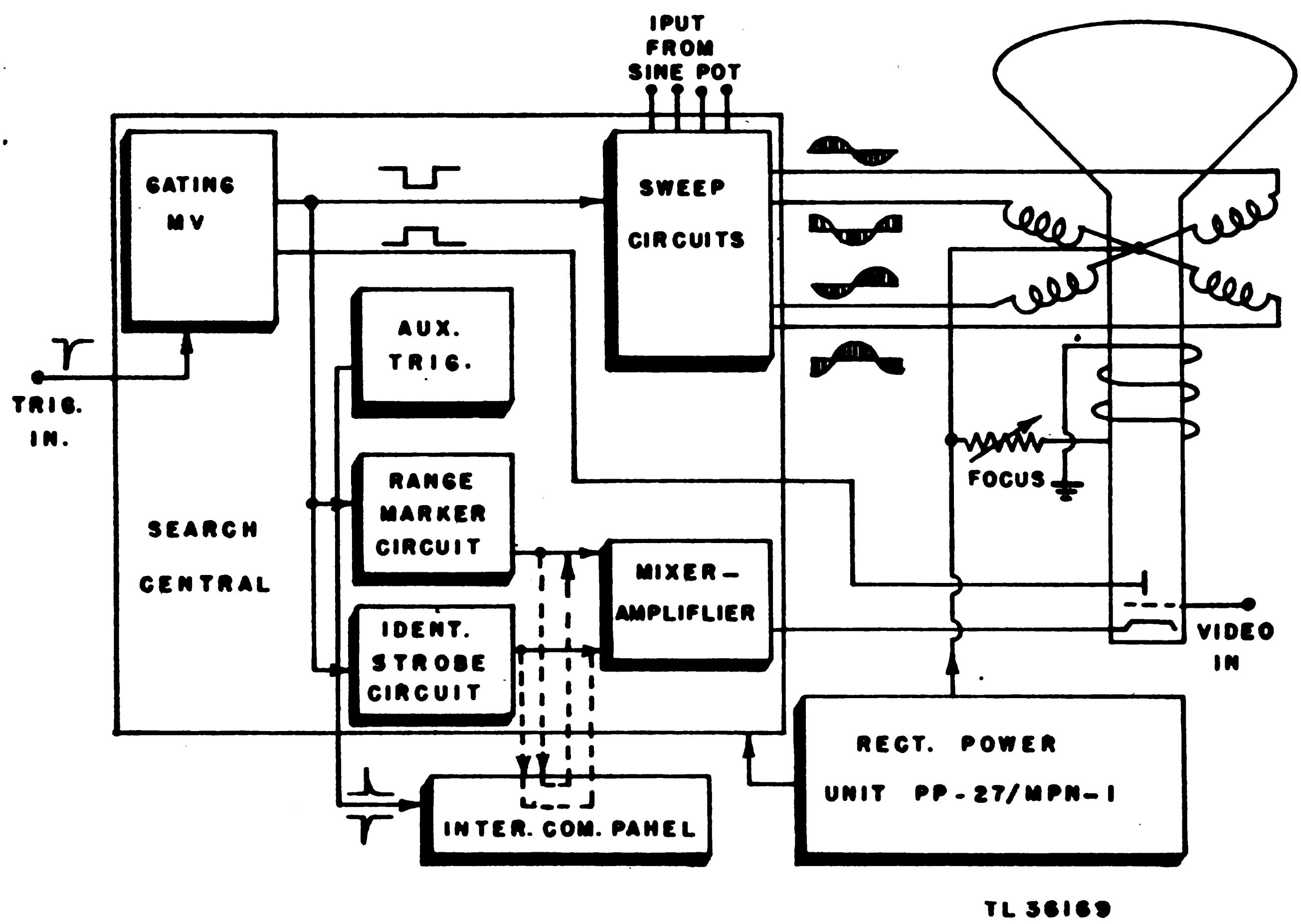

Figure 67. Search Indicator ID-35/MPN-1, block diagram.

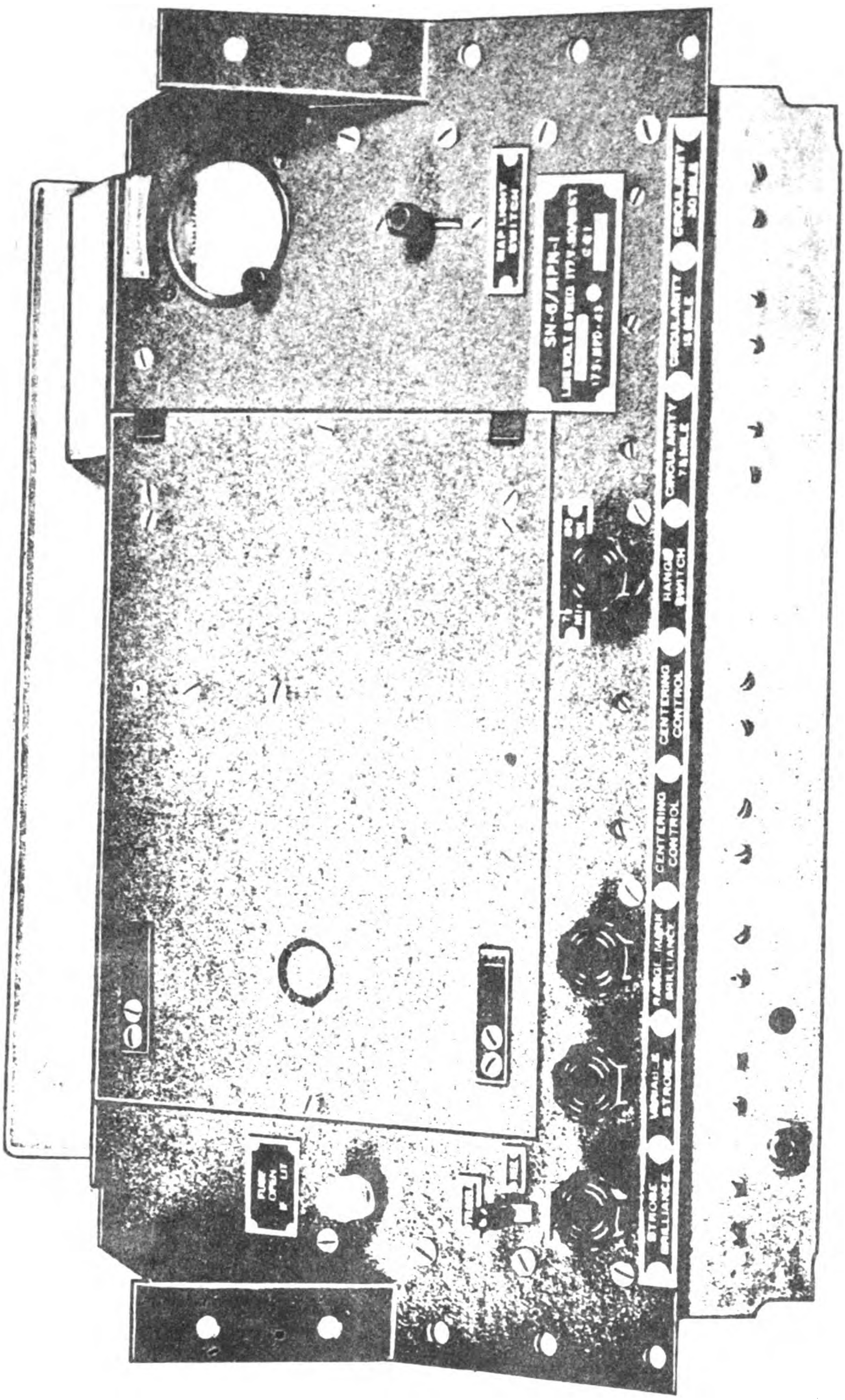

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Figure 68. Search Central SN-6/MPN-1, front view.

28. SEARCH CENTRAL SN-6/MPN-1.

a. General. One of the two search centrals is mounted in bay 4 of the indicator rack immediately above the operating desk and the other is located in a similar position in bay 6. The front panels of these units contain most of the controls necessary for operation at the two search positions (fig. 68). A map of the area covered by the search system is mounted on the panel in a position such that it may be viewed through a partially silvered mirror as a background to the reflected image of the PPI screen. The search centrals receive the sinusoidal output of the sine potentiometer and the negative-going trigger pulse from the synchronizer. They supply the sweep voltage, intensifying voltage, range markers, and identification strobe to the indicator tubes. Filament voltages for the search central are supplied by a transformer located within the unit itself. All other voltages are obtained from Rectifier Power Unit PP-27/MPN-1 located just behind the indicator unit. A block diagram of the search central appears in figure 69.

b. Gating Multivibrator. The gating multivibrator V5 (fig. 69), triggered by a negative-going pulse from the synchronizer, provides negative- and positive-going square wave outputs. The negative-going output actuates the sweep, range marker, and identification strobe circuits, while the positive-going output supplies intensifying voltage to the first anode of the cathode-ray tube.

c. Sweep Circuits. The sweep circuits consist of four sweep amplifiers, V13, V14, V15, and V16, and four switch tubes V9, V10, V11, and V12. Actuated by the negative-going square wave from the gating multivibrator, these circuits produce a set of voltages which when applied to the horizontal and vertical deflection coils of the search indicator, produce a continuously rotating linear sweep. Sweep ranges of 7.5, 15, and 30 miles are selected by means of a knob on the search central panel.

d. Range Marker Circuit. The range marker circuit consists of V3, V4, and a half of V6. The negative-going square wave from the gating multivibrator cuts off V3

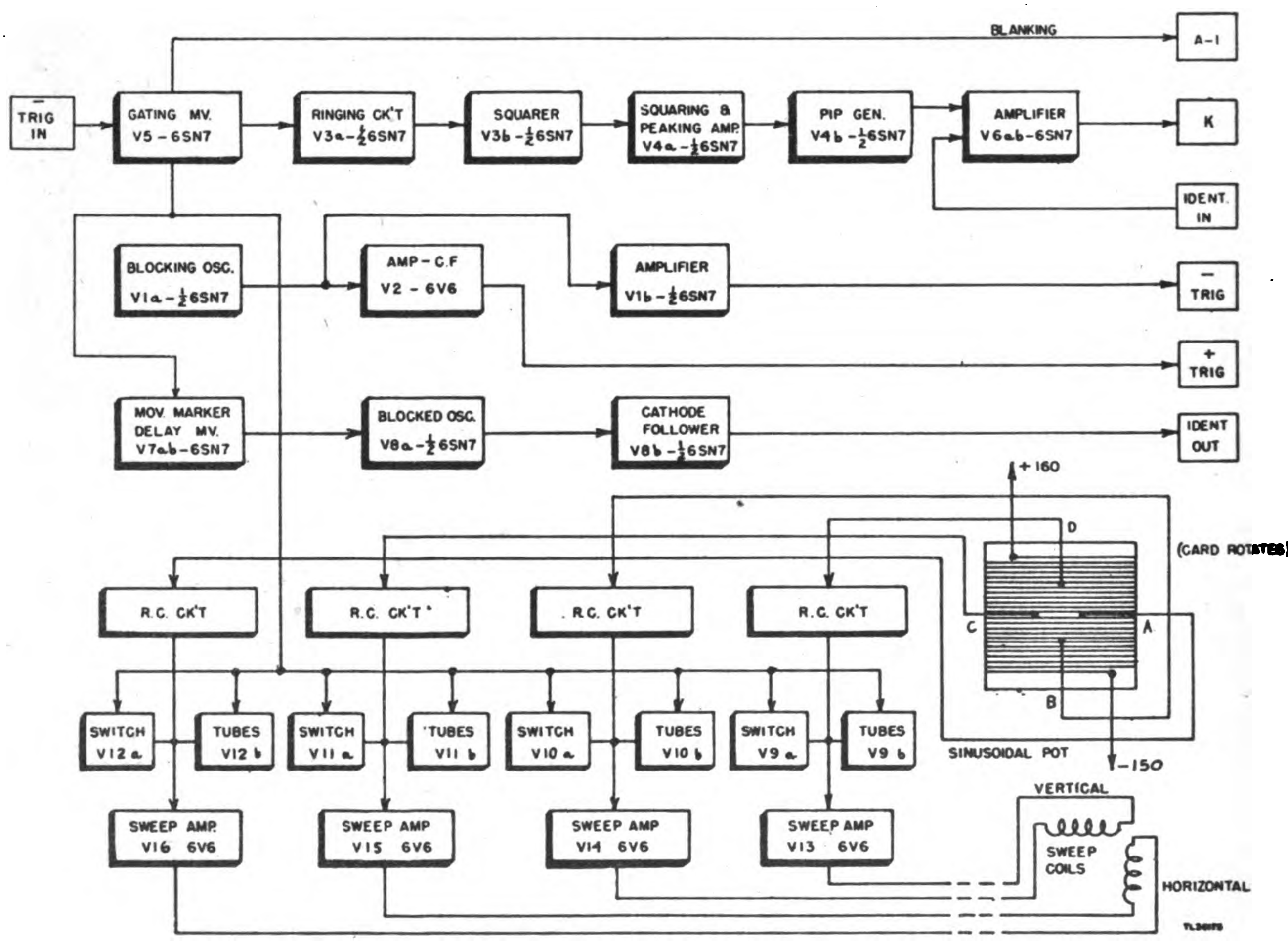


Figure 69. Search Central SN-6/MPN-1, block diagram.

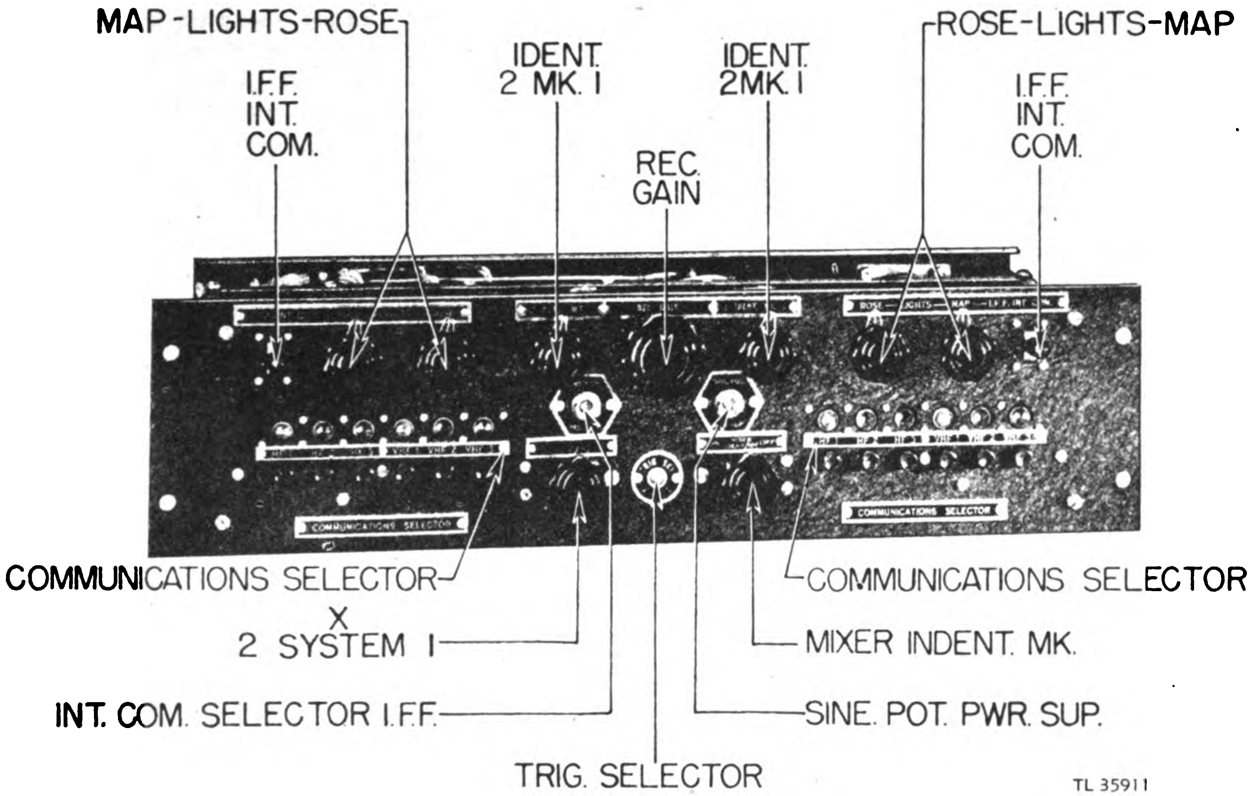


Figure 70. Intercommunications Panel SB-2/MPN-1, front view.

(a) setting a ringing circuit into operation. The resulting damped sine wave is squared, peaked, amplified by V6 (a), mixed in the plate circuit of this tube with the identification strobe pulse, and applied to the cathode of the search indicator. The range marker circuit supplies range markers at 2-mile intervals for the 7.5-mile sweep, and at 5-mile intervals for the 15 and 30-mile sweeps. Selection of the proper range marker circuit for a particular sweep is accomplished by the range switch.

e. Identification Strobe Circuit. The identification strobe circuit generates a marker pulse whose position along the timebase is variable by means of a control on the search central panel (fig. 68). By switching at the intercommunications panel (fig. 70) the identification strobe pulse from either of the two search centrals can be applied to the search indicators and to the precision indicator tubes. The strobe circuit operates from the negative-going square wave output of the gating multivibrator. The leading or negative-going edge of the pulse triggers a multivibrator V7 whose output is a positive-going square wave of variable width. The trailing edge of this variable square wave triggers a blocking oscillator V8(a) causing it to go through one cycle of oscillation. The resulting sharp positive-going pip is fed to the intercommunications panel by means of cathode follower V8(b). A potentiometer in the grid circuit of V7(b) controls the width of the square wave, and consequently the position of the sharp positive-going pip can be varied with respect to the timebase. This potentiometer is the identification strobe position control and is located on the search central panel (fig. 68). From the intercommunications panel, the strobe pulse is distributed to the search system requiring it. The strobe pulse selected returns to the search central where it is applied to the grid of V6(b). Mixed with the range markers in the plate circuit of V6, it is applied to the cathode of the search indicator. The selected strobe pulse is also fed to the precision indicators where it is used to bring certain aircraft to the attention of the precision operators.

f. Auxiliary Trigger Circuit. The auxiliary trigger circuit is provided for use when the synchronizer is not in operation. A free-running blocking oscillator V1(a) generates sharp positive-going pulses spaced at intervals of approximately 500 microseconds. Cathode follower V2 feeds the positive-going output pulse to the trigger selector switch on the intercommunications panel. Amplifier V1(b) inverts the output of the oscillator to provide a negative-going trigger pulse, which is also fed to the intercommunications panel for distribution. When the search system is to be used alone, the positive pulse triggers the transmitter and the negative pulse triggers the circuits of the search centrals. Selection is made by means of the trigger selector switch located on the intercommunications panel (fig. 70).

29. SEARCH INDICATOR ID-35/MPN-1.

a. General. The two search indicators are located directly above their associated search centrals in bays 4 and 6 of the indicator rack. These units provide mountings for the 7-inch cathode-ray tubes which present the PPI display. The indicator panel (fig. 71) slants forward at an angle, making the indicator screen visible by reflection in a horizontally placed semitransparent mirror. Metal sides and a hinged glass cover, combined with the semitransparent mirror, form a case which incloses the front of the unit. The hinged glass cover provides the means for mounting the colored glass filters used for viewing the indicator screen. The sweep intensity, video brilliance, and focus controls are mounted on a removable section of the cabinet top. A navigating head and an adjustable compass rose, engraved on transparent plastic disks, are mounted over the indicator screen. The compass rose is divided into degrees beginning at the line representing true north. The navigating head is engraved with a set of parallel lines, with a small picture of an airplane at the center to indicate direction of flight. Both disks rotate on rollers placed about the edge of the tube shield. Illumination for the compass rose and navi-

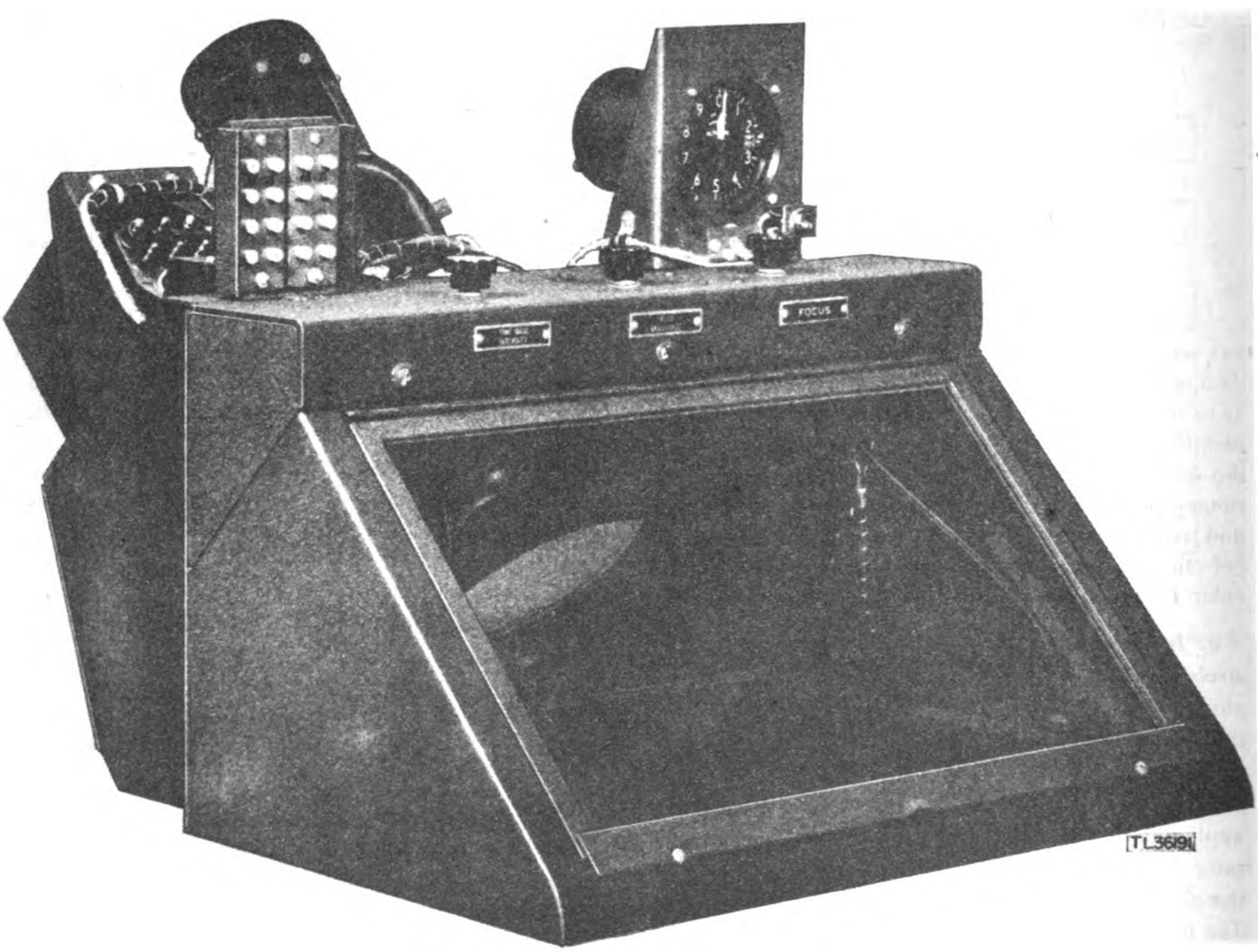


Figure 71. Search Indicator ID-35/MPN-1.

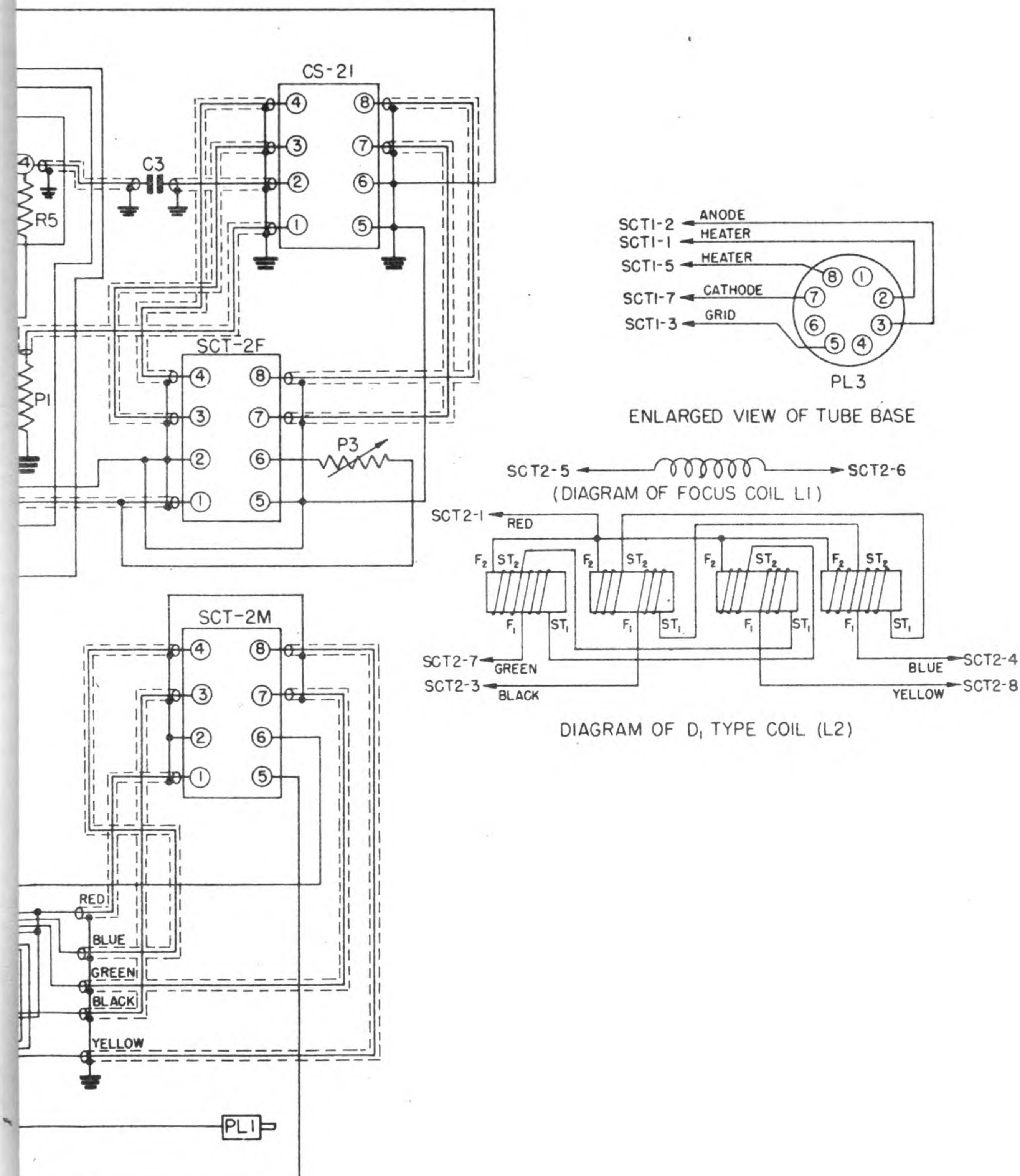


Figure 72. Search Indicator ID-35/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	68,000	2	20%
R2	470,000	½	20%
R3	22,000	½	20%
R4	47,000	5	10%
R5	4.7 Meg	½	20%
P1	2,000	2	10%
P2	25,000	4	10%
P3	25,000	4	10%
C1	.01 mf	600	10%
C2	.01 mf	600	10%
C3	.01 mmf	600	20%
L1	C00-6201		
L2	B00-3339-1		
JK1	78-1P		
JK2	78-1P		
JK3	78-1P		
JK4	78-1P		
PL1	AN3102-18-16P		
PL2	K-870326		
PL3	PF 8-7		
PL4	360		
PL5	360		
PL6	360		
PL7	360		
T1	15-3401		
CRT1	7BP7		
V1	6SN7GT		
LM1	55		
LM2	55		
LM3	44		
LM4	44		
LM5	44		
LM6	Mazda 323	3 V. 19 Amp.	
SW1	G.E. SPST	250 V. 3 Amp.	

gating head is provided by small bulbs placed about the edges of the plastic disks. An altimeter, mounted on top of the indicator in bay 6, is visible through a circular hole in the panel. This instrument is not present on the indicator in bay 4.

b. Indicator Circuit. A circuit diagram of the indicator appears in figure 72. The cathode-ray tube is magnetically deflected and magnetically focused. The vertical and horizontal deflection coils are placed so that their axes are perpendicular to each other and perpendicular to the axis of the tube. Plate voltage for the sweep amplifiers is provided by connecting the center taps of the two deflection coils to a 300-volt unregulated d-c source. The same d-c source supplies current to the focusing coil. Potentiometer P3, in series with the focusing coil, serves as a focus control. Positive bias is supplied to the cathode from a 250-volt regulated d-c source. Potentiometer P2 in the cathode circuit is the intensity control. The video signal is fed directly to the grid of the cathode-ray tube from the radar receiver. Potentiometer P1 is the video brilliance control. The diode clamping circuit using V1 returns the grid of the indicator rapidly to a constant no-signal level after each signal.

c. Operation of Clamping Diode. The clamping diode V1 operates as follows: The positive signal coming from the receiver is applied to the grid through capacitor C1, and across resistor R2. With its cathode driven positive by the signal, clamping diode V1 does not conduct. Consequently the signal voltage applied to the grid of the cathode-ray tube is equal to the potential drop caused by the charging current of capacitor C1 flowing through resistor R2. While the signal is present, capacitor C1 acquires a charge. When the signal passes this charge must leak off. If the diode were absent, C1 would discharge through potentiometer P1 and resistor R2, and a negative voltage would be applied to the grid of the cathode-ray tube, causing the trace to disappear or to be greatly reduced in brilliance. With the diode, however, this negative voltage is provided with a low resistance path to ground. The negative voltage applied to the cathode of V1 causes the tube to conduct, quickly discharging capacitor C1, and effectively shunting resistor R2. The negative voltage applied to the grid of the cathode-ray tube is thus held to the relatively small value resulting from the discharge current of the capacitor flowing through the low resistance of the conducting diode.

d. Indicator Voltages. A filament transformer mounted on the back of the indicator unit has two 6.3-volt secondaries, one supplying the heater voltage for the cathode-ray tube and the clamping diode, and the other supplying voltage for the pilot lights. The unregulated 300 volts supplied to the deflection and focus coils, and the regulated 250-volt cathode bias are obtained from Rectifier Power Unit PP-27/MPN-1, which is mounted just behind the indicator unit. High voltage for the anode of the cathode-ray tube is supplied from one of the 4,000-volt Rectifier Power Units PP-23/MPN-1, located in the lower part of bay 4 of the indicator rack.

e. Cathode-ray Tube. Electrons emitted from the cathode of the search indicator tube are swept toward the fluorescent screen by the high positive potential of the anode. The negative bias applied to the control grid of the tube is controlled by potentiometer P2 in the cathode circuit. This bias is normally adjusted to make the trace barely visible on the screen when no signal is present. The positive signal reduces this negative bias, increases the intensity of the beam, and appears on the screen as a spot of light. The beam is consequently said to be "intensity modulated." Positive voltage applied to the first anode is taken from the plate of the positive-going tube of the gating multivibrator in the search central. While the positive-going square wave supplied by this tube is absent, the first anode is sufficiently negative with respect to the cathode to cut off the electron beam entirely. When the square wave is present, the tube conducts at normal intensity. Thus the electron beam reaches the screen only during the interval occupied by the sweep, and fly-back is suppressed. The alternating voltage applied to the first anode is referred to as the brilliance or intensity voltage, or sometimes as the brilliance pulse.

f. Focus Coil. Being composed of like charges which repel each other, the electron beam tends to fan out and to occupy all of the space available within the tube. A coil carrying a current placed about the neck of the tube, however, prevents this random motion and focuses the beam. The operational theory for the focus coil appears below, following the discussion of magnetic deflection.

g. Magnetic Deflection. The pencil of electrons leaving the focus coil enters the magnetic field produced by the deflection coils. The physical arrangement of the deflection coils is shown schematically in figure 67. Eight coils are wound on an iron yoke so that four of them have a common vertical axis and the remaining four a common horizontal axis. Each set of deflection coils, energized by the sweep voltages, generates a magnetic field perpendicular both to the axis of the cathode-ray tube and to the field generated by the other set of coils. The resulting system consists of two mutually perpendicular magnetic fields and a current of electrons perpendicular to both fields. A current of electrons in a magnetic field is deflected in a direction perpendicular to the magnetic field and to the original direction of the current. The magnitude of the deflection is proportional to the strength of the magnetic field. Where the deflection is produced by two magnetic fields at right angles to each other, the magnitude and direction of the deflection are determined by the magnitude and direction of the resultant field strength.

h. Magnetic Focusing. The magnetic focus coil operates on the principles of magnetic deflection discussed above. This coil is a single solenoid placed so that its axis coincides with the axis of the cathode-ray tube. Current flowing in the focus coil creates a magnetic field whose axis also coincides with that of the cathode-ray tube. A stream of electrons flowing along this axis encounters no vertical component of magnetic field strength and thus continues on toward the screen with its direction unchanged. A stream of electrons flowing along any line other than the axis of the focus coil does, however, encounter a vertical component of magnetic field strength. The electrons composing this stream will consequently acquire a velocity perpendicular to their original direction of motion. This new velocity combines at right angles with the original velocity to produce motion along a helical path of decreasing radius. By properly adjusting the flow of current through the focus coil with a series variable resistor, these random electrons can be made to spiral into a path which lies close to the axis of the tube. The electron beam is thus brought into focus at a point on the tube screen with a sharpness generally surpassing that which is obtained with an electrostatically focused tube.

i. High-voltage Anode. The high-voltage anode consists of a coating of graphite deposited in the inside of the glass bell of the cathode-ray tube. Connected to the positive supply terminal of one of the 4,000-volt power supplies, this electrode provides the potential which accelerates the electron beam from the cathode toward the screen.

j. Long Persistence Screen. Cathode-ray tube screens are coated with chemicals which fluoresce or glow when bombarded with electrons. This property causes the trace to be illuminated. The chemical coating on the screens of the cathode-ray tubes used in the search indicators posesses not only this property of fluorescence. but that of phosphorescence as well. This latter characteristic produces a glow which continues for several seconds after the electron bombardment has ceased. Screens of this type are said to be long persistent.

30. ROTATING PPI SWEEP. The sweep trace of a PPI indicator moves at a uniform speed from the center to the outer edge of the screen and at the same time rotates about the center of the screen like a spoke of a wheel about the hub. The purpose of this paragraph is to establish the characteristics of a set of sweep voltages which will produce this type of sweep. Since ranges of 7.5, 15, and 30 miles have been provided, the sweep durations will be approximately 80, 160, and 320 microseconds respectively. Radio Set AN/MPN-1 has a prf of approximately 2,000; consequently the trace completes its traverse from the center to the outer edge of the screen approximately 2,000 times a second. At the maximum scanning speed of the antenna, the trace completes one rotation about the screen every 2 seconds.

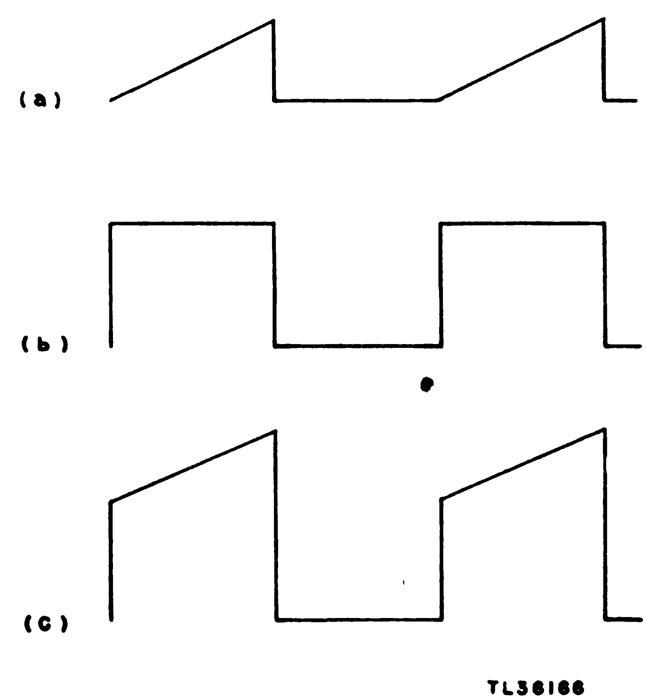


Figure 73. Production of a trapezoidal waveform.

a. Production of a Linear Sweep. In order that anges may be read uniformly from one end of the indicator trace to the other, the electron beam must sweep at a uniform speed. This means that the magnetic field, and hence the current causing the field, must increase linearly with time. The required current waveform therefore is that shown at (a) in figure 73. If the deflection coils had inductance only, the required sweep voltage would be the simple square wave shown at (b) in figure 73. The truth of this assertion is demonstrated by the following reasoning: The voltage developed across a pure inductance is equal to the inductance multiplied by the time rate of change of current. Since the increase of current was assumed to be linear, the rate of change of current must be constant, and since the inductance is known to be constant, the voltage must also be constant. Hence the required voltage is a square wave. However, this is an ideal case which will never be encountered practically, since all coils have resistance as well as inductance. It may readily be shown that a constant voltage applied across a coil having inductance and resistance causes an exponential rather than a linear rise of current. Since a linear rise of current is required, a square wave of voltage obviously cannot be used. It was shown above that a pure inductance requires a constant applied voltage to produce a linearly increasing current. From Ohm's law it is obvious that a linear increase in current through a resistance requires a linear increase in voltage. A coil may be thought of as consisting of a resistance in series with an inductance. Consequently, it is reasonable to expect that the voltage waveform producing a linear rise of current through the series combination will be that resulting from the addition of a square wave and a triangular wave of voltage. This waveform shown at (c) in figure 73, results from the addition of (a) and (b) in the same figure. A truly linear rise of current through the coil requires that the height of the square wave and the slope of the triangular wave be properly proportioned. The result arrived at in the foregoing discussion could have been obtained quickly by writing the equation for the voltage (E) across a coil having inductance (L) and resistance (R):

$$E = Ri + \frac{di}{dt}.$$

Since the increase of current (i) is linear, $\frac{di}{dt}$ is constant and the equation reduces to:

$$E = Ri + \text{a constant.}$$

This equation shows that the voltage necessary to produce a linear increase in current through a coil is the sum of a constant part and a part (Ri) which increases linearly with the current.

b. Production of a Rotating Sweep. If a voltage having the trapezoidal form described above is applied to either the horizontal or vertical deflection coils of the cathode-ray tube it causes the electron beam to sweep the screen uniformly in one direction only. This direction, as was explained in paragraph 29, is perpendicular to the magnetic field produced by the coil. If similar trapezoidal voltages are applied to both the vertical and horizontal deflection coils, the electron beam sweeps uniformly in the direction of the resultant deflecting forces produced by the vertical and horizontal coils. In figure 74 F_y represents the vertical deflecting force and F_x represents the horizontal deflecting force. If these two lines are drawn with their lengths proportional to the magnitudes of the two forces, the magnitude and direction of the resultant force (R) are determined by completing the parallelogram as shown by the broken lines. The magnitude of force R determines the distance through which the electron beam is deflected, and thus determines the length of the trace. Since the trace must remain constant in length throughout its rotation, R must be constant. To indicate the fact that R remains constant it has been represented in figure 74 as the radius of a

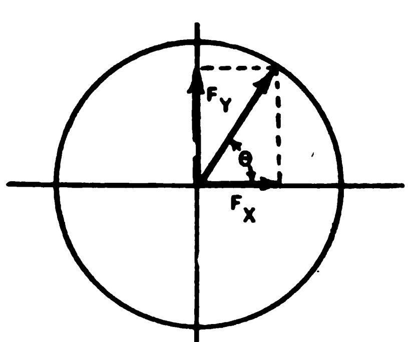


Figure 74. Addition of forces at right angles.

circle. The vertical and horizontal forces which add vectorially to produce R are represented as before by F_y and F_x. Suppose now that R is to rotate continuously in a counterclockwise direction. The problem is to determine the manner in which F_y and F_x must vary to produce this rotation, and at the same time, to keep R constant in magnitude. Figure 75 shows the resultant R in successive positions during one complete revolution. At (a), the vertical component F_y is zero and the horizontal component F_x is a maximum. At (b), the vertical and horizontal components are equal, and the resultant R is directed upward to the right at an angle of 45 degrees. At (c), the horizontal component is zero and the vertical component is a maximum. At (d), the components are equal and the resultant is directed upward to the left at an angle of 45 degrees. At (e), the horizontal component is a maximum and the vertical component zero. At (f), the components are equal. At (g), the vertical component is a maximum and the horizontal component zero. At (h), the components are again equal, the vertical component is decreasing and the horizontal increasing as the vector rotates toward its initial position. In figure 75, successive values of F_y, the vertical deflecting force, have been projected to the right and laid out along a linear degree scale. A line drawn through the tips of the arrows provides a graph of the values taken by F_y during one complete revolution. Since this graph is a sine curve it is apparent that the vertical force must vary as the sine of Θ, the angle R makes with the initial line. A similar graph for F_x has been constructed by projecting successive values of this component downward. This graph is a cosine curve, indicating that the horizontal force F_x must vary as the cosine of Θ. Since F_y varies as the sine of Θ and F_x varies as the cosine of Θ, these two components may be regarded as two sine functions displaced in phase with respect to each other by 90 degrees. Thus it has been shown that if two forces are to combine at right angles to produce a rotating resultant of constant magnitude, the two forces must be sinusoidal functions of the angle of rotation differing in phase by 90 degrees. Since the deflecting forces are proportional to the magnetic fields causing them, the magnetic fields of the horizontal and vertical deflection coils must also be sinusoidal functions.

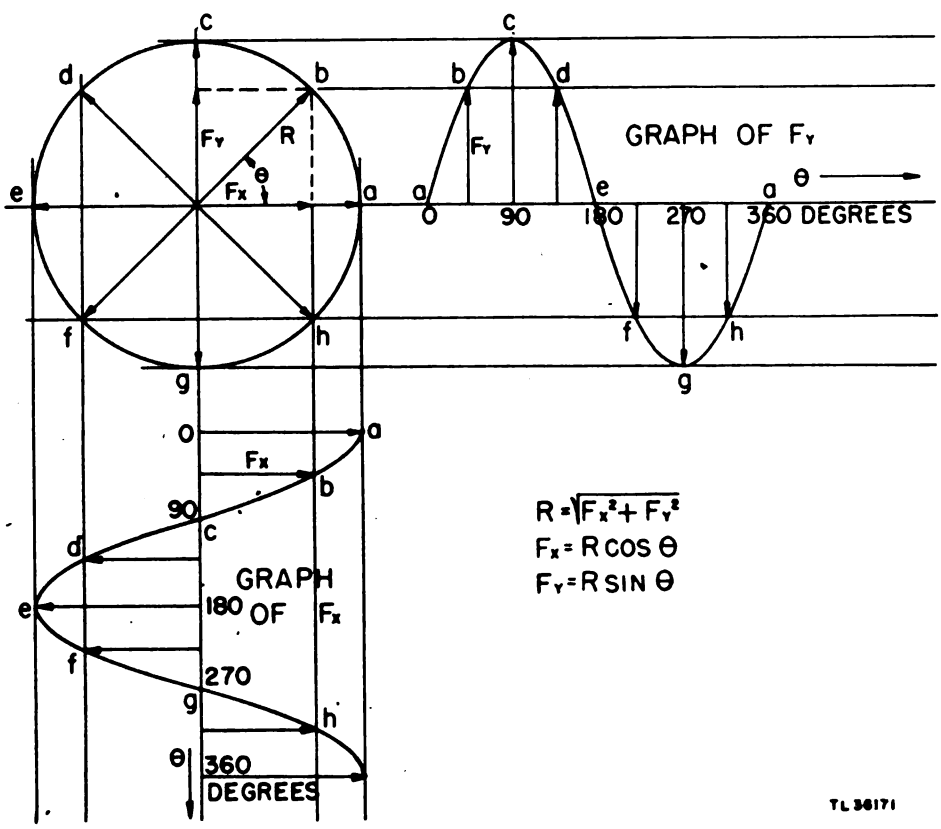


Figure 75. Generation of a rotating deflection force.

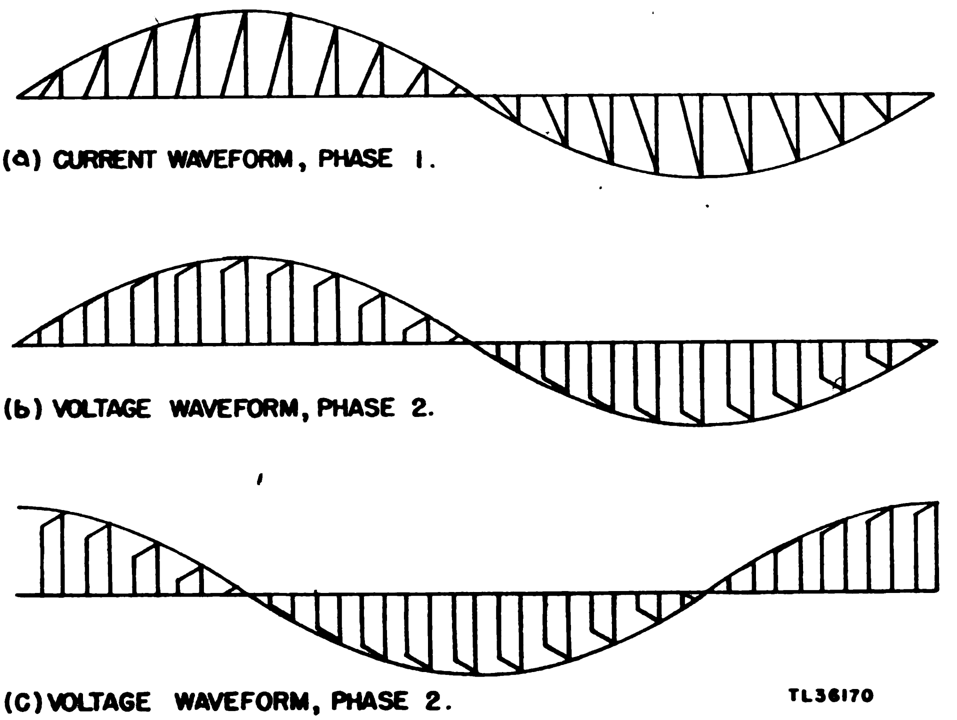


Figure 76. Sweep current and voltage waveforms.

This requires that the currents flowing in the coils vary sinusoidally. At the same time these currents must vary from zero to a maximum, approximately 2,000 times a second. One of the two current waveforms is that shown at (a) in figure 76, a rapid saw-tooth wave modulated by a sine wave. The voltage waveform producing this current is shown at (b) in figure 76. The voltage pulses whose maxima lie along the sine curve have the trapezoidal form necessary to cause a linear increase of current. Consequently the voltages applied to the two deflection coils will have the forms shown at (b) and (c) in figure 76, identical in shape but displaced 90 degrees in phase with respect to each other. Figure 76 shows only a few cycles of the sweep in each half-cycle of the sine wave. Since the sine wave requires 2 seconds for the completion of a cycle, each half-cycle will contain approximately 2,000 sweep cycles.

*c. **Sine Potentiometer.*** The two sinusoidal voltages used to modulate the trapezoidal voltage pulses generated in the sweep circuits are obtained from a specially designed sine potentiometer geared to the search antenna. The four sliding contacts of this device deliver four sinusoidally varying d-c components differing successively in phase by 90 degrees. These four outputs are applied, in pairs 180 degrees apart in phase, to the grids of the sweep amplifiers, where they determine the maximum voltage developed by the sweep circuits during each cycle. Thus the outputs of the sweep circuits are amplitude modulated by the output of the sine potentiometer. Since the sine potentiometer rotates with the antenna, the maximum voltage attained by each component of the sweep during any given sweep cycle depends upon the angular position of the antenna during that cycle. If the antenna is not rotating, the sweep continues to be developed, but the amplitudes of its horizontal and vertical components remain constant. The center of the sine potentiometer winding is grounded, and its two ends are supplied with positive and negative voltages from the search central. The negative voltage is the –150-volt regulated output of Rectifier Power Unit PP-27/MPN-1, which is provided directly to the sine potentiometer by a jumper connection within the search central. The positive potential for the other end of the winding is taken from the 270-volt regulated output of Rectifier Power

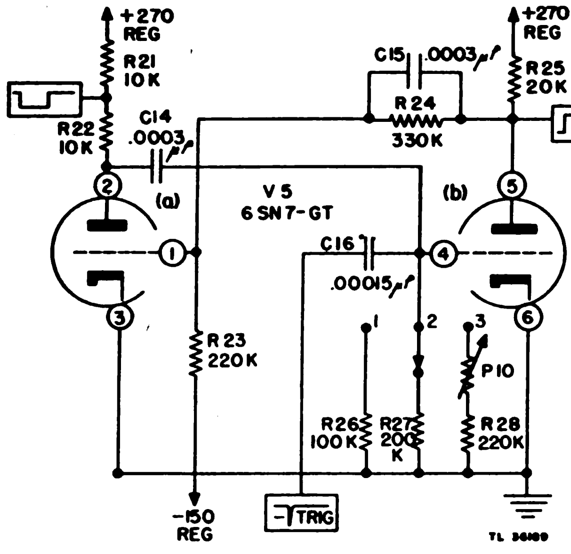


Figure 77. Gating multivibrator circuit.

Unit PP-27/MPN-1, but is dropped to approximately 150 volts by preset adjustable resistors. To provide suitable expansion of the trace on all ranges, two of these dropping resistors have been incorporated into the search central, one used with the 15- and 30-mile ranges and another used with the 7.5-mile range. These resistors, R46 and R88 in figure 86, are selected automatically by the range switch.

31. GATING MULTIVIBRATOR. The gating multivibrator, V5 in figure 77, is triggered by the negative-going master trigger pulse from the synchronizer. Prior to the application of this pulse V5(b) conducts, while V5(a) is held nonconducting by the fixed negative bias on its grid. Receiving the negative-going pulse at its grid, V5(b) is cut off, and the potential of its anode rises. This rise in voltage, coupled to the grid of V5(a) by C15 and R24, overcomes the negative bias and causes V5(a) to conduct. The resulting drop in voltage at the anode of V5(a), coupled back to the grid of V5(b) by the capacitor C14, keeps V5(b) cut off until C14 has discharged sufficiently to make the drop across the grid resistor less than cutoff. The grid resistor may be either R26, R27, or R28 and potentiometer P10, depending upon the position of selector switch A. The value of this resistance determines the rate at which C14 discharges, and hence governs the width of the square wave produced. The three gate widths provided correspond to the three ranges, 7.5, 15, and 30 miles, provided by the search indicator system. When the potential at the grid of V5(b) becomes less than cutoff, this tube resumes conduction and the potential of its anode falls to its original value. This fall of potential, coupled back to the grid of V5(a), cuts this tube off and causes its anode potential to rise. The voltage waveforms obtained at the grids and anodes of the two sections of the tube are shown in figure 78. The positive-going square wave taken from the anode of V5(b) is applied to the first anode of the indicator cathode-ray tube to intensify the trace while the sweep is applied. The negative-going square wave from the anode of V5(a) is fed to the sweep circuits, range marker circuit, and identification strobe circuit. The small capacitor C15 steepens the leading and trailing edges of the negative-going square wave from V5(a) by effectively shorting resistor R24 during the first few microseconds following a change in V5(a) from conducting to nonconducting or vice versa, and hence functions as a bypass for the high frequency components of the square wave.

32. SWEEP CIRCUITS. Each of the two search centrals contains a sweep circuit supplying the associated search indicator tube with horizontal and vertical deflection voltages having the waveforms illustrated at (b) and (c) in figure 76. These circuits (fig. 86) consist of four sweep amplifiers V13, V14, V15, and V16, each receiving on its grid one of the four sinusoidally varying voltage components from the sine potentiometer. Since these voltages are spaced in phase at 90 degree intervals, they may be paired off so that the two members of each pair differ from each other by 180 degrees in phase. With each of these pairs connected to the grids of either the two vertical sweep amplifiers or the two horizontal sweep amplifiers, they provide push-pull operation (fig. 79). The four 6SN7-GT tubes, V9, V10, V11, and V12, function as electronic switches. Controlled by a negative-going square wave from the gating multivibrator, these tubes switch the grids of the sweep amplifiers alternately between a constant reference potential and the potential impressed on the input circuit by the sine potentiometer. This has the effect of chopping the slowly varying sine wave provided by the sine potentiometer into pulses. Resistance-capacitance networks in the input circuits give these pulses the trapezoidal form necessary to produce a linearly increasing current in the deflection coils. Immediately after completing each sweep cycle the switch tubes, operating as clamping tubes, return the grids of the sweep amplifiers to a definite reference potential. This insures that the sweep will start each cycle from the same voltage level, and hence that the trace will always start from the same point on the cathode-ray tube screen.

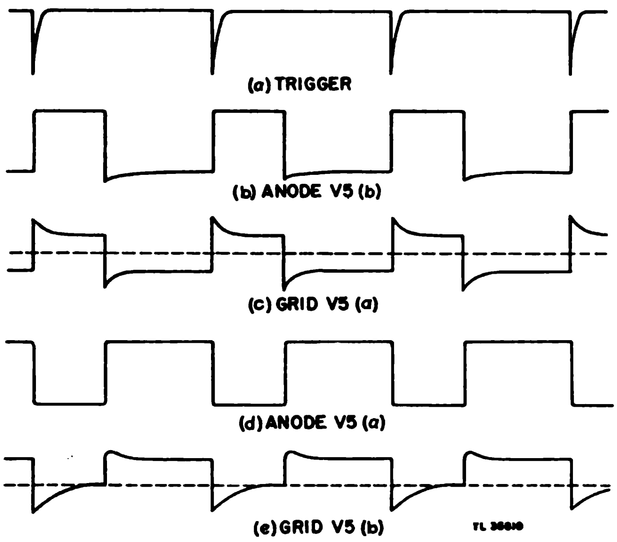


Figure 78. Gating multivibrator waveforms.

a. Functioning of Switch Tubes. Consider the circuit of V9 in figure 79. Anything said about the operation of this circuit applies equally to the circuits of V10, V11, and V12 (fig. 86). At the end of each sweep cycle, the two triode sections of V9, operating as a clamping circuit, return the grid of V13 to a definite positive potential and hold it there until the beginning of the next cycle. This insures that the sweep trace will always start from the same point on the cathode-ray tube screen. Potentiometer P8 in the cathode circuit of V9(b) is a centering control for adjusting the starting point of the sweep to the center of the indicator screen. The grids of V9(a) and V9(b) are held at a low positive value determined by the flow of the grid current of V9(b) through R67. The combined resistance of R48 and P5 is great enough to insure that the voltage applied to point X by the input circuit never becomes large enough to cut off V9(a) during the interval between gating pulses. Part of the plate current

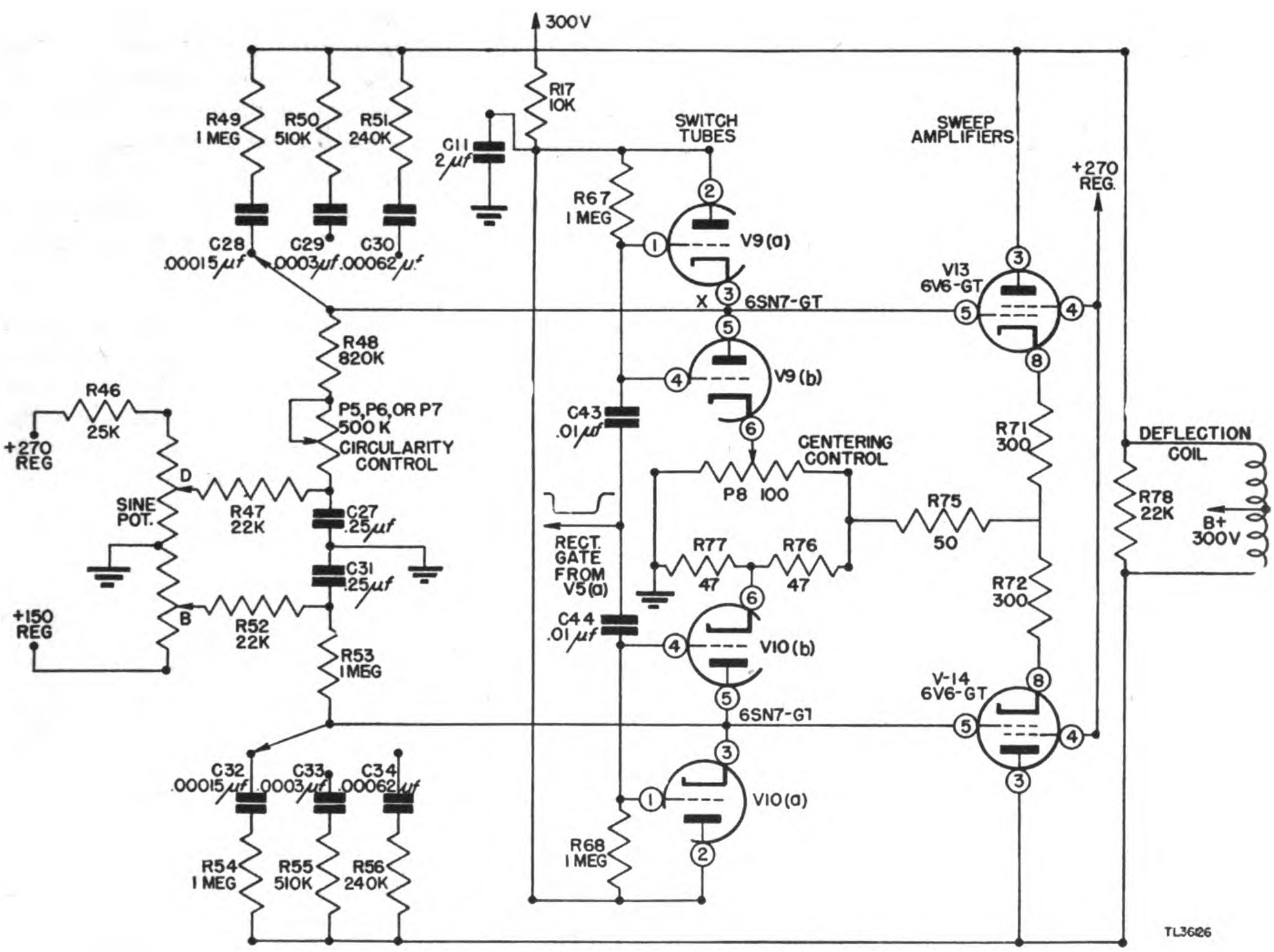


Figure 79. Sweep circuit, partial schematic diagram.

flowing through V9(b) comes from V9(a) and the remainder is supplied by the input circuit. The voltage drop across V9(b) and its cathode resistor provides a steady bias to the cathode of V9(a) and to the grid of V13. If the voltage applied to the input circuit is increased, the current through this circuit increases, and tends to increase the current through V9(b). If the potential of the input circuit is raised, the current flowing through this circuit increases and tends to increase the current through V9(b). However, the slight rise in potential that takes place at point X, increases the bias applied to V9(a) reducing its conduction. Thus the current supplied to V9(b) by V9(a) decreases and the total current through V9(b) tends to stay constant. Since the current through V9(b) remains constant, the voltage drop across the tube also remains constant and the grid of V13 is held at a very nearly constant potential. Reasoning similarly, a decrease in the voltage applied to the input circuit decreases the current supplied to V9(b) from the input circuit. The voltage at point X tends to decrease, increasing the current through V9(a). This increase in the current supplied to V9(b) by V9(a) helps to make up the deficiency in the current supplied by the input circuit, with the result that the current through V9(b) remains constant. Hence the voltage applied to the grid of V13 also remains constant.

b. Generation of a Trapezoidal Pulse. The negative-going square wave from the gating multivibrator, applied to the grids of the switch tubes, causes these tubes to cease conduction. Since C43 and R67 provide a long time constant, the switch tubes remain cut off for the duration of the square wave. Thus during the time of the gating pulse the switch tubes cease their clamping action and allow the voltage applied by the sine potentiometer to become effective at the grid of V13. Prior to the application of the gating pulse capacitor C28 was charged to the potential existing between the grid and plate circuits of V13. If the potential applied by the sine potentiometer at the moment the switch tubes cease conduction is greater than the reference value established by the clamping action, the new potential applied across C28 is less than that to which C28 is charged. Consequently C28 must discharge toward the new potential difference. The resulting current flows through the resistance in the input circuit and through R49 toward B+. Due to this flow of current about two-thirds of the voltage applied by the sine potentiometer is dropped across R48 and P5, which total approximately 1 megohm. The remainder appears across R49 and C28 and is applied to the grid of V13. This voltage is represented in figure 80 by the line a-b. As C28 continues to discharge, the current in the circuit decreases, and the grid potential of V13 rises along the more or less curved path b-c. If sufficient time were available, the voltage applied to the grid of V13 would approach the value supplied by the sine potentiometer. However, due to the long time constant provided by the combination of R48, P5, R49, and C28 only a small part of this voltage rise is attained in the time allowed by the gating pulse. In addition, the inverse voltage fed back from the plate of V13 continuously lowers the potential impressed across C28 and thus retards the decay of the current in the circuit. This inverse voltage feedback helps to linearize the rise of voltage at the grid of V13, by keeping the discharge current of C28 nearly constant. In figure 80 line a-e represents the potential applied by the sine potentiometer to the input circuit, a-b represents the part of this voltage that is immediately applied to the grid of V13. Sloping portion b-c represents the continuous increase in the voltage applied to the grid of V13 by the discharge of C28, and c-d represents the sudden drop which results when the gating pulse is removed. A similar explanation applies when the voltage impressed on the input circuit by the sine potentiometer is less than the reference value established by the clamping action of the switch tubes. In this case, however, C28 charges and the direction of the current is such that the initial drop in voltage at the grid of V13 is less than that finally attained.

c. Sinusoidal Modulation. Since during the generation of trapezoidal pulses in the manner described above, the maximum voltage attained by each pulse is determined by the voltage input from the sine potentiometer, the wavetrains supplied to the deflection coils will have the form illustrated at (b) and (c) in figure 76.

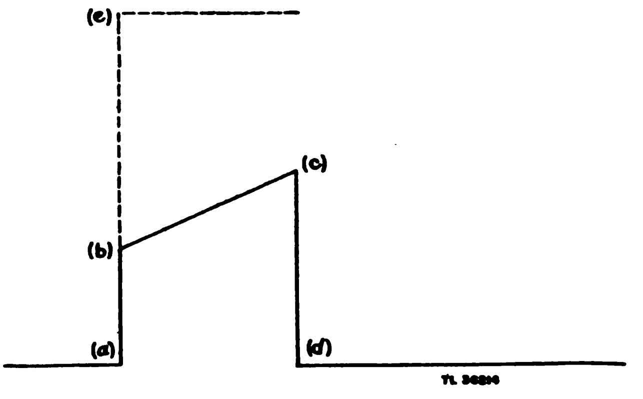


Figure 80. Generation of a trapezoidal waveform.

33. RANGE MARKER CIRCUIT. Range markers appear on the PPI display as concentric circles spaced from the center at 2-mile intervals on the 7.5-mile sweep, and at 5-mile intervals on the 15- or 30-mile sweeps. The range marker circuit appears in figure 81. Switch G which selects the proper range marker frequency for any given sweep range is ganged to the range switch (fig. 68). The intervals at which range markers appear along the timebase are determined by the natural frequencies of the two resonant circuits, selected by switch G, in the cathode circuit of V3(a). One of these tuned circuits supplies the 2-mile and the other the 5-mile range markers. The negative-going square wave from the gating multivibrator, applied to the grid of V3 (a), cuts this tube off. The sudden cessation of current through L1 shock excites the tuned circuit and causes it to generate a damped sine wave having a natural period of oscillation equal to twice the time required for a radar pulse to travel the distance represented by the spacing between range markers. Applied to the grid of V3(b) which is operated at a low bias, the positive half-cycles of the damped sine wave are clipped off by the flow of grid current through R15, and the negative half-cycles appear amplified and inverted at the anode. Further squared and inverted by V4(a), this voltage is applied to the grid of V4(b), which normally conducts a heavy current. The positive-going edges are without effect but the negative-going edges cut V4(b) off and bring the flow of current through L2 to a sudden stop. Shock excited by this sudden stoppage of current, L2 generates a damped sine wave. The first positive swing of this oscillation has a large amplitude but succeeding swings are rapidly damped out by the resistance of P2. This output is applied to the grid of V6(a) which is biased sufficiently beyond cutoff to prevent the tube conducting on any but the first large positive swing. The output of V6(a), a series of sharply peaked negative-going pulses, is applied to the cathode of the indicator tube. The operation of the circuit is summarized by the waveforms shown in figure 82. The square wave shown at (a) is the negative-going gating pulse. The waveform shown at (b) is the damped sine wave produced by the ringing of the oscillatory circuit in series with the cathode of V3(a). At (c) this same waveform is shown as it appears at the anode of V3(b), after having been subjected to grid clipping and inversion, and (d) shows the square wave resulting from further amplification and inversion by V4(a). The bursts of damped oscillations produced at the anode of V4(b) by the ringing of L2 are shown at (e), and the amplified and inverted output of V6(a) appears at (f).

34. IDENTIFICATION STROBE CIRCUIT. The identification strobe circuit generates a marker pulse movable along the timebase by means of a knob on the search central panel (fig. 68). By switching from the

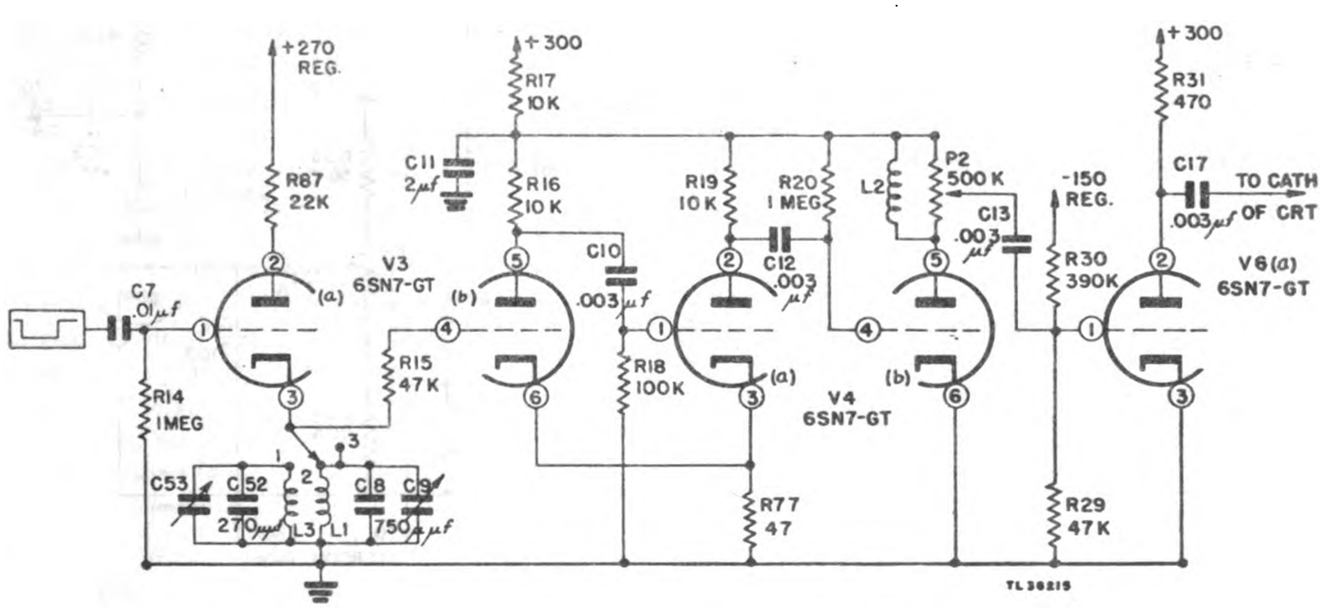


Figure 81. Range marker circuit.

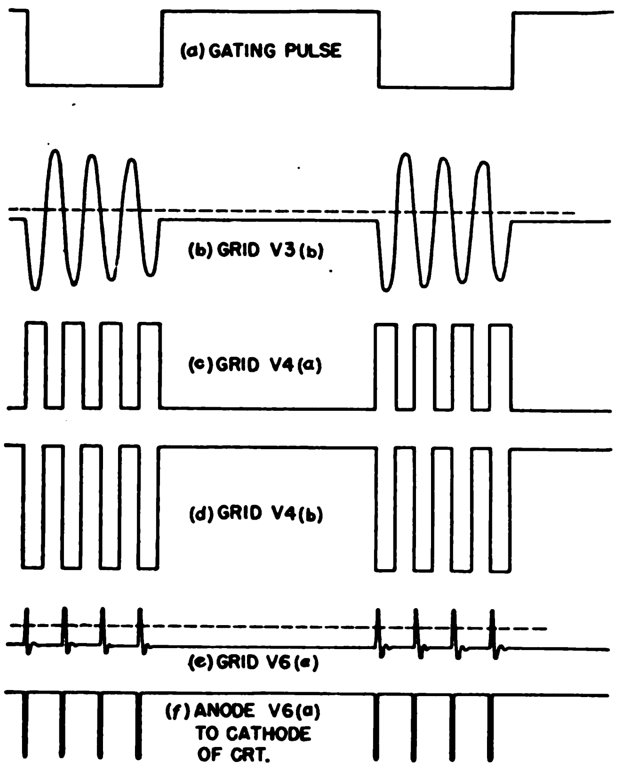


Figure 82. Production of range markers.

intercommunications panel, the marker pulse from either search central can be applied to either or both of the search indicators, and to the precision indicator tubes. Its appearance on the display is similar to that of the range marker circles. The search operator using the marker adjusts the positioning knob on the search central panel until the marker circle intersects the echo he wishes to indicate. This position is indicated simultaneously on the displays at other operating positions. The identification strobe circuit (fig. 83), consists of a multivibrator which generates a square wave of variable width, and a blocked oscillator triggered by the trailing edge of this square wave.

a. Variable Multivibrator. The negative-going square wave from the gating multivibrator is differentiated by the circuit consisting of C21, R38, P3, and R44, into a series of positive and negative pips which are applied to the grid of V7(b). Since V7(b) is already conducting, the positive pips have no noticeable effect. The negative pips, however, cut off V7(b) and initiate the action of the multivibrator. This circuit operates similarly to the gating multivibrator which was discussed in paragraph 31, except that the grid time constant is

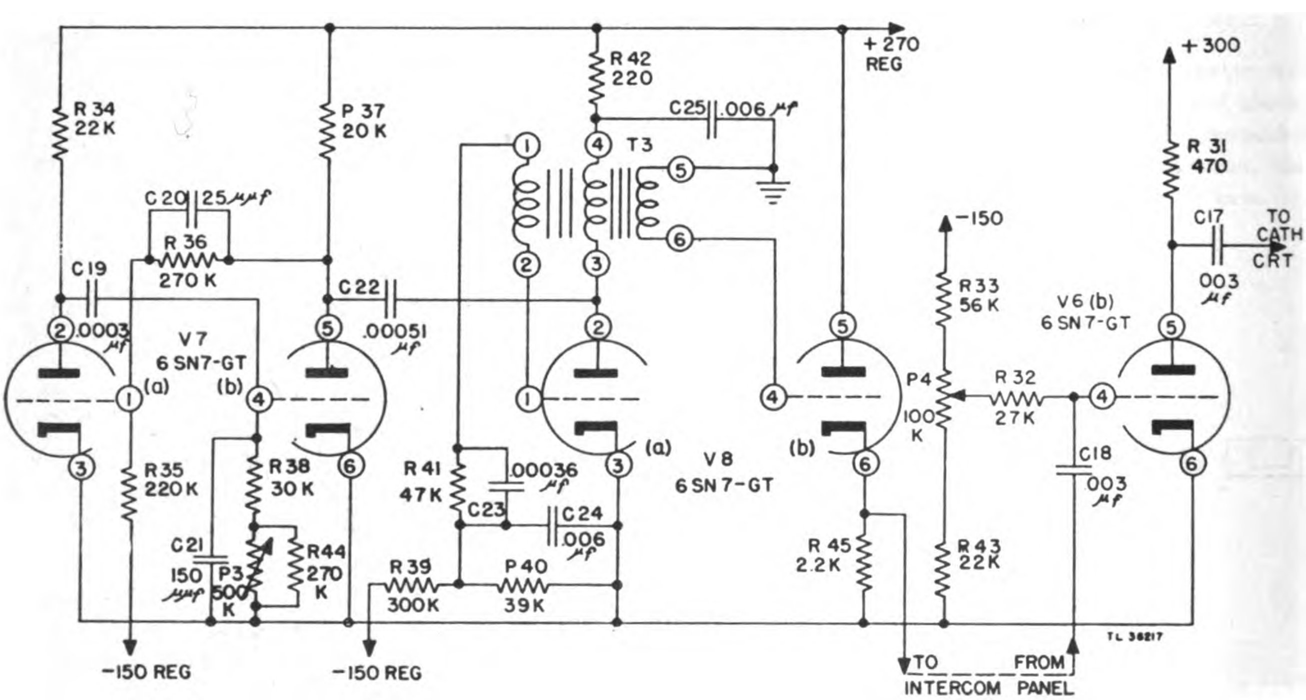


Figure 83. Identification strobe circuit.

continuously variable by means of a potentiometer P3. This potentiometer varies the discharge time of capacitor C19, and thus determines the width of the positive-going square wave produced at the anode of V7(b).

b. Blocking Oscillator. The positive-going square wave from the anode of V7(b), fed to the anode of V8(a) which is biased beyond cutoff, causes pulses of current to flow through the primary of T3. The secondary is connected to the grid so that the positive-going leading edge of the square wave applies a negative pulse to the grid and thus has no effect. The negative swings of the trailing edge, however, cause positive pulses to be applied to the grid of V8(a). These positive pulses overcome the standing bias and cause the tube to conduct. The resulting decrease in the potential of the anode of V8(a) causes further increase in the potential applied to the grid, and increases conduction. As the grid goes positive with respect to the cathode, grid current flows and charges capacitor C23. As V8(a) nears saturation, the plate current stops increasing, and the voltage pulse applied to the grid disappears. Capacitor C23 discharges through R41 and aids the standing negative bias in taking over. The tube again becomes nonconducting and remains so until the multivibrator again applies a negative-going voltage to the primary of T3. Thus V8(a) generates only one half-cycle of oscillation during each cycle of the square wave from V7(b). This sharply peaked voltage pulse is supplied by the tertiary of T3 to a cathode follower which feeds it as a positive-going pulse to the distribution switches on the intercommunications panel. Returned from the intercommunications panel to the grid of V6(b) the pulse is amplified and applied to the cathode of the indicator tube. The strobe brilliance control P4 is mounted on the search central panel.

c. Position Control. Potentiometer P3, mounted on the search central panel, controls the time constant in the grid circuit of V7(b), which determines the width of the positive-going square wave whose descending edge triggers the blocked oscillator. Varying the width of this square wave, varies the position of the negative-going edge with respect to the timebase and hence controls the position of the strobe pulse.

35. AUXILIARY TRIGGER CIRCUIT. Each of the search centrals contains an auxiliary trigger circuit which generates positive and negative-going pulses similar to those supplied by the synchronizer. Though not generally used during routine operation, these circuits are useful during testing or for occasions when the precision system is not operating. The auxiliary trigger circuit (fig. 84) consists of a free-running oscillator, an amplifier, and a cathode follower. Sharp positive-going voltage pulses generated by the oscillator are fed simultaneously to the cathode follower and amplifier which provide respectively the positive and negative-going outputs. These outputs are wired to a 3-position switch on the intercommunications panel. This switch allows three choices of trigger: No 1 search central, No. 2 search central, or synchronizer.

a. Blocking Oscillator. The grid of V1(a) is biased positively by a voltage dividing network connected to B+. Suppose that power to the circuit has just been turned on. The flow of plate current through the primary of T1 is increasing. The voltage induced across the secondary of T1 makes the grid more positive and assists the increase of plate current through the primary. Grid current flows and charges C1. Finally as V1(a) nears saturation, the current stops increasing, and the voltage induced across the secondary of T1 disappears. Capacitor C1 applies a large negative voltage to the grid of V1(a), causing the tube to cease conduction, and begins to charge through R1, P1 and R3. As C1 charges, the negative voltage applied to the grid of V1(a) decreases and finally becomes less than cutoff. At this point, conduction is resumed and the tube goes through another half-cycle of oscillation. The time interval between oscillations depends on the time constant provided by R1, P1, R3, and C1. Potentiometer P1 provides a means for varying this time constant, and hence controls the prf of the system when this trigger circuit is used.

b. Positive and Negative Trigger. The output obtained at the tertiary of T1 is a series of positive-going voltage pulses. Amplifier V1(b) inverts this output and provides the negative-going pulse which triggers the circuits of the search centrals. Cathode follower V2 provides the positive going trigger which actuates the transmitter modulator.

36. INTERCOMMUNICATIONS PANEL. The intercommunications panel (fig. 70), though really a part of the communications system of Radio Set AN/MPN-1, has several important functions in connection with the

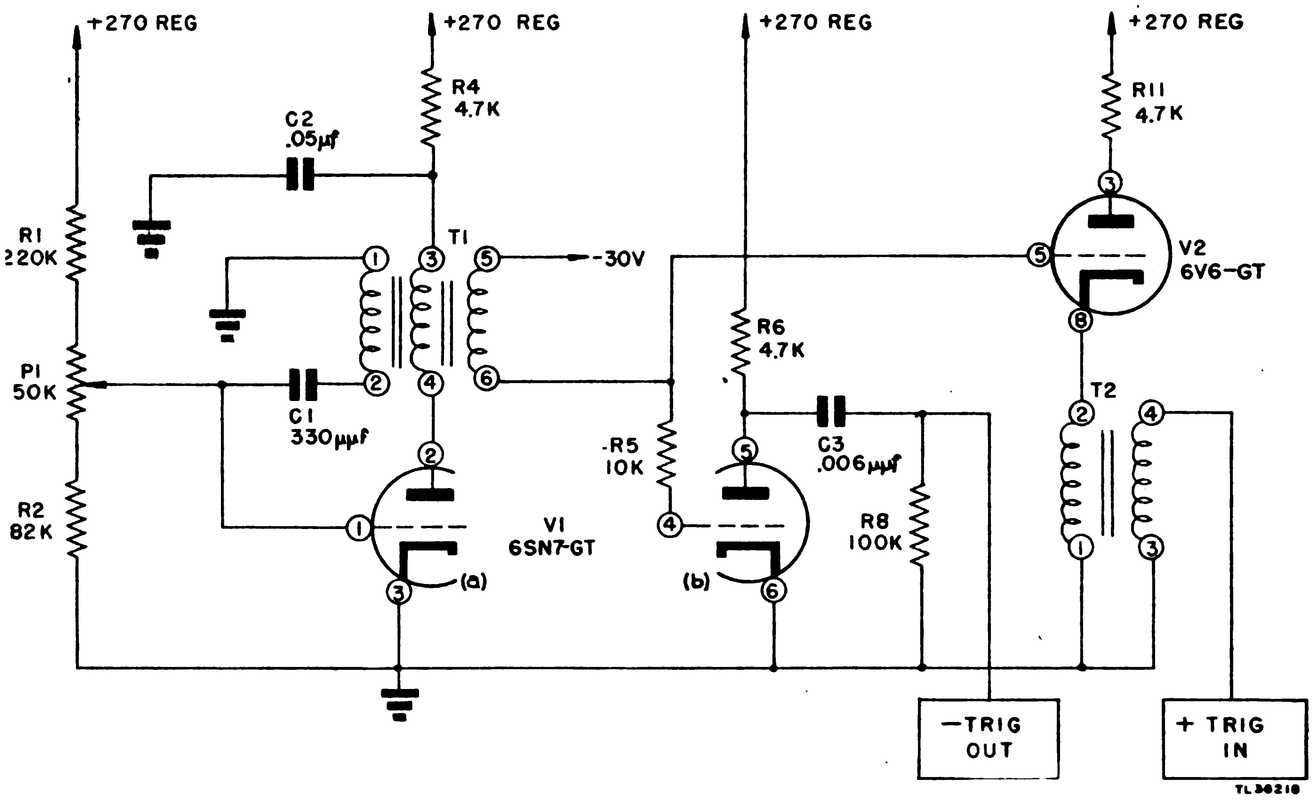
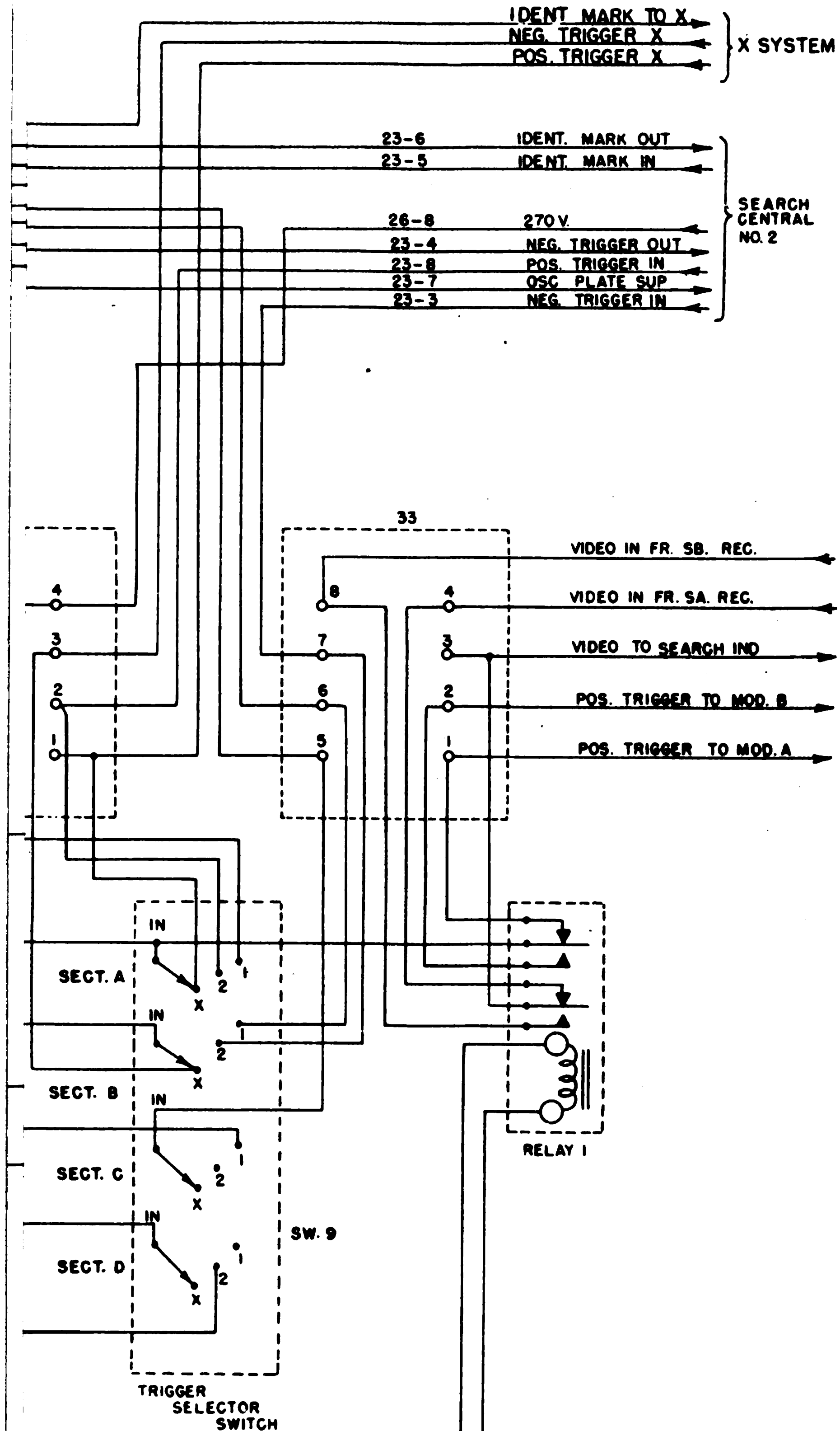


Figure 84. Auxiliary trigger circuit.

radar circuits. Some of these functions have been referred to in the preceding paragraphs of this section. Figure 85 is a diagram of the radar control circuit of the intercommunications panel. Connections having to do with the communications system are shown on a separate diagram given in chapter 4. The trigger selector switch is accessible by means of a screwdriver through a hole located at the bottom center of the panel. This switch has three positions, which allow the master trigger pulse to be taken from the No. 1 search central, the No. 2 search central, or the synchronizer. Of the seven knobs arranged in a row along the top of the panel, the first two from the left control the brilliance of the map and compass rose lights on the search indicator in bay 4, the third selects either of the two identification strobe pulses for application to the indicator in bay 4, the fourth controls the gain of the search receiver, the fifth selects either of the two identification strobe pulses for application to the search indicator in bay 6, the sixth and seventh control the brilliance of the compass rose and map lights on the indicator in bay 6. The knob to the left of the trigger selector switch selects either of the two identification strobe pulses for application to the precision indicators, and the knob to the right of the trigger selector switch applies both strobe pulses to all indicators simultaneously. A toggle switch selects the power supply for the sine potentiometer from either the No. 1 or the No. 2 search central. The remaining controls on the panel are associated with the communications or intercommunications system.



TL 36060

Figure 85. Intercommunications Panel SB-2/MPN-1, radar control circuit.

Symbol Designation	Description		
	Value	Rating	Tolerance
	Ohm	Watt	
R1	4,700	½	20%
R2	4,700	½	20%
R3	22,000	½	20%
R4	22,000	½	20%
C1	.01 mfd	600V	20%
P1	6	25	20%
P2	25	25	20%
P3	25	25	20%
P4	6	25	20%
P5 / P6	100,000	4	Dual Pot

SW1, SW2 & SW3—Omitted	
SW4	C&H #8373, 3 amp, 250V, D.P.D.T. Sw.
SW5	CRL (S.P.D.T.) #1460
SW6	CRL (S.P.D.T.) #1460
SW7	CRL (S.P.D.T.) #1460
SW8	CRL (S.P.D.T.) #1460
SW9	CRL #2515 (4 Circuit 3 Position)
SW10, SW11 & SW12—Omitted	
RLY1	Leach #1357

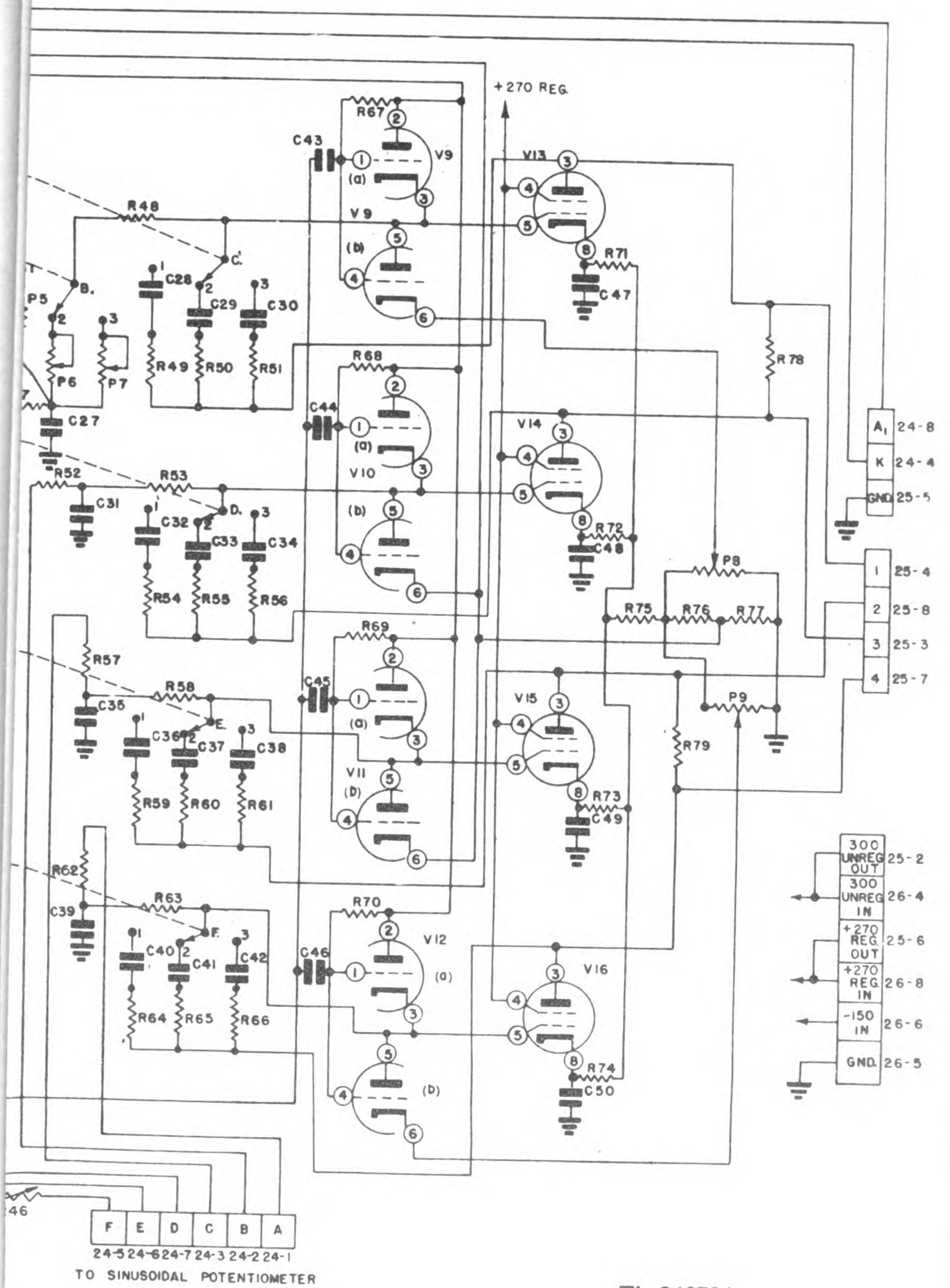


Figure 86. Search Central SN-6/MPN-1, schematic diagram.

l on	Description		
	Value	Rating	Tolerance
	220,000	½	20%
	56,000	½	10%
	4,700	½	20%
	20,000	½	10%
	330,000	½	20%
	1 Meg	½	20%
	47,000	½	10%
	10,000	2	10%
	10,000	20	10%
	100,000	½	20%
	10,000	½	20%
	1 Meg	½	20%
	10,000	2	10%
	10,000	2	10%
	220,000	½	10%
	330,000	½	10%
	20,000	10	10%
	100,000	½	5%
	200,000	½	5%
	220,000	½	10%
	47,000	½	20%
	390,000	½	10%
	470	1	20%
	27,000	½	10%
	56,000	½	10%
	22,000	2	10%
	220,000	½	10%
	270,000	½	10%
	20,000	10	10%
	30,000	½	5%
	300,000	½	5%
	39,000	½	5%
	47,000	½	10%
	220	½	20%
	22,000	½	20%
	270,000	½	10%
	2,200	1	20%
	25,000	25	10%
	22,000	½	20%
	820,000	½	10%
	1.5 Meg	½	5%
	510,000	½	5%
	240,000	½	5%
	22,000	½	20%
	1 Meg	½	5%
	1.5 Meg	½	5%
	510,000	½	5%
	240,000	½	5%
	22,000	½	20%
	1 Meg	½	5%
	1.5 Meg	½	5%

Symbol Designation	Description		
	Value	Rating	Tolerance
R60	510,000	½	5%
R61	240,000	½	5%
R62	22,000	½	20%
R63	1 Meg	½	5%
R64	1.5 Meg	½	5%
R65	510,000	½	5%
R66	240,000	½	5%
R67	1 Meg	½	20%
R68	1 Meg	½	20%
R69	1 Meg	½	20%
R70	1 Meg	½	20%
R71	300	2	10%
R72	300	2	10%
R73	300	2	10%
R74	300	2	10%
R75	50	10	10%
R76	47	2	20%
R77	47	2	20%
R78	68,000	1	10%
R79	68,000	1	10%
R80	100	2	10%
R81	200	2	10%
R82	100	½	5%
R83	100	½	5%
R84	6	½	5%
R85	250	½	5%
R86	250	½	5%
R87	22,000	2	10%
P1	50,000	2	
P2	20,000	2	
P3	500,000	2	
P4	100,000	2	
P5	500,000	2	
P6	500,000	2	
P7	500,000	2	
P8	100	2	
P9	100	2	
P10	500,000	2	
P11	100,000	2	
P12	5,000	4	
F1	Littlefuse-3AG	3 amp.	
PL1	AN3102-20-29P		
PL2	JK 33A		

CHAPTER 3

THEORY OF PRECISION SYSTEM

SECTION I

INTRODUCTION

37. FUNCTION OF SYSTEM. Radio Set AN/MPN-1, of which the precision system is a part, is designed to supply information as to the position of an aircraft in space. This information is utilized by the operators of the radio set to direct the movement of the airplane for a safe approach to the runway of the airfield. In order to perform this function, the radio set utilizes two complete radar systems which, to a large extent, operate independently of each other.

a. The first or "search" system supplies continuous information on the position of all near-by aircraft. This information is necessary to keep other airplanes (waiting to land) from colliding, to direct aircraft into the proper position for approach, and to keep a constant check over the area surrounding the runway to prevent all other aircraft from getting into the path of the approaching airplane. The search system is discussed completely in chapter 2.

b. As its name implies, the second or "precision" system supplies precise information on the location of the aircraft. When the antennas of the system are properly aligned with the runway, information presented on the indicators will locate any airplane in this field with respect to a predetermined glidepath. This information enables the operators of the radio set to guide the pilot of the aircraft over a proper approach to the airfield runway.

38. TECHNICAL CHARACTERISTICS.

a. Output. The precision system transmitter operates in the *X* band of frequencies, or at about 9,000 megacycles. The r-f output is in the form of short bursts or pulses of energy at a recurrence frequency of approximately 2,000 pulses per second (500 microseconds between pulses). Each pulse requires a time interval of approximately 0.5 microseconds. The average power output of the system is about 15 to 20 watts, and since the duty cycle (par. 8, TM 11-467) is 0.001, the peak power is approximately 15 to 20 kilowatts. The plate voltage supply to the transmitter is a negative pulse of 12-kv amplitude, somewhat less than that supplied to the search system transmitter.

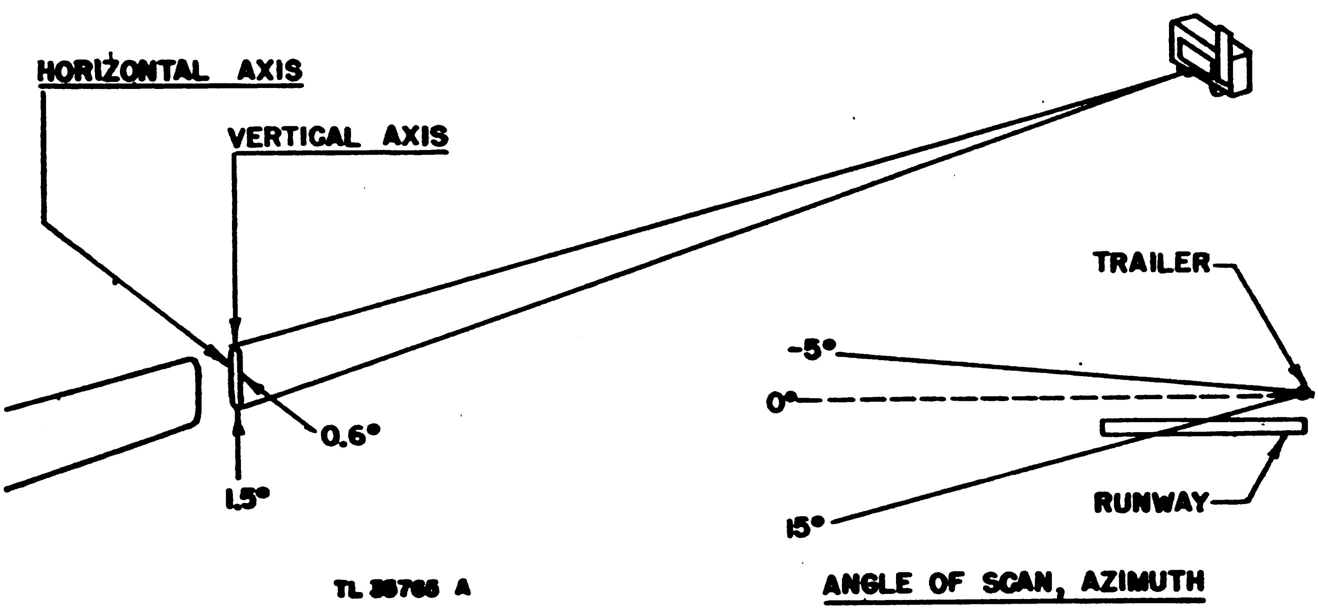


Figure 87. Azimuth antenna characteristics.

b. Coverage and Range. The antennas of the precision system scan a sector in space which adequately covers the runway and the approaching glidepath to the runway. This space is 20 degrees wide in azimuth and 6 degrees high in elevation. Space is scanned in azimuth from 5 degrees to the right to 15 degrees to the left of a line parallel to the runway (fig. 87) and scanned in elevation from 6 degrees above to 1 degree below a horizontal line (fig. 88). Two ranges are available on the system, these ranges being 2 miles and 10 miles. Both ranges are in use simultaneously, each range being shown on separate tubes on both indicators. Additional information on the indicator system is given in paragraph 41.

c. Accuracy. The system is designed for an approach to the runway only and not for an actual landing of the aircraft on the runway. As such it is required only to bring the aircraft over the runway to an altitude of 50 feet or less. However, if experienced operators are available, the accuracy of the system will permit much closer approaches. The very sharp output pulse of this system results in good definition of the aircraft in range. Construction of the precision antennas produces a sharp fan-shaped beam which improves target definition in azimuth and elevation. As shown in figures 87 and 88 the beam of the azimuth antenna is approximately 0.6 degrees wide in azimuth and 1.5 degrees wide in elevation while the elevation antenna beam is 3 degrees wide in azimuth and 0.4 degrees wide in elevation.

39. LOCATION OF COMPONENTS.

a. Transmitting System. All components of the transmitting system are located in the transmitter rack. This includes the two modulators (channels A and B) in bay 8 and the radio frequency unit (both channels on one chassis) in bay 9. Also included are the two high-voltage rectifiers (in bay 7) which furnish the high-voltage supply to the transmitting system along with the associated control box in bay 8.

b. Radio Frequency System. The radio frequency system, consisting of the two precision antennas and the waveguide transmission line connecting the transmitting system with the antennas, is located on the left-hand side of the trailer (fig. 90). The elevation antenna is placed at the rear left-hand corner of the trailer and extends above the trailer into a removable housing. The azimuth antenna is also on the left side of the trailer and is mounted underneath the communications rack B. The switching unit, which automatically switches from one precision antenna to the other at regular intervals, is located in the antenna compartment between the two antennas.

c. Receiving System. A part of the receiving system is included in the same chassis with a part of the transmitting system. The heterodyne converter is mounted in the r-f unit along with the transmitting oscillator. The two

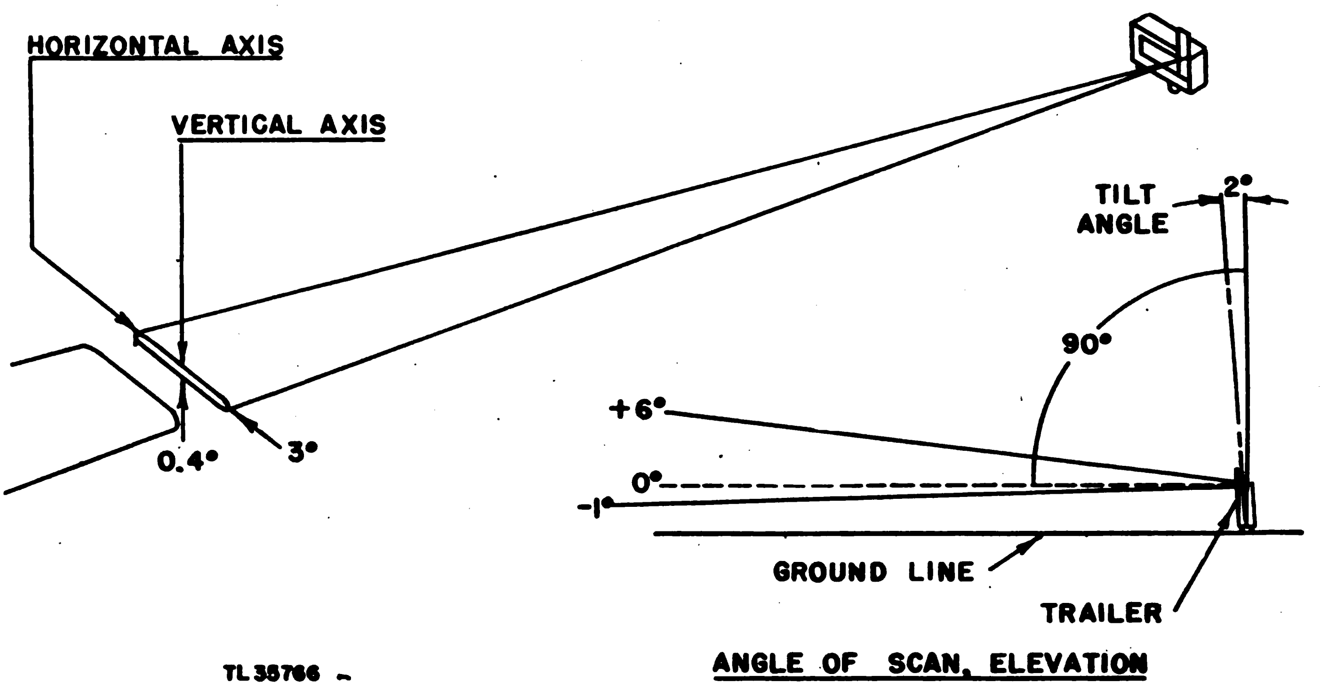


Figure 88. Elevation antenna characteristics.

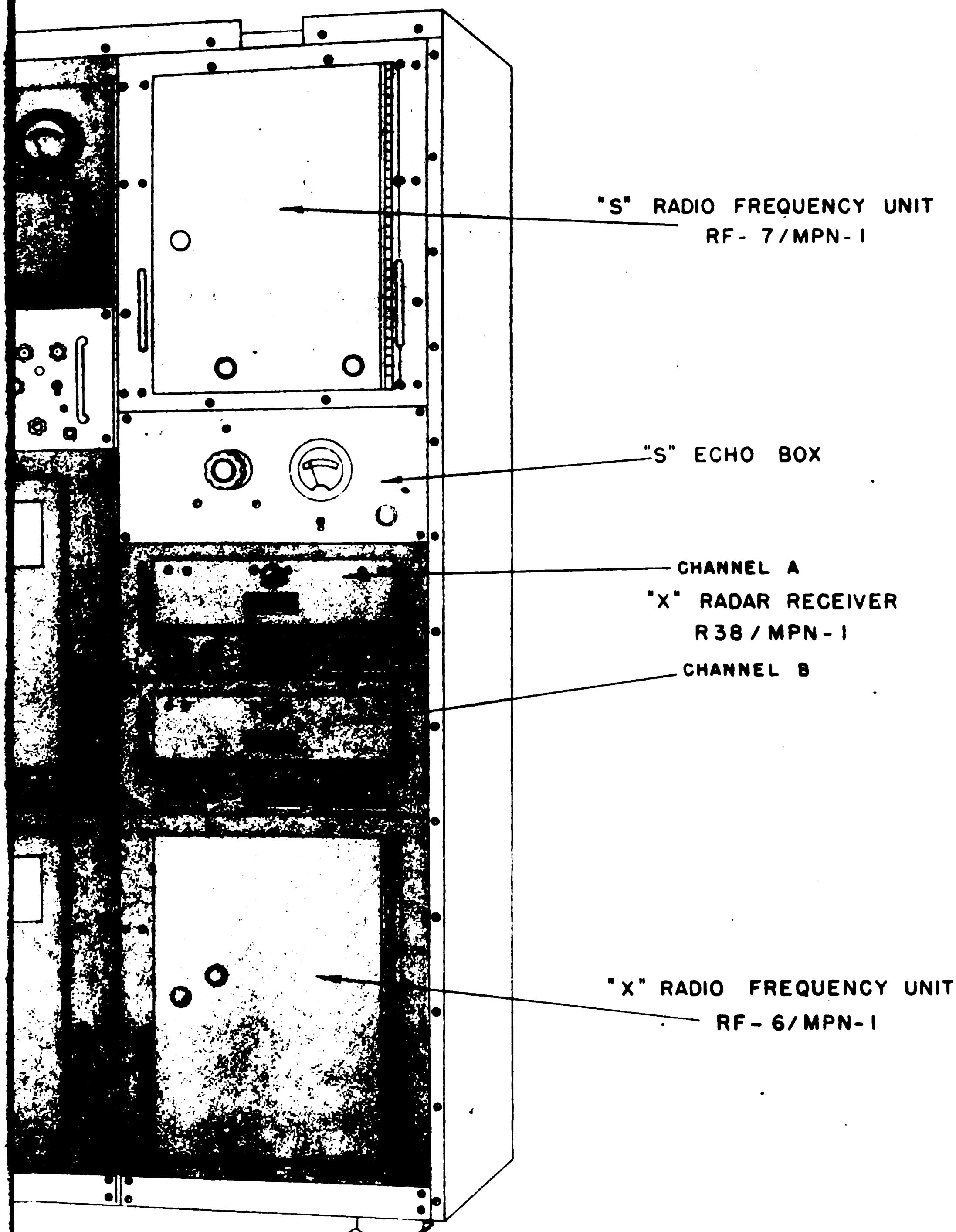


Figure 89. Transmitter Rack MT-119/MPN-1, precision system components.

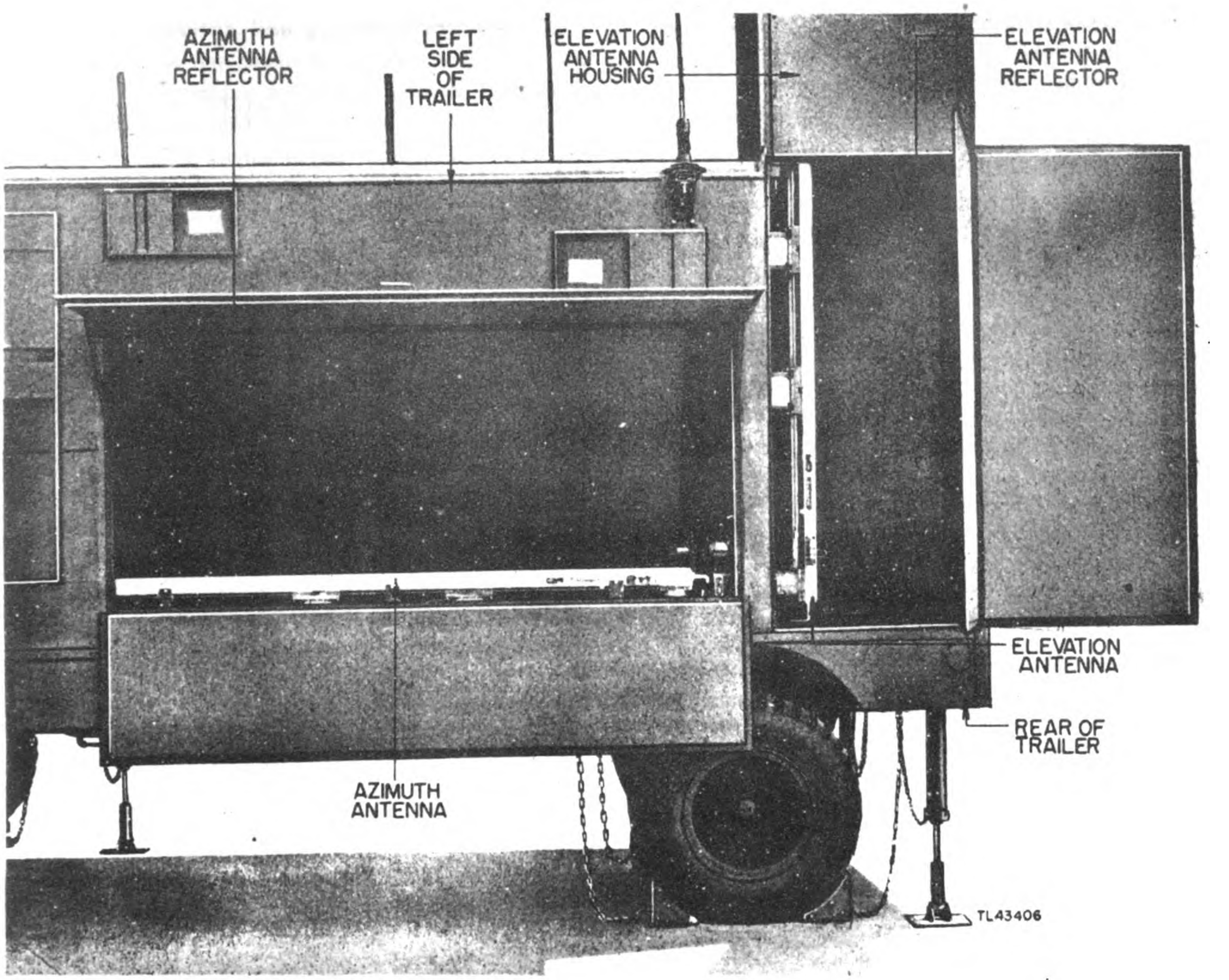


Figure 90. Location of precision antennas.

precision receivers (A and B) are mounted in bay 9 of the transmitter rack (fig. 89). A small part of the receiving system is also built into the synchronizer which is mounted in the indicator rack (fig. 91).

d. Indicating System. The entire precision indicating system is mounted in the first 3 bays of the indicator rack. The elevation indicator with its associated sweep amplifiers is mounted in bay 1, while the azimuth indicator and sweep amplifiers are mounted in bay 3. The approach indicator (error meters) is located in bay 2. The two aural signal units (channels A and B) are located in bays 1 and 2 respectively, directly below the operator's table. The synchronizers (channels A and B), which are closely allied with the indicator system, are mounted in bay 2.

e. Power Supplies. All power supplies used with the precision system, with the exception of the high-voltage power supply, are mounted beneath the operator's desk in the indicator rack.

40. CONNECTION OF COMPONENTS.

a. System Breakdown. In order to make a systematic analysis of the unit possible, the precision system has been subdivided into smaller systems according to the functions that the components perform. A functional block diagram is shown in figure 92.

b. Transmitting System. A sharp positive trigger from the synchronizer is formed into a negative high-voltage pulse by the modulator and is applied to the magnetron in the r-f unit. The high voltage necessary for forming the pulse is obtained from Rectifier Power Unit PP-26/MPN-1, while the magnitude of the pulse is controlled by Control Box C-61/MPN-1. The magnetron converts the negative high-voltage pulse into ultra-high-frequency oscillations.

c. Radio Frequency System. The oscillations from the magnetron are fed to the two precision antennas by means of hollow rectangular waveguides. The two antennas scan in different planes, one scanning in azimuth and the other in elevation. Each antenna is in use half the time, the switching unit directing the r-f energy to one or the other. The antenna switching process is very slow in comparison to the pulse repetition rate. The same antenna is used for receiving as was used for transmitting. Received energy travels back through the waveguide to the r-f unit.

*d. **Receiving System.*** The received signal is fed into the heterodyne converter in the r-f unit and converted to the intermediate frequency of 30 megacycles. In the receiver the signal passes through five i-f stages, a diode detector, and one stage of video amplification. Output is fed through a cathode follower to an additional stage of video amplification in the synchronizer and thence to the indicator system. Additional circuits in the receiver are an automatic frequency control (AFC) circuit to hold the local oscillator frequency at the proper value, and a sensitivity-time-control (STC) circuit to keep the intensity of all signals constant irrespective of range.

*e. **Synchronizer.*** The synchronizer is a timing device for both the search and the precision systems. It generates both positive and negative triggers, and all range markers and angle markers for the precision indicator system. These marker signals, together with the identification marker obtained from the search system, are mixed for application to the indicator tubes. Blanking of indicators and variation of receiver gain (in conjunction with antenna switching) is accomplished in the synchronizer.

*f. **Indicator System.*** Three indicators are used with the precision system: namely the elevation, azimuth, and approach indicators. Two different views of the scanned region which show the actual position of the approaching aircraft in space are shown on the elevation and azimuth indicators. The directors associated with these two indicators convert the information given on the displays into data on the actual distance that the approaching aircraft is deviating from the proper glidepath. This data is fed to the approach indicator and is read on the two meters in terms of actual feet of deviation. Video signals for the two indicators using cathode-ray tubes (azimuth and elevation) are obtained from the receiving system through the synchronizer. All marker voltages for these indicators are also generated and mixed in the synchronizer. Sweep voltages and timebase blanking voltages are generated in the associated sweep amplifiers, there being separate though identical sweep amplifiers for each indicator. The aural signal unit receives information from the azimuth indicator as to the course error of the approaching aircraft and converts this information to a correction tone which is transmitted to the pilot by radio.

*g. **Scan Synchronizing and Antenna Positioning Systems.*** The scan synchronizing system is an electrical connection between the antenna and the indicator system. Its function is to furnish data (on the position of the antenna beams) to the sweep amplifiers for the purpose of synchronizing the indicator sweep with the antenna beam movement. The antenna follower system is a mechanical linkage connecting the indicators with the antennas. This system utilizes the information given by the indicators to point the antennas at the approaching aircraft.

41. PRESENTATION OF INFORMATION.

*a. **Indicator Requirements.*** Because of the accuracy with which the location of the approaching aircraft must be determined, a special type of indicator is necessary. Since the region scanned by the precision system in space is rather limited (20° in azimuth and 7° in elevation) a plan position type of indicator (PPI) would present a very small display in comparison to the area available on the indicator tube. By moving the center of an ordinary PPI display to the edge of the indicator tube and by doubling the length of the range scale a slight improvement may be made. But by further expanding the azimuth scale (while keeping the range scale expansion constant) until the display occupies the major part of the indicator tube, an accurate indication of small angles of azimuth may be had. This conversion from a PPI display to an expanded partial plan position indicator (EPI) is illustrated by figure 6. A complete discussion of this type of display is given in paragraph 64. The same type of a display is applicable to the elevation indicator.

*b. **Azimuth Indicator.*** Video signals are presented on two indicator tubes on which range is shown in a vertical direction with the zero point near the top edge of the tube. The vertical line on the tube represents a line parallel to the airfield runway with the azimuth display showing an area 5 degrees clockwise and 15 degrees counterclockwise from this line. The horizontal (azimuth) scale of the display is expanded by a factor of 3. The two azimuth tubes carry identical azimuth indications but differ in range indications, the one having a maximum range of 2 miles and the other a maximum range of 10 miles.

*c. **Elevation Indicator.*** The elevation display is similar to that of the azimuth indicator except that range is shown along the horizontal line with the zero point at the left-hand side of the tube. The horizontal line on the display represents the ground line, and the display covers an area from 1 degree below to 6 degrees above this line. The vertical (elevation) scale of the tube is expanded by a factor of 10.

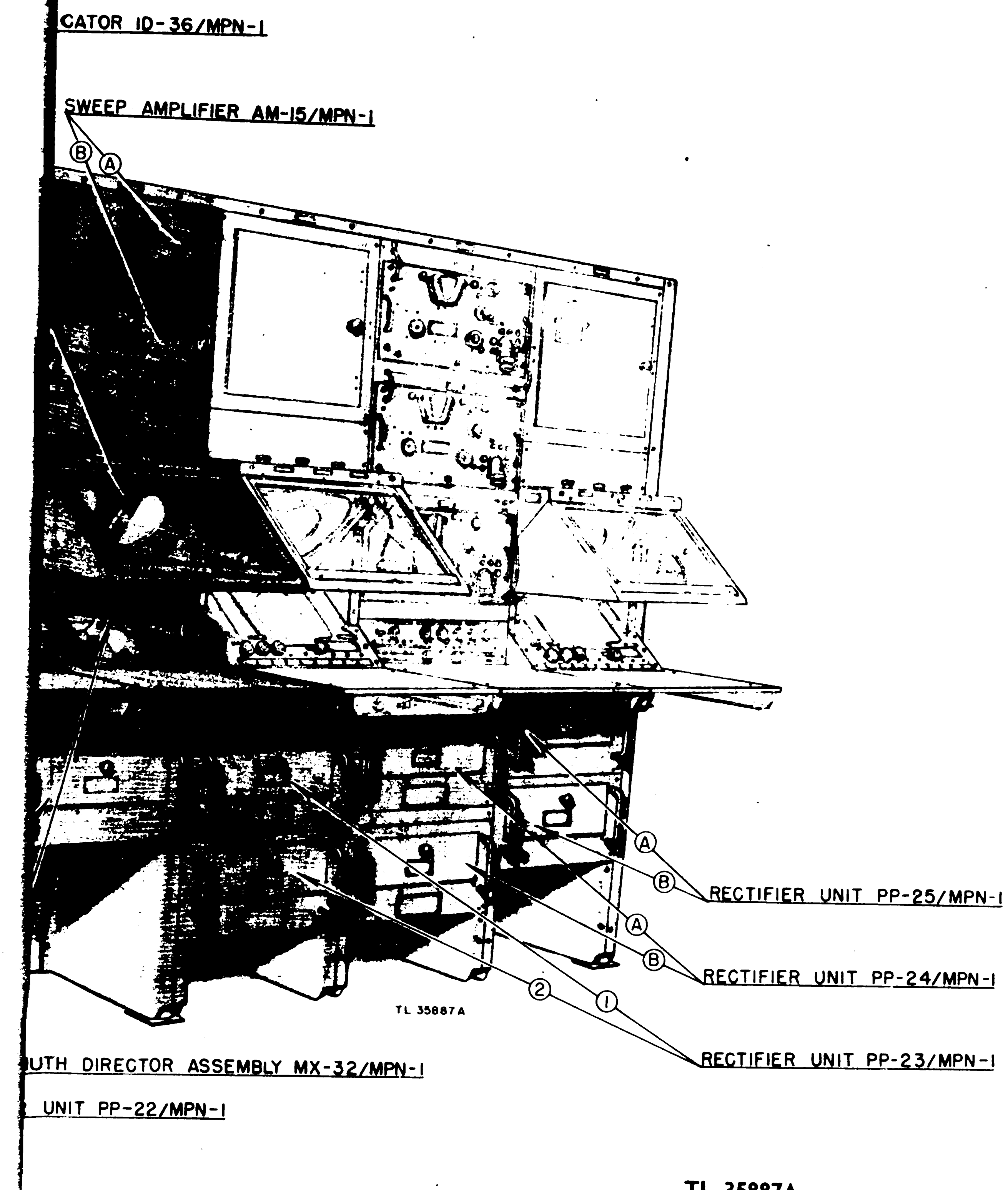


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Figure 91. Indicator Rack MT-118/MPN-1, precision system components.

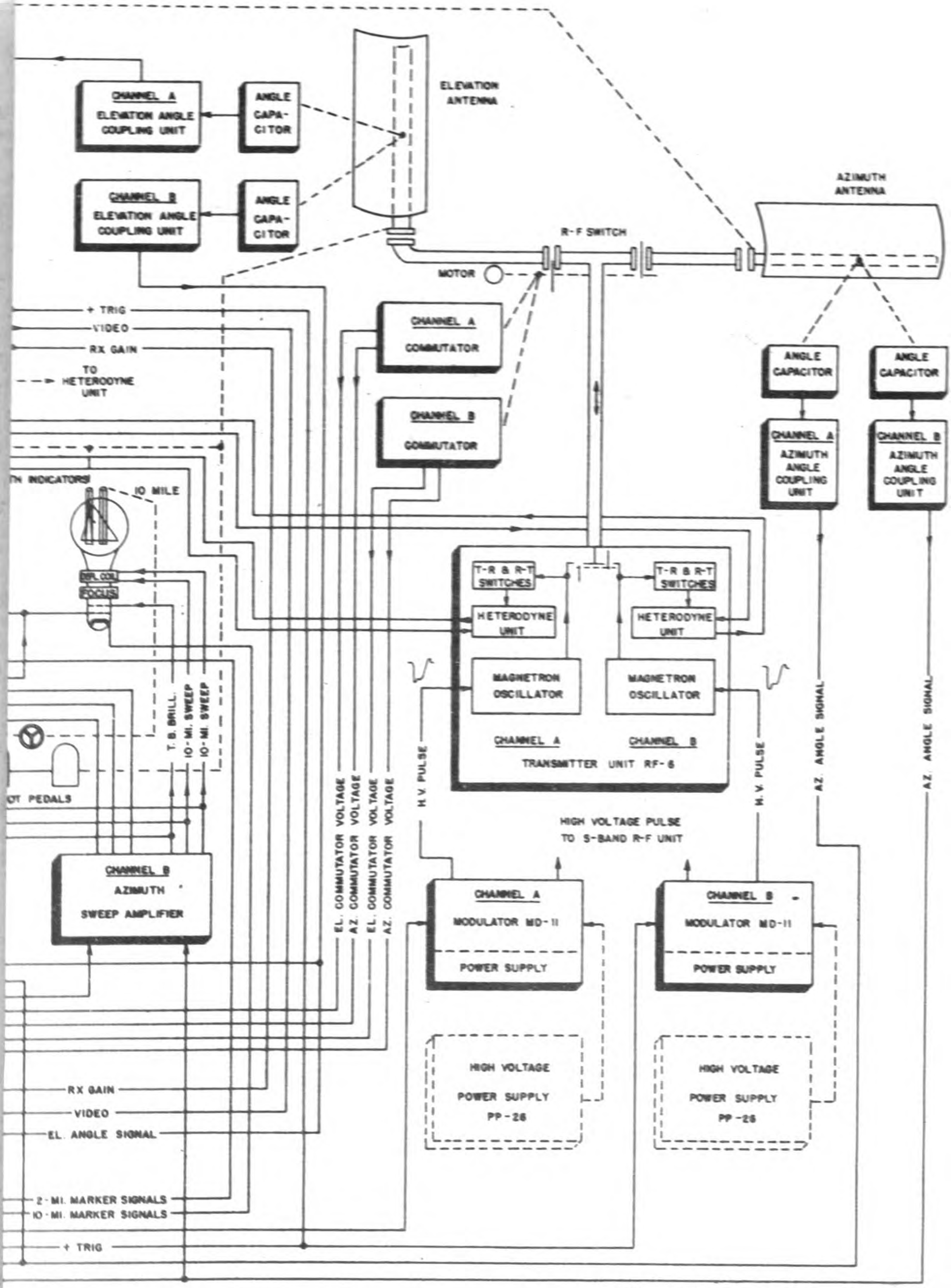

Figure 92. Precision system, functional block diagram.

42. CONNECTION TO OTHER SYSTEMS.

a. Search System. Besides the common power distribution system, several signal circuits of the precision system are connected to circuits in the search system. (1) The positive trigger for the synchronizer, a component of the precision system, leads to the modulator, the first stage of which is common to both the search and precision systems. Here the systems separate, two separate high-voltage pulses being generated for application to the individual magnetrons.

(2) The negative trigger from the synchronizer, as well as being used in the precision system, is fed to the search centrals to start the generation of indicator sweep voltages and range markers.

(3) If necessary, the search system may be operated alone by utilizing positive and negative trigger voltages generated in the search central itself.

(4) An identification marker (which is actually a movable range marker) is generated in each of the search centrals for aid in identifying signals appearing on the indicators. These markers are fed to the precision indicators (10-mile tubes only) through the mixer circuits of the synchronizer to be used in identifying approaching aircraft.

b. Communications System. (1) The three operating positions of the precision system are connected into the intercommunications system through microphones and headphones.

(2) In addition, the approach controller (operator at the approach indicator) has access to the communications equipment. This operator is able to select any one of the available communications channels to enable him to give instructions to the approaching aircraft.

(3) The aural signal unit, a part of the precision indicator system, is automatically connected to the communications channel selected by the approach controller.

SECTION II

TRANSMITTING SYSTEM

43. INTRODUCTION. The precision transmitting system functions to generate high-power microwave radio frequency pulses in a manner similar to that previously discussed under the search transmitting system (ch. 2, sec. II). The transmitting system is composed of Modulator MD-11/MPN-1, X-band Radio Frequency Unit RF-6/MPN-1, and Rectifier Power Unit PP-26/MPN-1 (fig. 93). The modulator and rectifier units are the same units that supply the search r-f magnetron. Since these units were described in detail under the search transmitting system, no attempt will be made to further discuss them in this section. The precision transmitting magnetron generates the high power r-f pulses which are radiated into space by the azimuth and elevation antennas. The pulses are timed by means of the modulator which converts the 2.5 microsecond trigger pulses from the synchronizer into ½ microsecond modulating pulses of approximately 12,000-volt amplitude. Provisions are also made so that the modulator may be triggered from either of the two search centrals of the search system. In normal operation, the trigger pulse is always supplied by the synchronizer; however, the additional trigger pulses from the search centrals are provided for test purposes and in case the search system should be used independently of the precision system. The precision system is duplicated in two channels designated as channels A and B. Only one channel is used at a time, the other channel being maintained as a stand-by.

a. Location of Components. The precision transmitting system components are located in Transmitter Rack MT-119/MPN-1 (fig. 89). Both high-voltage rectifier units are mounted in bay 7 along side of the channel A and channel B modulator units, located in bay 8. The X-band Radio Frequency Unit RF-6/MPN-1 is mounted in the lower section of bay 9 and houses duplicate r-f units for the two channels. The local oscillator, crystal mixer, and preamplifier unit for each channel are also in the radio frequency unit. These components are part of the receiving system and are discussed in detail in section IV of this chapter. Current and voltage readings for the precision transmitting system are read on the X-band meter in Control Box C-61/MPN-1. The meter readings are helpful in determining whether or not the equipment is operating normally, and in locating the faulty component or circuits if trouble should develop.

b. Modulator. A single modulator unit for each channel supplies the high-voltage modulating pulses to both S-band and X-band transmitters. The sharp positive-going trigger pulse from the synchronizer is applied to a blocked oscillator circuit in the modulator. The pulse triggers the blocked oscillator which produces a narrow output pulse, the width of which is determined by a delay network in the grid circuit. The narrow pulse output is applied to the grids of four switching tubes, two of which are used with the S-band transmitter, the other two being used with the X-band transmitter. A high-voltage capacitor is coupled to the plates of each pair of switch tubes and is charged to the potential of the high-voltage power supply. When the positive pulse from the blocked oscil-

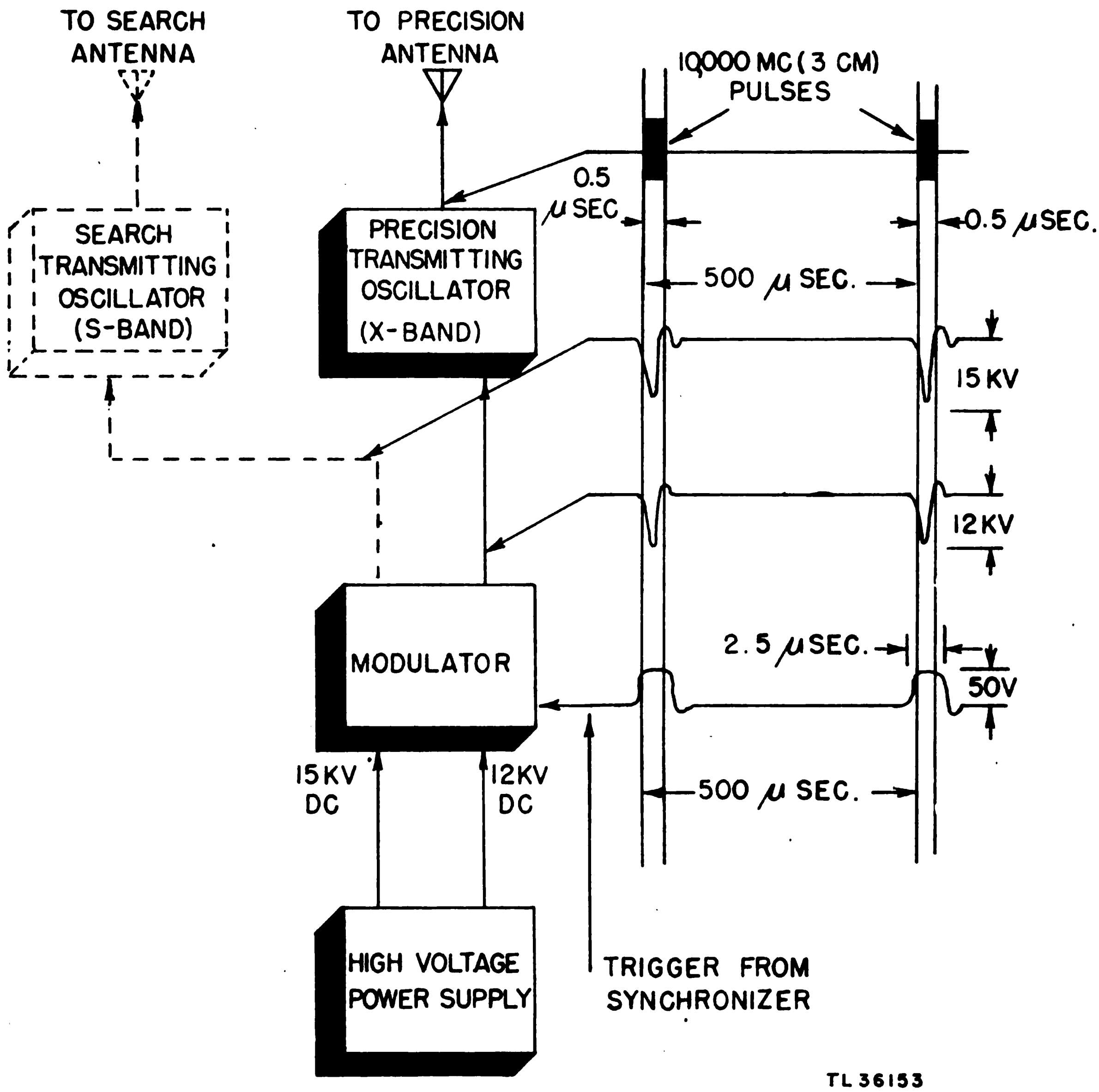

Figure 93. Precision transmitting system, simplified block diagram.

lator causes the switch tubes to conduct, the high-voltage capacitors are partially discharged through the magnetrons thereby producing the high-power r-f oscillations. As the discharge time is short in comparison with the time constant of the circuit, a negative square wave pulse is generated having a pulse width of approximately 0.5 microsecond. The 0.5 microsecond pulses are applied to the magnetron 2,000 times per second which is the pulse recurrence frequency of the system.

*c. **Power Supplies.*** (1) The high voltage required for pulsing the S-band and X-band transmitters is obtained from Rectifier Power Unit PP-26/MPN-1. The total high-voltage output is applied to the S-band switch tubes while the 12-kv output used for the X-band switch tubes is obtained by dropping the total supply voltage by a voltage divider network. Rectifier Power Unit PP-26/MPN-1 is discussed in detail in chapter 4.

(2) The modulator unit contains an additional power supply that furnishes +1,200-volt dc and –750-volt dc. The positive voltage is used as a plate supply for the blocked oscillator and as the screen supply for all the modulator tubes. The negative voltage is provided as a

bias supply for the switching tubes and blocked oscillator. In addition, this negative voltage is also used as the keep-alive voltage for the search and precision system T-R switches.

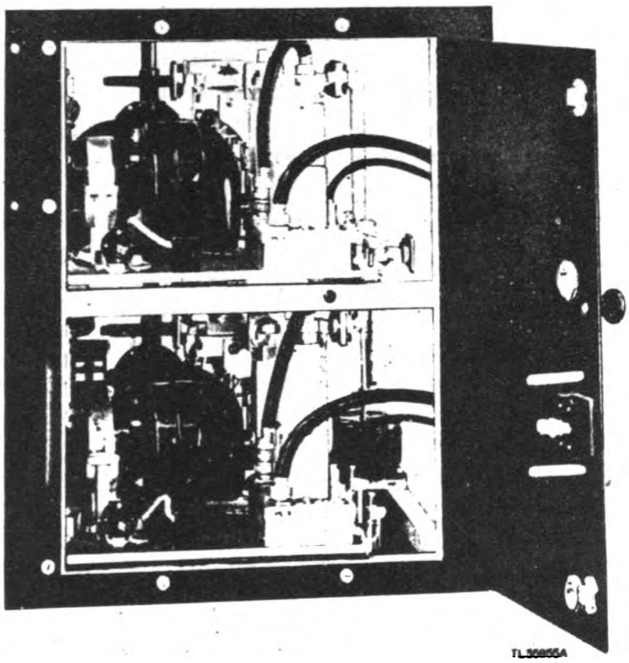

Figure 94. Radio Frequency Unit RF-6/MPN-1, front view.

d. Radio Frequency Unit. (1) The radio frequency unit (fig. 94) consists of two subchassis assemblies, each containing a magnetron oscillator and associated equipment (fig. 95). One magnetron oscillator is used with each channel. The 12,000-volt negative pulse developed by the modulator is applied to the cathode of the magnetron. The output of the magnetron is directly coupled to the waveguide transmission line by a small pick-up loop, inserted into the magnetron cavity.

(2) In addition to the transmitting magnetron, the r-f unit contains the T-R and R-T switches and r-f channel switching mechanism, a part of the r-f system explained in section III of this chapter, as well as the local oscillator, crystal mixer, and preamplifier for each channel, a part of the receiving system described in section IV of this chapter. The receiving system components located in the r-f unit provide a degree of amplification to the received signal in order to overcome the attenuation of the transmission line to the receiver proper.

44. MODULATOR MD-11/MPN-1.

The same modulator is used to key both the search and the precision transmitters simultaneously at a pulse repetition frequency of 2,000 pulses per second. Two identical modulators are included in Radio Set AN/MPN-1, one being used by the channel in operation and the other being maintained for stand-by purposes. The complete schematic diagram of the modulator unit is shown in figure 25. The operational theory will not be discussed under the precision transmitting system as the unit was thoroughly discussed in the search transmitting system (ch. 2, sec. II).

45. RADIO FREQUENCY UNIT RF-6/MPN-1.

a. Description. The radio frequency unit in the precision system is similar in construction and operation to the unit used in the search system. A single compartment houses the duplicate transmitting equipment for the A and B channels. The high-voltage pulse input from the channel A and channel B modulators is connected to their respective magnetron oscillators through the high-voltage insulated cables brought in to the back of the components. The transmit switch, on the power distribution panel, controls the channel switching and through its associated circuits applies voltage to the terminal strips of either the channel A or channel B magnetron oscillator circuits. The preheat switches, also on the power distribution panel, apply power to the filament transformers and blower motors of the transmitting equipment before the high voltage is applied. The r-f output of either the channel A or channel B magnetrons is fed to the common waveguide transmission system through a T-section channel switch. A pair of switching vanes block the unused

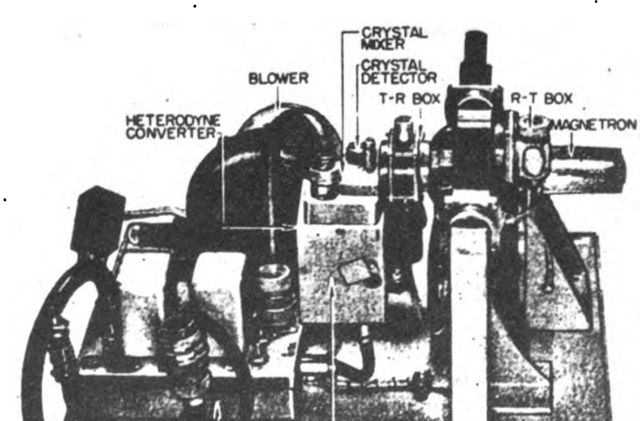

Figure 95. X-band transmitter subchassis assembly.

channel thereby allowing the energy to pass down the guide to the radiating antennas (sec. III). The complete schematic of the r-f unit is shown in figure 96. The preamplifier, local oscillator, and crystal mixer, shown on the complete schematic, are not a part of the transmitting system but function solely in a receiving capacity. They are, therefore, thoroughly discussed in the receiving system (sec. IV).

*b. **Magnetron Transmitting Tube.*** The source of the transmitted r-f energy is the magnetron tube, the heart of the transmitting system. The conventional type of vacuum tube oscillator cannot be used to generate the ultra-high frequencies used in the precision system (approximately 9,000 megacycles) since the transit time, or time required for the electrons to travel between the electrodes, becomes an appreciable part of the cycle at the high oscillating frequencies. Also, the inductance and capacitance between electrodes is a limiting factor in the maximum frequency at which an ordinary vacuum tube will oscillate. The magnetron tube was developed to overcome these difficulties. The magnetron used in the precision system is similar to the magnetron in the search system previously described (ch. 2, sec. II). The complete theory of this type of tube is beyond the scope of this manual, however, further details on the operation of the magnetron may be found in section XII of TM 11-466, Radar Electronic Fundamentals.

*c. **Magnetron Characteristics.*** (1) Each channel in the precision r-f unit contains a type 2J36 magnetron transmitting tube, V1 (fig. 96). In the magnetron cavity is a magnetic coupling loop feeding an electrostatic probe which radiates into a section of standard X-band waveguide. The magnetron is rigidly mounted in the field of a permanent magnet having a field density of 2,300 to 2,500 gauss. In order to avoid putting the housing of V1 at a high potential, the case is grounded and the high-voltage keying pulses from the modulator are applied as negative voltages to the tube's cathode. The d-c pulses, or keying voltages, have a duration of 0.5 microsecond and an amplitude of approximately 12,000 volts, causing V1 to oscillate during periods of pulse application. Since the cathode and filament of V1 are tied together, the secondary of filament transformer T1 is subjected to the high voltages applied to the cathode of the tube. Therefore, the transformer primary and secondary windings must be well insulated from each other. To prevent arc-over, and to keep the shunt capacitance from cathode to ground at a minimum in order to preserve pulse amplitude and shape, a special design of isolation transformer is used.

(2) Under normal operating conditions, the tube is pulsed 2,000 times per second, drawing an average current of about 12 to 16 milliamperes. Since the duty cycle, or ratio of operating time to quiescent period, is one to one-thousand, the peak current drawn approximates 14 amperes which, at 12,000 volts, gives a peak input power of 168 kw.

(3) No tuning adjustments are provided on the magnetron oscillator, the frequency of oscillation being mainly determined by the built-in tuned cavity. To shift the frequency, a new magnetron must be installed. The wavelength of the magnetrons used in the precision system should lie between 3.27 and 3.33 centimeters. The channel A and channel B magnetrons should be chosen so as to have frequencies close to each other, otherwise inaccuracies may result when switching channels. These inaccuracies are due to a shift in the beam pattern caused by a difference in frequency of the two magnetrons.

(4) Each magnetron is equipped with a motor driven blower (BL 1), connected to the 117-volt a-c preheat circuit. The blower is provided to dissipate the heat developed by the magnetron and is driven by a 117-volt a-c induction motor at 1,525 rpm.

SECTION III

R-F SYSTEM

46. INTRODUCTION. The precision r-f system of Radio Set AN/MPN-1, like the search r-f system, includes the waveguide transmission system, the T-R switching system, and the precision azimuth and elevation antenna arrays (fig. 97). The purpose of the r-f system is to couple the high-power r-f energy, developed in the transmitting magnetron, to the antenna arrays where it is radiated into space, and to pick up the returning reflected signals and apply them to the receiving system. In addition to the foregoing functions, the r-f system provides a means of alternately switching the transmitter output and receiver input between the azimuth and elevation antennas.

*a. **Waveguide Transmission Line.*** (1) The high-power r-f energy from the magnetron oscillator is conducted by means of a waveguide transmission line, through the r-f channel switch and r-f antenna switch, to either the azimuth or elevation antenna array. The waveguide transmission line used in the precision X-band system is similar to the S-band waveguide transmission line previously described. The theory of the two transmission lines is identical; however, the physical dimensions of the X-band waveguide are much smaller than those of the S-band waveguide due to the shorter wavelength of the X-band r-f energy.

CONNECTOR STRIP 20A & 20B CONNECTIONS			
TERMINAL	FUNCTION	OUT TO	IN FROM
1	AC COMMON		DIST. PANEL
2	AC PREHEAT		DIST. PANEL
3	AC TRANSMIT		13-5
4	N C		
5	INTERLOCK	19-3	
6	KEEP ALIVE		17-4
7	N C		
8	GROUND		GROUND BUS

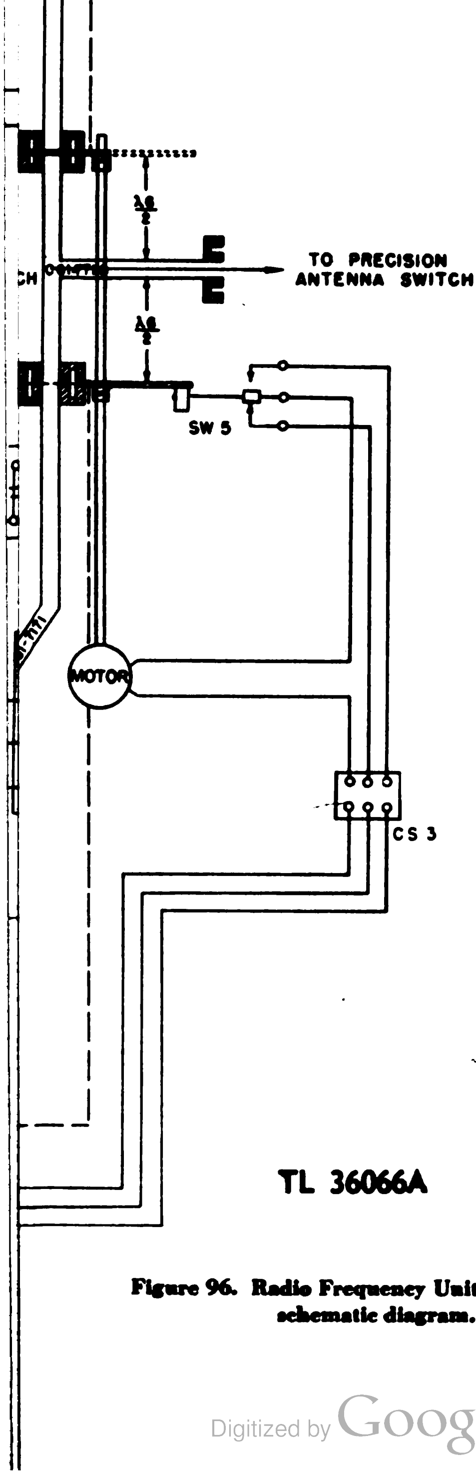

Figure 96. Radio Frequency Unit RF-6/MPN-1, schematic diagram.

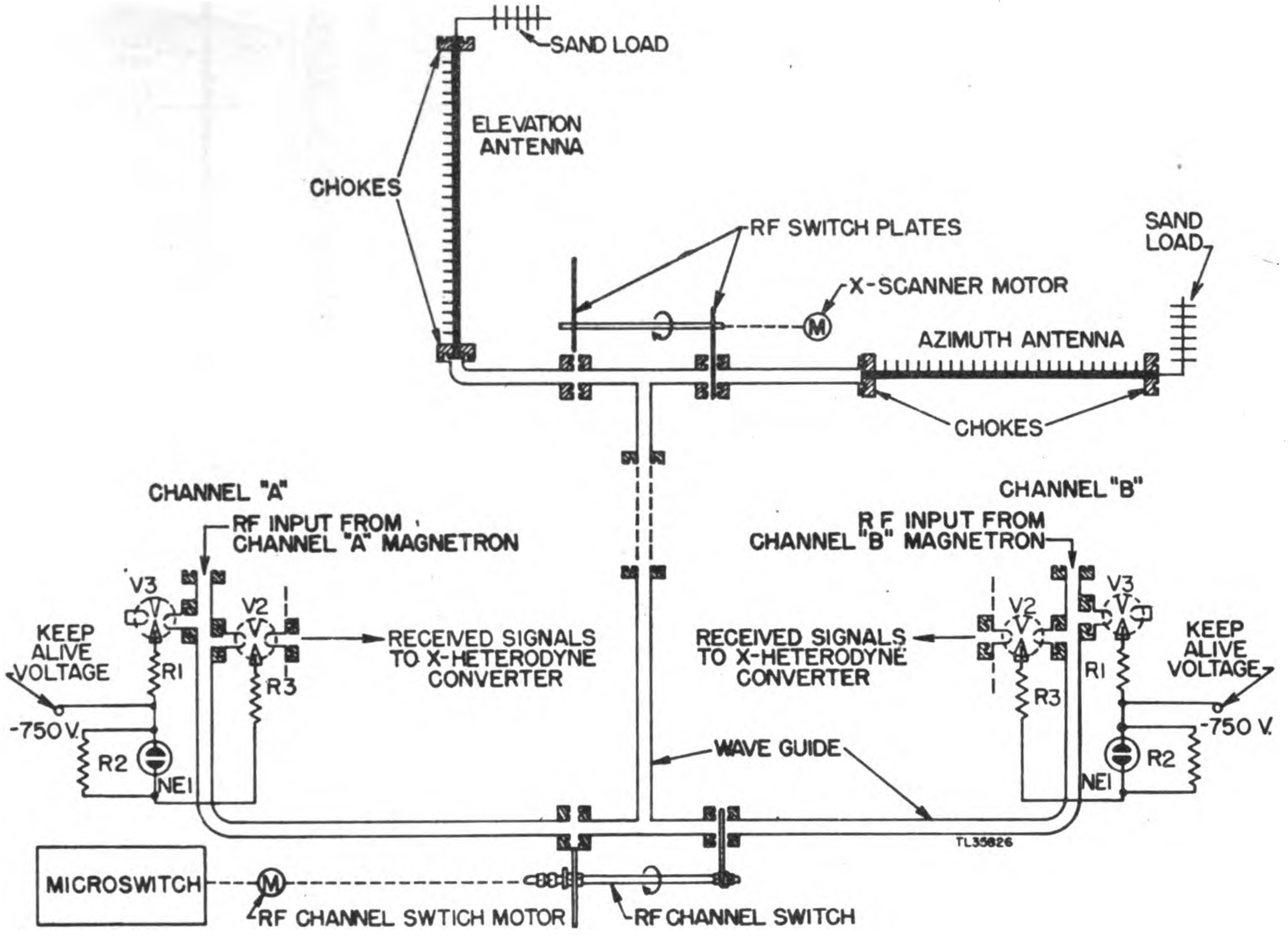

Figure 97. Precision r-f system, simplified schematic diagram.

(2) As in the search system, two identical transmitter units are utilized in the precision system, one being used in actual operation and the other being maintained in a stand-by condition. Thus some means of switching the r-f transmission line between the two channels must be used. This is accomplished by physically blocking the waveguide of the stand-by channel at a point one half-wavelength from its junction point with the main transmission line. Thus an electrical short will be reflected at the T-junction, causing it to appear as an L-section to the live channel transmitted energy.

(3) A similar switching system is used to alternately connect the transmission line to the azimuth and elevation antenna arrays. In this switch, r-f energy is distributed between the two antennas by alternately blocking the elevation and azimuth waveguides by means of rotary switch blades inserted in the waveguide sections. Thus when the waveguide feeding the azimuth antenna is blocked, the path to the elevation antenna will be open and the total r-f energy will be transmitted to the elevation array. With the waveguide feeding the elevation antenna blocked, the r-f energy will be fed to the azimuth array.

b. T-R and R-T Switches. The precision system transmit-receive switch is similar in operation to the T-R switch used in the search system. It functions to keep the high peak power of the transmitted pulse out of the sensitive receiver circuits, and presents a low-loss path to the receiver for the weak reflected echo signals. This is accomplished in the precision system by two switching tubes; a T-R tube similar to the T-R tube used with the search system, and an R-T tube used to block the branch waveguide to the transmitter during the period of reception. The two tubes are mounted near the transmitting magnetron in Radio Frequency Unit RF-6/MPN-1.

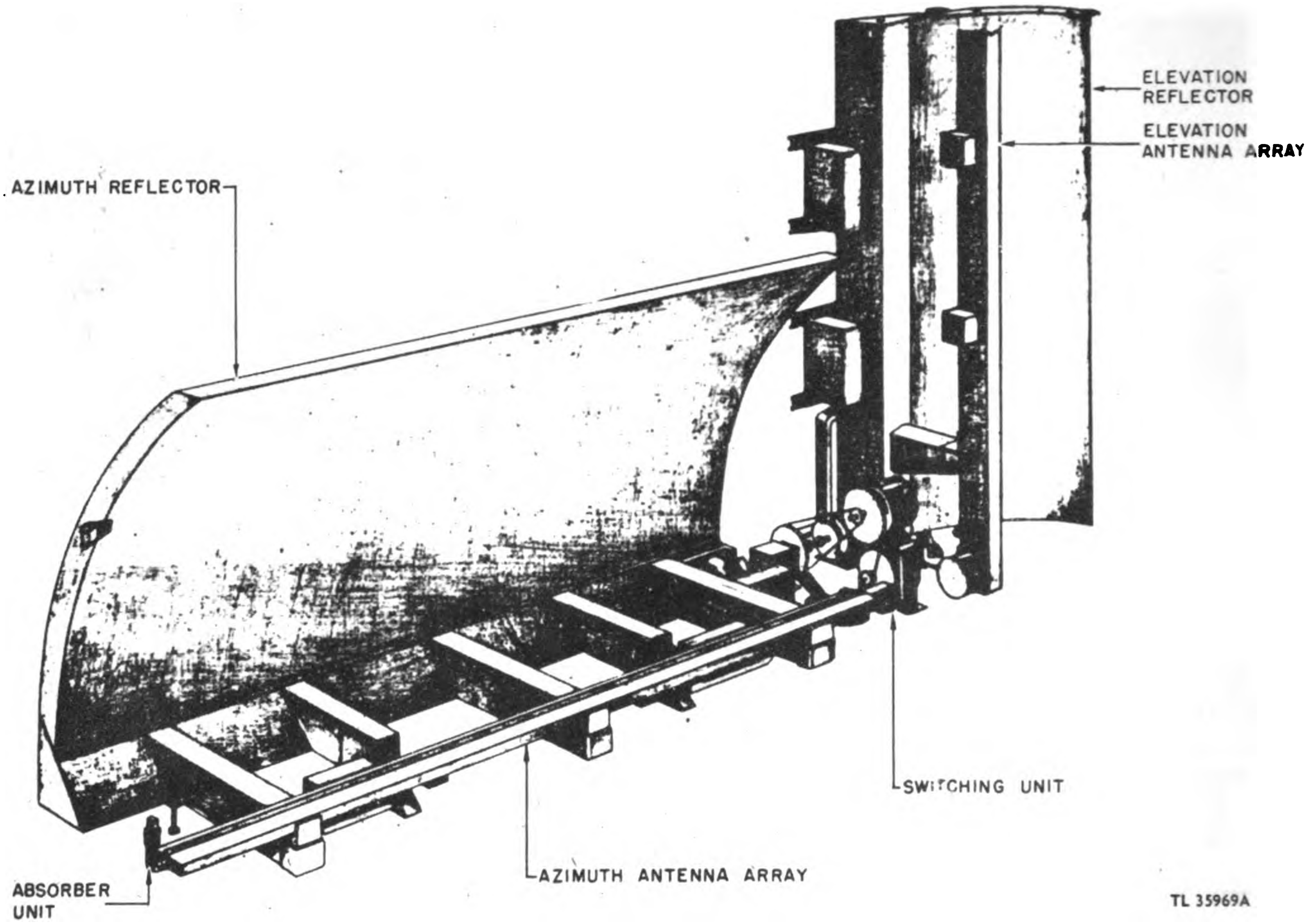

Figure 98. Precision antenna assembly.

c. Antenna Arrays. (1) Two separate antenna arrays (fig. 98) are used with the precision system of Radio Set AN/MPN-1; an elevation antenna to determine aircraft height, and an azimuth antenna to determine the direction of the aircraft. The two arrays are similar in construction and operation, the elevation antenna being composed of a broadside array of 173 dipole antennas, and the azimuth antenna consisting of 121 dipole antennas.

(2) The spacing of the dipoles is such that they are fed approximately 180 degrees out of phase and with alternate dipoles reversed to give an effect of all being fed inphase. The radiation from each dipole reaches its maximum at nearly the same instant. Traveling out from the array, these individual fields of radiation combine to form a single wave front nearly perpendicular to the array. At an angle from the normal to this wave front however, the fields become increasingly out of phase and tend to cancel each other. Thus the wave front is a radiation beam of highly directional characteristics.

(3) The radiation beam of each antenna is made to sweep through a small angle by mechanically changing the dimensions of the waveguide section feeding the dipoles. This alters the apparent wavelength of the radio waves traveling down the guide and thus changes the phase at which the dipoles are fed, thereby changing the effective direction of the beam radiation.

(4) The dipole arrays are placed at the focal line of a section of cylinder, having a parabolic cross-section, which acts as a reflector and forms the radiation from the dipoles into a narrow wedge-shaped beam. The parabolic type reflector used with the precision antennas is shown in figure 99. The elevation array is fixed in a vertical position but can be moved in azimuth to give proper orientation of the beam. Similarly, the azimuth antenna is fixed laterally, but can be moved in elevation by a foot-pedal servo system, explained in section VII of this chapter.

47. WAVEGUIDE TRANSMISSION LINE.

a. General. Standard X-band waveguide is used throughout the precision r-f system. At the high frequen-

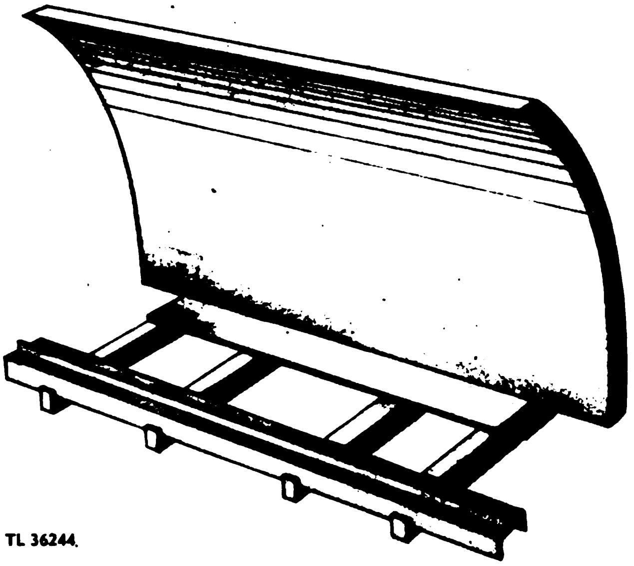

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Figure 99. Parabolic trough reflector.

cies present in this system, the use of waveguide transmission line is the most efficient means of conducting the transmitted r-f energy to the antennas and the reflected echo signals to the receiving system. The theory of X-band waveguide operation is identical with that of the S-band waveguide and will not be repeated here. Refer to chapter 2, section III of this manual as well as section XI of TM 11-466 for the operational theory of the waveguide transmission line.

b. X-band Waveguide. Standard X-band waveguide has an outside cross-section of 1.0 x 0.5 inches, with a wall thickness of 0.05 inches. It is constructed of rectangular brass tubing, silver plated for low surface resistance. From a small antenna or exciting probe, r-f energy is introduced into this rectangular guide and is reflected back and forth between the walls. In this manner the energy is conveyed down the length of the guide, and, since skin effect at the high X-band frequencies prevents penetration of the waveguide walls, very high efficiency of transmission is obtained.

c. Waveguide R-f Choke Joints. All connections between waveguide sections are accomplished by means of r-f choke joints, identical to those used in the S-band system. In addition, a knuckle joint is used in the precision system to provide a degree of flexibility between the rigid transmission line and the pivoted antenna arrays. Each transmission line is broken at a point on the axis about which the antenna is rotated. At this point a knuckle joint, composed of a choke flange facing a flat flange, is inserted (fig. 100). The members of the knuckle joint are separated about 1/8 inch and a metal bracket with mounting screws holds them in position. This arrangement allows a small degree of rotation in the plane in which the antenna is servoed.

d. R-f Channel Switch. (1) In order to connect either of the two oscillator units to the common waveguide transmission line, an r-f channel switch assembly, shown in figure 101, is provided. This switch consists of a T-section of waveguide with the arms of the T fed from channel A and channel B magnetrons via double choke joints. The channel switch is a part of Radio Frequency Unit RF-6/MPN-1. Switching from one r-f channel to the other is accomplished by means of two vanes mounted on a single shaft. By rotating the shaft, either of the vanes may be inserted into the waveguide to block one of the double choke joints.

(2) The T-junction is in the electric plane, since the sidearms branch from the wide dimension of the guide. For this reason they are in series with the main line. In theory, the functioning of this section follows closely the operation of a two-wire transmission line system to the extent to which quarter and half-wavelength dimensions determine its characteristics. When a short circuit is placed across one of the arms of the T at a distance a half-wavelength from the midpoint of the junction, power introduced from the main guide or from the other sidearm (fig. 102) is transmitted through the L-path, the shorted sidearm presenting a zero series impedance at the junction. However it is not possible to have perfect

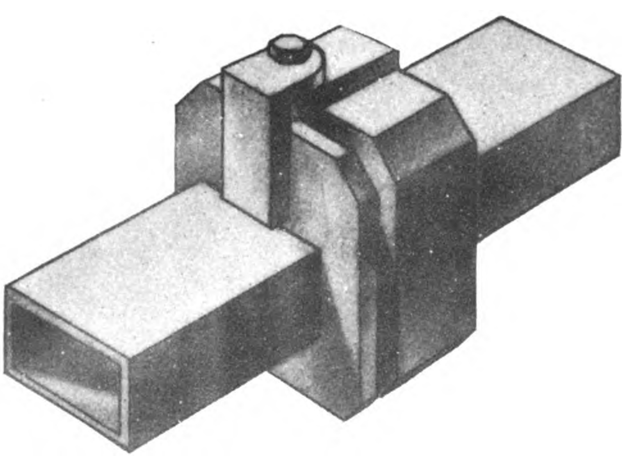

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Figure 100. Knuckle joint detail.

transmission around the corner of the L-section owing to the development of standing waves within the guide. Therefore to properly match the sections, it is necessary to place a matching diaphragm, composed of susceptance fins, in one arm. In this case the fins are "inductive windows" set in the narrow dimension where they are less liable to cause breakdown on application of high transmitted power pulses. The impedance matching effected by this diaphragm develops the lowest possible standing-wave ratio within the guide, essentially a unity ratio, together with complete transmittal of power down the desired path.

(3) Short-circuiting the sidearms is accomplished by the brass shutter disks of the switching unit. These disks are mounted on the drive shaft and guided by the T-section bracket. When the brass plate crosses an arm, an effective short circuit with negligible power leakage is developed. The plate is inserted between the two r-f choke joints, mounted rigidly with a 1/8-inch gap between them to provide clearance for the blade. The action when conduction takes place across the gap between the flanges is practically that of a continuous line, owing to the short-circuiting effect of the half-wavelength slot. The junction is not perfect however, as tests show an approximate 5 percent loss in power.

(4) The shaft for the r-f channel switch is directly driven by a small geared-down 117-volt a-c motor mounted on the r-f chassis.

e. R-f Antenna Switch. (1) In order to alternately connect the elevation and azimuth antennas to the waveguide transmission line, an r-f antenna switch, similar to the r-f channel switch, is used. This switch is a part of Switching Unit SA-8/MPN-1 (fig. 103). The antenna switch is comprised of a T-section, fed by the common transmission line. The two halves of the T-section feed the azimuth and elevation antennas, and are separated by a double choke joint in each leg, located a half-wave-

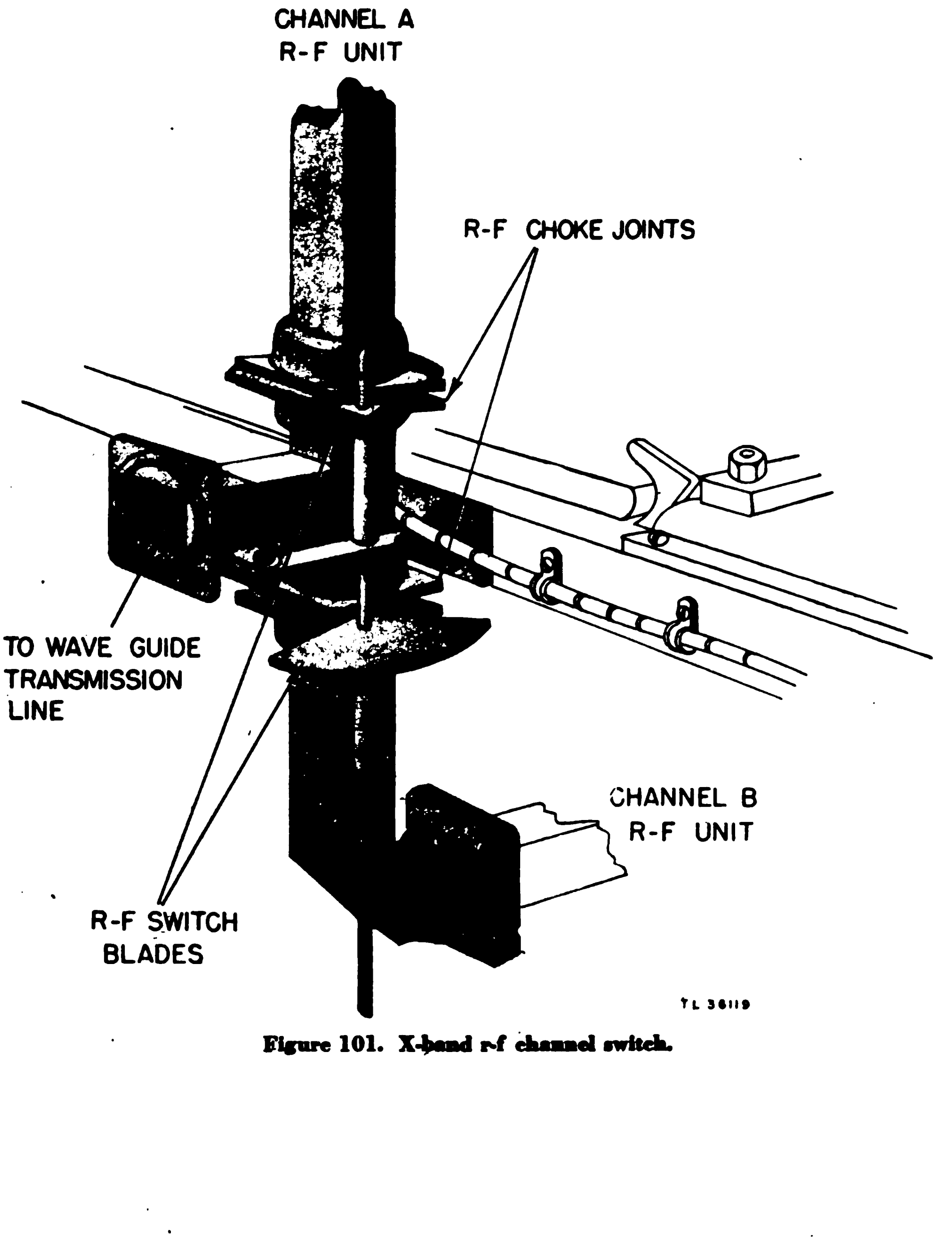


Figure 101. X-band r-f channel switch.

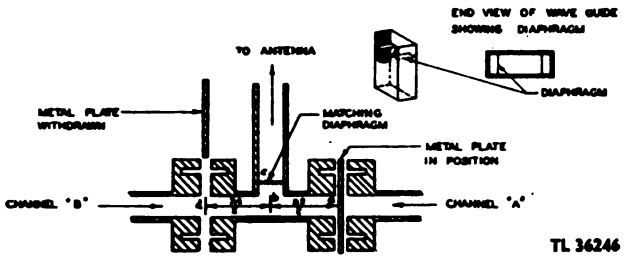


Figure 102. Waveguide T-section, cutaway view.

length from the T-junction. The two sidearms of the T are alternately blocked by rotating shutters, thereby applying a short circuit on alternate sidearm channels at the junction point with the main transmission line. This action is similar to the action of the r-f channel switch explained in the previous subparagraph. As the shutter disks rotate, first one antenna and then the other is energized.

(2) During the period that the elevation antenna is energized, the width of the elevation array waveguide is varied, thereby causing the radiated beam to sweep through its elevation sector. The eccentric which drives the antenna scanner is so designed that the waveguide motion does not scan the beam in the return direction until the r-f switch re-energizes that antenna (fig. 104). In the meantime, the other antenna has been energized and its beam has scanned in one direction, remaining at the end of its scan until the next period that this antenna is energized.

(3) The antenna switch and scanning mechanism are operated by a ¼-horsepower, 115-volt a-c electric motor. In order to provide a dual scanning speed for the precision antennas, two motors are used. The motors are

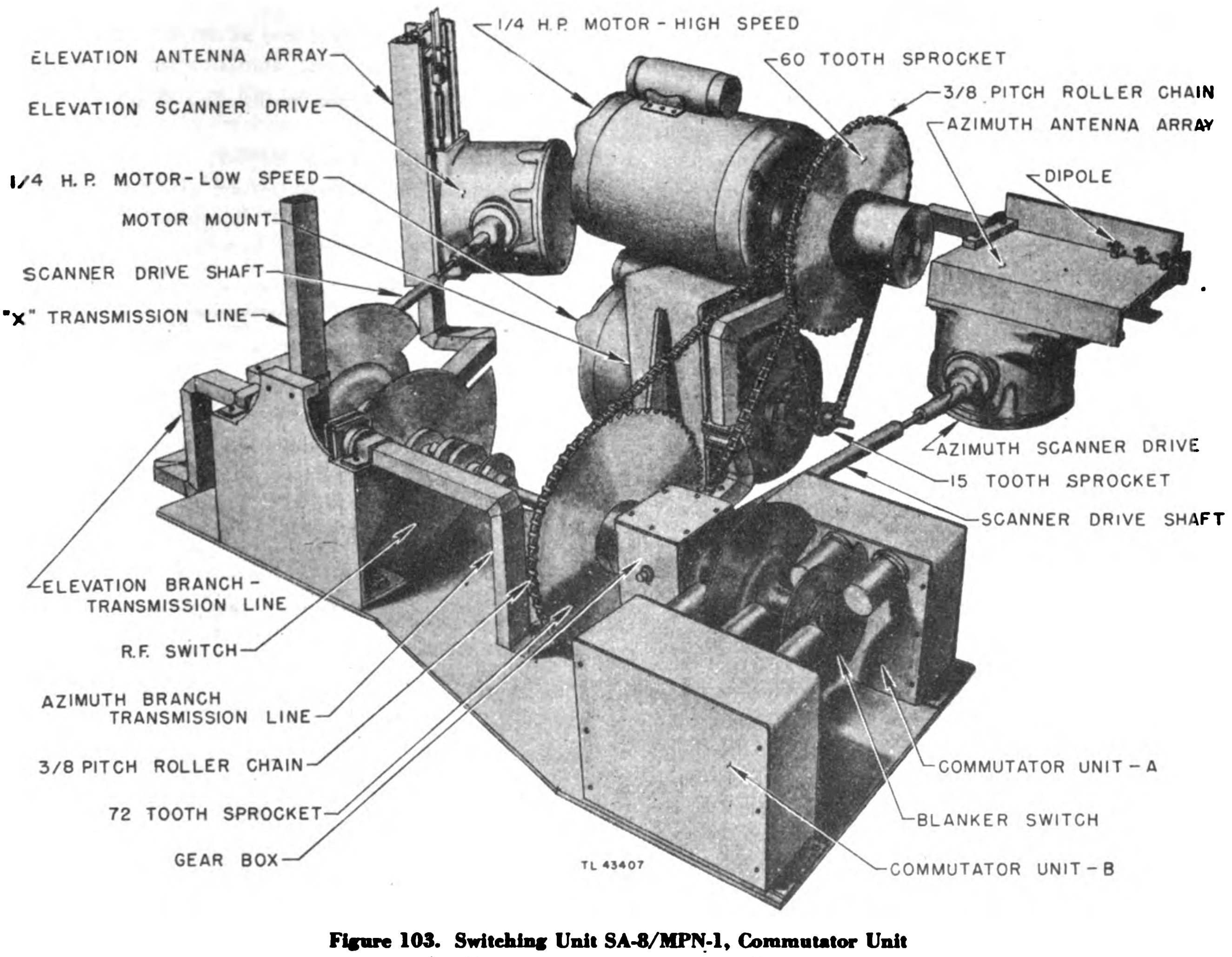


Figure 103. Switching Unit SA-8/MPN-1, Commutator Unit SA-40/MPN-1, and Motor Drive Unit PU-38/MPN-1.

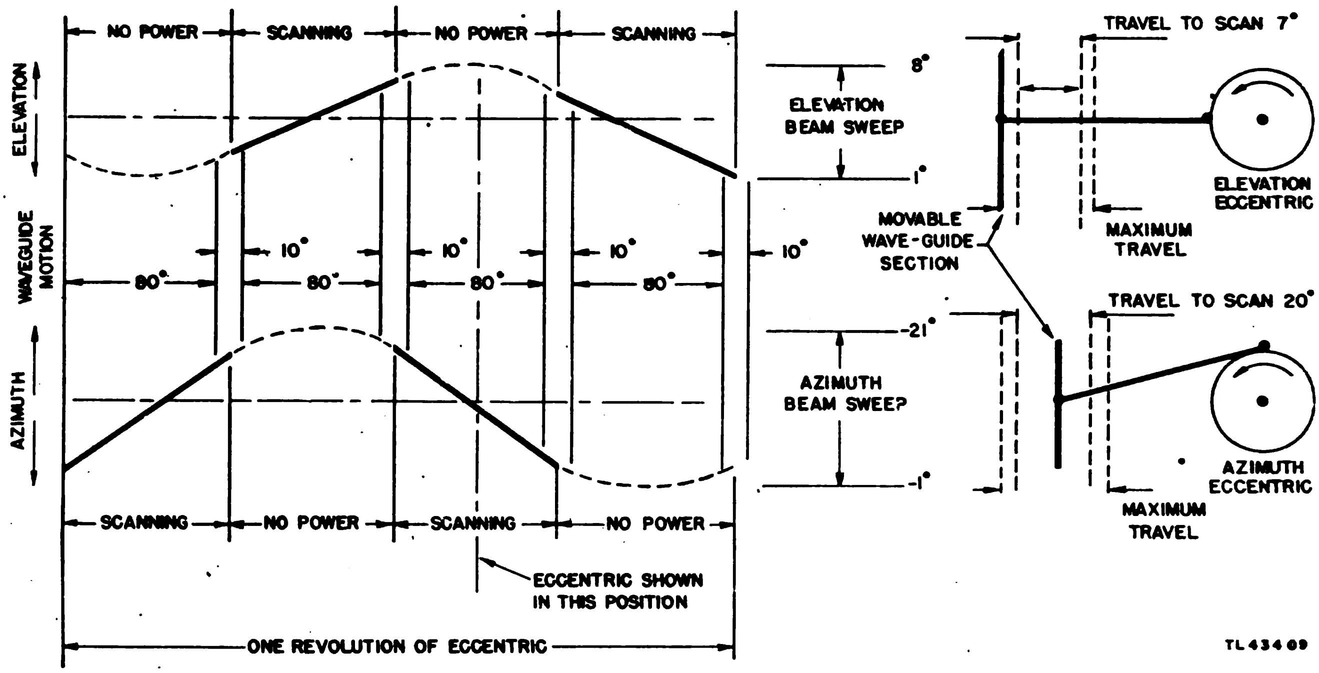


Figure 104. Precision antenna switching cycle.

identical and operate at the same speed, but are fitted with different diameter pulleys for a chain drive. The two pulleys are connected through a free-wheeling clutch and the shaft of the motor with the larger pulley is chain-connected to the rotating shaft of the switching unit drive.

(4) Only one motor is energized at a time, the selection being made by the azimuth tracker. If the motor having the smaller pulley is in use, the other motor will rotate and drive the chained pulley on the main drive shaft. However, if the larger pulley motor is energized, the clutch disconnects the other motor armature from the drive shaft and thus avoids having that motor driven at an excessive speed. The two driving speeds are at a four-to-one ratio. When the motor with the larger pulley is driving, the antennas are alternately energized and scanned at a rate to provide four "looks" a second per antenna. When the slower speed drive is applied, the rate is one "look" a second per antenna.

(5) The slower drive is provided to develop a greater concentration of transmitted energy upon a target near the extreme limits of the precision range. With the rapid scanning rate, approximately 250 pulses are transmitted during the ⅛-second period of each scan. At the limits of the range, therefore, these pulses are so widely separated that they may not detect all targets. At the slower rate, 1,000 pulses are emitted per scan, giving four times greater coverage of the scanned area.

(6) The shaft that drives the r-f antenna switch shutter disks also drives the photoelectric commutator disks. The operation of the commutator is explained under the scan synchronizing and antenna positioning system, section VII of this chapter.

f. Selector Line CG-25/MPN-1. (1) This line is a device for sampling a fixed portion of the transmitted power from the X-band r-f unit. It consists of a section of standard waveguide mounted in series with the trans-

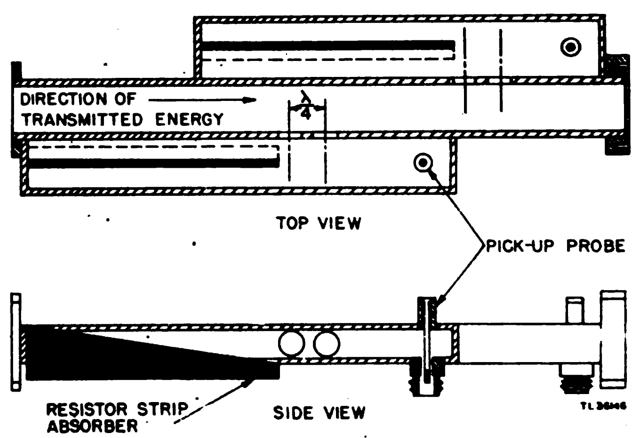


Figure 105. Selector Line CG-25/MPN-1, cutaway view.

mitter output and the main transmission line to the antennas. Two power sampling waveguide sections are built on flush with the narrow sides of the main guide section (fig. 105). Circular apertures are cut into the walls between the guide sections to permit leakage of the r-f power, and are spaced a quarter-wavelength apart. Each of the superimposed sections has a pick-up probe set into the wide side of the guide and terminating in a standard coaxial connector. At the opposite end of the section is inserted a 100-ohm resistor strip absorber. The sampling sections are staggered in their placement on the main guide but face in the same direction, since they are both used to sample output power. One can be used with a thermistor bridge type of r-f power meter, while at the same time the other is used with an echo box for determining the general efficiency of the system to that point.

(2) The r-f power to be measured is separated from any reflected waves which may be present in the following manner: Energy from the r-f unit enters the line from the flanged end, and as it passes the circular apertures in the side wall, a portion leaks out through each of the openings, and recombines to travel in the same direction within the side section. Since the travel is in the same direction, the spacing of the holes is of little effect, and the wave fronts recombine in the same phase to be picked up by the coupling probe. Reflected energy traveling back through the guide from the choke termination also leaks through the circular apertures; in the direction of the pick-up probe it can be seen that the energy recombines in an out-of-phase condition, since energy entering through the second aperture has traveled a total of a half-wavelength farther. In the direction of the main reflected wave, whatever energy enters the section is absorbed in the load or resistor unit. This identical action takes place in both power sampling sections.

48. T-R AND R-T SWITCHES.

a. General. The T-R and R-T switches used in the precision r-f system are identical in theoretical operation with the T-R switch discussed under the search r-f system, chapter 2, section III. However, the physical construction of the tubes in the two systems differs, and an additional R-T tube is used in the precision r-f system. Two short branching waveguide sections, located near the magnetron, are set into the narrow side of the main waveguide leading to the antenna. The first leads to the R-T switch and the second to the T-R switch and continues on through the mixer. Their construction is similar except that the R-T branch terminates a quarter-wavelength beyond the R-T tube, and the T-R branch continues beyond the T-R tube to the mixer.

b. Transmission. As in the search system, the main transmitted pulse traveling down the waveguide causes the T-R and R-T spark gaps to fire, producing an apparent short circuit at their junction points with the main waveguide (fig. 107a). Thus the transmitted pulse travels down the length of the guide to the antenna arrays and very little energy reaches the sensitive crystal in the receiver mixer stage.

c. Reception. At the end of the transmitted pulse the R-T and T-R arcs quench quickly, due to the water vapor content in the tubes, and the conditions are essentially

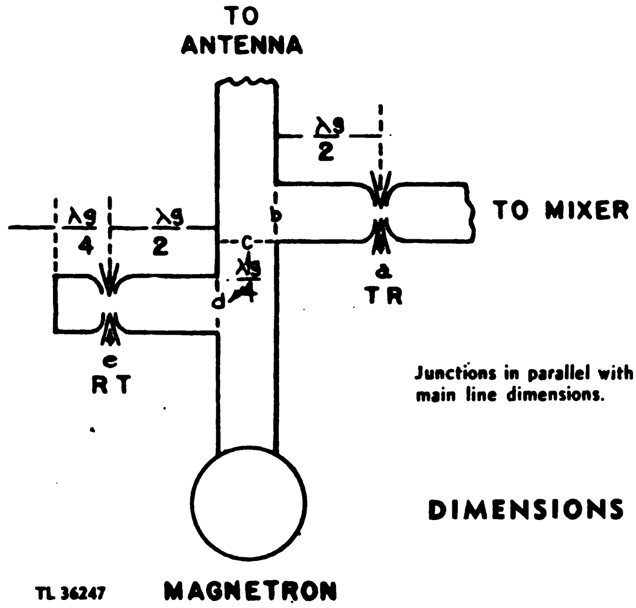


Figure 106. T-R and R-T switches, major dimensions.

reversed. The R-T tube no longer shorts its half-wave stub, but allows energy to flow freely to the closed end of the stub one-quarter wavelength farther (fig. 107b). This closed end is a short circuit which is reflected as an open circuit at the junction point with the main guide and hence as a short circuit across the guide at the point c, one-quarter wavelength farther. This will have much the same effect as though the guide were closed off by a sheet of metal at this point. Likewise the T-R tube does not short its half-wave stub and hence no longer reflects a short across its junction point with the main guide. Thus nearly all of the reflected energy from the antenna is diverted, by the apparent wall, through the T-R branch and T-R tube, and cavity to the mixer, with very little loss in the magnetron section.

49. PRECISION ANTENNA SYSTEM.

a. General. Two antennas are included in the precision system of Radio Set AN/MPN-1, one scanning in the elevation plane and the other in the azimuth plane. The two antennas are fed energy alternately from the X-band transmitter through an r-f switch described in paragraph 47 *e*, a part of Switching Unit SA-8/MPN-1. The method of antenna scanning is the same for both antenna systems.

b. Elevation Antenna Assembly AS-42/MPN-1. (1) The elevation antenna assembly comprises an Elevation Array AS-43/MPN-1 and an Elevation Reflector AT-21/MPN-1. The antenna array consists of a rectangular section of X-band waveguide, 14 feet long, supporting a linear broadside array of 173 British-type slotted dipoles. The dipoles are spaced 2.3 centimeters apart, producing a beam 0.4 degree wide in elevation. The development of the slotted dipole is explained under the search antenna array, chapter 2, section III.

(2) The slotted dipoles are mounted along the wide side of the supporting waveguide with the center conductor extending into the guide as a pick-up probe. The insertion depth of the dipole probes is varied along the length of the array to produce a "gable" distribution of power. The penetration depth of the probes into the waveguide is increased in groups of 10 for the first 80 dipoles from the feed end in order to develop a substantially uniform increase of power radiated from successive dipoles. Thereafter the depth of insertion is maintained constant and the attenuation in the waveguide gives an approximately uniform decrease of power along the remainder of the array. This type of energy distribution is utilized in order to reduce side lobes to a minimum. To avoid end-fire effects, the feed to alternate dipoles is reversed so that the dipoles may be spaced approximately a half-wavelength apart. The small percentage of power not picked up by the probes and reaching the far end of the guide is dissipated by an attached load or absorber unit. This prevents formation of high standing waves due to reflection.

(3) The construction of the supporting waveguide section is not in a single section as was the search antenna array, but consists of two parallel members, one movable upon the other. Thus the internal dimensions of the waveguide may be varied (fig. 108). This variation in guide width alters the apparent wavelength, or distance between interference maxima of radiation traveling along the guide, and thus changes the relative phase at which the dipoles are fed. The change in phase alters the effective direction of the radiated combined wave front or beam.

(4) When the dipole spacing is exactly a half-wavelength, it is found that large standing waves appear in the guide because of the reflections from individual probes returning in phase with the input into the guide. The probe spacing is therefore made slightly greater than half the maximum wavelength in the guide. As a result, the wave front is never perpendicular, and the radiation beam angle does not pass through the normal to the array. The beam angle is tilted from the normal toward the load end of the antenna.

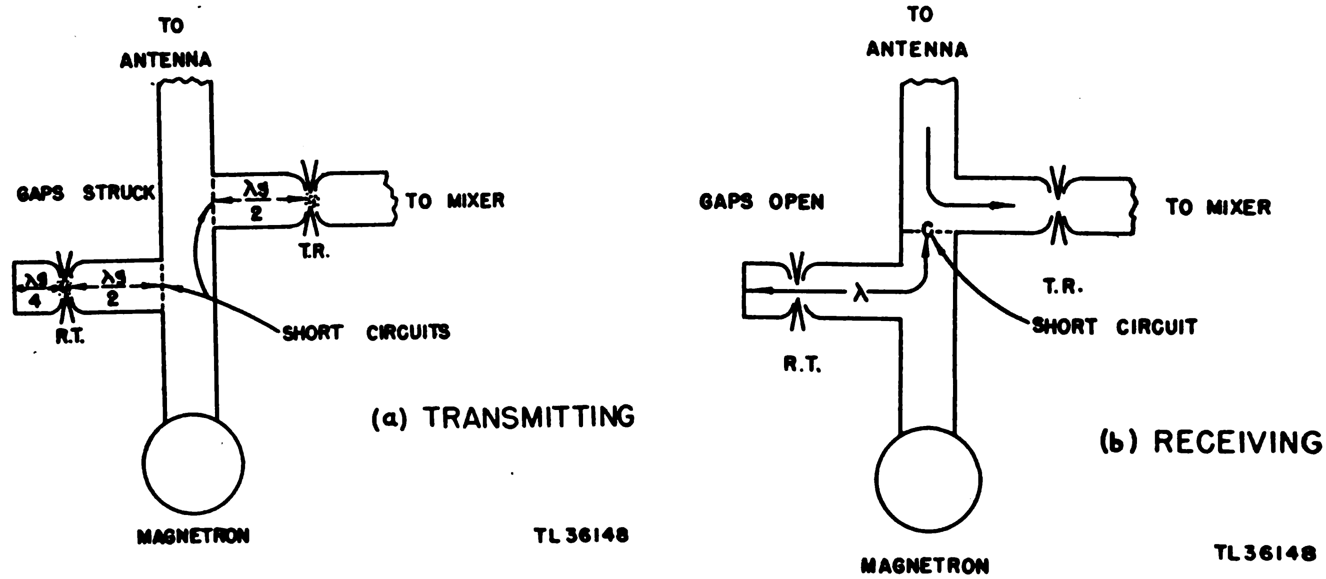
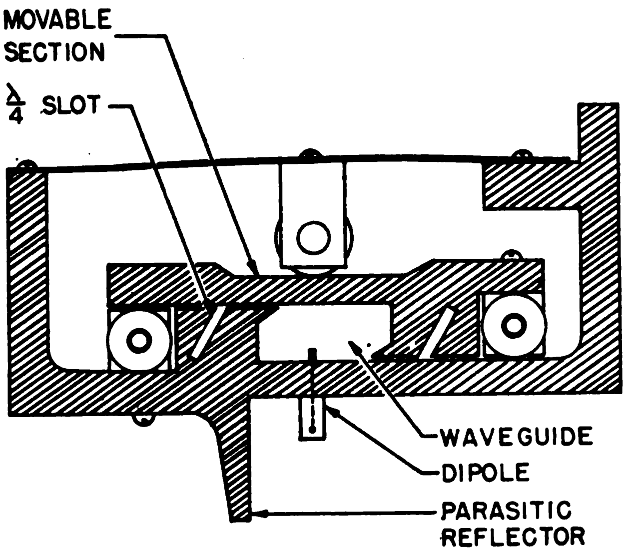


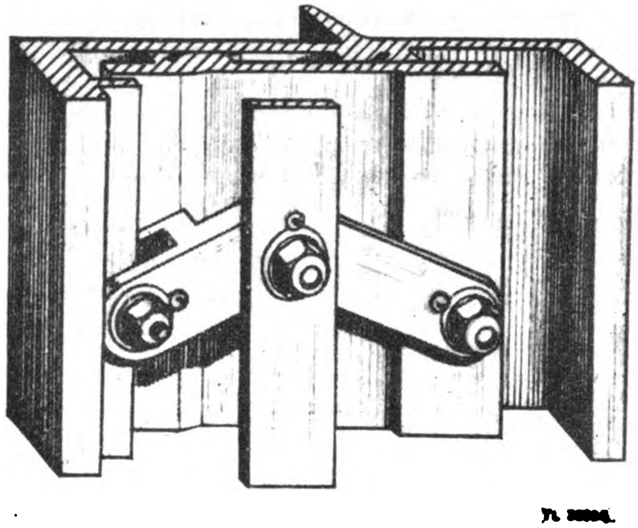
Figure 107. T-R and R-T switching system.

(5) During the period in which the antenna is energized, the minimum width of the waveguide corresponds to a radiation beam position of 1 degree to the normal (fig. 109a). As the wall of the waveguide is driven outward, the wavelength in the guide is shortened and radiation from any particular dipole now leaves at an earlier instant than before, relative to the preceding dipole. As the guide becomes progressively wider, the combined wave front of radiation is tilted at a progressively greater angle from the normal (fig. 109b). By oscillating the movable wall of the guide, the beam can be made to scan over a limited sector. This method of electrical scan is applied in the elevation antenna to give a scanning angle range of from 1 degree to 8 degrees on the side of the normal toward the load end of the array.

(6) To prevent power leakage between the stationary waveguide section and the movable section, quarter-wave



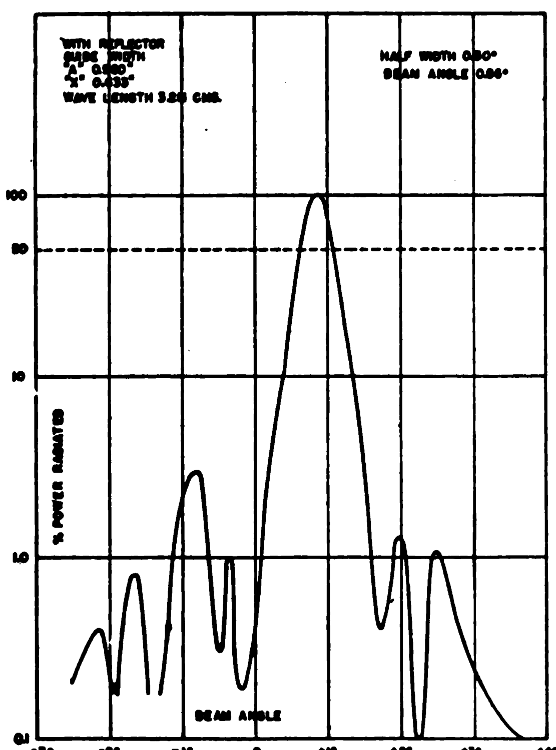
(a) Scanner cross-section.



(b) Scanner link assembly.

Figure 108. Variable cross-section waveguide.

slots are cut into both members, in such positions that at the junctions between sections an effective shorted half-wavelength stub prevents power losses (fig. 108a). (7) So that the choke-terminated transmission line will always match the changing impedance of the variable width waveguide section, the early models of Radio Set AN/MPN-1 have a constant aperture transformer section terminating the waveguide (fig. 110). Pivoted at both



(a) Minimum guide width.

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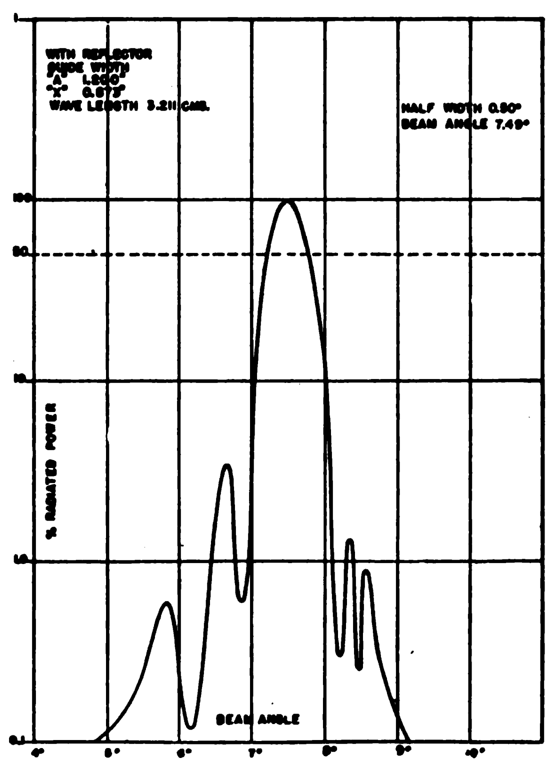


(b) Maximum guide width.

Figure 109. Elevation antenna scanning patterns.

ends, the outer end maintains a 1-inch fixed opening, while the other end, attached to the movable section, varies with its back and forth motion. In its 6-inch length, this transformer section provided a continually varying change in conductance characteristics of low order, and it was supposed to prevent any large and sudden discontinuities which would cause reflections. However, the section was found unnecessary, and was removed from later models.

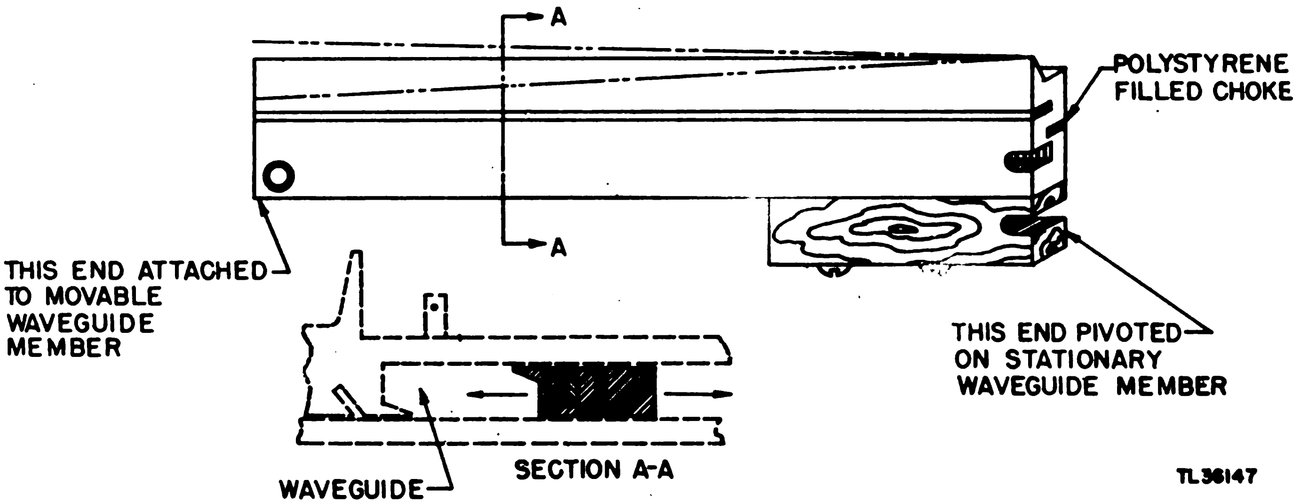


Figure 110. Constant aperture waveguide termination.

(8) The movable waveguide wall is supported and mechanically driven by pairs of toggle arms driven longitudinally by a rigid linking bar (fig. 108b). The pivoted end of the linking bar is driven in a reciprocal motion by a vertical arm connected to a four-to-one reduction eccentric and gear box mounted on the waveguide member. Driving force to the gear mechanism is applied through two universal joints and a drive shaft from an electric motor. a part of the switching unit, which also drives a similar mechanism on the azimuth antenna as well as the r-f switching assembly.

(9) The fraction of input power radiated by the antenna varies with the waveguide width, the average level of probe depth being so designed that about 5 percent of the input power emerges from the waveguide at the load end when the width is at its minimum point. This power is completely dissipated in a load or absorber unit, containing a mixture of graphite and sand, and equipped with external heat-radiating fins.

(10) The antenna array is placed along the vertical focal line of the elevation reflector. a cylindrical reflector of parabolic cross-section. The reflector is 14 feet long by 2 feet 2 inches wide and reduces the beam width to approximately 3 degrees in azimuth. The dipole array is backed by a narrow parasitic reflector forming a part of the supporting waveguide and insuring that all the energy radiated from the array will illuminate the reflector (fig. 111). The wide face of the waveguide feed, along with the parasitic reflector, functions to direct the radiated energy into only the upper half of a parabolic cross-section reflector. Thus the lower section is not needed and only a half parabolic cross-section reflector is used. Besides reducing the physical size of the reflector this type of beam direction minimizes the side lobe radiation on the side of the reflector towards the dipole array.

(11) The antenna assembly is pivoted on its base for proper orientation of the antenna beam and it can be rotated through 20 degrees in azimuth by means of a mechanical follower system. The follower system for the elevation antenna is controlled by the azimuth tracker's foot pedals.

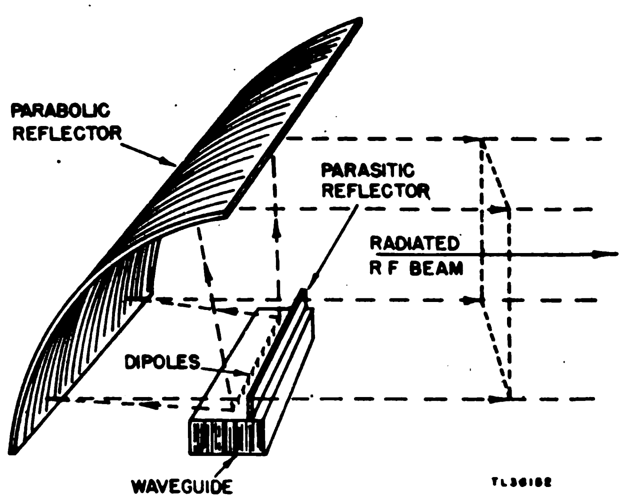
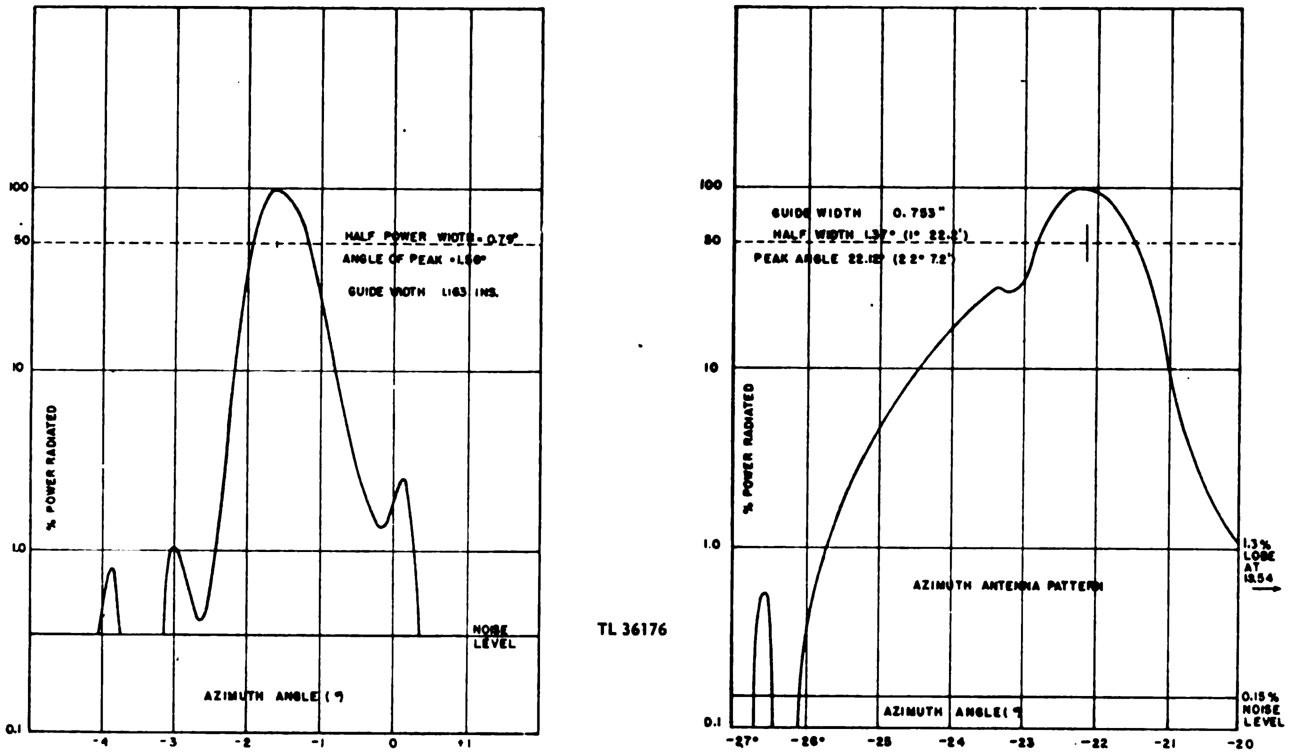


Figure 111. Formation of precision beam.



(a) Maximum guide width. (b) Minimum guide width.

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Figure 112. Azimuth antenna scanning patterns.

c. Azimuth Antenna Assembly AS-40/MPN-1. (1) The azimuth antenna assembly is comprised of Azimuth Antenna Array AS-41/MPN-1, and Azimuth Reflector AT-20/MPN-1. This assembly is similar in design and construction to the elevation antenna assembly described in the foregoing subparagraph. In this antenna, the supporting waveguide member is 8 feet 6 inches long, with a linear broadside array mounted along its wide side consisting of 121 dipoles spaced 1.9 centimeters apart. The beam produced by this array is 0.6 degree wide in azimuth.

(2) This spacing is slightly less than half the minimum wavelength in the guide so that the beam is tilted 1 degree from the normal toward the feed end when the rotating switch blades transfer the r-f energy to the elevation antenna (fig. 112a). As the guide wall is driven inward, the angle of tilt increases toward the feed end of the array to a maximum of 21 degrees from the normal (fig. 112b) at which point the r-f energy is again transferred to the elevation antenna.

(3) The probe depth variation is the same as in the case of the elevation array, however, the initial probe depth is greater since the same power has to be radiated from a smaller number of dipoles. The eccentric, which produces the motion of the waveguide wall, is made less symmetrical than the elevation antenna eccentric in order to transmit a greater lateral movement to the wall thereby achieving a larger scanning angle. The eccentrics driving the two antennas are set to operate 90 degrees out of phase with each other.

(4) The array is placed along the horizontal focal line of a cylindrical reflector of semiparabolic cross-section. The aperture of the parabolic cross-section is 3 feet 6 inches wide and reduces the beam width to 1.5 degrees in elevation. The entire assembly is fixed horizontally on its base, but can be moved 5 degrees in elevation by the follower system controlled by the elevation tracker's foot pedals.

SECTION IV

RECEIVING SYSTEM

50. INTRODUCTION. The function of the precision receiving system is to amplify the received r-f echo signals from the precision antennas, detect these signals and distribute the resulting video echo pulses to the various indicator tubes in the precision indicating system. Basically the precision receiving system is the same as the search receiving system previously described in chapter 2, section IV. The main difference between the two systems lies in the local oscillator and crystal detector and in the mixer stages which were designed to operate at the higher frequency of the precision system. As in the search system, two identical receiving systems are utilized, one being used in channel A and the other in channel B of Radio Set AN/MPN-1. A block diagram of the receiving system is shown in figure 113 and should be referred to during the following brief description of the precision receiving system. The precision receiving system is physically divided into two units; the X-band heterodyne converter located in Radio Frequency Unit RF-6/MPN-1, and the Radar Receiver R-38/MPN-1. The X-band heterodyne converter consists of the X-band receiver local oscillator, the crystal detector and mixer, and two stages of r-f preamplification (fig. 95). The converter is mounted close to the associated transmitting magnetron to avoid the use of long lengths of r-f transmission line or waveguide with the resultant loss of power in the reflected echo. This assembly of receiver elements is duplicated in the radio frequency unit, one converter being used with the channel in operation and the other being maintained in a stand-by condition as part of the B channel. The r-f input to the heterodyne converter in operation is obtained from the T-R tube associated with that converter, and is mixed, detected, and amplified in the converter assembly. In the form of i-f energy, the signal is applied to the input of Radar Receiver R-38/MPN-1 for conversion into video impulses.

a. Local Oscillator. (1) The local oscillator tube V3 is a type 723A klystron, capable of producing low-power oscillations over a fairly wide frequency range in the *X* band. In this type of ultra-high-frequency generator a single resonant cavity is used in the oscillating circuit and the velocity-modulated electron stream traverses the cavity twice by use of a repeller electrode or reflector. Changes in the physical spacing of the cavity grids varies the frequency of oscillations. An adjustment for varying the cavity grid spacing is provided on the tube.

(2) The r-f energy is obtained from the oscillator by means of a coupling loop inserted into the cavity. A tiny concentric line forms the leadout from the coupling loop. The resonant cavity is maintained at the same positive potential as the accelerating grid within the tube envelope. The cathode source of electrons within the tube is held at ground potential. The emitted electron stream must pass through the central aperture of the doughnut-shaped cavity.

(3) The oscillating frequency of the local oscillator is a function of the reflector voltage, the cavity size and accelerating voltage being constant. The negative voltage

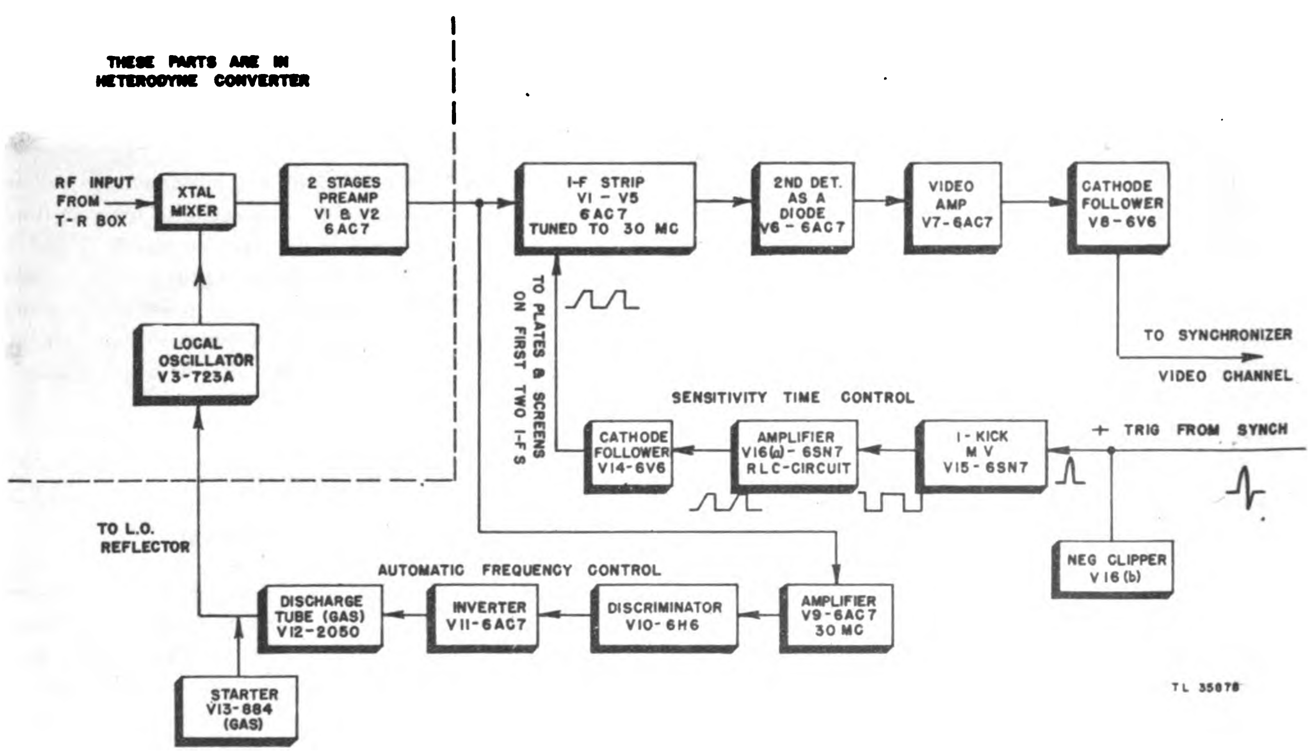

Figure 113. Precision receiving system, block diagram.

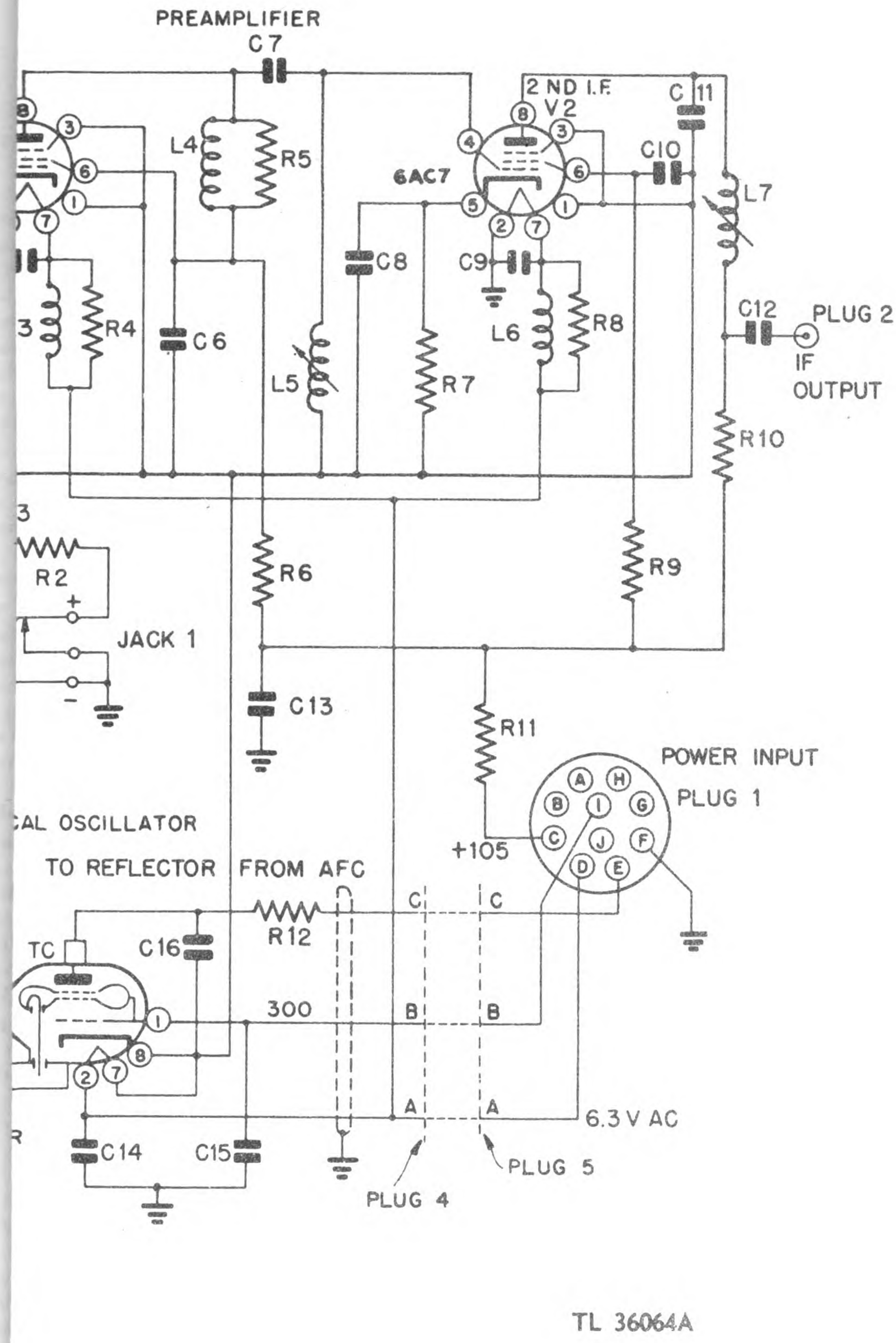

Figure 114. X-band preamplifier and heterodyne converter, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	47 Ohm	½W	10%
R2	47 Ohm	½W	10%
R3	47 Ohm	½W	10%
R4	1 Meg	½W	20%
R5	820 Ohm	½W	10%
R6	220 Ohm	½W	10%
R7	47 Ohm	½W	10%
R8	1 Meg	½W	20%
R9	220 Ohm	½W	10%
R10	1500 Ohm	1W	10%
R11	220 Ohm	½W	10%
R12	22000 Ohm	½W	10%
C1	10 mmfd	300V	20%
C2	.01 mfd	300V	20%
C3	.001 mfd	300V	20%
C4	.001 mfd	300V	20%
C5	.001 mfd	300V	20%
C6	.001 mfd	300V	20%
C7	.0001 mfd	500V	10%
C8	.001 mfd	300V	20%
C9	.001 mfd	300V	20%
C10	.001 mfd	300V	20%
C11	10 mmfd	300V	20%
C12	.01 mfd	300V	20%
C13	.01 mfd	300V	20%
C14	.001 mfd	300V	20%
C15	.001 mfd	300V	20%
C16	.001 mfd	300V	20%
L1	BOO-4934-1		
L2	BOO-4934-1		
L3	AOO-4417		
L4	AOO-4418		
L5	BOO-4934-3		
L6	AOO-4417		
L7	BOO-4934-4		
		Mfr. No.	
V1	VT-112	6AC7	
V2	VT-112	6AC7	
V3		723A	
J1	A2	MALLORY	
PL1	AN-3106-18-1P		
PL2	AN-3106-8S-1S		
PL3	C1U-49284 MENDELSOHN		
PL4	AN-3106-16S-5P		
PL5	AN-3102-16S-5S		

applied to the reflector is derived from the automatic frequency control (AFC) circuit in the receiver proper. This type of electrical tuning keeps the local oscillator in operation at a frequency which, when beat against the reflected r-f signal, produces an intermediate frequency at 30 megacycles.

b. Crystal Detector and Mixer. In the precision system, the transmitted frequency is so high that rather than attempt amplification of the reflected signal at the transmitted frequency it has been found necessary to convert the echo signal into an intermediate frequency of 30 megacycles before amplification. Frequency conversion is accomplished by use of a crystal detector inserted across a mixer cavity in a direction parallel to the electric field. R-f energy from the local oscillator is fed into the mixer cavity by means of an exciting probe, and echo signals passing through the T-R switch from the antenna system are fed directly into the cavity from the T-R tube. The 30 megacycle output of the crystal mixer is applied directly to the input of the i-f preamplifier through a short length of coaxial cable.

c. Preamplifier Unit. Before application to the receiver, the i-f output of the crystal detector is applied to two stages of low gain amplification provided in the preamplifier unit. The amplified output is brought out at the coaxial fitting, plug 2, and is transmitted through a low-impedance coaxial cable to the input of the X-band receiver. Power for operating the local oscillator and preamplifier stages is supplied at power input plug 1 through a five-conductor cable from the receiver.

d. Precision Receiver. (1) Two Radar Receivers R-38/MPN-1 are used in the X-band precision system. One receiver is used in actual operation while the other receiver is maintained for stand-by purposes. The receivers are identical in all respects, and interchangeable with the search system receivers. To each receiver is applied the output from one of the heterodyne converter units in Radio Frequency Unit RF-6/MPN-1. The video output from either receiver may be applied to both precision indicators through the channel switching relays mounted above the indicators.

(2) The sensitivity-time-control (STC) circuit which is inoperative in the search receivers is used in the precision receivers to vary the receiver gain with respect to the range of the echo signals. In this way, short range echo signals which are relatively strong receive less amplification than long range signals which are weak. Without this arrangement, the receiver gain would necessarily have to be high enough to receive distant signals satisfactorily, and as a result strong signals from near-by ground objects would saturate the indicators and completely obscure any near-by target signals.

51. LOCAL OSCILLATOR.

a. General. The local oscillator tube used in the heterodyne converter is a special type of vacuum tube known as the reflex klystron. This tube is similar in operation to the klystron oscillator used in the search receiving system. It is necessary to use a klystron type tube in order to generate the ultra-high frequency oscillations required for frequency conversion. An ordinary type vacuum tube is unsatisfactory at these frequencies. Power for the reflex klystron is obtained from the supply of the respective Radar Receiver R-38/MPN-1 through an interconnecting cable connected to power input plug 1 (fig. 114).

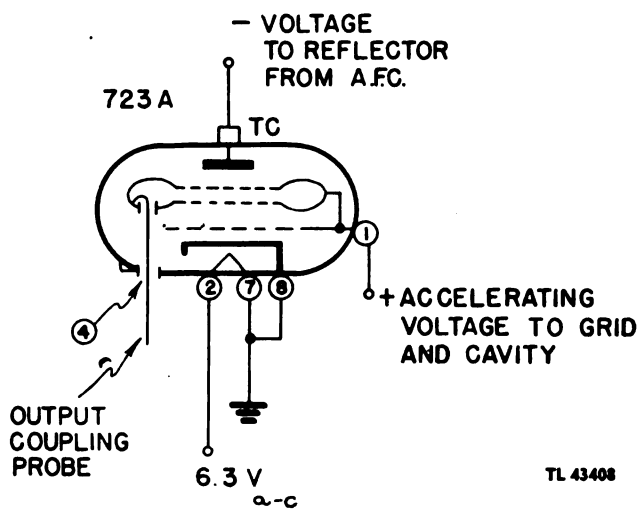

Figure 115. X-band local oscillator, schematic diagram.

b. Klystron Operation. The schematic circuit of the local oscillator tube V3, a type 723A Shepard-Pierce reflex klystron, is shown in figure 115. A stream of electrons emitted from the cathode is accelerated and focused by a grid maintained at a positive potential of from 200 to 300 volts. Electrically connected to this grid, at the same potential, is a resonant cavity whose physical dimensions permit the storage of energy in the form of electric and magnetic fields. The electron stream from the cathode passes through the cavity which functions as the tuned circuit of the oscillator and "bunches" or modulates the flow of electrons. After passing through the cavity the electron stream is subjected to a negative or decelerating field created by a reflector anode, or repeller, which is located on the far side of the cavity and is maintained at a negative potential. As a result of this negative field, the bunched electrons are reversed in direction and travel back through the cavity. Thus the electron beam passes through the cavity grids twice. The oscillations are produced as the result of the electrons on the walls surging back and forth at the approximate resonant frequency of the cavity, or 9,000,000,000 times a second (9,000 mc). During these oscillations, the electrons on the walls of the cavity pile up first on one grid and then on the other, thus producing an electric field between the two grids of the cavity. This electric field alternately speeds up and slows down the beam of electrons as it passes through the cavity grids. This action results in a grouping or bunching of the electrons in the beam. If the reflected bunches of electrons from the repeller anode arrive at the cavity grids at the proper instant, the oscillations will be reinforced and continuous r-f oscillations will result. Whether or not the oscillations are reinforced and maintained depends upon the tuning of the resonant cavity, the spacing between the cavity grids, and the voltage applied to the various electrodes of the tube. The reflector voltage determines the time taken for the bunches of electrons to be reflected back to the cavity grids where they give up their energy and support oscillations only if they arrive at the proper instants.

*c. **Tuning and Coupling.*** (1) Since oscillation depends upon the combination of the velocity imparted to the electron stream and the energy storage characteristics of the cavity, factors controlling the frequency of oscillations are as follows:

(*a*) Physical dimensions of the cavity and cavity grid spacing.

(*b*) Positive voltage applied to the accelerating grid and cavity.

(*c*) Negative voltage applied to the reflector.

(2) A number of combinations of these three variables can produce oscillations, each combination being referred to as a mode of operation. However, one particular combination of the three variables will usually result in a mode which produces oscillations of maximum power output. In this circuit the cavity and grid voltage is maintained at approximately 300 volts positive and the negative reflector voltage is varied to produce the desired oscillation frequency. This electrical tuning provides a variable range of approximately 20 megacycles, the frequency varying at an approximate rate of 0.6 megacycles per volt of reflector voltage variation. Negative variations of reflector voltage increases the frequency of oscillation while a less negative voltage decreases the frequency.

(3) The oscillation frequency is also dependent upon the spacing of the resonant cavity grids as well as on the voltages. Changes in the grid spacing vary the frequency. An adjustment for flexing the tube envelope and thereby varying the cavity grid spacing is provided for on the tube. This is a coarse adjustment only and should not be used unless the frequency is too far from the desired range to be brought back by voltage variation.

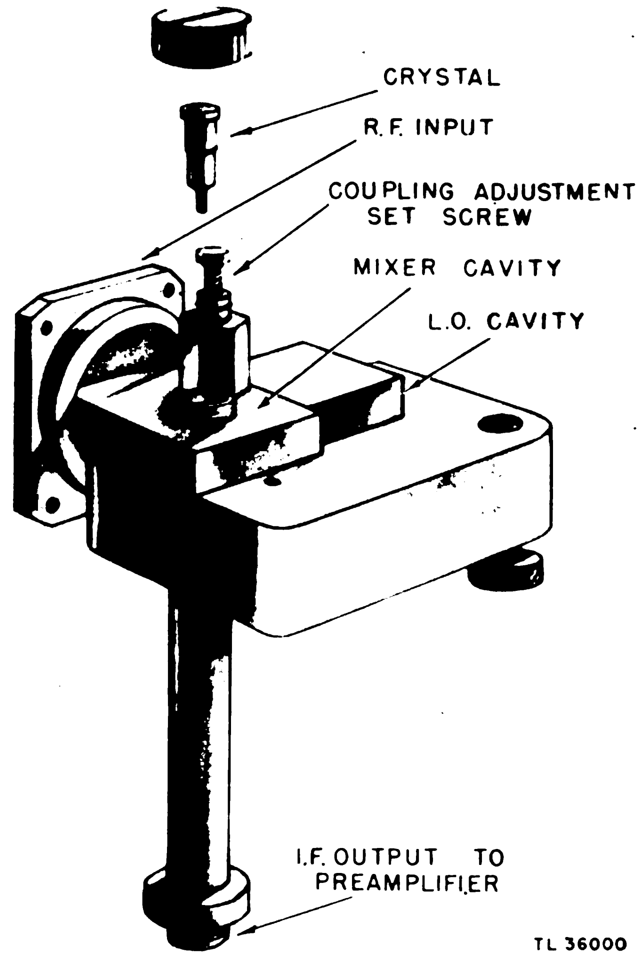

Figure 116. X-band crystal mixer.

CAUTION: Extreme care should be exercised in making the foregoing adjustments. The metal parts of the tube are at 300 volts, with respect to ground, and 500 volts exist between the shell of the tube and the reflector cap. These voltages are sufficient to cause serious injury. Do not tighten the screw too tightly, as excessive strain may permanently distort the cavity dimensions thereby damaging the tube.

(4) R-f energy is obtained from the oscillator by means of a coupling loop inserted into the cavity. A tiny concentric line forms the leadout from the coupling loop. A probe, longer than the other pins, extends upward entirely through the tube socket in the pin 4 position, and projects into the section of the waveguide upon which the tube is mounted (fig. 117). This probe serves to feed the local oscillator energy into the mixer cavity containing the crystal detector.

(5) A negative voltage derived from the automatic frequency-control (AFC) circuit in the receiver is applied to the reflector of the local oscillator tube. Variations in this voltage serve to vary the local oscillator frequency to make it always 30 megacycles higher than the X-band transmitter frequency; thus the intermediate frequency developed remains at 30 megacycles.

d. Indications of Oscillation. When the klystron tube goes into oscillation, the crystal current, as indicated on a milliammeter plugged into J1, will rise sharply. This meter indicates the rectified current produced by the local oscillator output flowing through the crystal detector. The crystal current reading therefore is a convenient indication of whether or not the klystron is oscillating, and of its relative output. The normal crystal current reading should be between 0.5 and 0.6 milliamperes. If the klystron should go out of oscillation it will be indicated by a sudden drop in crystal current.

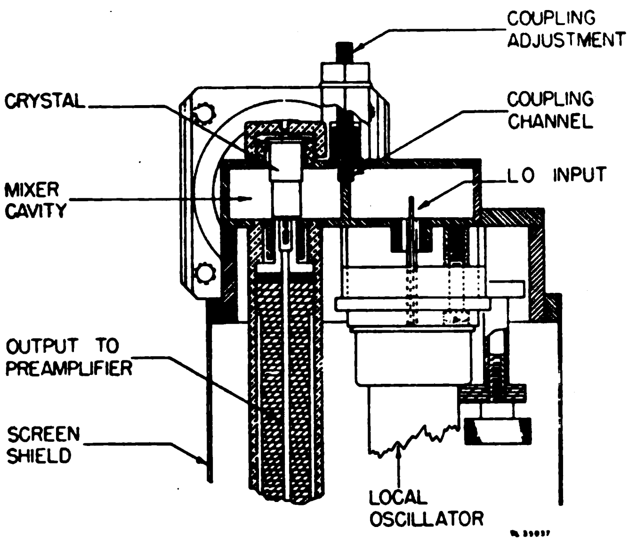

Figure 117. X-band heterodyne converter, cutaway view.

52. CRYSTAL DETECTOR AND MIXER.

a. General. The crystal mixer section of the heterodyne converter (fig. 116) functions as a mixer for the received echo signals and the output of the local oscillator, thereby producing a lower intermediate-frequency signal which can be more readily amplified to the desired level before detection. The frequency of the klystron local oscillator is adjusted to 30 megacycles above the frequency of the transmitting oscillator: and in the crystal mixer, the two frequencies are combined to produce a difference in frequency of 30 megacycles. The crystal mixer contains a specially designed silicon crystal detector mounted in a mixer cavity as shown in the cross-sectional view of the mixer (fig. 117). The entire unit is contained in a single mounting and is connected to the waveguide on the receiver side of the T-R tube (fig. 113).

b. Crystal Mixer Operation. The operation of the crystal mixer can best be explained by reference to figure 117. Echo signals passing through the T-R tube from the antennas are fed directly into the mixer cavity, while energy from the local oscillator is fed into the mixer by means of a short probe and a small adjustable restriction or channel. Since both signals are introduced into the mixer cavity, it may be considered as the mixer, although the actual mixing and detection are done in the crystal. No tuning adjustments are incorporated for matching the crystal to the waveguide, the entire assembly being pretuned. Energies from the two sources, at frequencies 30 megacycles apart, are present in the waveguide and are impressed upon the crystal. Here they are mixed, and as a result of the crystal rectifying action, appear in the crystal output lead (the cat's whisker) as detected i-f oscillation.

c. Mounting of Crystal. The silicon rectifying crystal is enclosed in a cartridge-type holder, into which is inserted a tungsten "cat's whisker" for making contact with the crystal. The cartridge is inserted across the mixer cavity in a direction parallel to the electric field. A threaded, knurled cap screws down over the crystal, holding it in place.

d. Crystal Mixer Coupling. Since the input echo signal is always weak, the coupling of the crystal mixer to the T-R tube is as tight as possible. On the other hand, since the output of the klystron is very much stronger, it is only loosely coupled to the crystal mixer; as a result of this loose coupling only a very small part of the echo signal is lost in the oscillator coupling. To prevent overload and damage to the crystal, the amount of energy from the local oscillator fed to the mixer chamber is adjustable. The energy from the local oscillator is injected into a separate chamber connected to the mixer cavity by a narrow passage. An adjustable setscrew is inserted into this passage and acts as a gate to control the amount of local oscillator energy fed through to the mixer chamber. Adjustment of the coupling may be made by loosening the locknut and turning the slotted setscrew.

e. Measurement of Crystal Current. A shorting-type jack J1 connects one side of the crystal output to ground through resistors R1 and R2 and inductance L1, as shown in figure 114. Since capacitors C2 and C3 will bypass all r-f current to ground, a milliammeter plugged into J1 will indicate only the d-c crystal current. This current should be between 0.5 and 0.6 milliamperes for best operation of the crystal. It should not exceed 0.7

milliamperes. A cord and plug is available inside the door on the precision transmitter chassis and may be plugged into the crystal metering jack of either the A or B channel as required. This cord leads to the meter circuit of Control Box C-61/MPN-1 where the crystal current is read for both the search and precision systems.

f. Care in Handling. The static discharge from an ungrounded piece of equipment or from the operator's person may burn out a crystal when it is being inserted in the mixer cavity. Avoid such discharges by holding the cartridge by the base and making electrical contact with the equipment through the hand before inserting the cartridge. Do not drop crystals nor subject them to heat or to strong r-f electrical fields generated by this equipment.

> CAUTION: The crystals used in this detector are extremely sensitive and will be damaged if not treated carefully. Any of the following actions may burn out the crystal:
> (1) Excessive local oscillator output.
> (2) T-R failure.
> (3) Static discharge.
> (4) Mechanical shock.
> (5) Strong magnetic fields resulting in induced currents in crystal leads.

53. PREAMPLIFIER UNIT.

a. General. Before application to the receiver, the i-f output of the crystal detector is applied to two stages of low gain single-tuned amplification provided in a preamplifier unit, a part of each heterodyne converter. In this way the signal is sufficiently amplified before being fed through a 72-ohm coaxial line to the receiver.

b. Operation. (1) The operation of the precision system preamplifier unit is identical to that of the search system preamplifier with the exception of the input coupling circuit. The 30-megacycle i-f output of the crystal detector is applied across the self-resonant inductance, L1 shown in figure 111. The signal input to the grid of V1 is developed across coil L2 which is tuned to resonance at 30 megacycles by the distributed capacity of the coil and the input capacity of V1. Coupling between L1 and L2 is accomplished by a small coupling capacitor C1 connected between the two coils. Thus the signal is capacitively coupled to the first tube of the precision preamplifier instead of inductively as in the search system preamplifier.

(2) The remainder of the precision system preamplifier circuit is identical to the search system preamplifier circuit whose theory of operation was described in chapter 2, section IV which should be referred to at this time.

54. RADAR RECEIVER R-38/MPN-1.

a. General. Two Radar Receivers R-38/MPN-1 are used in the precision receiving system of Radio Set AN/MPN-1. One receiver is used in actual operation while the other receiver is maintained in a stand-by condition. The receivers are identical in every respect with the two receivers used in the search receiving system. However, the sensitivity-time-control (STC) circuit incorporated in the receivers is only used in the precision or X-band system. The theory of the receiver unit was completely covered under the search receiving system (ch. 2, sec. IV) and will not be repeated in this section. The STC circuit however will be described in detail as it was not covered in the previous discussion.

b. Sensitivity-time-control Circuit. (1) The sensitivity-time-control circuit shown in figure 118 functions to vary the gain of the receiver with respect to the range of the echo signals. Thus relatively strong short-range signals receive less amplification than the weaker long-range signals. Without this arrangement the receiver gain would necessarily have to be high enough to amplify the weak signals sufficiently and the resulting strong signals from near-by ground objects would saturate the indicators and completely obscure any targets at close range. The near-by ground echoes do not seriously interfere with the operation of the search indicators due to the increased range of that system. Thus the STC circuit is used only in the precision receiving system.

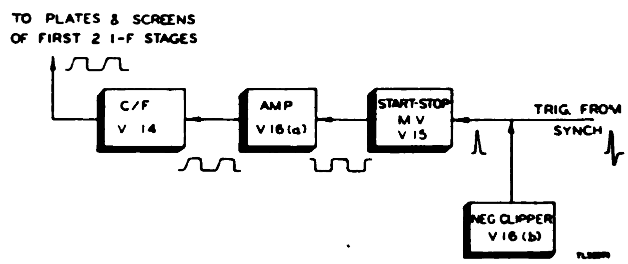

Figure 118. Sensitivity-time-control circuit, block diagram.

(2) The STC circuit consists of two dual triodes, V15 and V16 (6SN7-GT), and a cathode follower stage V14 (6V6-GT) as shown in figure 119. A positive trigger pulse from the synchronizer is applied to the grid of V15(b) through the coupling capacitor C53. To prevent the negative portion of the trigger pulse from reaching this biased multivibrator, a limiter or clamp tube, V16(b), is connected across the grid input of V15(b). The clamp tube, connected as a diode with its plate grounded, provides a shunt to ground for the negative overshoot of the trigger pulse applied to its cathode. Thus any nega-

tive signal drives the cathode negative and permits conduction, effectively bypassing the negative portion of the trigger and preventing it from affecting the grid of V15(b).

(3) The grid of V15(a) is at a positive potential of 220 volts, thus this section of the dual triode will conduct heavily. Since the grid of V15(b) is connected to ground through R61, this section of the dual triode will be cut off due to the large negative bias developed across the common cathode resistor P8 by the cathode current of V15(a). The positive trigger pulse, which occurs simultaneously with the transmitted main pulse, triggers the multivibrator, thereby producing a negative square wave at the plate of V15(b), its duration is determined by the time constant of C52 and R57.

(4) This negative square wave output from the multivibrator is applied through the coupling capacitor C51 to the grid of V16(a) and is of sufficient amplitude to bias the tube beyond cutoff. With V16(a) cut off, capacitor C50 will charge through the inductance L27 and resistance P3, thereby producing a saw-tooth waveform in the plate circuit. Potentiometer P3 varies the charging rate of C50 and hence the slope of the saw-tooth waveform, while L27 makes the charging curve of C50 linear with respect to time.

(5) The saw-tooth waveform from the plate circuit of V16(a) is applied to the grid of cathode follower V14 through the ON-OFF switch SW2 and the coupling capacitor C49. The positive going saw-tooth output of the cathode follower is the plate and screen supply voltage for the first two i-f amplifier tubes, V1 and V2, in the receiver. Thus the receiver gain will increase as the saw-tooth voltage increases, or as the range of the reflected echoes increase. With the switch SW2 in the OFF position, the saw-tooth waveform will not be applied to the cathode follower grid and the STC circuit will be inoperative.

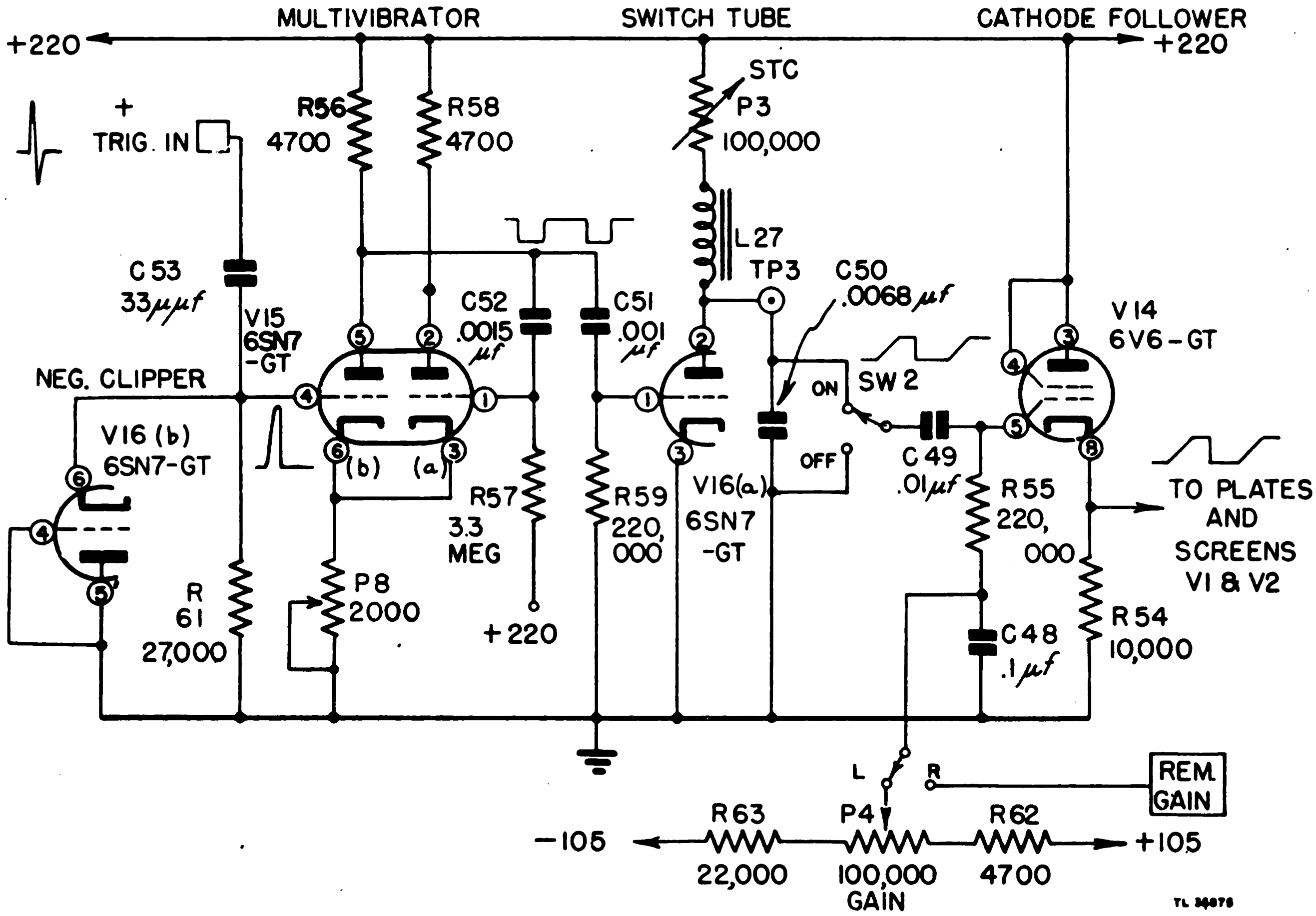

Figure 119. Sensitivity-time-control circuit, schematic diagram.

(6) In addition to the saw-tooth voltage, a controllable amount of d-c voltage is applied to the grid of cathode follower V14 (fig. 119). The d-c voltage controls the receiver gain with the STC circuit disconnected, or the minimum gain with the STC circuit in operation. The d-c gain voltage is obtainable from two separate sources dependent on the position of the LOCAL-REMOTE gain switch, SW3. With this switch in the LOCAL position, the grid of V14 is connected to the slider of potentiometer P4 in the resistance chain R63, P4, and R62. The resistor chain is connected between a positive 105 volts and a negative 105 volts, thus the grid bias of V14 and consequently the output voltage at the cathode can be varied over wide limits. Potentiometer P4 is labeled GAIN and is mounted on the front panel of Radar Receiver R-38/MPN-1.

(7) With the LOCAL-REMOTE switch in the REMOTE position, the d-c gain voltage is supplied by a gain switching circuit in the synchronizer, in conjunction with the azimuth and elevation gain controls mounted on the azimuth and elevation director assemblies respectively. By means of the gain switching circuit, the gain of the receiver, when receiving azimuth signals and when receiving elevation signals, can be separately controlled. The action of the gain switching circuit is described in the synchronizer theory section (ch. 3, sec. V).

c. ***Video Channel.*** (1) The video output of the precision receiving system is further amplified by a video amplifier channel before being applied to the grids of the precision indicator cathode-ray tubes. This additional video amplifier circuit is located on the synchronizer chassis and consists of three tubes, V22, V23, and V24. The schematic diagram of this circuit is shown in figure 120.

(2) The amplified video pulses are brought into the synchronizer from the precision receiver and applied to the cathode of V22 (6AC7), a cathode injector, the compliment of a cathode follower. This stage is characterized by a very low input impedance, large amplification, and a very high output impedance. The cathode follower stage, V23 and V24 in parallel, has a very high input impedance, a gain of slightly less than unity, and a low output impedance. The low input impedance of V22 provides a satisfactory termination for the low impedance line from the receiver, and its high output impedance matches the high input impedance of V23 and V24, operated as parallel triodes. The output of these tubes is taken across R87, their common cathode resistor. Thus their operation is that of a cathode follower with extremely low impedance output for matching to the low impedance line to the indicators.

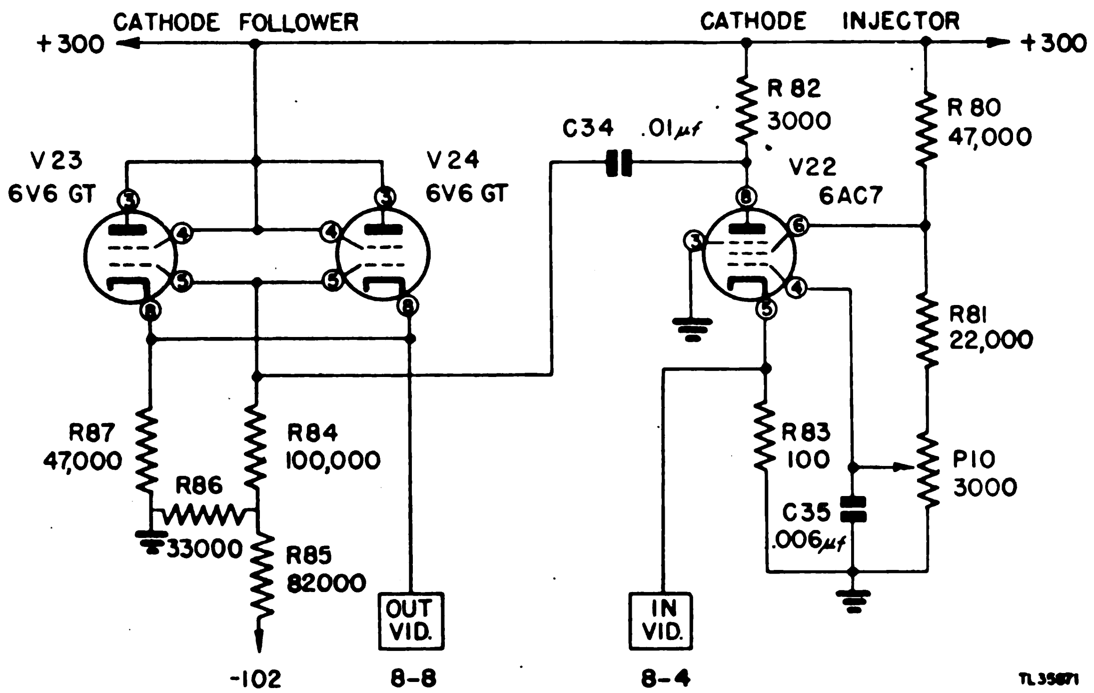

Figure 120. Video amplifier circuit.

(3) The gain of the amplifier stage V22 is variable by adjustment of the grid bias potentiometer P10. This control is a preset adjustment and is located on the top of the synchronizer chassis.

SECTION V

SYNCHRONIZER

55. DESCRIPTION. The synchronizer unit provides the trigger pulses for both transmitter systems, the trigger for the S-band search central, the trigger for the sensitivity-time-control circuit and the X-band sweep amplifiers, the blanking and intensifying voltages for the X-band receiver and indicators, and the range and angle calibrating marks for the X-band indicators. Also included in the unit is a part of the X-band receiver system composed of two stages of video amplification.

a. Block Diagram of Unit. (1) The unit may be broken down functionally into the elementary block diagram shown in figure 121. The various parts of the circuit are separated according to the functions they perform.

(2) A more complete block diagram is given in figure 122. Here the individual stages of the unit are shown with an indication of the type or purpose of each stage. The subparagraph which immediately follows gives a general description of each stage. Detailed explanations are to be given later in the section.

b. Circuit Description. (1) The action of the synchronizer begins with a blocking oscillator operating at a recurrence frequency of 2,000 cycles per second (fig. 122). The output of the blocking oscillator is amplified and sent out as a positive-going trigger pulse to the modulator where it is converted into a narrow high-voltage modulating pulse and is fed to the magnetron.

(2) The pulse from the first blocking oscillator also operates a multivibrator, the output of which activates a Hartley oscillator of carefully determined frequency. This oscillator produces the range marks for the precision system. The sine-wave output is converted into a series of pulses which are amplified and sharpened. The sharpened pulses trigger a second blocking oscillator which produces range-mark pips at 2,500-foot intervals for application to the cathodes of the 2-mile indicators. These markers are also applied to a controlled blocking oscillator counting down at a four to one ratio to provide range marks at 10,000-foot intervals for the 10-mile indicators.

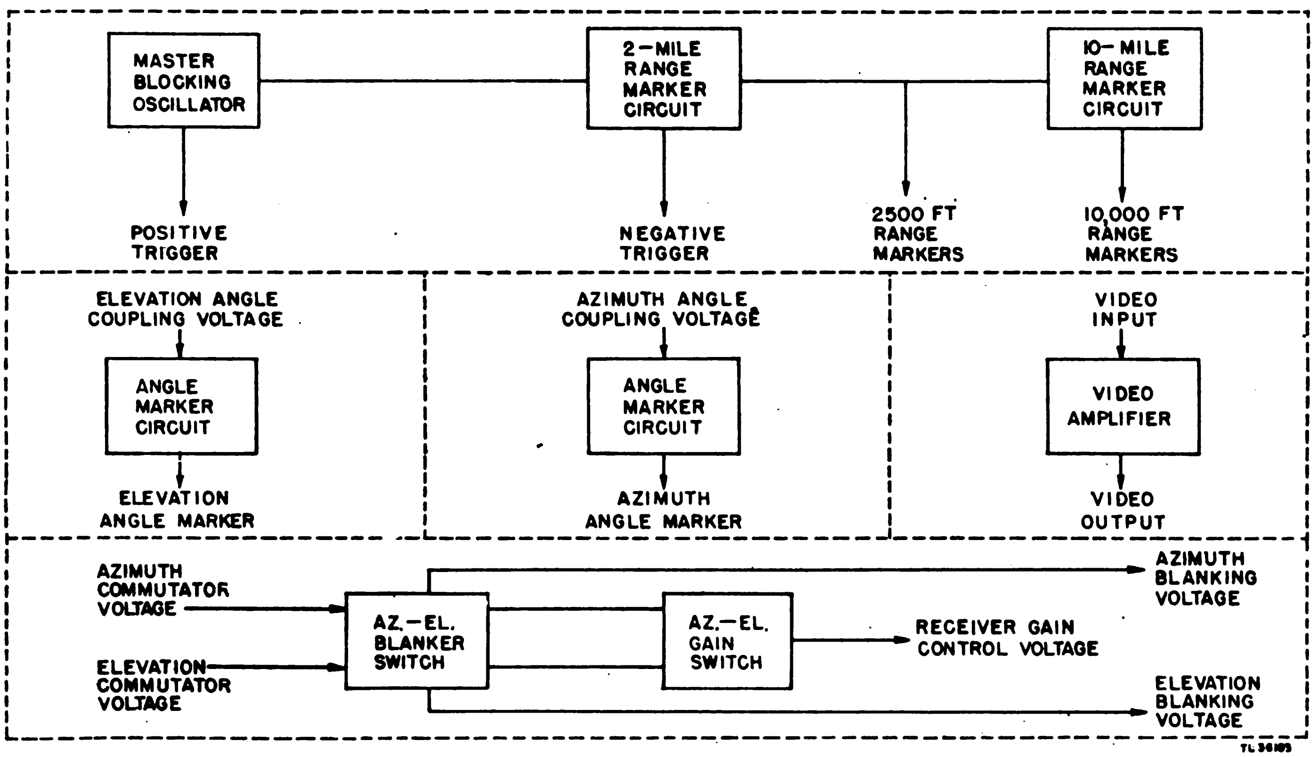

Figure 121. Synchronizer SN-5/MPN-1, functional block diagram.

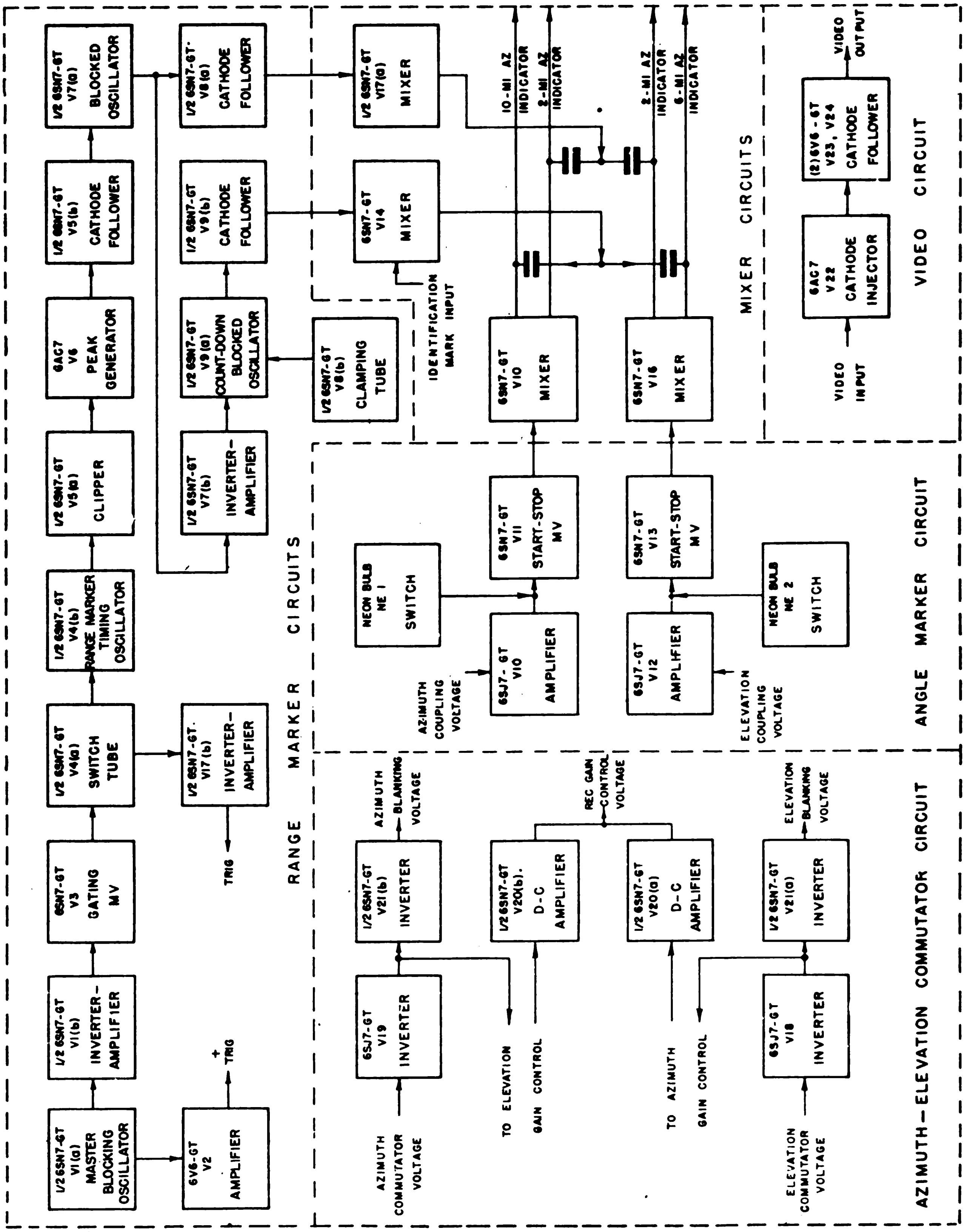

Figure 122. Synchronizer SN-5/MPN-1, block diagram.

Symbol Designation	Valu
C1	.05 m
C2	310 m
C3	.01 m
C4	Omitte
C5	.006 m
C6	.01 m
C7	.01 m
C8	200 m
C9	470 m
C10	22 m
C11	.003 m
C12	8-75 m
C13	300 m
C14	.25 m
C15	.006 m
C16	.1 m
C17	100 m
C18	100 m
C19	1.0 m
C20	.006 m
C21	.001 m
C22	.5 m
C23	.006 m
C24	250 m
C25	47 m
C26	510 m
C27	47 m
C28	470 m
C29	100 m
C30	47 m
C31	470 m
C32	100 m
C33	.1 m
C34	.01 m
C35	.006 m
C36	.25 m
C37	.003 m
C38	.003 m
C39	.003 m
C40	.003 m
C41	.003 m
C42	.003 m
C43	.003 m
C44	.003 m
C45	.01 m
C46	.01 m
C47	.01 m
C48	1.0 m
C49	1.0 m
C50	1.0 m
C51	003 m
C52	47 m
C53	33 m
C54	.003 m
L1	1 MH
L2	1 MH
L3	0.3 MH
L4	5.5 MH
L5	5.5 MH
L6	5.5 MH
NE1	T-4½
NE2	T-4½
P1	50,000
P2	5,000
P3	25,000
P4	30,000
P5	5,000
P6	30,000
P7	5,000
P8	10,000
P9	10,000
P10	3,000
P11	100,000
P12	100,000

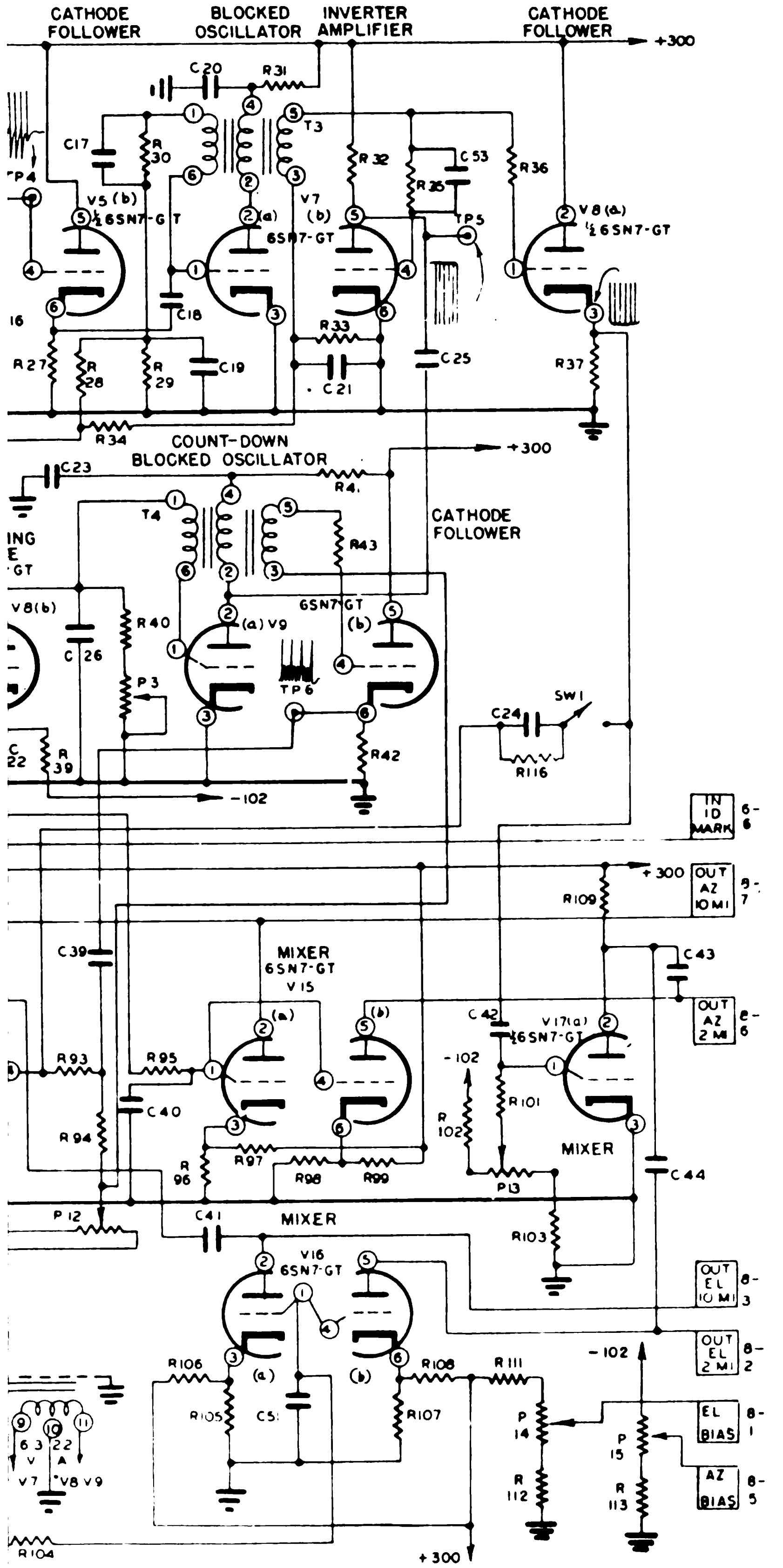

Figure 123. Synchronizer SN-5/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
P13	100,000	2	10%
P14	50,000	4	20%
P15	50,000	4	20%
R1	220,000	½	20%
R2	56,000	½	10%
R3	1 Meg	½	5%
R4	4,700	1	20%
R5	2,200	½	20%
R6	82,000	½	10%
R7	220,000	½	20%
R8	10,000	½	20%
R9	100,000	½	20%
R10	47,000	10	20%
R11	10,000	½	20%
R12	4,700	½	20%
R13	22,000	½	20%
R14	100,000	½	20%
R15	20,000	5	10%
R16	470,000	½	20%
R17	220,000	½	20%
R18	20,000	5	10%
R19	4.7 Meg	½	20%
R20	20,000	5	10%
R21	8,200	½	10%
R22	10,000	½	10%
R23	10,000	5	20%
R24	3,000	10	10%
R25	820	½	10%
R26	33,000	2	20%
R27	47,000	10	20%
R28	220,000	½	10%
R29	24,000	½	5%
R30	4,700	½	20%
R31	200	½	20%
R32	3,300	½	20%
R33	24,000	½	5%
R34	68,000	½	10%
R35	3.3 Meg	½	20%
R36	2,200	½	20%
R37	1,000	½	20%
R38	3,900	½	10%
R39	22,000	1	10%
R40	10,000	½	20%
R41	200	½	20%
R42	1,000	½	20%
R43	2,200	½	20%
R44	82,000	2	10%
R45	1 Meg	½	20%
R46	100,000	1	20%
R47	100,000	1	20%
R48	220,000	½	20%
R49	47,000	2	20%
R50	47,000	2	20%
R51	470,000	½	20%
R52	390,000	½	10%
R53	1 Meg	½	20%
R54	1 Meg	½	20%
R55	100,000	1	20%
R56	100,000	1	20%
R57	82,000	2	10%
R58	220,000	½	20%
R59	47,000	2	20%
R60	47,000	2	20%
R61	470,000	½	20%
R62	390,000	½	10%
R63	1 Meg	½	20%
R64	15,000	5	10%
R65	47,000	2	10%
R66	470,000	½	20%
R67	30,000	½	5%
R68	100,000	½	20%
R69	100,000	½	20%
R70	220,000	½	20%
R71	47,000	½	20%
R72	47,000	½	20%
R73	100,000	½	20%

Symbol Designation	Description		
	Value	Rating	Tolerance
R74	100,000	½	20%
R75	470,000	½	20%
R76	30,000	½	5%
R77	47,000	2	10%
R78	56,000	½	10%
R79	100,000	1	20%
R80	47,000	2	20%
R81	22,000	1	20%
R82	7,500	10	10%
R83	100	½	20%
R84	100,000	½	20%
R85	82,000	½	10%
R86	33,000	½	20%
R87	300	2	10%
R88	100,000	½	20%
R89	27,000	½	20%
R90	2,200	½	20%
R91	27,000	½	20%
R92	470	½	20%
R93	2,200	½	20%
R94	100,000	½	20%
R95	10,000	½	20%
R96	5,600	½	10%
R97	220,000	2	10%
R98	5,600	½	10%
R99	220,000	2	10%
R100	Omitted		
R101	100,000	½	20%
R102	47,000	½	10%
R103	39,000	½	10%
R104	10,000	½	20%
R105	5,600	½	10%
R106	220,000	2	10%
R107	5,600	½	10%
R108	220,000	2	10%
R109	470	1	20%
R110	330,000	½	10%
R111	20,000	10	10%
R112	50,000	10	10%
R113	50,000	10	10%
R114	470,000	½	20%
R115	82,000	½	10%
R116	47,000	½	20%
SW1	SPST #1460		
T1	Chicago 5227 D		
T2	GE (68G711)		
T3	Westinghouse 132 AW		
T4	Westinghouse 132 AW		
T5	15-3125 Heater Trans		
V1	VT231	6SN7-GT	
V2	VT107A	6V6-GT	
V3	VT231	6SN7-GT	
V4	VT231	6SN7-GT	
V5	VT231	6SN7-GT	
V6	VT112	6AC7	
V7	VT231	6SN7-GT	
V8	VT231	6SN7-GT	
V9	VT231	6SN7-GT	
V10	VT116	6SJ7-GT	
V11	VT231	6SN7-GT	
V12	VT116	6SJ7-GT	
V13	VT231	6SN7-GT	
V14	VT231	6SN7-GT	
V15	VT231	6SN7-GT	
V16	VT231	6SN7-GT	
V17	VT231	6SN7-GT	
V18	VT116	6SJ7-GT	
V19	VT116	6SJ7-GT	
V20	VT231	6SN7-GT	
V21	VT231	6SN7-GT	
V22	VT112	6AC7	
V23	VT107A	6V6-GT	
V24	VT107A	6V6-GT	

(3) The sharp pulses fed to the blocking oscillator are also fed through an amplifier. These pulses, being inverted (negative trigger), are applied to the X-band sweep amplifiers and S-band search centrals.

(4) Voltages representing the direction of antenna feed are supplied to a separate section of the synchronizer from the commutator unit controlled by the antenna switch assembly. These voltages are amplified and shaped to square waves to blank the elevation indicator when the azimuth antenna is radiating, and vice versa. The same voltages are also applied to the sensitivity control to permit the operators' remote controls to vary the gain of the X-band receiver, so that the single receiver can be adjusted to different sensitivities for azimuth and elevation signals.

(5) An angle-selector circuit is also included to intensify the sweeps at a given angle selected by the operator. A voltage from the angle coupling unit, which is proportional to the beam angle, is applied through a potentiometer to the grid of a tube that controls the firing point of a neon bulb. The resulting pulse is fed through the mixer to the cathode of the indicator tube, being timed to intensify a single sweep at the desired angle on the tube face. Two identical circuits are provided, one for the azimuth indicator and one for the elevation indicator.

(6) The detected output of the X-band receiver enters the synchronizer and is amplified by one stage of video amplification before it is applied to the grids of the four precision indicator tubes.

(7) A part of the control circuit of each azimuth and elevation angle coupling unit is included in the synchronizer. By locating the controls in the synchronizer they are made accessible for any change necessary during operation.

(8) Details of the circuits mentioned above are shown in figure 123. The circuits are completely described in the paragraphs that follow.

56. TRIGGER CIRCUIT.

a. Blocking Oscillator. (1) The master blocking oscillator and its associated amplifiers generate the primary triggers which are applied to both radar systems. The positive trigger keys the modulator and is applied to the radar receiver to operate the sensitivity-time-control circuit. It is also available at a terminal of Junction Box J-30/MPN-1, located at the front of the trailer. The negative trigger activates the gating multivibrator controlling the range mark circuit within the synchronizer, and, after passing through several stages for additional amplification and delay, is applied to the X-band sweep amplifiers and the search centrals to start the indicator sweeps.

(2) Figure 124 shows a circuit of the master blocking oscillator. The operation is conventional, using transformer coupling between the plate and grid of V1(a) to secure feedback. Blocking is obtained as plate current begins to increase and the voltage induced in the secondary winding of T1 drives the grid of V1(a) positive, augmenting the increase in plate current. This action, is cumulative until plate current reaches saturation, whereupon the induced grid voltage falls to zero. This causes a rapid decrease in plate current, which in turn induces a voltage of the opposite polarity in the secondary winding, carrying the grid well below cutoff. During the rising plate current cycle, the grid is held at a positive voltage and capacitor C2 is charged by the resulting flow of grid current which actually is a flow of electrons from the cathode to the positive grid. The charge developed across C2 is such that the grid side of the capacitor will be negative. Thus when V1(a) is suddenly cut off by the voltage surge in the secondary winding of T1, the negative charge on C2 will take effect and hold the grid well below cutoff.

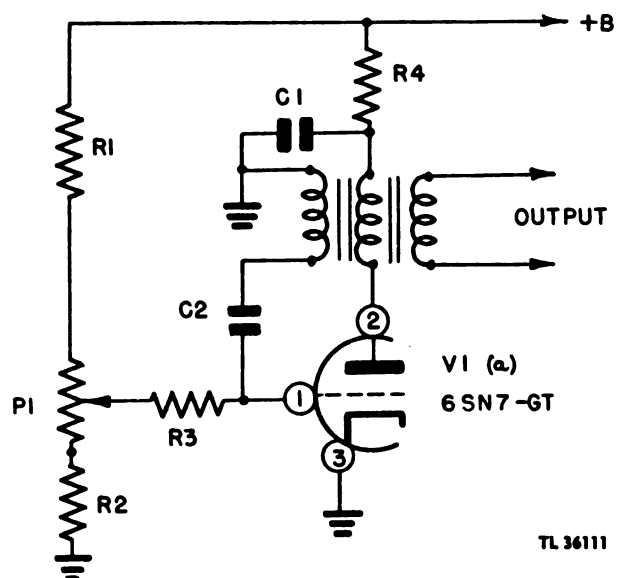

Figure 124. Master blocking oscillator circuit.

(3) C2 immediately begins to discharge through R3 and through the network composed of R1 and the upper part of P1 in parallel with R2 and the lower part of P1. The capacitor discharges, not toward zero but toward the value of voltage which exists at the sliding contact of P1 with no current flowing through R3. As C2 discharges the grid bias is removed from V1(a) until the tube again conducts. At this point, the cycle is repeated and the tube again blocks. The repetition rate of the blocking oscillator is 2,000 cycles per second and the width of the

pulse output is approximately 10 microseconds. The repetition rate may be varied by changing the setting of the variable tap on potentiometer P1. Figure 125 shows grid voltage and output voltage waveforms of the blocking oscillator.

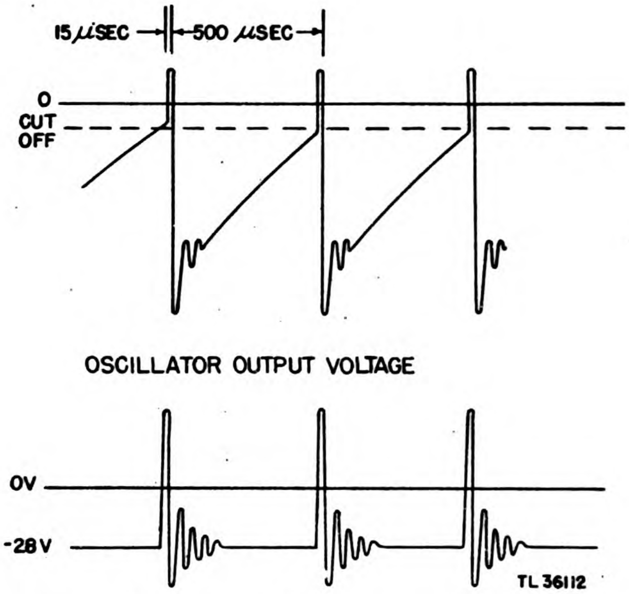

Figure 125. Master blocking oscillator waveforms.

(4) In order to increase the frequency stability of the oscillator, the grid of V1(a) is returned to a point of positive potential instead of to ground. Reference to figure 126 indicates how this is accomplished.

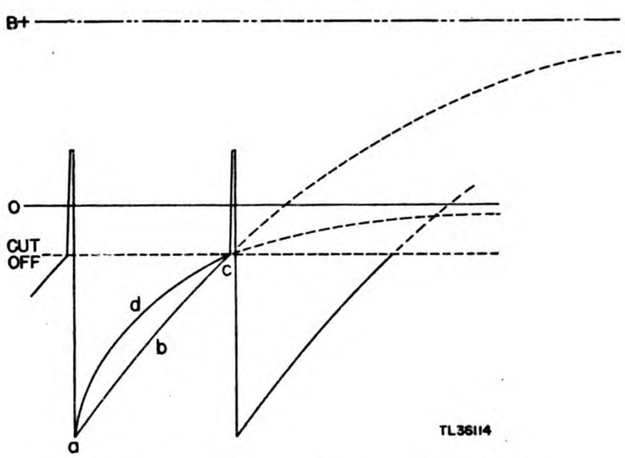

Figure 126. RC circuit discharge curves in blocking oscillator.

(5) The line *a b c* (with its dotted line continuation) is the discharge curve of capacitor C2 when the grid is returned to a positive potential. The line *a d c* (with its continuation) indicates the discharge of C2 (through a smaller resistor so that point *c* is reached in the same amount of time as before) when the grid is returned to ground. It is easily seen that the line *a b c* intersects the cut-off voltage of the tube at a sharper and more definite point than line *a d c*. Since this point of intersection is more definite, the period between pulses, and consequently the frequency of oscillation, is more stable when the grid is returned to a positive voltage.

(6) Coupling to other circuits is secured by using a third winding on the same core of T1. The output from the oscillator is in the form of sharp pulses which are delivered to the grids of amplifiers V1(b) and V2.

b. Trigger Amplifiers. (1) The tertiary winding delivers positive pulses to the grids of the amplifiers; they are biased below cutoff, thus only the sharp positive spikes of the pulses are amplified, and all transient oscillations about the reference axis are not transmitted.

(2) Amplifier V1(b) produces a negative pulse and acts as a phase inverter, its output supplying a trigger to the range marker circuit in the synchronizer. The amplifier is of conventional video design, using a low value of plate load resistance (2,200 ohms) to give a flat frequency response and to preserve the waveform. The variable resistance (P2) together with capacitor C54 constitutes a delay circuit which is variable and will advance or delay the beginning of the negative trigger to synchronize it with the positive trigger.

(3) The positive trigger amplifier V2 (6V6-GT) has the same input voltage impressed on its grid as the negative trigger stage. The stages differ in that V2 uses a line matching transformer with the secondary connected so as to produce a positive trigger at terminal 8 of connector strip 7. This pulse is fed to the modulator circuits, to the receiver STC circuits, and to the external IFF connection at Junction Box J-30/MPN-1.

57. TWO-MILE RANGE MARKER CIRCUITS.

a. General. (1) These circuits generate a series of very sharp and accurately spaced pulses. The pulses are synchronized with the sweep so that when these markers are impressed on the cathode of the 2-mile precision indicator tubes, they will produce bright spots along the sweep representing definite values of range. As the sweep scans the face of the tube in synchronism with the antenna scan these bright spots form lines of constant range. Due to the type of sweep used, these lines will be nearly straight, rather than curved as in a PPI display. The reason for this will be understood when the sweep amplifiers are discussed.

(2) The operation of the range marker circuits (fig. 122) consists in setting a gating multivibrator into operation,

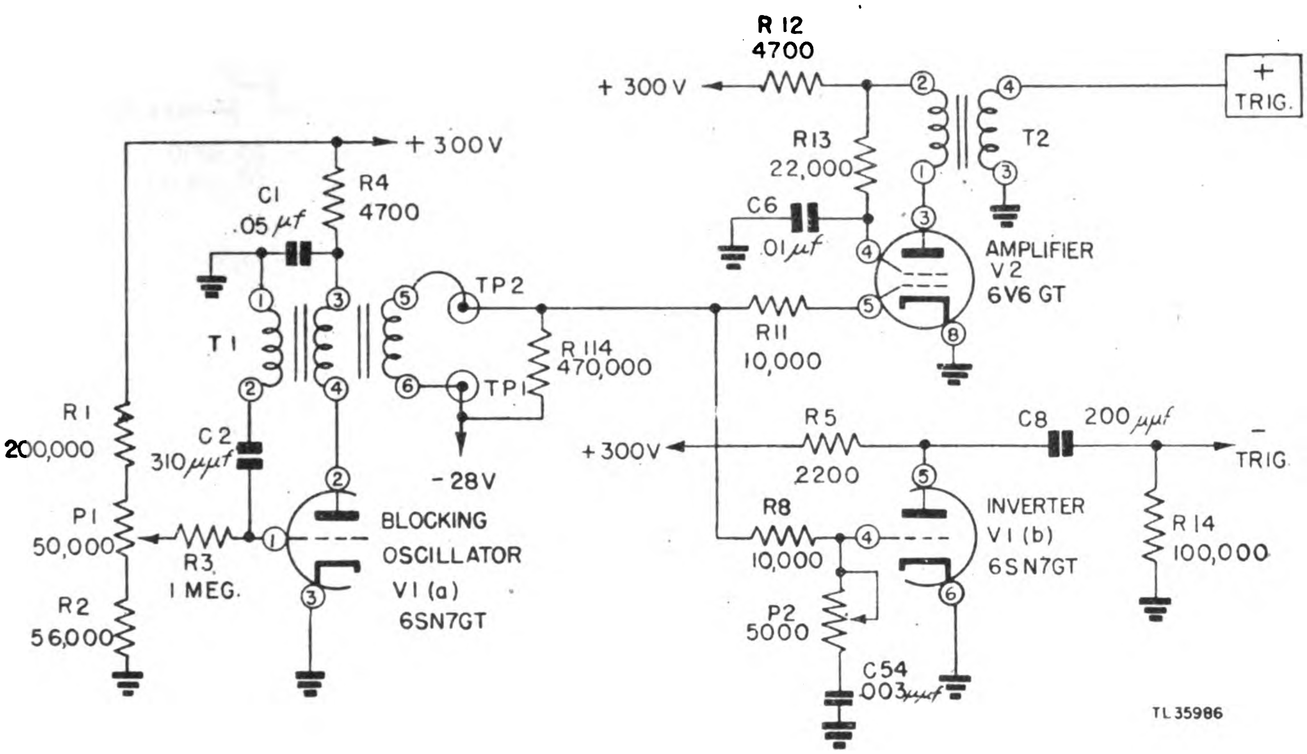

Figure 127. Trigger amplifier circuits.

thus producing a negative rectangular voltage gate. This removes a quenching circuit load from a fixed frequency Hartley oscillator, the rectified output of which produces a series of negative half-sine waves. Such waves are applied to a peak generator. and to a cathode follower, and thence to a blocked oscillator. The extremely sharp spikes which characterize the output of the blocked oscillator are passed on to a cathode follower and to a video amplifier whose output is delivered to the cathode circuits of the 2-mile azimuth and elevation indicator tubes.

b. Gating Multivibrator. (1) From the plate of V1(b) (fig. 127) the negative pulse is applied through capacitor C8 to the grid of V3(a) (fig. 128). The two halves of V3 (6SN7-GT) form a multivibrator which is prevented from oscillating freely by a negative bias applied to the grid of the second half. In the quiescent state, the following conditions exist: V3(a) is conducting: V3(b) is biased beyond cutoff from the -102-volt supply.

(2) The negative trigger from the preceding stage cuts off V3(a), permitting its plate voltage to rise from a very low value toward B+. This steep rise in voltage is applied to the grid of V3(b) through C10 and R16; V3(b) thus conducts, dropping its plate voltage to a low value. This voltage swing is applied back to the grid of V3(a) through C9 and acts in the same direction as the original trigger. The length of time V3(a) is cut off is determined by the time interval required for C9 to discharge through R14 to the cut-off voltage of the tube. During the time that V3(a) is cut off, V3(b) will continue to conduct, because the divider network composed of R16 and R17 is now connected to near B+, rather than to a low or near-ground potential, as is the case when V3(a) is conducting. Thus the bias will remain above cutoff for V3(b) and the output from the plate will be in the form of a negative rectangular-shaped gate. The small capacitor C10, paralleling R16, is used to preserve a reactance balance for the extremely high-frequency components present in the steeply rising wave front. It balances out the bypassing effect of the interelectrode capacity of V3(b). If C10 is omitted, the wave front will tend to round off slightly due to loss of the higher frequency components.

(3) The negative gate is slightly longer in time than that required for a 10-mile sweep, being approximately 120 microseconds in duration.

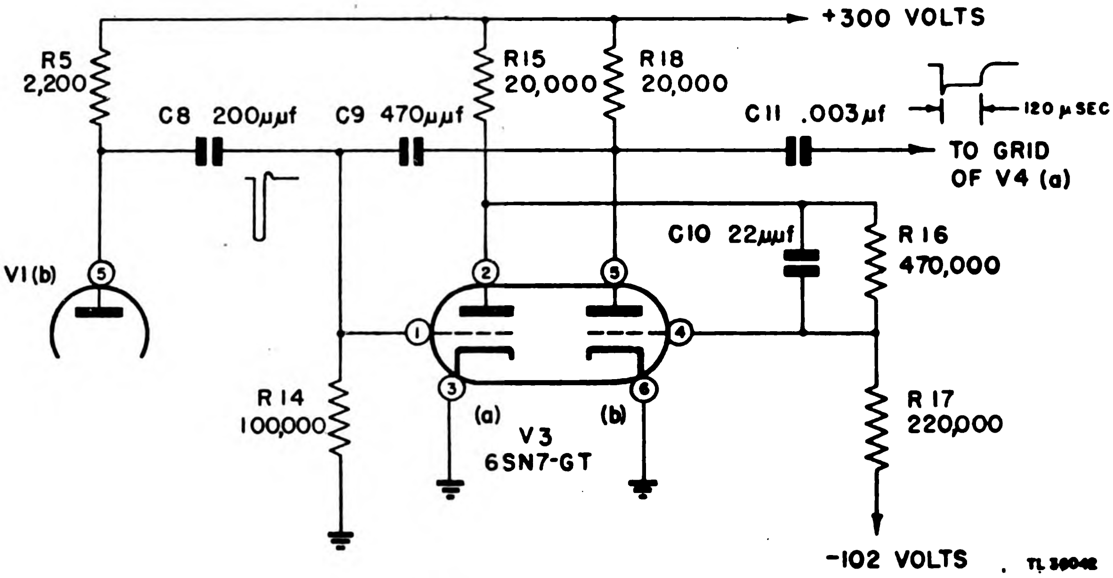

Figure 128. Gating multivibrator circuit.

c. Switch Tube. (1) The negative rectangular gate from V3(b) (fig. 129) is applied to the grid of the switch tube V4(a), removing the short-circuiting effect from the tank circuit of V4(b) and permitting the latter to oscillate at a frequency corresponding in time to 2,500-foot range marks. This is equivalent to a frequency of 196.6 kc.

(2) The grid of V4(a) is returned to a positive potential through R19, causing the tube to conduct heavily during the period of time from the end of one sweep to the beginning of the next (time between negative gates). This current flows thru L1 and L2 to ground. This is the equivalent of placing such a load on the resonant circuit

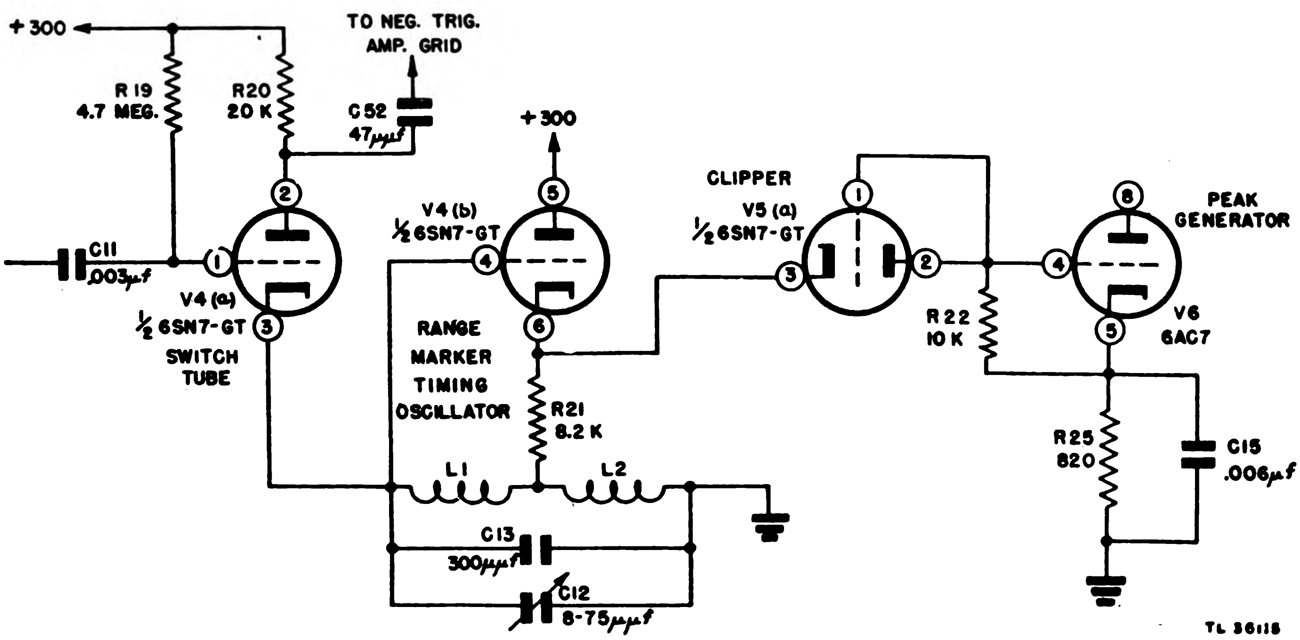

Figure 129. Range mark generator circuit.

that the range marker oscillator V4(b) will not oscillate. The negative gate applied to the grid of V4(a) cuts the tube off and removes the loading effect allowing V4(b) to oscillate.

d. Negative Trigger Amplifier. (1) The square wave voltage appearing at the plate of V4(a) is fed to the grid of V17(b) to be developed into the negative trigger voltage. This square wave is a positive gate of approximately 120 microseconds in width (fig. 130).

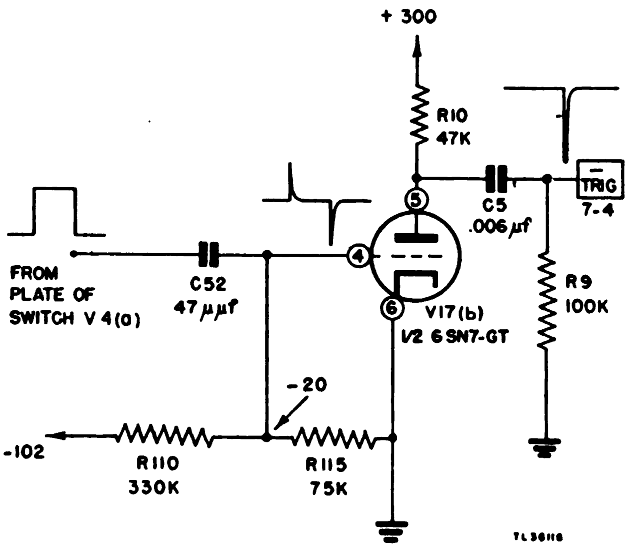

Figure 130. Negative trigger amplifier circuit.

(2) The positive gate is coupled to the grid of V17(b) through capacitor C52. This capacitor, in conjunction with the two resistors R110 and R115, constitutes a differentiating circuit. The primary characteristic of this circuit is that its output is proportional to the rate of change of voltage at the input. Refer to paragraph 53 of TM 11-466.

(3) The action of the differentiating circuit is to greatly sharpen the square positive gate obtained from V4(a). Tube V17(b) is kept beyond cutoff by the negative grid voltage applied from the voltage divider which consists of resistors R110 and R115. The sharp input pulse (positive) drives the tube to saturation causing a negative pulse signal to appear at the plate. The output of the stage is coupled to the negative trigger output terminal of the synchronizer through capacitor C5.

(4) The time constant of the differentiating circuit in the grid circuit of V17(b) determines the width of the output pulse. The circuit constants used will give a negative pulse output of approximately 3 microseconds in width.

e. Range-marker Timing Oscillator. (1) The tank circuit of the Hartley oscillator consists of L1 and L2, C12 and C13, with C12 as a trimmer to vary the total capacitance for fine frequency adjustment.

(2) While the resonant frequency of the oscillator determines the spacing of range markers on the indicator tubes, two further conditions must be satisfied. The circuit must begin oscillating at the same instant that sweep is begun. Also, the oscillations must have the proper phase to place the first range marker at the correct position on the sweep trace.

(3) Figure 131 shows how oscillations are begun. When the current thru V4(a) is cut off, the inductance of L2 and L3 will tend to maintain a continued flow of current. This current now flows into C12 and C13, which results in

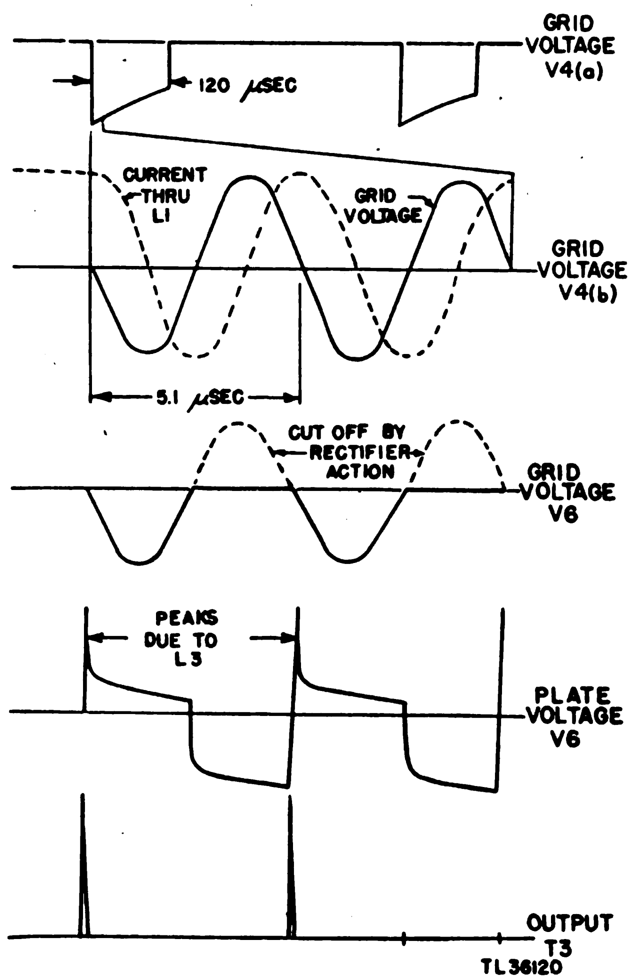

Figure 131. Waveforms, range marker circuit.

a voltage being built up on these capacitors, and with the phase relationship shown in the figure. A study of the circuits to follow will show how this results in producing range marks with the proper starting point.

f. ***Clipper.*** The sine-wave output from V4(b) is taken off between the cathode of V4(b) and ground and is applied to the cathode of the diode-connected rectifier V5(a), producing a series of negative half-sine waves appearing across R22 and R25 (fig. 132).

g. ***Peak Generator.*** (1) The negative half-sine waves developed across R22 are applied to the control grid of V6 (6AC7), an overcompensated video amplifier. Since the wave fronts of these sine waves are extremely steep near the zero axis, the plate current of V6 is abruptly cut off on the down swing of each wave, giving rise to a quite rapid positive excursion of plate voltage which appears across R24, the plate load resistor.

(2) In order to steepen the slope of this rising voltage, L3 is inserted in series with the plate load resistor. When the plate current is snapped off, the inductive voltage across L3 adds a sharp spike to the leading edge of the output voltage waveform. L3 can thus be used as a method of reintroducing high frequencies which have been lost due to the bypassing effects of tube inter-electrode capacitance.

h. ***Cathode Follower.*** (1) The spiked rectangular output of V6 is delivered to cathode follower V5(b) as shown in figure 132. The cathode follower fulfills the important function of counteracting the input capacitance of the following stage, thus reducing losses in the high-frequency components of the pulses.

(2) The positive pulses across R27, the cathode load resistor of V5(b), are applied through C18 to the grid of V7(a). The trailing edge of the output waveshape will be more rounded than the signal applied to the grid of V5(b). This is caused by the charging of C18 and the circuit's distributed capacitance through R27 and does not affect the operation of the subsequent circuit, as V7(a) is put into operation only by the spiked leading edge of the waveform.

i. ***Blocked Oscillator.*** (1) The circuit of V7(a) forms a blocking oscillator circuit with external bias applied to the grid. This circuit differs from the master blocking oscillator in that it must be triggered, and it is termed a "blocked" oscillator to distinguish it from the free-running type.

(2) A bias voltage of approximately −11 volts is developed by applying the −102-volt supply across the divider network composed of R28 and R29. While this bias voltage is not sufficient to hold the tube current completely

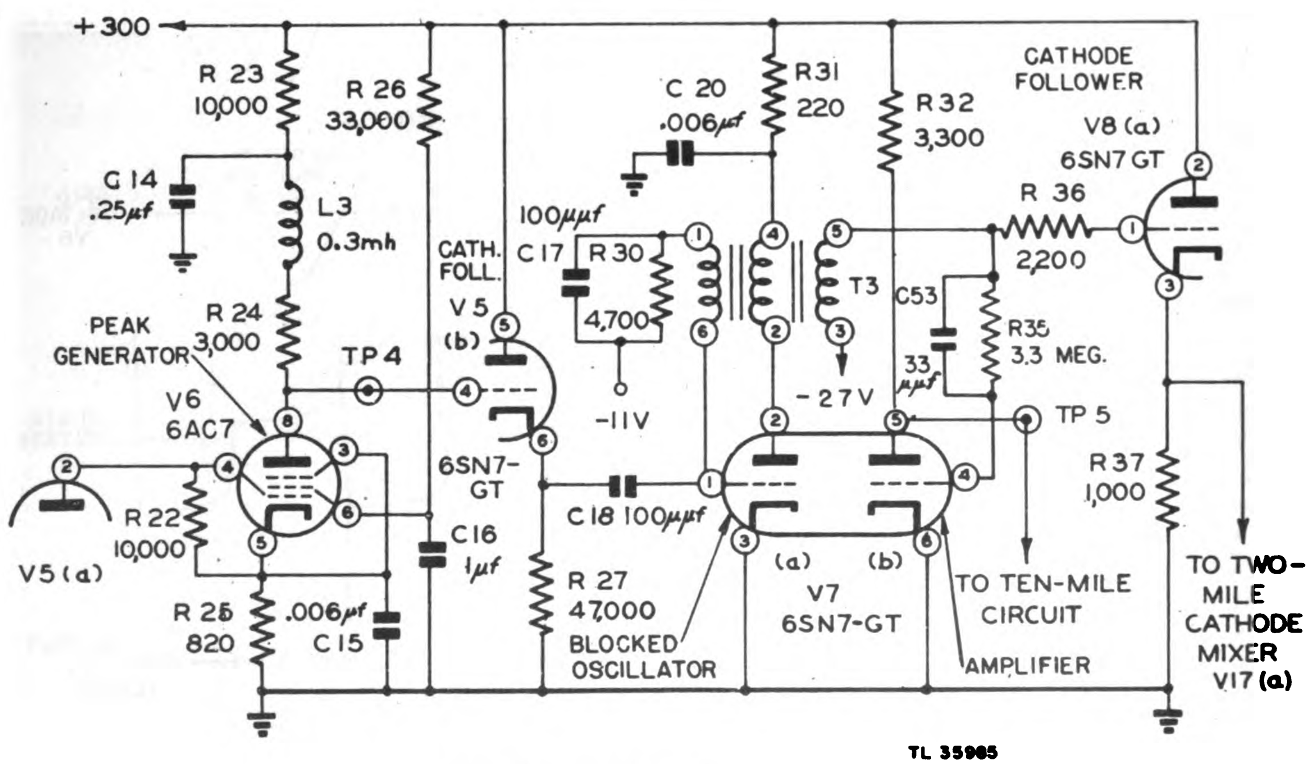

Figure 132. Two-mile range marker circuit.

cut off, it does reduce the transconductance of the tube by an amount sufficient to prevent oscillation.

(3) The sharp positive peaks (developed by inductance L3 in the plate circuit of V6) are applied to the grid of the blocked oscillator V7(a) through capacitor C18. When triggered, the oscillator goes through one cycle of operation and again becomes quiescent due to the grid bias. The time constant of capacitor C17 and resistor R30 is very short (approximately 0.5 microseconds) and does not hold the oscillator beyond cutoff for the entire time between triggering pulses. However, the purpose of the circuit is to prevent continuous triggering of the oscillator by the transients which occur directly after the pulsing of the oscillator.

j. Cathode Follower. The positive pulse output from transformer T3 is delivered to the grid of the two following stages. To complete the 2-mile range marker circuit, the pulse is applied to the grid of V8(a) operating as a cathode follower. The output across R37, the cathode resister, is another positive pulse. For further amplification and mixing with other marker voltages, these range markers are fed to the cathode mixer circuit (par. 60).

58. TEN-MILE RANGE MARKER CIRCUITS.

a. General. (1) The 10-mile indicator tubes use range markers similar to those on the 2-mile tube, with the exception that these markers are spaced at 10,000-foot intervals (approximately 2 miles) instead of 2,500-foot spacing.

(2) The output of the final 2-mile blocked oscillator drives two amplifiers (fig. 122). One of these amplifiers in turn triggers a count-down blocked oscillator having a four-to-one reduction in frequency between input and output. A clamping tube is used for stabilizing the counting circuit. The output of the count-down blocked oscillator consists of sharp spikes having 10,000-foot range intervals. Through another cathode follower, these spikes are applied to the 10-mile elevation and azimuth indicator tube cathodes.

b. Inverter. Positive pulses from V7(a) (fig. 132), a blocked oscillator, are applied to the grid of V7(b) which is biased past cutoff in order to eliminate transient oscillations in the plate output. Circuit elements R35 and C53 form an additional bias circuit which automatically keeps the output pulses at a nearly constant value for a large variation in input. The plate voltage output of V7(b) is in the form of extremely sharp negative voltage peaks. This output is used to drive V9(a), another blocked oscillator, which operates as a count-down circuit.

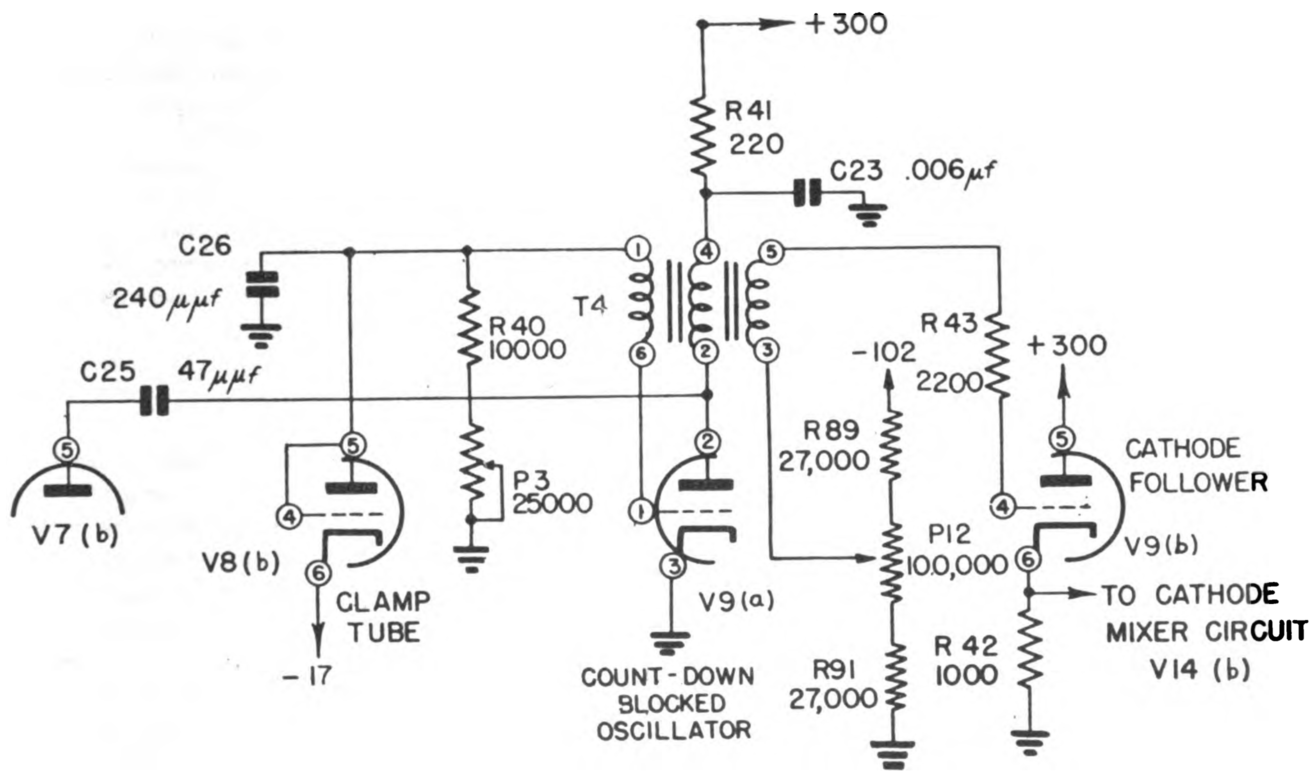

Figure 133. Ten-mile range marker circuit.

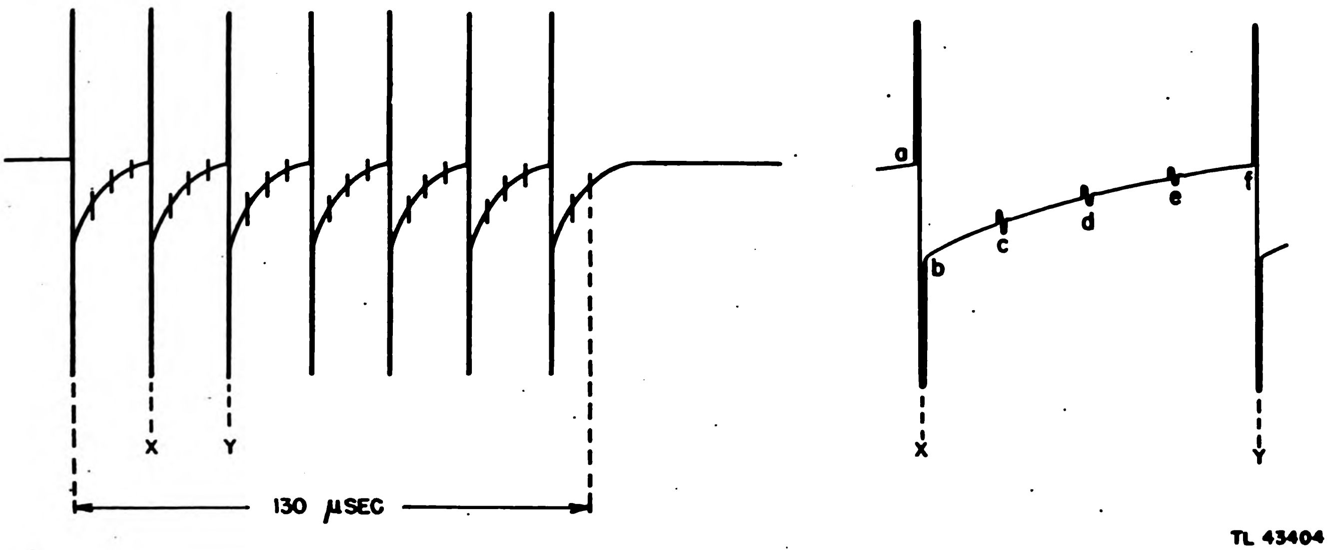

Figure 134. Count-down oscillator grid voltage waveform.

c. Count-down Oscillator. (1) The negative pulse output from V7(b) is applied to the plate of V9(a). Through inductive coupling, a positive voltage is induced in the secondary of pulse transformer T4 and applied to the grid. The input signal is fed to the plate circuit to assure triggering stability.

(2) Blocking oscillator action begins with a sharp increase in grid voltage and plate current, both of which rapidly reach a maximum. When the plate current reaches a maximum value, the grid is driven negative far beyond cutoff since the voltage across the grid winding of T4 is now zero and C26 has acquired a high negative voltage due to the flow of grid current. From this most negative point, the grid begins to return in a positive direction along the charging curve of the RC circuit, which consists of C26, P3, and R40, toward ground.

d. Clamping Tube. (1) To prevent self-triggering of the oscillator, the grid of the tube is biased near cutoff by an external fixed voltage derived from the divider network of R38, R39, V8(b), P3, and R40. This bias voltage is applied to the grid of the blocked oscillator through the clamping tube V8(b) (fig. 133).

(2) The clamping tube will halt the discharge of capacitor C26 toward ground by beginning to conduct when its plate rises above its cathode potential of about –17 volts. This value of voltage is determined by the voltage divider mentioned above. Capacitor C26 cannot be discharged through R40 and P3 to a value lower than this voltage; thus C26 and the grid of V9(a) remain at the same potential, which is substantially below cutoff for the tube, preventing it from operating as a free-running oscillator. The clamping tube operates only during the time when range marks are not being produced; that is, during the interval of approximately 380 microseconds between sweeps. At other times the RC circuit consisting of C26, R40, and P3 will keep the tube properly biased. The use of the clamping tube assures stability of operation in the count-down circuit.

e. Operation of Count-down Circuit. (1) In figure 134, which shows the count-down oscillator grid voltage waveforms, *a* represents the point where the grid is driven above cutoff by a trigger and reinforced by feedback from the plate circuit so that it is swung positive. When the plate current stops increasing, a negative voltage applied from C26 forces the grid to *b*, whereupon C26 begins to follow its charging curve toward ground as illustrated. The slope of this charging curve is controlled by the time constant of C26 and the series network R40 and P3 to ground. During the time interval from *b* to *f* the tube is inoperative. Along the curve *c*, *d*, and *e*, are the intermediate trigger pips, *f* being the fourth, which again trips the circuit and produces a four-to-one count-down ratio between point *a* and point *f*. Thus, the output derived from the tertiary winding of the pulse transformer will be a series of voltage pulses which recur at a rate of one for every fourth input pulse to the circuit. Variation of potentiometer P3 will change the count-down ratio so that every third or every fifth pulse will trigger the count-down oscillator.

(2) If the capacitor voltage (grid voltage) were permitted to decrease beyond the cut-off voltage of the tube, two possibilities might change the count-down ratio. The first is that the third trigger voltage *a* might trigger the tube; the second is that the grid might reach the point of tube conduction before the fourth voltage pip appears. Therefore, the clamp tube operates to stop the charging curve when the grid has reached a certain bias, after which the following voltage pip can trigger it. If the input circuit fails, the oscillator will not operate as a free-running circuit, but will remain biased at cutoff in a quiescent state.

(3) This last condition is what actually takes place during the period when no range marks are being generated (time between sweeps). The count-down oscillator is held on the verge of oscillation by clamping tube V8(b) so that it will be ready to trigger at the instant the sweep begins.

f. Cathode Follower. A positive output pulse from the tertiary winding of transformer T4 is applied to V9(b), operating as a cathode follower. Since the 2-mile range mark pips are applied to transformer T4 they will also be applied as positive pips to the grid of V9 (b). The grid of this tube is returned to a negative voltage which biases the tube beyond cutoff sufficiently to prevent the 2-mile pips from causing the tube to conduct and producing any output. The bias voltage is controlled by potentiometer P12, which also controls the bias on the associated mixer, V14(b) (par. 60). The 10-mile range marker pips produced by the count-down blocking oscillator are of a much larger amplitude and will cause V9(b) to conduct. Therefore only the 10-mile marker pips will pass through the cathode follower stage. The output of the cathode follower stage is impressed upon the grid of the mixer V9(b) through capacitor C39.

59. ANGLE MARKER CIRCUITS.

a. General. Two special types of electronically generated marks are used on the precision indicators. One of these, the angle marker, is used chiefly for orientation of the equipment in angular relationship to the runway. The other, the identification marker, is obtained from the search system, and is used to indicate to the precision operators which aircraft has been selected by the plane selector to make the next approach. Of these, only the angle markers are generated in the synchronizer. However, both sets of signals are combined in the mixer circuit as described in paragraph 60.

b. Use of Angle Marker. (1) In alignment, a corner reflector is placed at the far end of the runway and at the same distance from the center line as the radio set. Two electronic marks are available on the 2-mile azimuth indicator at the proper angle of scan, the transmitter signal at the vertex of the scanned area and the echo signal from the corner reflector. A line between these two points will be parallel to the runway. The angle marker itself is a brightening of one entire sweep on the indicator tube face (fig. 135). The angle at which the bright sweep appears can be chosen by the operator, as will be shown later. This same sweep is illuminated on both the 2-mile and the 10-mile azimuth scopes. As seen on the indicator tubes, the sweep is a straight line extending beyond the small runway indication, and is used as an indication of course direction.

(2) Two identical angle marker circuits are provided, one serving the azimuth indicator and one serving the elevation indicators. The discussion in the paragraph above refers to the alignment of the azimuth indicator by use of the azimuth angle marker. A similar procedure is followed in alignment of the elevation indicator, except that in this case the marker is generated by the elevation angle marker circuit and is used for the purpose of approximating the ground line.

c. Circuit Details. (1) INPUT VOLTAGE. Since a certain angle in the scanning sector must be chosen to produce the angle marker, it is evident that this brilliance modulation of one sweep must be a function of the desired angle voltage. The angle coupling unit (par. 71) generates a potential, rising and falling in amplitude corresponding to the beam angle of its associated antenna. The variation of this voltage is comparatively slow, having a frequency of about 2 cycles per second (4 sweeps) at maximum scanning speed. These voltage variations, besides being applied to tubes V10 and V12 in the synchronizer (the azimuth angle coupling unit supplying V10 and the elevation unit supplying V12) are also directed to the sweep amplifiers to control the precision weeps.

(2) PULSER CIRCUITS. The pulser circuit consists of V10 shunted by a small neon bulb NE1 (fig. 136). The power is supplied to V10 through the plate dropping resistor R48, and the bias is controlled by cathode bias resistor P4, the potentiometer which is the operator's angle mark selector control.

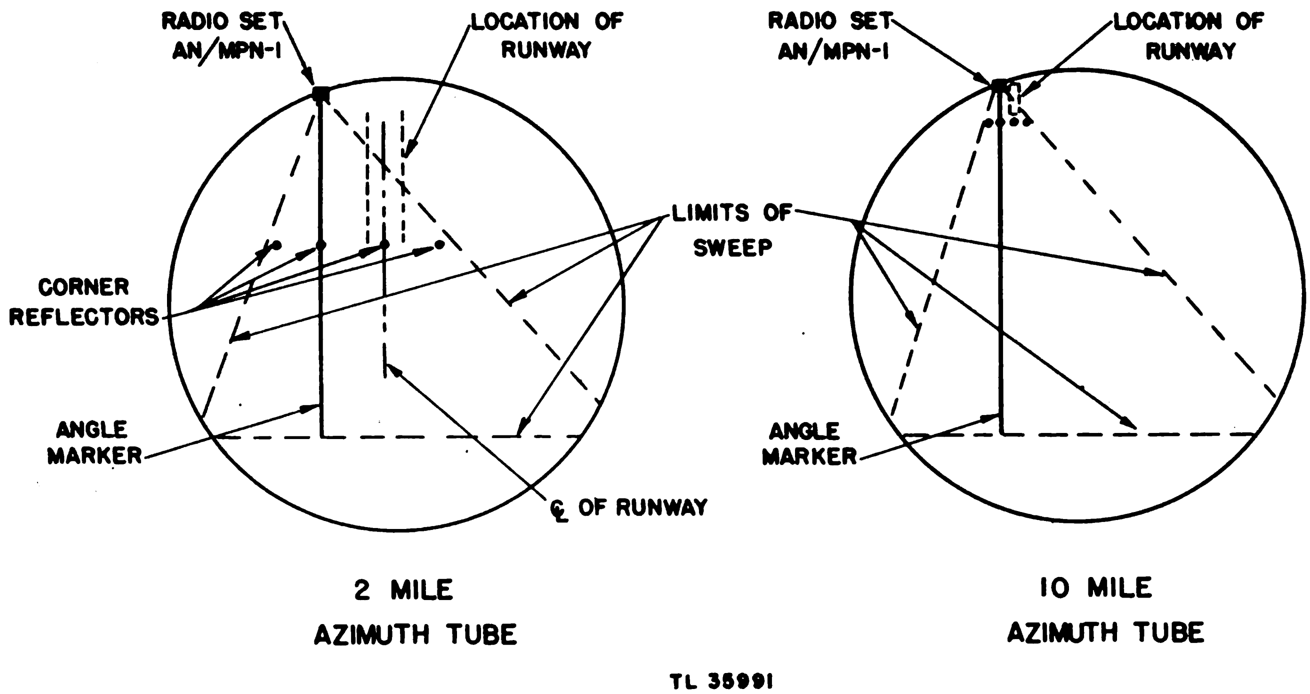

Figure 135. Appearance of angle markers on azimuth indicator tubes.

(*a*) In its normal state, V10 is conducting. As the grid goes more negative, due to angle voltage, the plate potential rises until NE1 reaches its critical voltage and fires. During conduction the voltage drop across such a gas tube is about 60 or 70 volts, so that a sudden sharp reduction of voltage is produced at point TP7.

(*b*) Circuit elements, capacitor C27 and resistor R53, constitute a differentiating circuit (par. 53, TM 11-466). A sudden sharp reduction of voltage (large rate of change) across the neon tube when it fires causes a short negative pulse to be developed across resistor R53. This negative pulse is due to the differentiating action of the RC circuit.

(*c*) The waveforms shown in figure 137 illustrate the circuit action described above. Curve *A* represents the applied grid excitation obtained from the angle coupling unit; curve *B* is the plate voltage and would have the same form as that of curve *A* (indicated by the dotted line) if the neon tube were omitted. As grid voltage drops the plate voltage rises and finally reaches some value (indicated by the point *i*) at which the neon tube fires. The plate voltage then drops to a constant value (*j*) and remains there as long as the neon bulb continues to conduct. The bulb maintains conduction until the internal impedance of the vacuum tube is low enough (due to decreasing grid bias) to drop the plate voltage below the extinguishing point. This is represented by point *k*, a point at which the neon bulb de-ionizes. Curve *C* shows the output of the differentiating circuit delivered as a trigger to the grid of the start-stop multivibrator V11.

(*d*) Potentiometer P4 varies the time of firing of the neon bulb by varying the cathode bias on V10. If P4 is varied so as to raise the voltage on the cathode of V10, a higher input voltage is necessary on the grid of the pentode to cause the neon bulb to fire. This variation causes a shifting of the trigger pips back and forth along the angle coupling voltage and thus varies the angular position of the marker that appears on the screens of the cathode-ray tubes.

(3) START-STOP MULTIVIBRATOR. As the neon tube fires, the negative pulse output from the differentiating circuit (curve *C*, fig. 137) triggers a biased multivibrator made up of the two sections of tube V11. This circuit is the start-stop type of multivibrator, the operation of which has been previously explained (par. 57).

(*a*) The firing point of a neon bulb is somewhat indefinite and its impulse to the biased multivibrator is not synchronized with the main sweep trigger. Hence the gate may brighten the end of one sweep and the beginning portion of the next. The intensifying gate, therefore, must be longer than the sweep time. The length of the gate used here is about 1,000 microseconds, which includes the sweep time and blanked return trace for approximately two cycles of operation. The time width

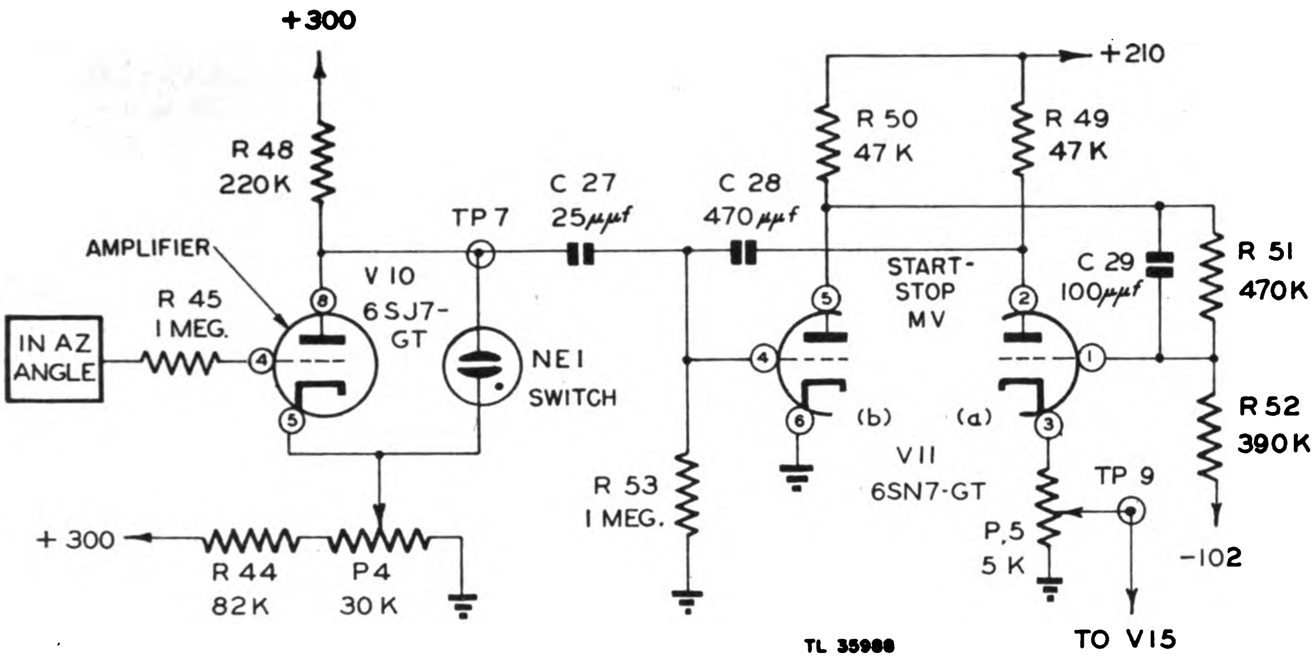

Figure 136. Azimuth angle marker circuit.

of the intensifying gate is controlled by two circuit elements of the multivibrator, capacitor C28 and resistor R53.

(*b*) The output of the multivibrator, a positive intensifying gate, is obtained from P5, a potentiometer in the cathode circuit of V11(a). Potentiometer P5 gives the operator control over the degree of amplitude of the intensifying voltage and thus varies the brilliance of the angle marker on the cathode-ray tube. This positive gate is applied to the grid of V15, a tube in the cathode mixer circuit (par. 60).

(*c*) Another characteristic of the angle marker is that it appears only once in each cycle of scan of the antenna; electrically it occurs while the angle voltage is traveling in a negative direction. At the maximum rate of four scans per second or two complete cycles, the brightened trace of the scope is renewed just twice a second. The long persistency of the screen however keeps the angle mark brilliant.

60. MIXERS FOR INDICATOR SIGNALS.

a. General. All range markers and angle markers generated in the synchronizer, as well as the identification marker obtained from the search central, are fed to the cathodes of the indicator tubes. In order to combine these signals and to feed them to the proper indicator tubes, the cathode mixer circuits are used.

b. Signal Distribution. The function of the mixer circuits is to distribute the cathode signals to the proper indicator tubes. The circuits for mixing and distributing these signals are shown in figure 138. The signals are distributed as follows:

Indicator	Signals
2-mile azimuth	2,500-foot range markers. Azimuth angle marker.
10-mile azimuth	10,000-foot range markers. Azimuth angle marker. Identification marker. 2,500-foot range markers (ratio test only).
2-mile elevation	2,500-foot range markers. Elevation angle marker.
10-mile elevation	10,000-foot range markers. Elevation angle marker. Identification marker. 2,500-foot range markers (ratio test only).

c. Circuit Details. (1) Angle marker voltages are injected into all cathode circuits, the azimuth marker

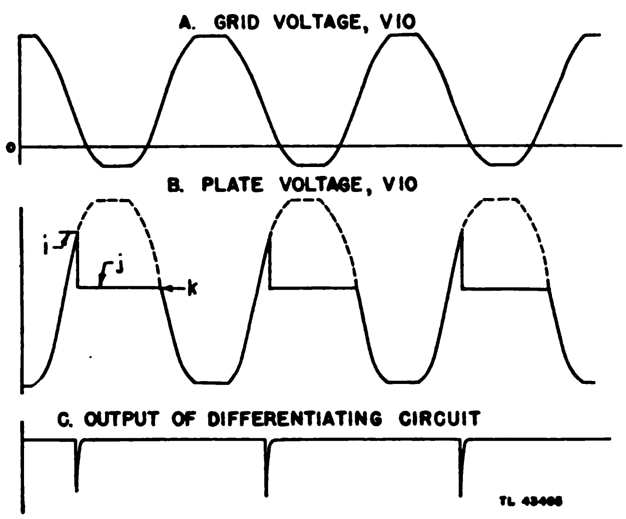

Figure 137. Voltage waveforms in angle marker circuit.

thru V15, and the elevation marker thru V16. Tube V15 feeds both the 2-mile and 10-mile azimuth scopes while tube V16 feeds the elevation scopes. The plate voltage supply for these two tubes is not located in the synchronizer but is obtained from the cathode bias voltage supply for the associated indicator tubes.

(2) Tube V14 feeds the required signals to the 10-mile indicator tube on both the azimuth and elevation indicators. The 10,000-foot range markers are fed to the grid of V14(b) while the identification marker is fed to the grid of V14(a). The plates of the two sections of V14 are connected together and the signals to both sections are combined and fed to both 10-mile indicator tubes. By closing switch SW1 (fig. 138) the 2,500-foot range markers may also be impressed on the grid of V14(b). This switch is closed during the count-down ratio test (par. 63, TM 11-1343). This test determines whether the 2,500-foot range markers and the 10,000-foot range markers exist in the proper ratio and that the count-down blocked oscillator is functioning properly. Variable bias voltages for the two sections of V14 are furnished from the two potentiometers P11 and P12. Variation of these potentiometers will change the intensity of the markers feeding to the cathodes of the 10-mile indicator tubes. These controls are located on the front panel of the synchronizer, P11 labeled STROBE BRILLIANCE and P12 labeled 10 MILE RANGE MARK BRILL.

(3) The 2,500-foot range markers are introduced into the 2-mile cathode circuits (azimuth and elevation) through V17(a). Potentiometer P13 varies the gain on this stage and controls the brilliance of the range markers on the 2-mile tube. It is labeled 2 MILE RANGE MARK BRILL.

(4) The manner in which the tubes are coupled and the signals mixed assures that signals will not be reflected back into circuits in which they should not appear. The mixing is all done prior to the signals leaving the synchronizer chassis, thereby requiring only a single lead to each scope cathode.

61. AZIMUTH-ELEVATION COMMUTATOR CIRCUIT.

a. Function. Discussion of the precision transmitter system (ch. 3, sec. II) points out that the r-f output is alternately switched from one antenna to the other. The commutator unit (par. 72) is arranged so that each of two photocells produces a positive-going rectangular voltage output during the time that its associated antenna is energized. These two voltages are fed to the azimuth-elevation commutator circuit in the synchronizer. This circuit has two functions. First, it switches the precision display from one indicator to the other (blanks out one and intensifies the other) at the same time that the precision antennas are switched. Secondly, it changes the gain of the precision receiver to compensate for differences in gain of the azimuth and elevation antennas and indicators.

b. Indicator Switching Circuit. (1) Positive voltages are alternately supplied to the azimuth and elevation intensifying circuits in the synchronizer. These voltages are developed in the photoelectric commutator of the switching unit. When the azimuth antenna is radiating, one photocell operates and its positive voltage output is fed to the grid of V19 (fig. 139). The amplified negative output from its plate is again inverted and amplified through V21(b). The circuit operates below ground potential, so that the plate output of V21(b), directly coupled to the grids of the azimuth scopes, biases them alternately at cutoff when the azimuth antenna is radiating, and well below cutoff when the antenna is not energized.

(2) When the elevation antenna is in use, the positive-going voltage to the elevation intensifying circuit is fed to the grid of V18. The resulting negative-going plate voltage is applied to the grid of V21(a). The positive-going plate voltage output is applied to remove the bias (below cutoff) from the grids of the elevation scope, thus permitting the video pulses to intensify the electron beam and produce a display on the indicator tube.

c. Receiver Gain Control. (1) Owing to the construction and radiation characteristics of the precision antennas, there may be a difference in gain of the received echoes during alternate periods of operation. Since the reflected pulses are developed into video signals through the same heterodyne converter and receiver, the gain of

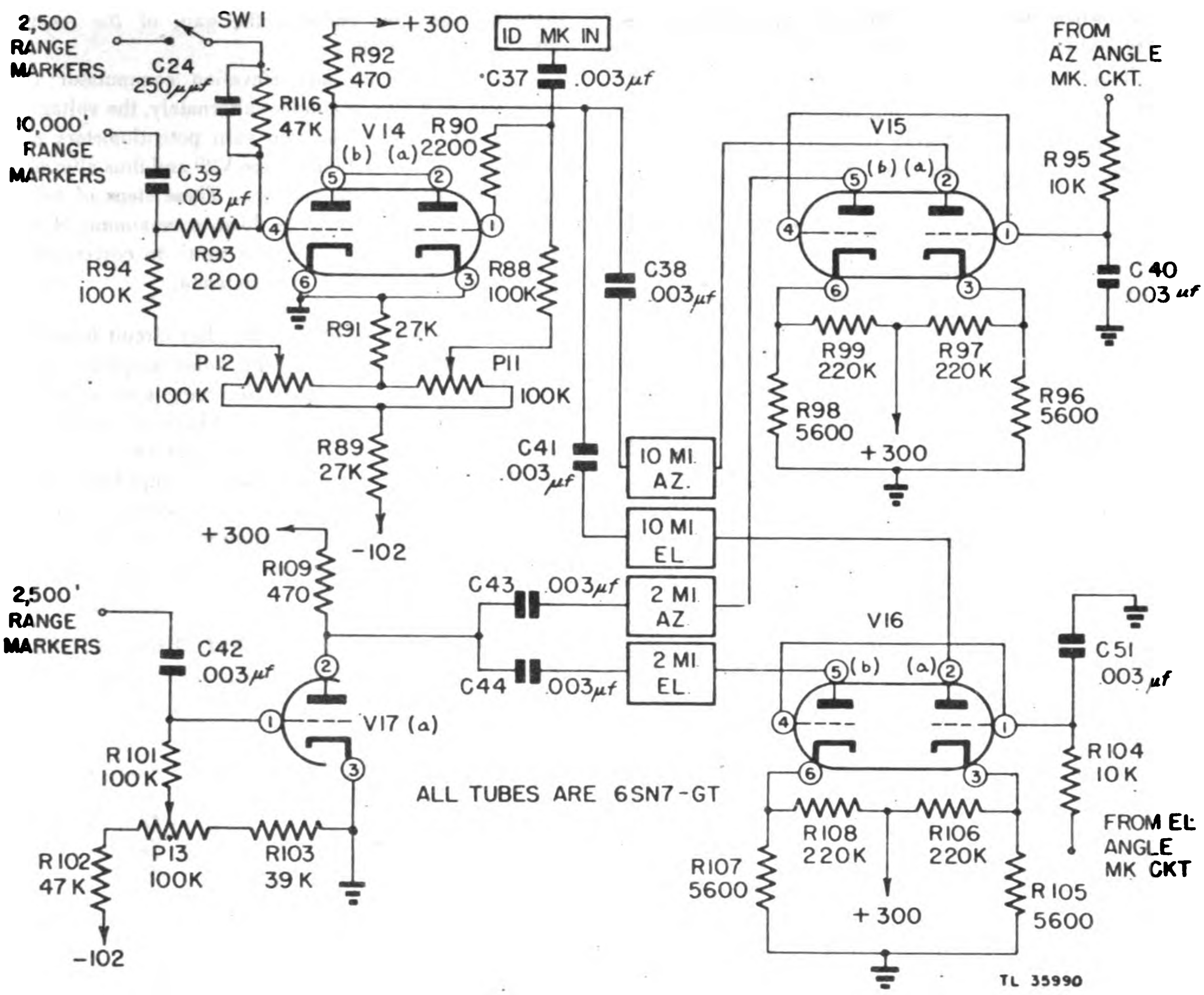

Figure 138. Cathode mixer circuits.

the receiver is changed to correspond to the periods of alternate operation of the antennas, thus enabling the operators to adjust each receiving system and associated indicator independently to the most satisfactory echo brilliance level.

(2) Since the azimuth and elevation sections of the gain control circuit are identical, the discussion to follow may be applied to either section simply by changing circuit element numbers.

(3) Tube V18 (fig. 139) supplies *elevation* indicator grid bias and *azimuth* receiver gain control voltages. Besides the conduction through the tube, an alternate current path is provided from ground through R65 to the azimuth gain potentiometer and then through R67 and P8 to -210 volts. The current travels through the entire gain potentiometer resistance element, and the variable tap picks off a certain portion of the voltage developed. This voltage is applied through R68 to the grid of V20(a), the output of that stage being the receiver gain control voltage.

(4) When the input voltage to the grid of V18 from the elevation commutator unit is positive, the plate voltage of the tube is at a low value. The grid of V21(a), being coupled directly to the plate of V18, is also at a low potential and the output is positive causing the elevation indicator to present its display. However, since the plate of V18 is at a low potential the voltage existing at the variable tap of the gain potentiometer is also at a low value, cutting off V20(a). Consequently the setting of this potentiometer has no effect upon the gain of the

receiver when the elevation indicator is presenting its display and must therefore control the receiver gain when the azimuth antenna is radiating (azimuth gain control).

(5) When V18 is cut off by the elevation blanking voltage, it offers an extremely high impedance to current flow. The voltage existing at the plate of V18 is therefore high and the current flows through the alternate path offered by the resistance network. The voltage at the variable tap of the gain potentiometer rises and permits V20(a) to conduct. The plate voltage of V20(a) drops an amount proportional to the amount of grid rise, and may now be controlled by the potentiometer setting. This plate voltage is fed to V14 in the receiver STC circuit (par. 54) through the remote gain terminal (1-7) on the receiver. This voltage serves as a bias for V14 (in the radar receiver) which is a cathode follower whose output is applied to the plates and screens of the first two i-f stages.

(6) Tube V19 operates in the same manner as V18. When the azimuth blanking signal to its grid cuts off the tube (and blanks out the azimuth indicator), its plate voltage rises and in turn raises the voltage at the variable tap of the elevation gain potentiometer. This potential in turn regulates the level of conduction of V20(b) whose plate voltage now controls the gain of the receiver, V20(a) being cut off.

(7) As the azimuth and elevation commutator units cause V18 and V19 to conduct alternately, the voltages at the variable taps of the two gain potentiometers alternately control conduction in tube V20 and thus alternately control the gain of the receiver. These steps of voltage vary the receiver gain up or down a maximum of eight times a second (rapid scanning rate) to correspond to the period of activity of each antenna.

62. VIDEO AMPLIFIER. Another circuit located on the synchronizer chassis is the video amplifier circuit which is used to connect the receiving system with the indicating system. This circuit utilizes a pentode as a cathode-injector type of amplifier and two tetrodes in parallel (cathode followers) used as impedance matching devices to the indicator tubes. Since this circuit has no connection with the synchronizer circuit itself, but is really a part of the receiving system, it is discussed in that section (par. 54).

63. ANGLE COUPLING UNIT BIAS CIRCUIT. Since it is difficult to gain access to the angle coupling units during operation, the bias-control circuits for these

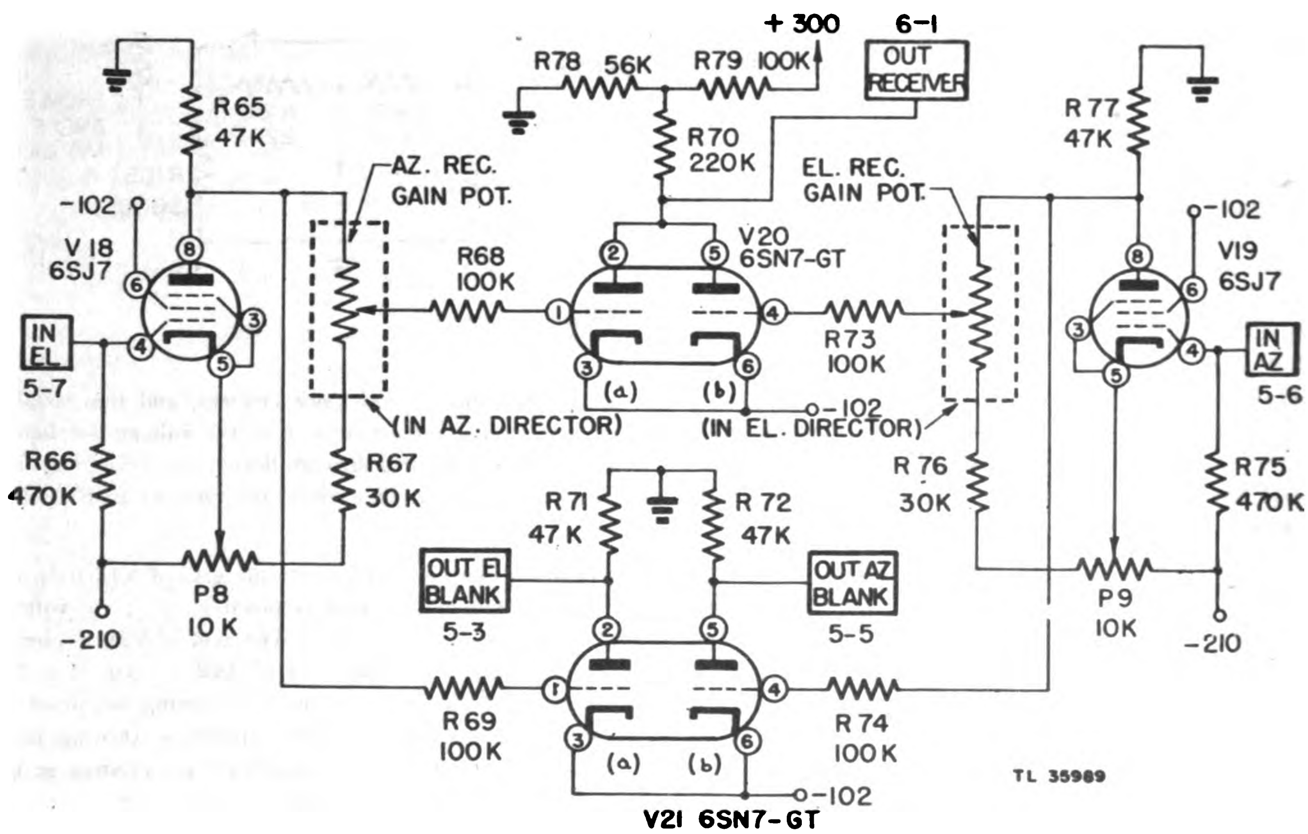

Figure 139. Azimuth-elevation commutator circuit.

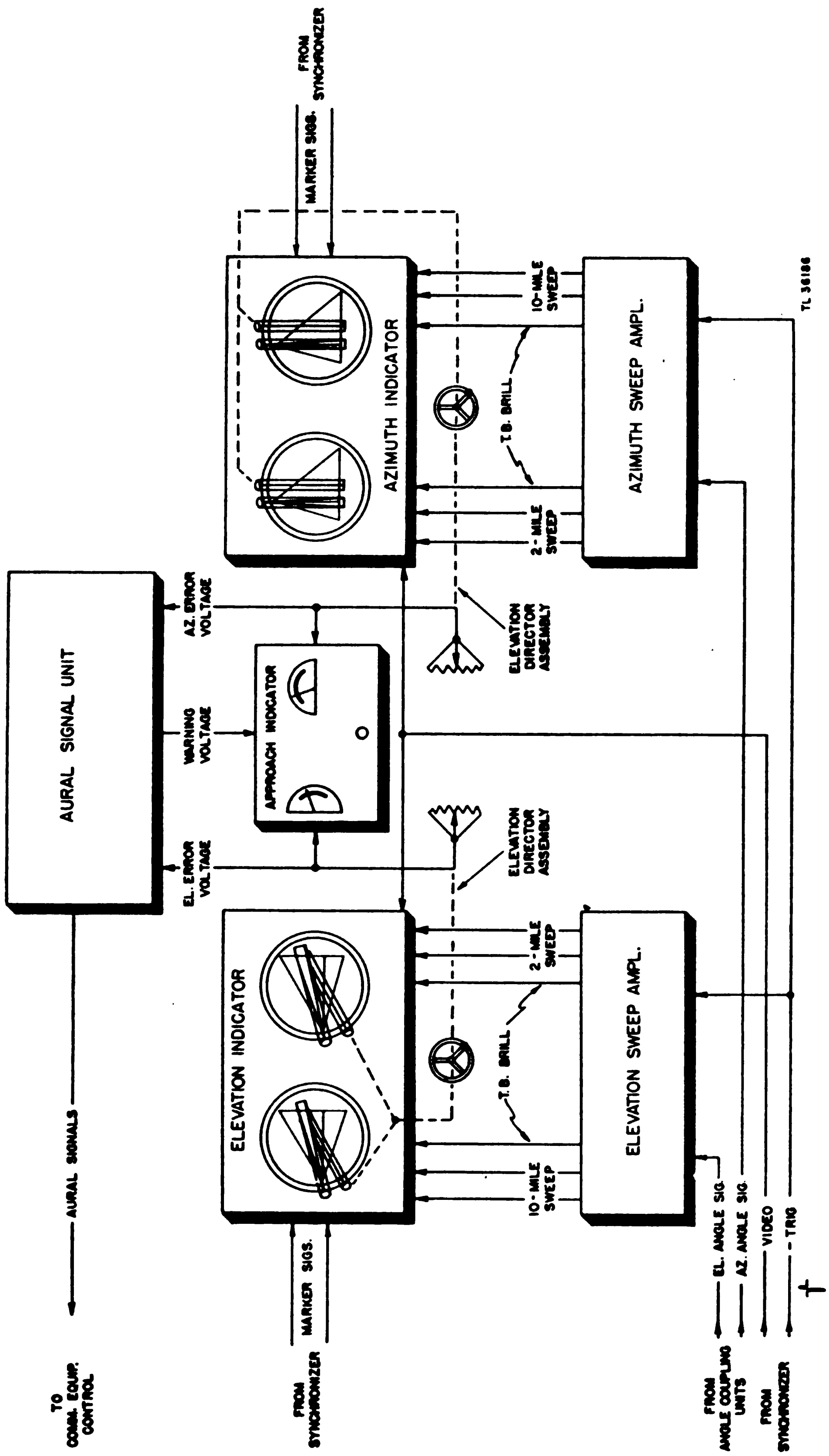

Figure 140. Indicating system, simplified block diagram.

units are located on the synchronizer. Two bias-control circuits are provided, one serving the azimuth coupling unit and the other the elevation coupling unit. These two bias controls are located on the front panel of the synchronizer and are labeled ELEVATION ANGLE BIAS and AZIMUTH ANGLE BIAS. For an analysis of the circuit and its use with connecting circuits refer to the discussion of the angle coupling unit (par. 71).

SECTION VI

INDICATING SYSTEM

64. INTRODUCTION. The precision indicating system of Radio Set AN/MPN-1 provides the means of displaying the target information picked up by the r-f system and processed by the receiving system. Four 7-inch cathode-ray tubes are utilized to present the information in such a manner that the exact location of an approaching aircraft can be determined in both height and azimuth. By means of this display, the variations of the aircraft from a predetermined glidepath are indicated and can be used to coach the pilot, by radio link, in making a successful blind landing.

a. Location of Components. The precision indicating system (fig. 140) consists of two indicator units, Elevation Indicator ID-37/MPN-1 and Azimuth Indicator ID-36/MPN-1, two director assemblies, Elevation Director Assembly MX-33/MPN-1 and Azimuth Director Assembly MX-32/MPN-1, four Sweep Amplifier AM-15/MPN-1 units, two Aural Signal Unit O-8/MPN-1's, and Approach Indicator ID-38/MPN-1. These indicator components are located in the first three bays of Indicator Rack MT-118/-MPN-1 (fig. 91). The sweep amplifiers and the aural signal unit are duplicated in the system, providing a stand-by channel for emergency use. Under normal operating conditions, one channel is maintained in an operating state while the other channel is held in a stand-by condition. In the event of failure of the operating channel, the stand-by channel may be switched into the circuit and operations continued without affecting the efficiency of the set.

b. Expanded Partial Plan Position Indicator. (1) The PPI type display, used with the search section of Radio Set AN/MPN-1, is not entirely suitable as a means of display in the precision system since only a comparatively small sector of the total area about the radar set, 20 degrees in azimuth and 7 degrees in elevation, is important in the landing operations. The PPI display could be modified to continually sweep through only the 20-degree operating sector, and through the 7-degree sector in elevation, thereby providing continuous information as to the azimuth and elevation of the approaching aircraft. However, if this type of presentation were used, the small areas covered by the indicator sweep would not result in a large enough picture to permit accurate observations to be made as to the airplane's position. It is evident that any attempt to expand the picture by increasing the angular sweep on the tube face would result in a distorted picture. For example, by increasing the angular sweep, a 20-degree antenna scan could be enlarged to 270 degrees on the display screen. However, with this type of expansion, straight lines would no longer exist as such on the CRT.

(2) To avoid this distortion, an expanded partial plan position indicator (EPI) display is used. This system makes use of the "picture on rubber" principle, expand-

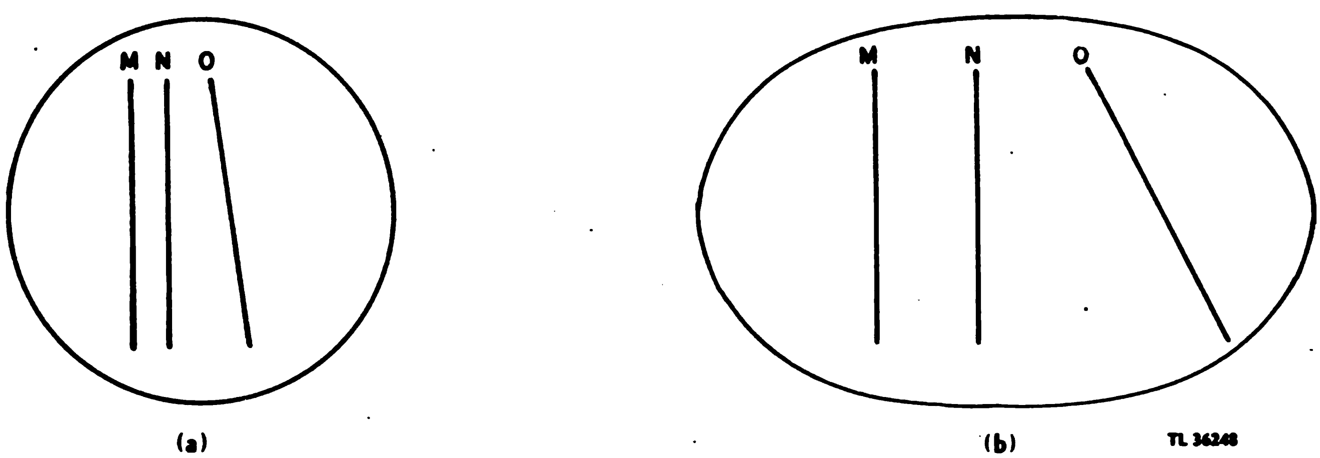

Figure 141. "Picture on rubber" type of linear expansion.

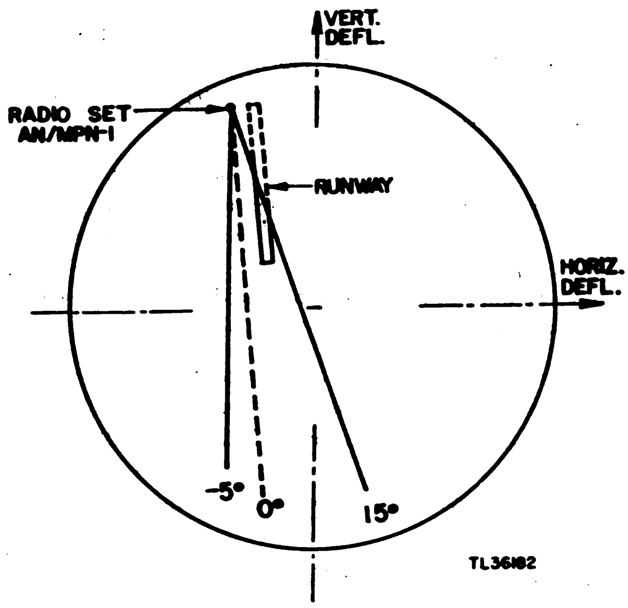

Figure 142. Location of Radio Set AN/MPN-1.

ing on one axis only. Referring to figure 141, suppose the lines M, N, and O were drawn on a thin rubber sheet and then this sheet was stretched or magnified in a direction at right angles to M so that M remains fixed as a reference line. It is apparent that:

(*a*) Straight lines remain as straight lines.

(*b*) Parallel lines remain parallel.

(*c*) The slope of any straight line will be changed unless the line is parallel or perpendicular to the direction in which magnification or expansion occurs.

(*d*) The magnification of the scale is different for different directions, varying from zero in a direction parallel to M (center of amplification) to a factor "N" (degree of stretching) in a direction perpendicular to the center of amplification line.

(*e*) Distance will remain equal on lines having the same slope on the CRT.

(3) It is evident from the foregoing discussion that if the lines M and N were runway boundaries, the azimuth information would be presented on a magnified scale. This expansion can be accomplished electrically by amplifying the *X* or horizontal sweep voltage before application to the deflection coil.

(4) In order to minimize flying hazards and to give a maximum coverage of the approach area, the operating trailer is located with respect to the runway as shown on the display scope (fig. 142). If the horizontal deflecting voltage is now amplified three times while the vertical deflecting voltage is held constant, the picture will be expanded perpendicular to the -5 degree line (fig. 143). This picture corresponds to (b) of figure 141, and results in an azimuth scale enlarged three times. Since the -5 degree line is the center of amplification, all range marks will be perpendicular to it.

(5) Tracking the approaching aircraft would be more convenient if the range marks were perpendicular to the runway center line. The runway center line must be parallel to the center of amplification if this is to be true. By gradually shortening the fixed vertical sweep as the angular sweep moves away from line M, the range marker lines can be tilted until they are perpendicular to the center line of the runway. This conversion can best be explained by reference to the diagram of figure 144. With no horizontal deflection component, the sweep trace

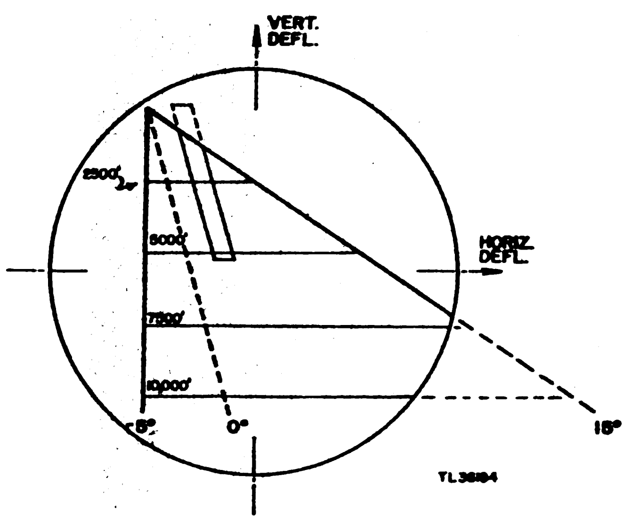

Figure 143. Horizontal expansion of azimuth EPI.

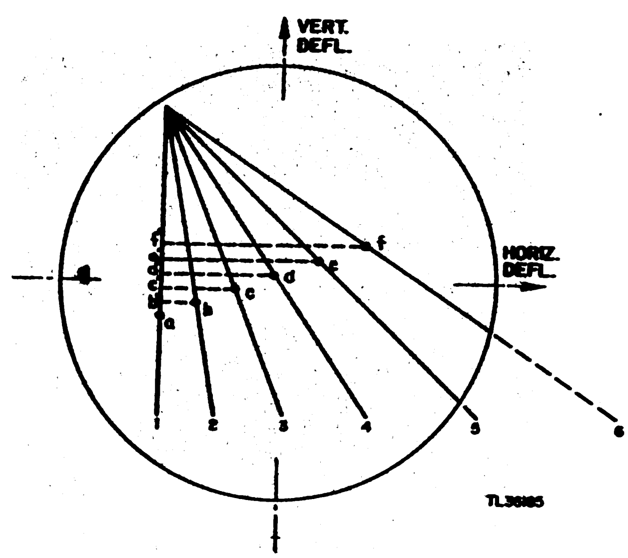

Figure 144. EPI presentation with inversely variable vertical sweep component.

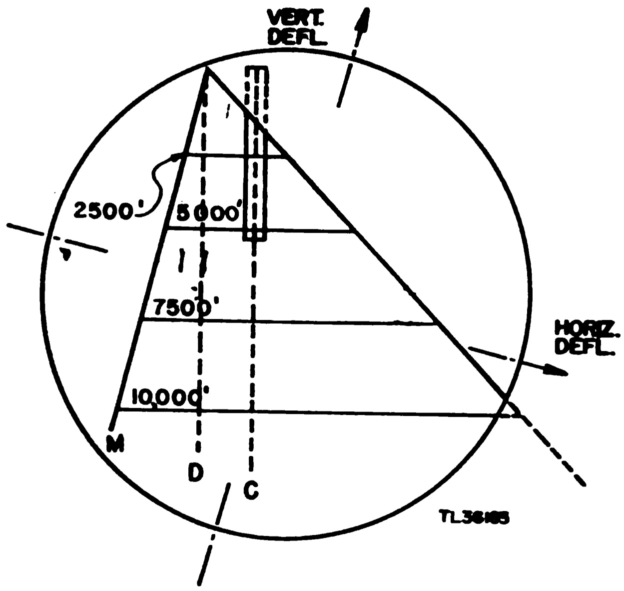

Figure 145. Corrected EPI azimuth display.

will be in position 1 and the range marker pulse will appear at point *a*. As the horizontal component increases, the sweep trace will be shifted to position 2, and since the vertical component has now decreased a distance *a-b'*, the range marker will appear at point *b*. With the sweep trace in position 3 and the vertical component decreased by a distance *a-c'*, the range marker will appear at point *c*, and so on. Since adjacent sweep traces are spaced much closer together than is shown in figure 144, the series of range markers will appear as a solid line whose angular position can be varied about the point *a* as the vertical component is decreased. In this manner the range marker lines may be made perpendicular to the runway center line.

(6) The corrected EPI display as used in the precision indicating system is shown in figure 145. The physical position of the tube is rotated through a small angle making the runway center line vertical so that the operator views the runway as a pilot would see it when making an approach, i.e., sighting down line C.

(7) The same reasoning applies to the elevation presentation. The ground line is the center of amplification and the degree of expansion is increased so that the 7 degrees coverage (1 degree below and 6 degrees above the ground) occupies a 60-degree angle on the tube face.

65. SWEEP AMPLIFIER (fig. 146). The two top compartments of bays 1 and 3 of the indicator rack house the precision elevation and azimuth sweep amplifier components, channels A and B (fig. 91). With one channel in use, the other can be held in reserve for immediate operation in the event that an operating component fails. Two sweep amplifier components are used simultaneously, one supplying sweep and intensifying voltages for the azimuth indicator, the other supplying similar voltages to the elevation indicator. Each component must supply 10-mile and 2-mile range sweeps to its associated indicator deflection coils as well as an intensifying voltage to the indicator anodes. The sweep amplifier components are identical and can be interchanged easily with only

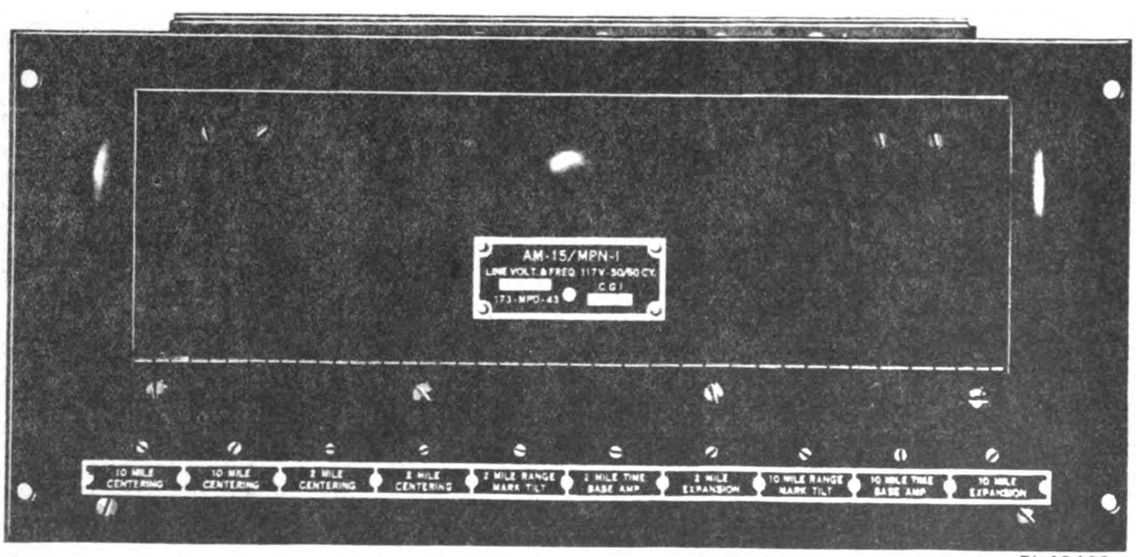

Figure 146. Sweep Amplifier AM-15/MPN-1, front view.

minor screwdriver and knob alignment adjustments. A schematic diagram of the sweep amplifier is shown in figure 150. In order to produce indicator sweeps which scan in synchronism with the antenna beams, the sweep currents are modulated by the angle voltages derived from the angle coupling unit (refer to par. 71). The amplifiers generate voltages which develop a combination of magnetic fields in the deflecting yokes of the CRT, varying in direction and strength to produce the desired indicator sweeps for the EPI presentation. The form of

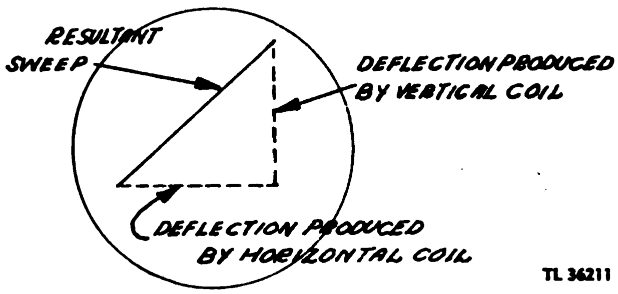

Figure 147. Deflection produced by equal saw-tooth currents in coils at right angles.

voltage required to produce the straight-line sweep across the indicator tube is one which will develop a saw-tooth variation of the current through the horizontal deflecting coils of the CRT. Initiated by a negative trigger from the synchronizer, the linear saw-tooth current variation in the horizontal deflection coils produces a resultant magnetic field which forces the electron beam sideways, producing a straight-line horizontal sweep across the tube face. If a second set of coils at right angles to the first set is also fed with a saw-tooth current wave at the same time, the resulting trace will be a straight line at an angle from the horizontal. The angle of the resultant trace will be determined by the relative magnitude of the two magnetic fields (fig. 147). Since the sweep must scan in synchronism with the antenna beam angle, the amplitude of the vertical saw-tooth wave must be variable to produce this scan. This is accomplished by modulating the vertical timebase components by means of a synchronizing voltage developed in the angle coupling unit. If the voltage introduced from the angle coupling unit varies from zero to maximum, the amplitudes of successive vertical deflecting current saw-tooth pulses likewise vary. To minimize distortion in the presentation, a small portion of the angle signal is inverted and fed to the horizontal deflecting system to make the horizontal sweep shorter as the angle increases. The sweep amplifier chassis provides sweeps for both 2-mile and 10-mile cathode-ray tubes. Owing to the differences in range, several minor variations in circuit design are required.

a. Two-Mile Sweep Generator. The block diagram of the 2-mile sweep generator circuit in the sweep amplifier is shown in figure 148. This circuit is composed of three separate channels; the variable-sweep generator channel, the fixed-sweep generator channel, and the intensifying channel. The function of the three channels is to generate the EPI timebase, to synchronize the timebase scan, and to intensify the forward sweep.

(1) INTENSIFYING CHANNEL.

(*a*) The negative trigger pulse from the synchronizer unit triggers multivibrator V1, a 6SN7-GT duo-triode.

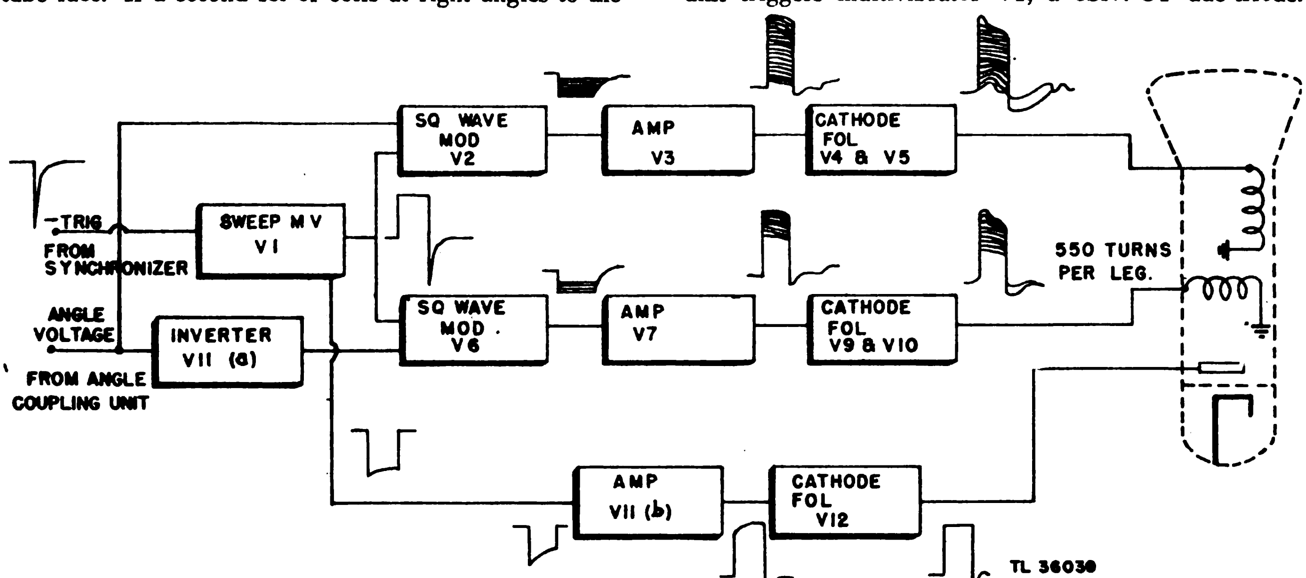

Figure 148. Two-mile sweep generator, block diagram.

With no trigger pulse applied to the multivibrator, V1(a) conducts heavily while V1(b) is cut off by the negative bias voltage applied to its grid. With the application of the negative-going trigger pulse to the grid of V1(a), this section of the tube is momentarily cut off and its plate voltage rises suddenly to the supply potential. The sudden positive surge is applied to the grid of V1(b) through capacitor C2 (fig. 149) causing V1(b) to conduct. The multivibrator remains in this state, with V1(a) cut off and V1(b) conducting, until the negative charge on C4 has leaked off sufficiently through R4 and P1 to allow V1(b) to again conduct and the multivibrator returns to its original condition. In this manner a negative-going square wave is developed in the plate circuit of V1(b) whose duration is dependent on the time constant of C4, R4, and P1, and is therefore controlled by the setting of P1, the 2-MILE GATE WIDTH control.

high impedance output of the amplifier stage and the relatively low input impedance of the interconnecting cable to the indicator unit.

(2) VARIABLE-SWEEP GENERATOR CHANNEL.

(*a*) The positive-going square wave at the grid of V1(b) is applied to the grid of V2, the square wave modulator tube (fig. 151). The square wave has a duration of approximately 40 microseconds which actually represents more than 2 miles on the range scope. The output of V2, a 6SJ7-GT pentode, consists of a series of negative-going square waves whose amplitude is determined by the plate voltage applied to V2. The square wave modulator is operated as a constant current pentode with a steady positive voltage of higher value than the maximum plate voltage, applied to the screen. Normally, the entire plate voltage supply of V2 is furnished by the

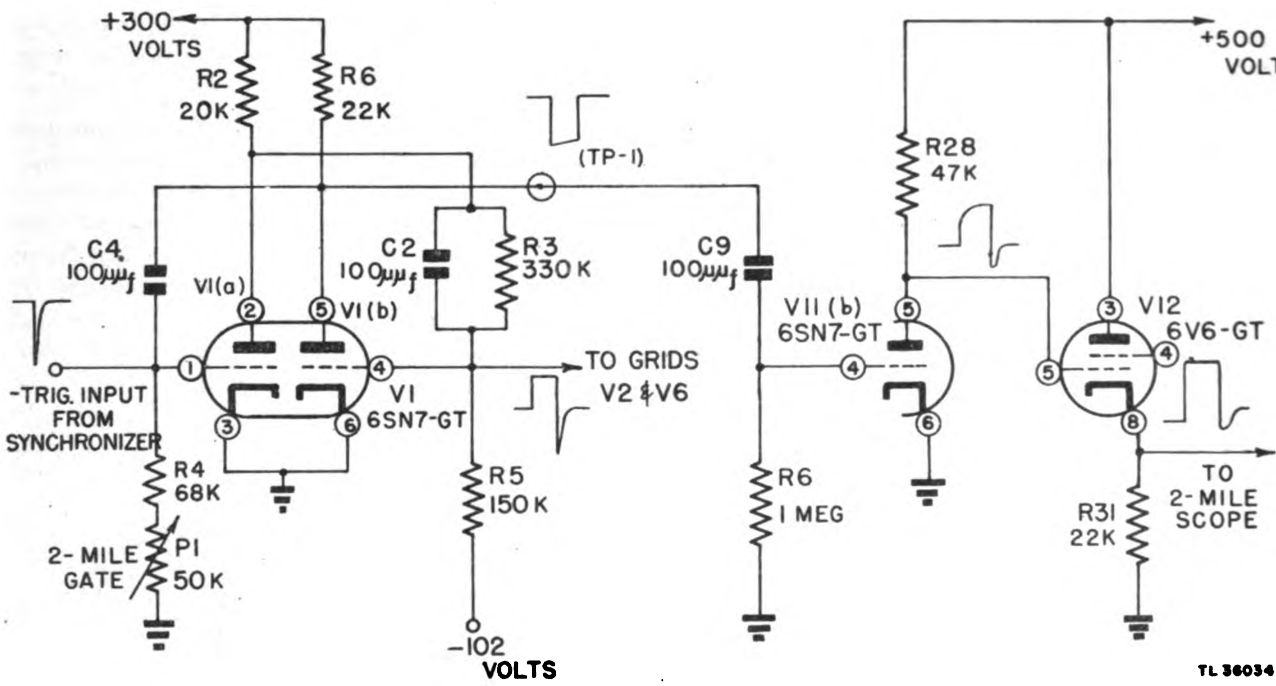

Figure 149. Two-mile gating multivibrator and intensifying circuit.

(*b*) The negative-going square wave at the plate of V1(b) is applied through capacitor C9 to the grid of amplifier tube V11(b). The square wave amplitude is sufficient to cut off V11(b), thereby producing a positive-going flat-top square wave in the output. The amplifier square wave is applied through cathode follower V12, a 6V6-GT beam tetrode, to the first anode of the 2-mile cathode-ray tube and serves to brighten the timebase trace during the forward sweep. The cathode follower functions as an impedance matching device between the angle signal input from the angle coupling unit. However, switching from one channel to the other may affect the baseline position on the indicator tubes. Thus the baseline adjustment control, P13, is provided to set the minimum plate potential or baseline from which the square wave will start. Adjustment of P13 moves the baseline to its correct position on the indicator tube. The angle signal voltage supplied across P2 and R9 varies from 2 volts to a maximum of 52 volts positive. A large part of the voltage is tapped off of P2 to supply the plate

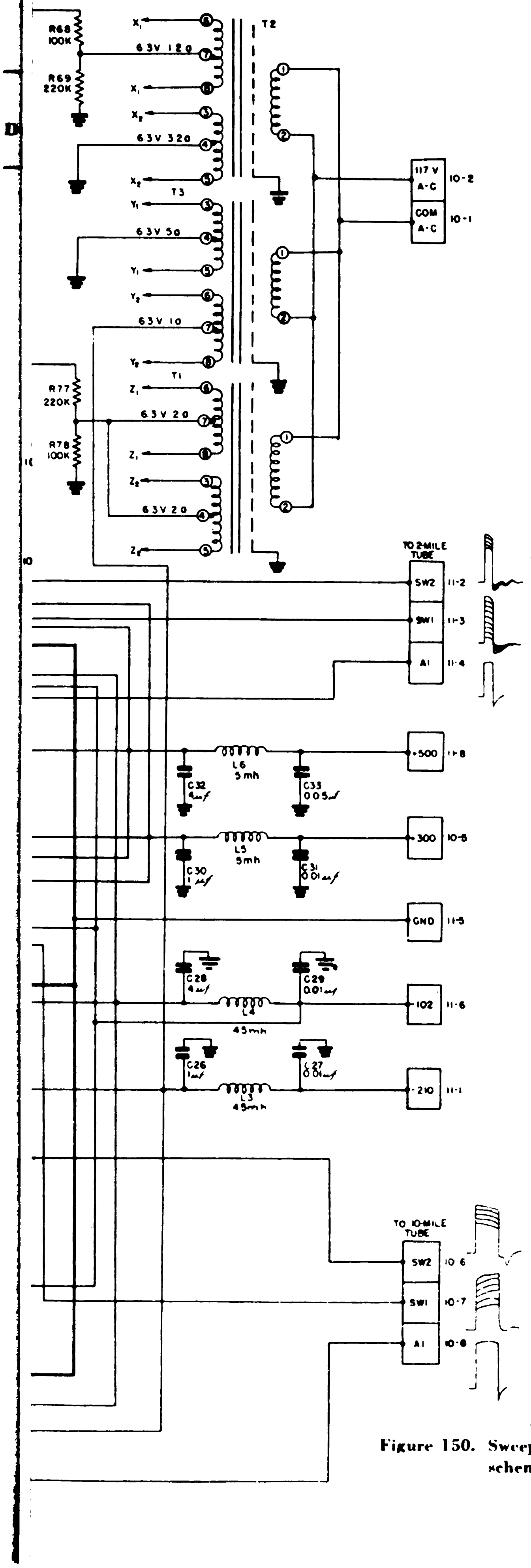

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Figure 150. Sweep Amplifier AM-15/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
V22	VT 100	807	
V23	VT 107	6V6-GT	
V24	VT 231	6SN7-GT	
V25	VT 107	6V6-GT	
L1	.75 H		
L2	.75 H		
L3	4.5 MH		
L4	4.5 MH		
L5	5 MH		
L6	5 MH		
T1	15-3380		
T2	15-3401		
T3	15-3381		
T4	15-3461		
R1	1,000	1	20%
R2	20,000	10	5%
R3	330,000	½	10%
R4	68,000	½	20%
R5	150,000	½	20%
R6	22,000	½	20%
R7	100,000	1	20%
R8	22,000	½	20%
R9	15,000	½	10%
R10	470,000	½	20%
R11	20,000	8	10%
R12	470,000	½	20%
R13	47	½	20%
R14	10,000	2	20%
R15	470	½	20%
R16	470	½	20%
R17	470	½	20%
R18	470	½	20%
R19	47	½	20%
R20	2,000	25	10%
R21	2,500	25	10%
R22	22,000	2	20%
R23	4,700	½	20%
R24	150,000	1	20%
R25	100,000	1	20%
R26	1 Meg	½	20%
R27	22,000	½	20%
R28	47,000	10	5%
R29	470,000	½	20%
R30	100,000	½	20%
R31	22,000	2	20%
R32	20,000	8	10%
R33	1 Meg	½	20%
R34	47,000	½	20%
R35	470,000	½	20%
R36	47,000	½	20%
R37	47	½	20%
R38	10,000	2	20%
R39	470	½	20%

Symbol Designation	Description		
	Value	Rating	Tolerance
R40	470	½	20%
R41	470	½	20%
R42	470	½	20%
R43	47	½	20%
R44	20,000	10	5%
R45	330,000	½	10%
R46	150,000	½	20%
R47	22,000	½	20%
R48	68,000	½	20%
R49	22,000	½	20%
R50	10,000	½	20%
R51	20,000	10	5%
R52	75,000	2	10%
R53	75,000	2	10%
R54	1,500	2	10%
R55	75,000	2	10%
R56	75,000	2	10%
R57	1 Meg	½	20%
R58	47	½	20%
R59	22,000	2	20%
R60	47	½	20%
R61	22,000	2	20%
R62	10,000	½	20%
R63	220,000	½	20%
R64	10,000	½	20%
R65	220,000	½	20%
R66	25,000	10	5%
R67	25,000	10	5%
R68	100,000	½	20%
R69	220,000	½	20%
R70	4,700	½	20%
R71	25,000	10	5%
R72	150,000	1	20%
R73	1 Meg	½	20%
R74	47,000	10	5%
R75	22,000	2	20%
R76			
R77	220,000	½	20%
R78	100,000	½	20%
R79	470,000	½	20%
P1	50,000	2	20%
P2	25,000	2	10%
P3	500	25	10%
P4	500	25	10%
P5	250,000	2	10%
P6	100,000	2	10%
P7	50,000	2	20%
P8	25,000	2	10%
P9	50,000	2	10%
P10	50,000	2	10%
P11	250,000	2	10%
P12	100,000	2	10%
P13	100,000	2	10%

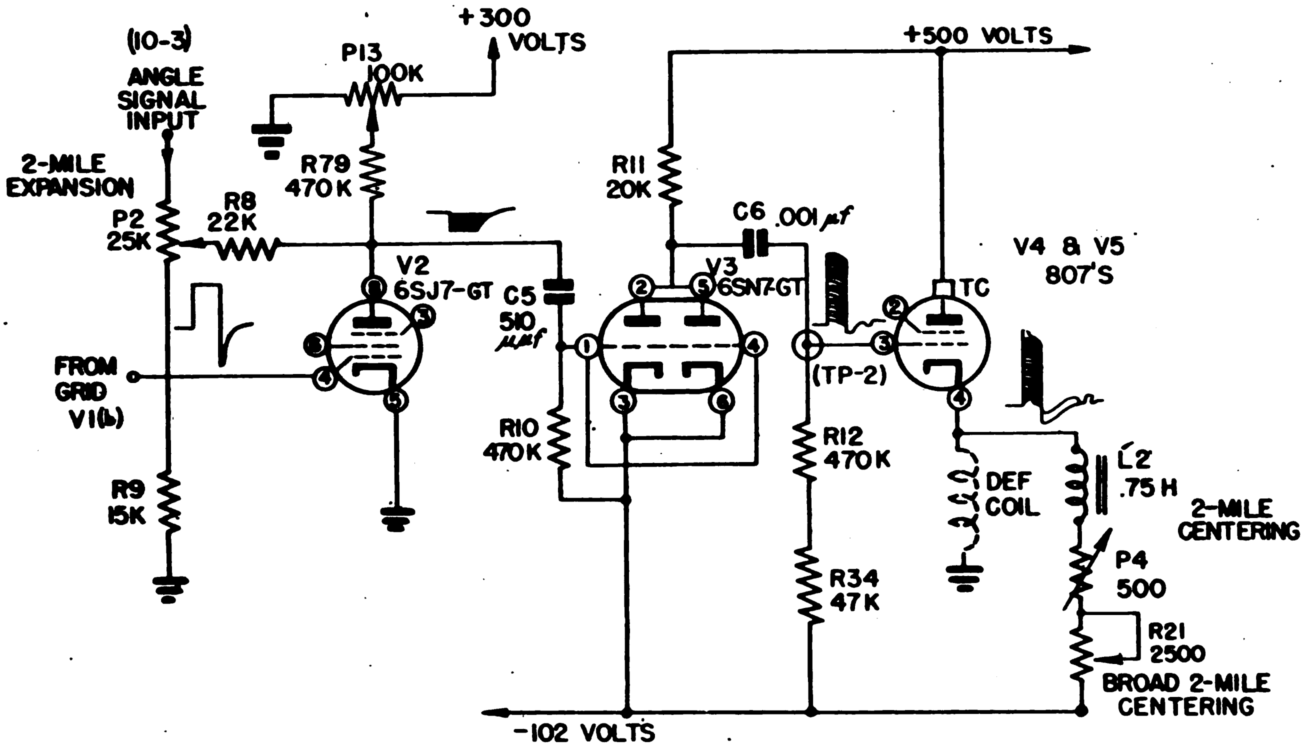


Figure 151. Two-mile variable sweep generator, simplified schematic diagram.

of the modulator tube. P2 provides the operator with a means of adjusting the gain of the stage and thus the amplitude of the variable-sweep component, and is known as the 2-MILE EXPANSION control.

(*b*) The amplitude of the negative-going square wave output varies from zero to approximately 30 volts and is applied to the following stage V3. V3, a 6SN7-GT duo-triode with its two sections connected in parallel, functions as an amplifier to provide a degree of amplification to the square wave before its application to the cathode follower tubes, V4 and V5. The cathode load of the parallel-connected cathode followers consists of the 2-mile CRT deflection coil in parallel with L2, P4, and R21. The positive-going square wave applied to the grids of V4 and V5 will cause them to conduct heavily; however, the current in the circuit will not build up instantly, due to the inductance of the deflection coil, but will rise gradually, thereby producing an approximately linear timebase sweep. The alternative current path consisting of L2, P4, and R21 is returned to the −102-volt supply at the input to the chassis ahead of LC filter. Choke L2 presents a high impedance to the timebase waveform while providing a comparatively low impedance path to dc from the −102-volt supply through R21, P4, L2, and the deflection coil to ground. By means of R21 and P4, the dc through the deflection coil can be varied, thereby providing a means of centering the timebase. R21 is a preset control and P4 a variable potentiometer labeled 2-MILE CENTERING (vertical) on the front panel.

(3) FIXED-SWEEP GENERATOR CHANNEL.

(*a*) The fixed-sweep generator channel (fig. 152) consists of V11(a), V6, V7, V9, V10, and their associated circuits. This channel is similar to the variable-sweep channel discussed in the preceding paragraph with a few exceptions. Since this channel provides the fixed-sweep component, the timebase waveforms should be of constant amplitude. However, as will be observed in aligning the scope picture, holding the sweep component absolutely constant causes distortion of the over-all picture and range lines do not appear perpendicular to the runway center line (par. 64). For this reason a portion of the angle voltage must be inverted and applied as a modulating voltage to the timebase square wave. V11(a) functions as an inverter tube for the angle signal voltage and a portion of its output, taken across R24 and P6, is applied as the plate potential of the square wave modulator, V6. Control P5, in the grid circuit of the inverter

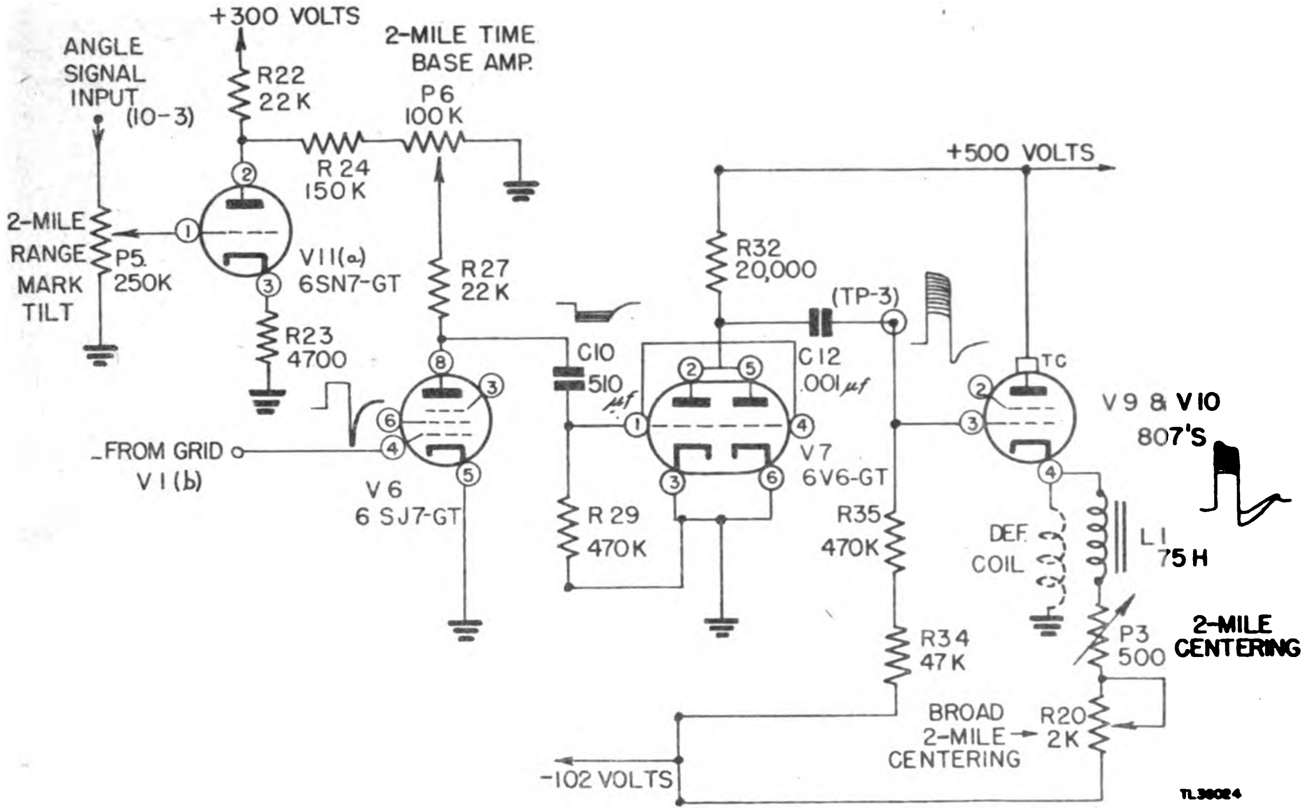


Figure 152. Two-mile fixed sweep generator, simplified schematic diagram.

tube, controls the amount of angle signal voltage applied to the fixed-sweep component and thus controls the angle of the range markers. P5 is labeled 2-MILE RANGE MARK TILT and is located on the front panel of the sweep amplifier. Potentiometer P6, in the output of V11(a), regulates the plate voltage applied to the square wave modulator tube and thus controls the amplitude of the variable-sweep component. P6 is labeled 2-MILE TIME BASE AMP and is located on the front panel.

(*b*) The remainder of the fixed-sweep channel functions the same as the variable-sweep channel; however, as the timebase square waves increase in amplitude in the variable-sweep channel, the fixed-sweep timebase component gradually decreases by a comparatively small amount. It should be noted that the voltage waveforms producing the saw-toothed current variations in the deflection coils are not the theoretical desired trapezoidal patterns. In this case however, the timebase of the 2-mile sweep is so short that a square wave of voltage is entirely satisfactory to produce a linear sweep. In fact, the waveform actually developed for application to the deflection cathode followers is slightly trapezoidal in the reverse sense due to the charging of the coupling capacitors C6 and C12. This causes the 2-mile timebase to deviate slightly from the desired linear sweep; however, the deviation is not serious enough to cause inaccuracies in operation.

b. Ten-Mile Sweep Generator. The 10-mile sweep circuits are similar to the 2-mile sweep circuits already described, with the exception of several modifications required in view of the longer sweep time of approximately 100 microseconds. Thus the coupling between stages must be augmented by the use of clamp circuits to reduce the inaccuracies in the timebase sweep caused by the interstage coupling. The block diagram of the 10-mile sweep generator is shown in figure 153. This circuit is composed of three channels whose functions are identical with the functions of the 2-mile circuit channels.

(1) INTENSIFYING CHANNEL.

(*a*) Besides triggering the 2-mile multivibrator, the negative-going trigger pulse from the synchronizer triggers the 10-mile multivibrator V13, a 6SN7-GT duo-triode. V13 is identical in mode of operation to V1 used in the 2-mile generator circuit. However, in order to produce the longer voltage gate required for the 10-mile sweep, larger capacitors, C16 and C18 were used. P7, the 10-

MILE GATE WIDTH control, permits adjustment of the grid time constant of V13(a), thus controlling the width of the square wave gate.

(*b*) The negative-going square wave at the plate of V13(b) is amplified by V24(b) and is applied to the first anode of the 10-mile CRT through cathode follower V25. The operation of V24(b) and V25 in the intensifying channel is identical, except for circuit constants, with the operation of V11(b) and V12 in the 2-mile intensifying channel.

(2) VARIABLE-SWEEP GENERATOR CHANNEL.

(*a*) Operation of the variable-sweep generator channel begins with the square wave modulator V14, identical in operation with V2 of the 2-mile sweep circuit with the exception of the baseline adjustment control, P13, which was omitted in the 10-mile circuit. The plate voltage output of V14, a variable-amplitude rectangular pulse, is coupled to the amplifier stage V15. In this amplifier stage the usual grid resistor, such as R10 in the corresponding 2-mile circuit, cannot be used since the coupling capacitor C19 would charge through the grid resistor during the gate interval, thereby causing the square wave to slope off at its trailing edge. Increasing the value of the grid resistor would reduce the charging rate of C19, resulting in a more nearly square waveform at the grid of V15. However, with the high grid resistance, the capacitor would not have time to discharge sufficiently in the comparatively short time interval between gate pulses. Thus over a period of time, the average charge on this capacitor would increase sufficiently to disturb the base level of the sweeps and shift the position of the trace. Using a larger capacitor for coupling would increase the modulator loading and further complicate the discharge problem. It is therefore necessary to apply two clamping tubes to the grid input circuit whose function is to maintain an accurate grid bias level between sweeps, preventing the accumulation of excess charges on C19.

(*b*) Between gate pulses, V8(b) and V21(b) are permitted to conduct as diodes, since V21(b) is diode connected and at this time the grid of V8(b) is driven positive. The plate of V8(b) is connected to –102-volt potential (fig. 154) and its cathode is connected to the grid input of V15. Therefore, any tendency for the grid of V15 to drop below the biasing point of –102 volts will permit V8(b) to conduct, and the grid will return to the desired potential. The action of V21(b) is similar. Its plate and grid, however, are tied to the grid input of V15 and its cathode is connected directly to –102 volts. Any tendency of the grid input system to rise above the desired bias permits conduction through V21(b) as its plate voltage rises above that of the cathode. The conduction of V21(b) thus removes any excess charge from C19 which would otherwise disturb the grid bias of V15. Since at the time of the sweep, a negative rectangular wave is applied to the grid of V15, the plate of V21(b) will be driven negative with respect to its cathode and the tube will not

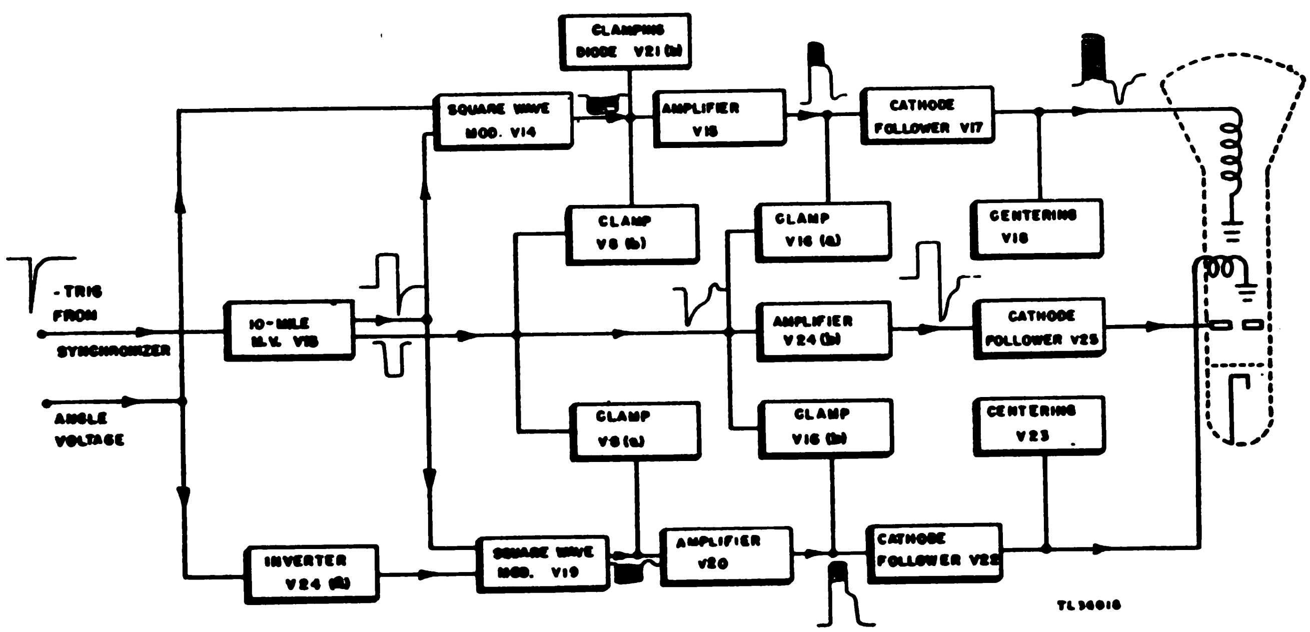


Figure 153. Ten-mile sweep generator, block diagram.

conduct. V8(b) is eliminated from the circuit at this time by the application to its grid of a rectangular negative voltage, from the gating multivibrator, sufficient to bias it past cutoff and prevent current flow through it. Therefore, the grid input of V15 may be considered to be of infinite impedance during the sweep time. At the end of the sweep, V8(b) is again permitted to conduct and its combined action with that of V21(b) again eliminates overshooting and removes residual charge on C19.

(*c*) A single cathode follower V17, a type 807 tube, is used in the 10-mile circuit of the variable-sweep channel, since instantaneous current requirements are smaller than the 2-mile sweep. Several factors combine to require the application of beyond cut-off bias to the grid of V17 between sweeps. The bias is applied by V16(a) whose plate is connected to the grid input and whose cathode is connected to –210 volts. As in the case of V8(a), a negative gate applied to the grid of V16(a) removes the tube from the circuit during the sweep period. Between sweeps the tube may conduct freely and biases the grid of V17 to –210 volts (fig. 155).

(*d*) V16(a) operates between sweeps to apply a large bias to the grid of V17 which is low enough to keep the tube below cutoff, despite any oscillations which might be set up in the deflection coil. Note that direct coupling is used between the plate of V15 and the grid of V17 to provide a d-c path from grid to cathode of V17. The grid bias of V17 is established by the plate potential of V15 because of the direct connection. Note that the variable sweep, which is the output of V17, must vary between zero and a maximum, making the grid bias on V17 quite critical. When the angle signal voltage is zero, so is the output from sweep amplifier V15. Since clamp tube V16(a) is now cut off by the negative square wave from the multivibrator, its plate voltage becomes positive to a value determined by the series network R52, R53, V15, and R54, between the 300 and –102-volt supplies. This increasingly positive voltage must not exceed the cut-off bias of V17, for if the grid of V17 is permitted to rise above cutoff and a false variable sweep component is permitted to reach the deflecting coils, the sweep angle will be distorted from its correct value. The value of resistor R54, which provides cathode bias for V15, is 1,500 ohms, which is sufficient to bring the grid of V17 back to the cut-off point when V16(a) disconnects it from the –210-volt supply. The combined action of the clamp tube and the resistance network assures that the amplitude of the rectangular pulses delivered to the deflection coils by V17 is proportional to the angle voltage.

(*e*) For sweep positioning on the indicator face, the beam power tube V18 is used, rather than the inductance-resistance combination satisfactory for the 2-mile positioning circuit. Owing to the longer sweep length and the larger percentage of low-frequency components, a much larger choke would be required to act as a constant-current device during sweep time. V18 operated as a constant-current tube fulfills both the function of blocking the peak sweep currents from the parallel circuit used in positioning, and in providing a conveniently variable resistance to regulate the constant value of dc through the deflecting coils. The screen grid is returned through R66 to the 300-volt supply, and the plate is connected directly to the cathode circuit of V17. Current flow through V18 is determined by the value of bias applied to its grid through a divider network comprising R62,

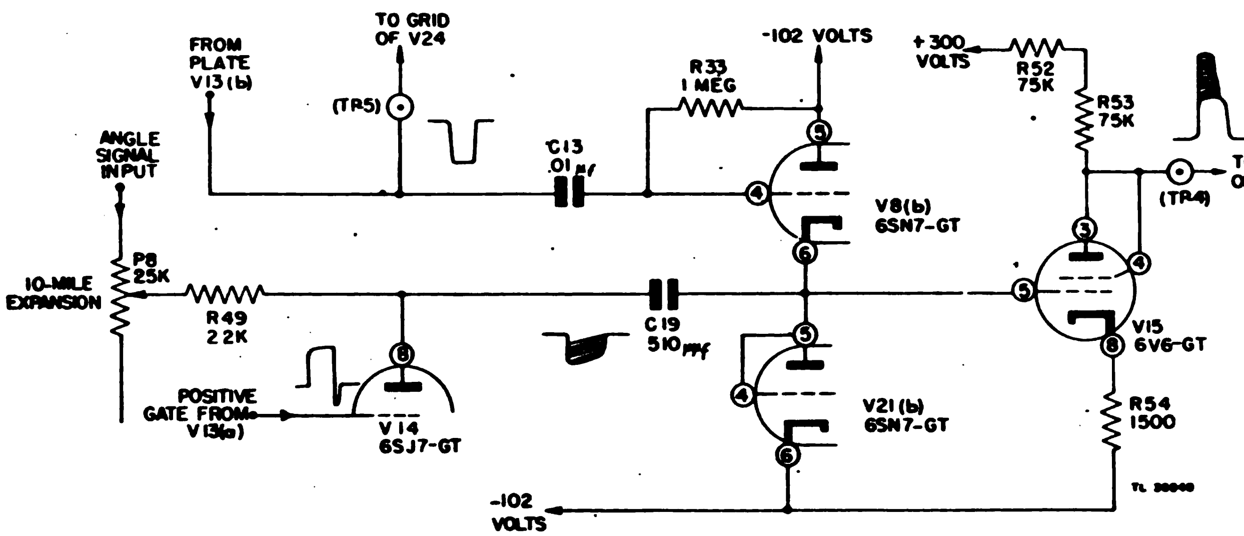


Figure 154. Ten-mile variable sweep generator clamping circuit.

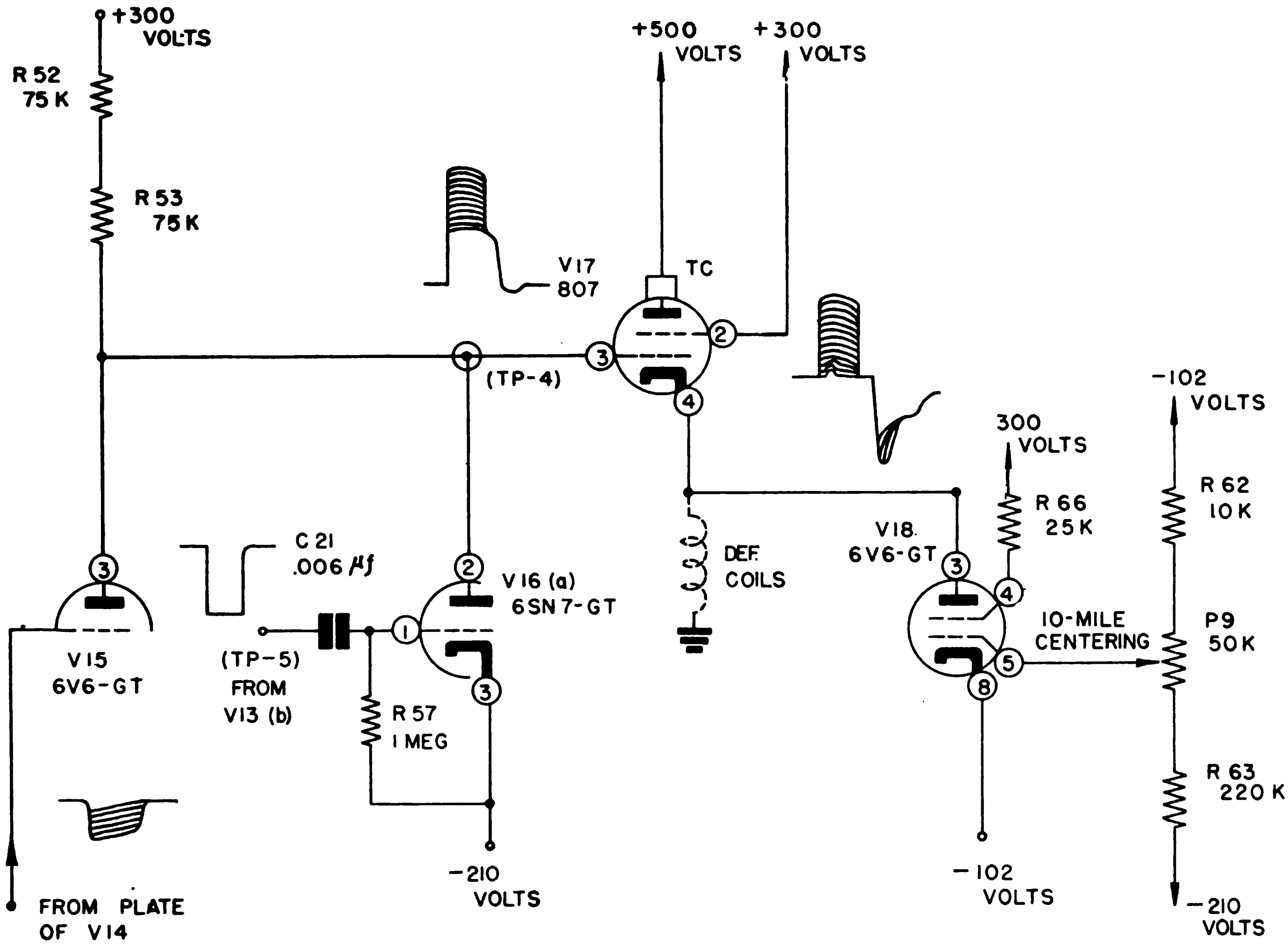


Figure 155. Ten-mile variable sweep cathode follower, clamping, and sweep-positioning circuit.

P9 (the 10-MILE CENTERING CONTROL), and R63 connected between the –102 and –210 volt sources (fig. 155). The cathode of V18 is returned to the unfiltered –102-volt supply at its input to the chassis, since it draws too much current for the filtering chokes. P9 thus serves as the operator's sweep-positioning control for the variable component.

(3) FIXED-SWEEP GENERATOR CHANNEL (fig. 156).

(*a*) The circuit connections to the gating multivibrator, the intensifying circuit, and the primary square wave fixed sweep circuit in the 10-mile sweep generator are the same as in the 2-mile. V24(a), which inverts and applies a portion of the angle signal to the square wave modulator operates the same as V11(a) in the 2-mile fixed circuit. The grid system of V20, the fixed sweep amplifier, is clamped in the same way as V15, already discussed in the preceding paragraph, except that it does not use the lower clamping diode but utilizes the flow of grid current to accomplish the same purpose. This is permissible since no cathode bias resistor is used, a condition made possible because the bias on cathode follower stage V22 is not extremely critical.

(*b*) V8(a) clamps the grid of V20 to prevent its reaching a lower value than –102 volts between sweeps. This is due to the fact that, as in the case of the 2-mile fixed sweep circuit, the plate voltage of the square wave modulator has a large steady component, in addition to the varying angle voltage component. Cathode follower V22 (807) is grid clamped by V16(b), the same as with the variable circuit of V17 and V16(a). As explained previously, V23, the constant-current positioning tube, and V18 are identical in operation.

*c. **Power Requirements.*** Two Rectifier Power Units PP-22/MPN-1 are included in Radio Set AN/MPN-1,

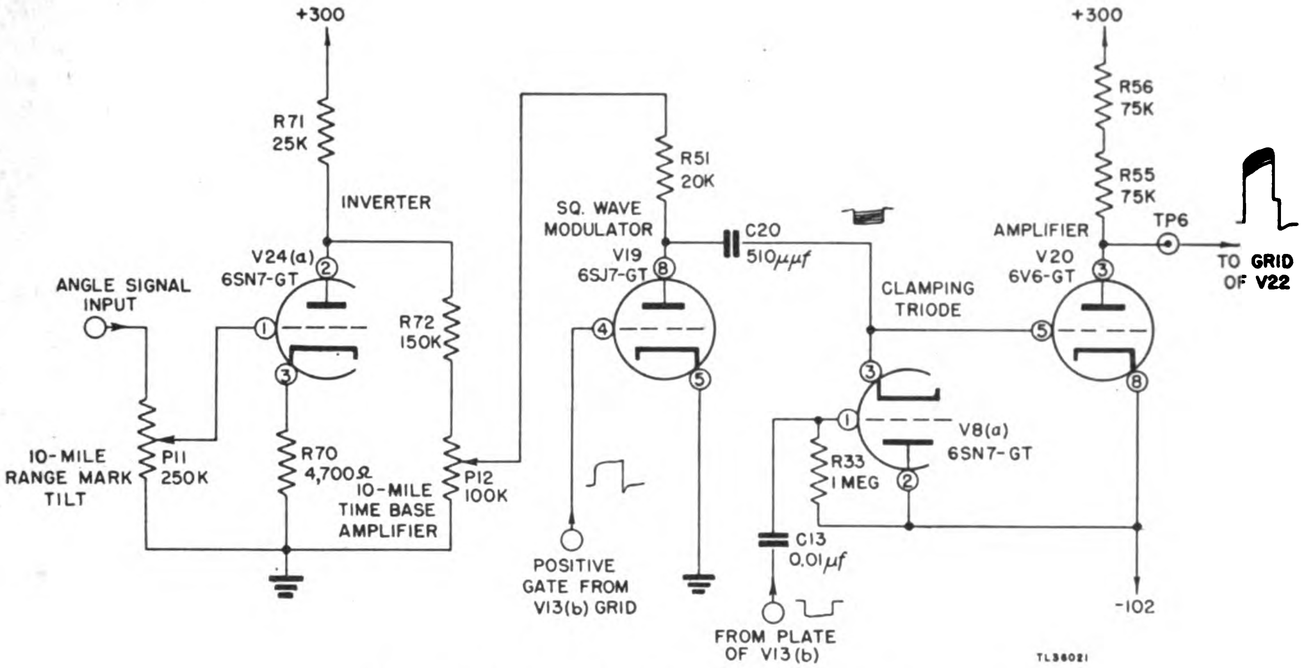


Figure 156. Ten-mile fixed sweep generator circuit, simplified schematic diagram.

located in bays 2 and 3 of the indicator rack. Channel A power supply is located in bay 2 and channel B power supply is located in bay 3. These units supply a regulated 300-volt power output rated at 450 ma to the elevation and azimuth sweep amplifiers, elevation and azimuth indicators, and synchronizer. Power Unit PP-24 supplies the 500-volt supply, and Power Unit PP-25 supplies the -210 and -102-volt supply to the sweep amplifier. Refer to chapter 4, section II.

66. PRECISION INDICATORS. Two precision indicators are used with Radio Set AN/MPN-1, Elevation Indictaor ID-37/MPN-1 and Azimuth Indicator ID-36/-MPN-1, located in bays 1 and 3, respectively, of Indicator Rack MT-118/MPN-1 (fig. 91). Each indicator is capable of measuring short time periods, of the order of a few microseconds, and of displaying this information visually in order to locate a target in space.

a. Elevation Indicator ID-37/MPN-1. The elevation indicator comprises two 7-inch cathode-ray tubes used as a 2-mile and 10-mile EPI presentation. The two tubes are mounted at an angle of 45 degrees from the horizontal (fig. 158), and the operator views the CRT screens on a horizontal, semitransparent mirror. Associated with each tube is a servo cursor, operated in conjunction with the azimuth antenna follower assembly, which serves to insure the proper alignment of the azimuth antenna in elevation. The two display scopes provide a vertical picture of the approaching aircraft (fig. 159); the left-hand scope covering a range up to 10 miles and the right-hand scope covering a range of 2 miles. By means of these elevation scopes and the elevation director assembly cursors, the variation in height from a predetermined glidepath can be determined for an approaching aircraft.

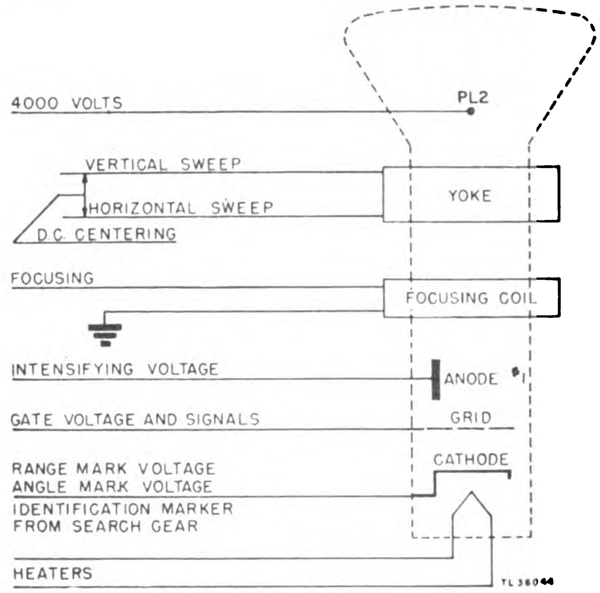


Figure 157. Indicator tube elements.

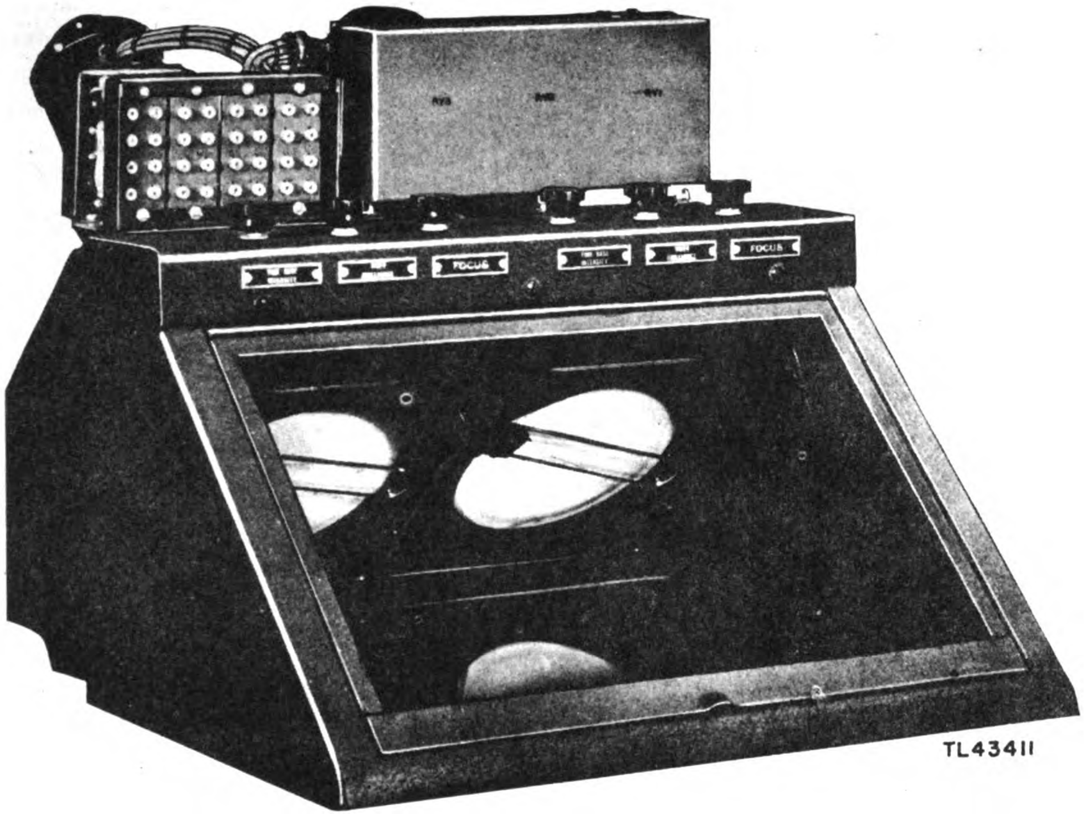


Figure 158. Elevation Indicator ID-37/MPN-1, front oblique view.

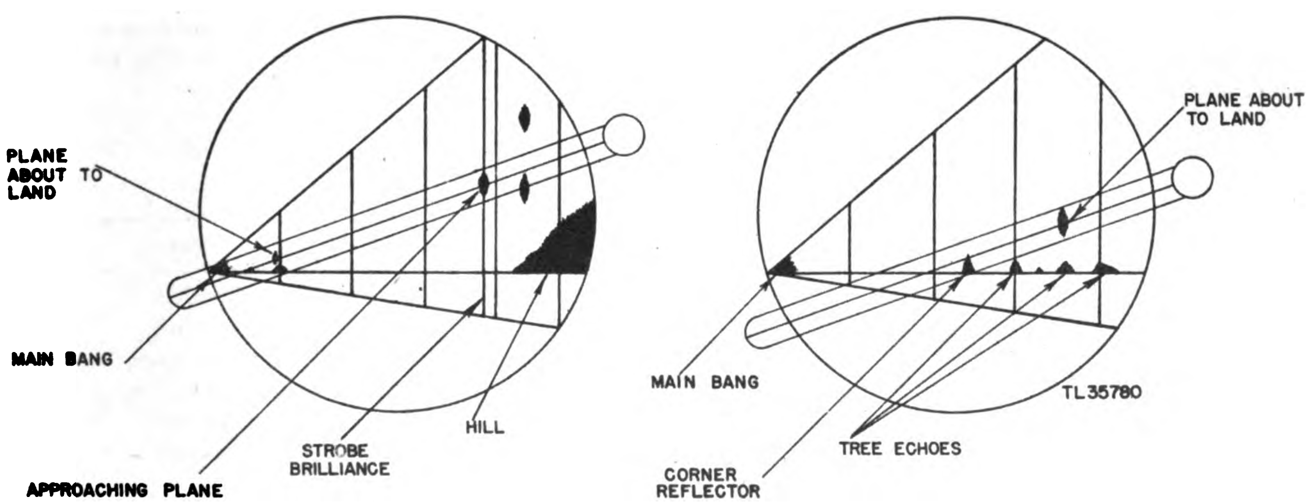


Figure 159. Elevation precision display.

(1) CIRCUIT ANALYSIS (fig. 160).

(a) The two type 7BP7 cathode-ray tubes in the elevation indicator (fig. 157) are of the magnetically focused and deflected type, the coils being positioned about the necks of the tubes. Focusing coils L3 and L1, used with the 10-mile and 2-mile tubes, respectively, are supplied from a 300-volt source through the variable resistors P3 and P6. These two FOCUS controls regulate the current in the coils, thereby providing a means of sharply focusing the electron beam. The 4,000-volt accelerating voltage from Rectifier Power Unit PP-23/MPN-1 is applied to a conducting layer of graphite, coated about the inner side of the bulb portion of the tube, which acts as a second anode. This anode provides a high accelerating potential for the electron stream and a return path for the electrons reaching the face of the tube.

(b) The intensity-modulated angle blanking pulse from the synchronizer is of long duration and therefore, is fed directly to the grids of the indicator tubes through resistors R1 and R4 (fig. 161). The blanking pulses supply two levels of grid bias, one at cutoff and the other considerably below cutoff. The video pulses originating from the receiver and amplified in the synchronizer are fed to the grids through P1, C1, and P4, C4, for the two tubes, and are prevented from feeding back into the intensification circuits by the blocking filters formed by R1, C2, in the 10-mile circuit and by R4, C5, in the 2-mile circuit. The intensifying pulses from the switching units are prevented from feeding into the video circuits by the comparatively low impedance to ground through C1 and C4. The video lead to the elevation indicator is paralleled with the video lead to the azimuth indicator by means of a common connection, inter-rack wire No. 814, from connector strip AB2, terminal 3, in the elevation indicator. The RC coupling network permits the required pulse distribution to the grids without feedback difficulties between the indicators.

(c) The indicator tube cathodes are coupled directly to the plates of the respective mixer tubes in the synchronizer, and mixer plate voltages and CRT cathode voltages are supplied from the 300-volt line through R2, P2, and R3 for the 10-mile tube, and through R5, P5, and R6 for the 2-mile tube. The potentiometers, labeled BRILLIANCE and located above the semitransparent mirror, vary the cathode voltages of the CRT's thereby controlling the over-all brilliance of the timebase trace.

(d) The vertical and horizontal deflecting coils for the cathode-ray tubes are contained in a single yoke mounted about the necks of the tubes. Each yoke, L4 for the 10-mile tube and L2 for the 2-mile tube, consists of four coils, connected as shown in figure 160. Two of the coils provide the vertical timebase component while the other two coils provide the horizontal component.

(e) Above the large sloping elevation indicator panel is a smaller vertical panel housing the three relays used for changing channels of operation. In the A channel position the relays are de-energized. With the channel switch in the B position, the relays are energized by a 117-volt a-c source. Voltages from either channel A or channel B are applied to the indicator tube elements through the action of the three relays (fig. 160). The following CRT connections are switched between channels A and B by the SPDT contacts in the three relays of the indicator units.

FUNCTIONS OF CHANNEL SWITCHING RELAYS

Relay	Contact	Function	Origin
1	1	Angle brilliance pulse to grids of scopes.	Synchronizer
1	2	Video pulses to grids of scopes.	Synchronizer
2	1	2-mile vertical deflection component.	Elevation sweep amplifier
2	2	2-mile horizontal deflection component.	Elevation sweep amplifier
2	3	2-mile range marks to CRT cathode.	Synchronizer
2	4	10-mile range marks to CRT cathode.	Synchronizer
3	1	10-mile vertical deflection component.	Elevation sweep amplifier
3	2	10-mile horizontal deflection component.	Elevation sweep amplifier
3	3	2-mile intensifying pulse to first anode.	Elevation sweep amplifier
3	4	10-mile intensifying pulse to first anode.	Elevation sweep amplifier

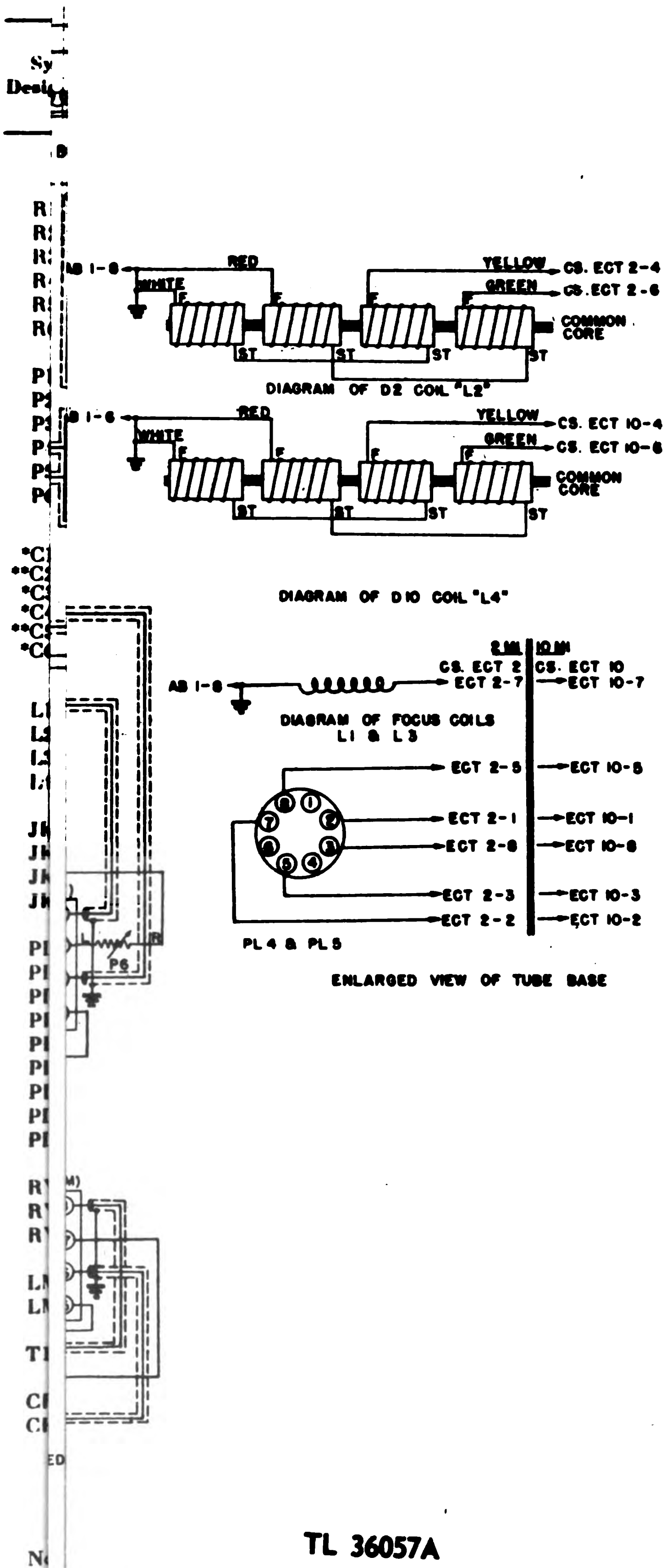


Figure 160. Elevation Indicator ID-37/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	100,000	½	20%
R2	47,000	2	10%
R3	22,000	½	20%
R4	100,000	½	20%
R5	30,000	5	10%
R6	22,000	½	20%
P1	2,000	2	10%
P2	25,000	3	10%
P3	25,600	3	10%
P4	2,000	2	10%
P5	25,600	3	10%
P6	25,000	3	10%
*C1	.01 mf	600	20%
**C2	.001 mf	500	20%
*C3	.01 mf	600	20%
*C4	.01 mf	600	20%
**C5	.001 mf	500	20%
*C6	.01 mf	600	20%
L1	C00	6201	
L2	B00	3339-2	
L3	C00	6201	
L4	B00	3339-10	
JK1	78-1P		
JK2	78-1P		
JK3	78-1P		
JK4	78-1P		
PL1	AN3102-18-16P		
PL2	K-870326		
PL3	K-870326		
PL4	PF 8-7		
PL5	PF 8-7		
PL6	360		
PL7	360		
PL8	360		
PL9	360		
RY1	2 Pole	1357	
RY2	4 Pole	2120G	
RY3	4 Pole	2120G	
LM1	55		
LM2	55		
T1	15-3427		
CRT1	7BP7		
CRT2	7BP7		

Note:
*1200 V—.01 mf—10% Capacitors may also be used for C1, C3, C4, C6.
**2500 V—.001 mf—10% Capacitors may also be used for C2 and C5.

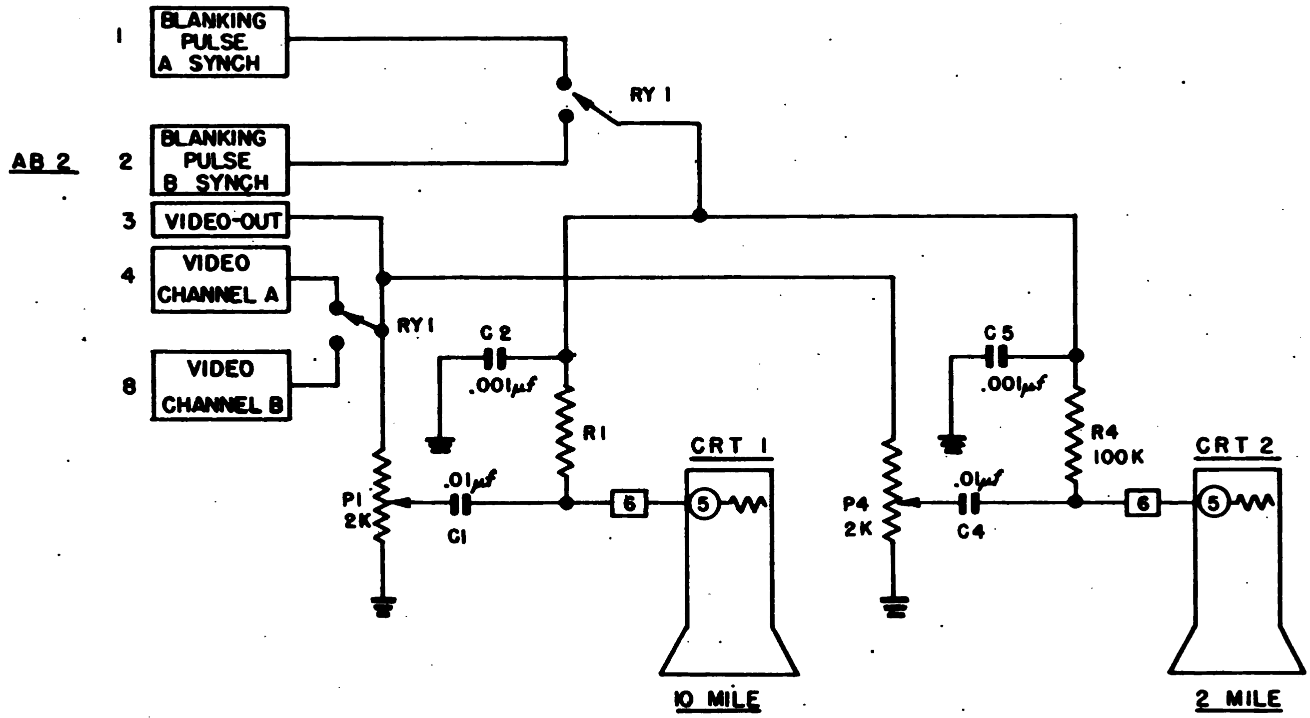


Figure 161. Video section of elevation indicator.

(2) MECHANICAL OPERATION. Mounted over each tube face in the elevation indicator is a servo cursor which is controlled by the foot-pedal servo system and is pivoted about the vertex of the scanned area. A transparent angular area on each cursor represents the width and direction in elevation of the azimuth antenna beam. As a result, as long as the elevation tracker operates the foot pedals to keep the echo signal within the transparent area, the azimuth antenna is properly positioned in elevation to scan the target. The antenna positioning system is fully explained in section VII of this chapter.

(3) POWER REQUIREMENTS. One of two 4,000-volt rectifier units supplies the high accelerating voltages to the indicator tubes through the high-voltage cable from plug 1. Power may be supplied from either of the 4,000-volt power units through a high-voltage, vacuum-type relay mounted in Relay Assembly R-3/MPN-1. Transformer T1 supplies filament power to the parallel filaments of both indicator tubes. Refer to chapter 4, section II, for a detailed discussion of the power supply.

b. Azimuth Indicator ID-36/MPN-1. The azimuth indicator (fig. 162) is similar in construction and operation to the elevation indicator previously described. The two display scopes in the azimuth indicator provide a plan view of the approach to the runway, the right-hand scope covering a range of 10 miles and the left-hand scope covering a range of 2 miles (fig. 163). By means of the azimuth scopes and the azimuth director assembly cursors, the variation of the approaching aircraft to the right or left of a predetermined glidepath can be indicated.

(1) CIRCUIT ANALYSIS (fig. 164).

(*a*) The only essential differences between the azimuth and elevation indicators are in the connections to relay 1 and the orientation of the deflecting coils about the neck of the display tubes. In the azimuth indicator, the second set of contacts of relay 1 serve to switch the 300-volt supply to the two indicators between the channel A and channel B power supplies. The video signal input to the azimuth indicator is paralleled with the video line in the elevation indicators, and switching between channels is accomplished by relay 1 in the elevation indicator.

(*b*) The yoke bearing the azimuth deflecting coils is rotated through 90 degrees with respect to the elevation coils so that the operator will have the same view of the runway on the scope as the pilot has of the actual runway. With this orientation, the origin or vertex of the EPI presentation is at the top of the apparent picture, with the timebase scanning downwards.

(2) MECHANICAL OPERATION. Mounted over each tube face in the azimuth indicator is a servo cursor similar to the cursors used with the elevation indicator. The azimuth cursors are controlled by the foot-pedal servo system and are pivoted about the vertex of the scanned

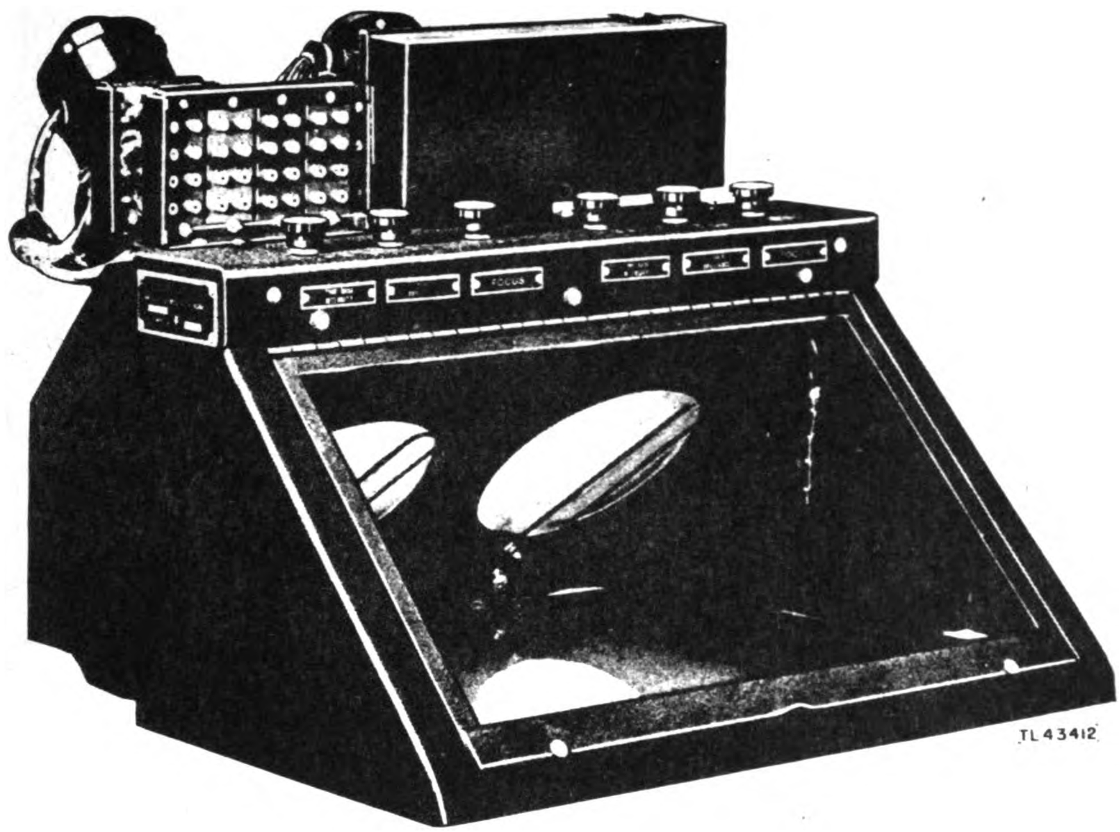


Figure 162. Azimuth Indicator ID-36/MPN-1, front oblique view.

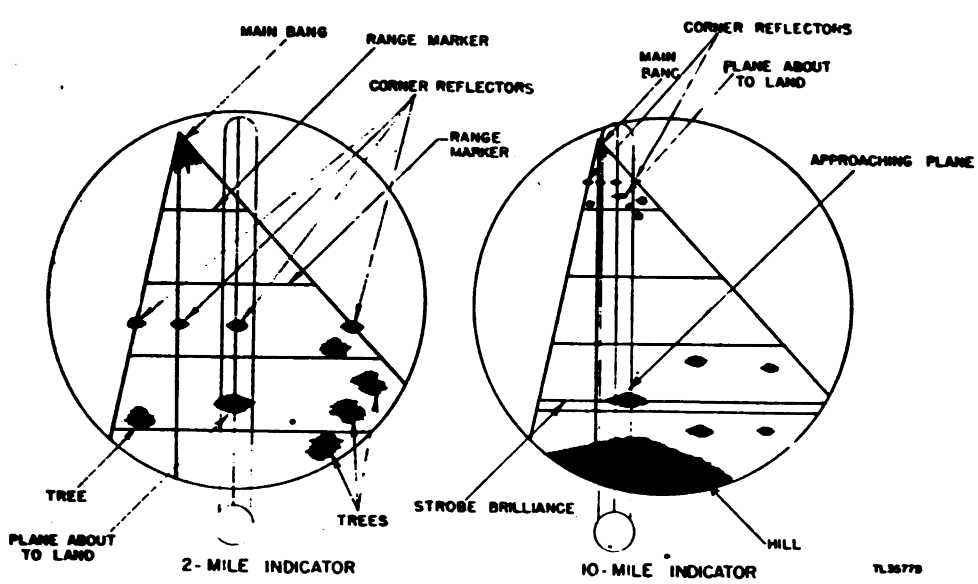
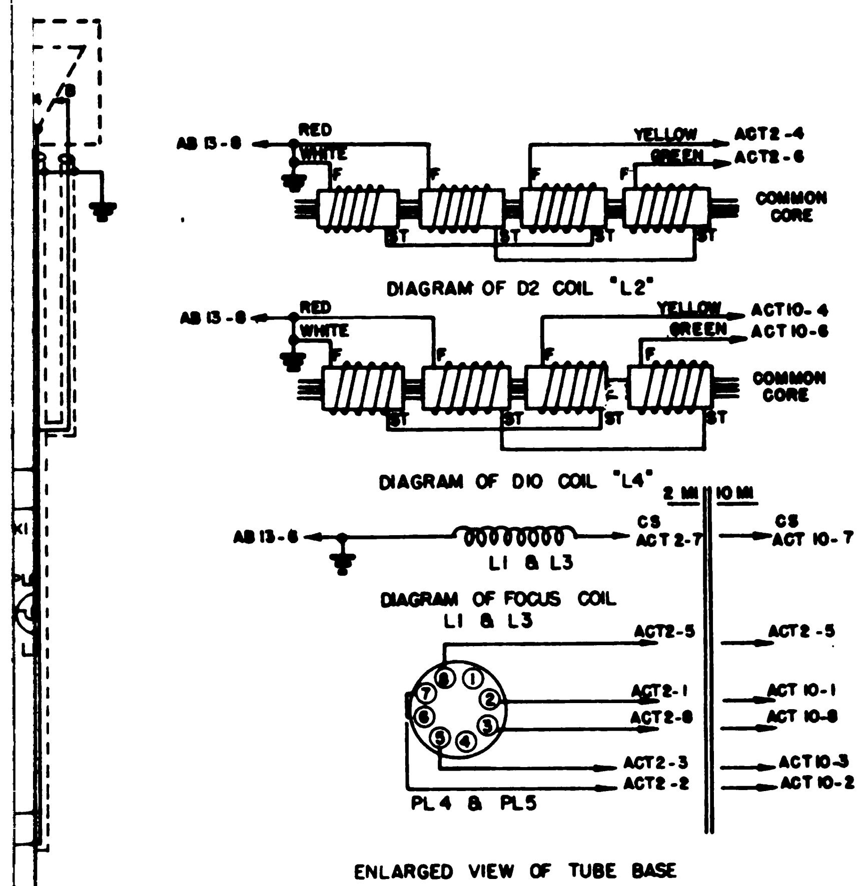


Figure 163. Azimuth precision display.



TL 36054A

Figure 164. Azimuth Indicator ID-36/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	100,000	½	20%
R2	30,000	5	10%
R3	22,000	½	20%
R4	100,000	½	20%
R5	47,000	2	10%
R6	22,000	½	20%
P1	2,000	2	10%
P2	25,000	3	10%
P3	25,000	3	10%
P4	2,000	2	10%
P5	25,000	3	10%
P6	25,000	3	10%
*C1	.01 mf	600	20%
**C2	.001 mf	500	20%
*C3	.01 mf	600	20%
*C4	.01 mf	600	20%
**C5	.001 mf	500	20%
*C6	.01 mf	600	20%
L1	C00-6201		
L2	B00-3339-2		
L3	C00-6201		
L4	B00-3339-2		
JK1	78-1P		
JK2	78-1P		
JK3	78-1P		
JK4	78-1P		
PL1	AN3102-18-16P		
PL2	K-870326		
PL3	K-870326		
PL4	PF 8-7		
PL5	PF 8-7		
PL6	360		
PL7	360		
PL8	360		
PL9	360		
RY1	1357		
RY2	2128G		
RY3	2128G		
LM1	55		
LM2	55		
T1	15-3127		
CRT1	7BP7		
CRT2	7BP7		

Note:
*1200 V—.01 mf—10% Capacitors may also be used for C1, C3, C4, C6.
**2500 V—.001 mf—10% Capacitors may also be used for C2 and C5.

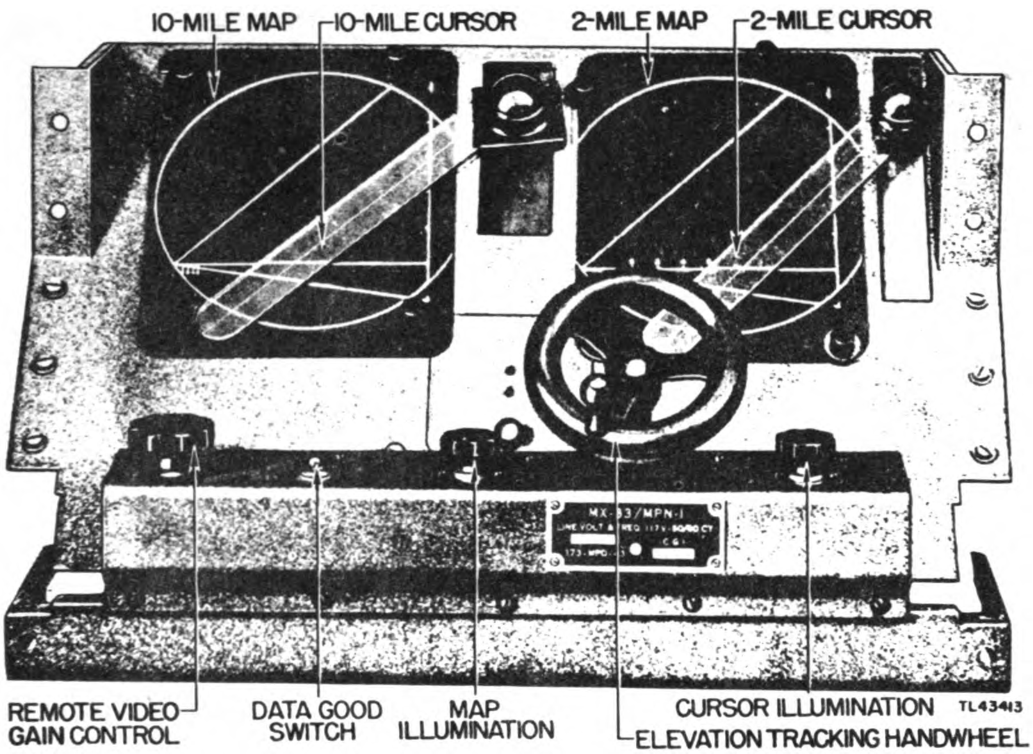


Figure 165. Elevation Director MX-33/MPN-1, front view.

area. A transparent angular area on each cursor represents the width and direction in azimuth of the elevation antenna beam. Thus, as long as the elevation tracker operates the foot pedals to keep the echo signal within the transparent area, the elevation antenna will be properly positioned in azimuth to scan the target.

(3) POWER REQUIREMENTS. The same high-voltage Rectifier Power Unit PP-23/MPN-1, that supplies the elevation indicator, furnishes the high accelerating voltage to the azimuth scopes. Connection for the accelerating voltage is made through plug 1 on the azimuth indicators.

67. DIRECTOR ASSEMBLIES. Two director assemblies are used with Radio Set AN/MPN-1, Elevation Director MS-33/MPN-1 and Azimuth Director MX-32/-MPN-1. The director assemblies are mounted below the indicator units (fig. 91) and provide a means of following an approaching aircraft and of translating the deviations of the aircraft from a predetermined course into proportionate error voltages.

a. Elevation Director MX-33/MPN-1. The elevation director assembly contains two removable maps, a 10-mile map and a 2-mile map, so positioned below the semitransparent reflector of the elevation indicator that the maps appear to be superimposed over the faces of the indicator tubes. Associated with each map is a tracking cursor which may be moved in a vertical direction across the map face by means of a tracking handwheel (fig. 165).

(1) MECHANICAL OPERATION. The two elevation tracking cursors are moved across the face of the elevation glidepath map by means of an eccentric double cam mechanically coupled to a single control handwheel (fig. 166). The cursors are mounted in a carriage, provided with magnetic rollers, which is free to move in a vertical direction. A screw adjustment is provided which releases the tracking cursors from the carriage for setting-up purposes. The cursor for the 2-mile indicator is driven by a wire and pulley arrangement from the handwheel shaft (fig. 167), while the 10-mile cursor is driven by

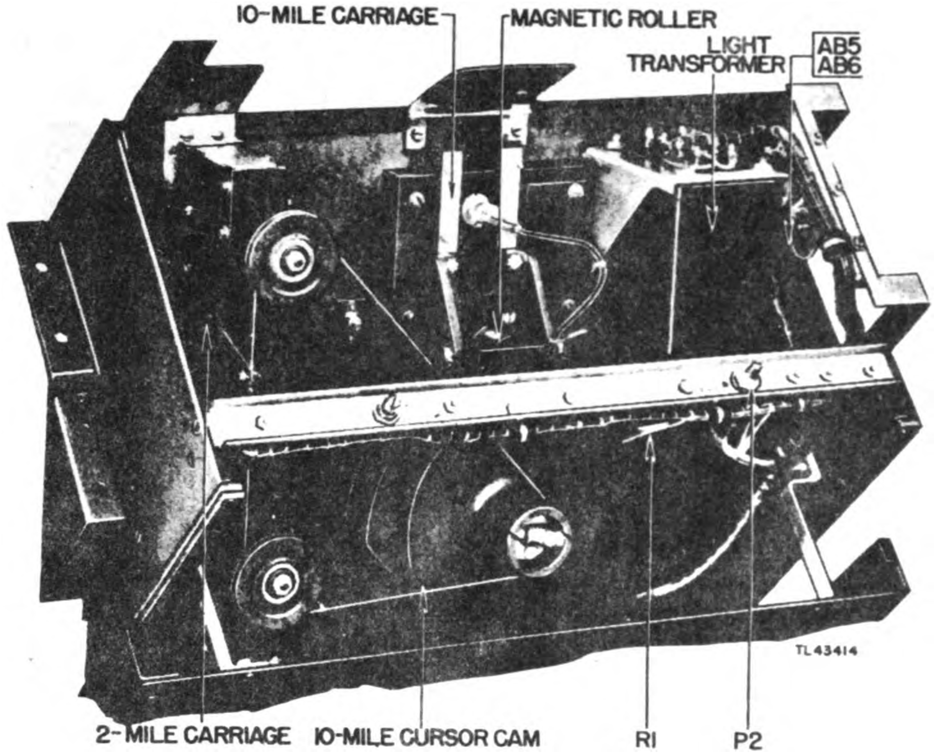


Figure 166. Elevation Director MX-33/MPN-1, rear view.

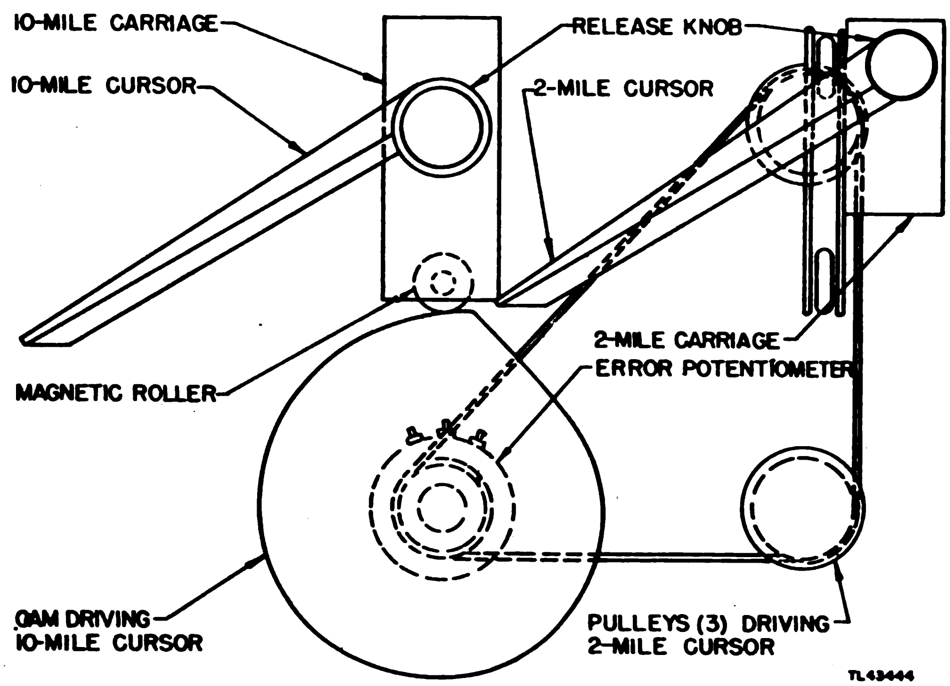


Figure 167. Elevation cursors, mechanical operation.

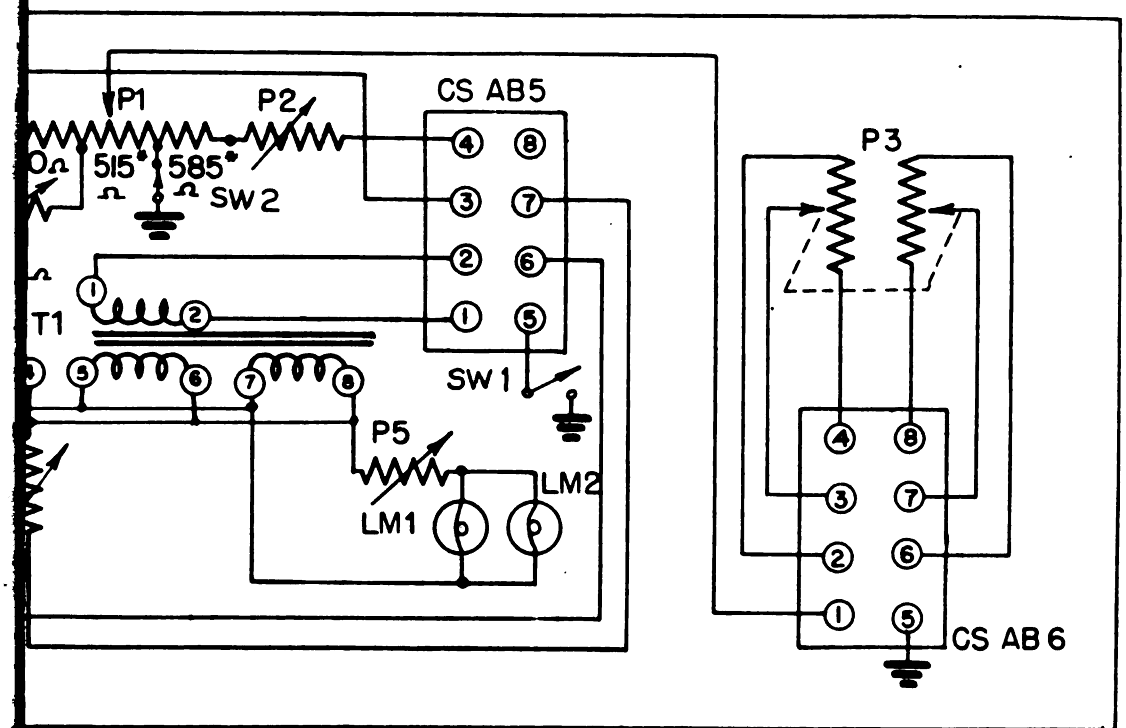


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Figure 168. Elevation Director MX-33/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	500 Ohm Adj.	10W	20%
P1	2,000 Ohm	6W	20%
P2	500 Ohm	2W	10%
P3	10,000 x 10,000	2W	20%
P4	6 Ohm	25W	20%
P5	6 Ohm	25W	20%
SW1	SPST Toggle SW1		
SW2	SPST Momentary Contact Normally Closed Switch.		
LM1	1855 Mazda light		
LM2	1855 Mazda light		
T1	15-3432 Dial Li. Transf.		

the cam. A pilot bulb is built into the release knob which illuminates an index mark engraved upon the top face of the cursor.

(2) CIRCUIT ANALYSIS.

(*a*) The drive shaft of the cam is also connected to the variable potentiometer P1 (fig. 168) which is across a 35-volt d-c supply from the aural signal unit. The error voltage is taken from the movable contact arm of P1 and is applied to the approach indicator and aural signal unit. The movable contact is so adjusted that it contacts the grounded center point of the potentiometer when the cursor is coincident with the glidepath, resulting in zero output voltage. The error voltage output increases in a positive or negative direction with respect to ground when the cursor, following the target echo, shows increasing deviation, respectively, below or above the proper glidepath. Resistor R1 is shunted across one end section of P1 in order to develop a voltage wave across the error potentiometer, conforming to the calibration of the errormeter. Potentiometer P2, in series with the error potentiometer, operates to balance the bridge circuit formed by the azimuth and elevation potentiometer connected in parallel.

(*b*) Transformer T1 supplies 6.3 volts ac for the operation of the associated pilot lights. Potentiometer P5, in series with the cursor lights, controls the brilliance of these pilot lights and is located on the panel of the elevation director. Potentiometer P4 functions in a similar manner to control the illumination of the map lights.

(*c*) Dual potentiometer P3 functions as an azimuth receiver gain control. One section of the potentiometer is connected to the azimuth gain control terminals on the channel A synchronizer, while the other section connects to corresponding terminals on the channel B synchronizer. The use of this control permits the elevation tracker to independently adjust the sensitivity of the radar receiver during periods of elevation system reception.

(*d*) DATA GOOD switch SW1 controls the elevation errormeter light on the approach indicator, and when closed, indicates to the approach controller that the information presented on the meter is correct and that the elevation tracker operator is following the echo signal properly.

b. Azimuth Director MX-32/MPN-1. The azimuth director assembly is similar to the elevation director assembly, permitting tracking of an echo signal on the two azimuth scopes with the tracking cursor mounted on the map area beneath the tubes (fig. 169). Besides supplying the azimuth errormeter on the approach indicator, the azimuth error voltage is fed to the aural signal unit to control the tone output of that unit as a further means of indicating azimuth error to the approaching pilot.

(1) MECHANICAL OPERATION. The mechanical arrangement of the azimuth cursors is similar to that of the elevation cursors, being operated by means of a handwheel under control of the elevation tracker. By means of a double cam mechanism, driven by the handwheel (fig. 170), these cursors are moved simultaneously across the map areas below the indicator tubes, the 2-mile cursor moving over its limited range five times as fast as the 10-mile cursor, but in unison with it. The cursors are mounted on movable carriages, free to slide only in a horizontal direction. Magnetic rollers are used with the carriages to insure constant following of the cam.

(2) CIRCUIT ANALYSIS.

(*a*) A 35-volt d-c supply from the aural signal unit is applied across error potentiometer P5. The error voltage is taken from the movable contact arm of P5 which is connected to the handwheel shaft. The contact arm is so adjusted that it contacts the grounded center point of the potentiometer when the cursor is coincident with the glidepath, resulting in zero output voltage. Deviations of the aircraft to the left or right of the glidepath produce a positive or negative error voltage, respectively. Due to the nonuniform scale (expanded center portion) used on the errormeter in the approach indicator, resistor R1 and R2 are shunted across the end portions of the winding of P5 in order to calibrate the meter scale against error voltage across P5.

(*b*) The remainder of the electrical circuit of the azimuth director is identical with the circuit of the elevation director previously described, with the exception of the antenna scan speed control switch SW1. Switch SW1 operates a motor-controlling relay (fig. 420), mounted on the rear of the narrow partition separating the precision antenna compartment doors, which selects the desired antenna scanning speed. Two speeds are available, the one in use depending on which of the two scanning motors is energized (ch. 3, sec. VII).

68. APPROACH INDICATOR ID-38/MPN-1.

a. General. The approach indicator is located in bay 2, immediately below the synchroscope and between the azimuth and elevation directors (fig. 91). While only being one assembly, the approach indicator electrically performs several distinct functions. In the indicating system it functions to display the elevation and azimuth error from the prescribed glidepath courses. In the communications system it offers the approach controller operator a selection of radio channels, for communication with approaching aircraft, by means of a switching panel on the front of the approach indicator.

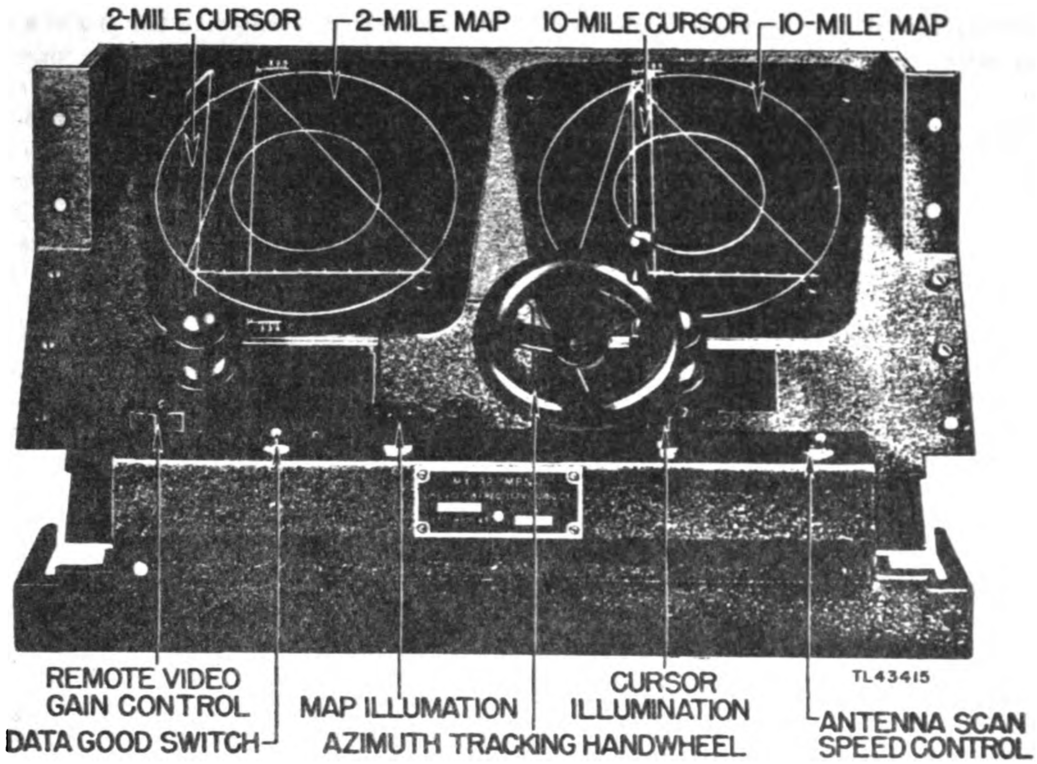

Figure 169. Azimuth Director MX-32/MPN-1, front view.

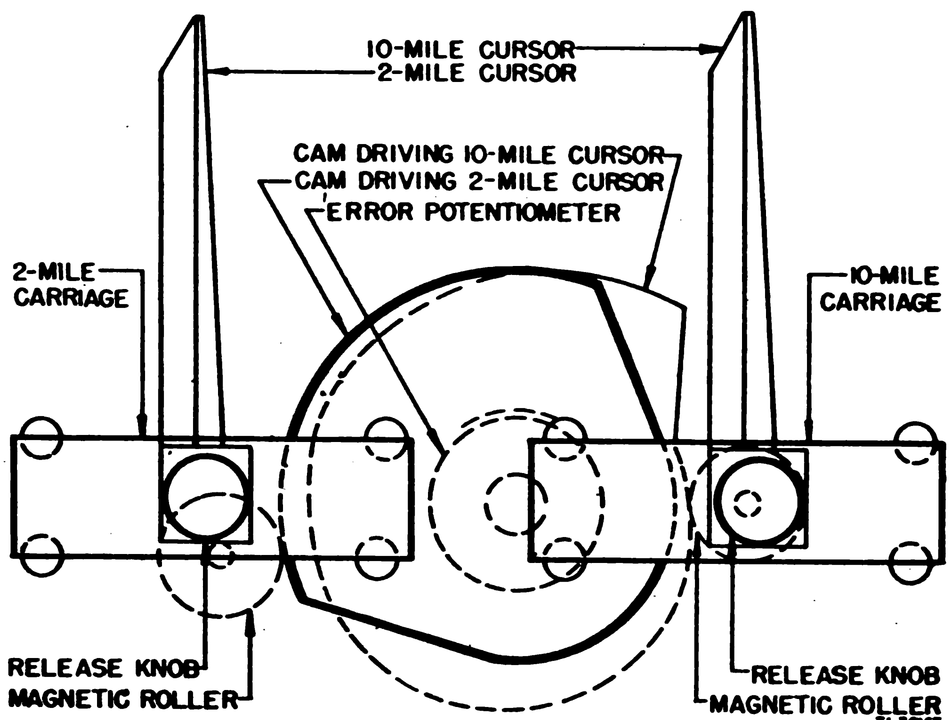

Figure 170. Azimuth cursors, mechanical operation.

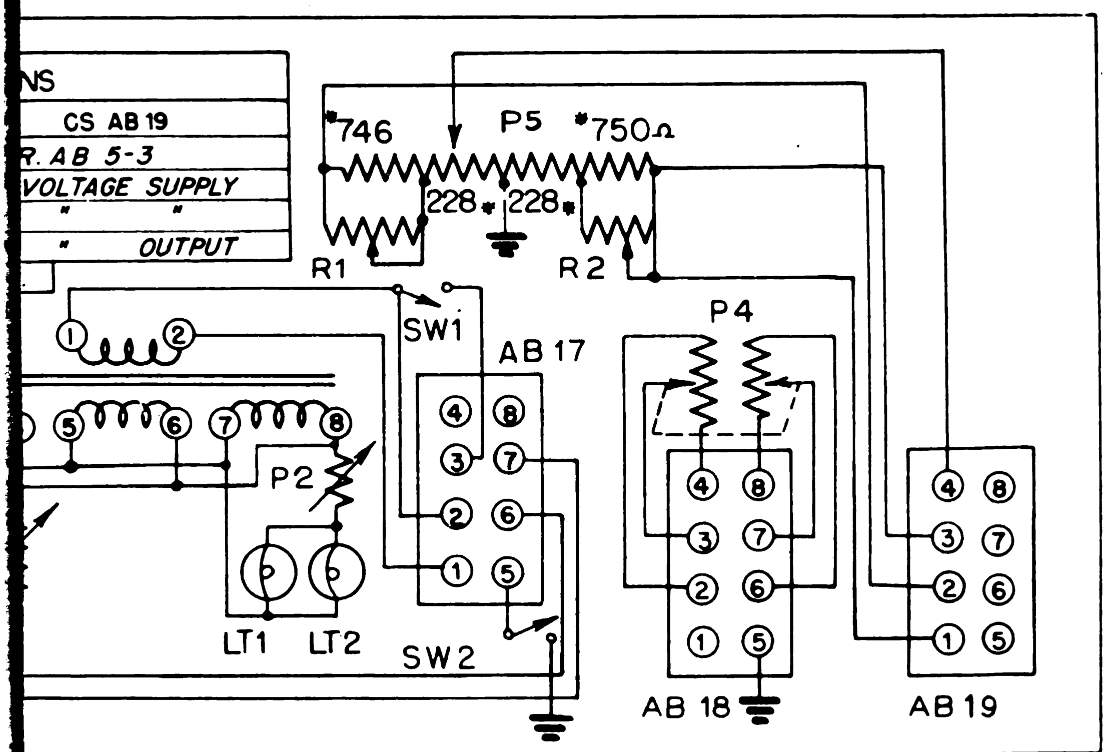

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Figure 171. Azimuth Director MX-32/MPN-1, schematic diagram.

visions for screwdriver adjustments at slotted shafts for varying both the elevation errormeter and the azimuth errormeter sensitivity.

c. Relay Switching. The approach indicator houses two relays used for channel switching. The voltage outputs from the error potentiometers in both directors are applied to the approach indicator chassis and from it to the aural signal unit in operation. The normal position of both relays, RY1 and RY2 (fig. 174), when not actuated, is for channel A operation. The errormeter inputs to the meters are paralleled to contacts on RY2 for application to either aural signal unit. The elevation warning light circuit also is brought to a contact on RY2 so that it may be controlled by either aural signal unit. Relay RY1 selects either aural signal unit tone output for application to the communications system, and also selects the d-c supplies from either aural signal unit to the error potentiometer in the directors. The relay also provides a means of selecting triggers from the A and B channel synchronizers for application to the test synchroscope in the indicator rack and to the master trigger selector control in the intercommunication panel between the search centrals.

d. Circuit Analysis. Two main groups of circuits are included in the approach indicator. One group is composed of the position errormeters and warning lights for use by the approach controller operator. These components are controlled by the error potentiometers in the elevation and azimuth director assemblies. The other group consists of rectifiers, audio amplifier and mixer stages, and the multiposition switches for the communication and the intercommunication control system (ch. 4, sec. III). The primary information from which the approach controller operator directs the movements of an aircraft is supplied by a pair of zero-centered meters, M1 and M2 (fig. 173). A dropping resistor and calibration potentiometer are in series with each meter input, the potentiometers being used to correct the range of meter variation with the error signal input of the associated meter. A voltage of 6.3 volts ac is supplied from a single source to pilot lights mounted on the panel of the approach indicator. Two lamps are mounted to illuminate the scale area of each meter. The return to ground for these lamps is through the DATA GOOD switch on the corresponding director assembly, so that the meter light can be turned on and off by the operator at that director.

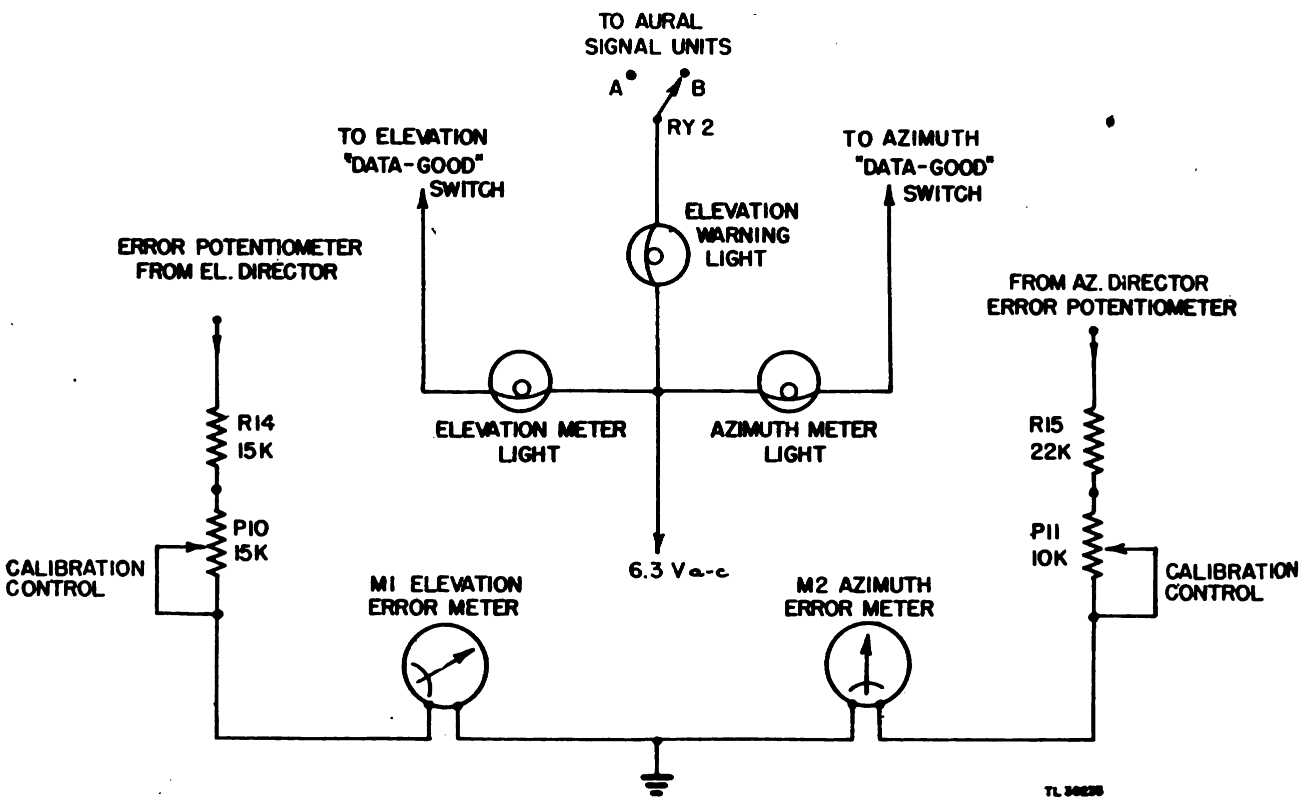


Figure 173. Position errormeters, simplified schematic diagram.

Symbol Designation	Value
	Ohms
R1	100
R2	200
R3	100
R4	100
R5	6
R6	250
R7	250
R8	820
R9	820
R10	820
R11	820
R12	Omitted
R13	Omitted
R14	20,000
R15	27,000
R16	25,000
P1	100,000
P2	500
P3	25
P4	25
P5	25
P6	500,000
P7	500,000
P8	500,000
P9	500,000
P10	20,000
P11	15,000
P12	10,000
P13	10,000
P14	10,000
C1	4 mfd
C2	1 mfd
C3	1 mfd
C4	1 mfd
C5	1 mfd
C6	40 mfd
C7	Omitted
C8	2000 mfd
C9	2000 mfd
C10	8 mfd
C11	8 mfd
L1	5H
L2	5H
L3	10H
F1	3 AG
F2	3 AG
JACK	JK-33-H

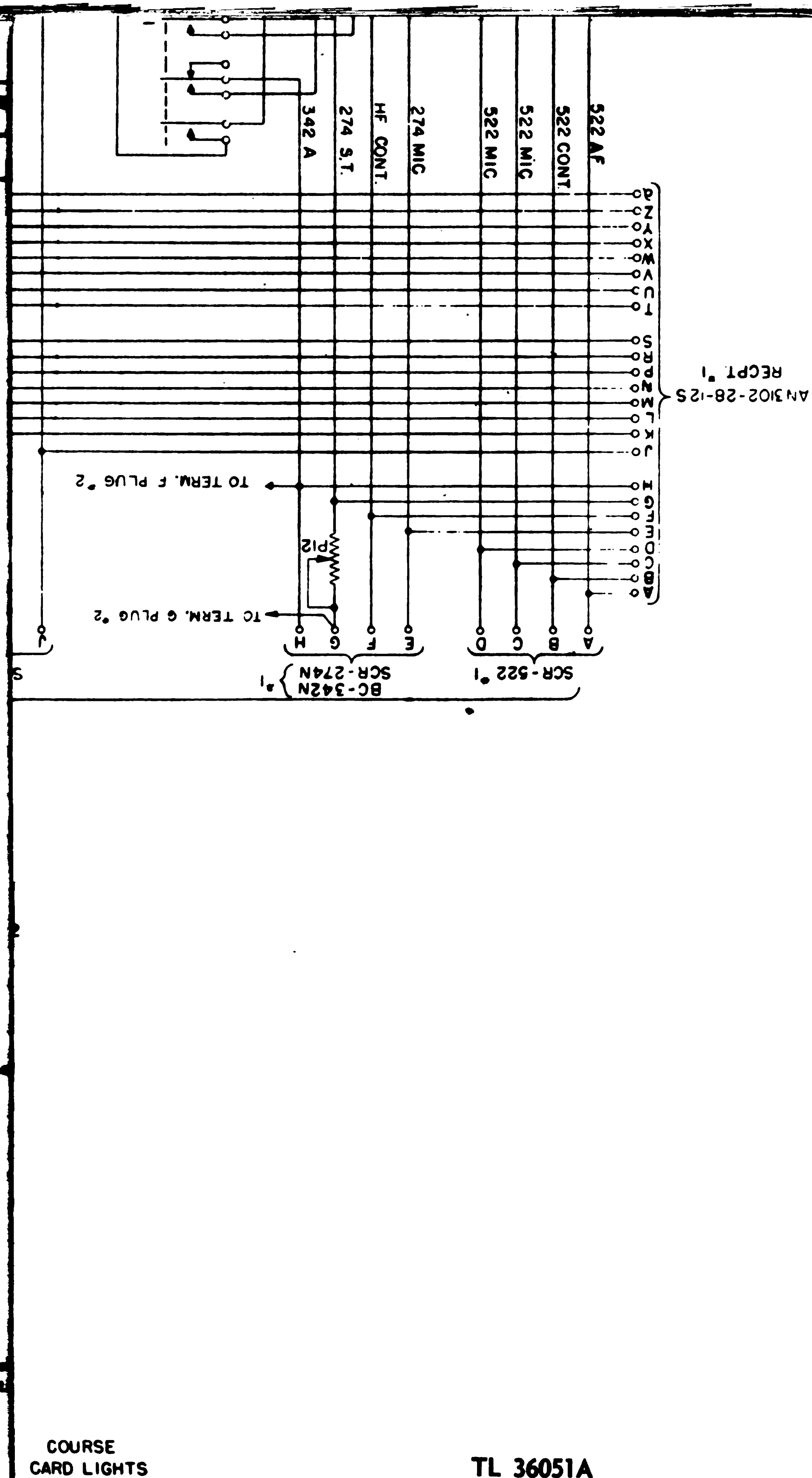


Figure 174. Approach Indicator ID-38/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
	Ohms	Watts	
R1	100	2	± 10%
R2	200	2	± 10%
R3	100	½	± 10%
R4	100	½	± 10%
R5	6	½	± 10%
R6	250	½	± 10%
R7	250	½	± 10%
R8	820	½	± 10%
R9	820	½	± 10%
R10	820	½	± 10%
R11	820	½	± 10%
R12	Omitted		
R13	Omitted		
R14	20,000	½	± 5%
R15	27,000	½	± 5%
R16	25,000	10	± 20%
P1	100,000	2	± 20%
P2	500	2	± 20%
P3	25	25	± 20%
P4	25	25	± 20%
P5	25	25	± 20%
P6	500,000	2	± 20%
P7	500,000	2	± 20%
P8	500,000	2	± 20%
P9	500,000	2	± 20%
P10	20,000	2	± 20%
P11	15,000	2	± 20%
P12	10,000	2	± 20%
P13	10,000	2	± 20%
P14	10,000	2	± 20%
		Volts	
C1	4 mfd	100	+40%, −15%
C2	1 mfd	600	+40%, −15%
C3	1 mfd	600	+40%, −15%
C4	1 mfd	600	+40%, −15%
C5	1 mfd	600	+40%, −15%
C6	40 mfd	150	+50%, −10%
C7	Omitted		
C8	2000 mfd	50	+65%, −10%
C9	2000 mfd	50	+65%, −10%
C10	8 mfd	600	+40%, −15%
C11	8 mfd	600	+40%, −15%
		Type	
L1	5H	15-3447	
L2	5H	15-3447	
L3	10H	15-3446	
F1	3 AG	3 amp.-.07	
F2	3 AG	3 amp.-.07	
JACK	JK-[illegible]3-H	shorting type tipjack	

Symbol Designation	Description		
	Value	Rating	Tolerance
NE1	#5122	0.1 Watt	
NE2	#5122	0.1 Watt	
LM1	WE #2-F.		
LM2	WE #2-F.		
LM3	WE #2-F.		
LM4	WE #2-F.		
LM5	WE #2-F.		
LM6	WE #2-F.		
LM7	WE #2-F.		
LM8	WE #2-F.		
LM9	WE #2-F.		
LM10	WE #2-F.		
LM11	GE Mazda #44		
LM12	GE Mazda #44.		
LM13	GE Mazda #44.		
LM14	GE Mazda #44.		
LM15	GE Mazda #51.		
LM16	GE Mazda #44.		
LM17	GE Mazda #44.		
SW1	6 Gang Oak Mfg. #26414-130		
SW2	Kellog ES-3519		
SW3	Kellog #1042		
SW4	Centralab #1409 4 pole double throw		
RY1	4 pole	110V	60 Cycle
RY2	4 pole	110V	60 Cycle
T1	Microphone Input #15-3443		
T2	Aural Signal #15-3454		
T3	Amplifier Output #15-3444		
T4	Amplifier Output #15-3444		
T5	Amplifier Output #15-3444		
T6	Amplifier Output #15-3444		
T7	Omitted		
T8	Omitted		
T9	Microphone Supply #15-3441		
T10	Power #15-3442		
M1	#271	500 microamps	
M2	#271	500 microamps	
RECT 1	Selenium	DE-303-S	
RECT 2	Selenium	DE-303-S	
V1	5R4GY Vac. Tube Rect		
V2	6SN7GT Amp. Tube		
V3	6SN7GT Amp. Tube		

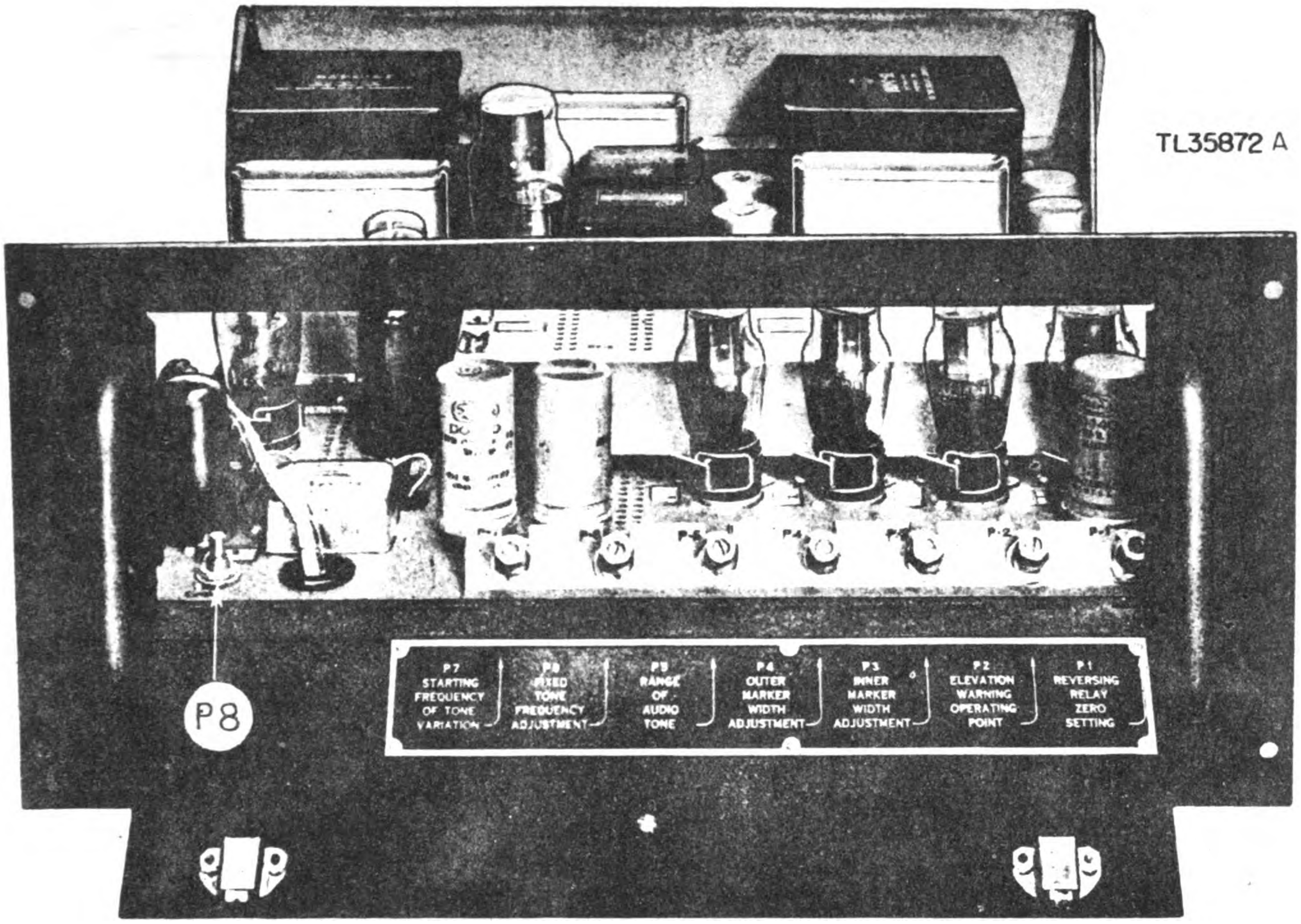


Figure 175. Aural Signal Unit O-8/MPN-1, front view.

Turning off the light indicates to the approach controller operator that the data presented from that director to the errormeter is not accurate. The approach controller operator is thus informed whether or not the meter data he received is based on the accurate tracking of an aircraft's echo signal. The fifth lamp is mounted behind a ruby jewel and is known as the ELEVATION WARNING LIGHT. The circuit to the lamp is completed through relay RY2 in the aural signal unit when the relay is actuated by a predetermined value of the elevation error voltage.

69. AURAL SIGNAL UNIT O-8/MPN-1 (fig. 175).

a. General. (1) Two aural signal units are provided in the indicator rack. The aural signal unit of channel A is housed in the compartment between the elevation director assembly and the azimuth antenna follower assembly and channel B is located to the right in bay 2 (fig. 91). The function of the aural signal unit is to provide the pilot of an approaching aircraft with an audio signal, transmitted to the aircraft by radio from the trailer, to indicate his left-right azimuth course correction. The audio signals indicate to the pilot that he should use either left rudder, maintain a steady course, or use right rudder.

(2) The azimuth error information is converted into an audio tone which increases in pitch with the increasing amplitude of the error voltage applied to the unit from the azimuth director assembly. An intermittent tone is transmitted if the aircraft's position is to the left of the glidepath on the azimuth errormeter, and a solid tone is transmitted if the aircraft is to the right of the path (fig. 176). When a correct approach is being made in azimuth, an ON-COURSE tone is produced, consisting of a series of dashes of low-pitched tone separated by about 3-second intervals. As deviations develop to either the right or to the left of the true glidepath, points are reached where this ON-COURSE tone changes, the error tone rising progressively in pitch. These points may be referred to as the inner markers. Errors in aircraft position to the left of the glidepath are indicated by a series of dashes of rising pitch, separated by a time interval of about five hundredths of a second. Errors to the right

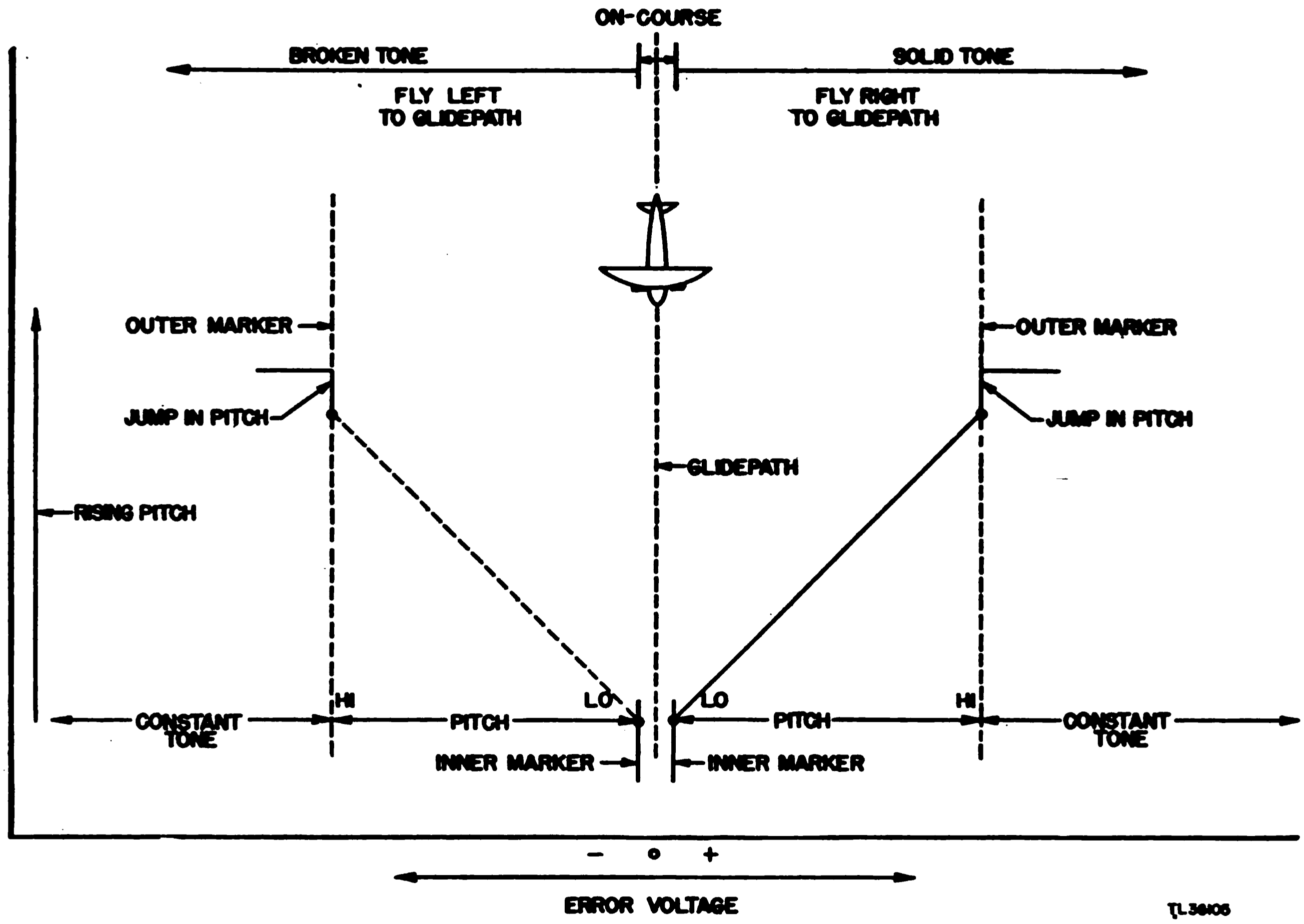


Figure 176. Aural signal unit output with azimuth deviation errors.

are indicated by an unbroken rising tone. If the aircraft deviates sufficiently from the glidepath to make the approach dangerous, the tone jumps to a high warning pitch. These points are known as the outer markers.

(3) In addition, the aural signal unit operates the elevation warning light at the approach controller operator's position. This last function acts as a forceful reminder, should the approaching aircraft drop dangerously low in altitude during an approach to the runway.

b. Functional Block Diagram (fig. 177). (1) Consider the operation of the aural signal unit through the complete range of azimuth error voltage, beginning with the existing condition at zero error voltage input from terminal 4-4. The reversing tube V1, inner marker tube V3, and outer marker tube V4 are inoperative. The keying multivibrator V9 being unbalanced, generates a short negative square-wave pulse, approximately once every 3 seconds, which is applied through the switch tube V10(a) to the audio oscillator. This pulse modulates the audio oscillator V8, producing a series of dashes of low-pitched tone, spaced at about 3-second intervals, which are applied to cathode follower V10(b). The output of the cathode follower is the audio ON-COURSE tone and is terminated at terminal 4-5 in the aural signal unit chassis.

(2) As the cursors of the azimuth tracking assembly are moved OFF-COURSE in a direction corresponding to a target position to the left of the glidepath, a positive voltage is developed in the azimuth error potentiometer, varying in magnitude with the OFF-COURSE position of the target in question. This azimuth error voltage is applied to the input terminal 4-4 of the aural signal unit. The positive error voltage causes the reversing tube V1 to conduct, operating RY5 through RY1 which applies the positive-going voltage to the marker tubes V3 and V4, and to the audio oscillator V8. The positive-going voltage applied to the inner marker tube V3 causes the tube to conduct and actuates relay RY3 which balances the keying multivibrator V8. The keying multivibrator now generates a negative-going square wave which is applied through switch tube V10(a) to the audio oscillator V8.

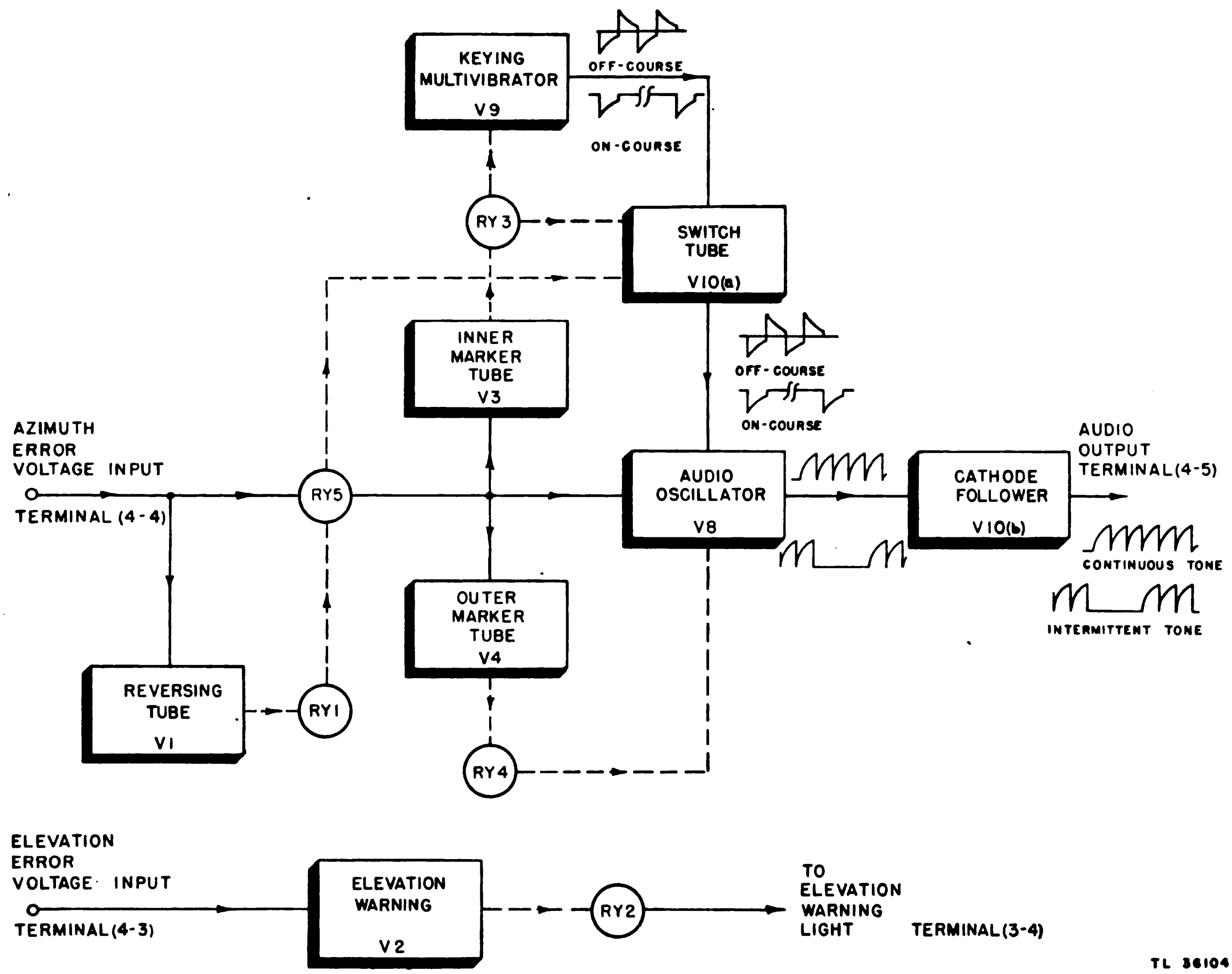


Figure 177. Aural Signal Unit O-8/MPN-1, block diagram.

The pulse modulates the audio oscillator, producing a series of tone dashes of rising pitch with increasing azimuth error voltage, indicating that the aircraft is to the observer's left of the glidepath. The audio pulses, separated by about five hundredths of a second, are applied to cathode follower V10(b). The output of the cathode follower is terminated at the audio output terminal 4-5. As the azimuth error voltage increases, a point is reached at which the outer marker tube V4 will conduct. V4 actuates relay RY4 and causes the pitch of the audio oscillator to jump to a high warning tone, thereby indicating that the aircraft is outside the outer marker limit.

(3) As the azimuth tracking cursors are moved to the opposite side of the glidepath, a negative-going error voltage is applied to the aural signal unit. The negative voltage will have no effect on the reversing tube V1, this stage remaining in operative. Through the normal relay connections the negative error voltage will be reversed, appearing as a positive voltage. The positive-going voltage applied to the inner marker tube V3 causes this tube to conduct, operating relay RY3 and disconnecting the switch tube and thus the keying square waveform to the audio oscillator V8. Therefore, the output of V8 will now be a steady tone, rising in pitch as the azimuth error voltage increases, which indicates that the aircraft is to the observer's right of the glidepath. Again as the azimuth error voltage increases, a point is reached at which the outer marker tube V4 conducts, causing the pitch of the audio oscillator to jump to a high warning pitch. This indicates to the aircraft that the outer marker limit has been passed.

*c. **Circuit Analysis*** (fig. 179). The voltages supplying the error potentiometers in the azimuth and elevation director assemblies are developed in a selenium rectifier, rectifier 2, in the aural signal unit. The rectifier is not

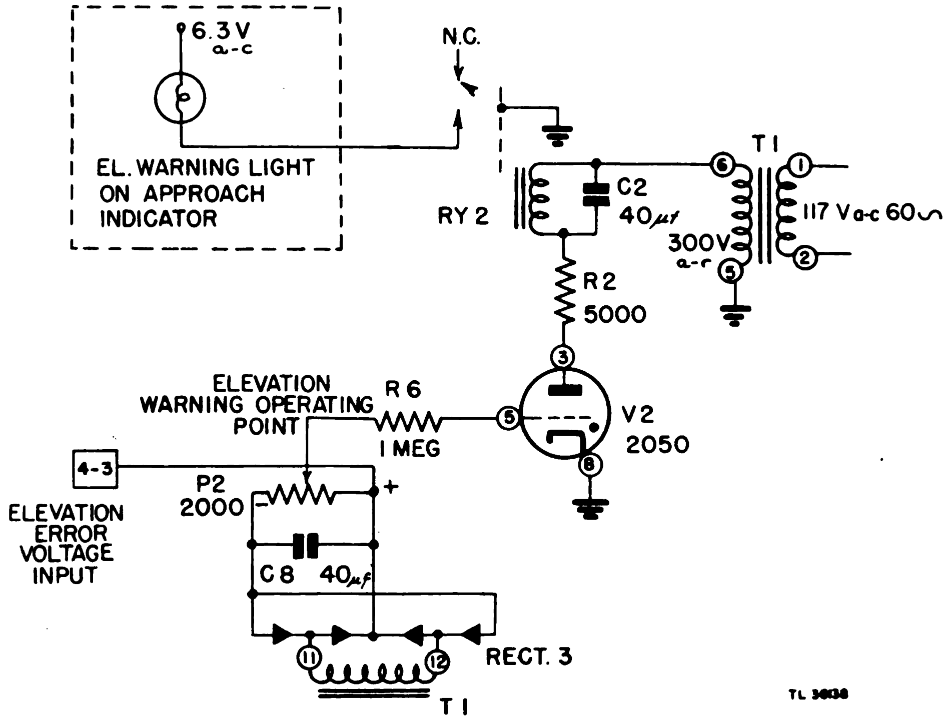


Figure 178. Elevation warning light circuit, simplified schematic diagram.

grounded except through the center tap on the potentiometer in the director assemblies. The error potentiometers are linear through the center portion of the winding, but by the use of shunt resistors, they are made less sensitive near the outer limits of the slider travel. The total voltage applied across the error potentiometer is established at 35 volts dc by potentiometer P8 in the aural signal unit. The error voltages returned to the aural signal unit through the error voltage input terminals, and supplied also to the errormeters in the approach indicator, are taken from the variable taps on the potentiometers.

(1) ELEVATION WARNING LIGHT CIRCUIT. The elevation warning light on the approach indicator panel operates to warn the approach controller operator when an approaching aircraft becomes dangerously low in elevation. A grid controlled thyratron, V2, actuates the controlling relay RY2. The grid bias of V2 is supplied by RECT. 3 through a 1-megohm resistor R6. With no elevation error voltage applied to its grid, the bias of V2, determined by the setting of potentiometer P2, holds the tube in an inoperative state. The upper end of P2, the ELEVATION WARNING OPERATING POINT control, is at ground potential with no error voltage being generated. The errormeter circuit is so arranged that if the elevation tracking cursors are on a target below the correct course, the error voltage is positive. When the positive error voltage input is applied to terminal 4-3 (fig. 178), the bias of V2 is reduced, since the upper end of P2 is more positive than ground. Thus, when the negative bias applied through the adjustment of P2 is overcome and the grid rises above cutoff, V2 fires and plate current flows, operating relay RY2. The elevation warning light circuit, therefore, is completed through to ground and the warning light on the approach indicator will glow. Since V2 is a gas tube, its grid bias has no control after the tube once fires. If the plate voltage of V2 was dc, it would continue to conduct, even if a relatively large grid bias was applied again when the deviation producing the error voltage was corrected. For this reason, the plate voltage applied to V2 is a 60-cycle a-c voltage from a winding of transformer T1. The plate voltage rises through zero 60 times a second, permitting the tube to fire during the positive intervals only so long as the grid bias remains above cutoff.

Symbol Designation	Value
R1	5,000
R2	5,000
R3	5,000
R4	5,000
R5	1 Meg
R6	1 Meg
R7	1 Meg
R8	1 Meg
R9	47,000
R10	100,000
R11	4,700
R12	27,000
R13	5,000
R14	1 Meg
R15	47,000
R16	47,000
R17	1 Meg
R18	1 Meg
R19	1,000
R20	1.5 Meg
R21	75,000
R22	47,000
P1	10,000
P2	2,000
P3	2,000
P4	10,000
P5	50,000
P6	10,000
P7	10,000
P8	1,500
C1	40 mfd
C2	40 mfd
C3	40 mfd
C4	40 mfd
C5	40 mfd
C6	40 mfd
C7	8 mfd
C8	40 mfd
C9	40 mfd
C10	40 mfd

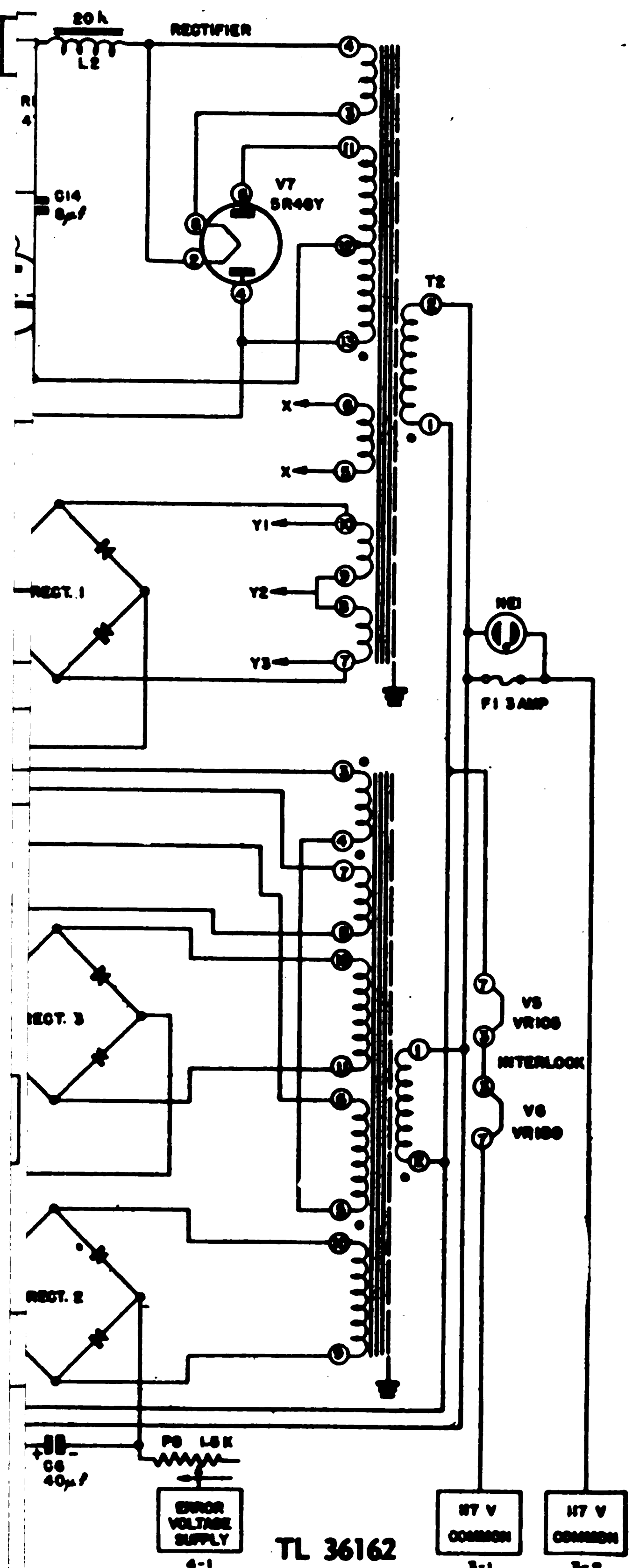


Figure 179. Aural Signal Unit O-8/MPN-1, schematic diagram.

…bol …tion	Description: Value	Rating	Tolerance
	5,000	8	20%
	5,000	8	20%
	5,000	8	20%
	5,000	8	20%
	1 Meg	½	20%
	1 Meg	½	20%
	1 Meg	½	20%
	1 Meg	½	20%
	47,000	10	5%
	100,000	25	5%
	4,700	½	10%
	27,000	10	5%
	5,000	25	Adj
	1 Meg	½	20%
	47,000	2	10%
	47,000	2	10%
	1 Meg	½	20%
	1 Meg	½	20%
	1,000	½	20%
	1.5 Meg	½	5%
	75,000	2	10%
	47,000	2	10%
	10,000	2	10%
	2,000	2	10%
	2,000	2	10%
	10,000	2	10%
	50,000	2	10%
	10,000	2	10%
	10,000	2	10%
	1,500	25	10%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	8 mfd	600	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%

Symbol Designation	Description: Value	Rating	Tolerance
C11	.1 mfd	600	20%
C12	.1 mfd	600	20%
C13	8 mfd	600	20%
C14	8 mfd	600	20%
C15	40 mfd	150	20%
C16	.05 mfd	600	20%
C17	.05 mfd	600	20%
C18	1 mfd	600	20%
C19	.003 mfd	800	20%
C20	.1 mfd	600	20%
		Type	
L1	20 H	15-3431	
L2	20 H	15-3431	
T1		15-3428	
T2		15-3429	
V1	VT 245	2050	
V2	VT 245	2050	
V3	VT 245	2050	
V4	VT 245	2050	
V5	VT 200	VR-105	
V6	VT 139	VR-150	
V7		5R4GY	
V8	VT 222	884	
V9	VT 231	6SN7-GT	
V10	VT 231	6SN7-GT	
Rect 1		1B1A1	
Rect 2		2B8C1	
Rect 3		1B8A1	
Ry 1		PC-1	
Ry 2		PC-1	
Ry 3		1037	
Ry 4		PC-1	
Ry 5		979B	
NE1		5122	
F1	3 Amp	3-AG	

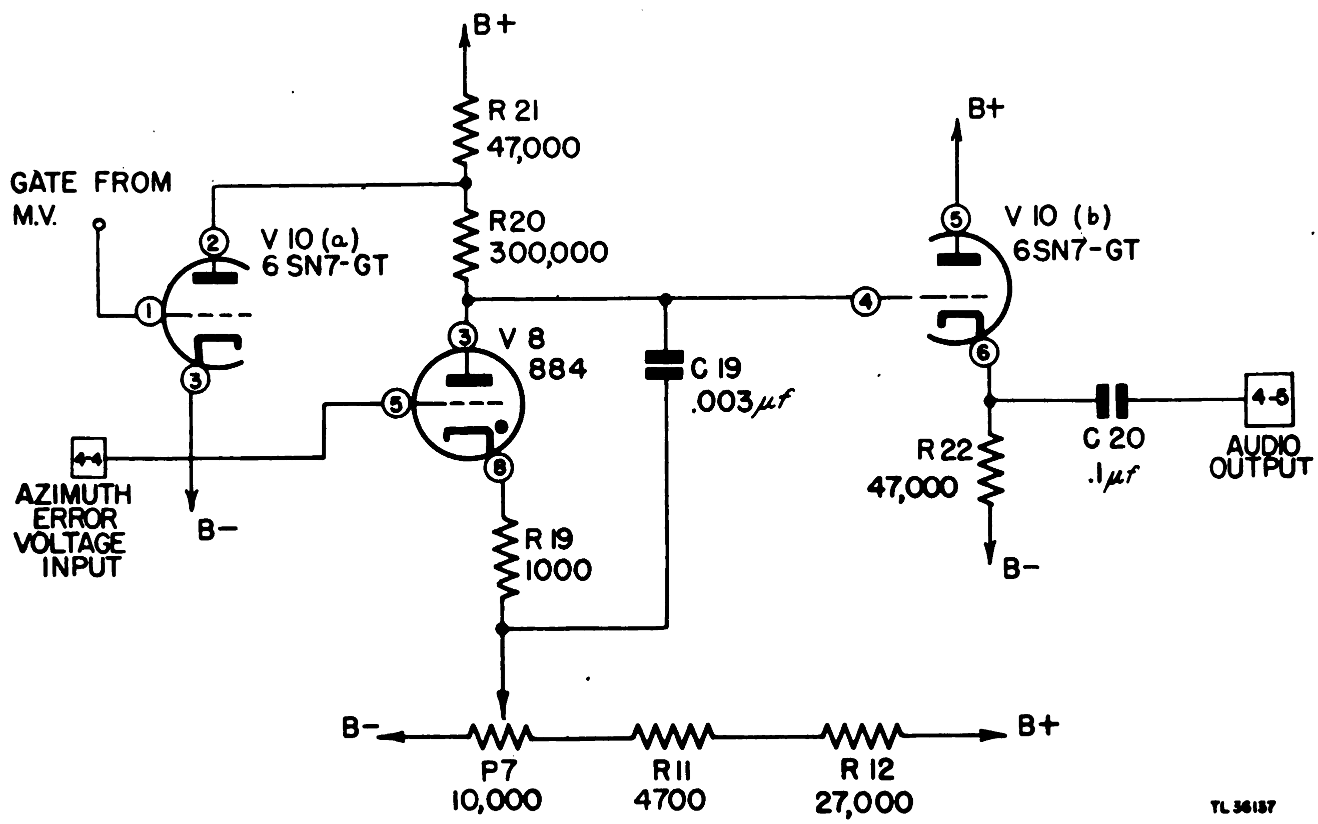


Figure 180. Audio oscillator, simplified schematic diagram.

(2) AUDIO OSCILLATOR.

(*a*) The audio oscillator V8, a simple relaxation type oscillator using a type 884 thyratron tube, generates the aural tone used to indicate the aircraft's position with respect to the glidepath. With the switch tube V10(a) inoperative, consider the start of a cycle of operation with capacitor C19 discharged (fig. 180). When the supply voltage is applied across the charging circuit, which consists of R21, R20, C19, and P7, the voltage across C19 will gradually rise towards the positive supply potential. Since the thyratron V8 is connected across the capacitor C19, the voltage across the tube will also rise until it reaches the ionization potential of the thyratron. At this point V8 conducts heavily, discharging the capacitor through the tube. When the potential across V8 falls below that required to maintain ionization of the tube, the thyratron will again become nonconducting and the charging cycle of C19 will be repeated. This process continues as long as the d-c supply potential is maintained. Thus the output of the audio oscillator consists of a series of saw-tooth waves whose frequency depends on the time required to charge C19 sufficiently to fire the thyratron, V8.

(*b*) Potentiometer P7 determines the potential of the thyratron cathode with respect to its grid and thus regulates the potential at which the tube will fire. As the grid bias of the thyratron is made increasingly negative, the potential required to fire the tube increases. Thus, the time required to charge C19 to the higher ionization potential will increase thereby lowering the frequency of oscillation (fig. 181). Potentiometer P7 is mounted on the front panel of the aural signal unit and is labeled

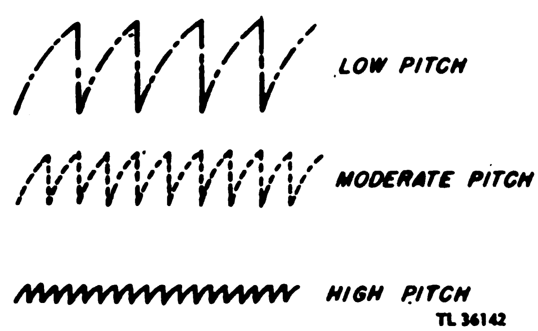


Figure 181. Relaxation oscillator output waveforms, grid-bias controlled frequency.

visions for screwdriver adjustments at slotted shafts for varying both the elevation errormeter and the azimuth errormeter sensitivity.

c. Relay Switching. The approach indicator houses two relays used for channel switching. The voltage outputs from the error potentiometers in both directors are applied to the approach indicator chassis and from it to the aural signal unit in operation. The normal position of both relays, RY1 and RY2 (fig. 174), when not actuated, is for channel A operation. The errormeter inputs to the meters are paralleled to contacts on RY2 for application to either aural signal unit. The elevation warning light circuit also is brought to a contact on RY2 so that it may be controlled by either aural signal unit. Relay RY1 selects either aural signal unit tone output for application to the communications system, and also selects the d-c supplies from either aural signal unit to the error potentiometer in the directors. The relay also provides a means of selecting triggers from the A and B channel synchronizers for application to the test synchroscope in the indicator rack and to the master trigger selector control in the intercommunication panel between the search centrals.

d. Circuit Analysis. Two main groups of circuits are included in the approach indicator. One group is composed of the position errormeters and warning lights for use by the approach controller operator. These components are controlled by the error potentiometers in the elevation and azimuth director assemblies. The other group consists of rectifiers, audio amplifier and mixer stages, and the multiposition switches for the communication and the intercommunication control system (ch. 4, sec. III). The primary information from which the approach controller operator directs the movements of an aircraft is supplied by a pair of zero-centered meters, M1 and M2 (fig. 173). A dropping resistor and calibration potentiometer are in series with each meter input, the potentiometers being used to correct the range of meter variation with the error signal input of the associated meter. A voltage of 6.3 volts ac is supplied from a single source to pilot lights mounted on the panel of the approach indicator. Two lamps are mounted to illuminate the scale area of each meter. The return to ground for these lamps is through the DATA GOOD switch on the corresponding director assembly, so that the meter light can be turned on and off by the operator at that director.

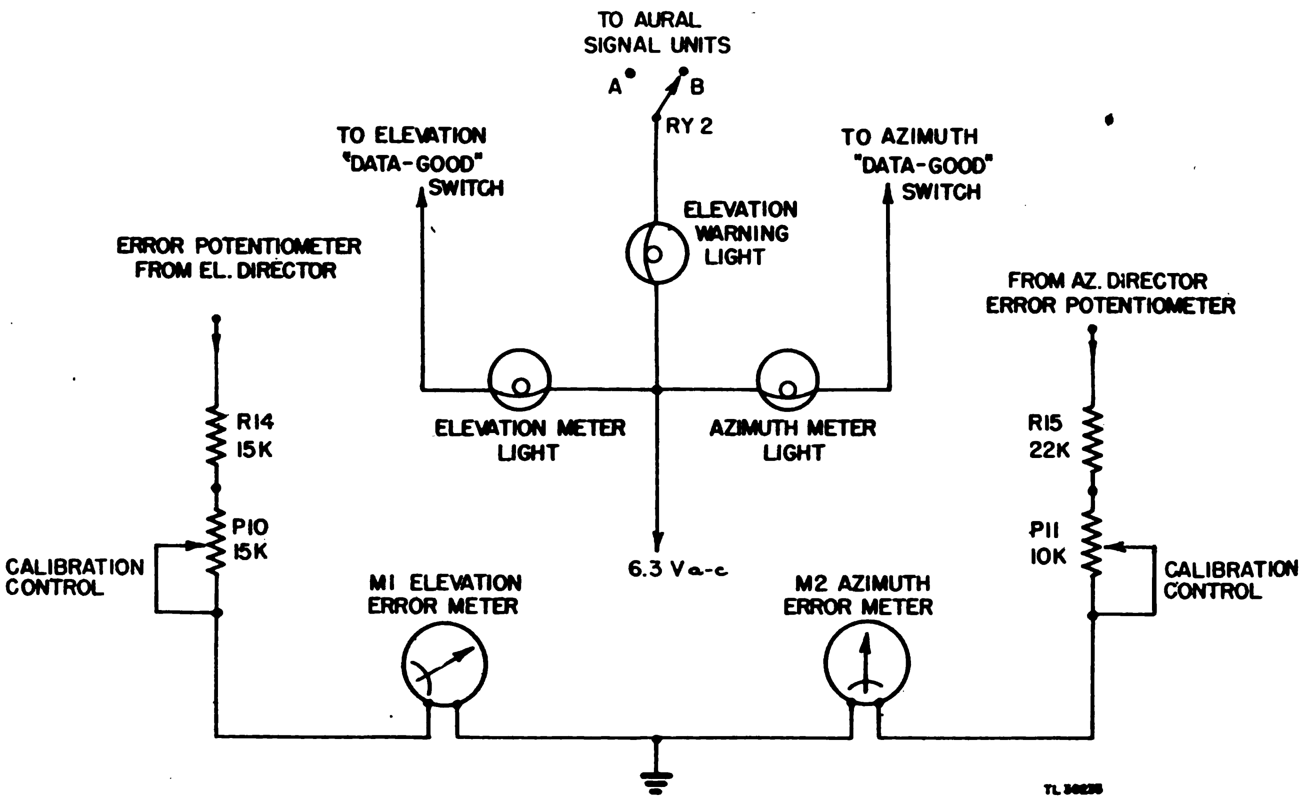


Figure 173. Position errormeters, simplified schematic diagram.

Symbol Designation	Value
	Ohms
R1	100
R2	200
R3	100
R4	100
R5	6
R6	250
R7	250
R8	820
R9	820
R10	820
R11	820
R12	Omitted
R13	Omitted
R14	20,000
R15	27,000
R16	25,000
P1	100,000
P2	500
P3	25
P4	25
P5	25
P6	500,000
P7	500,000
P8	500,000
P9	500,000
P10	20,000
P11	15,000
P12	10,000
P13	10,000
P14	10,000
C1	4 mfd
C2	1 mfd
C3	1 mfd
C4	1 mfd
C5	1 mfd
C6	40 mfd
C7	Omitted
C8	2000 mfd
C9	2000 mfd
C10	8 mfd
C11	8 mfd
L1	5H
L2	5H
L3	10H
F1	3 AG
F2	3 AG
JACK	JK-33-H

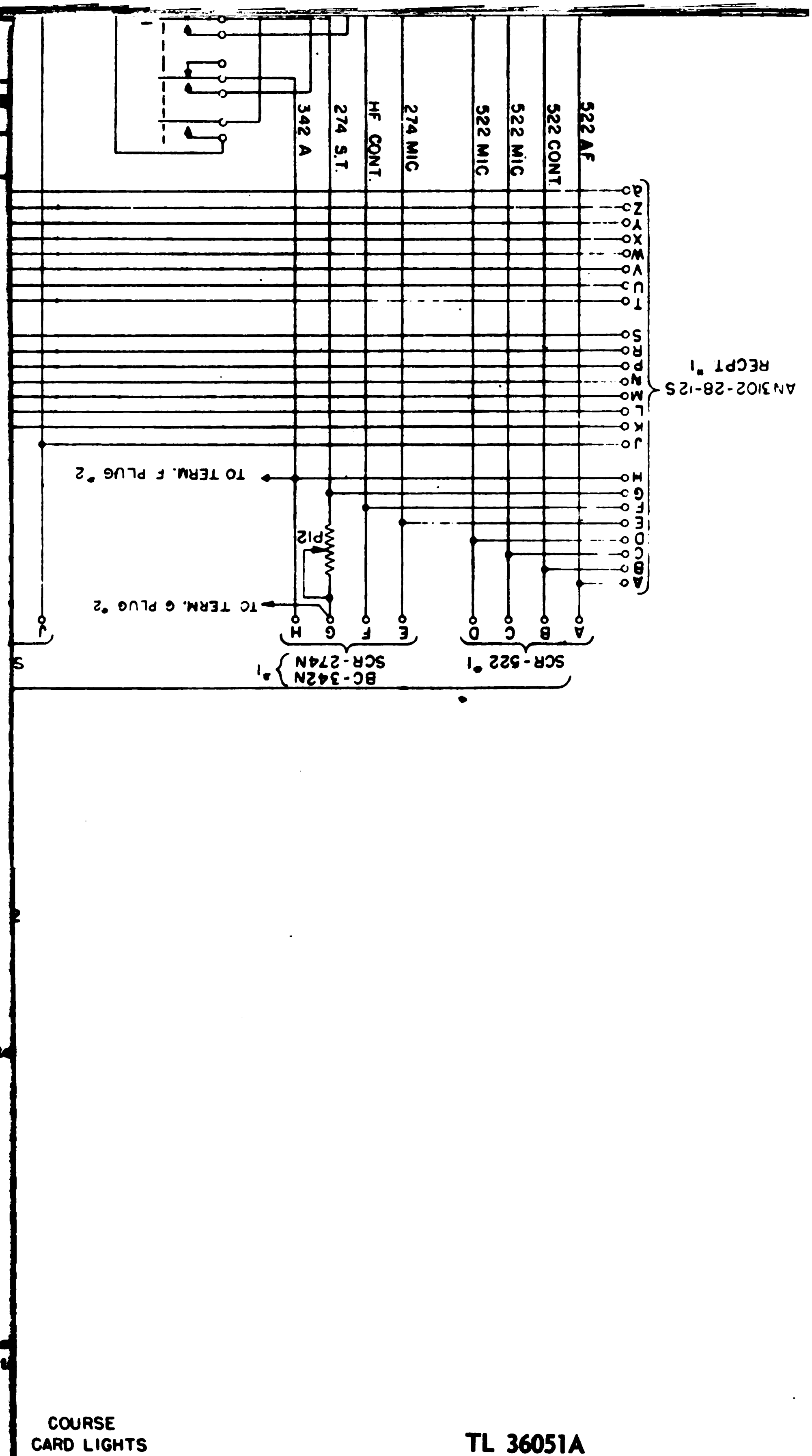


Figure 174. Approach Indicator ID-38/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
	Ohms	Watts	
R1	100	2	± 10%
R2	200	2	± 10%
R3	100	½	± 10%
R4	100	½	± 10%
R5	6	½	± 10%
R6	250	½	± 10%
R7	250	½	± 10%
R8	820	½	± 10%
R9	820	½	± 10%
R10	820	½	± 10%
R11	820	½	± 10%
R12	Omitted		
R13	Omitted		
R14	20,000	½	± 5%
R15	27,000	½	± 5%
R16	25,000	10	± 20%
P1	100,000	2	± 20%
P2	500	2	± 20%
P3	25	25	± 20%
P4	25	25	± 20%
P5	25	25	± 20%
P6	500,000	2	± 20%
P7	500,000	2	± 20%
P8	500,000	2	± 20%
P9	500,000	2	± 20%
P10	20,000	2	± 20%
P11	15,000	2	± 20%
P12	10,000	2	± 20%
P13	10,000	2	± 20%
P14	10,000	2	± 20%
		Volts	
C1	4 mfd	100	+40%, −15%
C2	1 mfd	600	+40%, −15%
C3	1 mfd	600	+40%, −15%
C4	1 mfd	600	+40%, −15%
C5	1 mfd	600	+40%, −15%
C6	40 mfd	150	+50%, −10%
C7	Omitted		
C8	2000 mfd	50	+65%, −10%
C9	2000 mfd	50	+65%, −10%
C10	8 mfd	600	+40%, −15%
C11	8 mfd	600	+40%, −15%
		Type	
L1	5H	15-3447	
L2	5H	15-3447	
L3	10H	15-3446	
F1	3 AG	3 amp.-.07	
F2	3 AG	3 amp.-.07	
JACK	JK-3-H	shorting type tipjack	

Symbol Designation	Description		
	Value	Rating	Tolerance
NE1	#5122	0.1 Watt	
NE2	#5122	0.1 Watt	
LM1	WE #2-F.		
LM2	WE #2-F.		
LM3	WE #2-F.		
LM4	WE #2-F.		
LM5	WE #2-F.		
LM6	WE #2-F.		
LM7	WE #2-F.		
LM8	WE #2-F.		
LM9	WE #2-F.		
LM10	WE #2-F.		
LM11	GE Mazda #44		
LM12	GE Mazda #44.		
LM13	GE Mazda #44.		
LM14	GE Mazda #44.		
LM15	GE Mazda #51.		
LM16	GE Mazda #44.		
LM17	GE Mazda #44.		
SW1	6 Gang Oak Mfg. #26414-130		
SW2	Kellog ES-3519		
SW3	Kellog #1042		
SW4	Centralab #1409 4 pole double throw		
RY1	4 pole	110V	60 Cycle
RY2	4 pole	110V	60 Cycle
T1	Microphone Input #15-3443		
T2	Aural Signal #15-3454		
T3	Amplifier Output #15-3444		
T4	Amplifier Output #15-3444		
T5	Amplifier Output #15-3444		
T6	Amplifier Output #15-3444		
T7	Omitted		
T8	Omitted		
T9	Microphone Supply #15-3441		
T10	Power #15-3442		
M1	#271	500 microamps	
M2	#271	500 microamps.	
RECT 1	Selenium	DE-303-S	
RECT 2	Selenium	DE-303-S	
V1	5R4GY Vac. Tube Rect		
V2	6SN7GT Amp. Tube		
V3	6SN7GT Amp. Tube		

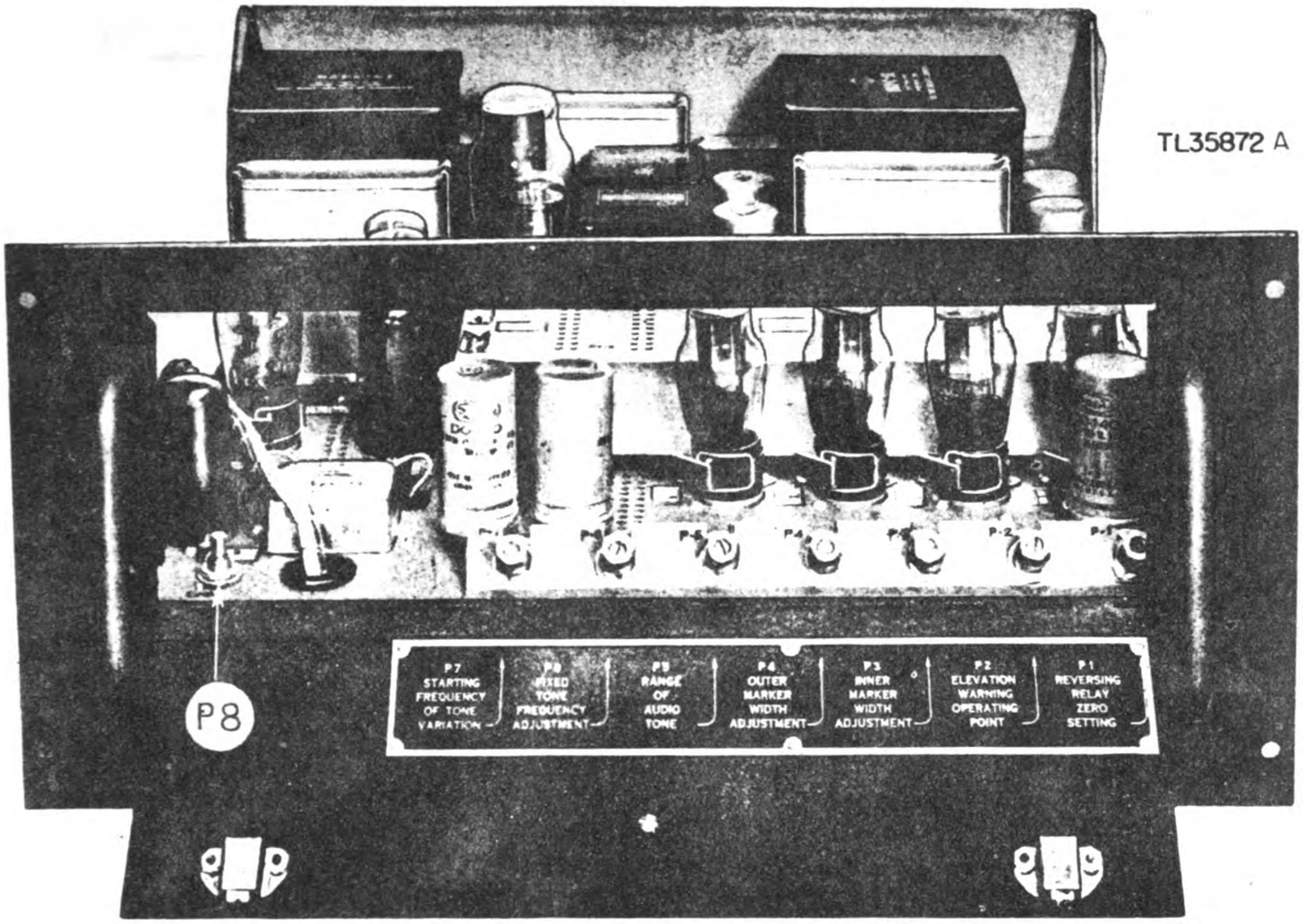


Figure 175. Aural Signal Unit O-8/MPN-1, front view.

Turning off the light indicates to the approach controller operator that the data presented from that director to the errormeter is not accurate. The approach controller operator is thus informed whether or not the meter data he received is based on the accurate tracking of an aircraft's echo signal. The fifth lamp is mounted behind a ruby jewel and is known as the ELEVATION WARNING LIGHT. The circuit to the lamp is completed through relay RY2 in the aural signal unit when the relay is actuated by a predetermined value of the elevation error voltage.

69. AURAL SIGNAL UNIT O-8/MPN-1 (fig. 175).

a. General. (1) Two aural signal units are provided in the indicator rack. The aural signal unit of channel A is housed in the compartment between the elevation director assembly and the azimuth antenna follower assembly and channel B is located to the right in bay 2 (fig. 91). The function of the aural signal unit is to provide the pilot of an approaching aircraft with an audio signal, transmitted to the aircraft by radio from the trailer, to indicate his left-right azimuth course correction. The audio signals indicate to the pilot that he should use either left rudder, maintain a steady course, or use right rudder.

(2) The azimuth error information is converted into an audio tone which increases in pitch with the increasing amplitude of the error voltage applied to the unit from the azimuth director assembly. An intermittent tone is transmitted if the aircraft's position is to the left of the glidepath on the azimuth errormeter, and a solid tone is transmitted if the aircraft is to the right of the path (fig. 176). When a correct approach is being made in azimuth, an ON-COURSE tone is produced, consisting of a series of dashes of low-pitched tone separated by about 3-second intervals. As deviations develop to either the right or to the left of the true glidepath, points are reached where this ON-COURSE tone changes, the error tone rising progressively in pitch. These points may be referred to as the inner markers. Errors in aircraft position to the left of the glidepath are indicated by a series of dashes of rising pitch, separated by a time interval of about five hundredths of a second. Errors to the right

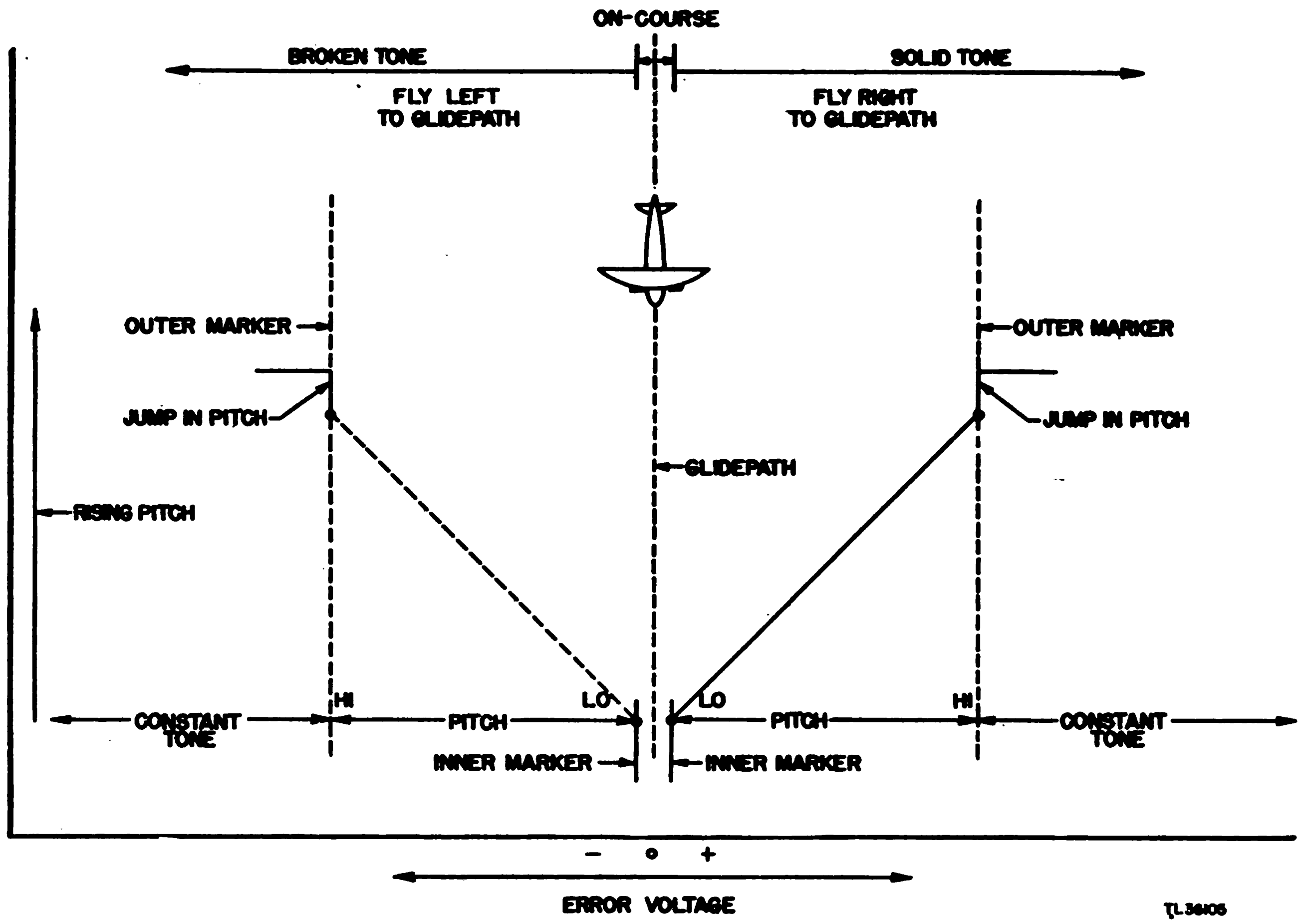


Figure 176. Aural signal unit output with azimuth deviation errors.

are indicated by an unbroken rising tone. If the aircraft deviates sufficiently from the glidepath to make the approach dangerous, the tone jumps to a high warning pitch. These points are known as the outer markers.

(3) In addition, the aural signal unit operates the elevation warning light at the approach controller operator's position. This last function acts as a forceful reminder, should the approaching aircraft drop dangerously low in altitude during an approach to the runway.

*b. **Functional Block Diagram*** (fig. 177). (1) Consider the operation of the aural signal unit through the complete range of azimuth error voltage, beginning with the existing condition at zero error voltage input from terminal 4-4. The reversing tube V1, inner marker tube V3, and outer marker tube V4 are inoperative. The keying multivibrator V9 being unbalanced, generates a short negative square-wave pulse, approximately once every 3 seconds, which is applied through the switch tube V10(a) to the audio oscillator. This pulse modulates the audio oscillator V8, producing a series of dashes of low-pitched tone, spaced at about 3-second intervals, which are applied to cathode follower V10(b). The output of the cathode follower is the audio ON-COURSE tone and is terminated at terminal 4-5 in the aural signal unit chassis.

(2) As the cursors of the azimuth tracking assembly are moved OFF-COURSE in a direction corresponding to a target position to the left of the glidepath, a positive voltage is developed in the azimuth error potentiometer, varying in magnitude with the OFF-COURSE position of the target in question. This azimuth error voltage is applied to the input terminal 4-4 of the aural signal unit. The positive error voltage causes the reversing tube V1 to conduct, operating RY5 through RY1 which applies the positive-going voltage to the marker tubes V3 and V4, and to the audio oscillator V8. The positive-going voltage applied to the inner marker tube V3 causes the tube to conduct and actuates relay RY3 which balances the keying multivibrator V8. The keying multivibrator now generates a negative-going square wave which is applied through switch tube V10(a) to the audio oscillator V8.

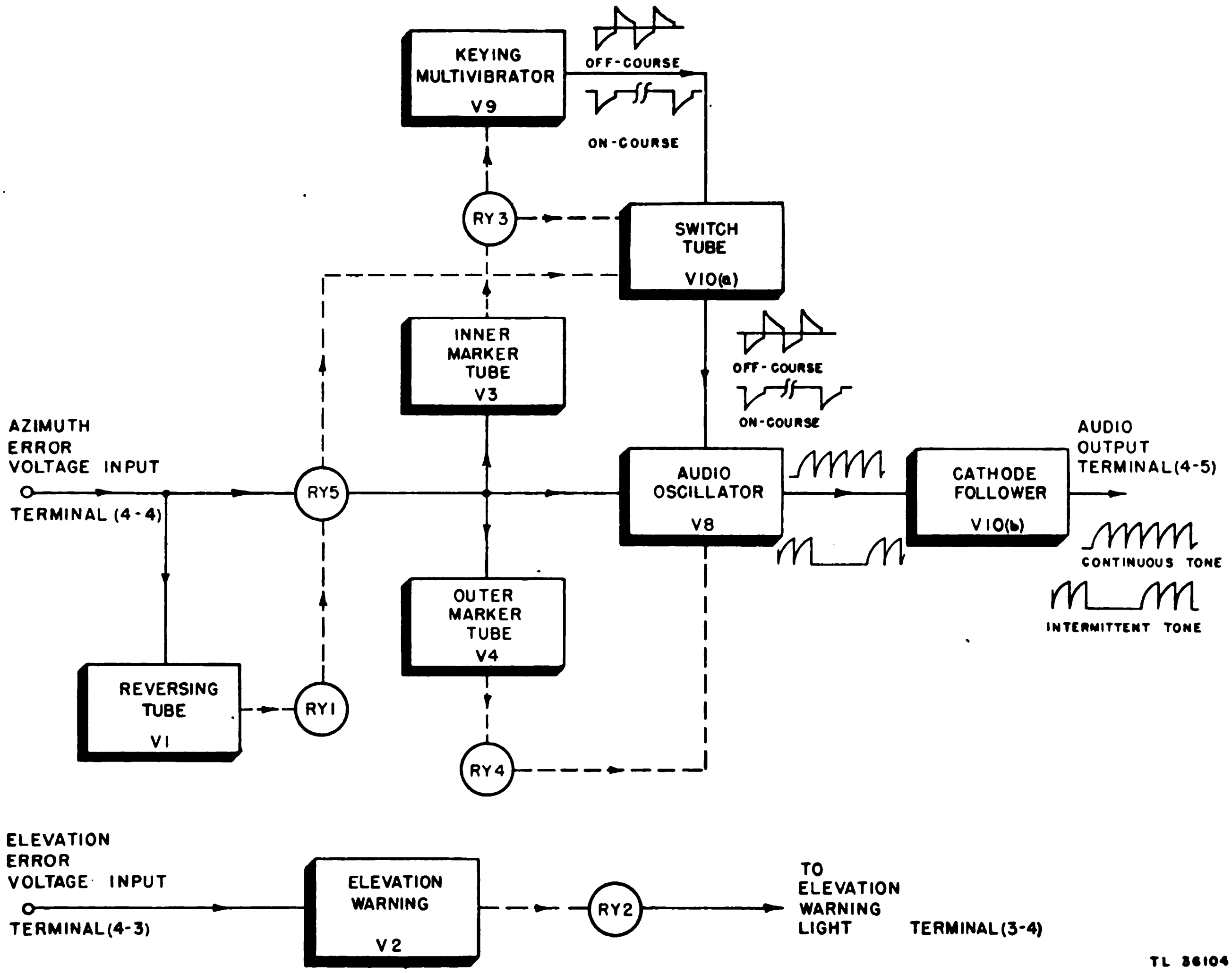


Figure 177. Aural Signal Unit O-8/MPN-1, block diagram.

The pulse modulates the audio oscillator, producing a series of tone dashes of rising pitch with increasing azimuth error voltage, indicating that the aircraft is to the observer's left of the glidepath. The audio pulses, separated by about five hundredths of a second, are applied to cathode follower V10(b). The output of the cathode follower is terminated at the audio output terminal 4-5. As the azimuth error voltage increases, a point is reached at which the outer marker tube V4 will conduct. V4 actuates relay RY4 and causes the pitch of the audio oscillator to jump to a high warning tone, thereby indicating that the aircraft is outside the outer marker limit.

(3) As the azimuth tracking cursors are moved to the opposite side of the glidepath, a negative-going error voltage is applied to the aural signal unit. The negative voltage will have no effect on the reversing tube V1, this stage remaining in operative. Through the normal relay connections the negative error voltage will be reversed, appearing as a positive voltage. The positive-going voltage applied to the inner marker tube V3 causes this tube to conduct, operating relay RY3 and disconnecting the switch tube and thus the keying square waveform to the audio oscillator V8. Therefore, the output of V8 will now be a steady tone, rising in pitch as the azimuth error voltage increases, which indicates that the aircraft is to the observer's right of the glidepath. Again as the azimuth error voltage increases, a point is reached at which the outer marker tube V4 conducts, causing the pitch of the audio oscillator to jump to a high warning pitch. This indicates to the aircraft that the outer marker limit has been passed.

*c. **Circuit Analysis*** (fig. 179). The voltages supplying the error potentiometers in the azimuth and elevation director assemblies are developed in a selenium rectifier, rectifier 2, in the aural signal unit. The rectifier is not

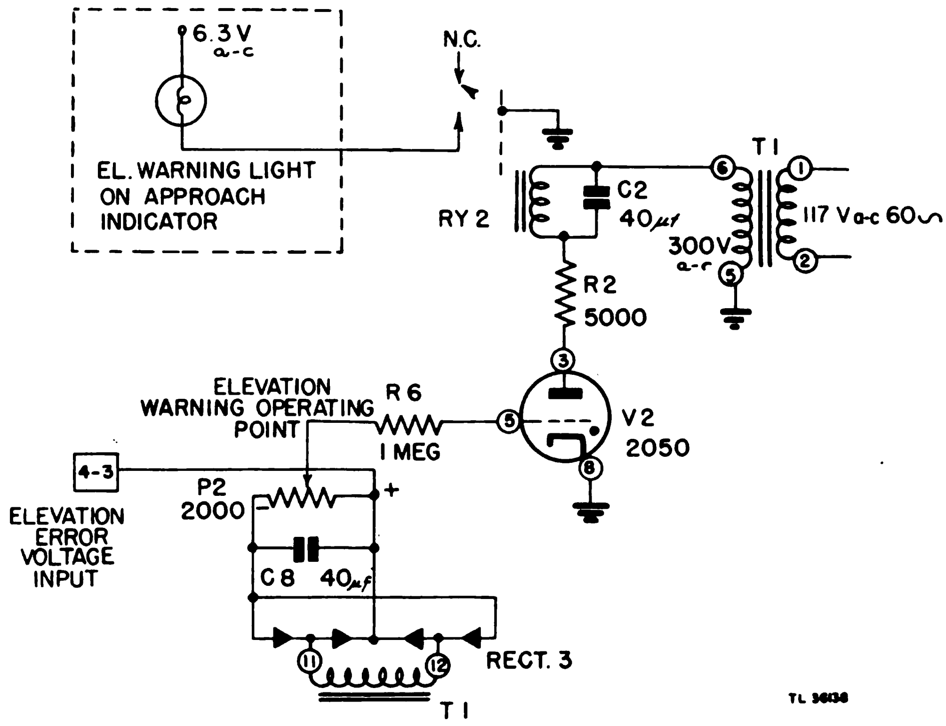


Figure 178. Elevation warning light circuit, simplified schematic diagram.

grounded except through the center tap on the potentiometer in the director assemblies. The error potentiometers are linear through the center portion of the winding, but by the use of shunt resistors, they are made less sensitive near the outer limits of the slider travel. The total voltage applied across the error potentiometer is established at 35 volts dc by potentiometer P8 in the aural signal unit. The error voltages returned to the aural signal unit through the error voltage input terminals, and supplied also to the errormeters in the approach indicator, are taken from the variable taps on the potentiometers.

(1) ELEVATION WARNING LIGHT CIRCUIT. The elevation warning light on the approach indicator panel operates to warn the approach controller operator when an approaching aircraft becomes dangerously low in elevation. A grid controlled thyratron, V2, actuates the controlling relay RY2. The grid bias of V2 is supplied by RECT. 3 through a 1-megohm resistor R6. With no elevation error voltage applied to its grid, the bias of V2, determined by the setting of potentiometer P2, holds the tube in an inoperative state. The upper end of P2, the ELEVATION WARNING OPERATING POINT control, is at ground potential with no error voltage being generated. The errormeter circuit is so arranged that if the elevation tracking cursors are on a target below the correct course, the error voltage is positive. When the positive error voltage input is applied to terminal 4-3 (fig. 178), the bias of V2 is reduced, since the upper end of P2 is more positive than ground. Thus, when the negative bias applied through the adjustment of P2 is overcome and the grid rises above cutoff, V2 fires and plate current flows, operating relay RY2. The elevation warning light circuit, therefore, is completed through to ground and the warning light on the approach indicator will glow. Since V2 is a gas tube, its grid bias has no control after the tube once fires. If the plate voltage of V2 was dc, it would continue to conduct, even if a relatively large grid bias was applied again when the deviation producing the error voltage was corrected. For this reason, the plate voltage applied to V2 is a 60-cycle a-c voltage from a winding of transformer T1. The plate voltage rises through zero 60 times a second, permitting the tube to fire during the positive intervals only so long as the grid bias remains above cutoff.

Symbol Designation	Value	D
R1	5,000	
R2	5,000	
R3	5,000	
R4	5,000	
R5	1 Meg	
R6	1 Meg	
R7	1 Meg	
R8	1 Meg	
R9	47,000	
R10	100,000	
R11	4,700	
R12	27,000	
R13	5,000	
R14	1 Meg	
R15	47,000	
R16	47,000	
R17	1 Meg	
R18	1 Meg	
R19	1,000	
R20	1.5 Meg	
R21	75,000	
R22	47,000	
P1	10,000	
P2	2,000	
P3	2,000	
P4	10,000	
P5	50,000	
P6	10,000	
P7	10,000	
P8	1,500	
C1	40 mfd	
C2	40 mfd	
C3	40 mfd	
C4	40 mfd	
C5	40 mfd	
C6	40 mfd	
C7	8 mfd	
C8	40 mfd	
C9	40 mfd	
C10	40 mfd	

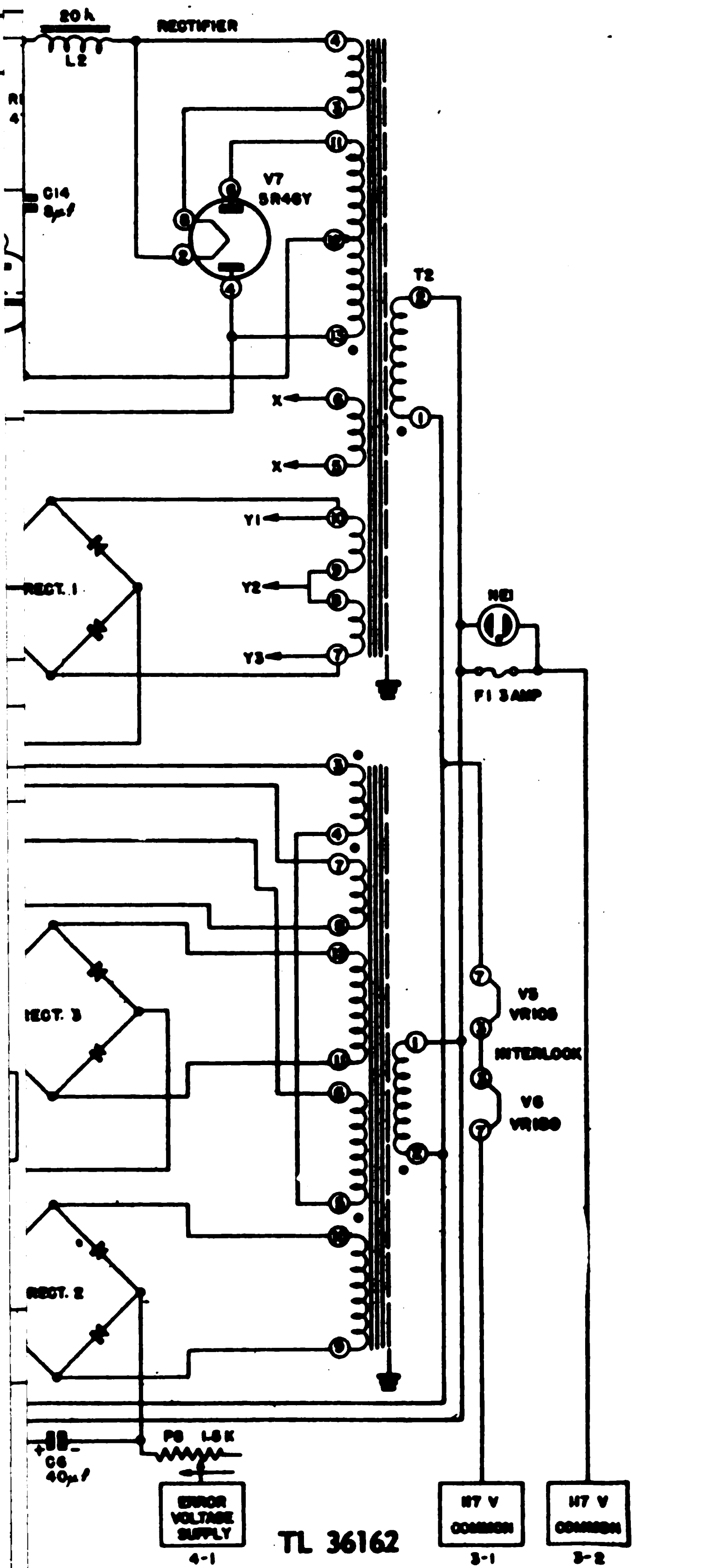


Figure 179. Aural Signal Unit O-8/MPN-1, schematic diagram.

bol tion	Description		
	Value	Rating	Tolerance
	5,000	8	20%
	5,000	8	20%
	5,000	8	20%
	5,000	8	20%
	1 Meg	½	20%
	1 Meg	½	20%
	1 Meg	½	20%
	1 Meg	½	20%
	47,000	10	5%
	100,000	25	5%
	4,700	½	10%
	27,000	10	5%
	5,000	25	Adj
	1 Meg	½	20%
	47,000	2	10%
	47,000	2	10%
	1 Meg	½	20%
	1 Meg	½	20%
	1,000	½	20%
	1.5 Meg	½	5%
	75,000	2	10%
	47,000	2	10%
	10,000	2	10%
	2,000	2	10%
	2,000	2	10%
	10,000	2	10%
	50,000	2	10%
	10,000	2	10%
	10,000	2	10%
	1,500	25	10%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%
	8 mfd	600	20%
	40 mfd	150	20%
	40 mfd	150	20%
	40 mfd	150	20%

Symbol Designation	Description		
	Value	Rating	Tolerance
C11	.1 mfd	600	20%
C12	.1 mfd	600	20%
C13	8 mfd	600	20%
C14	8 mfd	600	20%
C15	40 mfd	150	20%
C16	.05 mfd	600	20%
C17	.05 mfd	600	20%
C18	1 mfd	600	20%
C19	.003 mfd	000	20%
C20	.1 mfd	600	20%
		Type	
L1	20 11	15-3431	
L2	20 H	15-3431	
T1		15-3428	
T2		15-3429	
V1	VT 245	2050	
V2	VT 245	2050	
V3	VT 245	2050	
V4	VT 245	2050	
V5	VT 200	VR-105	
V6	VT 139	VR-150	
V7		5R4GY	
V8	VT 222	884	
V9	VT 231	6SN7-GT	
V10	VT 231	6SN7-GT	
Rect 1		1B1A1	
Rect 2		2B8C1	
Rect 3		1B8A1	
Ry 1		PC-1	
Ry 2		PC-1	
Ry 3		1037	
Ry 4		PC-1	
Ry 5		979B	
NE1		5122	
F1	3 Amp	3-AG	

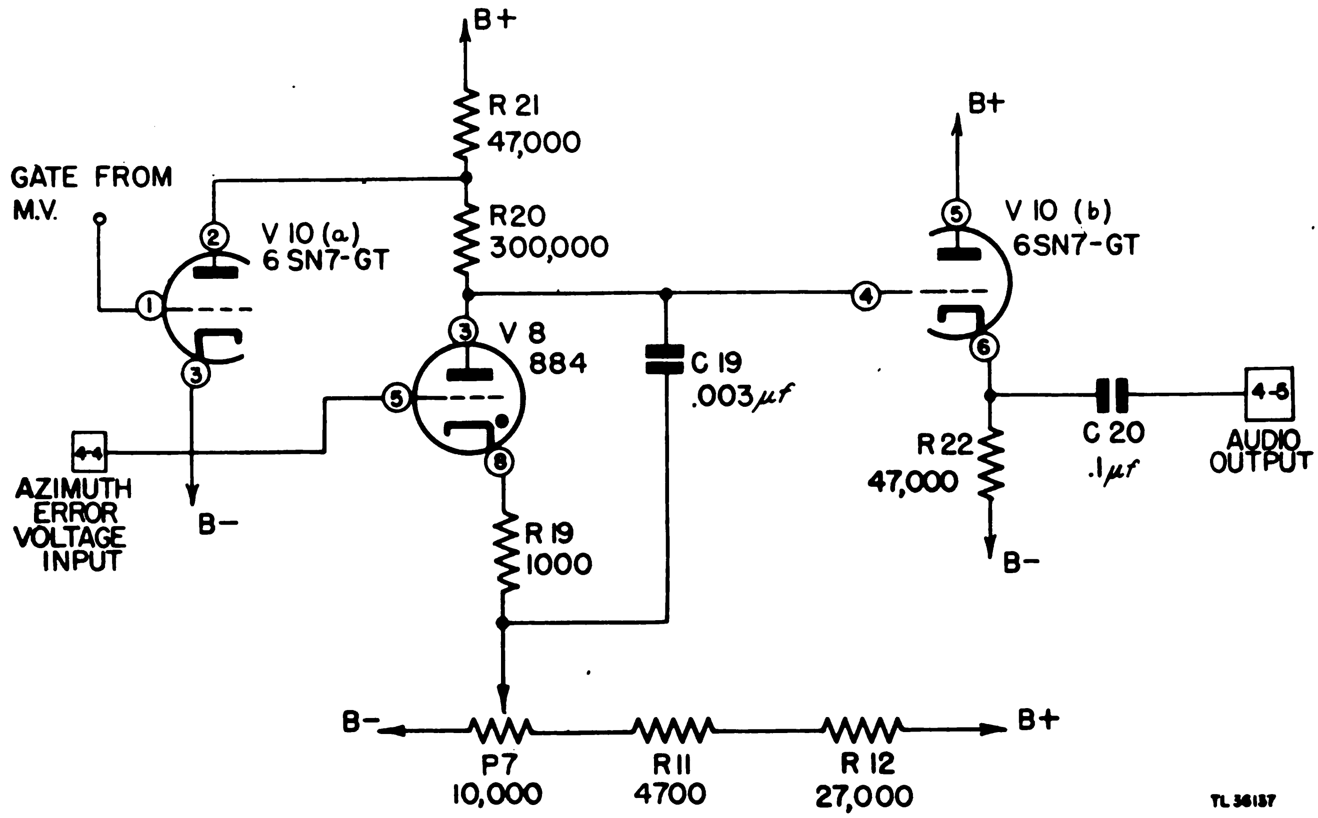


Figure 180. Audio oscillator, simplified schematic diagram.

(2) AUDIO OSCILLATOR.

(*a*) The audio oscillator V8, a simple relaxation type oscillator using a type 884 thyratron tube, generates the aural tone used to indicate the aircraft's position with respect to the glidepath. With the switch tube V10(a) inoperative, consider the start of a cycle of operation with capacitor C19 discharged (fig. 180). When the supply voltage is applied across the charging circuit, which consists of R21, R20, C19, and P7, the voltage across C19 will gradually rise towards the positive supply potential. Since the thyratron V8 is connected across the capacitor C19, the voltage across the tube will also rise until it reaches the ionization potential of the thyratron. At this point V8 conducts heavily, discharging the capacitor through the tube. When the potential across V8 falls below that required to maintain ionization of the tube, the thyratron will again become nonconducting and the charging cycle of C19 will be repeated. This process continues as long as the d-c supply potential is maintained. Thus the output of the audio oscillator consists of a series of saw-tooth waves whose frequency depends on the time required to charge C19 sufficiently to fire the thyratron, V8.

(*b*) Potentiometer P7 determines the potential of the thyratron cathode with respect to its grid and thus regulates the potential at which the tube will fire. As the grid bias of the thyratron is made increasingly negative, the potential required to fire the tube increases. Thus, the time required to charge C19 to the higher ionization potential will increase thereby lowering the frequency of oscillation (fig. 181). Potentiometer P7 is mounted on the front panel of the aural signal unit and is labeled

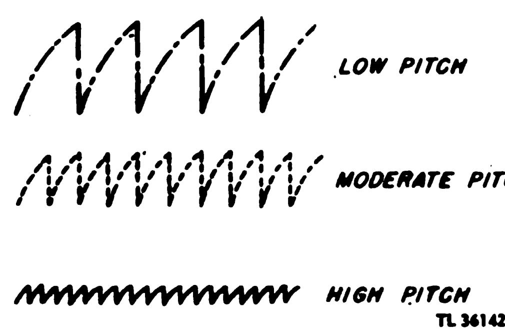


Figure 181. Relaxation oscillator output waveforms, grid-bias controlled frequency.

STARTING FREQUENCY OF TONE VARIATION.

(*c*) Since the firing point of V8 is determined by the grid potential of the tube, the pitch of the aural signal will be determined by the azimuth error voltage input applied to the grid of V8 through terminal 4-4. As the voltage on the grid of V8 becomes more positive, the plate voltage required to fire the tube decreases. Thus the thyratron will fire at an earlier point on the charging cycle of C19 and the time required for a complete cycle will be decreased, thereby causing the pitch of the aural tone to increase. Thus, as the approaching aircraft deviates to the right or left of the glidepath, the increasing error voltage at the grid of V8 will produce a corresponding increase in pitch of the aural tone, indicating that the aircraft is flying away from the desired glidepath. It should be noted that only a positive-going error voltage applied to the grid of V8 will produce a tone of rising pitch, therefore, for proper operation, the negative-going error voltage must be inverted in phase before application to the grid of V8. This is accomplished by the error voltage inversion circuit and is discussed under subparagraph (4).

(3) TONE INTERRUPTION CIRCUIT.

(*a*) The tone interruption circuit generates the keying pulse which is applied as a modulating voltage to the audio oscillator V8, thereby producing the intermittent ON-COURSE tone. This circuit also develops the OFF-COURSE broken tone modulating voltage required to indicate that the aircraft is to the left of the glidepath. The circuit consists of V9 and V10(a), both 6SN7-GT type tubes. Audio oscillator V8 operates only when the switch tube V10(a) is nonconducting. V10(a) conducts only during the positive portion of the keying pulse developed by the multivibrator V9. The plate voltage of V8 drops during the conduction of V10(a) to such a low value that the maximum voltage applied to the charging capacitor C19 will be insufficient to fire V8. Thus, no oscillations can be generated by V8 regardless of the value of grid voltage impressed on the tube. Therefore, V10(a) acts as a switch to key the audio oscillator in a fixed pattern determined by the keying voltage impressed on its grid from the multivibrator.

(*b*) The multivibrator output is taken from the grid of V9(a), appearing as a series of negative voltage pulses. The width of these pulses depends upon the RC constant of C16 and R14 (fig. 182), while the time interval between the pulses depends on the RC constant of R17 and C17 or C18, depending upon which of the two capacitors is selected by relay RY3.

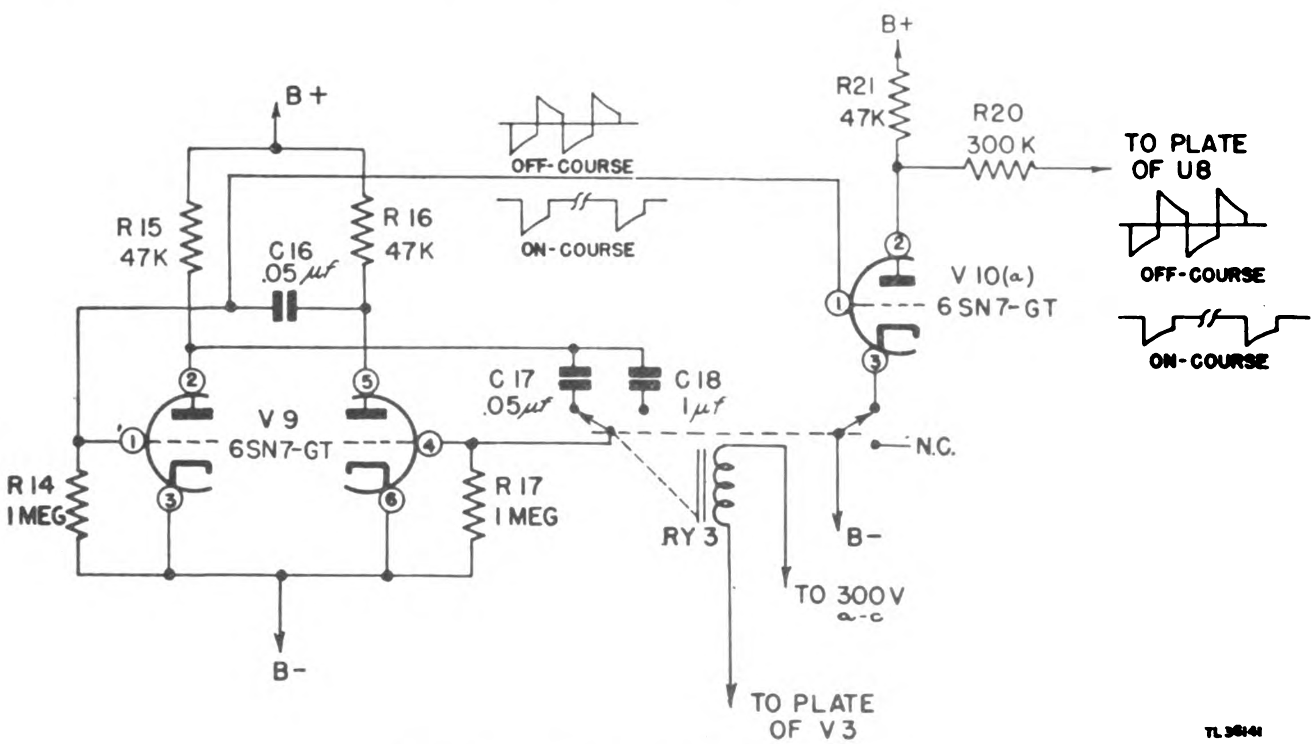


Figure 182. Tone interruption circuit, simplified schematic diagram.

(*c*) If C18 is selected by relay RY3, the negative pulses generated by the multivibrator will recur at a comparatively slow rate, approximately once every 3 seconds. If C17 is selected, a series of negative pulses is developed producing the OFF-COURSE intermittent tone. RY3, in conjunction with RY5, also serves to disconnect the switch tube V10(a), and thus the tone interruption circuit, from the audio oscillator stage V8. This allows the audio oscillator to generate the continuous tone indicating that the aircraft is to the right of the glidepath.

(4) MARKER CIRCUITS (fig. 183).

(*a*) The marker circuit consists of two tubes, an inner marker tube V3, and an outer marker tube V4. The circuit provides a means of changing the position indicating tone from the ON-COURSE signal to the OFF-COURSE tone when the aircraft deviates slightly from the glidepath, and provides an outer marker warning tone if the aircraft reaches a point sufficiently distant from the glidepath to cause the landing operation to be hazardous. Both marker tubes are type 2050 thyratrons. Variations of the azimuth error voltage with respect to ground serve as the basis of operation for the marker circuits.

(*b*) The grids of V3 and V4 are tied to the more positive side of potentiometer P5 through their grid-leak resistors R7 and R8 (fig. 183). The cathode of each tube is at a fixed voltage with respect to the B– power supply. As the azimuth error voltage increases, each grid becomes more positive with respect to its cathode. The cathode biasing, with relationship to B–, is determined by the settings of variable potentiometers P3 and P4 which are parts of the resistance network between B+ and B–. Therefore, the fixed cathode biasing determines the initial conducting point of the tubes; and P3, the INNER MARKER WIDTH ADJUSTMENT, and P4, the OUTER MARKER WIDTH ADJUSTMENT located on the front panel of the chassis, set the basic tube biasing points.

(*c*) Tube V3 has a small bias applied through the 2,000-ohm variable potentiometer P3, and a slight error voltage will cause this tube to fire. When the tube conducts, relay RY3 closes and selects capacitor C17 in the keying multivibrator circuit in place of the larger capacitor C18. This change in the time constant of the keying multivibrator removes the ON-COURSE keying pulse and substitutes the OFF-COURSE modulating voltage to the audio oscillator V8, producing the intermittent tone indicating that the aircraft's deviation is to the left of the glidepath. Relay RY3, when operated, breaks one of the parallel ground connections to the cathode of switch tube V10(a), thereby preparing the switch tube to become inoperative. If relay RY5 were actuated, it would break the other parallel ground connection to the switch tube cathode. This makes the switch tube inoperative and nonconducting and removes the multivibrator keying pulse, causing the audio oscillator V8 to operate continuously.

(*d*) Considerably heavier bias is applied to V4 through the 10,000-ohm potentiometer P4. This potentiometer,

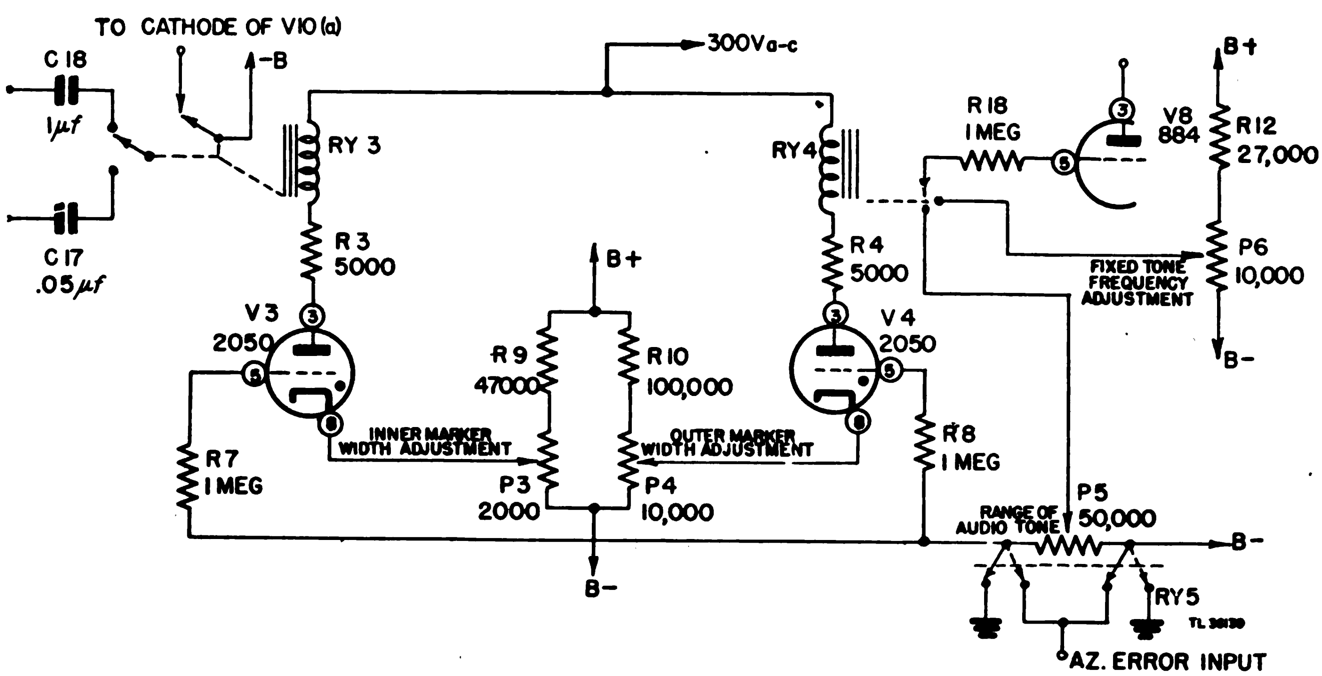
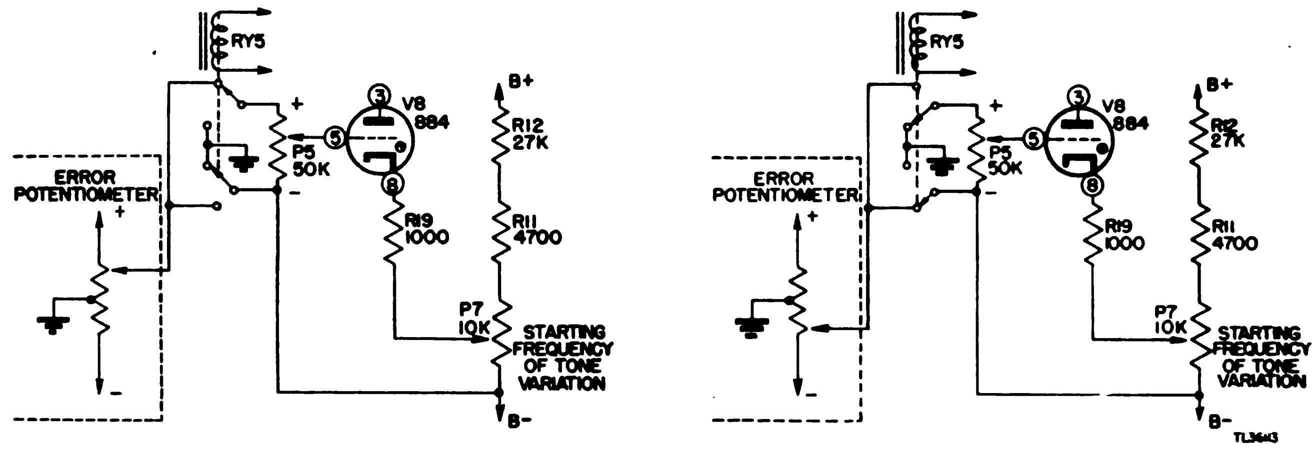


Figure 183. Marker circuits, simplified schematic diagram.



(a) POSITIVE ERROR VOLTAGE INVERSION CIRCUIT

(b). NEGATIVE ERROR VOLTAGE INVERSION CIRCUIT

Figure 184. Error voltage inversion circuit, simplified schematic diagram.

the OUTER MARKER WIDTH ADJUSTMENT, determines the initial conducting point of the tube and is set at a more negative point, thereby requiring a greater error voltage to fire the tube. When conduction through the tube begins, relay RY4 is actuated. Thus, the input voltage to the grid of the audio oscillator V8 is no longer obtained from the slider of P5, but is connected to a point whose potential is fixed with respect to the chassis voltage supply. This voltage supplied for the constant pitch warning tone is determined by the setting of P6 across a part of the output bleeder network of the power supply. P6 is designated on the front panel as the FIXED TONE FREQUENCY ADJUSTMENT.

(5) ERROR VOLTAGE INVERSION CIRCUIT.

(*a*) Any increase in azimuth error voltage, either positive or negative, must be impressed on the grid of the audio oscillator V8 as a positive increase of voltage. The operation of the inversion circuit is based upon the fact that the power supply within the chassis is not grounded at any point in its basic circuit. The cathode of the audio oscillator V8 is fixed with respect to B- by P7, the STARTING FREQUENCY OF TONE VARIATION control.

(*b*) In the circuit shown in figure 184b, the azimuth error potentiometer tap is moved below the grounded midpoint; thus the error voltage becomes negative with respect to ground. The current flows from ground through the upper contact of the third set of contacts on relay RY5, through potentiometer P5, through the upper contact of the first set of contacts on relay RY5, and out through the error potentiometer tap to the negative end of the winding. Note the direction of current flow across potentiometer P5. The variable tap on P5 applies a portion of the voltage drop across the potentiometer to the grid of audio oscillator V8, through the relay contacts of RY4. As the negative voltage of the error potentiometer becomes greater, the voltage drop across P5 also becomes correspondingly greater. The negative end of potentiometer P5 is directly connected to the B- terminal of the chassis power supply. The greater the voltage drop across P5, the more negative becomes the B- point, which determines the cathode voltage level of V8, and thus the grid voltage to V8 becomes proportionally less negative.

(*c*) When the voltage from the azimuth error potentiometer goes positive, the contacts of relay RY5 are reversed (fig. 184a). Under these circumstances, current flow is from the positive point on the azimuth error potentiometer winding and is applied to potentiometer P5 through the lower position of the third set of contacts on RY5. Current flows through P5, in the same direction as before, through the lower of the first section of contacts on RY5 to ground. The B- point, being connected to the lower end of P5, is now also directly connected to ground through RY5. Positive excursions of voltage from the error potentiometer will increase the voltage drop across P5 with reference to ground, and will thus increase the grid bias of V8, thereby increasing the frequency of oscillation.

(*d*) To operate relay RY5, a reversing circuit consisting of V1, a 2050 gas type thyratron tube, and relay RY1 is provided. This circuit functions as the azimuth error voltage passes through zero in a positive direction (fig. 185). The positive error voltage input establishes

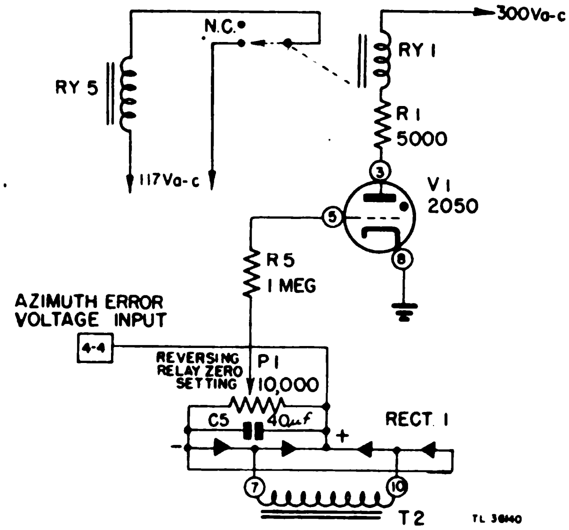


Figure 185. Reversing circuit, simplified schematic diagram.

the voltage at the positive end of the variable potentiometer P1, across selenium rectifier, RECT 1. Therefore, the grid bias applied to V1 rises and falls with the error voltage input. Selection of the operating point for the reversing tube is accomplished by varying the grid bias through variable potentiometer P1, designated as the REVERSING RELAY ZERO SETTING control and located on the front panel of the chassis. Thus, as a positive voltage from the error potentiometer of the azimuth director assembly is impressed on the grid circuit of the reversing tube, it will cause the tube to conduct when the tube has reached its ionization potential fixed by the grid bias adjustment P1. Tube V1 conducting, operates relay RY1 which in turn actuates relay RY5 and reverses its contact positions. Therefore relay RY5 is essentially a reversing relay. Since V1 is a gas tube, its grid bias has no control after the tube once fires. If the plate voltage of V1 is dc, the tube will continue to conduct, even if a relatively large negative grid bias is applied again when the deviation producing the positive error voltage is corrected. For this reason, the plate voltage applied to V1 is a 60-cycle a-c voltage from a winding of transformer T1. The plate voltage drops to zero once every 1/120th of a second, permitting the grid to again take control and prevent the tube from firing during the following cycle if the grid bias has dropped below cutoff.

(6) POWER SUPPLY.

(*a*) The power supply for the aural signal unit is contained on the aural signal unit chassis and consists of the conventional type full-wave rectifier, using a dual diode type 5R4GY tube and a choke input filter circuit. To maintain the voltage of the power supply constant, in spite of large changes of load current drawn from the supply or changes in the input voltage, a voltage regulating network is used. The regulator network consists of

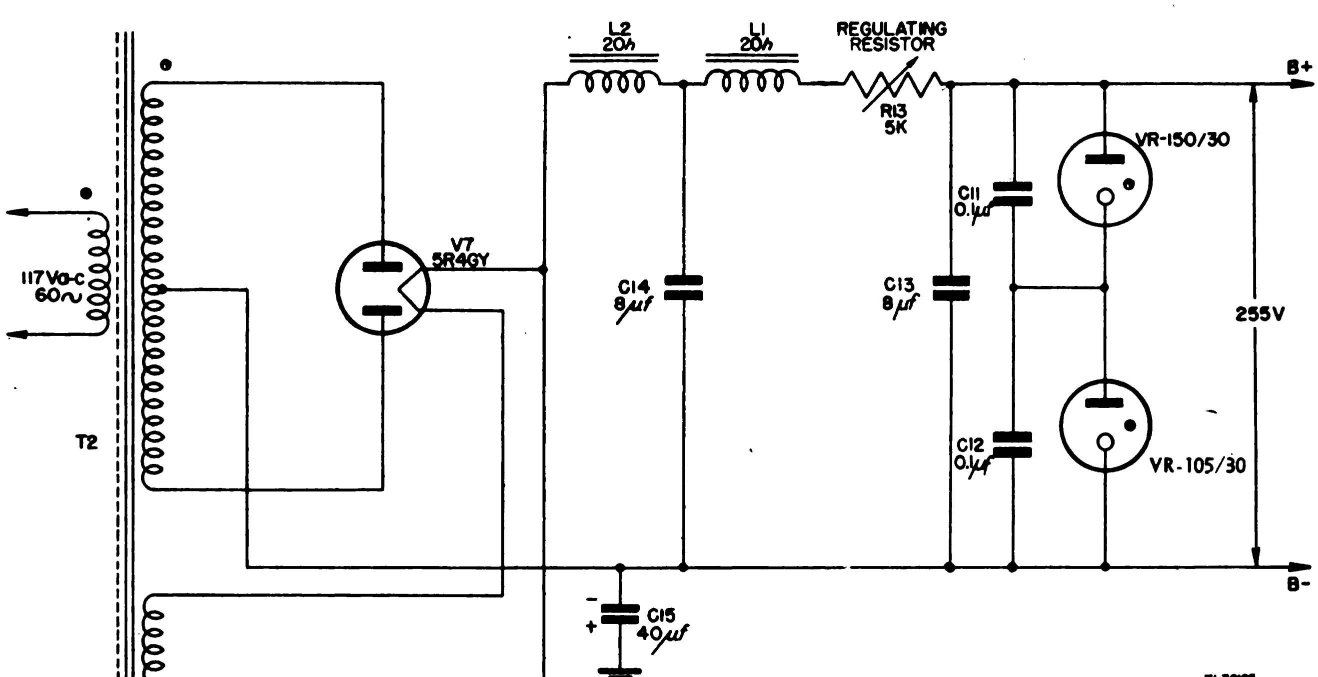


Figure 186. Aural signal unit power supply, simplified schematic diagram.

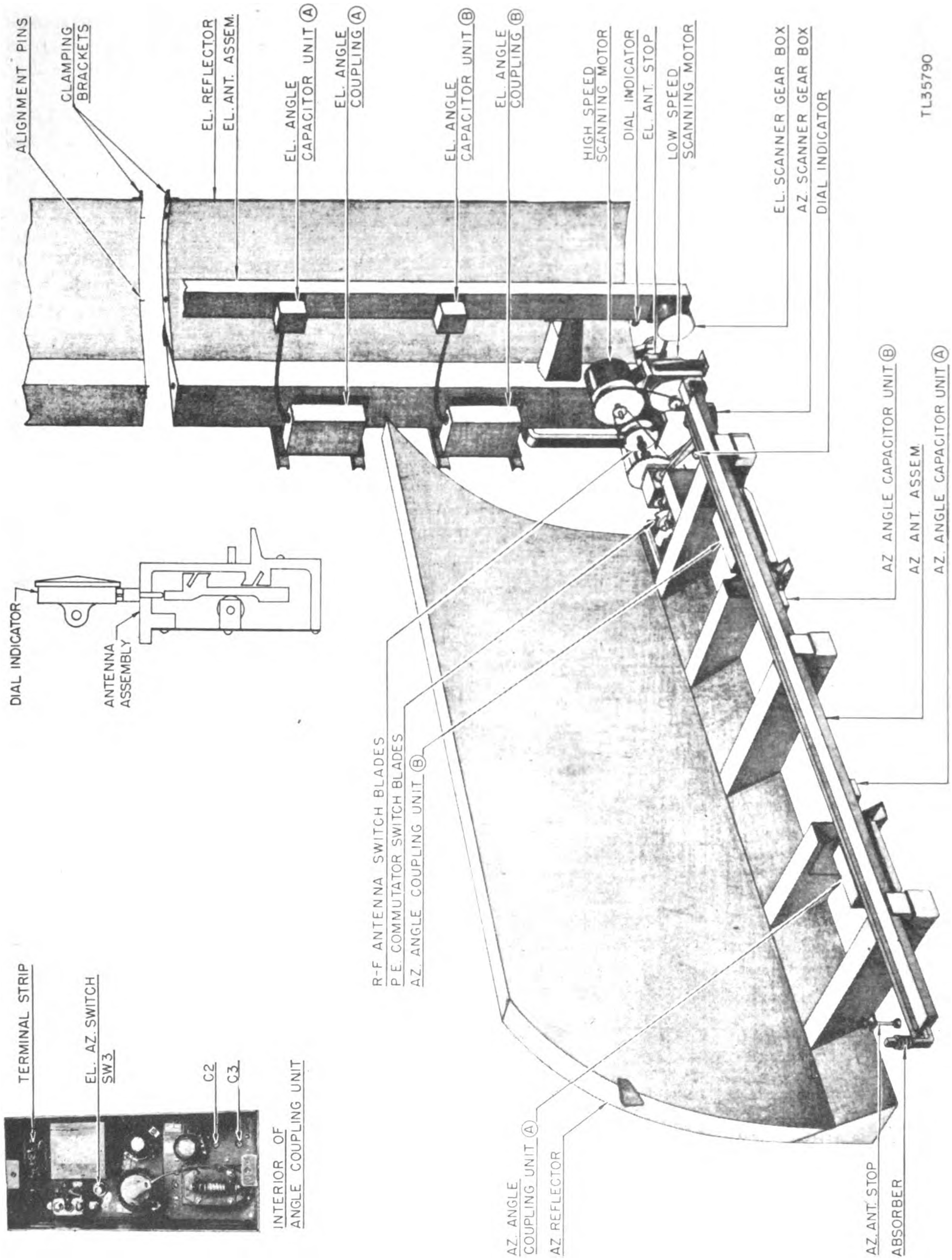
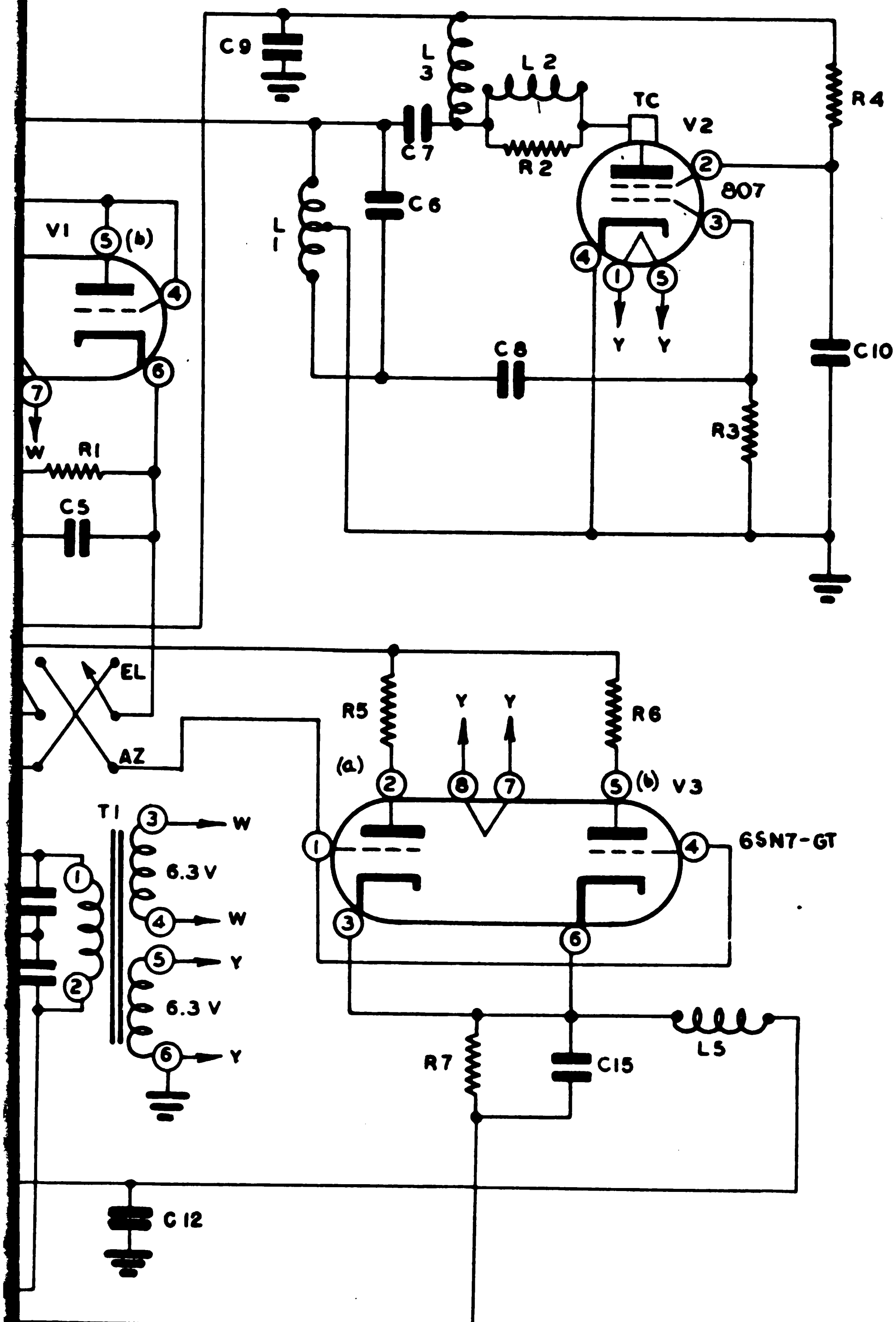


Figure 187. Azimuth and elevation antennas.



TL 36050A

Figure 188. Angle Coupling Unit CU-14/MPN-1 (including Angle Capacitor Unit CU-15/MPN-1), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	470,000	½ W	20%
R2	50 Ohm	10 W	20%
R3	20,000	10 W	10%
R4	50,000	10 W	10%
R5	47	½ W	20%
R6	47	½ W	20%
R7	15,000	10 W	10%
C1	338 mmf	MAX.	
C2	6.5-140 mmf	AP9-6	
C3	100 mmf	AP9	
C4	100 mmf	500 V	5% Mica
C5	100 mmf	500 V	5% Mica
C6	510 mmf	2500 V	5% Mica
C7	240 mmf	2500 V	5% Mica
C8	240 mmf	500 V	5% Mica
C9	.02 mf	1000 V	20%
C10	.004 mf	1000 V	20%
C11	.02 mf	600 V	20%
C12	.1 mf	600 V	20%
C13	.05 mf	600 V	20%
C14	.05 mf	600 V	20%
C15	.002 mf	1000 V	20%
L1	50 uh	COIL	
*L2	P-300 Ohmite		choke*
L3	2.5 mh		R-100
L4	2.5 mh		R-100
L5	10 mh		CH-126-B
	Type		
T1	15-3430		
SW1	3 POLE D.T.		2507
	Mfr. No.	Vt. No.	
V1	6SN7-GT	VT 231	
V2	807	VT 100A	
V3	6SN7-GT	VT 231	
CS	CONNECTOR STRIP		
PL1	831R		
PL2	831R		

* L2 wound on R2.

a variable resistor R13 and two voltage regulator type tubes, VR150/30 and VR105/30, connected across the supply (fig. 186).

(*b*) The voltage regulator type tubes are characterized by the nearly constant voltage drop across them during conduction. The voltage drop across each tube is determined by the tube construction and is of the order of 150 and 105 volts respectively for the two regulator tubes VR150/30 and VR105/30. Since both tubes are connected in series, the total voltage drop will be approximately 255 volts.

(*c*) The load current and the current through the argon glow-tube regulators both pass through the series resistor R13. If the supply voltage drops, the voltage across the regulator tubes tends to drop. However, with a decrease in voltage across the tubes, the argon gas de-ionizes slightly and less current passes through the tubes. Therefore, the current decreases in the regulator tubes. Since the current through R13 will also be less, the voltage drop across it will decrease and the output voltage will tend to increase. If the resistor is of the proper value relative to the load and to the regulator tubes used, the voltage across the load will be held nearly constant.

(*d*) The voltage required to cause ionization of the glow tubes when the circuit is first energized is approximately 30 percent greater than the operating terminal voltage. The voltage quickly drops to the operating value as the tubes begin to conduct. In order to maintain stable operation, a minimum current of 5 milliamperes should flow through the tubes, and the maximum current should be kept well below the rated 30 milliamperes which is controlled by the setting of R13.

(*e*) Since the voltage output of the power supply would increase sufficiently to damage the load circuits if the regulator tubes were removed, the 117-volt mains supply is interlocked through pins 3 and 7 of each regulator tube. In this manner, if a tube is removed, the 117-volt line will be broken and the power will be removed from the load circuits.

SECTION VII
SCAN SYNCHRONIZING AND ANTENNA POSITIONING SYSTEM

70. INTRODUCTION. To accurately determine the exact azimuth and elevation of an approaching aircraft, the azimuth and elevation antennas must continuously sweep through the sector containing the aircraft. In addition, to properly interpret the positioning information, the indicator system timebases must be made to scan a corresponding angle and must be exactly synchronized with the sweep of the antennas. In Radio Set AN/MPN-1 the beam sweep and timebase synchronization is accomplished by means of the scan synchronizing and antenna positioning system. This system consists of an electrical section and a mechanical section. The purpose of the electrical system is to generate a modulating voltage which is applied to the indicator sweep amplifiers in order to synchronize the scanning motion of the timebases with that of the corresponding antenna beam, and to provide a commutator voltage to alternately blank out the azimuth and elevation indicator tubes. The mechanical system provides a means of adjusting the two antennas in azimuth and elevation in order to continuously illuminate an approaching aircraft. The location of the various units comprising the scan synchronizing system is shown in figure 187.

a. Electrical Section. The electrical section of the scan synchronizing system consists of two angle capacitor units and two angle coupling units for each of the elevation and azimuth antennas, in addition to a commutator unit contained in the r-f switching unit previously described. One angle capacitor unit and one angle coupling unit with eaeh antenna is used in the actual operation of the equipment, while the duplicate units are maintained in a stand-by condition.

(1) In order to produce an indicator sweep whose scanning motion is synchronized with that of the antenna beam, a modulating voltage, with an amplitude proportional to the angle of the beam, is applied to the indicator sweeps. This modulating voltage is obtained from Angle Coupling Unit CU-14/MPN-1, a separate unit being required for each antenna. The modulating voltage must be developed by the same action that produces the antenna scan, namely, the waveguide variations. This is accomplished through the use of a capacitance voltage divider in which the output of an oscillator circuit, a voltage of fixed magnitude and frequency, is placed across a series of two capacitors. One of these is a variable air capacitor, contained in Angle Capacitor Unit CU-15/MPN-1, whose rotor is coupled to one of the pivot arms producing the waveguide variation. The change in capacitance is proportional to the change in waveguide width. The voltage across the variable capacitor is rectified and applied to the sweep amplifiers to vary the amplitude of the sweep voltages (ch. 3, sec. VI).

(2) Since a single receiver system is used for both elevation and azimuth indicators, a means of alternate switch-

ing must be used to present the video pulses to the proper indicators. The elevation and azimuth antennas are fed by a single transmitter through a T-section of waveguide of which first one branch and then the other is blocked by revolving brass disks.

(3) Similar brass plates are also used in developing intensifying voltages for application to the indicators. Photoelectric cells receive a beam of light interrupted by the passage of the disks. Their position is such that when energy is being fed to the elevation antenna the light beam to the elevation photocell is passed by the narrow section of the disk. The positive voltage gate produced is applied to the grid of a cathode follower and this output voltage is sent through two amplifier stages in the synchronizer. The resulting positive gate voltage is applied to the elevation CRT grid to permit the video signals reaching it to be above cutoff. At the same time, the azimuth photocell is not receiving the light beam, the wide section of the disk being opposite it; there is no voltage output from this photocell, and the azimuth CRT's remain biased below cutoff. The two brass disks are part of the r-f switching unit described in section III of this chapter. They are driven off the same shaft by the motor which also produces the antenna waveguide variation, the various actions thus being properly synchronized.

b. Mechanical Section. The function of the mechanical section of the scan synchronizing and antenna positioning system is to adjust the elevation and azimuth antennas in azimuth and elevation, respectively, in order to insure that the antennas are scanning that section containing the approaching aircraft.

(1) Since the elevation antenna emits a thin fan-shaped beam of energy which scans in the vertical plane, some method must be utilized for locating its direction in azimuth to permit detection of aircraft within the entire area scanned by the azimuth antenna assembly. The elevation tracker does not have the information available to position the elevation antenna in azimuth, thus the azimuth tracker must perform this function. Consequently Elevation Antenna Follower Assembly MX-48/MPN-1 is associated with the azimuth indicator and is operated by the azimuth tracker. Similarly, Azimuth Antenna Follower Assembly MX-47/MPN-1 is associated with the elevation indicator and functions to position the azimuth antenna in elevation.

(2) The antenna follower assembly comprises a foot-pedal servo, coupled to the antenna assembly through a cable and pulley arrangement, and also to a pair of servo cursors superimposed on the faces of the azimuth and elevation indicators.

71. ANGLE COUPLING AND CAPACITOR UNIT.

a. General. (1) Four sets of Angle Coupling Unit CU-14/MPN-1 and four sets of Angle Capacitor Unit CU-15/MPN-1 are a part of each radio set. Two sets of each are mounted on the azimuth antenna array waveguide member and two on the elevation antenna waveguide member. Each angle coupling unit is connected electrically with the angle capacitor unit mounted beside it by a short coaxial line, Cord CG-12/MPN-1. One set of these units on each antenna is used in operation, while the other is maintained in a stand-by condition. All four sets of units are interchangeable, but considerable calibration is necessary to adapt a particular angle coupling unit to either antenna.

(2) A modulating voltage proportional to the angle of antenna beam scan is applied to the azimuth and elevation sweep amplifiers, producing an indicator sweep, the scanning motion of which is synchronized with that of the associated antenna. The angle coupling and the capacitor units function to generate this modulating voltage for associated sweep amplifiers.

b. Electrical Circuits. (1) The angle coupling unit (fig. 188) consists of a 1-megacycle oscillator whose output is applied across a capacitance voltage divider in which angle capacitor C1 provides a capacitance variable with the waveguide scanning mechanism. The oscillator output, of relatively constant peak value, is applied across the voltage divider and the portion appearing across the variable capacitor, C1, when rectified and passed through a cathode follower, becomes the required angle data voltage. The oscillator consists of tube V2 (807) operated as a Hartley oscillator, the resonant circuit being composed of inductance L1 and capacitor C6. The parasitic suppressor combination of L2 wound upon R2, and r-f choke L3, operate respectively to minimize undesired oscillations and prevent a-c components from getting into the plate supply circuit. The output voltage of the oscillator is taken across the plate portion of inductance L1. Capacitor C1, which is across a part of L1, causes a slight frequency variation in the oscillator output as the antenna scans. To minimize this variation, the LC ratio is small so that frequency change, and the resultant output variation, will likewise be small.

(2) The variable voltage divider consists of the parallel combination of C1 and C3 in series with C2. The variable output voltage from the voltage divider is applied to the rectifier circuit consisting of one section of the dual-triode V1 (6SN7-GT) connected as a diode. The rectified output appears across the load resistor R1, the cathode end of the resistor being the more positive. R-f choke L4 provides a d-c return for the rectified current while presenting a high impedance to the 1-megacycle oscillation.

(3) The d-c output of the rectifier is applied to the paralleled grids of cathode follower V3 through the azimuth-elevation switch SW1. The simplified schematic of the circuit with the switch in the elevation position is shown in figure 189(a). With SW1 in the elevation position, the negative end of R1 is connected to the cathode follower grid while the more positive end of R1 is connected to the slider of potentiometer P14. The potentiometer, located on the synchronizer chassis, is a part of a resistance chain across a positive 300-volt source, and serves to supply a positive reference voltage to the grid of the cathode follower. The variable d-c output of the rectifier opposes the fixed reference voltage, thereby producing an increasing positive swing in the cathode follower output for a corresponding decrease in rectified d-c.

(4) With switch SW1 in the azimuth position (fig. 189(b)), the positive end of the rectifier load resistance is connected to the grid of the cathode follower V3 while the more negative end is connected to the slider of potentiometer P15. The potentiometer chain is also located on the synchronizer chassis and is connected across a negative 102-volt source with respect to ground, thereby furnishing a negative reference voltage to the grid of V3. Again the variable d-c output of the rectifier opposes the fixed reference voltage; however, since the reference voltage is now negative, an increasing rectifier output will produce an increasing positive swing in the cathode follower output circuit. The purpose for generating these positive voltage swings with variations of capacitor C1 is explained in subparagraph *c* below.

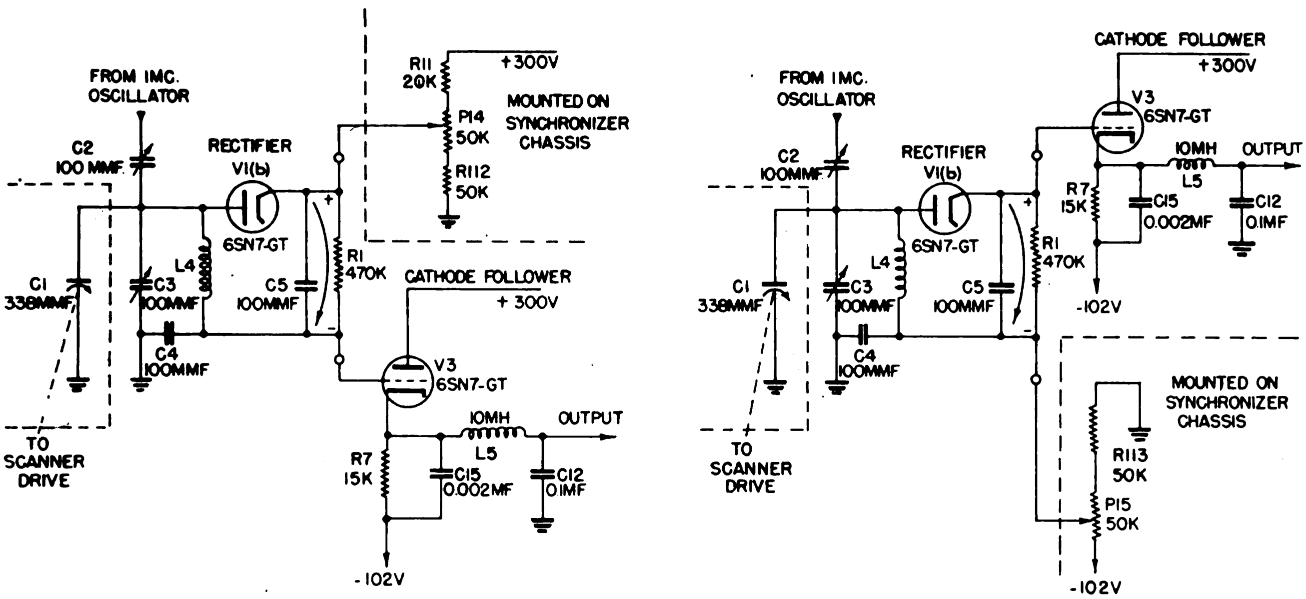
(5) The output angle voltage of cathode follower stage V3 is developed across cathode resistor R7. A filter circuit consisting of C15, L5, and C12 provides further smoothing of the output, thereby removing the r-f component. The d-c output is more positive than the grid voltage and has a slightly smaller variation, the grid level being adjusted through potentiometer P1. The cathode follower acts as a current amplifier, providing adequate output power while preserving a light load of the diode rectifier.

c. Azimuth and Elevation Adaptation. (1) To understand the use of the angle coupling unit with both elevation and azimuth antennas, it is necessary to consider the scanning characteristics of both antennas and the necessary steps to match the coupling unit's signal output with either antenna scanning curve. The following considerations apply:

(*a*) The maximum permissible range of guide width variation is from a half-wavelength to a full-wavelength in air. Below this range, transmission is impossible; above this range the mode of operation changes.

(*b*) The antenna beam must never scan through the normal to the array; at this point in the scanning range, standing waves become very high, owing to additive reflections from the dipole probes.

(*c*) With 2.2-centimeter spacing of the dipoles, the



(A) SW1 IN ELEVATION POSITION (B) SW1 IN AZIMUTH POSITION TL35003

Figure 189. Angle Coupling Unit, CU-14/MPN-1, simplified schematic diagram.

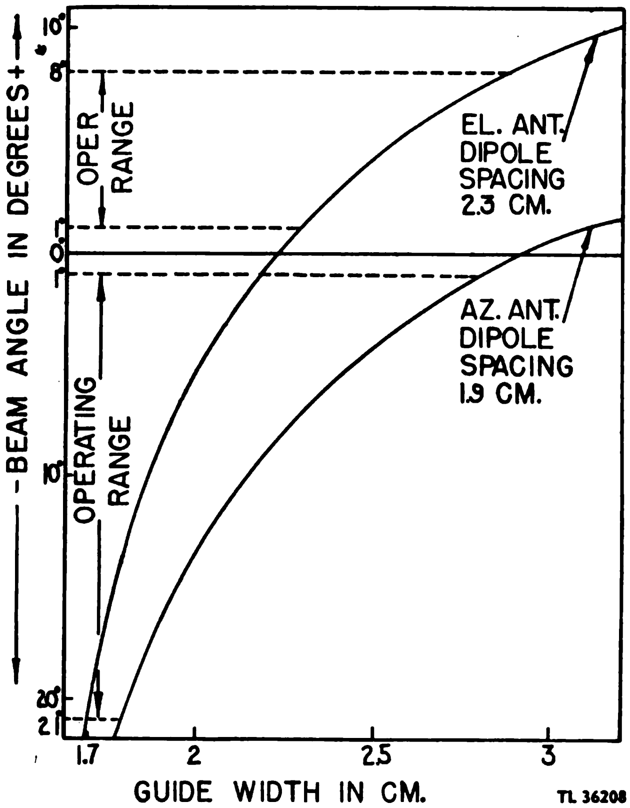


Figure 190. Waveguide width versus antenna beam angle for precision antennas.

scanning range is from 10 degrees to –30 degrees, considering positive angles toward the load end of the antenna and negative angles toward the feed end, and measuring from the normal.

(*d*) It is desirable, for convenience, to feed the two antennas at their adjacent point in the trailer; this determines the relationship of feed end and load end of the arrays.

(*e*) The elevation scanning range must be 7 degrees and the azimuth range 20 degrees.

(2) The above requirements are satisfied by using an elevation scanning range of 1 to 8 degrees, and azimuth scanning range of –1 to –21 degrees from the normal. The possible scanning range with 2.2-centimeter dipole spacing, from –30 degrees to +10 degrees, may be shifted about the normal by varying the dipole spacing. Reducing the spacing causes the range to shift toward the negative side, and increasing the spacing causes a shift in the positive direction. Since the two antennas must scan in opposite directions from the normal, the dipole spacing is made less than a half-wavelength in the guide for the azimuth antenna and more than a half-wavelength for the elevation antenna. In this way, the antenna scanning range is shifted toward the side of the normal on which the particular antenna is to scan. This relationship is shown in figure 190. Actual antenna operating characteristics may deviate slightly from these curves, which are based on theoretical calculations.

(3) In the case of the azimuth antenna, shifting the curve by decreasing the dipole spacing develops greater precision by reducing the beam angle change for a given guide width change in the 20-degree region used. In the elevation antenna, increasing the dipole spacing shifts the curve in such a way that the beam angle change for a given guide width change is increased, thus permitting complete coverage of the scanning sector.

(4) Angle capacitor C1 is linked mechanically to the moving plate of the variable width waveguide, its purpose being, in conjunction with the angle coupling unit, to produce a voltage proportional to the beam angle of the antenna. Since the curve of the antenna beam angle versus capacitor rotation is not linear (but resembles a portion of an hyperbola), the curve of the capacitor rotation versus output voltage must also be non-linear in such way as to exactly complement the former curve. The capacity divider circuit in the angle coupling unit, of which C1 is an element, produces the desired curve when the trimmers C2 and C3 are adjusted properly. For proper matching, the steepest portions of the two curves must occur at the same guide width positions. On both antennas the angle capacitor must be connected so that capacitor voltage increases as guide width decreases, meaning that for the azimuth antenna the capacitor voltage increases with increasing beam angle, and for elevation antenna the capacitor voltage decreases with increasing beam angle (fig. 191).

(5) For both antennas, the angle-signal output must vary between limits of from 2 to 52 volts. The antenna beams scan through increasing angles away from the normal. Switch SW1 is used to select the proper reference voltages.

(6) If the angle coupling unit is used on the azimuth antenna, switch SW1 is turned to the azimuth position. With the switch in this position, the negative end of R1 is connected through to the slider of P15. Potentiometer P15, mounted on the synchronizer chassis, regulates the voltage level with respect to ground at the negative end of R1, and the output to the grid of V3 is taken from the positive end of R1. In azimuth use, the rectified voltage across R1 increases in ratio with beam angle. For example, if P15 is set at –65 volts, and the total voltage drop across R1 varies from 65 volts to 115 volts, the voltage at the grid of cathode follower V3 will vary from 0 to 50 volts. Since the cathode output voltage of V3 is a few more volts positive than the grid voltage, the

output across R7 will vary from 2 to 52 volts, considering the cathode follower gain to be unity, which is the proper amplitude and polarity to modulate the azimuth sweeps.

(7) When the angle coupling unit is used on the elevation antenna, switch SW1 is thrown to the elevation position, thus the positive end of R1 is connected through to the slider of P14 which is located on the synchronizer chassis. Potentiometer P14 establishes the voltage level of the positive end of R1 with respect to ground, and the output to the grid of V3 is taken from the negative end of R1. The rectified voltage across R1 decreases with increasing antenna beam angle, and therefore the net output from the negative end of R1 is positive going, with its base level set by P14. For example, if P14 is set at 185 volts, and the drop across R1 varies between 185 and 135 volts, the voltage at the grid of cathode follower V3 will vary from 0 to 50 volts as the beam angle increases. Again, since the cathode voltage is a few more volts positive than the grid voltage, the cathode output voltage will vary from 2 to 52 volts, which is the proper amplitude and polarity to modulate the elevation sweeps.

(8) In general, field adjustment of the capacity divider will be unnecessary since the coupling units are factory calibrated with the antennas with which they are to be used. Therefore, do not disturb the capacitor settings or switch SW1 under normal conditions. If it becomes necessary, however, to install an angle coupling unit on a replacement antenna or to install a new angle coupling unit, the adjustment of C2 and C3 must be checked to insure that the output-voltage curve matches the antenna-beam curve. Instructions for performing this calibration against the radiation curve for a particular antenna will be found in chapter 3, paragraphs 56 and 57 of TM 11-1343.

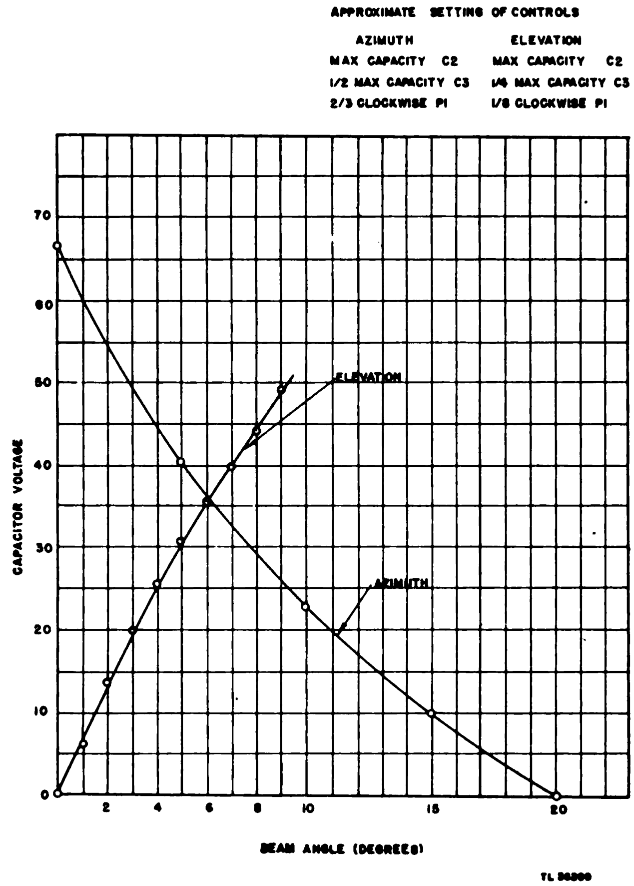


Figure 191. Angle Capacitor Unit CU-15/MPN-1, voltage and beam angle relationships.

72. COMMUTATOR UNIT SA-40/MPN-1.

a. General. (1) As was previously stated, the azimuth and elevation antenna beams occur alternately, one remaining stationary while the other scans. Since the azimuth and elevation indicator sweeps are electrically synchronized with the antenna beam direction by Angle Coupling Unit CU-14/MPN-1, they also have an alternating scanning motion, remaining stationary between sweeps. This would ordinarily result in a "piling up" of signals, producing a brilliantly illuminated line at the two edges of the indicator sweep scan. The commutator unit provides a means for preventing these signals from appearing while the sweep is stationary at the edge of the scanned area. The application of this voltage output to the indicators, and likewise to the receiver where it is used to vary the gain during the alternative periods of operation, takes place in the synchronizer.

(2) Two photoelectric commutator units are located in the switching unit for operation and stand-by use. They are placed on opposite sides of the second pair of semicircular brass shutter cams revolving about the main drive shaft (fig. 103). No physical contact is made with the shutters, the voltages being developed through the alternate interruption of light beams directed at the photocells. Since the shutters correspond in position to those used in the r-f channel switch, the voltages developed by the photoelectric cells are in synchronism with the direction of the antenna feed.

b. Electrical Circuits. The schematic diagram of the commutator unit is shown in figure 192. The unit consists of a light source LM1 and two photoelectric cells, V2 and V3, mounted in metallic housings which are slotted and aligned so that only narrow beams of light from LM1 can reach the cathodes of the photocells. The shutters are so designed that the azimuth photocell is dark and the elevation photocell receives light from the source while the elevation antenna is energized and vice versa.

(1) The photocells are connected in the grid circuits of two cathode follower triodes, V1(a) and V1(b) (6SN7-GT). The square wave output of the photocells has a duration equal to the scanning time of the antenna beams, thus requiring direct coupling from photocells to indicator circuits in order to maintain a flat-topped voltage wave. In order that the square waves will be at the proper voltage level for application to the circuits in the synchronizer, the cathode followers are operated at a potential below ground, the plate being at a –102 volts and the cathode at a –210 volts. Resistors R3 and R4 form a voltage divider across the two negative voltages supplied externally, the junction point of R3 and R4 being approximately –137 volts. Each photocell is connected in series with a 33-megohm resistor, R2 and R5, thereby forming a voltage divider circuit across R4 and its associated 73-volt drop. The junction of the photocell and resistor is connected to the grid of the corresponding cathode follower.

(2) When the photocell is not illuminated, its resistance is high, of the order of 70 megohms. Thus the voltage applied to the cathode follower grid will be low, approximately 3.5 volts above the –210-volt supply. In this condition the output voltage at the cathode of the cathode follower will be about –204 volts.

(3) When the photocell is illuminated, it will conduct and its resistance will fall to approximately 11.5 megohms. Thus the voltage applied to the grid of the cathode follower will increase to 15.6 volts above the –210-volt supply, developing an output voltage of –192 volts on the cathode of the cathode follower. Hence the output will be a square wave having an amplitude limit at –204 volts and –192 volts with respect to ground, constituting a voltage swing of 12 volts.

(4) The voltage outputs of the two cathode followers, V1(a) and V1(b), are identical in form if the photocells are matched, but are displaced in time so that the one is in the positive portion of the square wave while the other is in the negative portion.

(5) Transformer T1 supplies filament power for cathode follower tube V1, as well as power for the light source LM1, an automobile headlight-type lamp. LM1 operates at only 5 volts instead of the rated 6 to 8 volts, in order to provide a longer life, and the light source has sufficient thermal capacity so that the light is not appreciably modulated by the 60-cycle a-c supply. Line voltage variation, or illumination change from the light source will not cause any serious difficulties, since the 12-volt output swing is more than sufficient for its purpose.

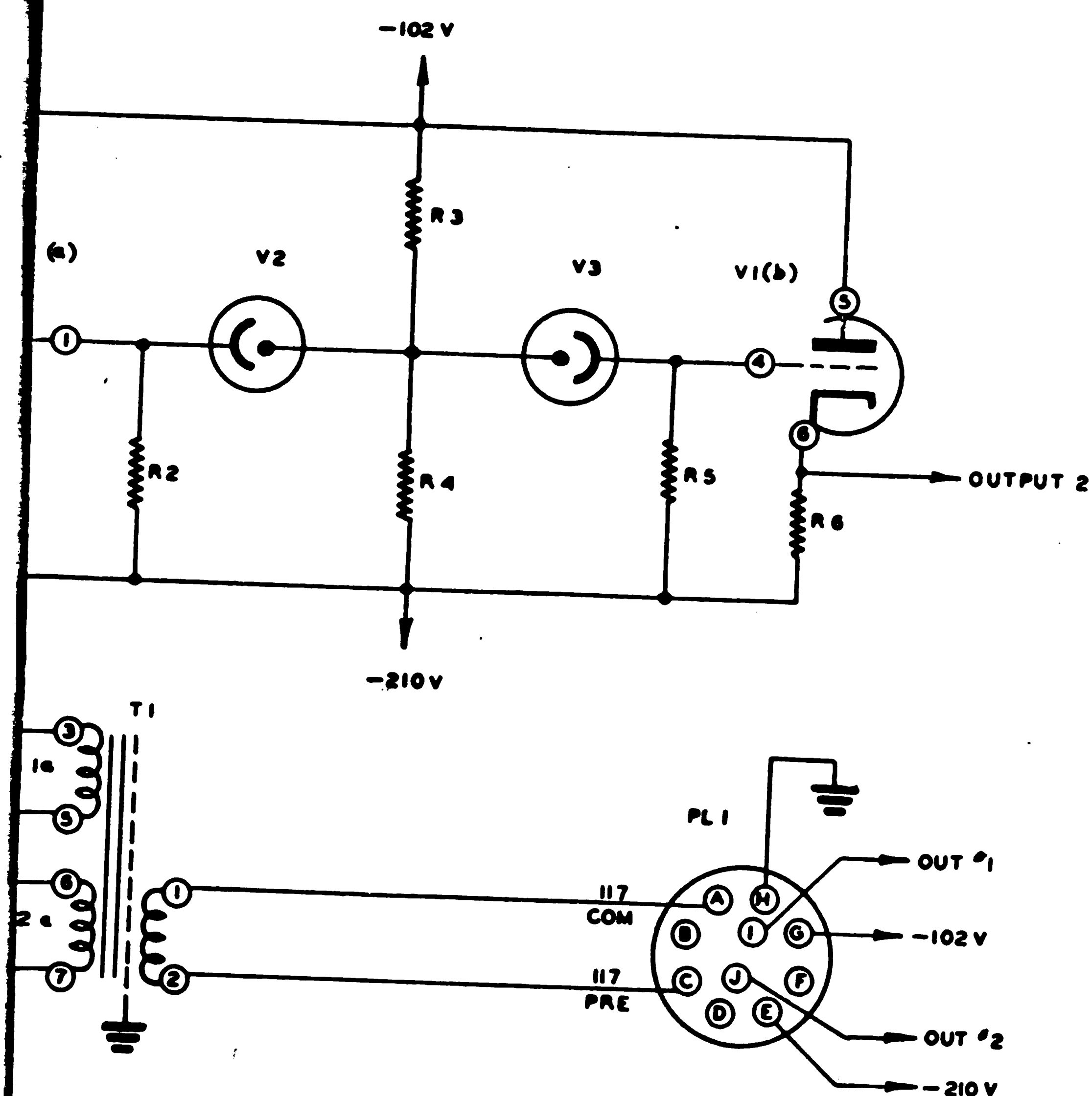
(6) The square wave outputs of the commutator unit are applied to the azimuth-elevation commutator circuit on the synchronizer chassis (ch. 3, sec. V) where they are used to alternately blank the elevation and azimuth tubes.

73. ANTENNA FOLLOWER ASSEMBLIES.

a. General. The antenna follower assemblies in Radio Set AN/MPN-1, shown in figure 193, provide a means of tracking an approaching aircraft in azimuth with the elevation antenna and in elevation with the azimuth antenna. A means of tracking is required since the narrow beam width of the two antenna arrays is not sufficient to continuously illuminate an approaching aircraft over the entire length of its glidepath. A separate foot-pedal servo system is used with each of the two antennas. Since the elevation tracker does not have sufficient information to aim the antenna in azimuth, the azimuth tracker performs this operation. Similarly, the elevation tracker aims the elevation antenna in azimuth.

b. Elevation Antenna Follower Assembly MX-45/MPN-1. The elevation antenna follower assembly comprises a foot-pedal servo, coupled to the elevation antenna through a cable and pulley arrangement. In addition, the pedals are connected to a pair of servo cursors superimposed on the faces of the azimuth indicators (detail B of fig. 193). Since the azimuth tracker has a clear picture of the scanned area in azimuth, it is easy for the tracker to position the elevation antenna in azimuth. The servo cursors, or angle indices, are transparent only in a narrow V-shaped area whose point is at the vertex of the tube map area. The system is mounted so that the cursor pivots about this vertex, and the angular transparent area represents the azimuth width and direction of the elevation scanning beam. Thus, as long as the azimuth tracker operates the foot pedals to keep the echo signal within the transparent area, the elevation antenna will be properly positioned in azimuth to scan the target aircraft.

c. Azimuth Antenna Follower Assembly MX-47/MPN-1. The azimuth follower, associated with the elevation indicator and elevation director assemblies, is identical in function to the elevation antenna follower. In this case, the elevation tracker operates a set of foot pedals to properly position the azimuth antenna with respect to the elevation of the target. Servo cursors located over the faces of the elevation indicator tubes are controlled by the foot pedals and pivot about the vertex of the scanned areas (detail A, fig. 193). The system is set up so that the transparent angular area on each cursor represents the width and direction in elevation of the azimuth antenna beam. Thus, as long as the elevation tracker operates the foot pedals to keep the echo signal within the transparent area, the azimuth antenna is properly positioned in elevation to scan the target. The method of mechanical coupling is shown in figure 193.



TL 36082A

Figure 192. Commutator Unit SA-40/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	100,000	½W	20%
R2	4.7 MEG	½W	20%
R3	47,000	½W	20%
R4	220,000	½W	10%
R5	4.7 MEG	½W	20%
R6	100,000	½W	20%
V1	VT 231	6SN7-GT	
V2		927	
V3		927	
LM1		MAZDA #82	
T1	THERMADOR 15-3462		
PL1	AN 3102-18-1P		

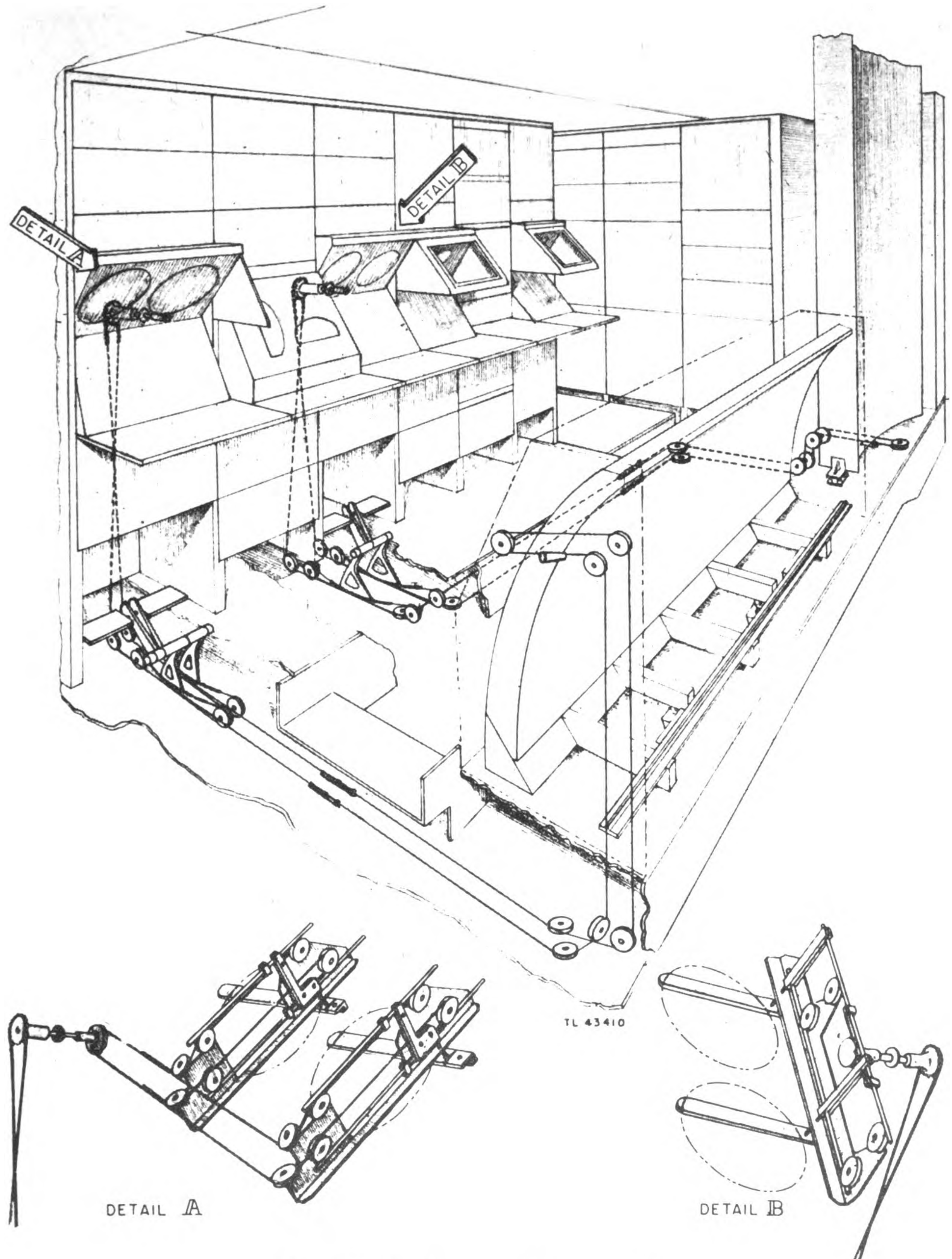


Figure 193. Precision antenna follower assemblies.

CHAPTER 4

ASSOCIATED EQUIPMENT

SECTION I

POWER DISTRIBUTION SYSTEM

74. DESCRIPTION. Primary power from the two Power Equipment PE-127-A units, or from an external commercial power source, is supplied to all components of Radio Set AN/MPN-1 through Power Distribution Panel SB-1/MPN-1. Provision is made for channel switching so that either channel A or B, but not both, may be operated at one time. The 6-volt ceiling light system is provided for emergency use. This lighting system is independent of the remainder of the power distribution system and is operated on the battery of the prime mover.

75. POWER DISTRIBUTION SUPPLY.

a. Commercial Power. When commercial power is used, power lines from the external commercial power source are connected to Junction Box J-29/MPN-1, on the outside of the trailer. The power is fed to a voltage regulator system on the commercial side of the main switch on the power distribution panel. This regulator system does not function when the generators are in use.

b. Generator Power. When generator power is used, the output of the two gasoline-driven generators is fed from the prime mover and Junction Box J-31/MPN-1, through polarized cables to Junction Box J-30/MPN-1, and then to the generator side of the main switch on the power distribution panel. Each generator connects to a different group of circuits (figs. 194 and 198). The voltage of each generator is regulated separately by the Silverstat regulator on each of the generator control panels. Detailed information will be found in the Instruction Book for Power Equipment PE-127-A, supplied with Radio Set AN/MPN-1. Should an emergency arise in which it is required to operate the equipment using but one power unit, a patching arrangement at the junction boxes makes this possible, provided that the reserve radar channel is shut down, the air conditioner is disconnected, and other current drawing outlets are reduced to the absolute minimum.

c. Six-volt Battery Supply. There are two systems of ceiling lights (fig. 198), one fed with 117 volts ac from Power Distribution Panel SB-1/MPN-1 and the other from the 6-volt battery of the prime mover. It is possible to operate both systems together although generally only one system is used at a time. The battery-fed system is for emergency use only and is completely independent of other power supply circuits except for the use of the same common return lead, C17. The emergency ceiling lights are connected through individual snap switches and their own set of door interlocks to the prime mover battery, through the 6-volt cable connection between Junction Box J-30/MPN-1 and Junction Box J-29/MPN-1

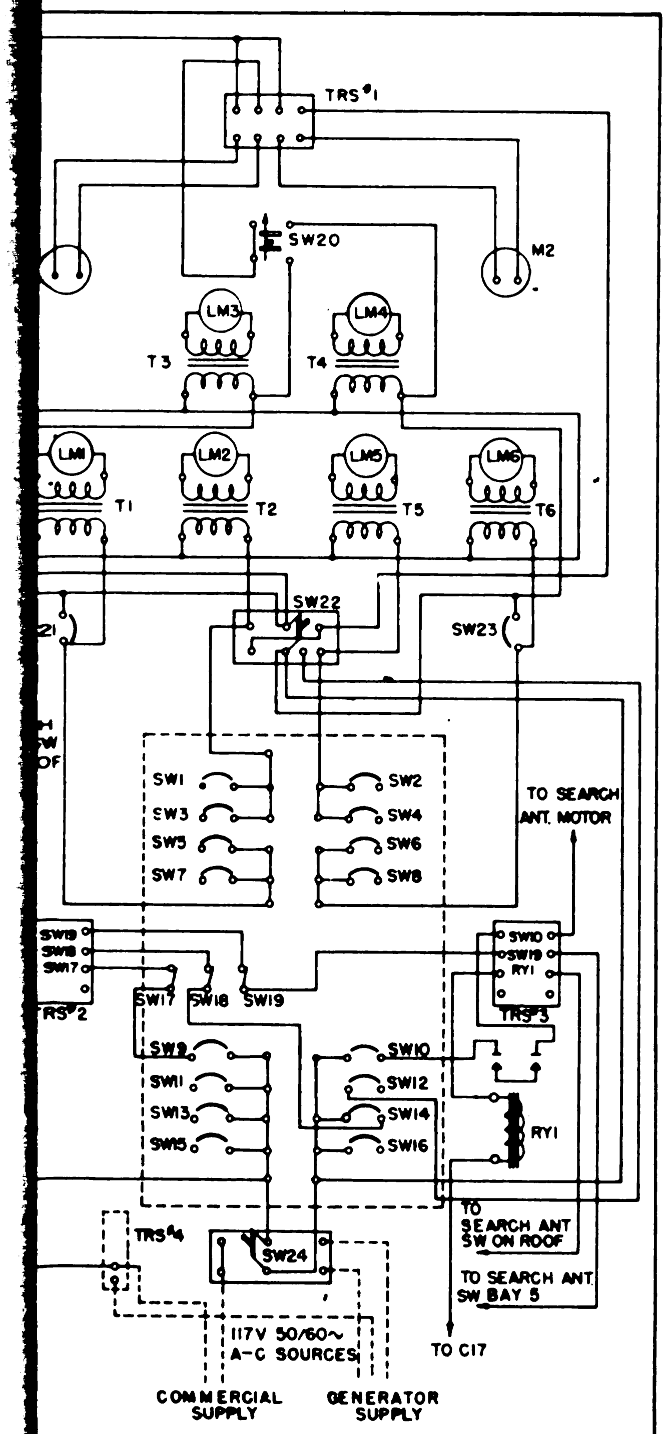
d. Battery Charger. The 6-volt prime mover battery is charged by a tunger charger which is included in the spare parts for the radio set. The circuit of the charger is shown in figure 195. Instructions for operation and maintenance are included with the unit.

76. EXTERNAL VOLTAGE SUPPLY CONNECTIONS.

a. 115-volt Source. In this case, as is the case for all operation of the radio set, the ground terminal is securely connected to a ground stake. One lead from the 115-volt source is connected to the common terminal on Junction Box J-29/MPN-1. The second lead is connected to the 115V AC terminal.

b. 230-volt, 3-wire Source. In this voltage supply system, the voltage between two of the three wires will be 230 volts. The third wire, called the common or neutral wire, will have a voltage of 115 volts existing between it and each of the other two wires. This neutral wire is connected to the COMMON terminal of the commercial power junction box. The second and third wires of the system are connected to the 115V AC and 230V AC terminals. The phase of the connections is unimportant.

c. 230-volt, 2-wire Source. In certain cases, the only external power source available will be a 230-volt, 2-wire source. In such a case, no wire is connected to the



SWITCH DIRECTORY

A	TRANSMIT	B
SW1	PRECISION A-B CHANNEL COMPONENTS	SW2
SW3	TRANSMITTER A-B CHANNEL COMPONENTS	SW4

A	PREHEAT	B
SW5	PRECISION A-B CHANNEL COMPONENTS	SW6
SW7	TRANSMITTING AND RECEIVING A-B CHANNEL COMPONENTS	SW8

SW17 PRECISION ANTENNA SCAN MOTORS
SW18 IFF OUTLET
SW19 SEARCH ANTENNA SCAN MOTOR

SW9 PRECISION INDICATORS DIRECTORS SCAN MOTORS	SEARCH INDICATOR CENTRALS SCAN MOTOR SW10
SW11 4,000-VOLT RECTIFIERS	A-B RELAYS SW12
SW13 COMMUNICATIONS RECEIVERS AND RECTIFIERS, INTERCOMMUNICATIONS, AND APPROACH INDICATOR	SYNCHROSCOPES IFF SW14
SW15 RACK BLOWERS, HYDRAULIC MOTOR	CEILING LIGHTS CONVENIENCE OUTLETS SW16

CIRCUIT BREAKERS SW1 TO SW12, SW14 AND SW16 RATED 20 AMPERES, SW13 AND SW15 RATED 25 AMPERES

PARTS LIST

SW20- SWITCH S.P.D.T.
LM3 & LM4-AMBER DIAL LIGHT
LM1 & LM6-GREEN DIAL LIGHT
LM2 & LM5-RED DIAL LIGHT
SW21-"A" PREHEAT SW S.P.
SW23-"B" PREHEAT SW S.P.
TRS 1 TO 3-TERMINAL BLOCKS 4P25A
TRS 4-NEUTRAL BLOCK C17
SW24- MAIN SWITCH D.P.D.T. 100A
M1-A-C VOLTMETER 0-150V
M2-"TIMETER" 120V 60~
SW17, SW18, SW19 - DESPARD S.P.S.T. 10A

TL 36063

Figure 194. Power Distribution Panel SB-1/MPN-1, schematic diagram.

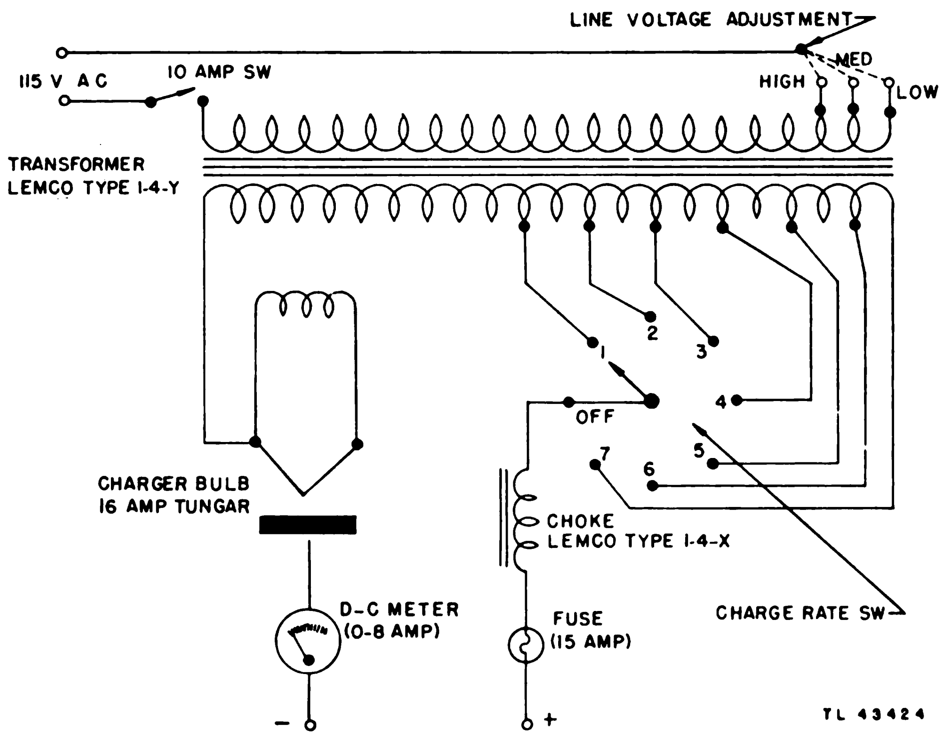


Figure 195. Battery charger, schematic diagram.

COMMON terminal on the junction box. The two leads from the power source are connected to the 115V AC and the 230V AC terminals. Ground return is now through the center tap of the auto transformer, which is connected to the COMMON and to the GROUND terminals on the junction box. This system may be used only when neither line from the power source is grounded.

> WARNING: Do not connect a 230-volt, 2-wire *grounded* system. The result will be doubling all supply voltages to the radio set. Do not connect any 230-volt system to the COMMON and 230V AC terminals. This system must be connected to the 115V AC and 230V AC terminals.

77. VOLTAGE REGULATOR UNIT CN-3/MPN-1. The voltage regulator system (fig. 196) consists of an autotransformer rated at 20 kva, Voltage Regulator Unit CN-3/MPN-1, and a regulator control panel. The commercial power supply is connected to the junction box as described above. The three terminals of the junction box are connected to the taps of the autotransformer, from which the 115-volt output is fed to the voltage regulator unit. The output of the voltage regulator unit is controlled by a contact-making voltmeter and a motor control relay mounted on the voltage regulator control panel, and is fed directly to the power distribution panel. One line is connected to both poles on one throw of the main switch SW21. The other line, used as the common line, is attached directly to the common block in the power distribution panel and to the ground lug in the commercial power junction box.

78. INDUCTION VOLTAGE REGULATOR ASSEMBLY.

a. General. The induction voltage regulator unit is designed to produce a steady output voltage of 117 volts through variations of up to 10 percent of the nominal 115-volt input supply. Manual control of the voltage output may be effected by means of a handwheel located at the top of the regulator. Usually, the system is automatically controlled by the voltage control panel. which comprises the contact-making voltmeter and a motor control relay. The voltage control panel has a three-position switch which permits either automatic control, manual control, or circuit testing. In the automatic position, the contact-making voltmeter regulates the output voltage to hold it at the predetermined level. In the man-

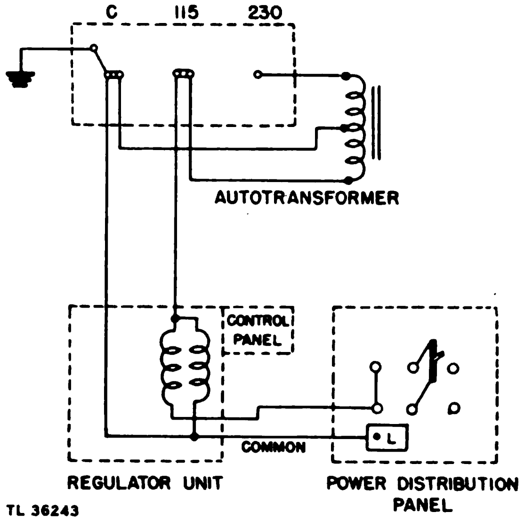


Figure 196. Voltage regulator system, simplified connections.

ual position of this switch, the regulator output is adjusted by RAISE and LOWER push-button switches on the control panel.

b. Regulator Unit. (1) The basic regulator circuit (fig. 197) consists of a rotor winding connected across the input line, and a stator winding connected in series with the line. They are magnetically coupled to form a continuously variable autotransformer. This coupling is arranged so that the induced voltage may either add to or subtract from line voltage, according to the position of the rotor. Limit switches mounted on the rotor assembly prevent operation of the regulator outside its working limits.

(2) In addition, the regulator has a short-circuited winding with a phase displacement of 90 degrees relative to the rotor winding. This winding has the effect of equalizing the losses and the reactance of the regulator when the rotor is in various coupling positions.

(3) The rotor is driven over a limited arc by a reversible motor whose direction of rotation is governed by motor control relays in the voltage control panel. This motor has a high starting torque for rapid acceleration and it is capable of changing the output of the regulator from maximum to minimum in 40 seconds. For emergency

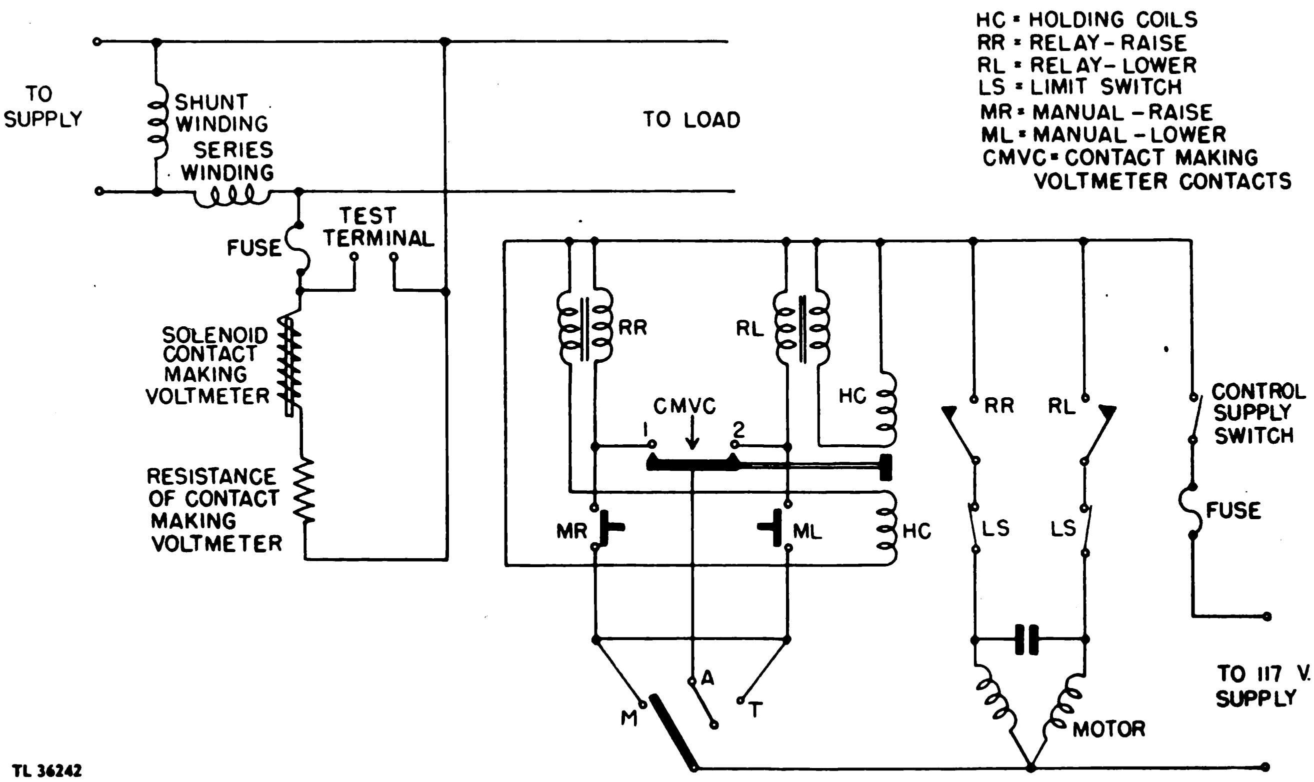


Figure 197. Voltage Regulator Unit CN-3/MPN-1, schematic diagram.

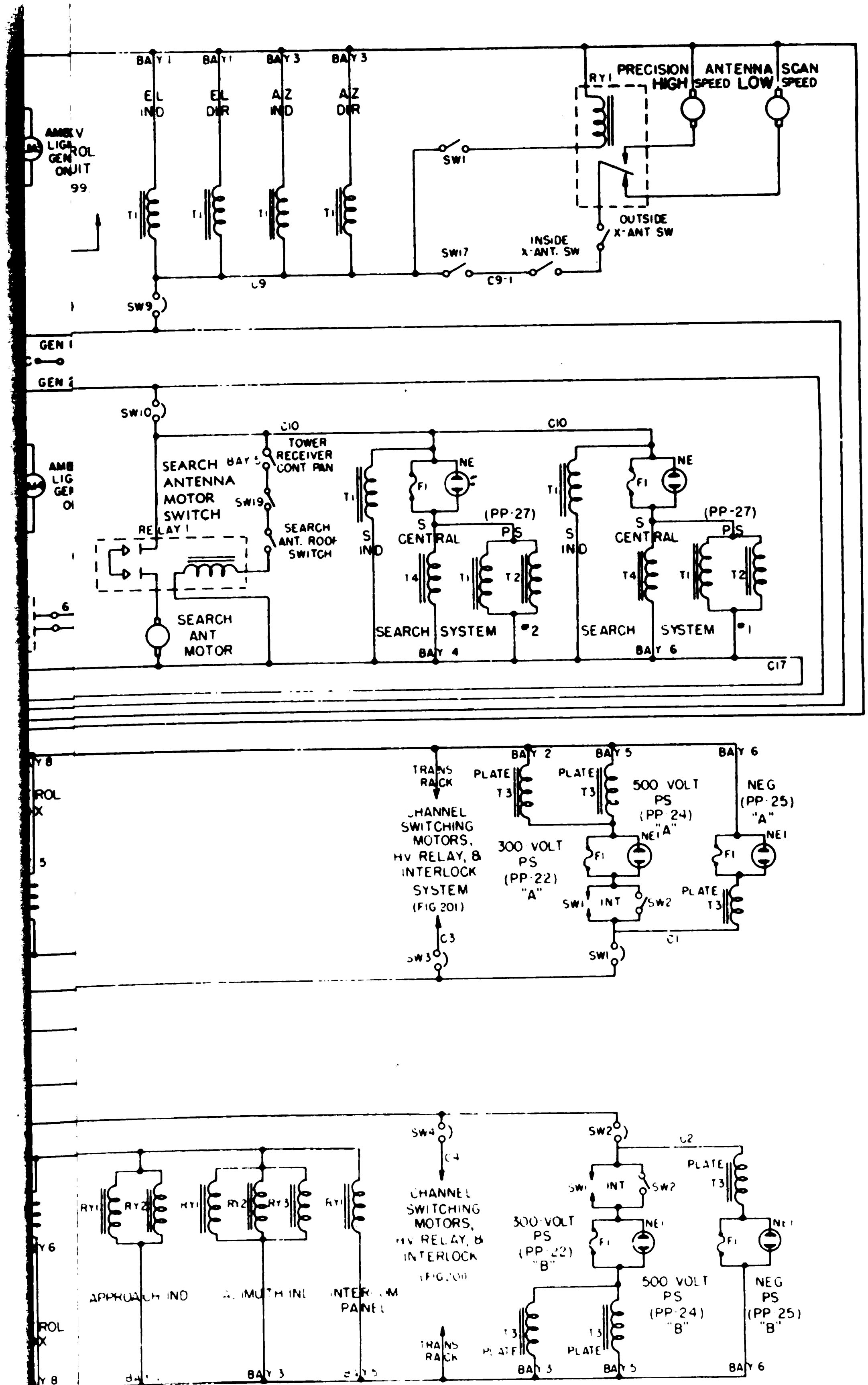


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Figure 198. Power distribution control circuit.

operation, there is a handwheel at the top of the motor shaft which permits adjustment of the voltage when the motor or voltage control panel is inoperative.

c. Voltage Control Panel. The voltage control panel consists of a contact-making voltmeter, motor control relays, and a number of control switches.

(1) The contact-making voltmeter is a spring loaded solenoid. The solenoid arm operates a set of single-pole, double-throw contacts mounted on a pivoted beam. With no input voltage, contact 1 is closed. As the input voltage is increased, the pole on the solenoid begins to overcome the tension of the spring, until contact 1 is broken. At this instance, neither contact 1 nor contact 2 is completed and no regulation takes place (fig. 197). As the voltage rises still further, the pole of the solenoid causes contact 2 to be completed. The difference in voltage between the breaking of contact 1 and the making of contact 2 is called the band width; as long as the output voltage remains within these limits, the regulator is inoperative. The band width is adjusted by raising or lowering the fixed contacts of the switch contact-maker, thus altering the distance of travel between the break of one set of contacts and in the make of another set. The tension of the loading spring determines the voltage around which regulation takes place. Holding coils, mounted above and below the contact beam, are energized when their respective contacts are closed. When one set of contacts is closed, the associated holding coil exerts a force on the contact beam to hold the contacts together until the voltage has been restored to a value beyond that at which the contacts closed. These holding coils prevent arcing at the contacts and produce positive regulating action.

(2) The two motor control relays (raise and lower) are operated either from the manual push-button switches or from the contact of the contact-making voltmeter switch. When the "lower" relay is energized, the rotor of the control motor is driven in such a direction as to induce a voltage into the stator which opposes the supply and reduces the regulator output. The "raise" relay causes the rotor to be driven in the opposite direction and the output voltage to rise.

(3) The AUTOMATIC-RAISE-TEST switch is a three-position switch which enables the regulator to be operated automatically by the contact-making voltmeter, manually by the RAISE and LOWER switches, or by both methods for test purposes. In general, only the AUTOMATIC position of this switch will be used during operation. The other two positions are for emergency and test purposes.

79. REGULATOR UNIT FUNCTIONING.

a. Low Supply Voltage. First consider the case when the output voltage drops below the allowable limit. As the voltage approaches the lower limits of the band, contact 1 of switch CMVC (contact-making voltmeter contact) approaches the fixed contact of this switch. At the lower limit, contact 1 closes and connects the raise relay coils across the primary line. Energizing this relay closes the raise relay contact. The auxiliary winding, or holding coil, which is connected across the relay, is also energized, increasing the effect of the solenoid by clamping contact 1 more firmly against the fixed contact point. This action continues until the regulator output voltage has increased sufficiently to supplement the pull of the solenoid and to overcome the holding coil. Contact 1 will then be broken and the raise relay coil will be de-energized. When the raise relay contact is closed, the motor is driven to change the coupling between the rotor and the stator of the regulator. Direction of rotation is such as to cause the induced voltage to add to the line voltage, and the regulator output to increase to a point within the prescribed limits of voltage.

b. High Supply Voltage. When the supply voltage increases and causes the output voltage to increase beyond the upper allowable limits, the pole of the solenoid overcomes the tension of the spring an amount sufficient to allow contact 2 of switch CMVC (fig. 197) to close. This energizes the "lower" relay coil and its contacts close. The closing of these relay contacts drives the regulator motor in a direction to change the couplings between the rotor and stator and reduce the regulator output. A second holding coil operates to hold contact 2 firmly in position until the change in solenoid voltage is sufficient to cause it to overcome the action of the holding coil. For any voltage variations inside the band, the moving arms of switch CMVC are in motion but never reach either contacts 1 or 2.

c. Manual Control. With the selector switch on the control panel in the MANUAL position, the contacts of the contact-making voltmeter are out of the circuit. Instead, the RAISE and LOWER push-button switches are connected in series with the raise and lower relays across the a-c supply line. These switches replace the contacts of the contact-making voltmeter and control the operation of the voltage regulator motor. Depressing the RAISE button energizes the raise relay and closes its contacts, causing the motor to drive the regulator rotor to raise the output voltage. This increase of voltage will continue until the RAISE button is released or until the limit

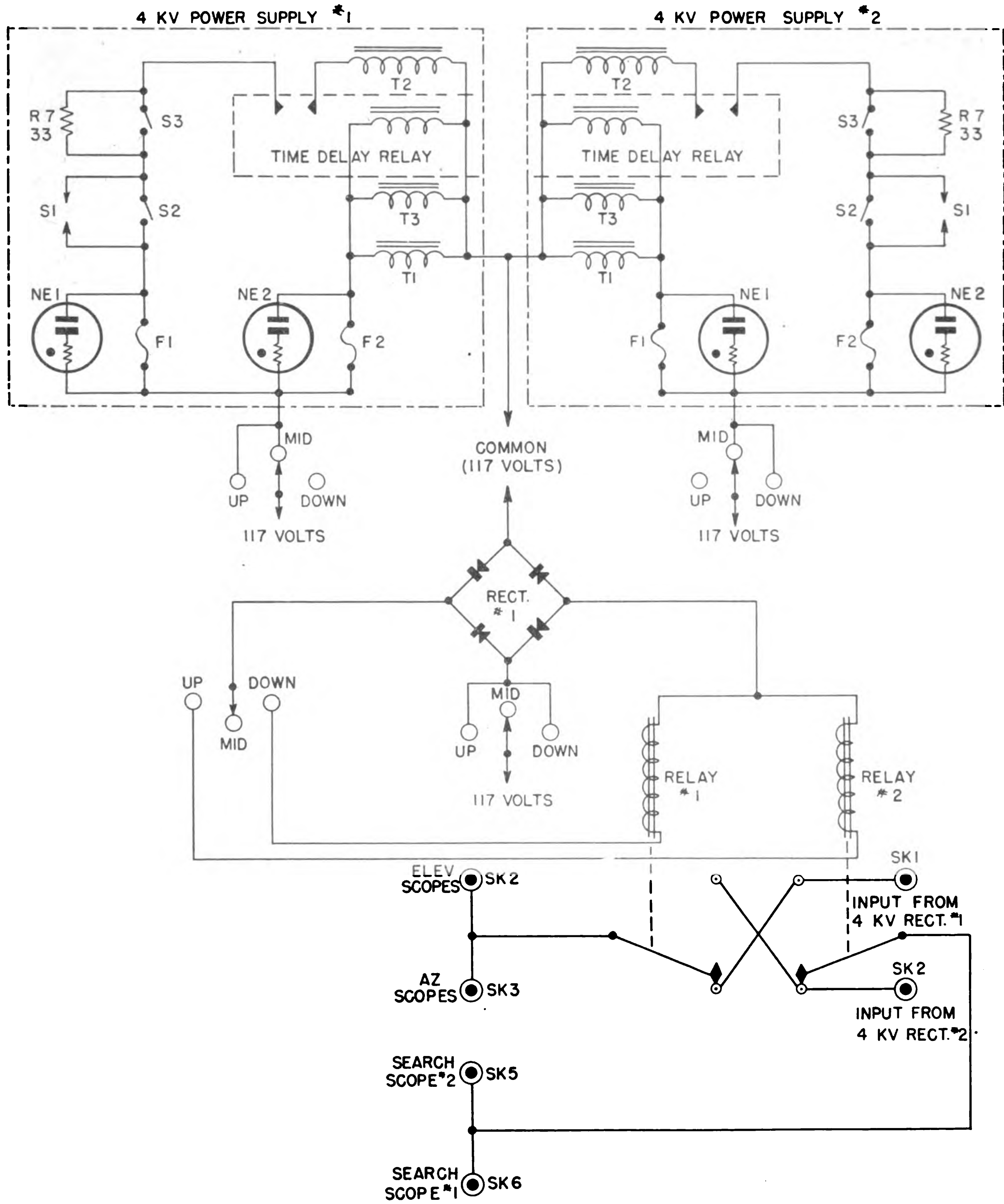


Figure 199. 4-KV relay control circuit.

switch is broken at the limit of rotor travel. When the limit switch circuit is broken, the supply to the motor is interrupted and the rotor position does not change. Pressing the LOWER button operates the lower relay and the reverse action takes place. Another limit switch also limits rotor travel in this direction.

d. Test Position. With the selector switch in the TEST position, both automatic and manual control circuits are brought into play. This position is intended only for use in setting up the band width of the regulator. Adjustments of the regulator are discussed in chapter 9.

80. POWER DISTRIBUTION PANEL SB-1/MPN-1.

a. Main Switch Connections. Primary power from the two Power Equipment PE-127-A units, or an external commercial power source, is supplied to all components of Radio Set AN/MPN-1 through Power Distribution Panel SB-1/MPN-1 (figs. 194 and 198). When the main switch SW24 is in the GENERATOR POWER position, the line voltage from either power unit can be applied across the a-c voltmeter M1 (fig. 198) through a single-pole, double-throw switch by placing it in the GEN 1 or GEN 2 position. With the main switch in the COMMERCIAL POWER position, and with power supplied from an external commercial source, line voltage can be read at either position of the voltmeter selector switch SW20. Two amber dial lights, LM3 and LM4, connect to the high sides of the power input mains at the main switch and indicate when power units are operating.

b. Circuit Breakers. A group of 20-ampere circuit breaker switches, Nos. SW1 to SW16 inclusive (SW15 is 25 amperes), control the application of power to all components except the air conditioner. These circuit breakers, SW1-SW16, are not adjustable and will trip at their rated overload current. When tripped, they will stay in the tripped position (see plate on power distribution panel) until reset by moving handle as far as possible beyond the OFF position and then throwing the handle to the ON position. Circuit breaker SW15 is clamped in the ON position and cannot be turned off without removing the clamp. This is done to insure that the rack blower motors which it supplies will always be ON when power is supplied to any of the circuits. The hydraulic motor is also connected to circuit breaker SW15 through a start-stop button. As indicated in the simplified schematic (fig. 198), circuit breakers SW9-SW16 (except SW12) are supplied directly from the main switch. Circuit breaker SW11 controls the 4-kv power supply circuits (fig. 199). Switches 1 to 8 inclusive are divided into two groups, with switches 1, 3, 5, and 7 fed through the channel A PREHEAT switch and switches 2, 4, 6, and 8 fed through the channel B PREHEAT switch.

c. Preheat Circuits. Circuit 5, supplying preheat voltages for channel A precision system components, and circuit 7, supplying preheat voltages to the r-f system components of channel A, are controlled by the A PREHEAT switch SW21. Throwing the A PREHEAT switch also completes the circuit for the green dial light LM1 which indicates that A PREHEAT circuits are connected. Similarly, switches 6 and 8 operate through the B PREHEAT switch SW23 for the corresponding components in channel B. Green lamp LM6 indicates that switch SW23 is on. Switches SW21 and SW23 are single-pole single-throw switches.

d. Transmit Switch Circuits. Time meter MZ is connected to the contacts of TRANSMIT switch SW22 to register operating time when the switch is thrown to either operating position. Circuit breakers SW1 and SW3 are connected to one side, and SW2 and SW4 to the opposite side of the double-throw TRANSMIT switch. Breaker SW1 supplies the circuits for channel A transmit voltages to the 500-volt, 300-volt, and the negative rectifier power units. SW3 supplies the transmit circuit for the channel A high-voltage rectifier. Circuit breakers SW2 and SW4 complete the circuits to the corresponding components in channel B. With these four circuit breakers in the ON position, channel selection is made by the use of the TRANSMIT switch. The TRANSMIT switch also completes the circuit to either of the red dial lights, LM2 and LM5, depending upon which channel is in operation. A further contact in the B position of this switch completes the circuit through circuit breaker SW12 which actuates the change-over relays, all of which are paralleled across the a-c line controlled by this switch.

e. Auxiliary Switch Circuits. ON-OFF control for the antenna drive motors is provided by small standard switches SW17 and SW19. SW17 is fed through SW9 and controls the motors driving Switching Unit SA-8/MPN-1, the precision antenna scanning drive. For details on the operation of the precision antenna scan motors see figure 200. The precision ANTENNA FAST-SLOW switch, SW1 on the azimuth director in bay 3 of the indicator rack, controls relays (fig. 420) which determine whether the fast or slow speed precision antenna motor will operate. The inside and outside safety switches controlling the motors must be in the closed position. The motor driving the search antenna is controlled through a number of switches and relay RY1 in the power distribution panel. The search antenna motor gets its power through circuit

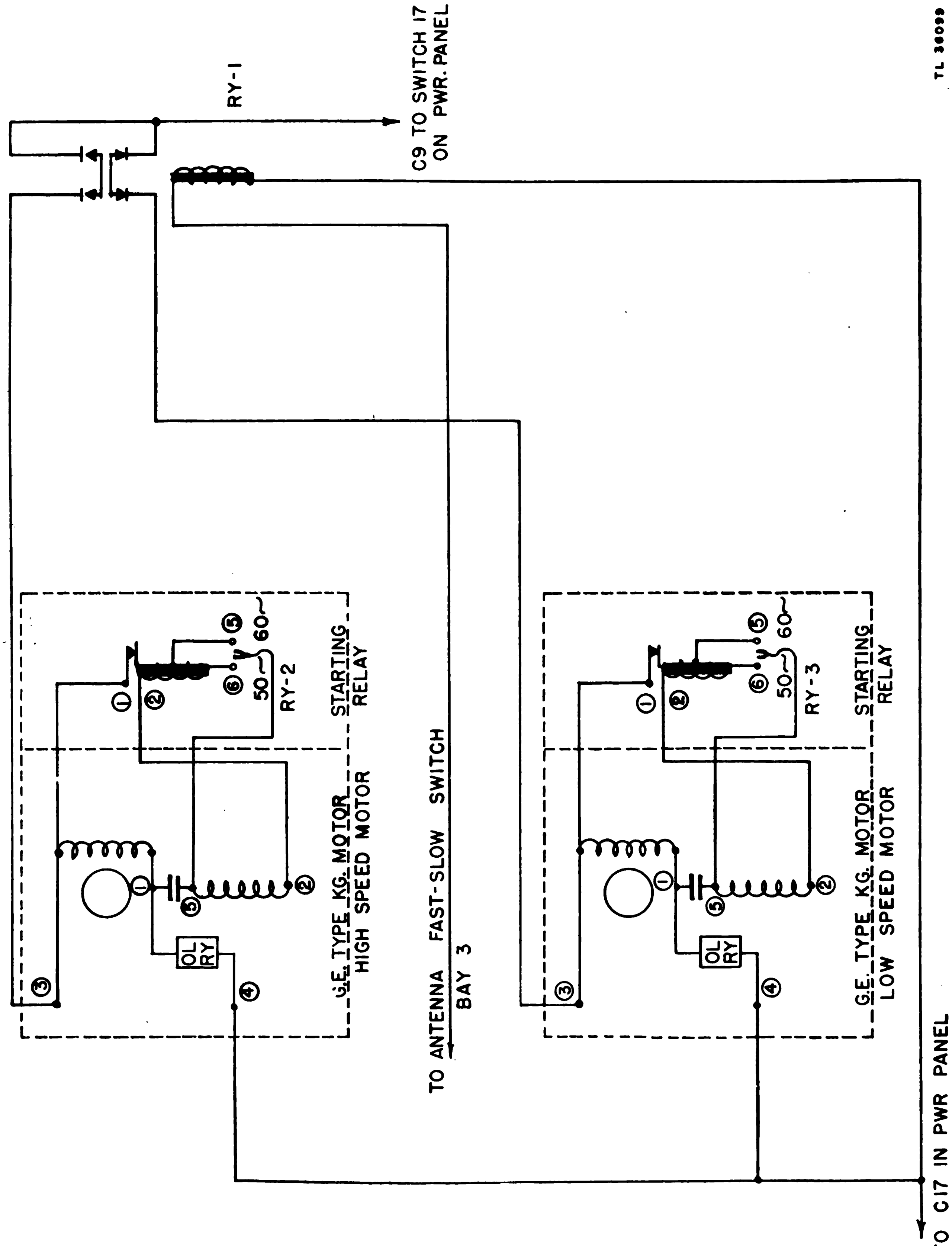


Figure 200. X-scanning motors, schematic diagram.

breaker SW10 and the contacts of relay RY1. Relay RY1 is controlled by switch SW19, the search antenna switch on the roof of the trailer, the search antenna switch in bay 5, and circuit breaker SW10. SW18 controls the IFF power outlet line. In the wiring from the distribution panel through the racks, a single lead is used for each circuit.

f. Communication. The grouping of communications equipment places all components on circuit 13. Radio Receivers BC-342-N, Rectifier Power Unit PP-100/MPN-1, Rectifier Power Units PP-28/MPN-1, Rectifier Units RA-62, and the intercommunications amplifier and microphone supplies to the approach indicator, receive 117 volts a-c from this circuit. Radio Sets SCR-522-A are each supplied power from an RA-62, the SCR-274-N transmitters from their associated Rectifier Power Units PP-28/MPN-1, and the Tower Receiver BC-1206 (beacon receiver) from the PP-100/MPN-1 rectifier. Switches at each input on Rectifier Units RA-62 and Rectifier Power Units PP-28/MPN-1 permit shutting down any transmitter without breaking the entire circuit.

81. TRANSMIT CIRCUIT CONTROL.

a. Preheat Filament Supply. To permit sufficient warm-up time for vacuum tubes, the application of transmit voltages to the various components is delayed through the use of time delay relays (RY5 for channel A and RY6 for channel B) in Control Box C-61/MPN-1 (fig. 201). In the starting operation, the preheat switches are closed before the transmit switch, though if the transmit should be closed first no harm will result as the transmit circuit will not be closed until the time delay relays have operated. Closing the preheat channel A, switch SW21 feeds the corresponding circuit breakers SW5 and SW7. Through circuit breaker SW7, the filaments of the transmitter high-voltage power supply, the modulator, and S- and X-band transmitter and their corresponding fan motors will be immediately energized as well as the time delay relay RY5. Circuit breaker SW5 feeds filaments of the channel A precision components. Preheat channel B switch SW23 feeds the corresponding channel B preheat circuit breakers SW6 and SW8 duplicating the filament circuits of channel A and energizing the time delay relay RY6. Though only one channel is operated at a time, both channels may be prepared for instant operation by having all the preheat switches closed.

b. Transmit Plate Supply. When the transmit switch is thrown to either channel in the starting operation the transmit voltage is supplied to Control Box C-61/MPN-1. No plate voltage can be applied to the magnetron until the time delay relay RY5 for channel A or RY6 for channel B has completed its 1-minute cycle. Operation of the time delay relay closes contacts in the transmit circuit and allows voltage to be applied to the plate contactor relay RY1 for channel A or RY2 for channel B in Control Box C-61/MPN-1. The circuit applying this voltage is completed through the interlock switches in the corresponding high-voltage rectifier, the modulator, the two transmitters, and the overload current relay RY3 for channel A or RY 4 for channel B, in Control Box C-61. All of these contacts being in series, it is necessary that they be closed before the start of high-voltage operation. The RESET A button on the front panel of Control Box C-61 must be pushed in for RY3 to close each time it trips. The RESET B push button works in a corresponding fashion for RY4.

82. CHANNEL SWITCHING.

a. X-band Channel Switching. Channel switching in the X-band radio frequency unit is accomplished by the insertion of a movable vane in one of the two waveguide branches from the two magnetrons. These vanes are driven by an electric motor whose period of operation is controlled by a microswitch. Voltage is supplied to the change-over motor from the a-c transmit line through the single-pole, double-throw contacts of the microswitch. The position of the contacts in the microswitch is determined by one of the switch blades acting as a semicircular cam. The switch contacts select the supply voltage for the motor from either the A transmit or B transmit line.

b. S-band Channel Switching. A pivoted waveguide section is used for channel switching in Radio Frequency Unit RF-7/MPN-1. A half revolution of the switch section is still required to change channels, and the motor control arrangement is identical to that of the X-band unit. However, the cam which operates the microswitch serves no other purpose than that of waveguide positioning. In both the X-band and S-band systems it is essential that the variac on the channel to be selected is set at zero, and no voltage be applied from this variac until switching action in the r-f units is completed.

c. Switching Motor Action, Channels A to B. Discussion in the following paragraphs apply to the action of both the X-band and S-band r-f units. When changing from channel A to channel B, the cam holds the microswitch in such a position as to complete the motor circuit to the channel B transmit line, which is unenergized. When the TRANSMIT switch on the power distribution panel is thrown to channel B, this line is supplied with power and the motor circuit is energized.

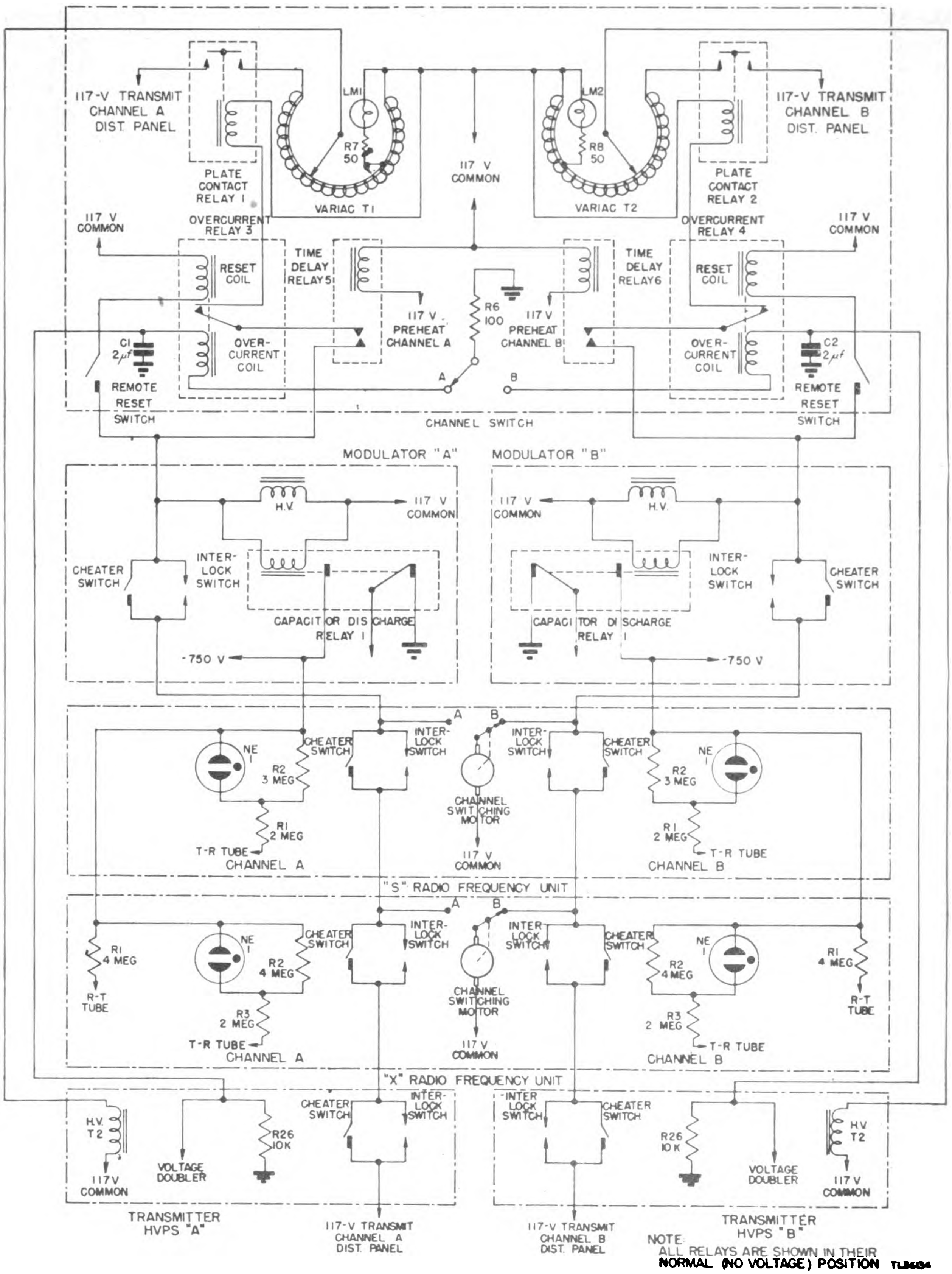


Figure 201. High-voltage relay and interlock system.

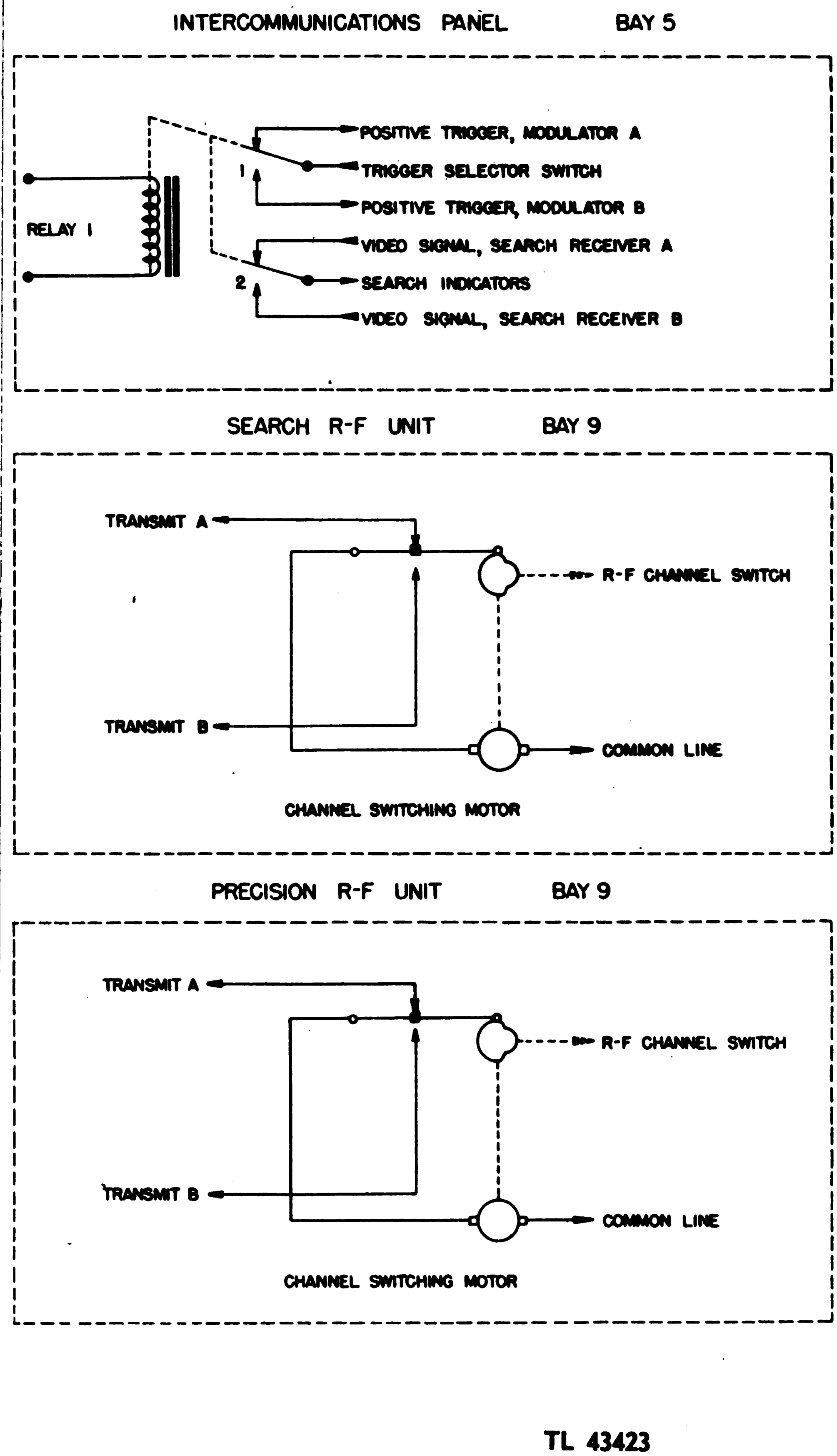


Figure 202. Channel switching diagram.

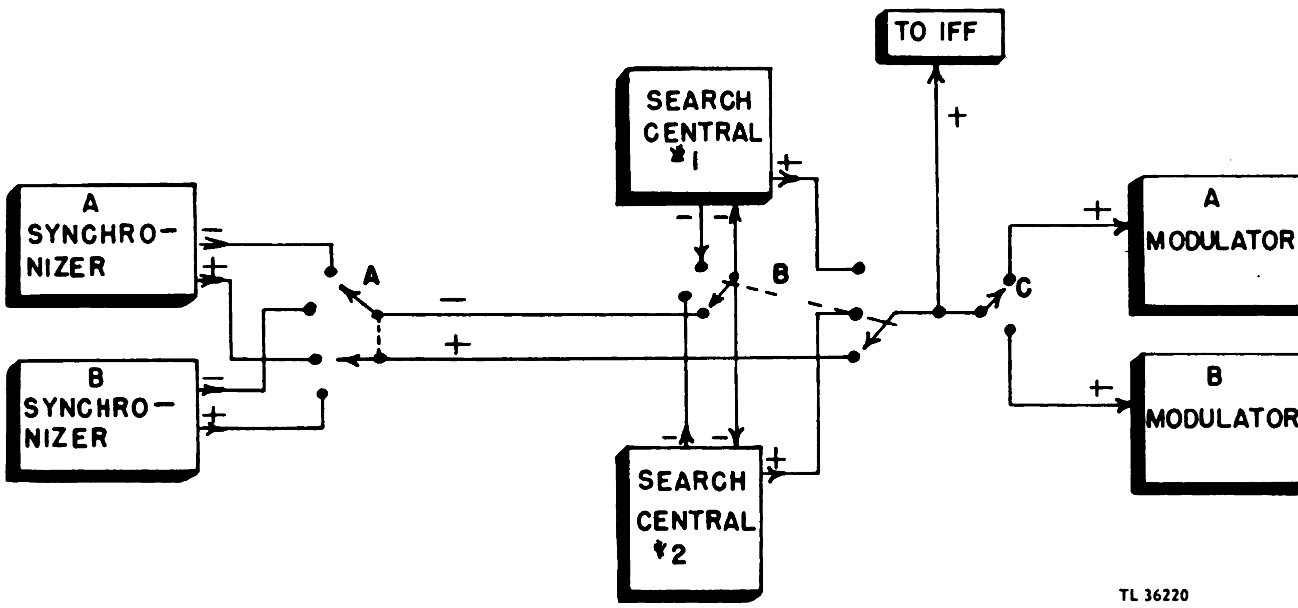


Figure 203. Trigger selection circuits, functional block diagram.

As the motor revolves, the r-f switching mechanism is changed so that the energy from the channel B transmitter is fed into the r-f system. The controlling cam on the drive shaft is likewise rotated and, upon reaching the proper point in the switching cycle, the microswitch contacts are switched to the channel A position and the motor circuit is completed through the channel A transmit line. Since the channel A transmit circuit is now dead, the motor stops with the channel switching mechanism in the correct position.

d. Switching Motor Action, Channels B to A. To switch to channel A, the TRANSMIT switch on the power panel is thrown to the A position which activates the channel A transmit line. Since the microswitch connects the switching motor to the channel A circuit, the motor circuit is energized and the motor rotates the switching mechanism. At the proper point, the cam causes the contacts of the microswitch to switch the motor circuit to channel B transmit lines. The switching motor stops with the channel switching mechanism in the proper position.

e. Switching Relay. (1) Relays are used for channel switching in certain circuits of the equipment. Alternating-current operated relays are used for this purpose throughout. These relays are connected in parallel to a single a-c line. In their unenergized position, they complete the circuits of the channel A system. To energize these relays and to switch to channel B, a pole on the TRANSMIT switch is connected to the a-c supply when the switch is thrown to the channel B position (fig. 198). This circuit is controlled through circuit breaker SW12 on the power distribution panel.

(2) In the case of the precision system, channel switching must be utilized to properly feed the output of the synchronizer, sweep amplifiers, transmitting system, receiving system, and power supplies in either channel to a single set of indicator tubes. A similar situation occurs in the search system where duplicate receiving and transmitting systems are provided and one must be selected for use with the single indicator system.

(3) All relays and motors of the channel switching system are shown in figure 202. Relays are located in the azimuth indicator, approach indicator, elevation indicator, and intercommunications panel. Switching motors are provided in both the X-band and S-band r-f units. The relays may serve either the precision system or the search system, or both, regardless of their physical location. Actual circuits switched by the relays are shown on the diagram in figure 202.

f. Trigger Selection. Relay RY1 in the approach indicator unit controls the selection of trigger voltages from the two synchronizer units. Positive and negative trigger voltages are brought to contacts on this relay with either channel being selected for application to the search centrals and the modulators by the relay action. A further selection takes place in the intercommunication panel. The precision system triggers are used to initiate the search central and modulator operations except when a screwdriver adjustment switch in the center of the intercommunication panel permits selection of triggers from the synchronizer or from either one of the search centrals. When operating on channel A, any one of the three triggers selected is applied through relay RY1 on the intercommunications panel to the channel A modulator. When RY1 is operated by throwing the TRANSMIT switch to channel B, the selected trigger pulse goes to the channel B modulator. Figure 203 summarizes the course of the various trigger voltages and the means of selecting them.

SECTION II

POWER SUPPLY CIRCUITS

83. RECTIFIER POWER UNIT PP-22/MPN-1. Two Rectifier Power Units PP-22/MPN-1 are included in Radio Set AN/MPN-1, one for each of channels A and B. The channel A unit is located at the bottom of bay 2 of the indicator rack; the channel B, at the bottom of bay 3. Each unit supplies in its channel a regulated 300-volt source for the synchronizer and the elevation and azimuth sweep amplifiers' indicators, and angle coupling units. The elevation indicator receives its 300 volts from power supply A or B, depending upon which one is in operation, via the azimuth indicator. A channel relay is contained in the latter for this purpose. Electronic regulation is utilized in this rectifier to maintain the d-c output voltage constant over considerable load and input voltage variations. In the following discussion refer to figure 204 for a complete schematic of the unit.

a. When the preheat switch in the power distribution panel is closed, 117 volts are applied directly to filament transformers T1 and T2, supplying filament voltage to all tubes in the unit. When the transmit switch in the power distribution panel is closed, 117 volts are applied to the primary of high-voltage transformer T3. The transmit supply to the primary is fused by F1 in the 500-volt rectifier power unit of the same channel.

b. The output of transformer T3 is applied to a full-wave bridge-type rectifier circuit (fig. 205) composed of tubes V1 to V4 (5R4GY). The rectified output is taken between ground and the center tap of the filament windings supplying tubes V1 and V2. Choke L1 and capacitor C1 act as a basic filter circuit.

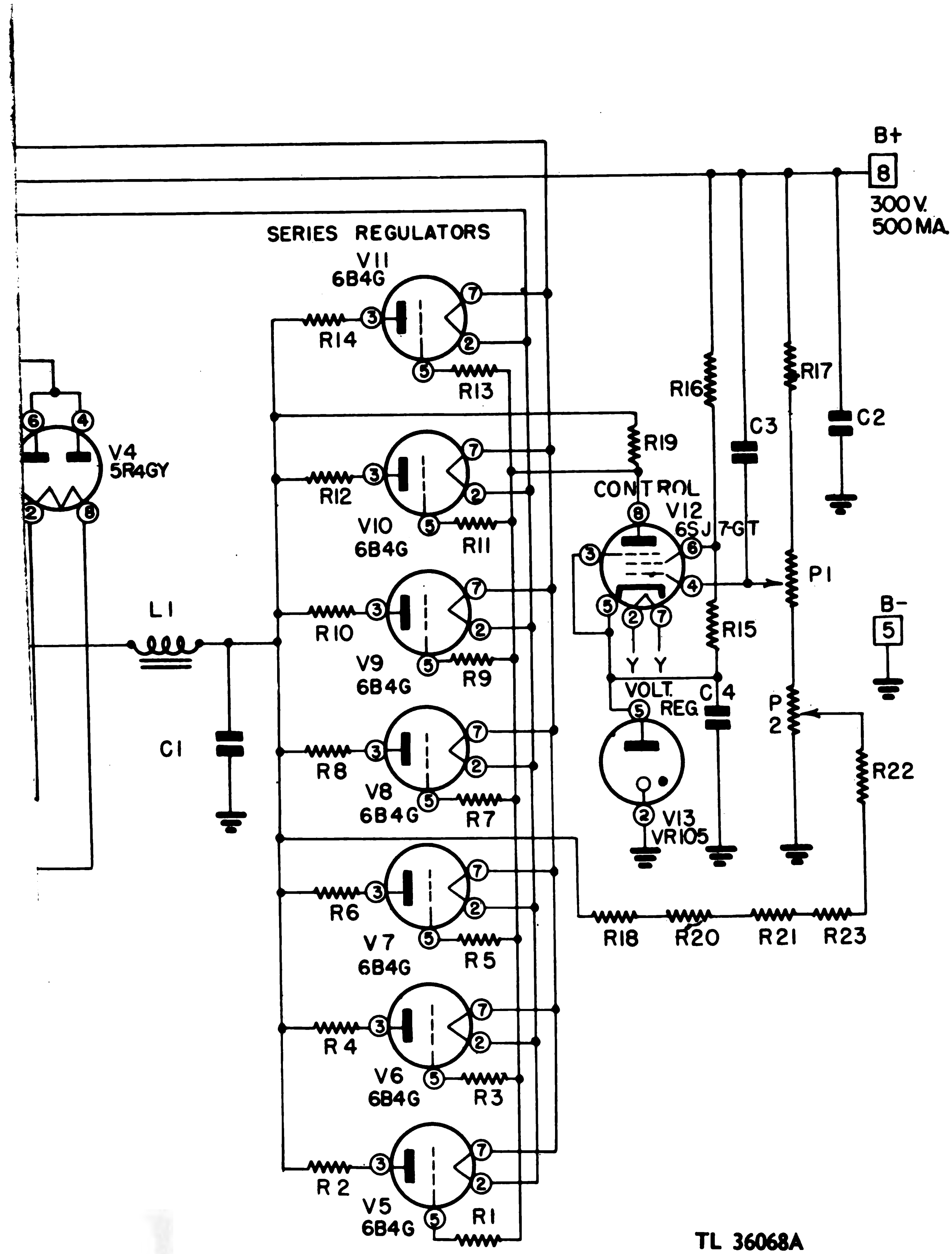
c. Following the filter circuit are the paralleled regulator tubes V5 to V11 (6B4G), placed in series with the output line as a means of developing a regulated voltage across bleeder resistor network R17, P1, and P2. Tubes V5-V11 are connected in parallel in order to provide sufficient current-carrying capacity. The simplified schematic diagram (fig. 206) shows only one regulator tube, since the action of all these tubes is identical.

d. In series with the grids of the seven regulators is control tube V12 (6SJ7-GT). The cathode of this tube is maintained at a fixed reference voltage of 105 volts by V13 (VR-105) which is located between the cathode of V12 and ground. The grid bias of V12 is adjusted by the variable tap on potentiometer P1. By means of this tap the output voltage of the power supply is set at 300 volts.

e. The regulation action of the circuit is as follows: (1) Let us suppose that the output load decreases; that is, the voltage across the bleeder network increases. V12 will draw more current because of the increased grid voltage obtained from the tap on P1. Consequently, the plate voltage of V12 will decrease. Since the plate of V12 is connected to the grids of tubes V5-V11, the grid bias on the latter will become more negative, thereby increasing the voltage drop across them. Thus the output voltage will fall again to approximately 300 volts. A similar argument holds for the case in which the output voltage decreases.
(2) Since the regulation circuit depends upon action and reaction between the tube element voltages of V5-V11 and those of V12, a slight oscillatory condition is set up between the regulator tubes and the control tube. This results in a small amount of hunting, due largely to variations in the voltage from the bridge rectifier. Here there is a steady 120-cps ripple superimposed on the positive d-c voltage at the plates of the regulator tubes. To stabilize the regulating circuit for this ripple variation, a small amount of input voltage from the basic filter is applied across a portion of the bleeder circuit determined by the setting of P2. When the input voltage rises above the average value, the voltage drop across the grounded portion of P2 is increased. This raises the tap potential of P1 to a slightly higher value than it would have otherwise and causes a slightly greater drop across tubes V5-V11.
(3) The small resistors in the grid and plate circuits of tubes V5-V11 dampen out any parasitic oscillations that may develop in these tubes.

f. Regulation from this circuit is good over a wide range of both input and load variations. Extreme accuracy of regulation is necessary in all the power rectifiers of Radio Set AN/MPN-1, since there are abrupt load variations 2,000 times a second whenever the set is operating.

84. RELAY ASSEMBLY RE-3/MPN-1. The relay assembly is housed just below the plane selector's desk



TL 36068A

Figure 204. Rectifier Power Unit PP-22/MPN-1 (300-volt power supply), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	470	1	20%
R2	68	1	20%
R3	470	1	20%
R4	68	1	20%
R5	470	1	20%
R6	68	1	20%
R7	470	1	20%
R8	68	1	20%
R9	470	1	20%
R10	68	1	20%
R11	470	1	20%
R12	68	1	20%
R13	470	1	20%
R14	68	1	20%
R15	3,300	1	10%
R16	10,000	5	10%
R17	33,000	2	20%
R18	150,000	1	10%
R19	680,000	1	20%
R20	150,000	1	10%
R21	150,000	1	10%
R22	82,000	1	10%
R23	150,000	1	10%
P1	25,000	4	
P2	10,000	4	
C1	8 mfd	1500	10%
C2	4 mfd	600	10%
C3	1 mfd	600	10%
C4	.1 mfd	600	10%
V1		5R4GY	
V2		5R4GY	
V3		5R4GY	
V4		5R4GY	
V5		6B4G	
V6		6B4G	
V7		6B4G	
V8		6B4G	
V9		6B4G	
V10		6B4G	
V11		6B4G	
V12	VT-116A	6SJ7-GT	
V13	VT-200	VR 105	
T1	15-3418		
T2	15-3417		
T3	15-3415		
L1	10 H 70 ohms 15-3420		

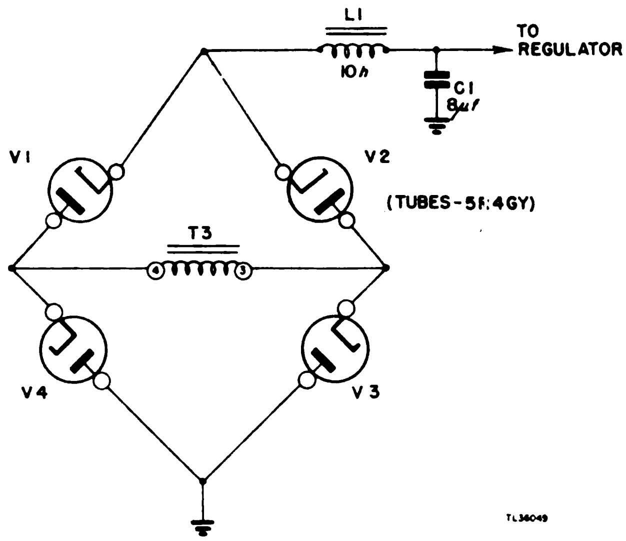


Figure 205. 300-volt bridge rectifier, simplified schematic diagram.

in bay 4 of the indicator rack. The purpose of this relay is to switch on and off the 4-kv (kilovolt) anode supplies for the cathode-ray tubes. Under ordinary operating conditions, Rectifier Power Unit PP-23/MPN-1 No. 1 supplies the four precision indicator tubes, while unit No. 2 supplies the two search indicator tubes, the toggle switch on the left side of the chassis front panel being in the middle of 4 KV #1 AND #2 ON position. When the switch is in the up or 4kv #1 ON position, rectifier unit No. 1 alone is operating and supplying 4kv to all six indicator tubes; in the down (4 KV #2 ON) position, unit No. 2 alone is operating.

a. Figure 207 shows the complete schematic diagram of the relay assembly. Toggle switch SW1 is here represented in its midposition, figure 208 representing the other two positions. The second and fourth keys in each of the four sets of keys are mechanically, but not electrically, connected. These are the keys moved by the actuating roller, labeled SW1 in the diagrams, when the position of the toggle switch is changed. Note that the roller, which is directly connected to SW1, is at its lowest point when the switch is in the up position and at its highest point when the switch is in the down position. As shown in figure 207 the rear view of the cam key does not agree with its schematic representation. The top left and bottom right sets of keys are shown unconnected, which is not the case. Actually, the ten keys on the right are connected in parallel with the ten keys on the left, each key being in parallel with the one directly opposite it on the other side of the roller. For a photograph of the keys and their connections see figure 209.

b. The control circuit of the 4-kv power supplies and the relay assembly is shown in its entirety in figure 196. Here the toggle switch and its associated keys are represented by four three-position switches which are to be regarded as ganged together. These switches have no actual physical existence and are shown as such merely to demonstrate the action of the toggle switch. In the customary MID position of these switches, corresponding to the central position of the toggle switch, 117 volts are applied to the primary circuits of both 4-kv power supplies: Voltage is applied through fuse F2 to the 4-kv filament transformers T1 and T3 and to the time delay relay. This relay provides a 15-second time delay between the application of filament and plate voltages, since its contacts are in series with the plate voltage input. For a further description of this relay see paragraph 93. The delay allows the high-voltage rectifier tubes to heat sufficiently before the high voltage is applied. When the relay closes, the 117-volt power source is applied to the primary of high-voltage transformer T2 through fuse F1, through interlock switches S1 and S2, and through test switch S3 and resistor R7. In parallel with each fuse is a neon lamp which lights up when the fuse blows. In the central position of the toggle switch no voltage is applied to rectifier

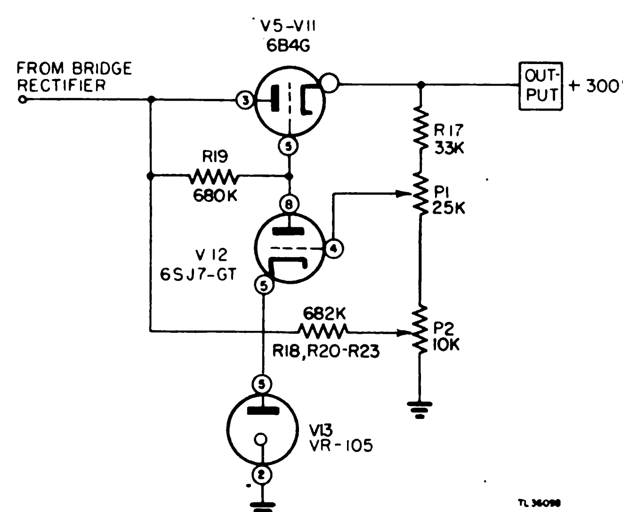


Figure 206. 300-volt regulation circuit, simplified schematic diagram.

RECT. 1 (fig. 199). As a result, neither of the two relays is energized. In the UP position of the switches, corresponding to the 4KV #1 ON position (see front panel of relay box) of toggle switch SW1, 4-kv power supply No. 1 is the only supply activated. Power is now applied to RECT. #1, and RELAY #2 is connected to the rectifier output. The metallic rod of this relay is raised, and the 4-kv output of rectifier unit No. 1 is now applied to all six however, raises the voltage drop across the tapped portion of P1 plus R9, and thus increases the grid bias to V1. The augmented bias of V1 increases the voltage drop across this tube and thereby minimizes the rise in voltage across R3. At the same time the increased line voltage increases the current through R4, and hence through P1 and R9, to augment further the grid bias to V1. It is apparent that if R4 were sufficiently low, or R9 plus the tapped portion of P1 sufficiently high, overregulation would result. A suitable amount of resistance in R9 plus the tapped portion of P1 may be selected and, together with a proper adjustment of P2, will result in perfect regulation for line voltage variations. No regulation is required for load variation since the current drain of the indicator tubes is extremely small.

c. The parallel combination of switch S3 and resistor R7 provides a means of testing for proper regulation of the unit. This switch is ordinarily closed; when it is open, the applied voltage to the primary of T2 is reduced by the voltage drop across R7. If the unit is regulated properly, the output voltage will remain constant whether S3 is open or closed. The switch control is located at the lower right-hand corner of the front panel over the nameplate marked REGULATION TEST. The switch is opened by pushing the control in.

86. RECTIFIER POWER UNIT PP-24/MPN-1. Rectifier Power Units PP-24/MPN-1 are included in Radio Set AN/MPN-1, one for each of channels A and B. The channel A unit is the second component from the bottom of bay 5 of the indicator rack; the channel B, the bottom component of this bay. Each unit supplies a regulated 500-volt source to the elevation and azimuth sweep amplifiers and angle coupling units. Electronic regulation is utilized in the 500-volt power supply; its operation is identical with that of the regulator circuit previously described for the 300-volt supply in paragraph 83. There are a few variations between the two circuits; namely, that the regulator tubes V5-V11 here are type 807 and the cathode of control tube V12 is biased to 210 volts through the use of two VR tubes V13 and V14 (VR-105) in series between the cathode of V12 and ground. The 117-volt transmit supply to the primary of transformer T3 is applied through interlock switch SW1 and fuse F1. Fuse F1 is so connected that it also serves to protect the 300-volt rectifier power unit transmit circuit. Neon lamp NE1, mounted on the lower left side of the front panel of the unit, will glow when fuse F1 is open. See figure 211 for a complete schematic of the 500-volt power supply.

87. RECTIFIER POWER UNIT PP-25/MPN-1. Rectifier Power Units PP-25/MPN-1 are included in Radio Set AN/MPN-1, one for each of channels A and B. The channel A unit is the second component from the bottom of bay 6 of the indicator rack; the channel B, the bottom component of this bay. Each unit supplies in its channel a –102-volt source to the synchronizer and to the elevation and azimuth sweep amplifiers and angle coupling units. It also supplies a –210-volt source to the sweep amplifiers and the synchronizer.

a. The negative power supply consists of two rectifying circuits which are individually controlled by electronic regulation, one supplying –102 volts and the other –210 volts. The complete schematic of the unit is shown in figure 212.

b. The 117-volt preheat voltage is applied to filament transformers T1 and T2 through fuse F2, while transmit voltage is applied to power transformer T3 through primary fuse F1. Indicator lamps NE1 and NE2 are in parallel with fuses F1 and F2, respectively, and glow to indicate an open fuse.

c. One secondary winding of T3 supplies the –102-volt circuit through a full-wave rectifier composed of tubes V1 and V2 (5R4GY). A basic filter composed of L1 and C2 is connected between the cathodes of these tubes and mid-point (7) of T3 (fig. 213). The positive side of the circuit is grounded and contains the series regulator tubes V5 to V12 (6B4G), inclusive. The output voltage appears across bleeder resistors R1 and R2. The grid bias on tubes V5-V12, and hence the voltage drop across them, is governed by the plate voltage of control tube V14 (6SJ7-GT), whose grid bias is maintained constant at –105 volts by gas tube V16 (VR105). Any increase in voltage across the bleeder resistors will decrease the bias voltage on V14, the cathode of which is connected directly to the –102 volt output. This causes V14 to draw more current and hence drives the plate voltage more negative with respect to ground. This plate voltage is also the grid bias on the regulator tubes, whose cathodes are grounded. Therefore, their grid bias becomes more negative with respect to ground, increasing the tube drop and decreasing the voltage appearing across bleeder resistors R1 and R2. A similar discussion holds for the case in which the output voltage decreases.

d. The other secondary winding of T3 supplies the –210-volt output circuit through the full-wave rectifier tube V3 (5R4GY) and through the filter circuit, L2 and C1. The positive side of the circuit is again grounded and the regulation circuit operates in the same manner as the corresponding one in the –102-volt supply, the chief difference being that the cathode instead of the grid of control tube V13 (6SJ7-GT) is maintained at a constant

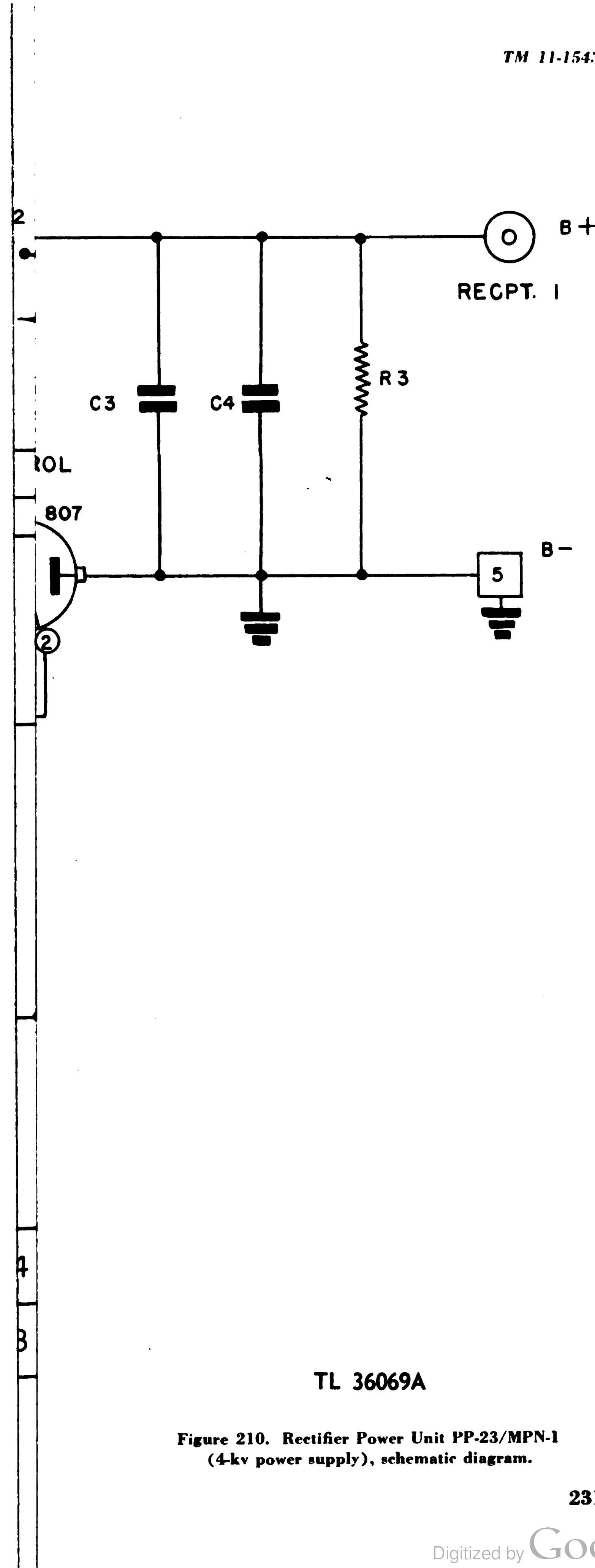


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Figure 210. Rectifier Power Unit PP-23/MPN-1 (4-kv power supply), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	100,000	2	10%
R2	200,000	2	10%
R3	4 Meg	4	10%
R4	12 Meg	4	10%
R5	24,000	10	5%
R6	4,700	5	10%
R7	33	5	10%
R8	68,000	1	20%
R9	33,000	1	20%
R10	10,000	1	20%
P1	50,000	4	20%
P2	50,000	4	20%
C1	.1 mf	6200	20%
C2	.1 mf	6200	20%
C3	.1 mf	4000	20%
C4	.1 mf	4000	20%
C5	1.0 mf	600	20%
C6	1.0 mf	600	20%
C7	1.0 mf	600	20%
	Type		
T1	15-3427	Pri-117V Sec-6V	
T2	15-3467 GB	Pri-117V Sec-4300V Sec-2.5V	
T3	15-3422 GB	Pri-117V Sec-5V Sec-405V	
	VT No.	Mfr. No.	
V1	VT 100A	807	
V2	VT 200	VR105	
V3	2J5R4GY	5R4GY	
V4	VT 119	2x2	
NE1	Littelfuse	5122	
NE2	Littelfuse	5122	
F1	Littelfuse 3AG 1 Amp		
F2	Littelfuse 3AG 1 Amp		
RLY1	Cramer #TD4-120S Relay Time Delay Type		
SW1	GE ML7460330G4		
SW2	CH 8201		
SW3	AH&H 3592-C		
Recpt 1	AN3102-18-16S Amphenol Receptacle		

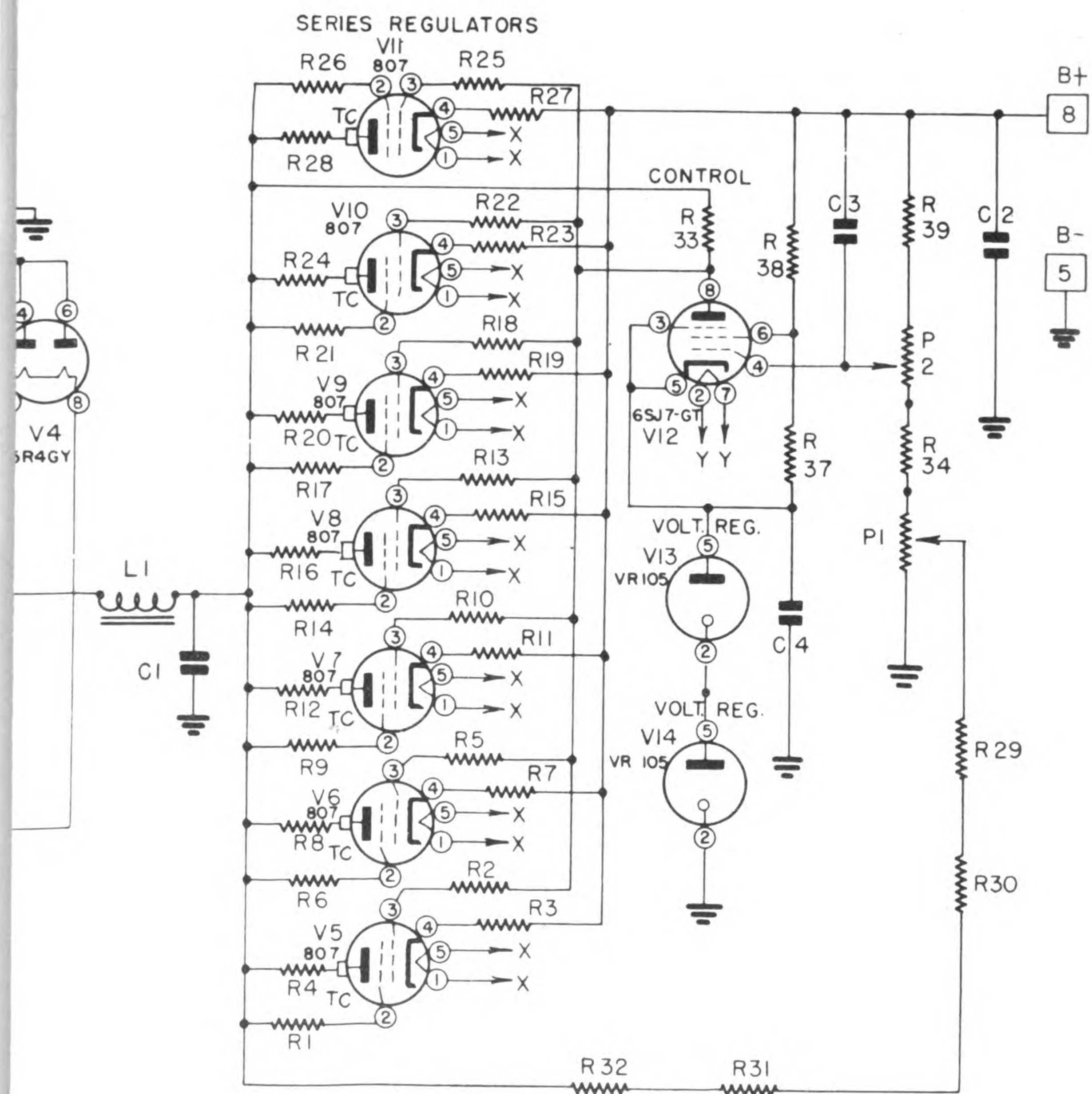

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Figure 211. Rectifier Power Unit PP-24/MPN-1 (500-volt power supply), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	2,200	1	20%
R2	470	1	20%
R3	68	1	20%
R4	68	1	20%
R5	470	1	20%
R6	2,200	1	20%
R7	68	1	20%
R8	68	1	20%
R9	2,200	1	20%
R10	470	1	20%
R11	68	1	20%
R12	68	1	20%
R13	470	1	20%
R14	2,200	1	20%
R15	68	1	20%
R16	68	1	20%
R17	2,200	1	20%
R18	470	1	20%
R19	68	1	20%
R20	68	1	20%
R21	2,200	1	20%
R22	470	1	20%
R23	68	1	20%
R24	68	1	20%
R25	470	1	20%
R26	2,200	1	20%
R27	68	1	20%
R28	68	1	20%
R29	120,000	1	10%
R30	100,000	1	10%
R31	100,000	1	10%
R32	100,000	1	10%
R33	680,000	1	20%
R34	68,000	1	10%
R35	eliminated		
R36	eliminated		
R37	4,700	1	20%
R38	22,000	5	5%
R39	100,000	2	10%

Symbol Designation	Description		
	Value	Rating	Tolerance
P1	5,000	4	
P2	50,000	2	
C1	8 mfd	1500	
C2	2 mfd	1000	
C3	.1 mfd	600	
C4	.1 mfd	600	
L1	15-3420	10 h	
T1	15-3418		
T2	15-3417		
T3	15-3416		
V1		5R4GY	
V2		5R4GY	
V3		5R4GY	
V4		5R4GY	
V5	VT 100	807	
V6	VT 100	807	
V7	VT 100	807	
V8	VT 100	807	
V9	VT 100	807	
V10	VT 100	807	
V11	VT 100	807	
V12	VT 116A	6SJ7-GT	
V13	VT 200	VR 105	
V14	VT 200	VR 105	
SW1	GE ML-7460330G4		
SW2	AN 3015		
F1	8 Amp		
NE1	Littelfuse 5122		

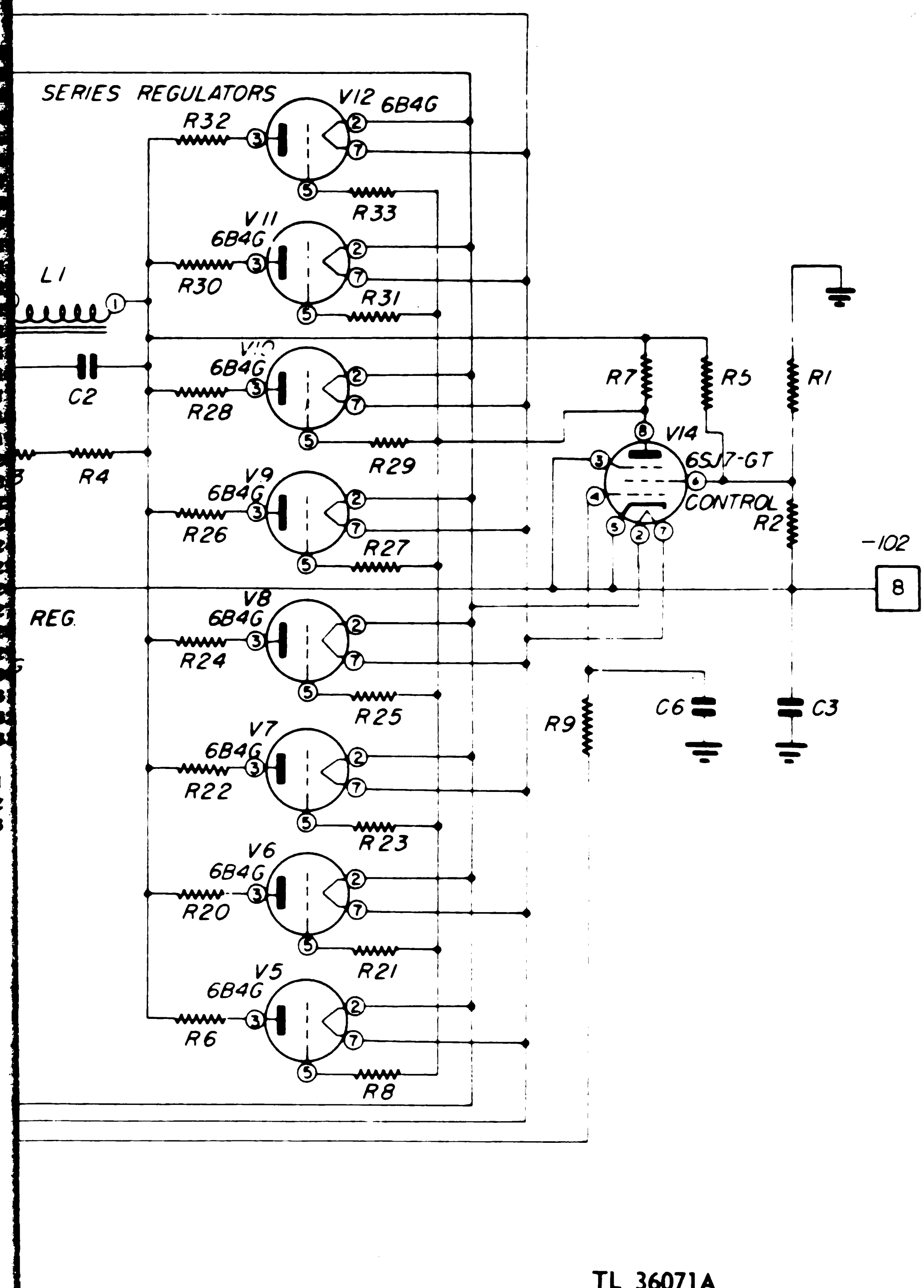


Figure 212. Rectifier Power Unit PP-25/MPN-1 (negative power supply), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	47,000 Ohm	1	20%
R2	47,000 Ohm	1	20%
R3	150,000	2	20%
R4	150,000	2	20%
R5	220,000	2	10%
R6	68	1	20%
R7	680,000	1	20%
R8	1000	1	20%
R9	1 Meg	1	20%
R10	15,000	2	20%
R11	330,000	1	20%
R12	680,000	1	20%
R13	100,000	1	20%
R14	100,000	1	20%
R15	100,000	1	20%
R16	100,000	1	20%
R17	6,800	2	10%
R18	2,200	2	20%
R19	100,000	1	20%
R20	68	1	20%
R21	1000	1	20%
R22	68	1	20%
R23	1000	1	20%
R24	68	1	20%
R25	1000	1	20%
R26	68	1	20%
R27	1000	1	20%
R28	68	1	20%
R29	1000	1	20%
R30	68	1	20%
R31	1000	1	20%
R32	68	1	20%
R33	1000	1	20%
C1	8 mfd	1000V	
C2	8 mfd	1000	
C3	4 mfd	600	

Symbol Designation	Description		
	Value	Rating	Tolerance
C4	.1 mfd	600	
C5	1 mfd	600	
C6	1 mfd	600	
C7	.1 mfd	600	
C8	.1 mfd	600	
L1	10 h 40 ohms	500 MA	15-3411
L2	10 h 460 ohms	65 MA	15-2479
T1	15-3414		
T2	15-3413		
T3	15-3410		
	Vt. No.	Mfr. No.	
V1		5R4GY	
V2		5R4GY	
V3		5R4GY	
V4		6B4G	
V5		6B4G	
V6		6B4G	
V7		6B4G	
V8		6B4G	
V9		6B4G	
V10		6B4G	
V11		6B4G	
V12		6B4G	
V13	VT-116A	6SJ7-GT	
V14	VT-116A	6SJ7-GT	
V15	VT-200	VR 105	
V16	VT-200	VR 105	
P1	50,000	2W	
F1	Littelfuse 3AG 3 Amp		
F2	Littelfuse 3AG 2 Amp		
NE 1	Littelfuse 5122		
NE 2	Littelfuse 5122		

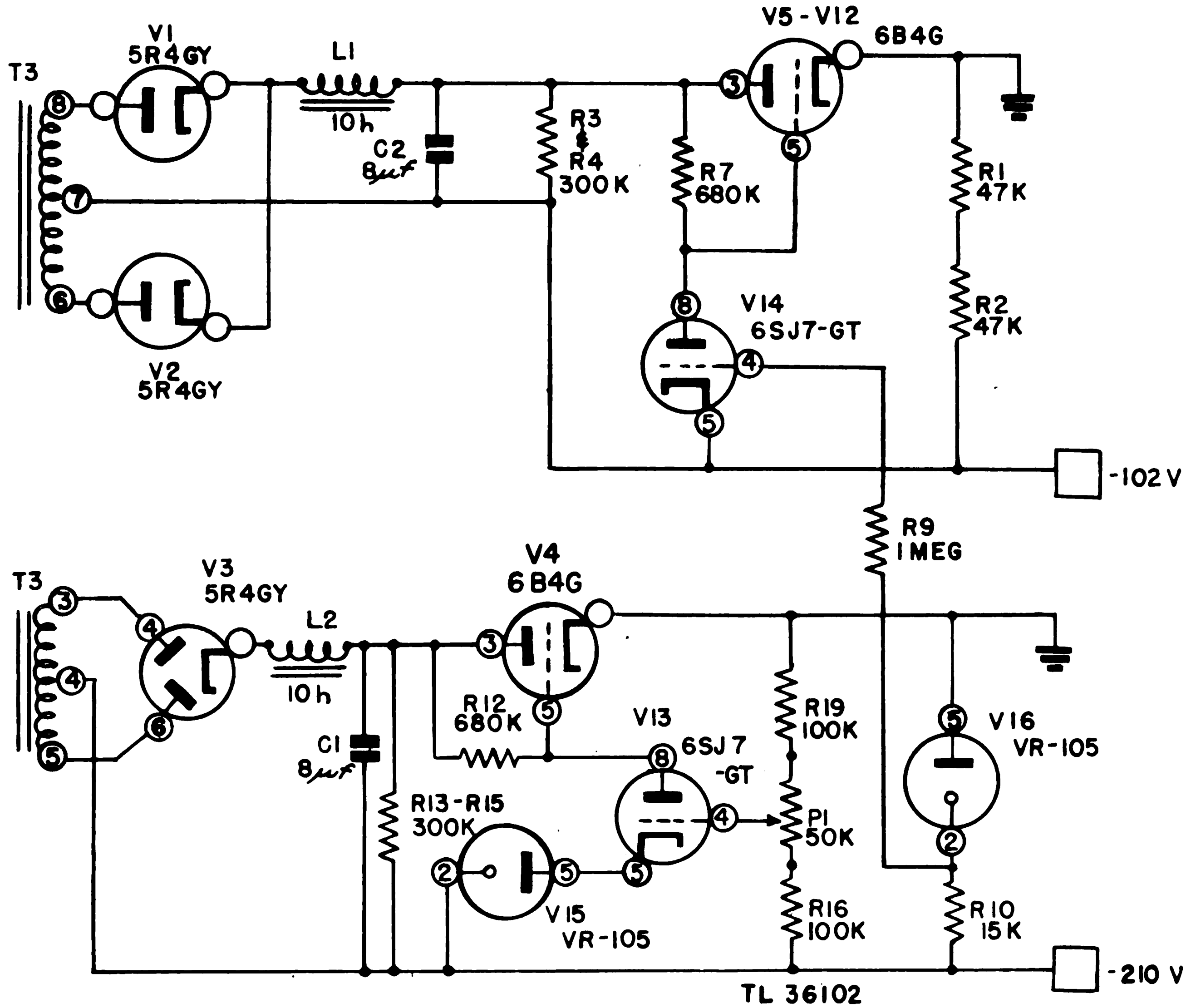


Figure 213. Negative power supply, simplified schematic diagram.

potential. The output voltage is adjusted to –210 volts by varying the tap on P1. which controls the grid bias of V13. Any increase in voltage across bleeder resistors R19. P1. and R16 results in an increased bias on V13 and hence an increased voltage drop across V4. Regulator tube V4 (6B4BG) operates in the same manner as paralleled tubes V5-V12 do for the –102-volt supply. except that the lighter current drain at this voltage permits the use of a single tube to pass the current.

88. CONTROL BOX C-61/MPN-1.

a. Function. Control Box C-61/MPN-1 is the top component of bay 8 of the transmitter rack. It controls the high voltage supplied to the transmitter in both A and B channels. In addition, there are two meters on the front panel of the unit. which. together with their associated circuits and switches. provide the measurements listed below. In all cases the values given by the meters are average values. A complete schematic diagram of the control box may be found in figure 214.

(1) S-BAND METER.

(*a*) Grid current of modulator switch tube V4: I GRID S1.

(*b*) Grid current of modulator switch tube V5: I GRID S2.

(*c*) Rectifier load current through the high-voltage doubling circuit: I RECTIFIER X 100.

(*d*) Rectified d-c current of the S-band crystal mixer: I XTAL "S".

(e) Modulator S-band high voltage: X 20K H.V. "S".

(f) S-band magnetron current: X 40 I MAG "S".

(2) X-BAND METER.

(a) Grid current of modulator switch tube V6: I GRID X1.

(b) Grid current of modulator switch tube V7: I GRID X2.

(c) Rectified d-c current of the X-band crystal mixer: I XTAL "X".

(d) Modulator X-band high voltage: X 20K H.V. "X".

(e) X-band magnetron current: X 40 I MAG "X".

b. ***Control Circuit.*** The high-voltage control circuit (fig. 201) consists of a series of relays and interlocks and a variac which transmits power to the high-voltage primary of the transmitter HVPS. There are two independent control circuits, one for each of the two channels. The S-band high voltage is adjusted to its proper value by means of the variac control. No high voltage will appear until the circuit shown in figure 201 is completed. When the high voltage is on, one of the two channel lights (A or B) will be illuminated, depending upon which channel is in operation. In order for the high-voltage primary to be energized it is necessary for the normally open PLATE CONTACT RELAY to be closed. This requires the closing of the four interlock switches and the contacts of the other two relays.

(1) The interlocks of the modulator, the two radio frequency units, and the transmitter HVPS must be closed to complete the high-voltage circuit. The interlock switch for each unit is bypassed by a cheater switch for test purposes. It should be noted that the channel switching motors of both radio frequency units and the capacitor discharge relays of the modulators are connected to the interlock system and cannot operate unless the interlock circuit is completed.

(2) The TIME DELAY RELAY contacts are closed 1 minute after power is first applied. For a description of this relay and the method of adjusting it see paragraph 93.

(3) The OVERCURRENT RELAY contacts are normally closed. A short or an unusually heavy load in the high-voltage circuit will operate the OVERCURRENT COIL and open these contacts. When that has occurred and the trouble has been corrected, the contacts may be closed again by pressing the RESET switch. A discussion of this relay may be found in paragraph 94.

c. ***Metering Circuits.*** There are five switches in the control box, only three of which are used in the metering circuits. The other two are the remote reset switches described above. Switch SW1 controls the channel switching and should always point toward the illuminated channel light. Switch SW2 selects the desired X-band, and switch SW3, the desired S-band metering circuit. A typical metering circuit is shown in figure 215. The modulator high voltage and the rectifier load current circuits are illustrated in the transmitter HVPS simplified schematic of the following paragraph. The magnetron current circuits are described in paragraph 16. Crystal current is measured by inserting a meter plug into the jack on the desired preamplifier. There is one plug for the A and B S-band and one for the A and B X-band preamplifiers. Thus switch SW1 will not switch channels for crystal current measurements. Instead, this is accomplished by placing the plug in either the channel A or the channel B unit.

89. RECTIFIER POWER UNIT PP-26/MPN-1.

Two Rectifier Power Units PP-26/MPN-1 are included in Radio Set AN/MPN-1, one for each of channels A and B. The channel A unit is located in the center of bay 7 of the transmitter rack, and the channel B unit is immediately below it.

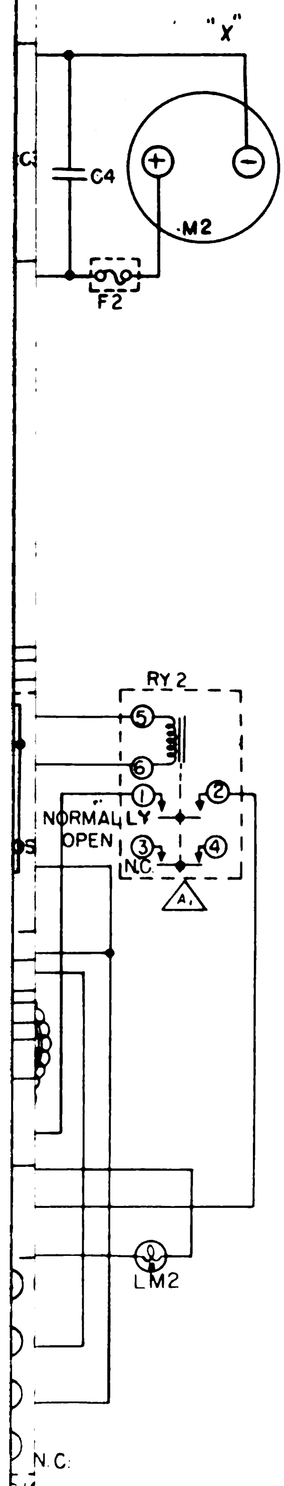
a. As discussed in paragraph 16 on the modulator, a half-microsecond pulse of high voltage is applied to the ultra-high-frequency transmitter in order to make it generate short pulses of r-f energy. These short pulses are obtained by the partial discharge of a high-voltage capacitor. The length of the discharge period itself is controlled by the modulator switch tubes. The function of the high-voltage rectifier is to furnish 12 to 15 kilovolts for charging the capacitor in the modulator which supplies the high-voltage pulses to the transmitter. For the complete high-voltage power supply schematic diagram see figure 217.

b. (1) The high-voltage supply circuit comprises a voltage doubler consisting of transformer T2 supplying the plates of the two rectifier tubes V1 and V2 (705-A), two capacitors C1 and C2, load resistors R21 and R29, and R26 which acts as a ground return. The operation of the circuit is as follows:

(a) During one-half the a-c cycle, the plate of rectifier tube V1 is positive; therefore V1 conducts charging capacitor C1 to the peak voltage of the transformer secondary. On this half of the cycle rectifier tube V2 is nonconducting since its plate voltage is negative.

(b) On the next half of the cycle V1 remains idle and V2 conducts, charging capacitor C2 to the peak voltage of the transformer secondary.

(c) Since these capacitors are connected in series, the polarity of the charges on each adds to produce a load voltage of twice that on either. The alternate charging of the capacitors is repeated every cycle, and a more or less constant load voltage is obtained. The output voltage is not quite twice the peak voltage of the transformer



CS 15A&B			
NO	FUNCTION	TO	FROM
1	AC COMMON		DIST PANEL
2	AC PREHEAT		" "
3	INTERLOCK SYSTEM		24-6
4	N.C.		
5	A.C. TRANSMIT	13-6	
6	A.C. TRANSMIT		DIST PANEL
7	I RECTIFIER MEASUREMENT		13-4
8	N.C.		

CS 16A&B			
NO	FUNCTION	TO	FROM
1	I GRID S1 MEASUREMENT		17-2
2	I GRID S2 "		17-3
3	N.C.		
4	I MAGNETRON X		24-7
5	I GRID RETURN	17-6	
6	I GRID X1 MEASUREMENT		17-7
7	I GRID X2 "		17-5
8	N.C.		

CS 23A&B			
NO	FUNCTION	TO	FROM
1	GROUND	GND BUS	
2	I XTAL S (-)		PREAMP S
3	I XTAL X (-)		PREAMP X
4	HVS		13-7
5	HVX		13-2
6	I XTAL S(+)	PREAMP S	
7	I XTAL X (+)	PREAMP X	
8	I MAGNETRON S		24-8

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Figure 214. Control box C-61/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	10,000	1	5%
R2	4,000	1	5%
R3	100	1	5%
R4	100	1	5%
R5	4,000	1	5%
R6	100	1	5%
R7	50	5	20%
R8	50	5	20%
C1	2 mfd	600	GE 9CE5A93
C2	2 mfd	600	GE 9CE5A93
C3	.25 mfd	600	C-D DYR-6025
C4	.25 mfd	600	C-D DYR-6025
T1	Variac 2 KVA		
T2	Variac 2 KVA		
RY1	Plate Contact		
RY2	Plate Contact		
RY3	Overcurrent		
RY4	Overcurrent		
RY5	Time Delay		
RY6	Time Delay		
SW1	14 Pole DT		
SW2	3 Pole 6 Position		
SW3	3 Pole 6 Position		
SW4	Remote Reset SQ D #986		
SW5	Remote Reset SQ D #986		
LM1	Pilot Lamp	6 V. .25 Amp.	
LM2	Pilot Lamp	6 V. .25 Amp.	
F1	Instrument Littelfuse 1/100 amp.		
F2	Instrument Littelfuse 1/1000 amp.		

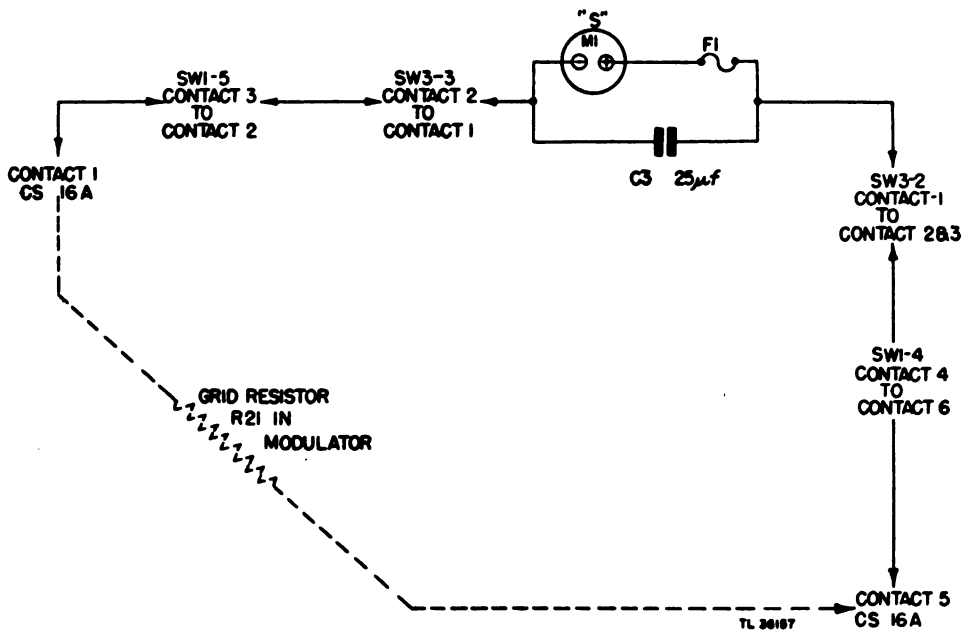

Figure 215. I GRID S1 metering circuit, channel A.

secondary because of loading. It should be approximately 15 kilovolts. For a simplified schematic of the circuit see figure 216. The portions of the circuit represented by dotted lines indicate parts which appear in Control Box C-61/MPN-1. The meter shunting circuit in parallel with R26 provides a means of measuring the total load current. All the meter circuits (shown in dotted lines) may be switched in or out of the high-voltage power supply by means of switches located in the control box.

(2) The plate voltage supply for the S-band switch tubes in the modulator is taken across the entire load resistance to ground and may be varied only by means of the variac in the control box; that is, by changing the transformer primary voltage applied to T2. The plate supply to the X-band switch tubes, however, is taken across only that portion of the load resistance determined by switch S3.

(3) The two voltmeter circuits located in the control box are connected across resistors R27 and R28 (the return to ground of output load resistors R23 and R22, respectively) and indicate the voltages applied to the S- and X-band switch tubes, respectively.

90. RECTIFIER POWER UNIT PP-27/MPN-1.

Two Rectifier Power Units PP-27/MPN-1 are included in Radio Set AN/MPN-1, each unit supplying one unregulated source of 300 volts and two regulated sources of 270 volts and -150 volts each. Power supply No. 1 is located behind the search indicator in bay 6 of the indicator rack. It supplies the 300 and the 270-volt sources to its associated search central and search indicator and the -150-volt source to its search central and the sine potentiometer. In addition, the sine potentiometer receives 150 volts from the search central, obtained from the 270-volt source after it has been reduced by a voltage divider. The sine potentiometer receives its voltage via the intercommunications panel, where a switch determines which search system will supply its power. Power supply No. 2 is located behind the search indicator in bay 4 and supplies the voltages for search system No. 2. Both power supplies are working at the same time and are not placed alternately in and out of operation by switching channels. In the following discussion, refer to figure 218 for a complete schematic diagram of the unit.

a. Voltage from the 117-volt preheat circuit is supplied to filament transformer T2 and power transformer T1 of the rectifier power unit. The primaries of both transformers are fused jointly with the filament transformer primary of the associated search central. The secondary of T1 feeds two circuits: one, a full-wave rectifier for the 270-volt and 300-volt supplies; the other, a half-wave rectifier for the -150 volt supply (fig. 219).

b. The -150-volt circuit consists of rectifier tube V2 (5R4GY) connected as a half-wave rectifier, filter circuit C3, L2, and C4, dropping resistor R1, and regulator tube

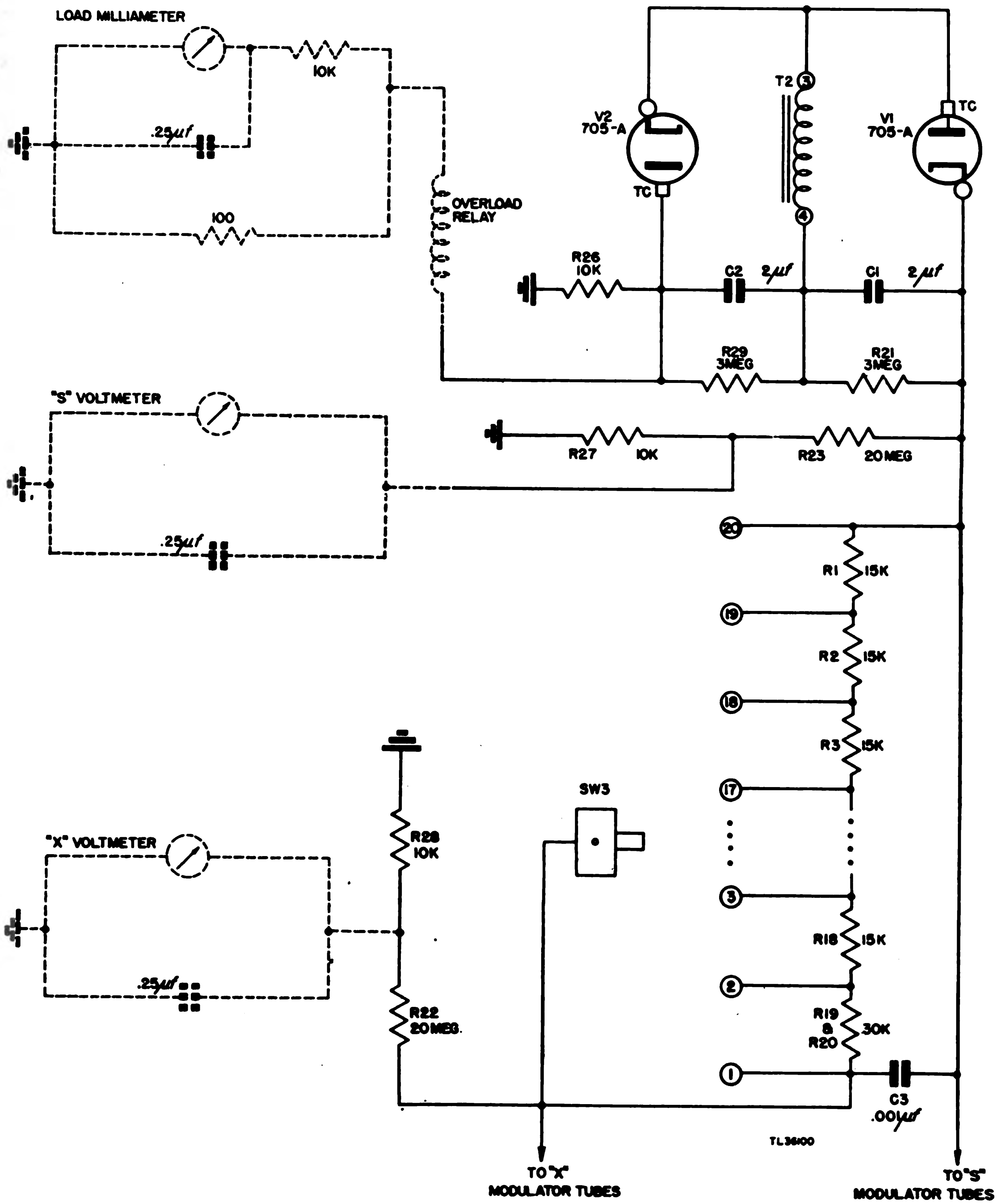

Figure 216. High-voltage power supply, simplified schematic diagram.

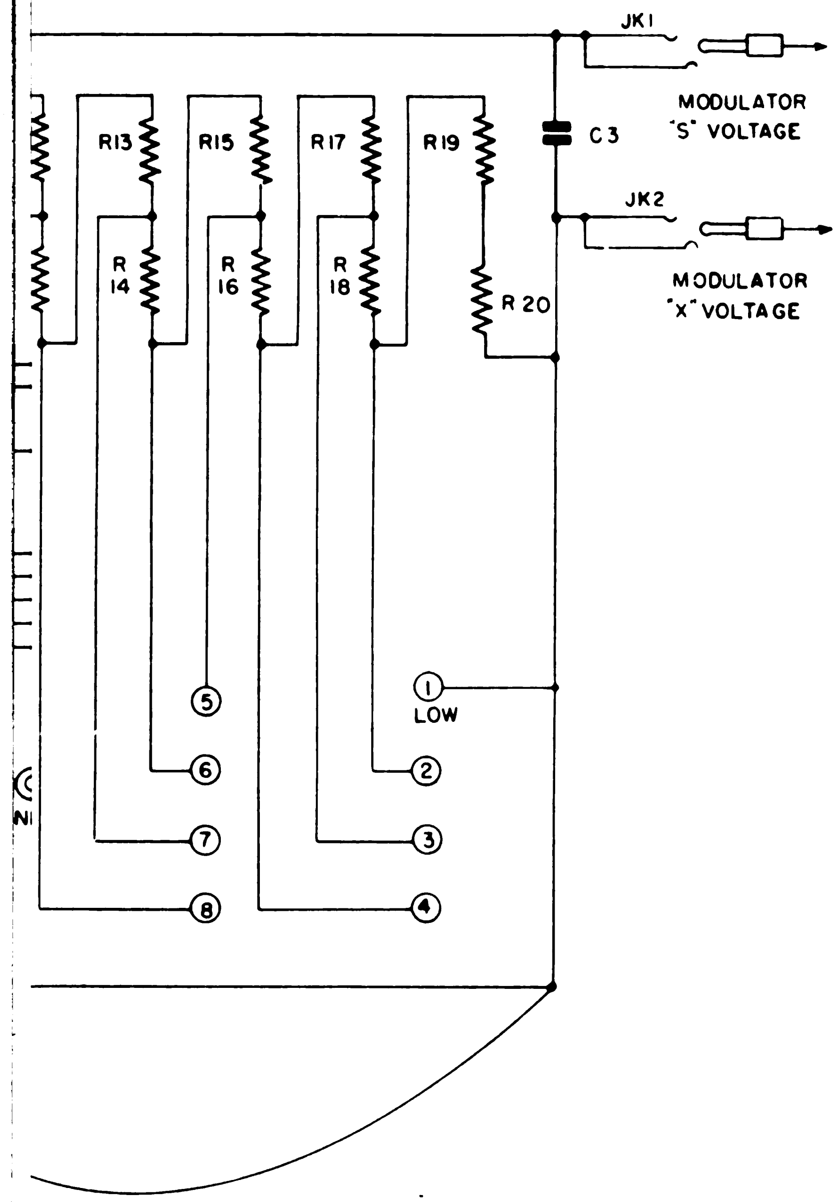

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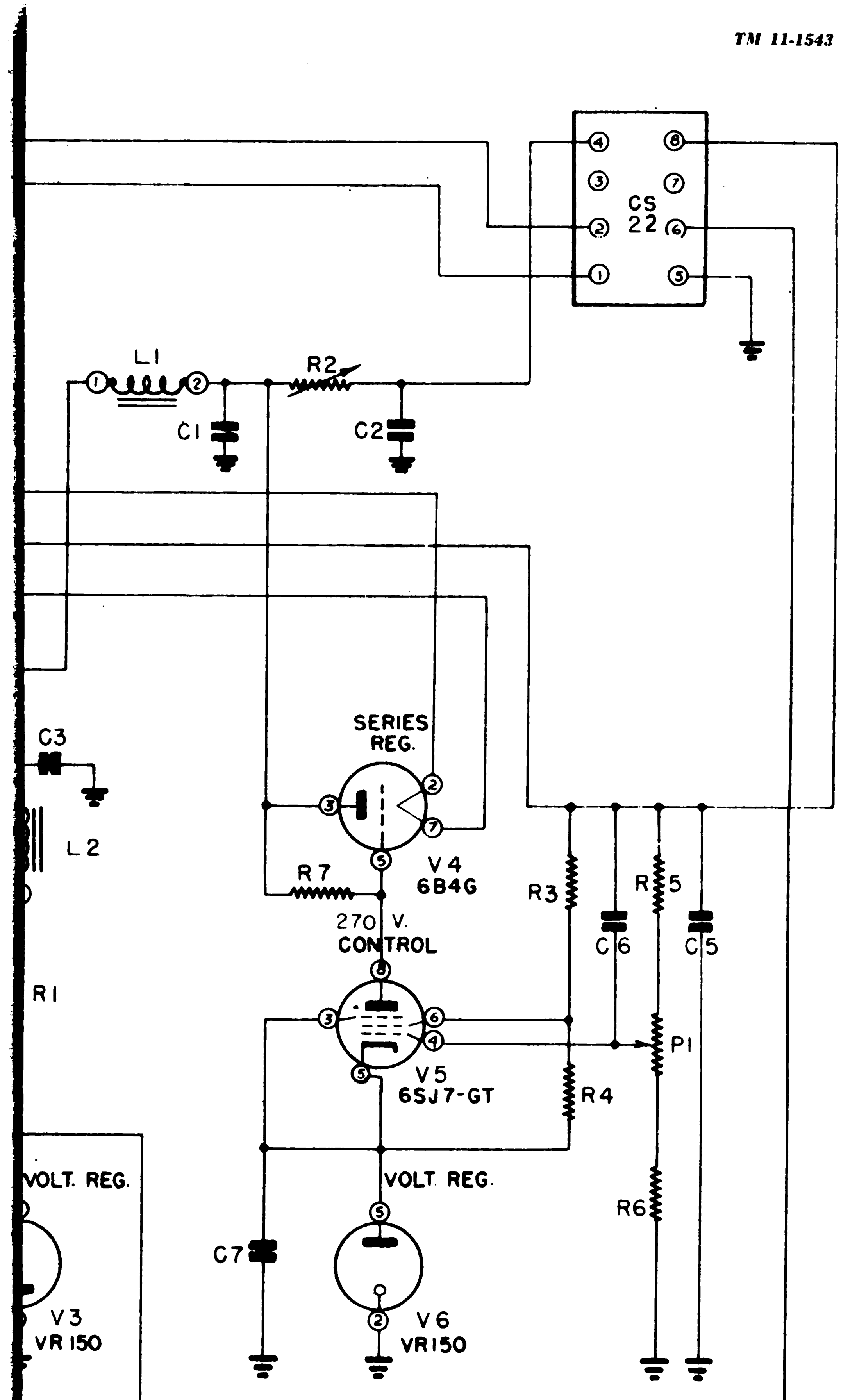
Figure 217. Rectifier Power Unit PP-26/MPN-1 (transmitter HVPS), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
		Watts	
R1	15,000	8	± 20%
R2	15,000	8	± 20%
R3	15,000	8	± 20%
R4	15,000	8	± 20%
R5	15,000	8	± 20%
R6	15,000	8	± 20%
R7	15,000	8	± 20%
R8	15,000	8	± 20%
R9	15,000	8	± 20%
R10	15,000	8	± 20%
R11	15,000	8	± 20%
R12	15,000	8	± 20%
R13	15,000	8	± 20%
R14	15,000	8	± 20%
R15	15,000	8	± 20%
R16	15,000	8	± 20%
R17	15,000	8	± 20%
R18	15,000	8	± 20%
R19	15,000	8	± 20%
R20	15,000	8	± 20%
R21	3 Meg	22	± 10%
R22	20 Meg	15	± 10%
R23	20 Meg	15	± 10%
R26	10,000	24	± 20%
R27	10,000	2	± 20%
R28	10,000	2	± 20%
R29	3 Meg	22	± 10%
		Volts	
C1	2 mfd	7500	10%
C2	2 mfd	7500	10%
C3	.001 mfd	12500	10%
T1	UX-6899 Ratheon Filament Transformer		
T2	15-3455 Conrae Plate or H.V.T. Transformer		
SW1	G.E.-7460330-G4		
SW2	CH-8201		
V1	705-A Western Elec.		
V2	705-A Western Elec.		
JK1	Yaxley-Mallory GJ1 #B-111-745x		
JK2	Yaxley-Mallory GJ1 #b-111-745x		



TL 36073A

Figure 218. Rectifier Power Unit PP-27/MPN-1 (search central power supply), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	7,500	20	10%
R2	1,000	50	10%
R3	6,800	2	20%
R4	4,700	2	20%
R5	82,000	½	10%
R6	100,000	½	20%
R7	470,000	½	20%
P1	50,000	2	
C1	8 mfd	1000V	
C2	8 mfd	1000V	
C3	4 mfd	1000V	
C4	4 mfd	1000V	
C5	2 mfd	600V	
C6	.01 mfd	600V	
C7	.01 mfd	600V	
T1	15-3426B		
T2	15-3463		
L1	15-2474		
L2	15-2479		
V1	5R4GY		
V2	5R4GY		
V3	VR150		
V4	6B4G		
V5	6SJ7-GTVT116A		
V6	VR150		
22 CS	B00-4468 (G.B.) Connector Strip		

* Thermador Transformer
† Thermador Choke
✓ Gardner Electric

V3 (VR150). Since the voltage drop across V3 is inherently 150 volts within the current limits of the tube, the output is connected directly to the cathode of V3.

c. The positive voltage output circuit consists of a full-wave rectifier tube V1 (5R4GY) and filter circuit L1 and C1. The full output of over 300 volts appears across C1 where the circuit divides into two branches.

(1) One branch is through dropping resistor R2 and forms the output circuit for the unregulated 300-volt supply. The shorting strap on R2 serves as a manual adjustment for this output voltage by varying series resistance in the circuit.

(2) The second branch is through regulator tube V4 (6B4G), the 270-volt output being taken across bleeder resistors R5, P1, and R6. Electronic regulation is utilized in this circuit by using V5 (6SJ7-GT) as a control tube. The cathode of V5 is held at constant potential by regulator tube V6 (VR 150) and the grid bias of V5 is adjusted by the variable tap on P1. The output voltage is set by the potentiometer tap. The operation of this circuit is very similar to that of the 300-volt power supply described in paragraph 83.

91. RECTIFIER POWER UNIT PP-28/MPN-1. Three Rectifier Power Units PP-28/MPN-1 are mounted in bay 15 of Communications Rack MT-121/MPN-1. Each unit contains two rectifier circuits providing all the necessary operating voltages for each Radio Set SCR-274-N. For a complete schematic of the SCR-274 power supply see figure 220.

a. The first rectifier circuit supplies unregulated 550 volts dc from a full-wave rectifier tube V1 (5R4GY) feeding a two-section choke input filter. Bleeder resistor R1 is paralleled to ground across the output. Transformer T1 supplies all the operating voltages for this circuit from the 117-volt preheat line. Door interlock switch SW2 and bypass switch SW1 are in series with the transformer primary, as well as overload fuse F1 and telltale neon lamp NE1 mounted in the front panel to indicate a blown fuse.

b. The second rectifier circuit supplies a voltage output of approximately 26 volts.. Dc is converted from ac by selenium rectifier RECT. 1 and is applied to choke L13 and capacitor C3, which act as a filter circuit. C3 is a 2,000 mfd electrolytic capacitor and is almost a perfect short for even a 60 cps ripple. Protecting fuse F2 and telltale neon lamp NE2 in parallel are inserted in the primary lead to transformer T2, which supplies the selenium rectifier. The 117-volt preheat voltage is supplied to T2 from the input terminals of the chassis ahead of the interlock switch. Both rectifier circuits may be shut down by means of power switch SW3.

92. RECTIFIER POWER UNIT PP-100/MPN-1. Rectifier Power Unit PP-100/MPN-1 is located at the top of bay 4 of the indicator rack and supplies 26 volts dc to the tower receiver. Its circuit is identical in operation with the d-c circuit of the SCR-274 power supply described in the preceding paragraph.

93. TIME DELAY RELAYS. There are two types of time delay relay used in Radio Set AN/MPN-1: one type is in the control box for the transmitter HVPS; the other, in the 4-kv power supply.

a. HVPS Relays. Each of the two channels in the control box contains a Ward Leonard type 362-642 time delay relay. This relay has two sets of contacts, only one of which is used. The circuit is shown in figure 222. When 117 volts are first applied to the relay at terminals 1 and 5, the 60-cps synchronous motor operates at once as does also a metal rod controlled by the brake coil. Through a differential gear mechanism, the motor operates a shaft connected to the brake drum (fig. 224), the shaft striking switch A (fig. 222) after 60 seconds. This switch in its normally closed position shorts out the relay coil. After switch A is struck, however, the motor is open-circuited and voltage is applied to the relay coil. Switch A is kept open by the brake coil metal rod, which does not allow the brake drum to fall back to its original position after the motor has stopped running. The relay coil then closes contacts B and C, and voltage is applied to the HVPS primary. When the set is turned off, contacts B and C open, the brake coil metal rod springs back, and the brake drum is released. The procedure for adjusting the relay is as follows:

(1) TIME SETTING MECHANISM (fig. 223).

(*a*) Loosen the timing disk locking screw (1).

(*b*) Rotate the time indicator friction nut (2) in a clockwise direction until the timing disk stop (4) rests against the timing disk clamp (5), at which point the motor switch lever (3) should be resting on the motor switch (6).

(*c*) Tighten the timing disk locking screw.

(*d*) With a wrench, rotate the time indicator friction nut until it registers zero.

(*e*) Loosen the timing disk locking screw and rotate the time indicator friction nut in a counterclockwise direction until the indicator registers 60.

(*f*) Tighten the timing disk locking screw. The time delay mechanism should now be adjusted.

(2) BRAKE MECHANISM (fig. 224).

(*a*) Press the armature (11) down until it rests on the core pin (10).

(*b*) Adjust the adjustment nuts (12) until there is approximately 1/32-inch clearance between the cotter pin (13) and the armature.

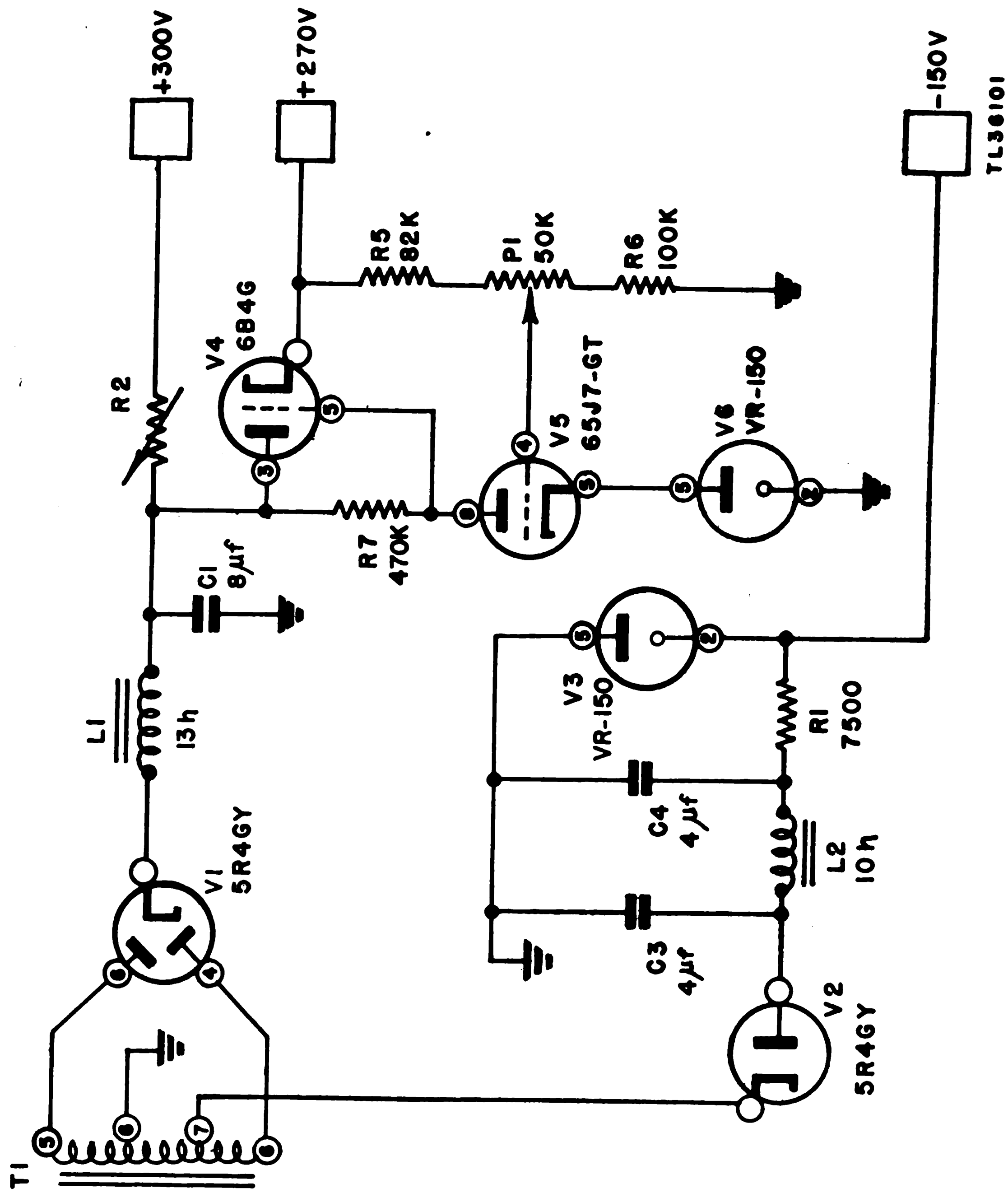


Figure 219. Search central power supply, simplified schematic diagram.

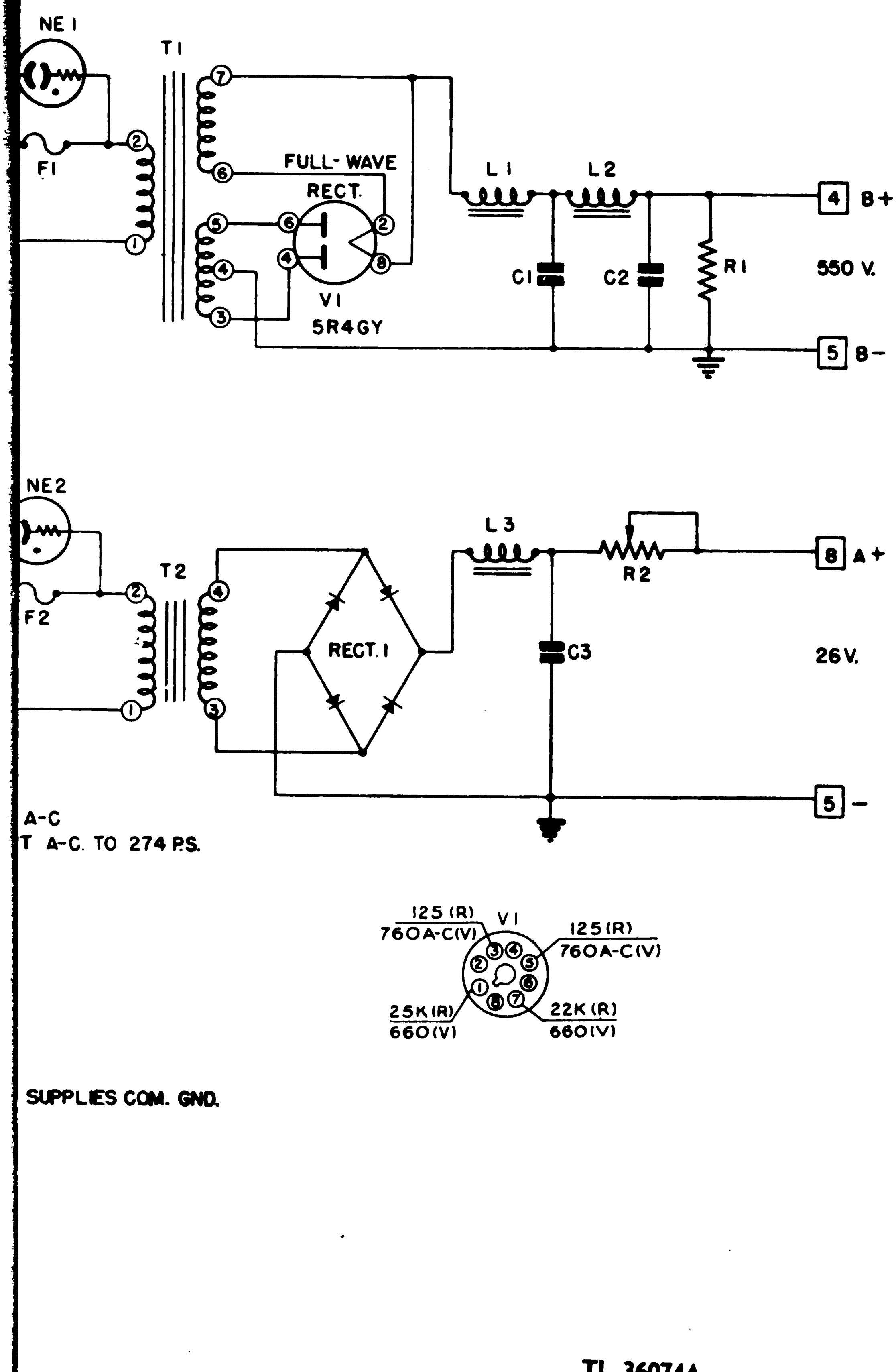


Figure 220. Rectifier Power Unit PP-28/MPN-1 (SCR-274 power supply), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
		Watts	
R1	25,000	50	20%
R2	5	160	20%
		Volts	
C1	8 mf	1500 volts	-10%, +20%
C2	8 mf	1500	-10%, +20%
C3	2000 mf	50	10%, +65%
V1	5R4GY		
		Type	
T1		15-3448	
T2		Mallory T4660	
L1	10 H	15-3449	
L2	5 H	15-3450	
L3		Mallory T4659	
F1	3 amp	Littelfuse 3AG	
F2	3 amp	Littelfuse 3AG	
NE1		Littelfuse 5122	
NE2		Littelfuse 5122	
Rect. 1		Mallory 1S80C9	
SW1		AN 3015	
SW2		GE ML-746033004	
SW3		CH 8244	

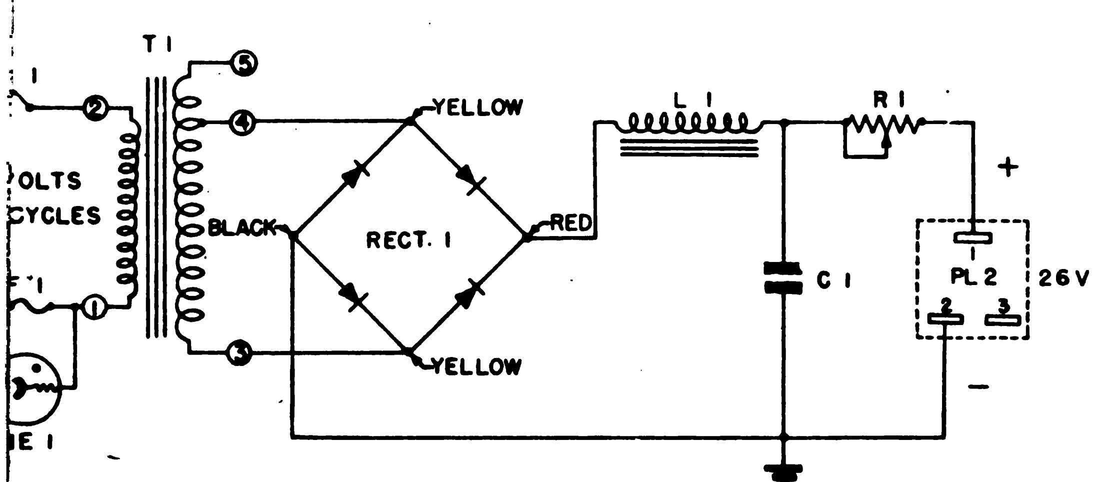


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Figure 221. Rectifier Power Unit PP-100/MPN-1 (tower receiver power supply), schematic diagram.

ing HF Control Box BC-451-A (fig. 227b) and tuning the corresponding Radio Receiver BC-342-N to the desired frequency. The other three sets (SCR-522-A) operate in the VHF band. Each of these sets has four possible channels, selected by pressing the appropriate push buttons in the corresponding VHF Control Box BC-602-A (fig. 227a). Thus there are 21 complete communication channels available to the operators of Radio Set AN/MPN-1, besides the monitoring of the tower receiver. But only three complete channels can be used at one time as there are only three communications channel selector sets of six red push buttons. One set is located in Approach Indicator ID-38 and the other two sets are in Intercommunications Panel SB-2. Each of the three operators will have a clear channel available in both the HF and VHF bands by pressing the appropriate push buttons in any one of the three operating positions. In the table below these channels are designated as 1, 2, and 3. In actual tactical use their designations and exact frequency will be assigned by the service using the equipment. The channels are distributed as follows:

Operator	Channel	Frequency	Equipment
Director	1 (HF)	3-7 mc	SCR-274-N and BC-342-N
Director	1 (VHF)	100-156 mc	SCR-522-A
Selector	2 (HF)	3-7 mc	SCR-274-N and BC-342-N
Selector	2 (VHF)	100-156 mc	SCR-522-A
Controller	3 (HF)	3-7 mc	SCR-274-N
	2 (HF)	3-7 mc	BC-342-N
Controller	3 (VHF)	100-156 mc	SCR-522-A

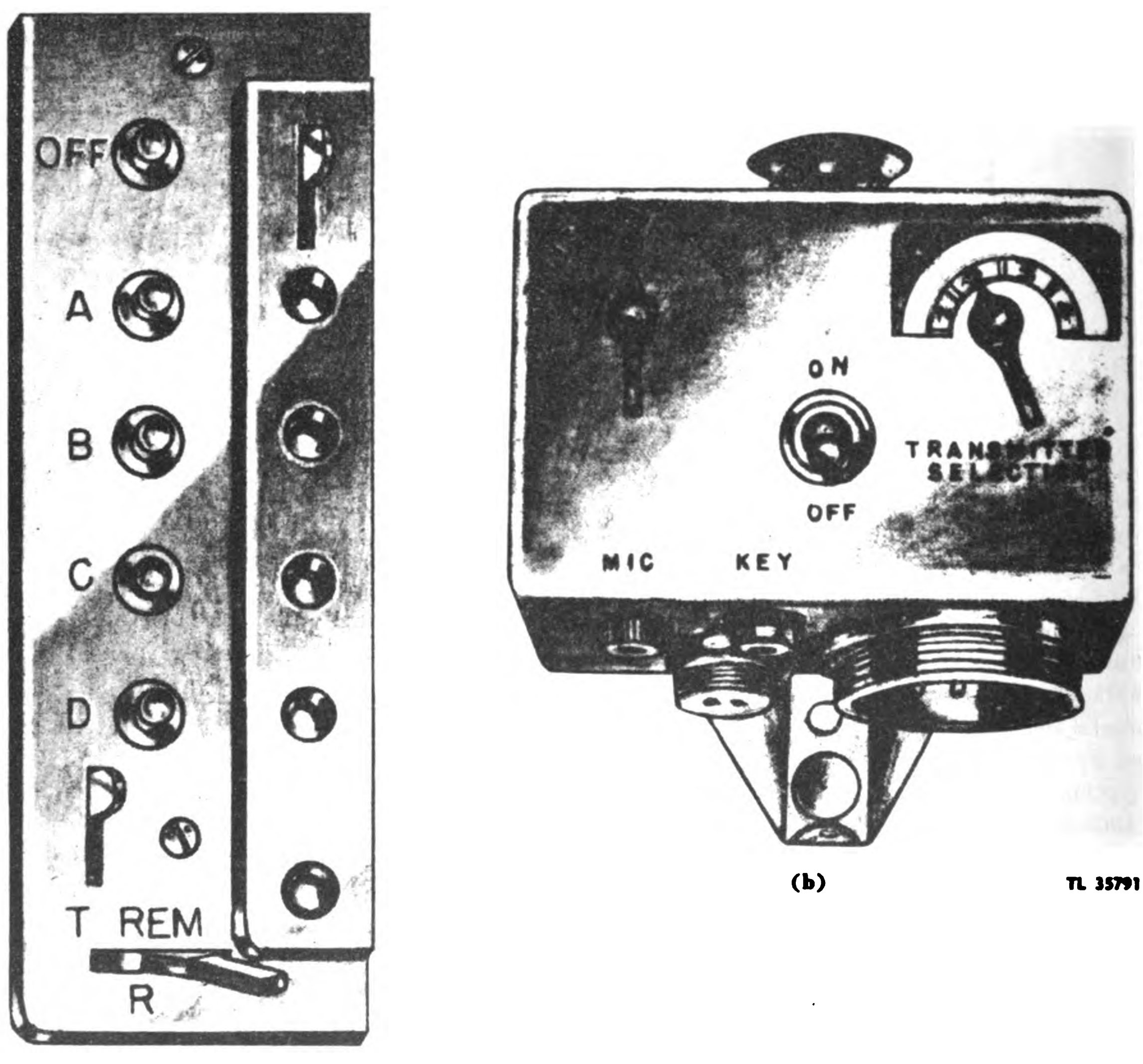

Figure 227. Radio Control Box BC-602-A and Radio Control Box BC-451-A.

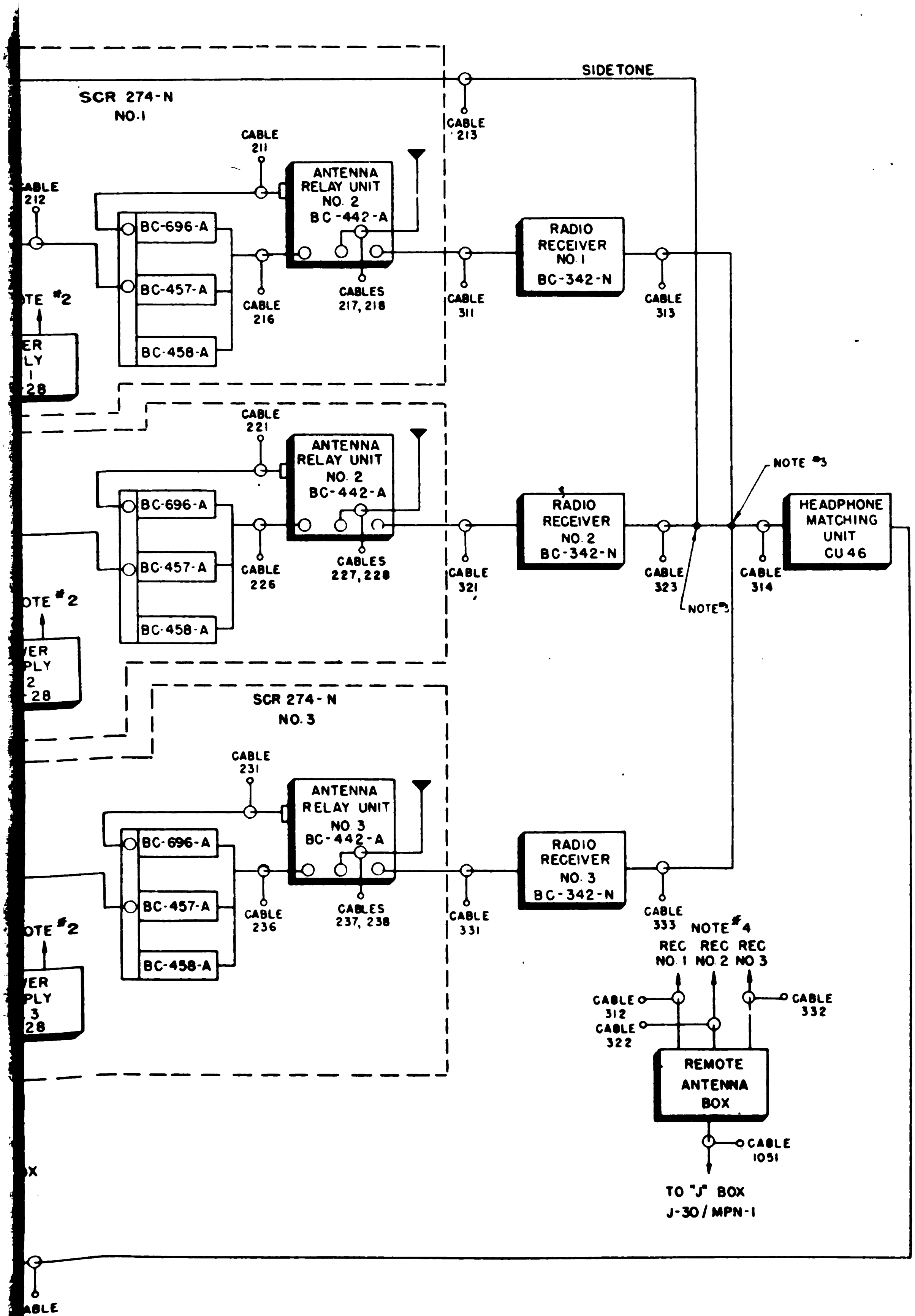

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Figure 228. Cabling block diagram of communications system.

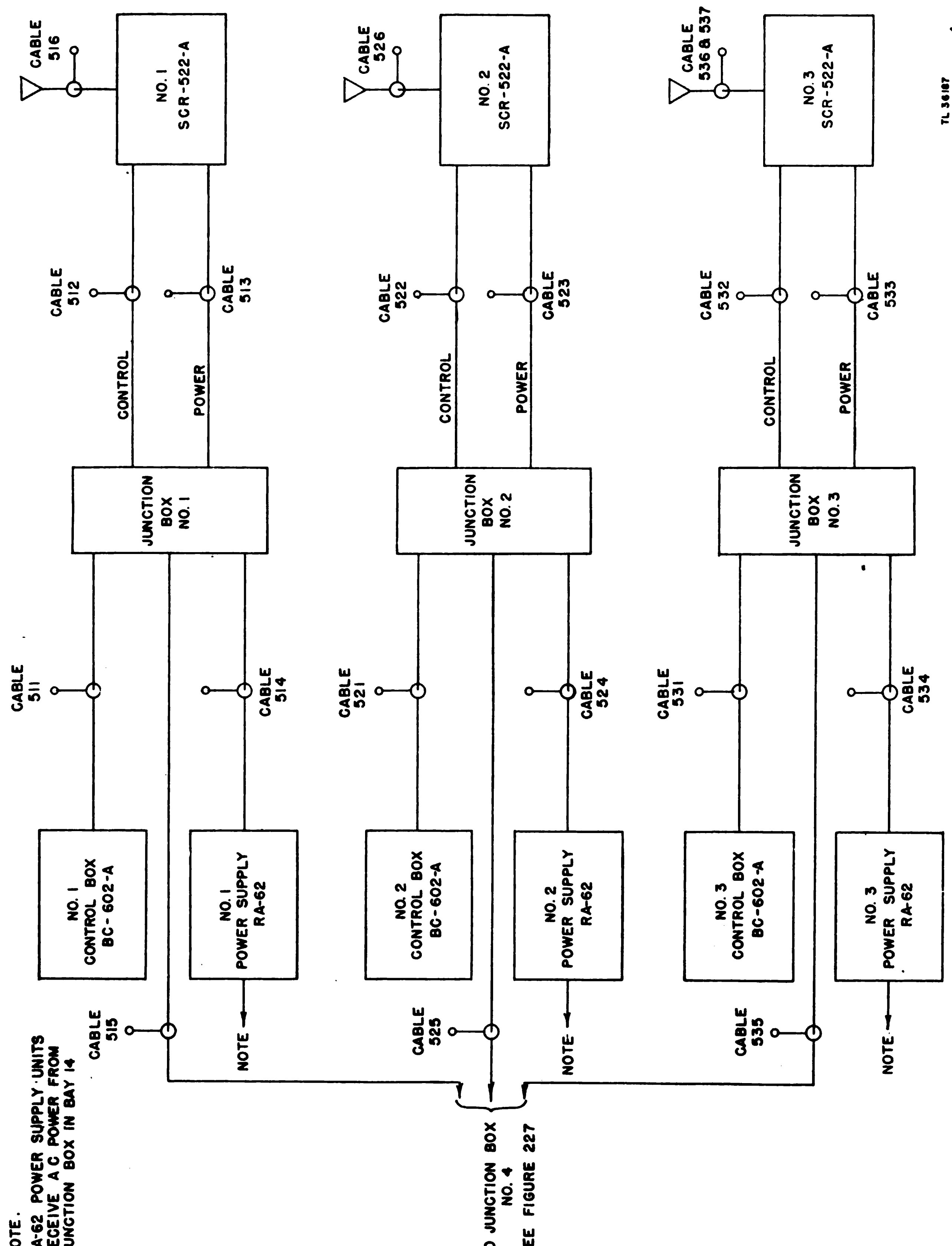


Figure 229. Cabling block diagram of Radio Set SCR-522-A.

96. OPERATING POSITIONS. At each operating position there is located a COMMUNICATIONS CHANNEL SELECTOR set of six red push buttons. Above each push button there is a pilot light. Two of the pilot bull's-eyes are green, indicating the push buttons which should be depressed for normal operations. The other four bull's-eyes are purple. A transmit-receive-intercommunications key and a jack for the operator's microphone and headset are also located at each operating position. In front of the controller there is an aural signal switch which, when pressed down, connects the output of the aural signal unit (figs. 175 and 179) to continuously modulate the output of the transmitter in use. This enables the pilot and both trackers to hear the azimuth tone signal while they are also hearing the controller's voice. When the aural signal unit is on, the transmitter selected by the controller is continuously modulated even though the TRANS-REC key is on the REC position. Because the transmitter is continuously modulated, the controller's receiver is blocked when the aural signal is on. Therefore, if the aircraft operator desires to contact the trailer, he must use a different channel than the one transmitting the aural signal until such time as the aural signal is switched off. This means that only the traffic director or plane selector may hear the aircraft operator when the aural signal unit is in operation, as they use a different transmitting and receiving channel. When the observer has his key on transmit, he cuts off the aural signal unit and takes over the controller's transmitter. This enables him to talk directly to the aircraft on the same channel or transmitter as previously operated with aural signal modulation. The traffic director and the plane selector have means whereby either of them may have his headset and microphone circuits connected to the external intercommunications circuit. This is done through a selector switch located at the center of the intercommunication panel (fig. 70) and through the two push-to-talk keys (I.F.F.-INT.-COM.), one at each end of the panel. Each search system operator may communicate with either the truck cab or IFF equipment through an external connection by pressing down their I.F.F.-INT.-COM. key. A toggle switch on the intercommunications panels switches either the No. 1 or No. 2 operator to the external intercommunications circuit. Thus only one operator can use the external circuit at a time. As only one external communications circuit is provided, the telephone outlet box is interchanged between the cab and the IFF equipment as needed. The circuit has a single audio stage in the approach indicator (fig. 174) and terminates at the IFF communications outlet in Junction Box J-30/MPN-1. Telephone Box TA-6/MPN-1 (a jack and transformer box), a male plug, and a long connecting cord (figs. 230 and 232) are provided for external use. It couples into the IFF communications outlet. A standard headset and microphone combination plugs into the jack box for use in the IFF equipment if provided or in the cab of the truck. The jack box in the truck cab is used for the electronic positioning of the equipment. The driver is supplied with a headset and microphone so that he may hear instructions from an operator at the azimuth tracker's position, who is using a headset and microphone plugged into the plane selector's outlet. The azimuth and elevation trackers have in front of them only PHONE jacks into which they plug their headphones. The tracker's headphones are in parallel with the controller's headphones, which are connected for side-tone monitoring. The side-tone monitoring circuit provides feedback from the microphone to the headphone circuits enabling the operator to hear his own conversation. The azimuth and elevation trackers thus hear the information being given out by the controller through their parallel headphones.

97. MAIN UNIT CONTROLS.

a. Standard Controls. The standard controls and internal circuits for the SCR-274-N, the BC-342-N, and the SCR-522-A have not been altered, with the exception of the OFF-ON switch in the control boxes. Operation of these radio sets is covered in the separate technical manuals furnished with each Radio Set AN/MPN-1. Instruction Book for Operation and Maintenance of Radio Set SCR-274-N (Army Air Forces T.O. No. 08-10-50), covers the HF transmitter which is made up of three individual transmitters in one rack, BC-696-A, BC-457-A, and BC-458-A (fig. 233a). In addition, the manual covers Antenna Relay Unit BC-442-A, Modulator BC-456-B (fig. 233b), and Radio Control Box BC-451-A (fig. 227b) which are also a part of Radio Set SCR-274-N. Each SCR-274-N has its own Rectifier Power Unit PP-28/-MPN-1. The radio receiver used with Radio Set SCR-274-N is described in Instruction Book for Operation and Maintenance of Radio Receiver BC-342-N, a separate manual. Instruction Book for Operation and Maintenance of Radio Set SCR-522-A (Army Air Forces T.O. No. 08-10-105) covers the SCR-522-A (fig. 234) and its associated Radio Control Box BC-602-A (fig. 227a). Information on the power supply for the SCR-522-A is given in the manual Operating and Maintenance Instructions for Rectifier Unit RA-62.

b. Variations from Standard. Channel selection on the VHF Radio Sets SCR-522-A is accomplished through the push-button controls and indicated by the illumination of a corresponding pilot light. The transmit-receive-remote (T-R-REM) switch on Radio-Control Box BC-602-A should be left in the remote position to enable control through the key switch at the indicator rack operating

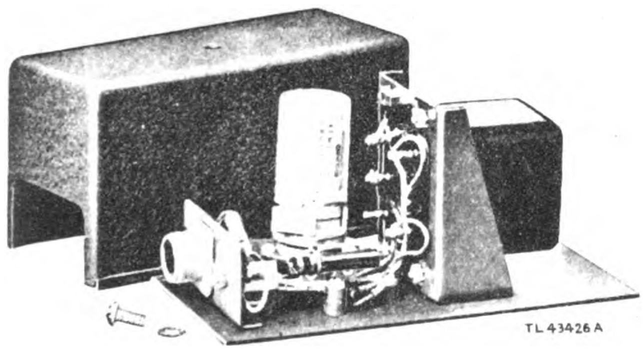


Figure 230. Telephone Box TA-6/MPN-1, top view.

stations. The transmit-receive positions in which this switch may be placed will be used only when testing the unit. The ON-OFF switch on Radio Control Box BC-451-A is open and not used.

c. Approach Indicator ID-38 MPN-1. (1) Two main groups of circuits are included in Approach Indicator ID-38/MPN-1 (figs. 173 and 174). One group is composed of the position errormeters and the warning lights for use by the approach controller. This group of circuits is controlled by the error potentiometers in the azimuth and elevation directors. The other group consists of rectifiers, audio amplifier and mixer stages, and multiposition switches for the communications and intercommunication control system. Only the second group is discussed here.

(2) Inside the approach indicator are four gain controls, P6, P7, P8 and P9, for the intercommunication amplifier channels marked TR'KERS & CONT., IFF, PPI No. 2, and PPI No. 1. P1 is a microphone gain control potentiometer for the controller's microphone and is labeled CONT. MIC. INPUT. Three potentiometers, P12, P13, and P14, marked TRANS. #1, TRANS. #2 and TRANS. #3 on the panel, are for controlling sidetone level from the HF transmitters. In addition, there is potentiometer P2, marked AURAL SIGNAL OUTPUT GAIN on the panel, for controlling the aural signal level. Besides the power supply there is the intercommunications amplifier which is a four-channel amplifier. There is one channel for each search operator and one channel for both the approach controller and the observer. The remaining channel is for the external intercommunication outlet (IFF or prime mover telephone set). On the front panel of the approach indicator are various switches, controls, and lights, all of which are used in the communication or intercommunications control system, except the azimuth-elevation meter sensitivity controls (fig. 172). When the A and B MIC. SUPPLY switch is in the A position, it furnishes power for the intercommunication amplifier and microphone current; in the B position, the switch furnishes microphone current only and is used in case of an emergency. The six red push buttons, with their appropriate indicator lights, select the communication channels HF or VHF. There are two keys with appropriate indicator lights. These keys, the aural signal switch, and the transmit-receive-intercommunications switch, connect with the circuits as indicated in figure 174.

d. Intercommunications Panel SB-2/MPN-1. On the intercommunication panel (figs. 70 and 238) there are various controls and switches not used for the communication or intercommunication systems. These controls and switches will not be discussed here. There are two sets of communications channel selectors of six red push buttons each, one set for the No. 1 search operator and the other set for the No. 2 search operator. There are also two keys (an individual I.F.F. INT. COM. key for each operator on the right and left-hand corners) and a selector switch (fig. 70) to control the IFF intercommunication outlet.

e. Search Centrals. Transmit-intercommunication keys are located on the left side of No. 1 and No. 2 search centrals. Jacks for the headsets and microphones are located on the left side below the desk top. Volume control potentiometers P11 are on each of the search centrals and control the microphone current to the corresponding jacks (figs. 68 and 86).

98. SWITCH POSITIONS.

a. Transmit-receive Switch (fig. 231). The three-position key at each operating position completes the

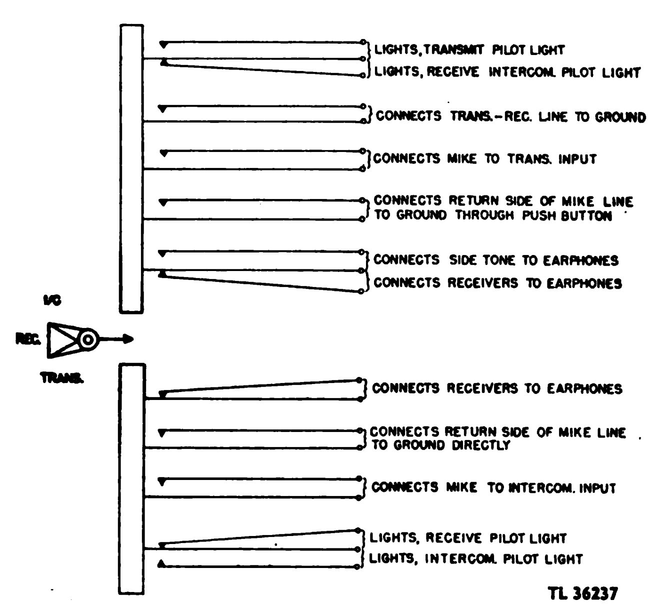
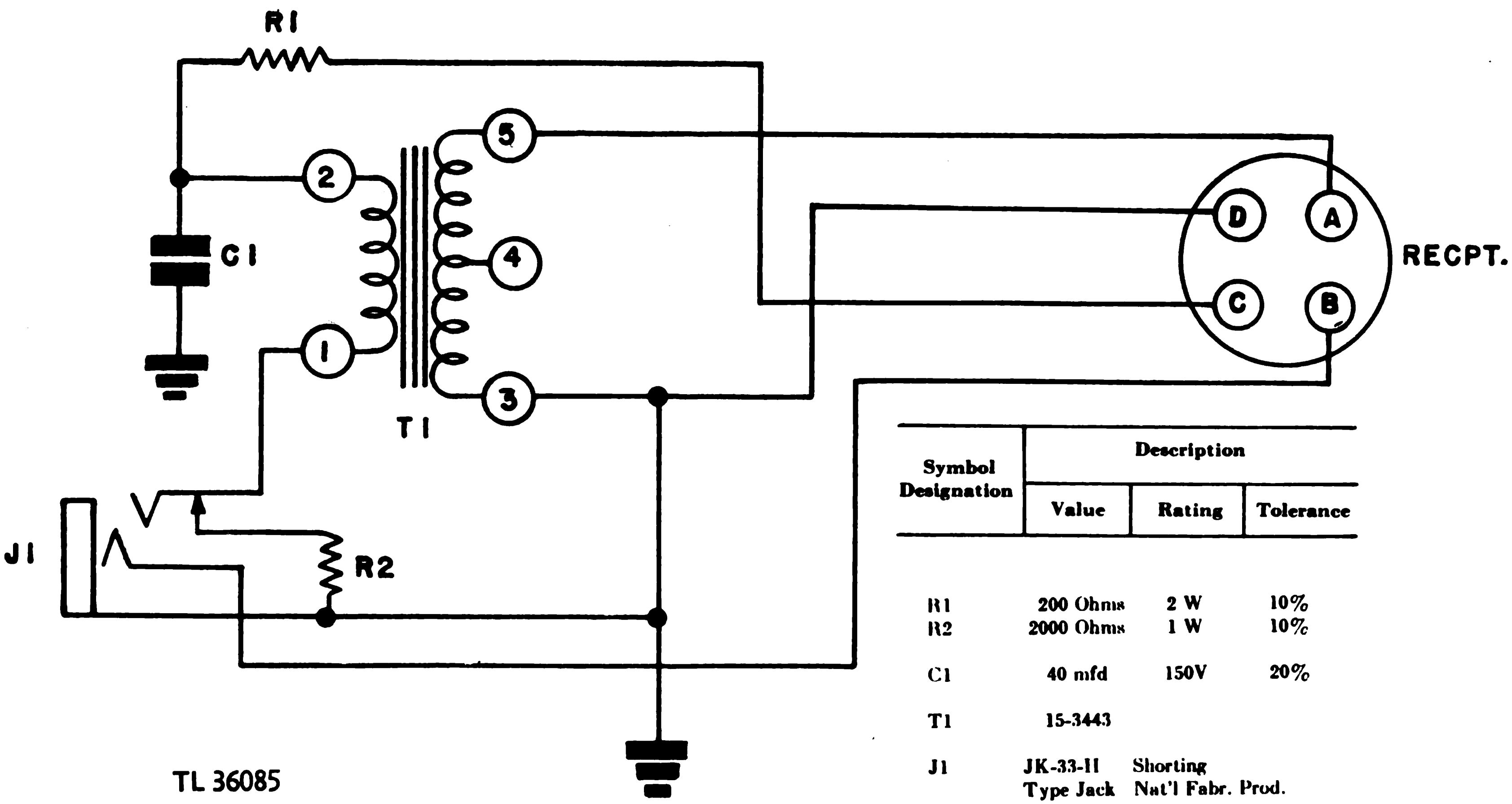


Figure 231. Transmit-receive switch diagram.



Symbol Designation	Description		
	Value	Rating	Tolerance
R1	200 Ohms	2 W	10%
R2	2000 Ohms	1 W	10%
C1	40 mfd	150V	20%
T1	15-3443		
J1	JK-33-11 Type Jack	Shorting Nat'l Fabr. Prod.	
Recpt. 1	Amphenol (AN-3102-14S-2S)		

Figure 232. Telephone Box TA-6/MPN-1, schematic diagram.

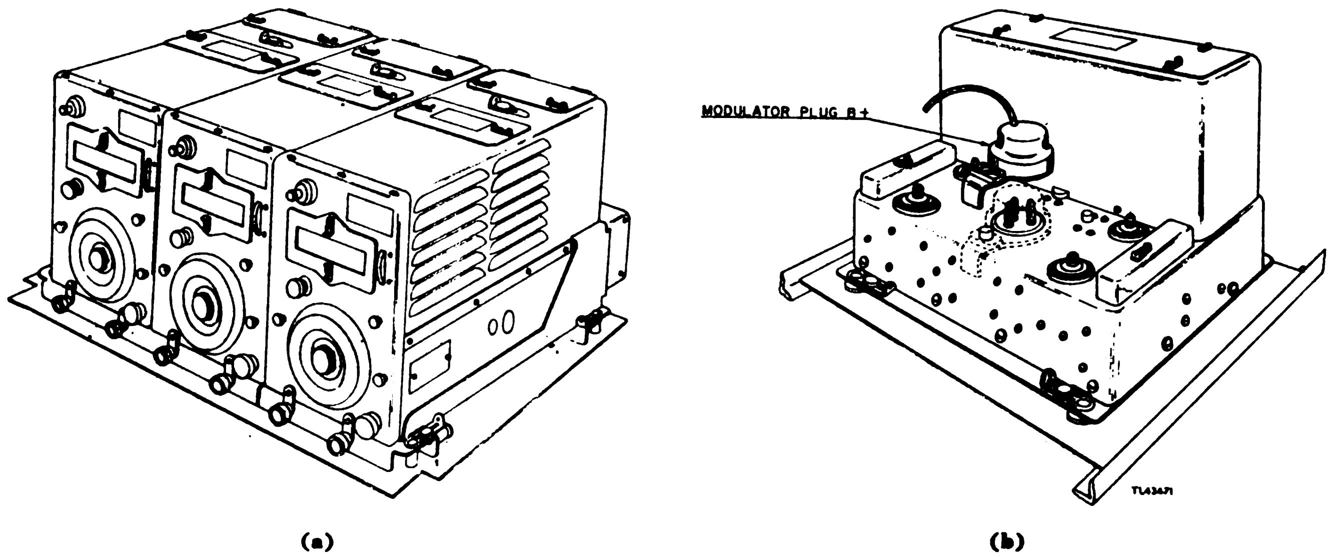


Figure 233. Radio Transmitters BC-696-A, BC-457-A, and BC-458-A, and Modulator BC-456-B.

circuits set up at the push buttons in the following manner:

(1) When the transmit-receive switch is in the forward or transmit position, the following circuit connections occur:

(*a*) The transmit pilot light is lighted at the controller's position only.

(*b*) The key circuit of the transmitter selected is closed. This connects the antenna to the transmitter and turns on the r-f carrier as indicated by the click of the relay and indicated on the HF by the reading of the antenna meter on the corresponding transmitter.

(*c*) The microphone is connected to the transmitter audio input.

(d) The side-tone circuit connects the operator's headphones with his microphone.

(2) When the transmit-receive switch is in the center or receive position, the following circuit connections occur:

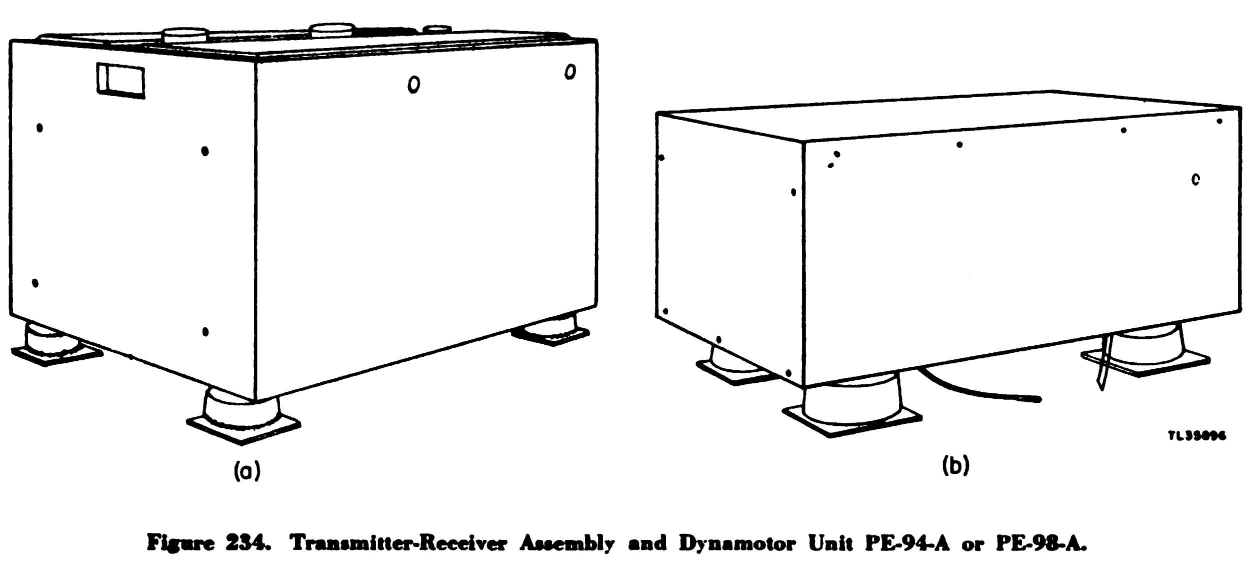
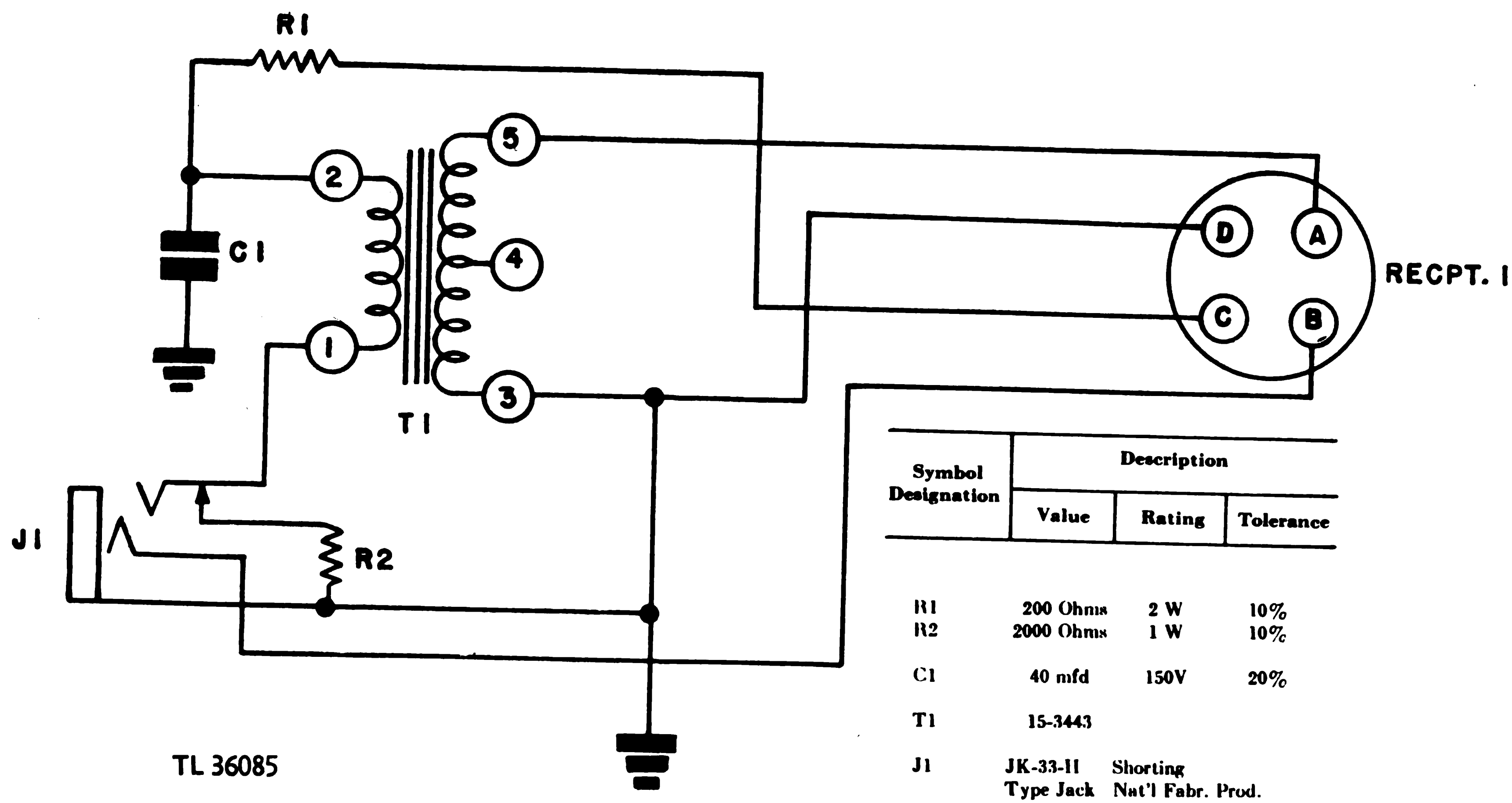
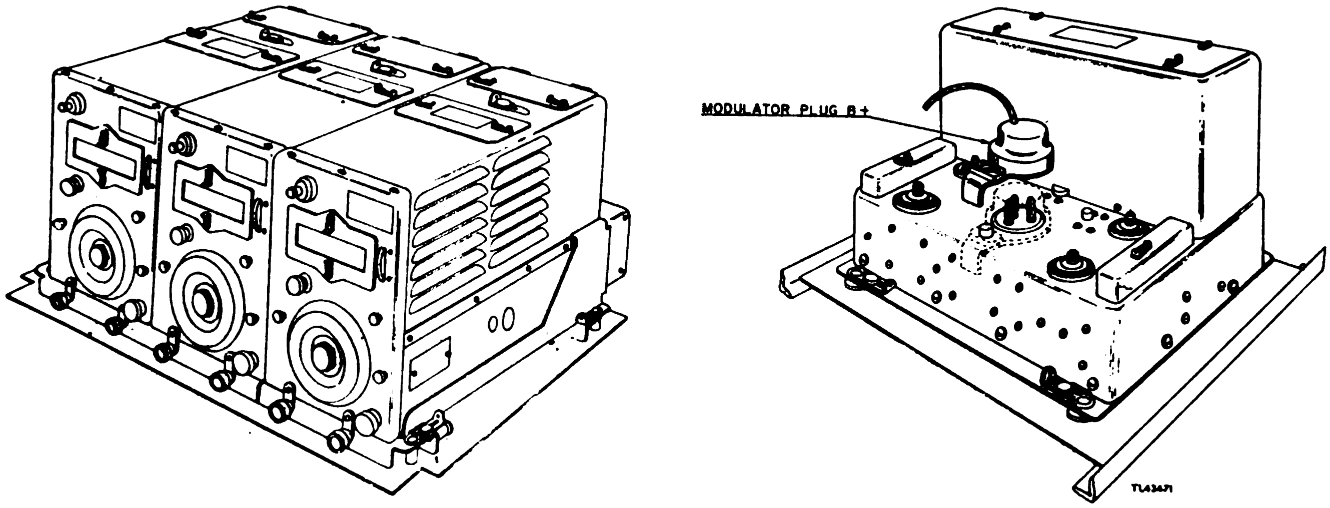


Figure 234. Transmitter-Receiver Assembly and Dynamotor Unit PE-94-A or PE-98-A.



Symbol Designation	Description		
	Value	Rating	Tolerance
R1	200 Ohms	2 W	10%
R2	2000 Ohms	1 W	10%
C1	40 mfd	150V	20%
T1	15-3443		
J1	JK-33-11 Type Jack	Shorting Nat'l Fabr. Prod.	
Recpt. 1	Amphenol (AN-3102-14S-2S)		

Figure 232. Telephone Box TA-6/MPN-1, schematic diagram.



(a) (b)

Figure 233. Radio Transmitters BC-696-A, BC-457-A, and BC-458-A, and Modulator BC-456-B.

circuits set up at the push buttons in the following manner:

(1) When the transmit-receive switch is in the forward or transmit position, the following circuit connections occur:

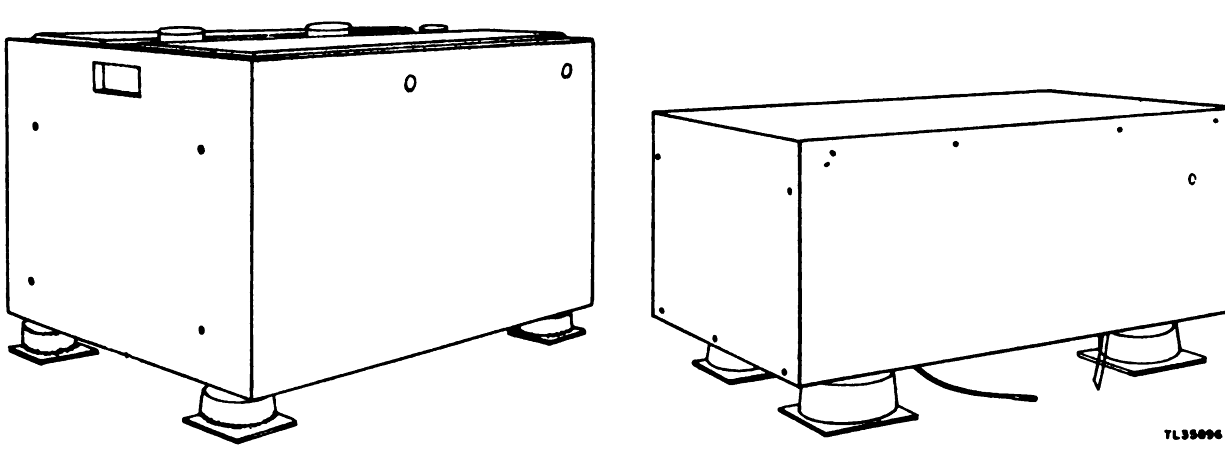
(*a*) The transmit pilot light is lighted at the controller's position only.

(*b*) The key circuit of the transmitter selected is closed. This connects the antenna to the transmitter and turns on the r-f carrier as indicated by the click of the relay and indicated on the HF by the reading of the antenna meter on the corresponding transmitter.

(*c*) The microphone is connected to the transmitter audio input.

(d) The side-tone circuit connects the operator's headphones with his microphone.

(2) When the transmit-receive switch is in the center or receive position, the following circuit connections occur:



(a) (b)

Figure 234. Transmitter-Receiver Assembly and Dynamotor Unit PE-94-A or PE-98-A.

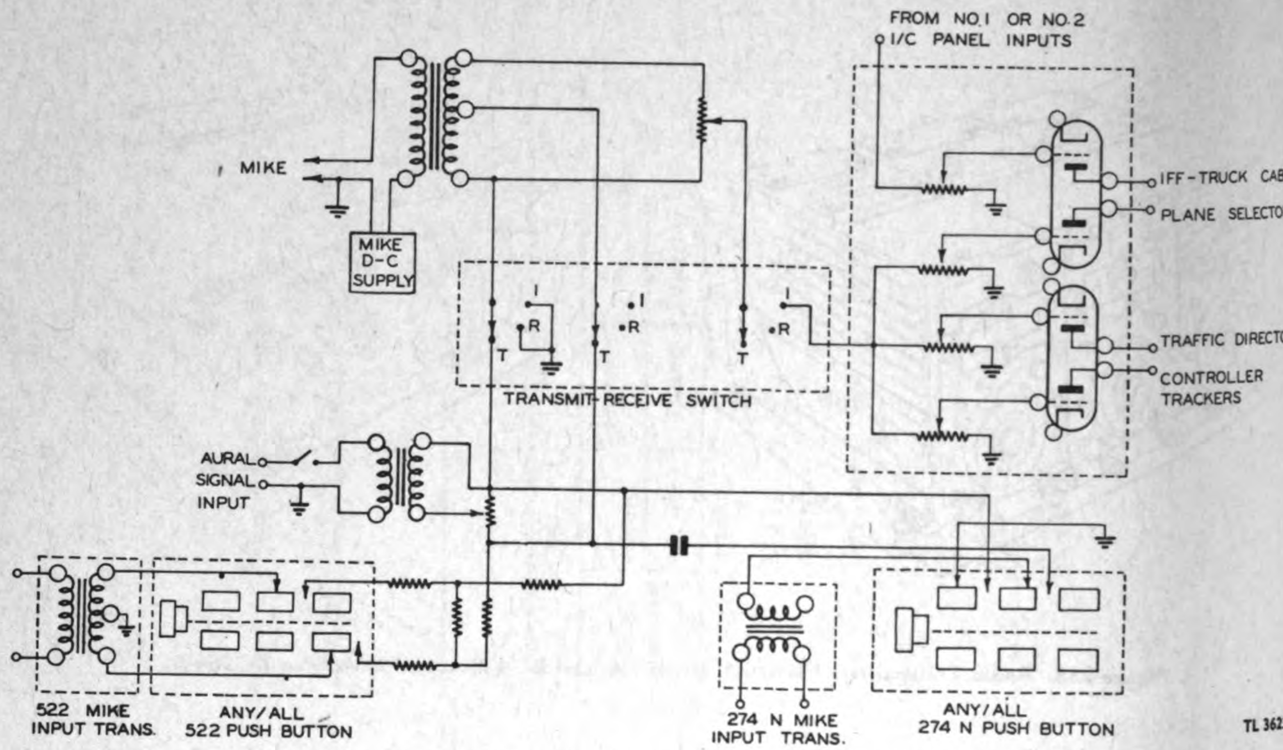


Figure 235. Microphone input and intercommunications amplifiers, simplified schematic diagram.

(*a*) The receive pilot light is lighted on the controller's position only.

(*b*) The transmitter key circuit is open, connecting the antenna to the receiver and shutting off the transmitter's r-f carrier.

(*c*) The output of the microphone transformer is open-circuited.

(*d*) The audio output of the receiver and the intercommunications output are connected to the headphones.

(3) When the transmit-receive switch is held back in the intercommunication position, the following circuit connections occur:

(*a*) The intercommunication pilot light is lighted on the controller's position only.

(*b*) The transmitter key circuit is open so the antenna is connected to the receiver and the r-f carrier is off.

(*c*) The microphone transformer is connected to the intercommunications input.

(*d*) Only the intercommunications output is connected to the headphones.

NOTE: While talking on intercommunications, the operator cannot hear an aircraft which calls him during that time.

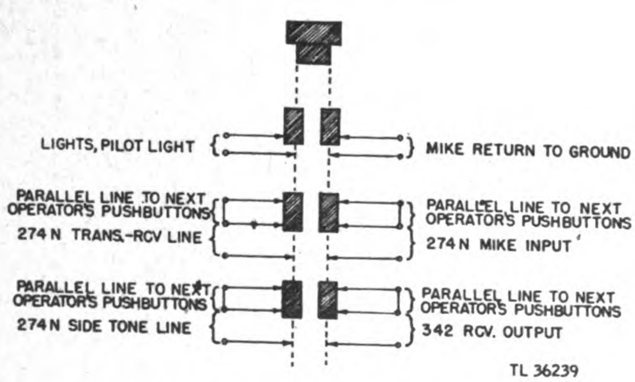


Figure 236. Typical HF channel push-button diagram.

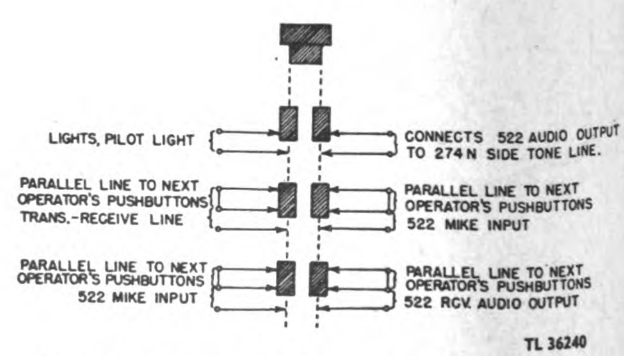


Figure 237. Typical VHF channel push-button diagram.

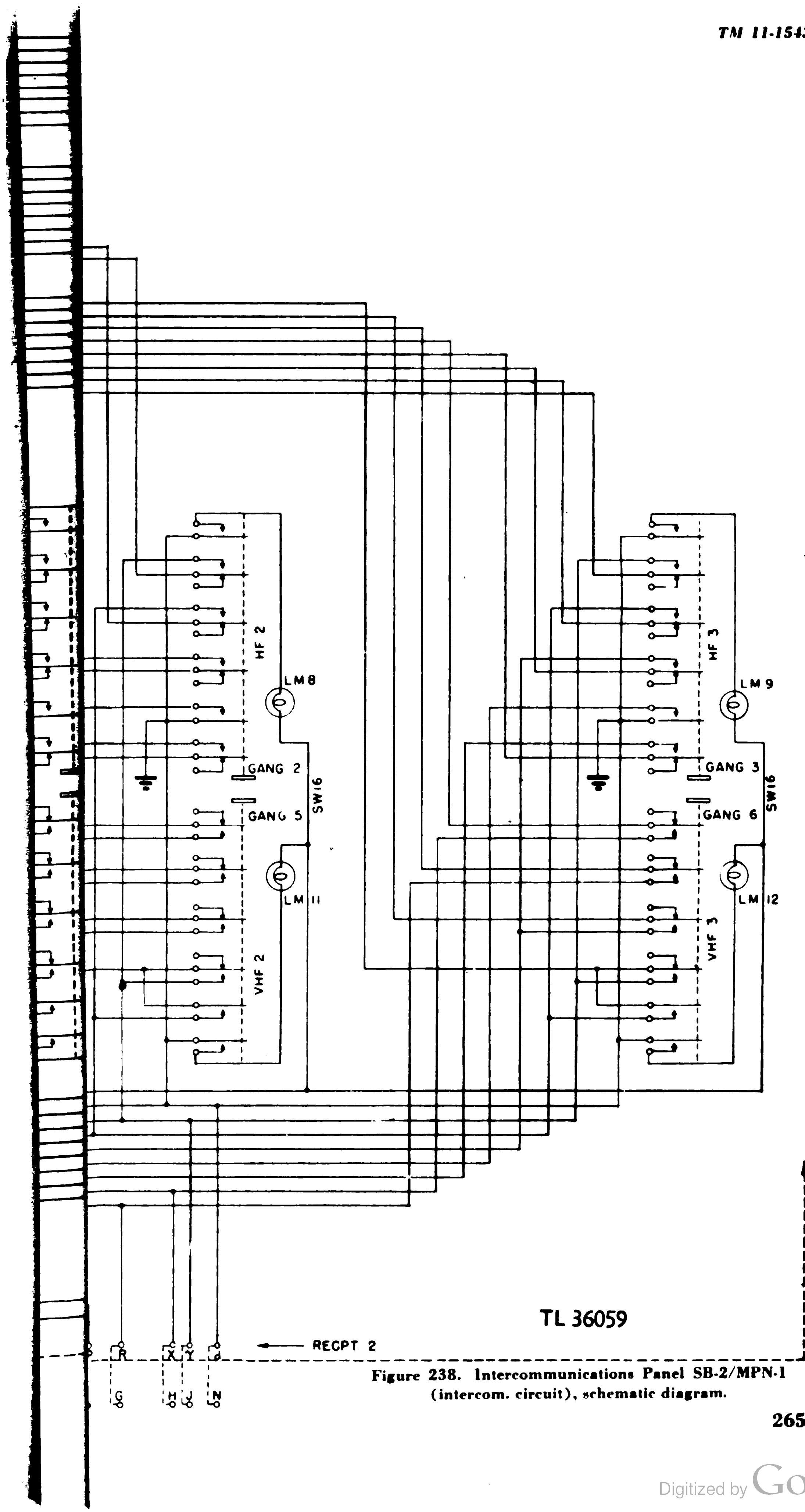


Figure 238. Intercommunications Panel SB-2/MPN-1 (intercom. circuit), schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
LM1	Western Electric #2F		
LM2	Western Electric #2F		
LM3	Western Electric #2F		
LM4	Western Electric #2F		
LM5	Western Electric #2F		
LM6	Western Electric #2F		
LM7	Western Electric #2F		
LM8	Western Electric #2F		
LM9	Western Electric #2F		
LM10	Western Electric #2F		
LM11	Western Electric #2F		
LM12	Western Electric #2F		
SW13	Kellogg #1001		
SW14	Kellogg #1001		
SW15	6-Gang-Oak Mfg #26414-130		
SW16	6-Gang-Oak Mfg #26414-130		
SW17	3 Amps	250 V-C-H #8373	
RECPT 1	AN3102-28-12P		
RECPT 2	AN3102-28-12S		

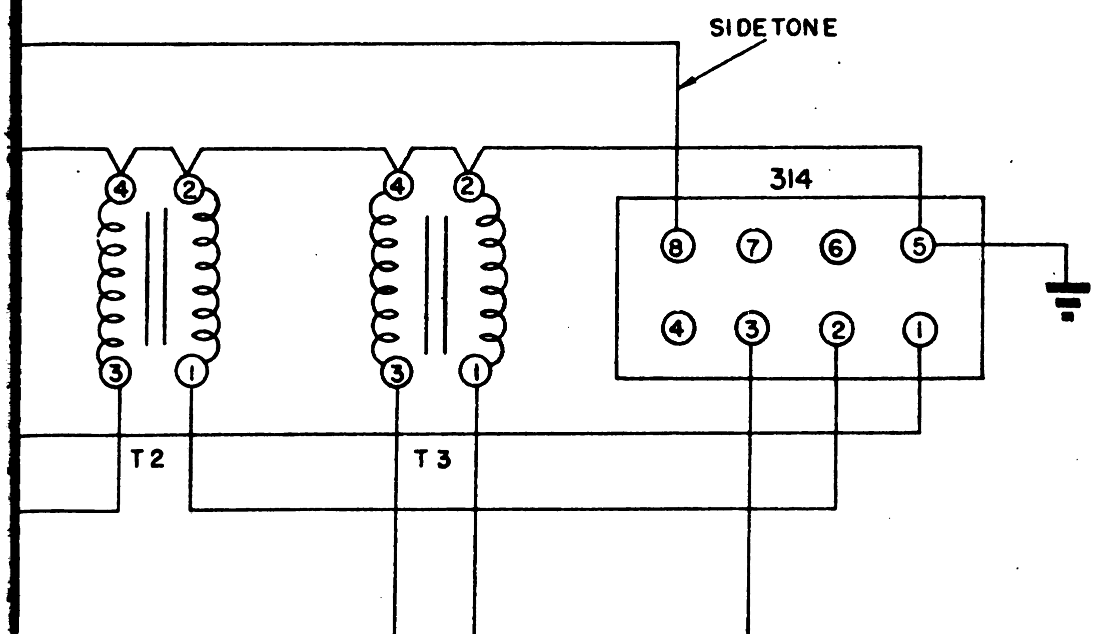


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Figure 239. Headphone Matching Assembly CU 46/MPN-1, schematic diagram.

Symbol Designation	Description
	Audio Matching Trans.
T1	Type 15-3456
T2	Type 15-3456
T3	Type 15-3456
RECPT 1	AN-3102-14S-5S Receptacle

b. Push-button Controls. The three sets of COMMUNICATIONS CHANNEL SELECTOR push buttons are wired similarly to complete a normal circuit to the communications equipment from the operator's push-to-talk switch (fig. 231). The following circuits are connected when a push button is pressed in:

(1) The operator's microphone output to the transmitter audio input.

(2) The operator's headphones to the receiver audio output.

(3) The transmit-receive key line to the communications equipment antenna relay and control line.

(4) The operator's headphones to the transmitter side-tone monitor output.

(5) The channel indicator light circuit is completed. Note in figures 236 and 237 that the parallel line circuits to the next operating station are shorted. The connecting wires have also been removed, so that each selector operates independently, without any interlocking control.

99. CIRCUITS.

a. Intercommunications Circuits. In the INT. COM. position of the key, the microphone transformer secondary is connected to the grid inputs of the intercommunications amplifier stages, which are in parallel (fig. 235). Gain control is provided by using variable potentiometers as grid resistors. The outputs are applied through transformers to the headphone input contacts in the key. The approach controller's, the azimuth tracker's, and the elevation tracker's headphones are supplied from one output; their receiving and monitoring circuits are similarly in parallel. The traffic director and plane selector headphones are supplied from separate outputs. A separate audio circuit, with output to the external intercommunications outlet in Junction Box J-31/MPN-1, has its grid circuit driven from either the traffic director or the plane selector microphone input. A selector switch and two selector keys on the intercommunications panel complete this circuit to either position.

b. Impedance Matching Circuits. (1) Microphone and aural signal (input) and headphone (output) circuit impedance matching is required because the standard controls and communications sets have not been altered to permit interchangeability with depot stocks. The method used is partially illustrated in figure 235.

(2) For voice transmission, a transformer is used to match each microphone input circuit to:

(*a*) An SCR-522-A, having a 200-ohm input circuit, designed for a dynamic microphone having approximately –40-db level.

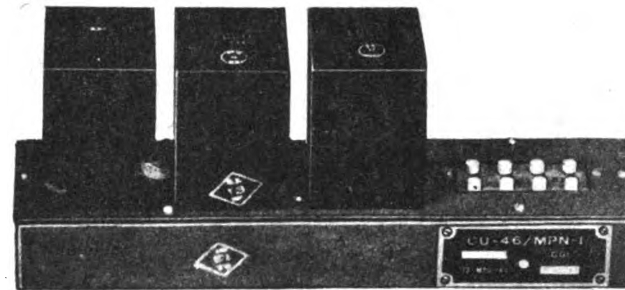

Figure 240. Headphone Matching Assembly CU 46/MPN-1.

(*b*) An SCR-274-N, designed for a 200-ohm input circuit, using a carbon microphone having a 0-db reference level.

(*c*) An intercommunications circuit, of high input impedance, feeding the grids of the intercommunication amplifier tubes.

(3) The microphone current is taken from a 24-volt d-c supply, and is limited to a safe value by a dropping resistor in series with the microphone transformer. This resistor is bypassed in order that no audio voltage be lost across it.

(4) Each microphone transformer secondary has a high impedance winding which feeds the intercommunication amplifier. This winding is tapped to provide a 500-ohm output circuit, to feed either the SCR-274-N microphone input circuit, or an attenuator network in the SCR-522-A microphone input circuit. The SCR-522-A attenuator

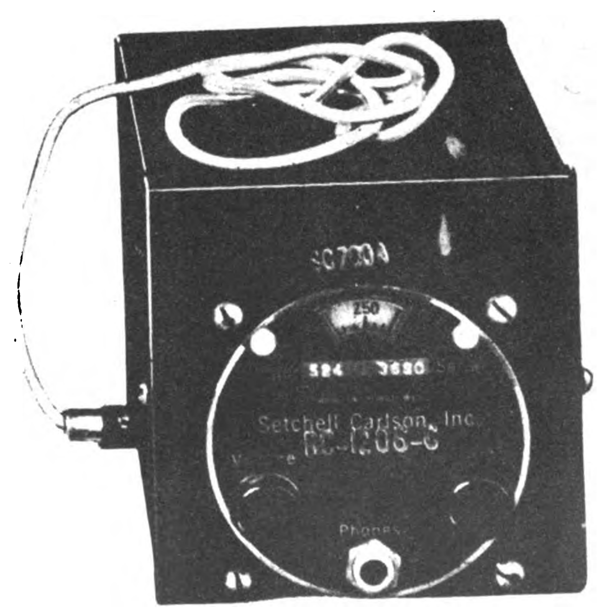

Figure 241. Tower Receiver BC-1206-C, front view.

Figure 242. Tower Receiver Control Box C-140/MPN-1, front view.

reduces the microphone voltage to a small fraction of its original value. This is done in order not to overload the input tube in the SCR-552-A.

(5) The aural signal transformer has approximately a 500-ohm output impedance and delivers sufficient audio signal to modulate either the HF or VHF transmitter selected. The level of the modulation is adjustable so voice modulation can be used at the same time. The aural signal transformer secondary is paralleled at all times with the controller's microphone transformer secondary. By depressing the aural signal switch, the primary circuit of the aural signal transformer is closed.

(6) The headsets used are 300 ohms at 400 cycles. The SCR-522-A has output taps of 50, 300, or 4,000 ohms impedance, and the 300-ohm winding is used in this hookup. Any sets received from depot stocks should be checked to make sure the 300-ohm tap is used. Matching of the SCR-522-A output with standard headsets is satisfactory.

(7) The BC-342-N output impedance is 4,000 ohms at 400 cycles, and a better match is required for optimum output to the headsets. This is accomplished by an impedance matching transformer with a ratio of 4,000 to 300 ohms. From this point, the circuits can be brought out to the operator's earphones without mismatch problems. These transformers of Headphone Matching Assembly CU-46/MPN-1 (figs. 239 and 240) are mounted physically in bay 5 of the indicator rack behind the top Radio Receiver BC-342-N.

100. INTERFERENCE PROBLEMS. Interference with the reception of the BC-342-N units by the radar system may prove serious. If such a difficulty occurs, provisions have been made for the use of a portable tripod antenna set up at some distance from the trailer. A coaxial termination in Junction Box J-30/MPN-1 is provided for coupling. From this coupling about 80 feet of coaxial line is brought out to an antenna position. A coaxial line has been brought from the connector on the junction box to bay 5 of the indicator rack, so that if necessary, the BC-342-N receivers may be paralleled off the line and fed from the same external antenna. This emergency line normally is not connected. The regular antennas are disconnected when the emergency antennas are used. The remote antenna box is connected as indicated in figure 228.

101. TOWER COMMUNICATION RECEIVER SYSTEM. The tower communication receiver system consists of Tower Receiver BC-1206-C (figs. 241 and 244), Tower Receiver Control Box C-140/MPN-1 (figs. 242 and 245), Observer's Control Box C-139/MPN-1 (figs. 243 and 246), and Rectifier Power Unit PP-100/MPN-1 (fig. 221) for Tower Receiver BC-1206-C. The function of the tower receiver is to monitor the tower transmitter, thus enabling the AN/MPN-1 and the tower to coordinate their operations.

a. Tower Receiver BC-1206-C is a conventional superheterodyne circuit arranged so that AVC will prevent over-

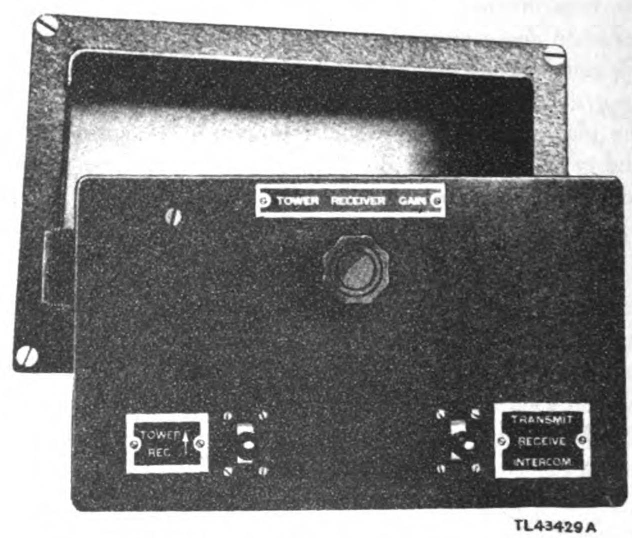

Figure 243. Observer's Control Box C-139/MPN-1, front view.

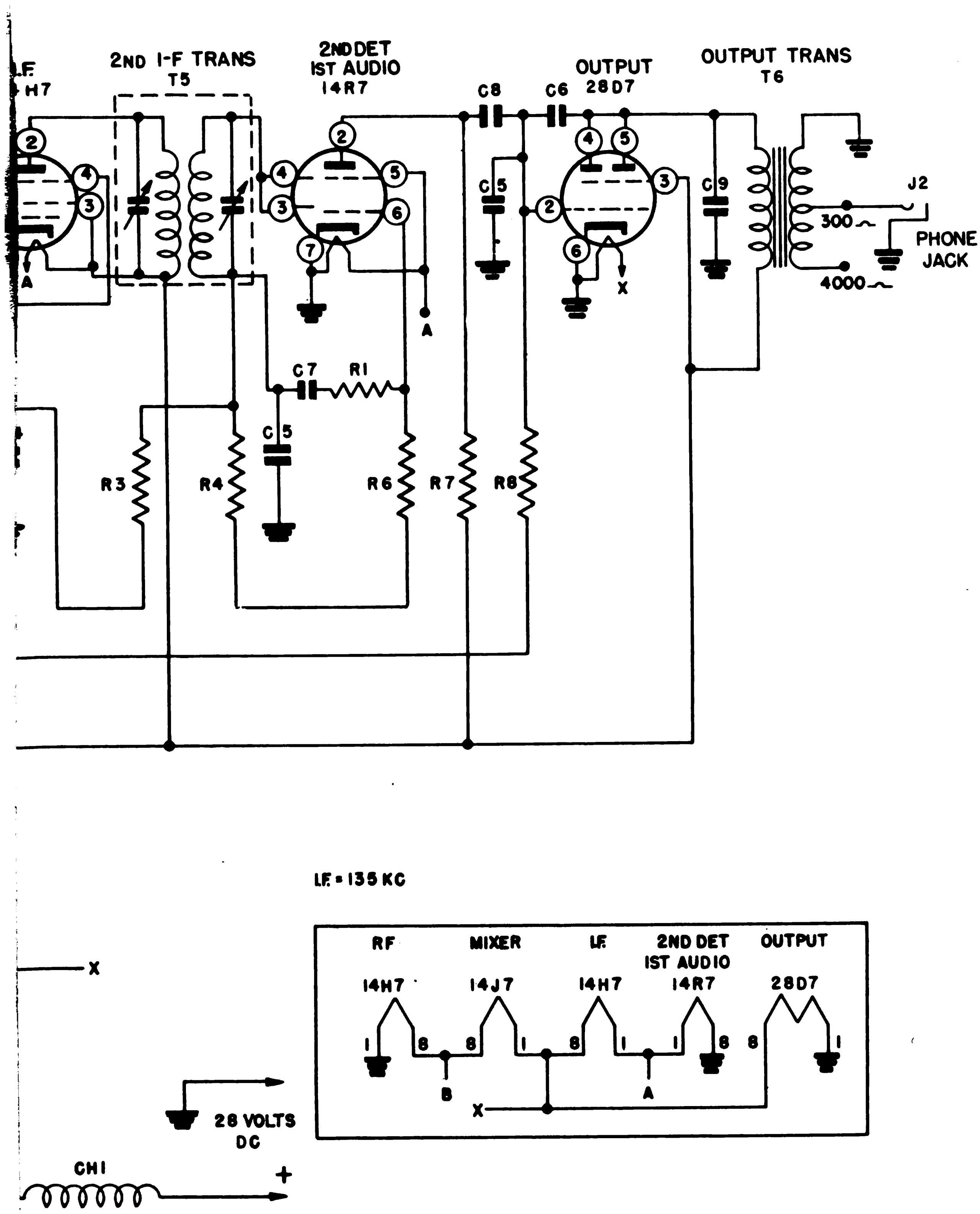

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Figure 244. Tower Receiver BC-1206-C, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
C1	.05 mfd	200	
C2	.25 mfd	200	
C3	350 mmfd	300 to 500 mfd	
C4	.05 mfd	200	
C5	.00025 mfd		Mica
C6	.0001 mfd		Mica
C7	.006 mfd	400	
C8	.006 mfd	400	
C9	.006 mfd	400	
C10	.5 mfd	200	
C11	.5 mfd	200	
CH1	Choke	No. 16 Wire	
CH2	Choke	No. 16 Wire	
J1	Antenna socket		
J2	Phone jack		
R1	100,000	1/3	
R2	25,000	1/3	
R3	1 Meg	1/3	
R4	500,000	1/3	
R5	500,000	1/3	
R6	2 Meg	1/3	
R7	75,000	1/3	
R8	500,000	1/3	
SW1	Off-on switch		
T1	Antenna Coil		
T2	RF Coil		
T3	Oscillator Coil		
T4	1st IF Coil		
T5	2nd IF Coil		
T6	Output Transformer		
VR1	100,000	2	

Symbol Designatio
R1
R2
P1
P2
SW1
SW2
SW3
Recpt 1
Recpt 2

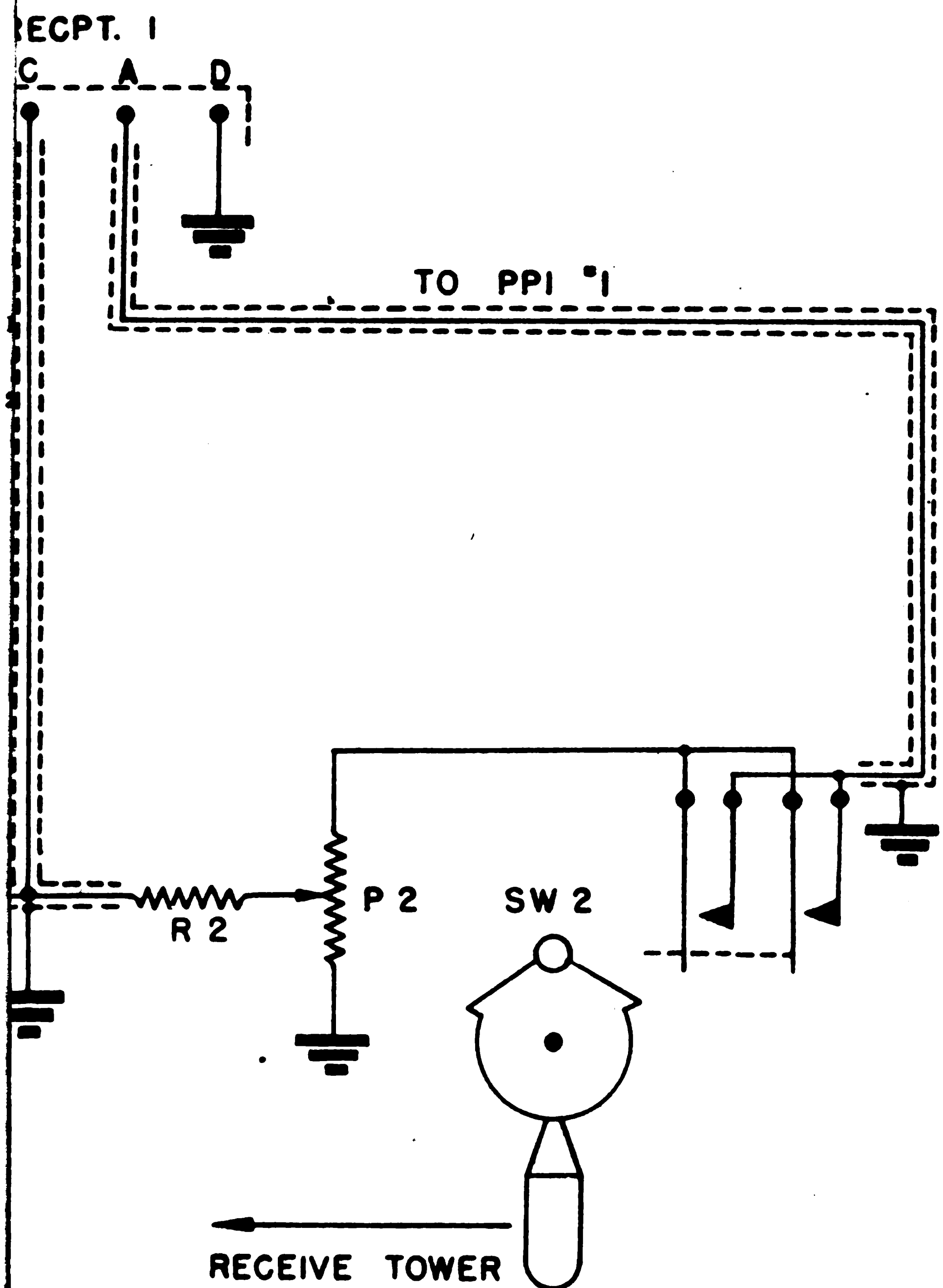

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Figure 245. Tower Receiver Control Box C-140/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	1,000	1 W	10%
R2	1,000	1 W	10%
P1	10,000	2 W	20%
P2	10,000	2 W	20%
SW1	Key Switch	Type Kellog No. 1001	
SW2	Key Switch	Kellog No. 1001	
SW3	Toggle Switch	A-H&H 80607-AB	
Recpt 1	Receptacle AN-3102-14s-2S Amphenol		
Recpt 2	A.C. Receptacle 61-M-10 Amphenol		

N-1,

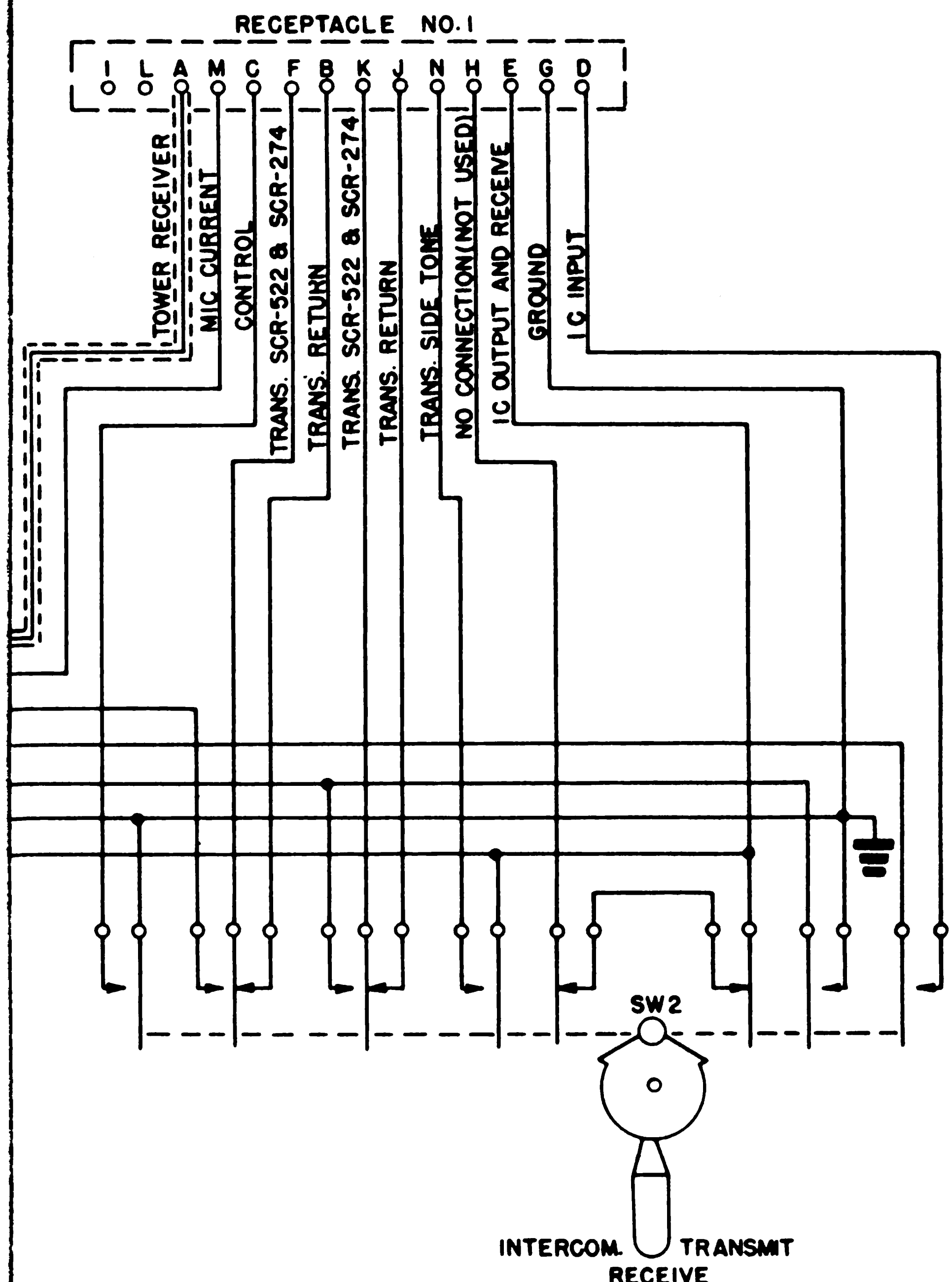

Figure 246. Observer's Control Box C-139/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	200	2	10%
R2	100	1	10%
R3	1,000	1	10%
P1	100,000	2	20%
P2	10,000	2	20%
C1	40 mfd	150	+50% −10%
SW1	Kellog #1028		
SW2	G.B. No. COO-13969 Key Switch Assembly		
T1	15-3443		
J1	JK-33H		
Recpt 1	AN-3102-20-1S		

loading on strong signals. The manual volume control is in the cathode circuits of the r-f and i-f tubes and controls the gain of the receiver. The receiver operates directly from 26 volts which is supplied from Rectifier Power Unit PP-100/MPN-1. No high-voltage supply is necessary as 26 volts is all that is required for A, B, and C supply. The PP-100 is fed from circuit breaker SW13 of the power distribution panel. Further information is furnished in the Instruction Manual, Beacon Receiver BC-1206-C accompanying the unit.

b. Tower Receiver Control Box C-140/MPN-1 is located below the desk in bay 5, directly under the intercommunication panel. Either or both of the search system operators may receive the tower by pushing switches SW1 and SW2 in the direction of the arrow on the tower control box. Volume may be regulated by the corresponding gain control potentiometer. Search antenna motor switch SW3, in the center of the tower receiver control box, is not part of the communication system.

c. Observer's Control Box C-139/MPN-1 is located in the top of the observer's desk. It has two keys; one for transmit, receive and intercommunication; and one to receive the tower receiver. The transmit-receive-intercommunication key is in parallel with the controller's key and takes over from the controller when in the transmit position. When the tower receiver key is pushed in the direction of the arrow, all other audio circuits are broken. The tower receiver volume is regulated by the gain control located to the rear of the top panel. Below the desk top in the front of Observer's Control Box C-139 there is located a headphone-microphone jack and an intercommunication input gain control which normally should be left in full ON position.

SECTION IV

HYDRAULIC LEVELING SYSTEM

102. DESCRIPTION. In order that the precision system antennas may scan in their proper horizontal and vertical planes, it is necessary that the trailer be tilted slightly to the correct angle and kept at this angle during the operation of the radio set. Hydraulic Leveling System MX-34/MPN-1 provides such a means of controlling the tilt angle of the trailer, in addition to affording a stable base for the trailer when it is in operating position. The system is a permanent part of the trailer body assembly, with the controls operated from inside the trailer.

103. OPERATION OF SYSTEM.

a. Connection of Components. Power for the system (fig. 247) is furnished by a 1,725-rpm motor (M), activated through a start-stop switch by the 117-volt a-c line. This motor drives a pump (P) through a one-to-four ratio reduction gear (RG) which reduces the speed with which the pump is driven to 450 rpm. The pump, through a set of alternately opening and closing valves, pumps the hydraulic fluid (oil) into the master valve unit (MV). The master valve unit, located on top of the sump tank (ST), has a master lever (ML) on one side which controls the raising and lowering process, and two pipe openings, A and B, on the top. The breather pipe and cap openings on the master valve unit connect to the sump tank and act as an escape valve for excessive pressure. The pipe connection to opening A branches out through four jack control valves (V1, V2, V3, and V4) to supply a path for the flow of the hydraulic fluid to the top of the corresponding hydraulic jack cylinder (J1, J2, J3, or J4) located at each corner of the trailer. The lower opening of each corresponding cylinder is connected directly to the pipe opening B on the master valve unit.

b. Raising Trailer. In raising or lowering the trailer, the jack control valve corresponding to the jack at the corner of the trailer to be moved must first be opened (turning counterclockwise opens). With the valve on the master lever pushed in, the fluid passes through the open jack control valve to the top of the corresponding jack cylinder, forcing out the jack plunger which in turn raises the trailer corner. At the same time, the fluid in the lower part of the jack cylinder is forced back through the lower pipe opening to opening B in the master valve unit, and through the double-acting valve (D) to the sump tank. When the trailer corner has been raised sufficiently, releasing the master lever will stop the operation of the jack and will automatically return the master lever to the neutral position.

c. Lowering Trailer. To lower the trailer, the master lever valve must be pulled out and held in that position until the corresponding trailer corner has been lowered sufficiently. When lowering, the high-pressure path for the hydraulic fluid is reversed by means of the double-acting valve on the master valve unit. The fluid now goes from the high-pressure opening (HP) of the pump through the double-acting valve and through opening B to the lower chamber of the hydraulic jack cylinder. The fluid at the top part of the cylinder is forced out through the top opening of the cylinder back through the opened jack control valve. The fluid returns through opening A which is now connected to the sump tank in the low-pressure side of the system by the double-acting valve.

d. Improvements. (1) With all four jacks properly adjusted, and the trailer in the operating position, the two spirit levels in the hydraulic well will indicate a level

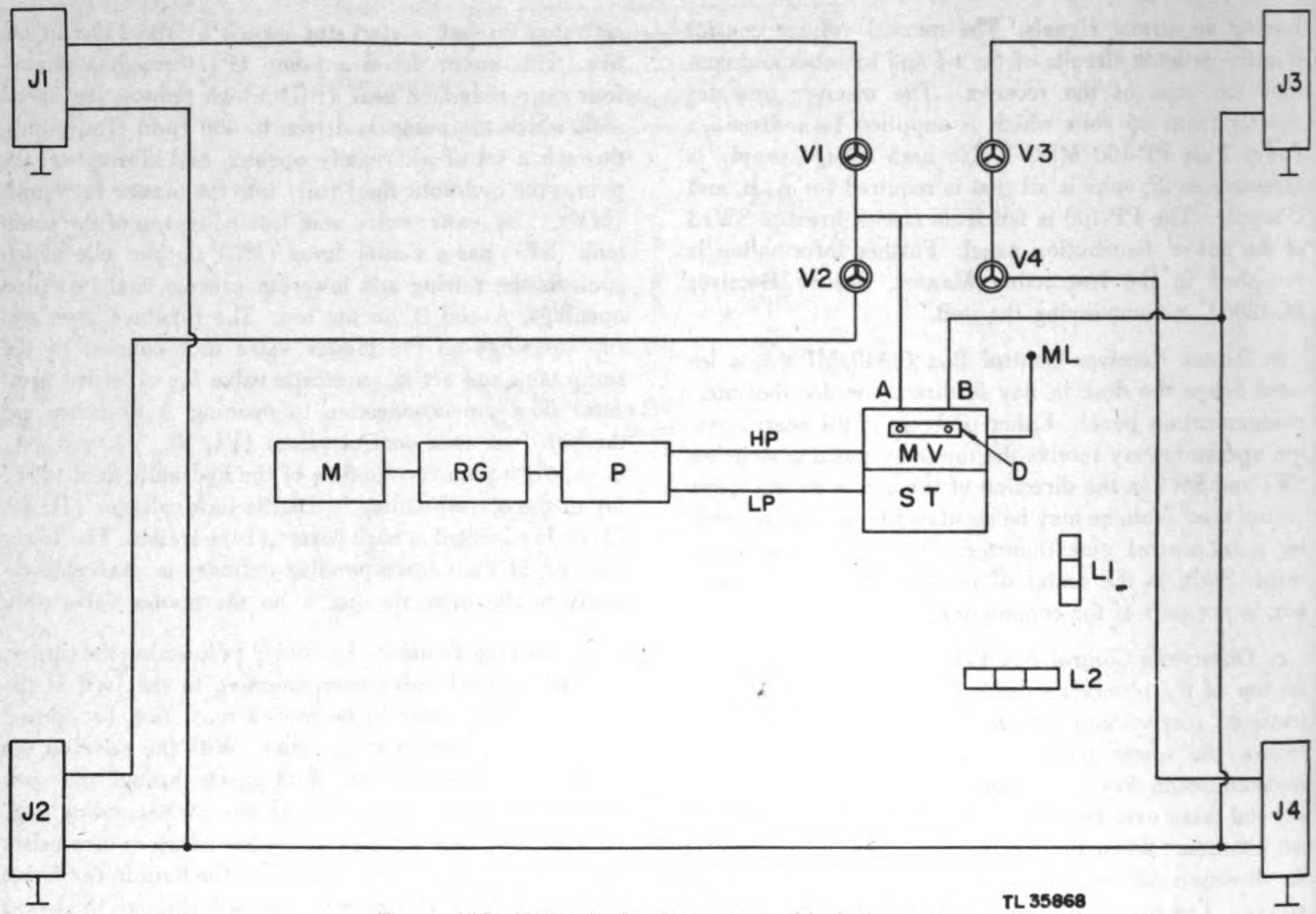

Figure 247. Hydraulic leveling system, block diagram.

position as they have been previously adjusted to the correct tilt (2 degrees) required.

(2) A switch and light assembly supplies sufficient illumination for reading the spirit levels and for the operation of the valve controls. This light is located in the hydraulic well itself.

SECTION V

AIR CONDITIONER

104. PURPOSE. Air Conditioner MX-31/MPN-1 has been provided to insure operator alertness for the efficient functioning of Radio Set AN/MPN-1. The air conditioner is a cooler and dehumidifier unit which provides comfortable operating conditions of constant temperature and humidity within the enclosed trailer. For a general description of the air conditioner see paragraph 15 of the Technical Operation Manual, TM 11-1343. A brief discussion of the theory of operation follows below.

105. THEORY OF OPERATION.

a. General Principles. Air can hold but a certain amount of moisture at a given temperature. The amount it does contain, expressed as a percentage of its total capacity at that temperature, is called its relative humidity. The warmer the air the more moisture it can hold, and vice versa. Thus, if air with a certain amount of moisture is warmed and no moisture is added, its relative humidity drops because the amount of moisture that the air can hold has been increased by raising its temperature. On the other hand, cooling the air reduces the amount of moisture it can hold, hence its relative humidity. The dew point of air is the temperature at which, in the process of cooling the air, it reaches 100 percent relative humidity or saturation. When cooled beyond that temperature the air cannot hold all the moisture, so the excess precipitates out of the air as dew or fog. In the air conditioner unit it is condensed on a cold evaporator coil just as drops of water form on a glass of ice water. The process of condensing moisture out of the air by cooling it below its dew point is called dehumidification. Note that air must be cooled to dehumidify it. When the air is dehumidified, it leaves the evaporator coil at about 100 percent relative humidity. However, when this air is blown into the space being air conditioned, it absorbs heat from the enclosed area, reducing its relative humidity as its temperature rises. Thus there must be two major flows within the air conditioner system. One circuit provides for the cooling, dehumidification, and circulation of air; the other circuit provides, through circulation of a refrigerant, for removing heat from the air and dissipating it.

b. Conditioned Air Circuit. From the output of the air conditioner unit, conditioned air is forced through a 10-inch circular canvas duct to a vent near the top of the front trailer wall. From this vent, over Communications Rack MT-121/MPN-1, the air is guided through a transformation chamber. From here it flows into the interior of the trailer through a vent on the ceiling. At this point the air has sufficient force to carry it throughout the trailer. By means of grilles in the bottom compartment of the same communications rack, exhaust air escapes through a circular vent in the front trailer wall and thence through a canvas duct to the return air duct connection of the air conditioner unit. Fresh outside air can be added to the circuit at the return to the air conditioner. All the return and outside air passes through a filter composed of woven wire mesh coated with oil to which dust adheres, assuring that clean air will be supplied to the trailer. From the filter the air is forced through the supply air duct and the cycle is repeated.

> NOTE: As the filter becomes dirty it loses its dust-holding capacity. The air flow is thus restricted and the conditioning capacity of the system is reduced. For frequency and details of cleaning the air filter, see the Preventive Maintenance Manual TM 11-1443.

c. Refrigeration System. The refrigeration circuit is entirely within the air conditioner. Liquid refrigerant (Freon 12) is fed into the tubes of an evaporator coil, over which passes the air to be cooled. The heat absorbed by the refrigerant in this process of cooling the air makes the liquid boil or evaporate into a gas, which is sucked into a compressor unit and pumped from it into a condenser. Air (in a separate circuit from the conditioned air circuit) is drawn through the condenser, takes heat from the compressed refrigerant, and discharges the heat externally. As the refrigerant gas inside the condenser tubes loses heat, it condenses to a liquid and flows into a receiver to accumulate. An expansion valve meters the flow of the liquid refrigerant from the receiver to the evaporator coil, automatically adjusting the flow to the cooling demand.

CHAPTER 5

SUMMARY OF THEORY

SECTION I

COMPLETE BLOCK DIAGRAM

106. PURPOSE OF DIAGRAM.

a. The block diagram of Radio Set AN/MPN-1 shown in figure 248 is a complete functional presentation of the electrical circuits of the equipment. Following the separate descriptions of the circuits given in the preceding chapters, it shows the relationship of these circuits and their individual functions in the over-all operation of the equipment.

b. The block diagram is ideal to use while making a quick review of the operation of the equipment, or when instructing others in the broad details of its performance. Also, while trouble shooting, it enables the radar officer or technician to follow the course of a signal from circuit to circuit without having to bother with the detailed circuit tracing which would be necessary if the schematics were used. Thus, when trouble is suspected in an individual circuit, reference can easily be made to the proper schematic and trouble-shooting data to accurately locate the source of trouble.

107. USE OF DIAGRAM.

a. Figure 248 shows the various circuits of each component as blocks marked with the name of the circuit. A chassis or major component is represented by a large block, and the circuits within it are represented by smaller blocks. Interconnections have been simplified and are indicated by solid lines with arrowheads which show the direction in which the signal is progressing. When the signal leaves a major component, and the line is opposite one of the smaller blocks within that component, the signal comes from the circuit identified by the smaller block. Also, when the circuit is shown to enter a major component opposite a smaller block, this indicates that the signal is applied to the circuit represented by this block.

b. The a-c distribution system as well as all d-c power supplies, both external and internal, have been omitted from the block diagram in order to simplify it. Also, filament connections and d-c connections within the various units have been left out for the same reason. As the purpose of this diagram is to emphasize the functional or signal-carrying connections, any other connections which might confuse the diagram and defeat its purpose have not been included.

c. As a safety measure, a great many of the radio set components have been included in duplicate. In the case of equipment failure during operation, this system provides for a rapid change-over from an inoperative to an operative channel. However, to reduce the complexity of the block diagram, only one channel (A) is shown of all duplicated components. Any component having the symbol "A" used in conjunction with the name of the component is provided in duplicate.

d. Points throughout the circuits at which important waveforms exist are numbered. All these waveforms are shown along the right-hand side of the block diagram. In order to find what signals appear at any particular numbered point, refer to the waveform with the same number in the waveform list. Exercise caution in using these waveforms since they are theoretical values, and actual signals may vary slightly from those indicated. Also, due to physical limitations of space, it has been impossible to show all signals to the same timebase and amplitude scales.

SECTION II

SEARCH SYSTEM

108. PRIMARY FUNCTIONS. The search system must locate aircraft within range of the GCA equipment. Data must be presented in such a way that azimuth and range of all targets can be determined instantly. The PPI indicators fill this requirement by providing a circular radar map of the space covered by the search system. This information enables the GCA operators to control traffic of aircraft waiting their turn to land and bring one ship at a time to a place where the precision system takes over

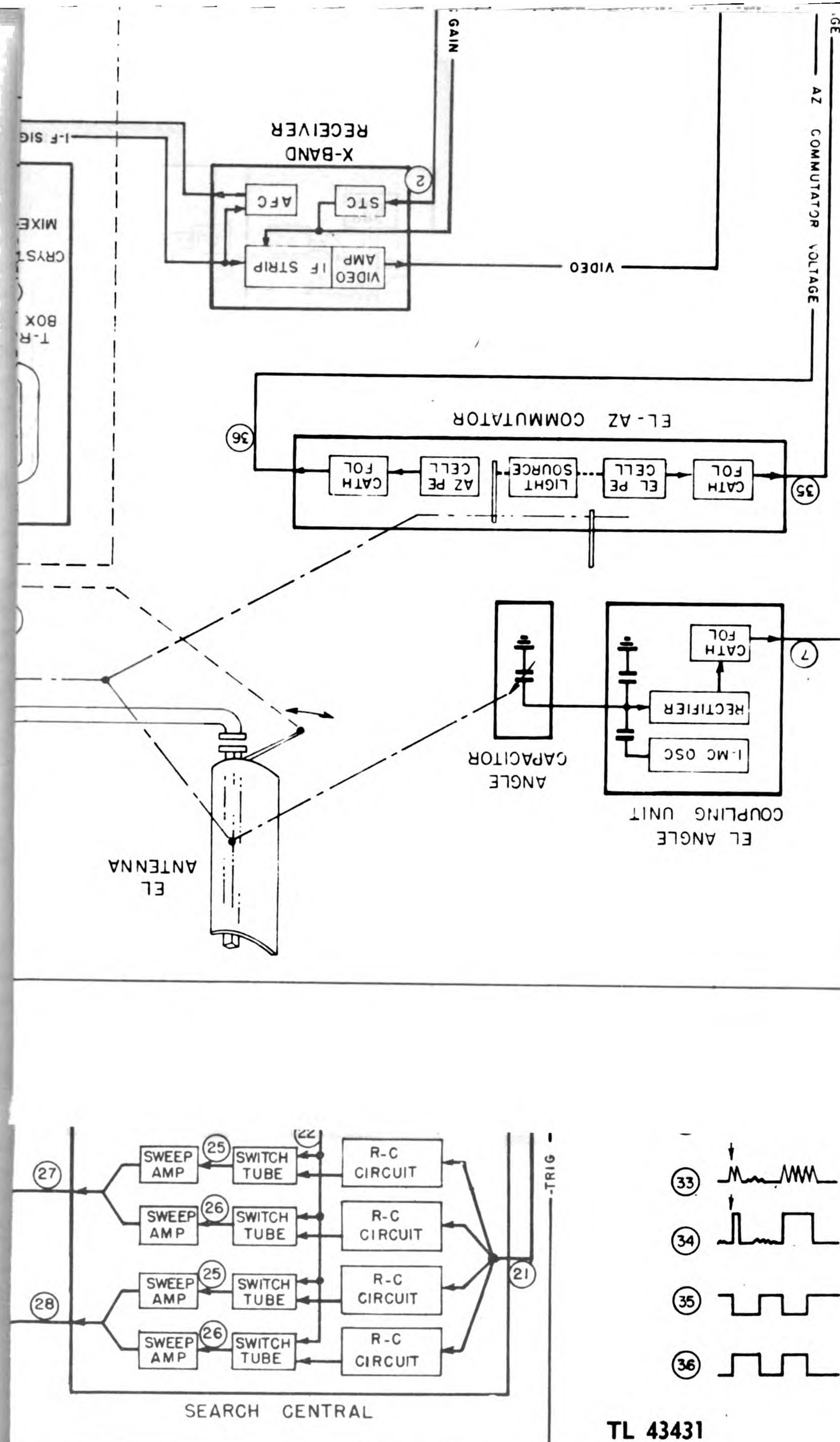

Figure 248. Radio Set AN/MPN-1, complete block diagram.

for the actual landing approach. As a safety measure to prevent failure of the system during landing operations, the transmitting and receiving equipment has been duplicated, providing two channels, either of which can be used. The brief analysis that follows reviews the functions of the search system components.

109. TRANSMITTING SYSTEM.

a. A positive trigger pulse from the synchronizer is applied to the grid of the modulator driver tube (fig. 248). This tube is a blocked oscillator controlled by a delay line, or network, which limits the time of conduction and consequently the output pulse to 0.5 microsecond.

b. The short positive output pulse from the driver tube is coupled through a special pulse transformer to the grids of two pairs of switch tubes. One pair of switch tubes connects a high-voltage capacitor circuit, charged to about 15 kv, across the magnetron oscillator of the search transmitter. The second pair of switch tube pulses the magnetron oscillator of the precision transmitter.

c. This negative high-voltage pulse from the modulator is applied to the magnetron and causes ultra-high-frequency oscillations to take place at considerable power within the magnetron. The frequency of oscillation is determined by the physical characteristics of the tube and oscillations take place only during the 0.5 microsecond period that the high-voltage pulse is applied. A coupling loop inserted into the magnetron cavity transfers the magnetron power to a transmission line connecting with the antenna system.

110. RADIO FREQUENCY SYSTEM.

a. The output of the magnetron oscillation is coupled to the rectangular brass waveguide section which feeds the search antenna by a short length of coaxial line. Wherever waveguide sections are joined together, loss is prevented by a choke joint. This joint has a slot cut in its base in such a manner that it presents a high impedance to r-f leakage.

b. A short S-shaped section of waveguide within the transmitter compartment connects the output of the magnetron transmitter assembly to the waveguide transmission line leading to the search antenna. This S-shaped section of waveguide is rotated by the r-f channel switching motor. It comes to a stop directly over the waveguide terminating section of either the channel A or channel B magnetron oscillator; whichever is in operation at the time.

c. The rectangular waveguide transmission line runs from the transmitter rack along the roof of the trailer to the search antenna drive mechanism. At this point the waveguide terminates into a coaxial line which goes up through the hollow shaft that rotates the search antenna. A special sealed rotary joint in this section of coaxial line permits the antenna to rotate. This coaxial line connects directly to the antenna array assembly.

d. The antenna array is mounted vertically and consists of 33 dipoles set from a rectangular section of waveguide. The array is backed by a semicylindrical reflector of parabolic cross-section and produces an antenna pattern which is flat-topped at approximately 4,000 feet in altitude. Scanning is accomplished by mechanically rotating the whole antenna assembly in azimuth at approximately 30 rpm. The sine potentiometer is geared to the search antenna and furnishes voltages that synchronize the rotating sweep on the PPI indicator tube with the rotating antenna.

e. Received echo signals travel back toward the transmitter, and as they are not strong enough to ionize the gas tube in the T-R box, the signals effectively go through the T-R box into the crystal mixer. The length of coaxial transmission line between the T-R box and the magnetron is such that it presents a high impedance to the echo signal. Therefore, almost all of the energy takes the path into the T-R box.

111. RECEIVING SYSTEM.

a. The incoming signal from the antenna is mixed with the output of the local oscillator in the crystal mixer unit. The crystal detector, a rectifier, is in series with the center conductor of the coaxial line. The local oscillator is tuned to a frequency 30 megacycles above the transmitter frequency to produce an i-f frequency of 30 megacycles. To assure that the i-f frequency is kept constant, at 30 megacycles, the AFC circuit in the receiver regulates the voltage applied to the reflector plate of the klystron local oscillator tube. This automatically corrects the local oscillator frequency to produce a constant i-f frequency.

b. The i-f frequency output from the crystal mixer is fed to the preamplifier unit, which consists of two stages of low gain i-f amplification. The preamplifier output goes to the receiver proper.

c. The receiver has an additional five stages of i-f amplification, a second detector, and a video amplifier. The video output passes through RY (relay) 1 on the intercommunications panel before being applied to the grids of the search indicators. RY 1 is in the channel switching circuit and connects either the channel A or the channel B receiver to the PPI indicators.

d. The AFC circuit in the receiver taps off a small portion of the i-f input and develops a voltage which is proportional to the frequency of the incoming signal. This voltage is used to regulate the negative bias applied to the repeller plate of the local oscillator.

e. See addenda for the latest information concerning the STC circuit in connection with its use in the search system.

112. INDICATING SYSTEM.

a. There are two identical PPI indicators used in the search system; one used by the traffic director and the other used by the plane selector. Both indicators are in operation regardless of which channel is being used. These indicators produce a radar map of the space scanned by the system and provide data on range and azimuth of all aircraft being handled by GCA.

b. Each indicator tube has a search central which supplies sweep voltage, intensifying voltage, range marks, and an identification strobe to the indicator tubes. The negative trigger pulse from the synchronizer triggers the gating multivibrator which provides both negative and positive square wave output pulses. The negative pulse actuates the sweep, range marker, and identification strobe circuit. The positive pulse supplies the intensifying voltage to the first anode of the cathode-ray tube.

(1) The sweep circuit consists of four RC charging networks, four switch tubes, and four sweep amplifiers. The output from the sine potentiometer is fed to the RC charging network. This circuit causes the sweep to rotate in synchronism with the search antenna by producing an output at points 25 and 26 (fig. 248) that is in time phase quadrature. The switch tubes are controlled by the gating multivibrator which thus determines start and stop of the timebase sweep.

(2) The range marker circuit is triggered from the negative output of the gating multivibrator. This sets a ringing circuit into oscillation which starts the formation of range markers. The oscillations from the ringing circuits are fed through two stages of amplification that function respectively to shape and invert the pulses. The output from the inverter amplifier is fed to a peaking circuit which shapes the pulses into the sharp pips needed for range marks. These range marker pips are mixed with the identification strobe pulses in the mixer of each search central and applied to the cathode of the CRT tube.

(3) The identification strobe circuit generates a marker pulse which has a variable position along the timebase sweep. The circuit is triggered from the negative output of the gating multivibrator. The leading edge of this pulse actuates the variable multivibrator in the strobe circuit which produces a position square wave output of variable width. The trailing edge of this variable square wave triggers the blocked oscillator causing it to go through one cycle of oscillation. The resulting sharp position pip from the blocked oscillator is mixed with the range marker pips in the mixer circuit before being applied to the cathode of the indicator tube.

(4) The blocking oscillator, cathode follower, and inverter stages shown at the top of each main search central block furnish an internal trigger to be used in place of that ordinarily supplied by the synchronizer. The internal trigger is useful when the search system is operated independently of the precision system, or for test purposes.

(5) The various outputs from the search centrals are applied to the PPI indicator tubes. These voltages, together with the video output of the search radar receiver, complete the requirements of the PPI indicators. With the exception of power supplies, all major components of the search system have now been described.

SECTION III

PRECISION SYSTEM

113. PRIMARY FUNCTIONS. As the name implies, the precision system supplies precise information on the location of approaching aircraft. When the antennas of the system are properly aligned with the runway, information presented on the indicators will locate any airplane in the field of approach with respect to a predetermined glidepath. This information enables the operators of the radio set to guide the pilot over a proper approach to the airfield runway. The following brief analysis of the various functional divisions of the precision system will indicate how this information is obtained.

114. TRANSMITTING SYSTEM.

a. A sharp positive trigger voltage from the synchronizer is applied in the modulator to the grid of the driver tube, a controlled blocked oscillator. A delay line, or network, which controls the time of conduction of the oscillator tube, limits the output pulse to 0.5 microseconds.

b. This short pulse is coupled through a special pulse transformer to the switch (output) tube. The switch tube in turn connects a charged capacitor across the magnetron producing a potential difference of about 12 kv between plate and cathode.

c. This causes ultra-high-frequency oscillations to take place with considerable power within the magnetron. These oscillations, at a frequency determined by the physical characteristics of the tube, continue during the 0.5-microsecond period in which the voltage is applied. A magnetic coupling loop transfers the power from the magnetron to the transmission line and antenna system.

115. RADIO FREQUENCY SYSTEM.

a. The transmission line leading from the magnetron to the antennas is made up of rectangular brass tubing or waveguide, known as r-f plumbing. Choke joints prevent losses between sections of the waveguide transmission line.

b. The transmission line leading from the magnetron has two branches, the first leading to the precision antennas and the second to the receiving system. The T-R box prevents loss of energy into the receiving system during the transmitted pulse.

c. The transmission line to the precision antennas is further branched, one branch leading to each of the precision antennas. The choke switch, operated by the switching motors, switches the r-f energy alternately from one antenna to the other. Each of the precision antennas is in use 50 percent of the time.

d. The precision antennas are multiple dipole arrays and, with a semicylindrical reflector of parabolic cross-section, produce a narrow fan-shaped pattern of radiation. Scanning of both antennas is accomplished by mechanical means,. and is also controlled by the motors on the switching unit. Switching and scanning are synchronized so that an antenna makes one scan during the time it is energized. The elevation antenna can be adjusted in azimuth and the azimuth antenna in elevation to keep an approaching target within the narrow sectors of the beams. These adjustments are controlled by the antenna follower assemblies at the indicator positions.

e. Received signals travelling back toward the transmitter are blocked from the magnetron by the R-T switch (sometimes known as an anti-T-R box). The T-R box no longer blocks the energy and the signal is now directed into the receiving system.

116. RECEIVING SYSTEM.

a. The incoming signal from the antenna is mixed with the output of the local oscillator which is fed into one end of the waveguide by a probe. The crystal mixer, a simple rectifier, is inserted across the waveguide. The local oscillator is tuned to a frequency 30 megacycles above the transmitted frequency, and a beat frequency of 30 megacycles is produced. An automatic frequency control circuit in the receiver controls the frequency of the local oscillator in the r-f unit.

b. This intermediate frequency signal is applied to the preamplifier, which consists of two stages of i-f amplification. The output of the preamplifier is fed to five stages of i-f amplification in the receiver.

c. A sensitivity-time-control circuit controls the gain of the first two i-f stages. This circuit varies the gain of the receiver with respect to time so that strong signals from near-by reflecting objects will not be amplified as much as the signals from far-away objects. This results in indicator signals of constant intensity for all ranges.

d. The video signal is produced by the second detector in the receiver and passed through a video amplifier to the synchronizer. Here the signal receives further amplification and is fed to the grids of the precision indicators.

117. SYNCHRONIZER.

a. The synchronizer is the timing device for both the search and the precision systems. A master (blocking) oscillator is located in the synchronizer and, together with associated amplifiers, produces both positive and negative trigger pulses. The positive pulse is fed to the modulator to trigger the transmitter system. The negative pulse is applied to the X-band sweep amplifiers and S-band search centrals to start sweeps and produce range marks.

b. The negative pulse actuates a range marker circuit which produces range mark pips at 2,500-foot intervals for the short range (2-mile) tubes and 10,000-foot intervals for the long range (10-mile) tubes of the precision indicators.

c. A signal known as an angle marker is generated for application to the indicator tubes. This marker appears as a radial line, radiating from the point representing the position of the radio set on the indicator displays, and is used in aligning the indicator tubes. Input to this circuit is from the angle coupling units.

d. Mixing circuits combine the range markers, the angle markers, and a variable range identification marker received from the search centrals (in the search system) for application to the proper indicator tubes.

e. Another circuit shapes the output of the photoelectric commutator into blanking voltages for alternately switching the two precision indicators on and off in synchronism with the antenna switching. Another part of the circuit varies the gain of the precision receiver at the same time that the output energy is switched from one antenna to the other and at the time the corresponding indicators are switched by the blanking circuits.

f. As explained previously, a circuit in the synchronizer amplifies the video output of the receiver and matches it to the indicator tubes.

118. INDICATING SYSTEM.

a. Three indicators are used with the precision system: namely the elevation, azimuth, and approach indicators. The actual signal from the airplane is viewed on the elevation and azimuth indicators. These indicators, when used in conjunction with their associated directors, provide information as to the actual distance that the airplane is deviating from the proper glidepath. This data is fed to the approach indicator and is read on the two meters in terms of actual feet of deviation.

b. The azimuth and elevation indicators each have two indicator tubes, one having a maximum range of 2 miles and the other, a maximum range of 10 miles. Range markers, angle markers, and the identification marker mixed in the synchronizer are all applied to the cathodes of the various indicator tubes. Video signals and intensifying pulses (intensifying and blanking done in conjunction with the precision antenna switching) from the sychronizer are applied to the grids of the various indicator tubes. The timebase intensifying pulse for brightening the electron beam during the sweep is applied to the first anode of the indicator tubes, while a d-c voltage of 4 kv is applied to the second anode. Focusing and sweeping of the electron beam are done electromagnetically.

c. Sweep voltages for the indicator tubes are provided by the sweep amplifiers, one pair (two channels) being provided for each indicator. Each sweep amplifier produces sweep voltages for each indicator tube, since the tube has two deflecting coils each producing a component of sweep at right angles to the other. The sweep for one of the coils is essentially constant while the sweep for the other varies from nearly zero to a maximum value, depending upon the output of the associated angle coupling units. The sweep amplifier also produces the intensifying pulse for brightening the electron beam during the sweep as mentioned above.

d. Each indicator has an associated director mounted directly below the indicator itself. Two phenolic maps (one for each of the associated indicator tubes) are mounted on the front panel of each director. A tracking cursor for following the path of the approaching airplane is placed across each phenolic map, and the position of the tracking cursors is controlled by a hand-operated wheel. The maps on the directors are placed at right angles to the faces of the associated indicator tubes with a semitransparent mirror set between the two (at an angle of 45° with each). The image of the indicator tubes is reflected by the mirror, with the tracking cursors being visible through the mirror directly underneath the indicator tube images. The positions of the tracking cursors indicate, by means of an error voltage (from a potentiometer geared to the tracking handwheels), the position of the aircraft with respect to the glidepath.

e. The error voltages (azimuth and elevation) are fed to the errormeters on the approach indicator. The errormeters convert the error voltages into readings (in feet) of the distance between the path of the airplane and the correct glidepath. The operator viewing the errormeters is in constant radio contact with the approaching airplane, and gives the pilot continuous information on the correctness of his course.

f. An auxiliary component, the aural signal unit, converts the azimuth error voltage into correction information and impresses that information on the communications channel along with the operator's instructions. The output of the aural signal unit is a constant tone if the aircraft is to the right of the glidepath, while an interrupted tone is produced if the craft is to the left of the glidepath. The pitch of the tone rises as the distance from the glidepath is increased.

119. SCAN SYNCHRONIZING AND ANTENNA POSITIONING SYSTEMS.

a. The scan synchronizing system is an electrical connection between the antennas and the indicator system. Its function is to furnish data on the position of the antenna beams and to supply this data to the indicating system. The angle capacitor unit is mechanically coupled to the mechanism which varies the direction of the beam on the antenna. As the capacitance varies in accordance with the change in the antenna beam angle, a change is produced in the output voltage of the associated angle coupling unit. This output voltage, which is adjusted for a linear relationship to the antenna beam angle by the controls on the angle coupling unit, is fed to the sweep amplifiers. There the voltage controls the magnitude of the sweep voltages applied to the indicator tubes.

b. The antenna follower system is a mechanical linkage connecting the indicators with the antennas. By means of this system, information available on the indicators is used to insure that the region scanned by the precision antennas includes the position of the approaching airplane. Since the azimuth operator has no information as to the elevation of the approaching aircraft, he must rely on the elevation operator who has this data to adjust the elevation angle of the azimuth antenna radiation. This is done at the elevation operator's position by means of foot pedals connected through cables to the azimuth antenna. Servo cursors, connected to this follower system, are placed across the face of the elevation indicator tube and indicate the elevation angle of the azimuth antenna radiation. By means of the foot pedals, the elevation operator can adjust the servo cursor and the connected azimuth antenna until the beam of radiation includes the position of the approaching airplane. A similar mechanism utilizes information given on the azimuth indicator to position the elevation antenna in azimuth.

SECTION IV

ASSOCIATED EQUIPMENT

120. POWER DISTRIBUTION SYSTEM.

a. Power Distribution Panel SB-1/MPN-1 is fed 117 volts ac from the two power units (Power Equipments PE-127-A) in the prime mover, or from an external com-

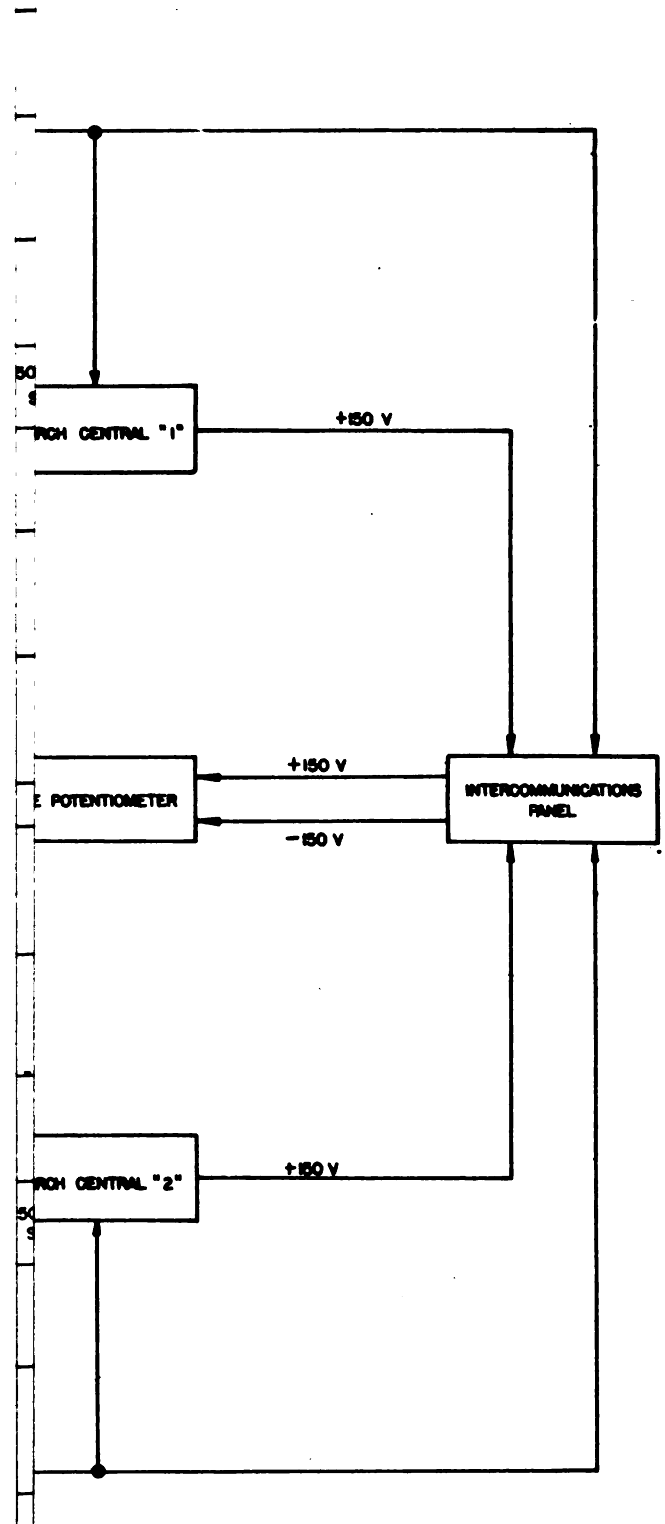

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Figure 249. Power supplies and associated components, block diagram.

mercial power source. All power circuits in the radio set, except the one for the air conditioner, are supplied thru the power distribution panel. Channel switching relays in the various components are controlled by circuits in this panel.

b. When a-c power is supplied from an external commercial supply, it is fed to the power distribution system thru a voltage regulator system. The system includes an autotransformer for changing the incoming voltage to a value required by the induction Voltage Regulator Unit CN-3/MPN-1. This unit controls the output voltage by variable coupling between primary and secondary winding of a transformer. A regulator control panel contains circuits for automatic control of the regulator unit, with provisions for manual control if desired.

c. The power distribution panel contains a voltmeter to measure the input voltage from the a-c supply circuit and a time meter to indicate running time. The main switch SW24 selects commercial or generator power whichever is available. A number of colored lights indicates which circuits are being energized. A group of circuit breakers SW1 to SW16 and switches SW17 to SW19 controls the 119-volt a-c power supply to the various components. The TRANSMIT switch SW22 controls all channel switching relays, as well as a plate power on all power supplies.

d. Control Box C-61/MPN-1, a part of the power distribution system, provides control of the magnitude of the voltage input (and voltage output) to the high-voltage power supply. Time delay relays are incorporated to provide time for power supply filaments to heat before application of plate voltage. Metering circuits in the control box are not a part of the power distribution system.

121. POWER SUPPLIES.

a. There are 12 power supplies, two of each type, in the radar section of Radio Set AN/MPN-1. Of these, six power supplies (300-volt, 500-volt, and negative) are used exclusively in the precision system; two (search central) exclusively in the search system; and four (4-kv, and transmitter HVPS), in both systems. Eight power supplies (300-volt, 500-volt, negative, and transmitter HVPS) are switched on and off by channels; two (4-kv) are switched on and off by a relay assembly; two (search central) are turned on and off with the search indicators. Four power supplies (4-kv, and transmitter HVPS) are controlled by time delay relays. All power supplies yielding over 300 volts have component interlock switches. All radar voltage sources are regulated for both input line and output load variations except for the 4-kv sources (which are regulated for line variations only), the transmitter HVPS, and the 300-volt source of the search central power supply. The components furnished voltage by the power supplies and the power supplies themselves are illustrated in figure 249. The intercommunications panel and the relay assembly shown in the block diagram act as switches between voltage sources and components.

b. Relay Assembly RE-3/MPN-1 controls the switching of the two 4-kv power supplies. In the central or normal position of the relay assembly toggle switch both 4-kv power supplies operate: unit No. 1 supplying the elevation and azimuth indicators; unit No. 2, both search indicators. In the UP position of the switch, unit No. 1 alone is in operation and supplies 4-kv to all six indicators; in the DOWN position, unit No. 2 supplies all the 4-kv.

c. Control Box C-61/MPN-1 (not shown in the block diagram) controls the two transmitter high-voltage power supplies by means of a variac for each of the two channels. This component also houses the high-voltage time delay relays, the high-voltage overcurrent relays, and the S and X-band meters and metering circuits.

d. In addition to the radar power supplies, there are seven supplies for the communications equipment: three Rectifier Power Units PP-28/MPN-1 for the three Radio Sets SCR-274-N; one Rectifier Power Unit PP-100/MPN-1 for the tower receiver; three Rectifier Units RA-62 for the three Radio Sets SCR-522-A. Each SCR-274-N power supply furnishes two voltage sources: one of 550 volts and one of 26 volts; the tower receiver power supply, a 26-volt source; each SCR-522 power supply, a 300-volt, a –150-volt, and a 13.4-volt source. All voltage sources in the communications equipment are unregulated.

122. COMMUNICATIONS SYSTEM.

a. The communications system consists of the following:
(1) Six communication sets; three HF and three VHF.
(2) An intercommunication system with controls on both the intercommunication panel and the approach indicator.
(3) Associated microphones, headsets, and controls.
(4) Three communication receivers for use in conjunction with the HF communication sets.
(5) The tower receiver for monitoring the airfield control tower transmitter.

b. With this system the traffic director, plane selector, and approach controller are in direct radio communication with aircraft during operation and can communicate with each other. Each of these three operators has a microphone and headset, and will have a clear communications channel available in either the HF or VHF bands. The proper channel is selected by pressing the appropriate push button in the set of six communications channel selector push buttons at the operating position. One of these sets of push buttons is on the front panel of the approach indicator and two sets are on the intercommunications panel, one serving the traffic director and the other the plane selector.

c. Each of the three HF communication sets (Radio Set SCR-274-N) has three frequency channels available at the turn of a switch. Any one of the three preset frequencies may be selected by turning the proper switch on the associated Radio Control Box BC-451-A to the proper position. Each of the three VHF sets (Radio Set SCR-522-A) has four crystal-controlled frequency channels, any one of these channels being selectable on associated Radio Control Box BC-602-A.

d. The controller operates the aural signal switch on the approach indicator, mixing the output of the aural signal unit into the signal modulating the transmitter in use, thus enabling the pilot to hear the azimuth tone signal at the same time that he receives instructions from the controller. The other two precision system operators, the elevation tracker and the azimuth tracker, have headphones only which are connected in parallel with those of the controller. All are connected for sidetone monitoring of the communications channel in use or for intercommunications. Thus, the trackers can check the accuracy of the controller's information.

e. The two search system operators, the plane selector and the traffic director, may talk to the other radio set operators on the intercommunications system or to the pilots of the airplanes awaiting landing instructions. These two operators may also speak to operators of the IFF equipment over the intercommunication system by pressing a key on the intercommunication panel. Only one operator may use this channel at any one time, selection being made by a switch on the intercommunication panel.

f. The receiving equipments of Radio Sets SCR-274-N are not included, but Radio Receivers BC-342-N are used instead. Three are provided. Remote antenna, completely separate from the radio set, may be used with any one of these receivers which has a serious interference problem.

g. The tower communications receiver system consists of Tower Receiver BC-1206-C with its associated power supply. The tower receiver control panel permits the two search system operators to independently receive and adjust the magnitude of the signal from the tower receiver.

h. The observer's control box gives the observer access to the output of the tower receiver. Facilities are also provided whereby the observer may take charge of the controller's communication panel when the aircraft is observed to break through the overcast.

123. HYDRAULIC LEVELING SYSTEM.

a. The hydraulic leveling system is energized by a 117-volt a-c motor which drives a pressure pump through a reduction gear. The hydraulic fluid (oil) is pumped through a master valve (which controls the rate of flow of fluid), and through individual control valves to the corresponding cylinders of the four hydraulic jacks. These jacks are used for raising or lowering the trailer to the proper tilt.

b. Direction of jack movement is controlled by a double-acting valve in the master valve unit. In one position the valve allows high pressure to be exerted at the top of the jack cylinder with a low-pressure return thru the part at the bottom. This forces the jack plunger downward and raises the trailer. In the other position of the double-acting valve the high and low pressures are reversed, the jack cylinder forced upward, and the trailer lowered.

c. With all four jacks properly adjusted, and the trailer in the operating position, the two spirit levels in the hydraulic well will indicate a level position as they have been previously adjusted to the correct tilt (2 degrees). Required lighting is provided by a switch and light combination in the well itself.

124. AIR CONDITIONER. Radio Set AN/MPN-1 has been furnished with an air conditioner. It is both a cooler and a dehumidifier, providing comfortable operating conditions of temperature and humidity within the trailer. The unit contains two major flow systems: the conditioned air circuit, for cooling, dehumidifying, and circulating the air through the trailer; and the refrigeration circuit, for removing and dissipating the heat from the air through the circulation of a refrigerant. The unit is powered by a 1,750-rpm repulsion-induction motor, operating on single phase 117-volt a-c lines. In the conditioned air circuit a supply air fan, directly coupled through a universal joint to the motor, forces air into the trailer through a supply air duct. The air comes back to the unit via a return air duct and is cooled and purified by evaporator coils and an air-dust filter. In the refrigeration circuit, which is entirely within the air conditioner, liquid refrigerant in the evaporator coils cools the air passing over them. This cooling process causes the refrigerant to evaporate, and the resulting gas is sucked into a compressor and then pumped into a condenser. The compressor is coupled through a V-belt to the motor, as is a fan which is used to draw air over the condenser coils. The compressed refrigerant is thereby cooled and condensed to a liquid. It is then accumulated in a receiver, whence it flows back to the evaporator coils through an expansion valve.

CHAPTER 6

TROUBLE-SHOOTING PROCEDURES

SECTION I

GENERAL INFORMATION

125. INTRODUCTION. No matter how well equipment is designed and manufactured, faults are bound to occur in service. When such faults do occur, the repairman must locate and correct them as rapidly as possible. This section contains general information to aid personnel engaged in the important duty of trouble shooting. Remember that preventive maintenance will minimize the necessity of trouble shooting.

a. Trouble-shooting Data. Take advantage of the material supplied in this manual to help in rapidly locating faults. Consult the following trouble-shooting data when necessary.

(1) BLOCK DIAGRAM OF THE SYSTEM.

(2) COMPLETE SCHEMATIC DIAGRAMS. These diagrams include all components and show all the connections (power, input, and output) to all other units.

(3) SIMPLIFIED AND PARTIAL SCHEMATICS. These diagrams are particularly useful in trouble shooting, because they enable the electrical functioning of the circuits to be followed more clearly than on the complete schematics, thus speeding trouble location.

(4) VOLTAGE AND RESISTANCE DATA AT ALL SOCKET CONNECTIONS.

(5) VOLTAGE, RESISTANCE, AND WAVEFORM DATA AT TEST JACKS. Blocking capacitors are omitted from most leads to the test jacks, to enable measurement of the d-c voltage at the plate or other points to which the test jacks connect. For this reason, be careful not to touch the measuring instruments which carry high voltage when connected to the test jacks.

(6) ILLUSTRATIONS OF COMPONENTS. Front, top, and bottom views aid in locating and identifying parts.

(7) PIN CONNECTIONS. Pin connections on sockets, plugs, and receptacles are numbered or lettered on the various diagrams.

(*a*) Seen from the bottom, pin connections are numbered in a clockwise direction around the sockets. On octal sockets the first pin clockwise from the keyway is pin No. 1. Pin numbers appear on both the schematic diagrams, and the wiring diagrams, so that any tube element can be readily located.

(*b*) Plugs and receptacles are numbered on the side to which the associated connector is attached. To avoid confusion, some individual pins are identified by letters which appear directly on the connector.

b. Trouble-shooting Steps. The first step in servicing a defective radar set is to sectionalize the fault. Sectionalization means tracing the fault to the component responsible for the abnormal operation of the set. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition.

(1) The Equipment Performance Log (EPL) and the starting procedure aid in tracing the fault to the defective component. The procedures to be followed are explained in subparagraphs *c* and *d*.

(2) Some faults such as burned-out resistors, r-f arcing, etc. can be located by sight, smell, and hearing. The majority of faults, however, must be located by checking voltage, resistance and waveforms.

c. Equipment Performance Log Sectionalization. The Equipment Performance Log sheet is a record of the normal and abnormal operation of the station. In the event of station failure or abnormal operation, references to the Equipment Performance Log will usually aid in sectionalizing the defect. When a station failure occurs, refer to the log sheet and note the operation of the station for the past 24 hours. The failure may be the result of a previous abnormal condition not serious enough in itself to have caused the station to go off the air at the time it occurred. The abnormal condition will have been entered in the station log. Check the log entry to obtain direct information leading to the cause of the failure.

d. Starting-procedure Sectionalization. The starting procedure is the systematic method used to put the station on the air. This procedure is used in sectionalization when the cause of the station failure is not known. In most cases, it will trace the defect to a particular component. The steps of the starting procedure are performed in sequence until an abnormal result is obtained. As each step is performed, the visible and audible results of the action are noted. The use of the starting procedure is described in detail in section III of this chapter.

*e. **Localization.*** Chapters 7, 8, and 9 describe the method of localizing faults within the individual components. These chapters contain trouble-shooting charts which list abnormal symptoms and their causes. The charts also give the procedure for finding out which of the probable locations of the fault is the exact one. The chapters also tell what waveforms should be obtained at the test points. In addition, there are diagrams which show the resistance and the voltage at all socket-pin connections. The method of using voltage and resistance data in checking a circuit is described in detail in paragraphs 126 *d* and 127 *c*.

126. VOLTAGE MEASUREMENTS.

*a. **General.*** Voltage measurements are an almost indispensable aid to the repairman, as most troubles result from abnormal voltages or produce abnormal voltages. Voltage measurements are easily made because they are taken between two points in a circuit, and the circuit need not be interrupted.

(1) Complete information on normal operating voltage is given in the trouble-shooting section. Unless otherwise specified, the voltage is measured between the indicated point and ground.

(2) Always begin by setting the voltmeter on the highest range, so that the voltmeter will not be overloaded. Then, if it is necessary to obtain increased accuracy, set the voltmeter to a lower range.

(3) In checking cathode voltage, remember that a reading can be obtained when the cathode resistor is actually open. The resistance of the meter may act as a cathode resistor. Thus, the cathode voltage may be approximately normal only as long as the voltmeter is connected between cathode and ground. Before the cathode voltage is measured, a resistance check should be made with the circuit cold in order to determine if the cathode resistor is normal.

*b. **Precautions Against High Voltage.*** Certain precautions must be followed when measuring voltages above a few hundred volts. High voltages are dangerous, and can be fatal. When it is necessary to measure high voltages, observe the following rules:

(1) Connect the ground lead to the voltmeter.

(2) Place one hand in your pocket.

(3) If the voltage is less than 300 volts, connect the test lead to the hot terminal (which may be either positive or negative with respect to ground).

(4) If the voltage is greater than 300 volts, shut off the power, connect the hot test lead, step away from the voltmeter, turn on the power, and note the reading on the voltmeter. Do not touch any part of the voltmeter, particularly when it is necessary to measure the voltage between two points, both of which are above ground.

*c. **Voltmeter Loading.*** It is essential that the voltmeter resistance be at least 10 times as large as the resistance of the circuit across which the voltage is measured. If the voltmeter resistance is comparable to the circuit resistance, the voltmeter will indicate a lower voltage than the actual voltage present when the voltmeter is removed from the circuit.

(1) The resistance of the voltmeter on any range can always be calculated by the following simple rule: resistance of voltmeter equals the ohms-per-volt multiplied by the full-scale range in volts. Two examples are shown below:

(*a*) What is the resistance of a 1,000 ohms-per-volt voltmeter on the 300-volt range?

R = 1,000 ohms-per-volt x 300 volts = 300,000 ohms.

(*b*) What is the resistance of a 20,000 ohms-per-volt voltmeter on the 300-volt range?

R = 20,000 ohms-per-volt x 300 volts = 6 megohms.

(2) To minimize voltmeter loading in high resistance circuits, use the highest voltmeter range. Although only a small deflection will be obtained (possibly only 5 divisions on a 100 division scale) the accuracy of the voltage measurement will be increased. The decreased loading of the voltmeter will more than compensate for the inaccuracy which results from reading only a small deflection on the scale of the voltmeter.

(3) When a voltmeter is loading a circuit, the effect can always be noted by comparing the voltage reading on two successive ranges. If the voltage readings on the two ranges do not agree, voltmeter loading is excessive. The reading (not the deflection) on the highest range will be greater than on the lowest range. If the voltmeter is loading the circuit heavily, the deflection of the pointer will remain nearly the same when the voltmeter is shifted from one range to another.

(4) The voltage and resistance drawings used in this manual are based on readings taken with an actual meter. The ohms-per-volt sensitivity of the meter which was used is printed on the drawing. The trouble shooter should use a meter having the same ohms-per-volt sensitivity. Because the meter used in testing for the voltage will produce the same amount of loading as the meter used in measuring the voltage, it is necessary to consider the effect of loading.

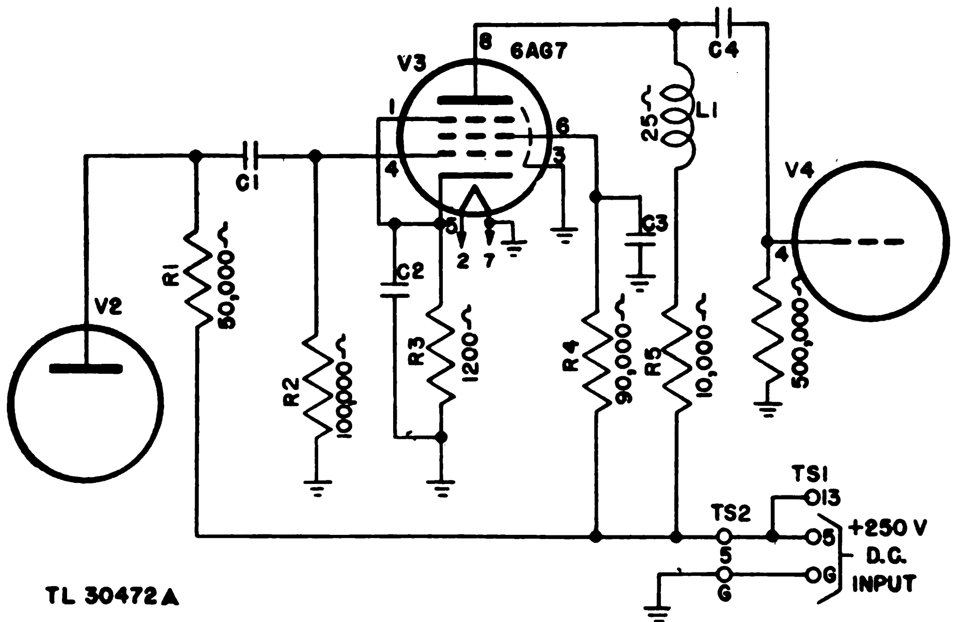


Figure 250. Schematic diagram for voltage analysis.

d. Practical Example of Voltage Analysis. Figure 250 illustrates a typical amplifier stage. The values of the various parts are labeled as well as the input voltages. The normal voltages at the V3 tube socket pins are:

Pin No.	1	2	3	4	5	6	7	8
Voltage	7.2	6.3 a-c	0	0	7.2	195	0	185

NOTE: All voltages are d-c voltages unless otherwise specified. The d-c readings were taken with a 1,000 ohms-per-volt voltmeter. Drawings for each component, giving the voltage at each socket connection, can be found in the section on trouble shooting of the component. To check the stage shown in figure 250 for an abnormal voltage measurement, measure the voltage between the socket contacts and the chassis.

(1) The voltage between contact 1 and the chassis is normally 7.2 volts (see above chart). This voltage should be the same as that between socket contact 5 and the chassis, since they are directly connected (subpar. (3) below).

(2) The voltage between contact 2 and the chassis should be 6.3 volts a-c, since contact 2 is one side of the filament. On the diagram, no connections are shown because the filaments of amplifier tubes are always connected to a low-voltage a-c source. If this voltage is abnormal, check the voltage across the winding of the transformer which supplies the voltage.

(*a*) If the voltage of the transformer is normal, the trouble is a broken connection between the transformer and the contact.

(*b*) If the voltage of the transformer winding is abnormal, measure the voltage of the transformer primary winding.

(*c*) If the primary voltage is normal and the voltage on the winding that delivers the filament voltage is abnormal, either the transformer is defective or an abnormally high drain is being placed on the filament winding. This can be checked by removing one of the wires from the filament winding and again testing the voltage across this winding. If the transformer is defective, the voltage reading will still be abnormal. If the transformer is normal, the voltage will be a little higher than usual. However, if the voltage on the transformer primary is abnormal, the source of this voltage must be checked.

(3) The voltage between contact 3 and the chassis should be zero, since this contact is directly connected to the chassis.

(4) The voltage between contact 4 and the chassis should be zero, since this is a class A amplifier and normally no grid current flows through resistor R2. If capacitor C1 should short-circuit, the high positive voltage on the plate of tube V2 would be delivered to contact 4 and a d-c positive-voltage reading would be obtained. It is also possible for a short circuit inside the tube to cause a reading on this contact.

(5) The voltage on contacts 1 and 5 should be 7.2 volts. (An important consideration in measuring cathode voltage is explained in the paragraph on voltage measurements.) The plate cathode voltage and the grid cathode voltage normally cause a current to flow through the cathode resistor, R3. This current is normally 0.006 ampere, since resistor R3 is 1,200 ohms and the voltage across it is 7.2 volts.

$$I = \frac{E}{R} = \frac{7.2}{1{,}200} = 0.006 \text{ ampere}$$

(*a*) If no voltage is obtained, the trouble may be a lack of the plate-supply voltage, a burned-out tube V3, a shorted resistor R3, a shorted capacitor C2 (this capacitor, if shorted, would connect the cathode to the chassis), or a broken connection.

(*b*) If the voltage was found to be low, the trouble could be a tube V3 with low emission, a leaky capacitor C2, an open-circuited resistor R3 or R5, a shorted capacitor C3 or C4, low plate-supply voltage, and open-circuited coil L1, a poor connection, or an increase in the resistance value of any of the resistors.

(*c*) If the voltage was found to be too high, the trouble could be a gassy tube, a short-circuited resistor, too high an applied voltage, or a connection in either the plate-cathode or screen grid-cathode circuits shorted by an external circuit.

(6) The screen voltage is checked as follows:

(*a*) The voltage on contact 6 normally should be 195 volts. The voltage drop across the resistor normally would be 55 volts, since the voltage on one side of the resistor is 195 volts and 250 volts on the other side. The normal current through this resistor would be 0.0006 ampere.

$$I - \frac{E}{R} = \frac{55}{90{,}000} = 0.0006 \text{ ampere}$$

(*b*) If no voltage is obtained on contact 6, the trouble could be a lack of applied voltage, and open-circuited resistor R4, a broken connection, or a shorted capacitor C3.

(*c*) If the voltage on contact 6 is too low, the trouble could be a gassy tube, a leaky capacitor C3, too low an applied voltage, or too low a bias voltage on the grid of tube V3 (grid is biased by the 7.2 volts on the cathode).

> NOTE: A gassy tube, or the lowering of the grid bias of tube V3, would increase the screen grid current. Increasing this current would increase the voltage drop across resistor R4. If capacitor C3 were leaky or shorted, the screen grid of the tube V3 would be connected near or at ground potential, lowering the voltage on contact 6. The current through resistor R4 would rise if capacitor C3 were shorted. Resistor R4 would be the only resistance between the applied voltage and the chassis ground. Resistor R4 probably would burn out because of the high current flow unless the resistor had a high power rating. Any fault that would make high current flow through the screen grid-cathode circuit might burn out either resistor R3 or R4.

(7) The voltage between contact 7 and ground normally should be zero, according to the chart above, since this contact is connected directly to the chassis ground.

(8) The plate voltage is checked as follows:

(*a*) The voltage between contact 8 and the chassis normally should be 185 volts. This voltage is at one of the points in the plate-cathode circuit which comprises resistor R5, coil L1, the plate resistance of tube V3, and resistor R3. The applied voltage in this circuit is 250 volts. The voltage drop across the resistor normally would series is 65 volts (250 volts - 185 volts). The current through resistor R5 and coil L1 is 0.0064 ampere.

$$I - \frac{E}{R} = \frac{65}{10{,}025} = 0.0064 \text{ ampere}$$

(*b*) If no voltage is obtained on contact 8, the trouble could be a lack of applied voltage, an open-circuited resistor R5 or coil L1, or a broken connection between terminal 5 on terminal strip TS1 and contact 8.

(*c*) If the voltage on contact 8 is too low, the trouble could be a gassy tube V3, too low an applied voltage, a shorted or leaky capacitor C2, or a shorted resistor R3. A gassy tube V3, shorted or leaky capacitor C2, or a shorted resistor R3, would cause the current through the plate-cathode circuit to rise, increasing voltage drop across resistor R5 and coil L1. This would lower the voltage on contact 8. Increased current through this circuit may also burn out resistor R3 or R5, unless the power rating of each is ample.

(*d*) If the voltage is too high, the trouble could be a burned-out tube V3, low emission in tube V3, a burned-out resistor R3, a shorted resistor R5, too high an applied voltage, or a burned-out resistor R4. If the tube were burned out or resistor R3 were open, no current would flow through the plate-cathode circuit, and there would be no voltage drop between the applied voltage and the plate of the tube.

(9) Capacitor C4, a coupling capacitor to the grid of tube V4, can be checked for a shorted or leaky condition by measuring the voltage between contact 4 on V4 and the chassis ground. If the positive d-c voltage is higher than normal when measured on contact 4 of tube V4, the capacitor is leaky or shorted.

127. RESISTANCE MEASUREMENTS.

a. General. (1) NORMAL RESISTANCE VALUES. When a fault develops in a circuit, its effect will very often show up as a change in the resistance values. To assist in the localization of such faults, trouble-shooting data includes the normal resistance values, as measured at the tube sockets and at the test jacks. These values are measured between the indicated points and ground, unless otherwise stated. Often it is desirable to measure the resistance from other points in the circuit, in order to determine whether the particular points in the circuit are normal. The normal resistance values at any point can be determined by referring to the resistance values shown in the schematic diagram.

(2) PRECAUTION.

(*a*) Before making any resistance measurements, turn off the power. An ohmmeter is essentially a low range voltmeter and battery. If the ohmmeter is connected to a circuit which already has voltages in it, the needle will be knocked off scale and the voltmeter movement may be burned out.

(*b*) Capacitors must always be discharged before resistance measurements are made. This is very important when checking power supplies that are disconnected from their load. The discharge of the capacitor through the meter will burn out its movement and in some cases may endanger life.

(3) CORRECT USE OF LOW AND HIGH RANGES. It is important to know when to use the low-resistance range and when to use the high-resistance range of an ohmmeter. When checking the circuit continuity, the ohmmeter should be set on the lowest range. If a medium or high range is used, the pointer may indicate zero ohms, even if the resistance is as high as 500 ohms. When checking high resistance or measuring the leakage resistance of capacitors or cables, the highest range should be used. If a low range is used, the pointer will indicate infinite ohms, even though the actual resistance is less than a megohm.

(4) PARALLEL RESISTANCE CONNECTIONS. In a parallel circuit, the total resistance is less than the smallest resistance in the circuit. This is important to remember when trouble shooting with the aid of a schematic diagram.

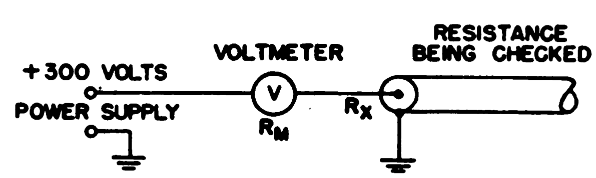
(*a*) When a resistance is measured and the value is found to be less than expected, make a careful study of the schematic to be certain that there are no resistances in parallel with the one that has been measured. If a resistor appears too low, disconnect one terminal from the circuit and measure its resistance again to make sure that the low reading was not because some part of the circuit was in parallel with the resistor.

(*b*) In some cases, it will be impossible to check a resistor because it has a low-voltage transformer winding connected across it. If the resistor must be checked, disconnect one terminal from the circuit before measuring its resistance.

(5) CHECKING GRID RESISTANCE. When checking 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.

(6) TOLERANCE VALUES FOR RESISTANCE MEASUREMENTS. Tolerance means the normal difference that is expected between the rated value of the resistor and its actual value.

(*a*) Most resistors that are used in radar circuits have a tolerance of at least 10 percent. For example, the grid resistor of a stage might have a value of 1 megohm. If the resistor were measured and found to have a value between 0.9 megohm and 1.1 megohms, it would be considered normal. As a rule, the ordinary resistors used in circuits are not replaced unless their values are off more



$$R_X = \frac{300}{V} R_M \text{ (APPROX.)}$$

EXAMPLE

V = 5 VOLTS. THE METER IS USED ON ITS 300 VOLT RANGE AND HAS A RESISTANCE OF 1,000 OHMS-PER-VOLT.

$$R_M = 300 \times 1{,}000 = 300{,}000 \text{ OHMS.}$$

$$R_X = \frac{300}{5} \times 300{,}000 = 18 \text{ MEGOHMS.}$$

TL 35530

Figure 251. Measurement of high resistance.

than 20 percent. Some precision resistors and potentiometers are utilized. When a resistor is used whose value must be very close to its rated value, the tolerance is ~~usually~~ stated on the diagram.

(*b*) The tolerance value for transformer windings is generally between 1 and 5 percent. As a rule, suspect a transformer which shows a resistance deviating more than 5 percent. Allow the transformer to cool off before the resistance test is made.

b. High-resistance Measurements. Many leakages will not show up when measured at low voltages. Most ohmmeters use a maximum test voltage of 15 volts on the highest resistance range. Where it is necessary to measure resistance above a few megohms, or to measure the leakage resistance between conductors of a cable, the test should be made using an applied voltage of 100 volts or more. Where it is possible to ground one end of the resistance being checked, one of the low-voltage power supplies in the equipment can be used to provide about 300 volts for making these high-resistance measurements. The manner in which such measurements are made is indicated in figure 251. This method should be used only when the resistance being measured is very high. Be careful not to handle the meter after the circuit has been completed. The meter used should have an ohms-per-volt sensitivity of 1,000 ohms or more. The resistance of the meter is equal to the ohms-per-volt sensitivity multiplied by the range to which the meter is set. The derivation of the formula $Rx = \frac{300Rm}{V}$ is very low. If the voltage used is not 300 volts, the correct value should be inserted in the formula in place of 300.

c. Practical Example of Resistance Analysis. The low-voltage power supply shown in figure 252 will be used in this example. Suppose that a fuse in the primary circuit of the power transformer has blown out. The cause is obviously an overload. The overload may be a short circuit in the unit to which the power supply furnishes power, a short circuit in the power supply, or a short circuit in the primary circuit of the power transformer.

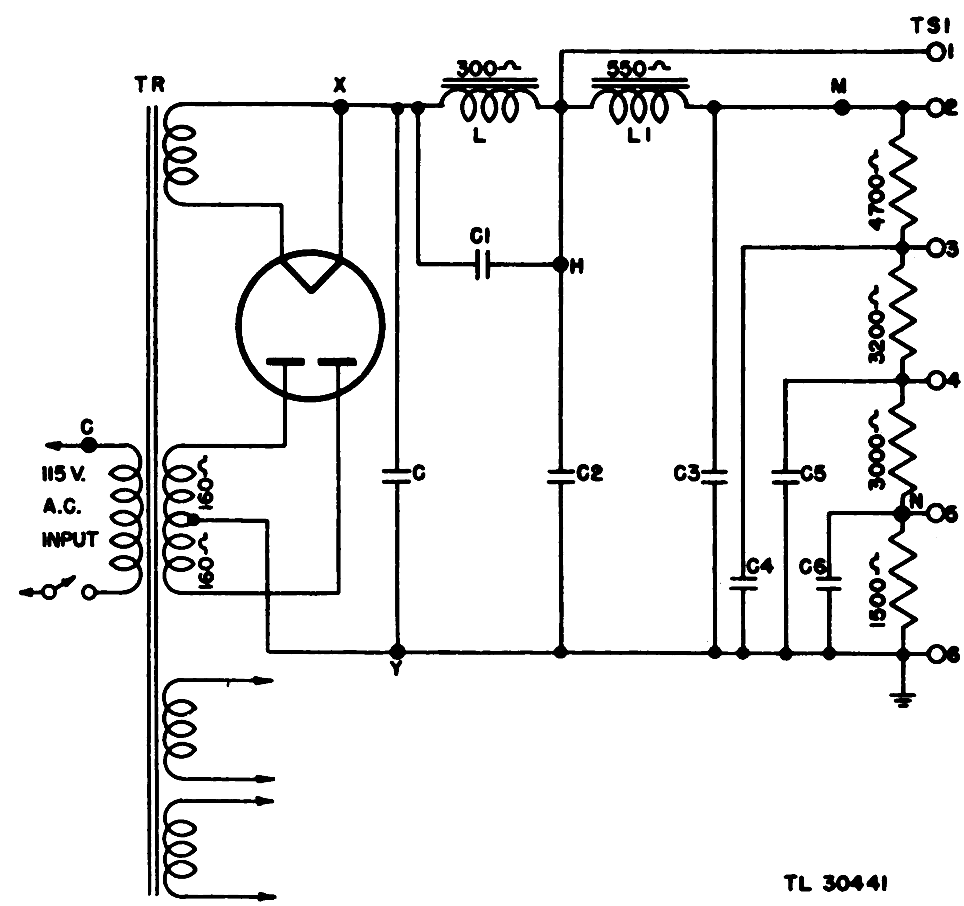


Figure 252. Schematic diagram for resistance analysis.

(1) Points 1, 2, 3, 4, 5, and 6 represent connections to a plug which takes power away from the power supply. Disconnect the plug and replace the blown fuse. (Since this is a low-voltage circuit, it is not likely that any damage will be done by blowing another fuse). Turn the power on. If the fuse blows again, the trouble was not in the unit to which power is supplied.

(2) If the fuse blew the second time, the resistance between point 2 and ground should be checked. If this resistance is within 10 percent of 12,400 ohms (the sum of the resistances in the bleeder chain equals 12,400 ohms), the trouble is in the secondary or primary of the transformer. For this analysis, it will be assumed that the resistance was found to be much less than 12,400 ohms.

(3) If the resistance between point 2 and ground is found to be zero, capacitor C3 must be shorted. In order to test the capacitor, disconnect its lead from point M. The actual resistance of the capacitor can then be measured.

(4) A resistance between point 2 and ground of 550 ohms, indicates that capacitor C2 is shorted, since coil L1 has a resistance of 550 ohms. Test capacitor C2 by disconnecting it from ground and by measuring its resistance.

(5) A resistance of 850 ohms between point 2 and ground indicates a short circuit in the rectifier tube, the filament winding, or capacitor C. To discover which is shorted, remove the tube from its socket and again measure the resistance between point 2 and ground. If the fault is still present, it is either in capacitor C or in the filament winding. If the fault disappears when the tube is removed, the fault is in the tube.

(6) If the resistance between point 2 and ground is about 1,000 ohms, the trouble is in either the circuit to the right or to the left of point M. To isolate the trouble disconnect the circuit at M. If the resistance between point 2 and ground is still much less than 12,400 ohms, the fault is in the bleeder chain. To check the chain, proceed as follows:

(*a*) Measure the resistance between points 2 and 3. If it is not close to 4,700 ohms, the resistor between these points should be replaced.

(*b*) If the above check was satisfactory, the resistance between point 3 and ground should be checked. From figure 252, it is seen that the reading should be 7,700 ohms. If the reading is zero, first disconnect capacitor C4 and check it. If capacitor C4 is normal, check the 3,200-ohm resistor. If the resistance between point 3 and ground was greater than zero but much less than 7,700 ohms, disconnect capacitors C4, C5, and C6 from the circuit. Then check the capacitors and the 1,500-ohm and the 3,000-ohm resistors individually.

128. CAPACITOR TESTS. Capacitors which are leaky or shorted can be found by resistance checks of the stage. A capacitor which is suspected of being open can best be checked by shunting a good capacitor across it. In i-f circuits, keep the lead to the capacitor as short as the original capacitor leads. In video and low-frequency circuits (less than 1 megacycle), the test capacitor leads may be several inches long.

129. CURRENT MEASUREMENTS. Current measurements, other than those indicated by the panel meters, are not ordinarily required in trouble shooting in the radar set. Under special circumstances where the voltage and resistance measurements by themselves are not sufficient to localize the trouble, a current measurement can be made by opening the circuit, and connecting an ammeter to measure the current. This procedure is not recommended except in very difficult cases.

a. When the meter is in a circuit to measure current it should always be inserted away from the r-f 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 which connects to the power. This precaution is necessary to keep the meter from upsetting the r-f voltages.

> CAUTION: A meter has least protection against damage when it is used to measure current. Always set the current range to the highest value. Then, if necessary, decrease the range to give a more accurate reading. Avoid working close to full-scale reading because this increases the danger of overloading the meter.

b. In most cases, the current to be measured flows through a resistance which is either 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 its resistance value. The drop across the cathode resistor is a convenient method of determining the cathode current. For an example, see the paragraph on voltage measurements.

130. TUBES.

a. Tube Failures. Tube failures are responsible for a large percentage of the faults which occur in radar sets. There are, however, too many tubes in a radar set for a trouble shooter to attempt to find a fault by indiscriminate tube changing. Do not resort to tube changing until the fault has been traced to a particular stage.

(1) When putting a new tube into a circuit, note the position of all controls before making any changes. If retuning the controls with the new tube in the circuit does

not correct the abnormal condition, return the controls to their original position and put the old tube back in the circuit, unless a tube test shows the tube to be definitely bad.

CAUTION: In many radar circuits the interelectrode capacitance of a tube is a part of a tuned circuit. When tubes are switched, the tuning of the circuits is upset. If too many tube substitutions are made, the set may become seriously misaligned as a result of the tube changes.

(2) When replacing a tube in a circuit, decide at once whether or not to keep the old tube. Do not change the tubes indiscriminately, or the spares box will become full of tubes whose age and condition are uncertain.

b. Tube Checking. Tube checkers are used to check the emission of electrons from the cathode, and to test for shorted elements. Tube checkers will not test the performance of high-voltage tubes and rectifiers and some special tubes in the modulator and rectifier. Tube checkers are useful, however, for checking receiving-type tubes used in the various components.

(1) 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 which is known to be good. 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.

(2) An operating chart and an instruction book are provided with the tube checker. This chart indicates the setting of the tube checker for each tube type. The number of controls, their arrangement, and settings vary with different types of tube checkers.

131. CHECKING WAVEFORMS.

a. Signal Tracing. Basically, signal tracing means following the progress of a signal through a circuit. The signal may mean a video signal, a sweep voltage, a widegate voltage, or any other waveform which appears in the various parts of the equipment. A departure from the normal waveform indicates a fault located between the point where the waveform is last normal and the point where it is observed to be abnormal. For example, if a waveform is observed to be normal at the grid of a stage and abnormal at the plate of the same stage, this indicates that the trouble lies in that stage.

(1) When the waveform of a multivibrator, a blocking oscillator tube, or a similar circuit is found to be abnormal, replace the tube before making any further tests. If replacing the tube does not correct the waveform of the original tube, place it back in the socket.

(2) When a component does not give the expected waveform, the fault is not necessarily in the component. The abnormal waveform may be due to the absence of a synchronizing or triggering pulse from another component. The point at which to start signal-tracing a component is at the input trigger plug.

(3) It is sometimes desirable to know definitely if a signal voltage (used in the broad sense) is getting to the grid of the first tube in a channel. To determine this when a test jack is not provided, remove the first tube in the channel involved so as to make the grid connection of the tube available from the top of the chassis. Then insert the test lead of the oscilloscope in the grid connection of the tube socket in order to see the waveform.

b. Use of Test Oscilloscope. Waveforms are the basis of radar operation. The outstanding advantage of the oscilloscope is that it can be used to observe and to measure waveforms at the various test jacks and other points in the equipment. By comparing the observed waveform with the actual reference waveform shown in the data, the fault can be rapidly localized. If, however, waveforms are measured at random, without a logical procedure, such as that originating with the starting procedure, the result may be a loss of time in finding the fault. The measurements of the waveforms with the test oscilloscope involve several essential points:

(1) INITIAL ADJUSTMENTS. The oscilloscope must be set up in accordance with the manufacturer's instructions.

(2) SWEEP FREQUENCY. Adjust the sweep frequency to a frequency lower than the recurrence frequency of the waveform being observed. For ordinary measurements, adjust the sweep frequency so that 2 or 3 cycles of the waveform appear on the screen. If more detail is desired, increase the sweep amplitude to spread the waveform.

(3) SIXTY-CYCLE WAVEFORMS. Some of the waveforms have a fundamental or recurrence frequency of 60 cycles. In observing these waveforms the sweep frequency can be set so that 2 cycles of the waveform are observed.

(4) SYNCHRONIZATION. Avoid excessive synchronizing voltage. If the SYNC control is advanced too far, the sweep will become nonlinear, with the result that the waveform will be distorted. Be sure that the fine frequency control on the oscilloscope is properly set so as to obtain a nearly stationary image. Then, advance the SYNC control only far enough to make the trace stationary.

(5) SIXTY-CYCLE PICKUP. If some fault is present, it may be impossible to obtain a stationary pattern, even though the oscilloscope frequency control is properly adjusted. This effect is usually due to the presence of 60-cycle modulation or 60-cycle pickup combined with the observed waveform. To check, turn the oscilloscope sweep frequency to 30 cycles. If the effect is due to line pickup, a stationary pattern will be observed. The inside of this pattern will, of course, be more or less filled, because of the much higher frequency of the waveform being observed.

(6) REACTIONS OF OSCILLOSCOPE ON WAVEFORM. Remember that the oscilloscope, because it shunts capacitance and resistance across the circuit, modifies the actual operating waveforms present in the circuit. This does not affect the usefulness of waveform measurements. The reference waveforms shown in this manual were taken with a typical oscilloscope under the same conditions as the repairman takes the waveforms.

(7) TEST LEADS. Avoid the use of a shielded test lead or twisted leads when taking waveforms. Each of these shunts a capacitance across the circuit under test, causing the waveform to be distorted and therefore different from that shown in the data. The waveforms shown in the test data were taken by using an unshielded lead. The ground lead should be connected at all times.

(*a*) Keep the ungrounded oscilloscope test lead away from other circuits to avoid introducing feedback. The test leads should be brought from the test points in a way which introduces the minimum amount of coupling to other stages.

(*b*) The leads to the oscilloscope must be kept short when measuring grid voltages from circuits where the grid capacitors are small. The smallest reaction on the waveform is introduced when measuring the voltage across the output (cathode) of a cathode follower, or of any low-impedance circuit.

(*c*) In measuring waveforms in high-impedance circuits, do not handle the hot test lead. If this precaution is not observed, the waveform will be distorted as a result of loading the circuit and picking up the 60-cycle voltage.

(*d*) If a signal voltage is picked up on the test leads, the oscilloscope indication may be misleading. For example, a signal may appear on the oscilloscope even when a plate-to-grid coupling capacitor is open. This effect occurs most often in circuits carrying narrow-pulse waveforms. It can be recognized by the fact that the waveform will be reduced in amplitude below the normal and will be distorted because the high-frequency components are overemphasized.

(8) R-F AND I-F CIRCUITS. Do not attempt to measure voltages or waveforms in any of the r-f or i-f circuits. These frequencies are beyond the range of ordinary test oscilloscopes and no indications useful in trouble shooting can be obtained.

(9) REVERSING LINE PLUG. In some instances, a more stable pattern may be obtained by reversing the a-c line plug of the oscilloscope circuit. This may reduce the amount of 60-cycle pickups, if they happen to be troublesome.

(10) RELATIVE AMPLITUDE. In following the path of the signal through a component, the amplitude of the waveform will usually increase as the checking point is advanced from the input stage toward the output stage. As the reference waveforms show, however, this is not always true. For example, when going from the grid to the cathode-follower stage, there is a loss in signal amplitude of about 10 percent. This is a normal condition. Another example is in connection with waveshaping circuits, where a decrease in the width of a signal is sometimes accompanied by a decrease in amplitude (as in differentiating circuits).

(11) CALIBRATION. If it is necessary to measure the actual voltage of the waveform, the oscilloscope must be calibrated. Calibrate the oscilloscope by finding how many volts correspond to a 1-inch deflection on the screen. This is the sensitivity of the scope.

(12) HIGH-VOLTAGE MEASUREMENTS. When voltages above a few hundred volts are measured, connect the test lead with the power turned off.

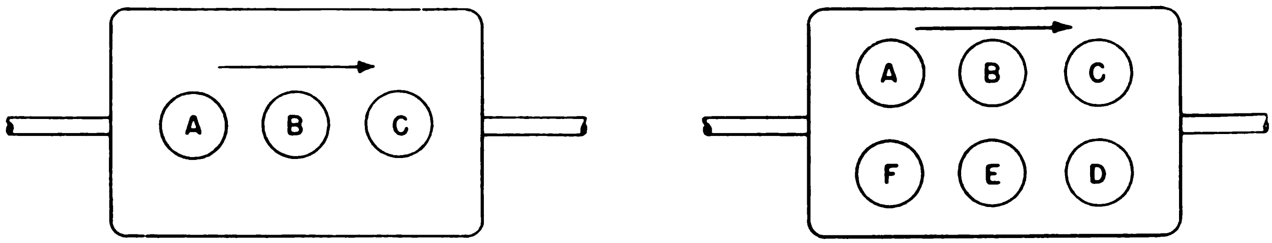
> CAUTION: Some test jacks do not have blocking capacitors. The capacitors are left out so that d-c voltages can be measured at the test jacks.

c. Comparison of Waveforms. If there is no fault in the circuit or equipment, an actual waveform taken at a point in the equipment should closely resemble the reference waveform. In some cases, however, differences in shape may occur for the following reasons:

(1) The test leads to the oscilloscope may not be placed in the same manner.

(2) A different oscilloscope may be used, having values of input resistance and capacitance which differ from those of the oscilloscope used in taking the reference waveforms.

(3) The various controls in the equipment may not be in the same position as when the reference waveforms were taken. Note the conditions specified in the reference waveform.



ONE ROW DOTS	COLOR	TWO ROWS OF DOTS
DOT A	INDICATES FIRST SIGNIFICANT FIGURE OF CAPACITANCE VALUE IN MICROMICROFARADS	DOT A
DOT B	INDICATES SECOND SIGNIFICANT FIGURE	DOT B
	INDICATES THIRD SIGNIFICANT FIGURE	DOT C
DOT C	INDICATES MULTIPLIER	DOT D
USUAL TOLERANCE ±20%	INDICATES TOLERANCE IN PER CENT OF THE NOMINAL CAPACITANCE VALUE IF NO COLOR APPEARS TOLERANCE IS 20%	DOT E
RATED VOLTAGE USUALLY 500 VOLTS	INDICATES THE RATED VOLTAGE	DOT F

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	TOLERANCE PER CENT (IF GIVEN)	RATED VOLTAGE (IF GIVEN)
BLACK	0	1		
BROWN	1	10	1	100
RED	2	100	2	200
ORANGE	3	1000	3	300
YELLOW	4	10,000	4	400
GREEN	5	100,000	5	500
BLUE	6	1,000,000	6	600
VIOLET	7	10,000,000	7	700
GRAY	8	100,000,000	8	800
WHITE	9	1,000,000,000	9	900
GOLD		0.1	5	1,000
SILVER		0.01	10	2,000
NO COLOR			20	500

TL 35619

Figure 253. Capacitor color code.

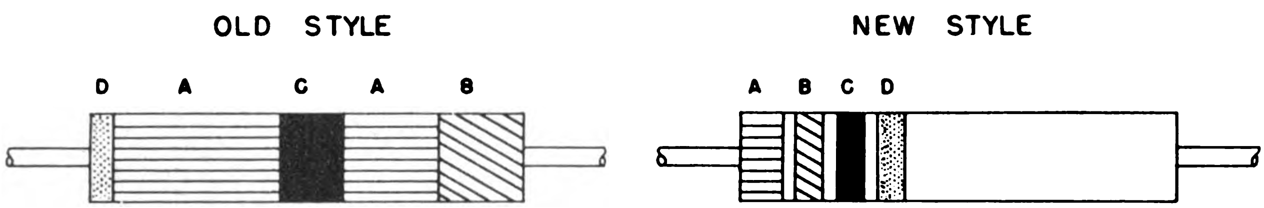
(4) The same number of cycles may not be present.

(5) The vertical or horizontal amplitudes of the reference and the test patterns may not be proportional. This will produce apparent differences in the shape of the two waveforms, when there is actually no real difference.

(6) Whether or not a waveform is regarded as abnormal will depend upon the symptom accompanying the fault which is being traced. The discrepancy should be considered significant if the fault could be caused by a minor difference in waveform at the point under test. Otherwise, time should not be spent in hunting down the cause of relatively minor differences between the shape of the reference waveforms and the test waveforms.

132. USE OF THE SIGNAL GENERATOR. Signal generators are used to locate defective stages in radar receivers and to align the i-f amplifiers.

a. Signal Tracing. (1) The signal generator output is fed to the first i-f frequency of the radar receiver. The output of the signal generator should be amplitude modu-



OLD STYLE	COLOR	NEW STYLE
BODY A	INDICATES FIRST SIGNIFICANT FIGURE OF RESISTANCE IN OHMS	BAND A
END B	INDICATES SECOND SIGNIFICANT FIGURE	BAND B
BAND OR DOT C	INDICATES MULTIPLIER	BAND C
END D	IF ANY, INDICATES TOLERANCE IN PER CENT OF THE NOMINAL RESISTANCE VALUE. IF NO COLOR APPEARS TOLERANCE IS ± 20%	BAND D

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	TOLERANCE PER CENT (IF GIVEN)
BLACK	0	1	
BROWN	1	10	
RED	2	100	
ORANGE	3	1,000	
YELLOW	4	10,000	
GREEN	5	100,000	
BLUE	6	1,000,000	
VIOLET	7	10,000,000	
GRAY	8	100,000,000	
WHITE	9	1,000,000,000	
GOLD		0.1	5
SILVER		0.01	10
NO COLOR			20

TL 35620

Figure 254. Resistor color code.

lated at an audio-frequency rate of between 400 to 10,000 cycles per second. For information concerning the setting up of the signal generator, refer to the manufacturer's handbook accompanying the signal generator.

(2) Make the leads from the signal generator to the receiver as short as possible. Insert a coupling capacitor in the hot lead. For frequencies above 20 megacycles, the capacitance of the coupling capacitor should be around 0.005 microfarads.

(3) The i-f signal should be coupled by means of the coupling capacitor to the grid of the first i-f stage. If no output is shown on the radar oscilloscopes, connect a test oscilloscope to the plate of the detector. If no output is seen on the oscilloscope, the fault lies in or between the first i-f amplifier and the detector (subpar. (*a*) below). If a sinusoidal waveform having the same frequency as the chosen modulating frequency is seen, the i-f stages and the detector are operating. In that case, the test oscilloscope should be connected to the plate of the output stage of the receiver. If no output is seen there, the fault lies in or between the first video amplifier and the output stage (subpar. (*b*) below).

(*a*) If the fault is found to be in the i-f stages or in the detector, connect the signal generator to the grid of the middle stage of the i-f amplifier. If there is a normal output from the detector, the fault is in one of the first i-f stages. If the detector has no output, the fault is in or between the middle stage and the detector. By moving the signal generator output either forward or backward, stage by stage, the faulty stage can be rapidly located. In order to locate the defective part in the stage, change the tube. If replacing the tube does not clear up the fault, make resistance and voltage checks of the stage.

(*b*) If the fault is found to be in the video amplifiers, leave the signal generator connected to the first i-f stage and move the test oscilloscope from the grid to the plate of each video stage until the defective stage is located. If changing the tube does not correct the fault, make resistance and voltage checks to locate the defective part.

b. I-f Alignment. A signal generator is used in aligning i-f stages. The modulated output is fed to the grid of the stage preceding the stage being aligned. This is done to prevent the shunting effect of the signal generator from upsetting the circuit being aligned. The stage closest to the detector is aligned first. By working backward through the i-f stages, they are all brought into alignment. Each stage is adjusted to produce maximum indication on the oscilloscope. Adjust the stages with a nonmetallic aligning tool. If no tool is available, one can be made from a dry wooden rod. At all times, use the minimum signal generator output that will produce a satisfactory indication.

133. REPLACING PARTS. Careless replacement of parts often makes new faults inevitable. Note the following points:

a. Before a part is unsoldered, note the position of the leads. If the part, such as a transformer, has a number of connections to it, tag each of the leads.

b. Be careful not to damage other leads by pulling or pushing them out of the way.

c. Do not allow drops of solder to fall into the set, since they may cause short circuits.

d. A carelessly soldered connection may create a new fault. It is very important to make well-soldered joints, since a poorly soldered joint is one of the most difficult faults to find.

e. When a part is replaced in r-f or i-f circuits, it must be placed exactly as was the original one. A part which has the same electrical value, but different physical size, may cause trouble in high-frequency circuits. Give particular attention to proper grounding when replacing a part. Use the same ground point as in the original wiring. Failure to observe these precautions may result in decreased gain, or possibly in oscillation of the circuit.

SECTION II

TEST EQUIPMENT

134. TEST EQUIPMENT SUPPLIED WITH SET.

a. Standard. The following standard test equipment is furnished with Radio Set AN/MPN-1:

(1) Test Equipment IE-19A.
(2) Test Set RC-55-A.
(3) Analyzer, Weston, model 772.
(4) Oscilloscope, DuMont, model 241.
(5) Signal generator, Hickock, model 19X.
(6) Tube tester, Hickock, model 540.

b. Special. Special test equipment is also furnished with the radar set, in addition to two Synchroscopes TS-64/MPN-1. The special equipment is as follows:

(1) Test Set TS-224/UP.
(2) Power Monitor TS-125/AP.
(3) Power Monitor TS-36/AP.
(4) Voltage Divider TS-222/MPN-1.
(5) Flux Meter TS-15/AP.
(6) Echo Box TS-217/MPN-1.
(7) Test Set TS-13/AP, modified.
(8) Echo Box TS-225/MPN-1.

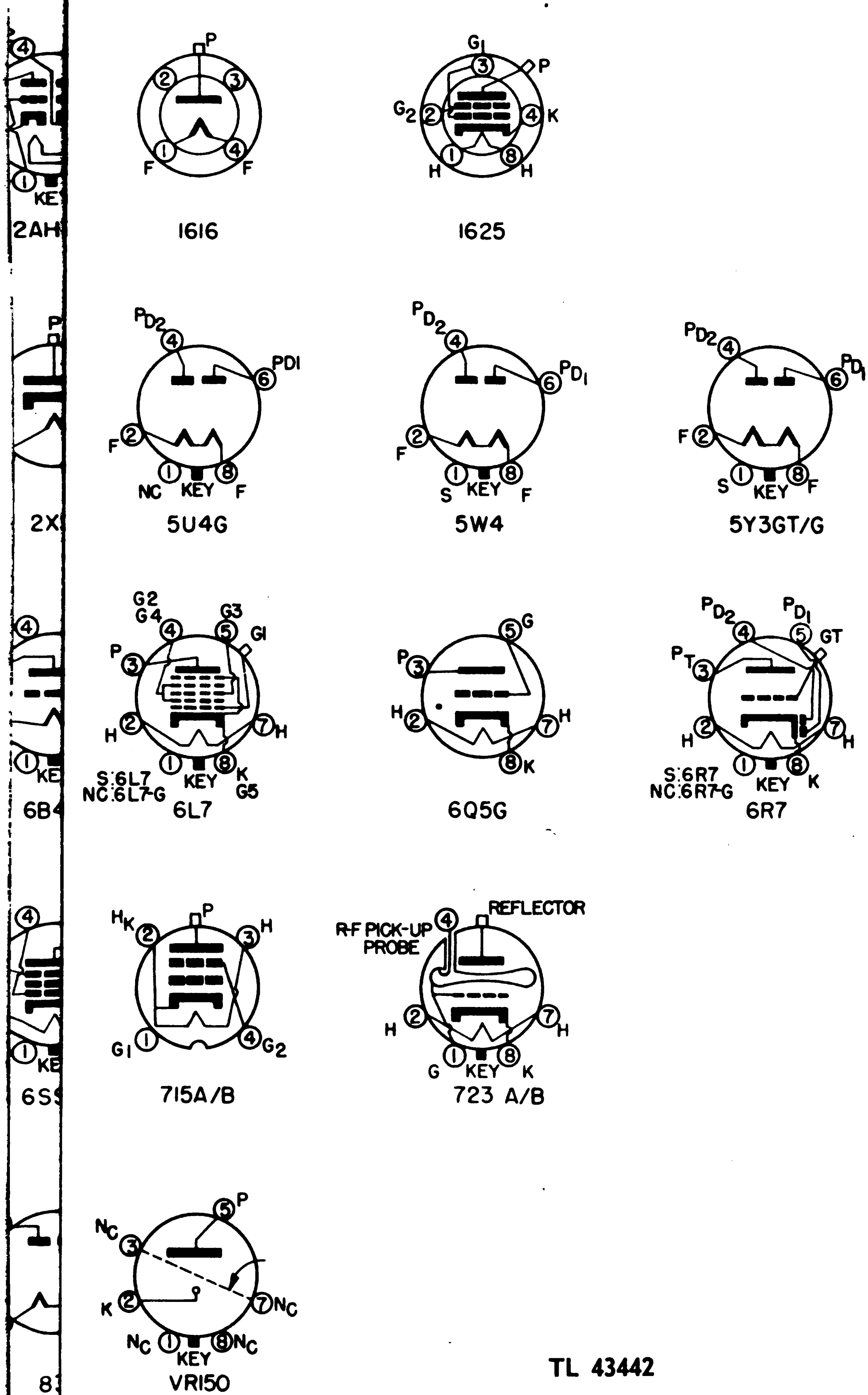


Figure 255. Tube base chart.

Figure 256. Analyzer and multiplier.

c. Instructions. For application and functioning of the analyzer (fig. 256), oscilloscope (fig. 257), signal generator (fig. 258), and tube tester (fig. 259) refer to the operating instruction book packed with each test set. For application and use of standard Test Equipment IE-19-A and Test Set RC-55-A for use with the communications installations of the equipment, refer to the instruction books as supplied with each test set. The following paragraphs contain complete functional descriptions and operating instructions for the use of all special test equipment.

Figure 257. Oscilloscope.

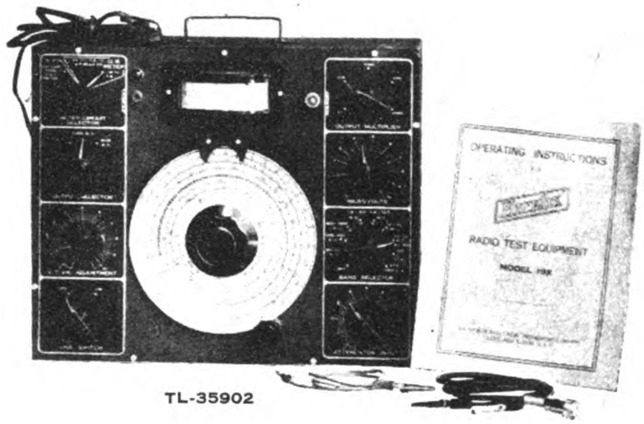


Figure 258. Signal generator.

Figure 259. Tube tester.

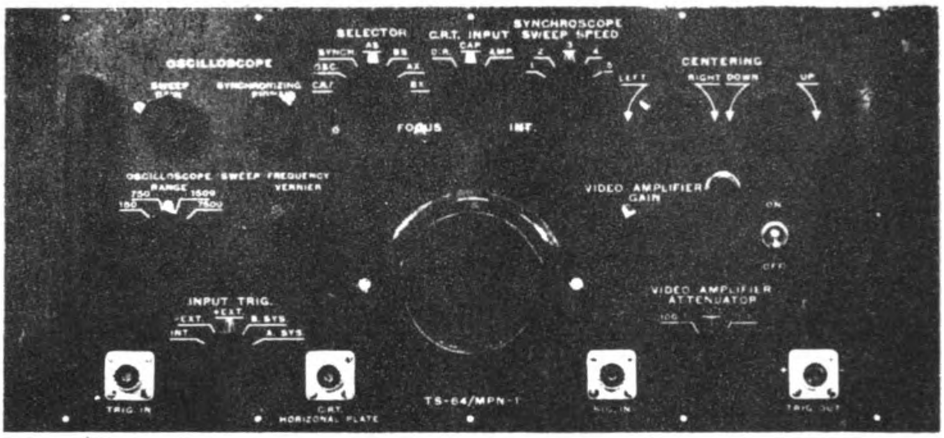


Figure 260. Synchroscope TS-64/MPN-1, front view. TL-38840

135. SYNCHROSCOPE TS-64/MPN-1.

a. Description. (1) The synchroscopes are used as test instruments for aligning and checking electronic components of the radar system. One synchroscope is mounted in bay 2 of the indicator rack (fig. 11), immediately below the channel B synchronizer; the other is located in bay 8 of the transmitter rack (fig. 10).

(2) The front panel of the synchroscope (fig. 260), contains the face of the 3-inch cathode-ray tube, and all the controls necessary for the operation of the unit as an oscilloscope, a synchroscope, or as a cathode-ray tube. The panel also mounts jacks for the interconnection of the synchroscope with the unit being tested. Synchroscope TS-64 combines in one piece of equipment a synchroscope having sweep speeds ranging from 2.5 to 250 microseconds per inch, and an oscilloscope having a linear sweep frequency ranging from 150 cycles to 7,500 cycles per second. The synchroscope may be triggered from an internal or external source, and is capable of furnishing positive or negative triggers at the same recurrence rate as the system. A self-contained power supply, a video amplifier and an attenuator are included.

(3) Test leads, provided with each synchroscope, may be connected between the input jacks on the synchroscope front panel and the test points located in the various component chassis for viewing voltage waveshapes at these points. The video output circuits of all four receivers, S-band and X-band, A and B channels, are connected to a selector switch on the synchroscope, making it possible to view video output pulses of any operating receiver. The synchroscope may be synchronized with either the A or B channel positive synchronizer triggers or by the use of its own internal trigger.

(4) The synchroscope is used as an *A* scope for system tuning, by applying the synchronizer trigger to the synchroscope sweep circuit and the video pulse of one of the receivers to the vertical deflection plates.

CAUTION: Extremely high voltages will be encountered if the cover of the synchroscope is removed during operation.

b. Comparison of Synchroscope with Oscilloscope. (1) The synchroscope is a test instrument designed to analyze the voltage functions which the standard test oscilloscope is unable to handle. It can be adjusted for viewing waveshapes over a considerable range of frequencies. Most test oscilloscopes are not suitable for viewing discontinuous waveshapes, even though they are repeated periodically. Impulse waves of extremely short duration in comparison with their recurrence frequency, such as the various trigger and sweep voltages generated in this equipment, are especially inconvenient for oscilloscope observation.

(2) If a pulse of short duration is placed on an oscilloscope whose sweep speed is adjusted to be synchronized with its return trace or period, the sweep will be so slow that the pulse (whose duration may be 5 or 10 microseconds) will show up on the oscilloscope as a straight vertical line. If the sweep speed is increased in order to spread the pulse waveshape on the scope face, a synchronization problem will be encountered. At first there is a single sweep in which the pulse appears and then there will be a large number of sweeps having no signal impressed on them due to their occurrence in the period between pulses. If an oscilloscope sweep frequency of 1,000 sweeps per second, with a pulse of 1 microsecond duration and a recurrence rate of 1,000 per second is to be viewed, each sweep will take 1,000 microseconds to complete its trace; the signal pulse, one microsecond wide, will occupy a space on the scope equal to 1/1000th of the sweep, and this image appears merely as a straight line. If, for example, the sweep

frequency is increased to 500,000 sweeps per second; each sweep will require 2 microseconds for completion and the signal pulse to be viewed will occupy one half of the sweep, which makes a study of its waveform possible. However, a number of sweeps, in this instance 499, appear between pulses and complete their straight-line trace with no signal being impressed. Synchronizing of the sweeps cannot be done accurately enough to insure the 500th sweep (on which the signal is impressed) of being synchronized so that the signal will repeat over the trace of the preceding signal. Enough shifting takes place to make this type of application of little value in studying such waveforms.

(3) The two requirements of the basic synchroscope design are as follows:

(a) It must provide a sweep fast enough to spread the viewed pulse well across the face of the cathode-ray tube (CRT).

(b) The sweep must be synchronized with the pulse to prevent shifting of the image on the face of the CRT.

(4) In a synchroscope, the sweep circuit is set into operation by use of a trigger voltage nearly in phase with the signal pulses and having the same recurrence rate. This trigger is applied to the sweep circuits at the same time that the pulse to be viewed is applied to the synchroscope. A timed sweep is provided which is fast enough to spread the pulse image across the face of the CRT, with one sweep being generated for each signal repetition. After each sweep, the spot on the tube face returns to its origin and remains there until the next pulse and trigger are applied to the sweep circuit; thus the sweep remains idle between pulses and by use of the trigger it is synchronized with the signal voltage. In this way, the synchronization problem in the oscilloscope is avoided and the synchroscope may be used to observe waveforms of very short duration.

*c. **Circuit Analysis.*** The synchroscope consists of the following circuits (fig. 261) which are assembled on a single chassis and operated by controls located on a front panel:

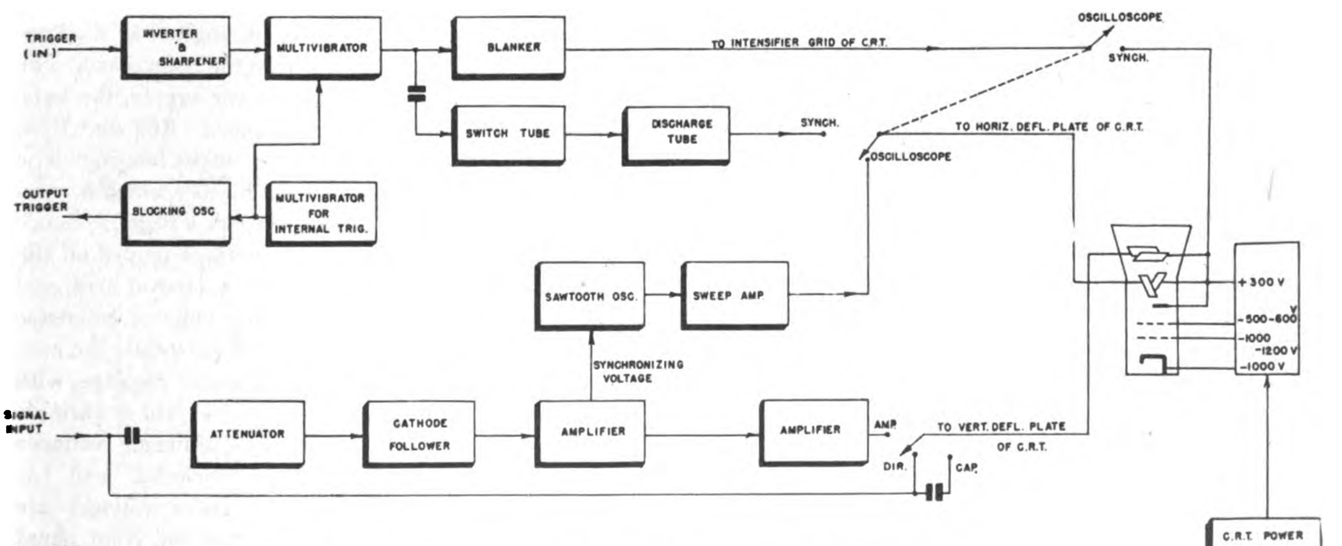
(1) A cathode-ray tube (CRT), and its associated low and high-voltage power supplies.

(2) A signal input circuit by means of which the input signal may be applied to the vertical deflection plates of the CRT either directly, through a capacitor, or through a controlled gain amplifier.

(3) An oscilloscope sweep circuit which generates a continuous saw-tooth wave voltage providing a linear horizontal sweep on the CRT.

(4) A synchroscope sweep circuit which supplies a linear horizontal sweep during the time in which the pulse to be viewed is applied to the vertical CRT plates. The spot on the CRT is deflected only during this period and remains idle between pulses. The circuit is triggered by the pulse that triggers the waveshape to be viewed; therefore, the CRT sweep is synchronized with the pulse to be viewed.

(5) An auxiliary trigger generating circuit may be used to trigger the entire radar system or any particular component which is being separately tested. Provision is made for utilizing the internal trigger to actuate the synchroscope sweep circuit generator.



TL 36025

Figure 261. Synchroscope TS-64/MPN-1, functional block diagram.

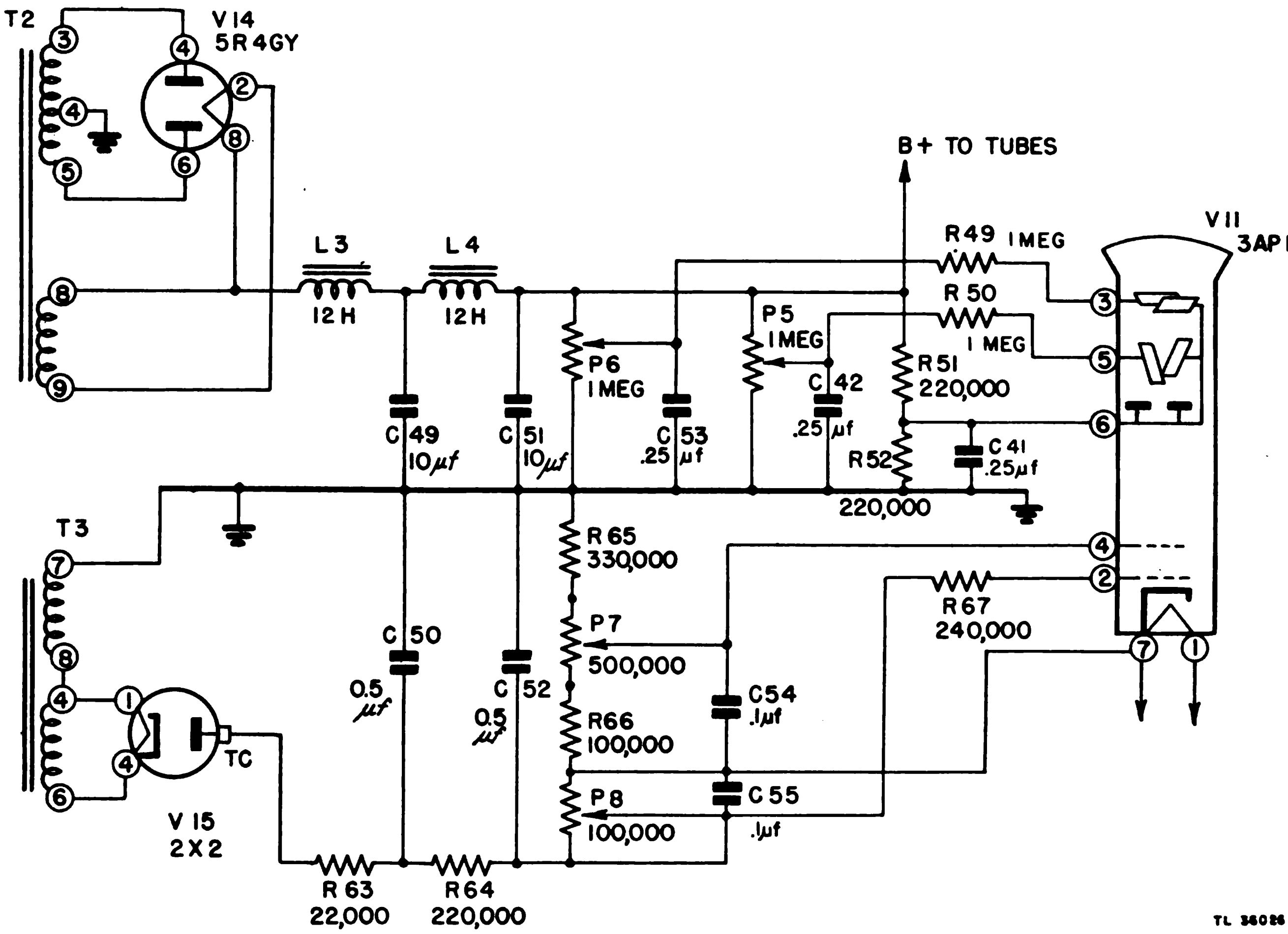


Figure 262. Synchroscope CRT and power supply, simplified schematic diagram.

d. Cathode-ray Tube and Power Supplies. CRT V11 (3AP1) is an electrostatic deflection type tube, with a 3-inch viewing screen. Bias and d-c centering voltages are supplied by high-voltage rectifier units located in the synchroscope chassis. Figure 262 presents a simplified schematic diagram of the power supply and its connections to the CRT. Note that the negative side of the low-voltage power supply is grounded and that relatively small positive voltages are supplied to the horizontal and vertical deflection plates and to the first anode. The low-voltage power supply is a full-wave rectifier, V14 (5R4GY), with regulation produced by a choke-input, double-section filter comprising the 10-henry chokes, L3 and L4, and C49 and C51, which are 10-microfarad capacitors. The 1-megohm potentiometers, P5 and P6, supply the output bleeder resistors with variable taps for application of positive voltages to one of each pair of deflection plates. An output positive voltage of 290 volts is applied as a plate-voltage supply to other tubes within the component. The positive side of the high-voltage power supply, the half-wave rectifier V15 (2X2), is grounded. R63 and R64, together with C50 and C52, provide output filtering. The voltage appearing across the output bleeder which is comprised of R65, P7, R66, and P8, reaches a negative maximum of 1,125 volts. The negative voltages tapped off the resistor network are placed on cathode, control grid, and focusing grid. The cathode is made a point of reference at approximately 1,000 volts negative potential; the control grid bias is variable to 125 volts negative with respect to the cathode; and the focusing grid is variable between –500 and –950 volts. These differing voltages provide adjustment for brilliance, focusing, and for horizontal and vertical centering. These voltages are controlled by potentiometers located on the front panel of the unit.

e. Input Signal Circuit. (1) The waveform to be studied is applied to the synchroscope either through the signal input jack, located on the front panel, or from the receiver video output wired to the synchroscope connector strip. Selection of the input and the type of operation is made through selector switch SW3 (fig. 263). Three-position switch SW5 permits choice of positions DIR. CAP., or AMP.

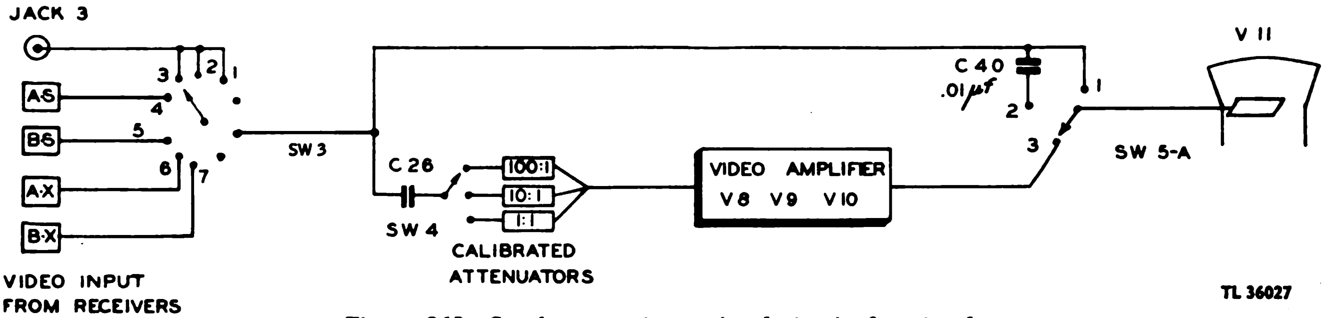


Figure 263. Synchroscope input signal circuit, functional block diagram.

(2) By placing the selector switch in the DIR. position, the signal is placed directly on the vertical deflection plates of the CRT. If the signal has a d-c component this may be eliminated from the trace on the CRT by placing the selector switch in the CAP. position, thus coupling the signal to the plate through capacitor C40. Should the incoming signal require amplification before being applied to the CRT, the switch may be placed in the AMP. position. In this case, the signal is first coupled to a calibrated attenuator composed of three capacitor-resistor networks. Variable capacitors C27 and C29 (fig. 264) provide a linear frequency-response characteristic adjustment, as well as an attenuation ratio adjustment. Three attenuator ratios may be selected by means of switch SW4, providing input signal attenuation ratios of 100-1, 10-1, or 1-1.

(3) The output of the attenuator circuit is fed to the grid of the cathode follower tube V8(a) (6SN7-GT). The output appearing across R37 is coupled through C32 to appear across voltage divider P1 and R39. P1 is the VERTICAL GAIN CONTROL on the front panel. The signal taken off is coupled through capacitor C33 to the grid of V9 (6AC7), an inductance-compensated video amplifier. This stage is designed to have a broad frequency response characteristic in order to avoid distorting the signal pulse. Plate inductance L1 serves to broaden the over-all response characteristic by resonating with the various circuit capacitances at higher frequencies, and prevents amplification from falling off.

(4) The output of tube V9 is fed through capacitor C36 to the grid of V10 and is video-compensated through the application of L2 in its plate circuit. The output pulses

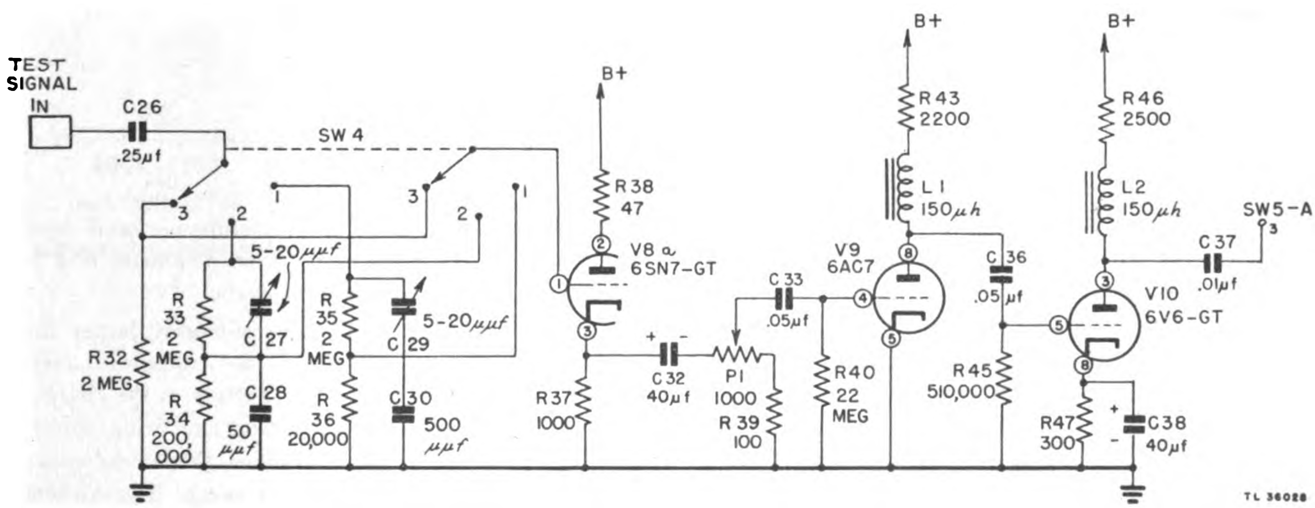


Figure 264. Synchroscope attenuator and amplifier, simplified schematic diagram.

are applied through C37 to position 3 (AMP.) of selector switch SW3-A for application to the vertical deflection plate of the CRT.

(5) When the unit is used as an ordinary CRT, the vertical deflection signal is applied to the tube in the usual manner, as described above, and the horizontal deflection plates are disconnected from the internal sweep circuit by means of multiposition switch SW3-2 (fig. 275) and are connected at position 1 on the switch to plug 2, the HORIZONTAL INPUT jack. External horizontal deflection voltage is now applied to the CRT through this connector. The d-c operating voltages for the CRT are provided by the two power supplies.

f. ***Oscilloscope Sweep Circuit.*** (1) Saw-tooth voltage waves generated by this circuit are applied to the horizontal deflecting plates of the CRT, producing a linear horizontal sweep for test oscilloscope application. Tube V12 (884) (fig. 265) and the RC network operate as a variable frequency relaxation oscillator. The output is amplified by tube V13 (6SJ7-GT).

(2) As selected by switch SW6, capacitor C43, C44, C45, or C46 is charged through resistors R55 and P3 from the B+ supply. The capacitor charging curve is exponential, but only the linear lower portion is used. Somewhere along this portion of the curve the voltage reaches a point where it equals the striking voltage required by tube V12. As the tube starts to conduct, the capacitor discharges rapidly through the tube. Because the capacitor discharge through the low series resistance of R54 (270 ohms) and tube V12 is very small, the discharge time is negligible in comparison with the charging time. As soon as the capacitor voltage falls below the minimum value necessary to keep V12 ionized, the tube de-ionizes and the charging of the capacitor begins again.

(3) By using a plate voltage considerably larger than the firing voltage of tube V12, the capacitor charges toward the higher value and the portion of the charging curve between the tube de-ionization and firing voltages is essentially linear. When amplified, this linear voltage produces the oscilloscope saw-tooth sweep. The saw-tooth wave appears across resistor combination R58 and P4. From the tap on P4, a portion of the voltage is applied to

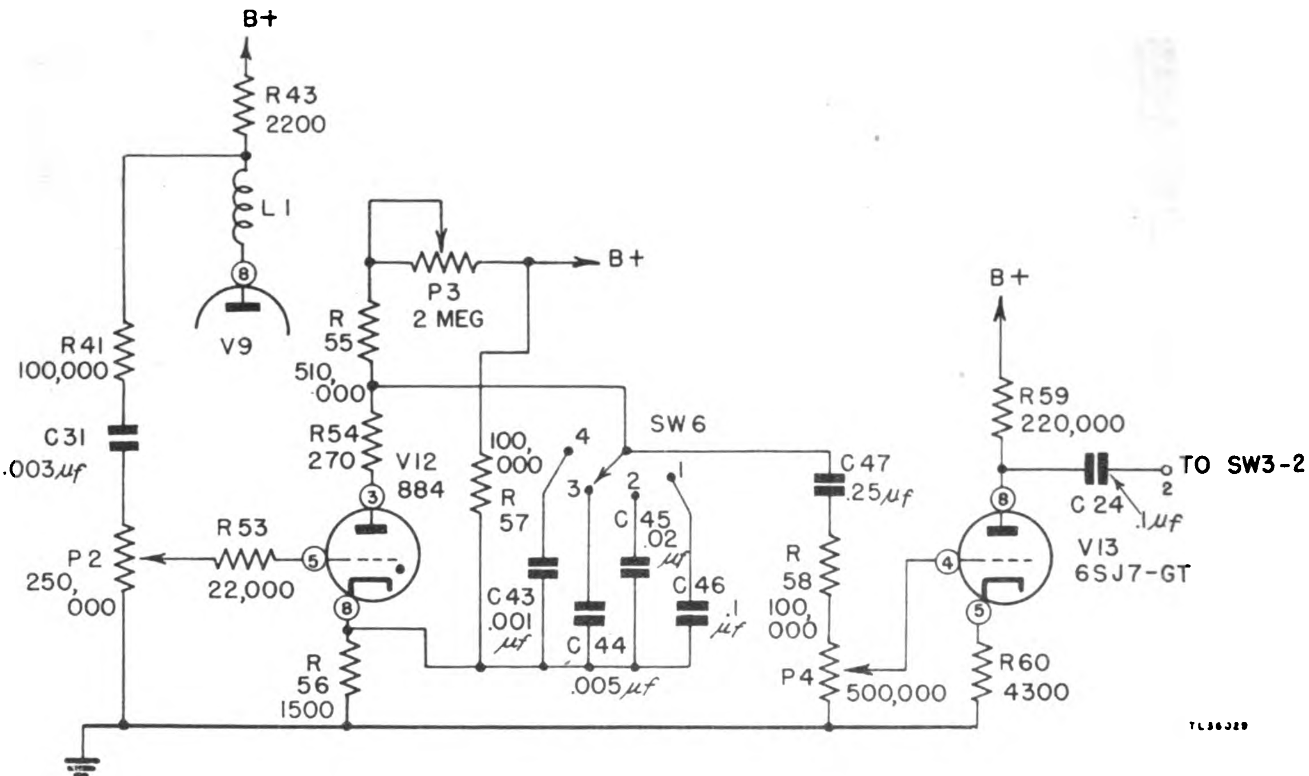


Figure 265. Oscilloscope sweep circuit, simplified schematic diagram.

the grid of V13 to be amplified and applied through C24 to one of the contacts on switch SW3-2, from which it can be applied to the horizontal deflecting plates of the CRT.

(4) Frequency of the saw-tooth sweep is controlled by varying the length of time required for the charging curve between the tube de-ionization voltage and the striking voltage. This elapsed time, and the frequency of the sweep, are roughly controlled by varying the size of the charging capacitor. To increase the capacitor size would decrease the slope of the charging curve, resulting in a lower frequency, or to decrease the value of the capacitor would increase the frequency. Switch SW6, which selects one of the four values of capacitance, is located on the front panel and is the frequency-coarse adjustment. A vernier adjustment of frequency provided by potentiometer P3 produces small changes in the charging rate by varying the amount of series resistance in the charging circuit. This potentiometer is located on the front panel and is the frequency-fine adjustment.

(5) Sweep lock control P2 establishes the level of grid voltage for V12 and is coupled through C31 to the plate circuit of V9, the first amplifier tube in the signal input circuit. Thus a small portion of the amplified signal input can be fed back to the oscillator grid circuit to serve as a synchronizing voltage.

(6) Since V12 is a grid-controlled thyratron, this synchronizing voltage causes the firing voltage of the tube to vary directly with the input signal voltage. If the oscillator frequency is adjusted to approximately the signal frequency, the synchronizing voltage on the grid of V12 will trip the tube at a given point on the input signal wave and will lock the sweep in synchronism with the signal frequency. This will prevent the signal from drifting, despite small changes in circuit voltages.

g. Internal Trigger Circuit. (1) The synchroscope includes its own internal trigger source (fig. 266) to permit greater flexibility in its use. When no system trigger is available, the synchroscope trigger actuates the component being tested, and synchronizes the internal circuit of the test instrument.

(2) Free-running multivibrator V5 (6SN7-GT) (fig. 266) develops an output rectangular wave of 500 microseconds duration. Both leading and trailing edges of this wave are differentiated to form sharp voltage peaks 500 microseconds apart. These peaks are applied to trigger blocking oscillator V6. The output of V6 (6SN7-GT) is brought to the TRIG. OUT jack on the front panel. The multivibrator output wave is also applied through the INT. position of trigger selector switch SW1-1A to the synchroscope sweep generator circuit beginning with V2 (6SN7-GT). See figures 266 and 270.

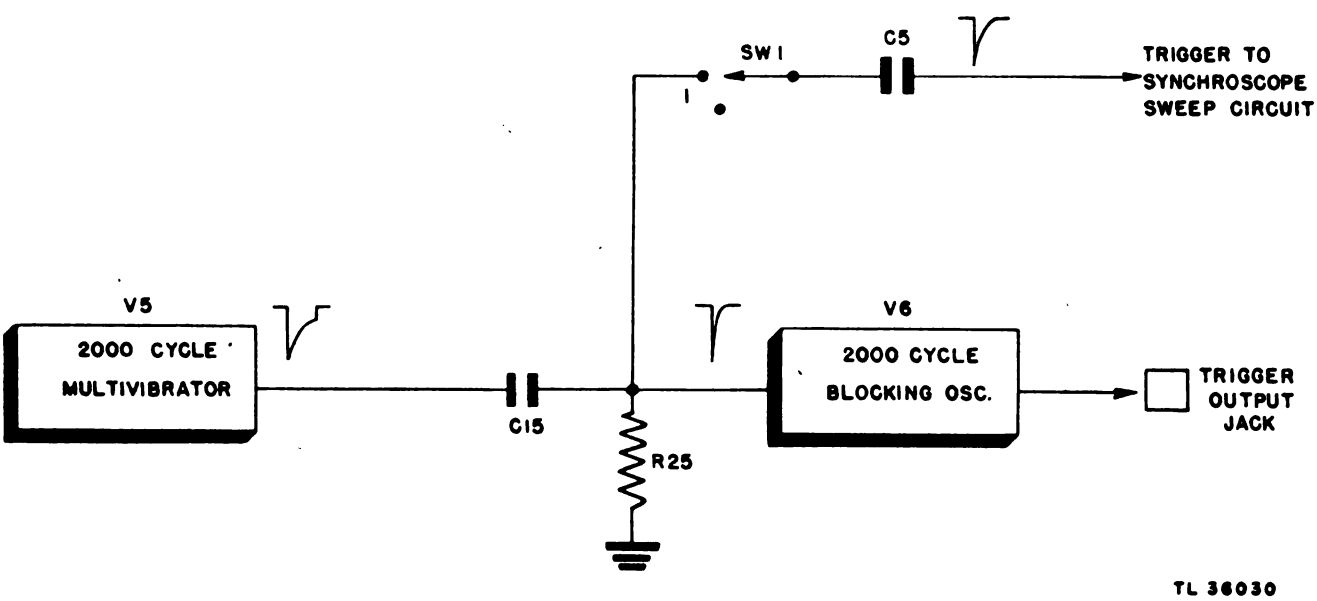


Figure 266. Synchroscope internal trigger circuit, functional block diagram.

(3) Multivibrator V5 (fig. 267) operates freely, the time of conduction of the triodes being determined by the two RC combinations R23-C13 and R24-C14. Both capacitors are of the same value, 0.002 mf but resistors R23 and R24 are 62,000 and 22,000 ohms respectively. The voltage output is taken from the plate of V5(b) and applied to the inverter amplifier stage V6(a) through C15 and across R25. R25 and the small value of C15 produce pulses with an extremely short time constant. Therefore the plate output wave from V5 is not impressed on the following grid but only the differentiated leading and trailing edges, which appear as sharp positive and negative pulses. The plate output of V6(a) is coupled to the grid of V6(b), a typical blocking oscillator. Only positive pulses will be applied to the grid of V8(b), owing to the clipping and inverting action of V8(a).

(4) On examination of the grid voltage waveforms (fig. 268) it is apparent that the 500 microsecond pulse from V6(a) raises the grid above cutoff and triggers the blocking oscillator earlier than would occur if the natural charging curve were followed.

(5) The transformer tertiary winding is loosely coupled to the plate winding and its terminals brought out to the

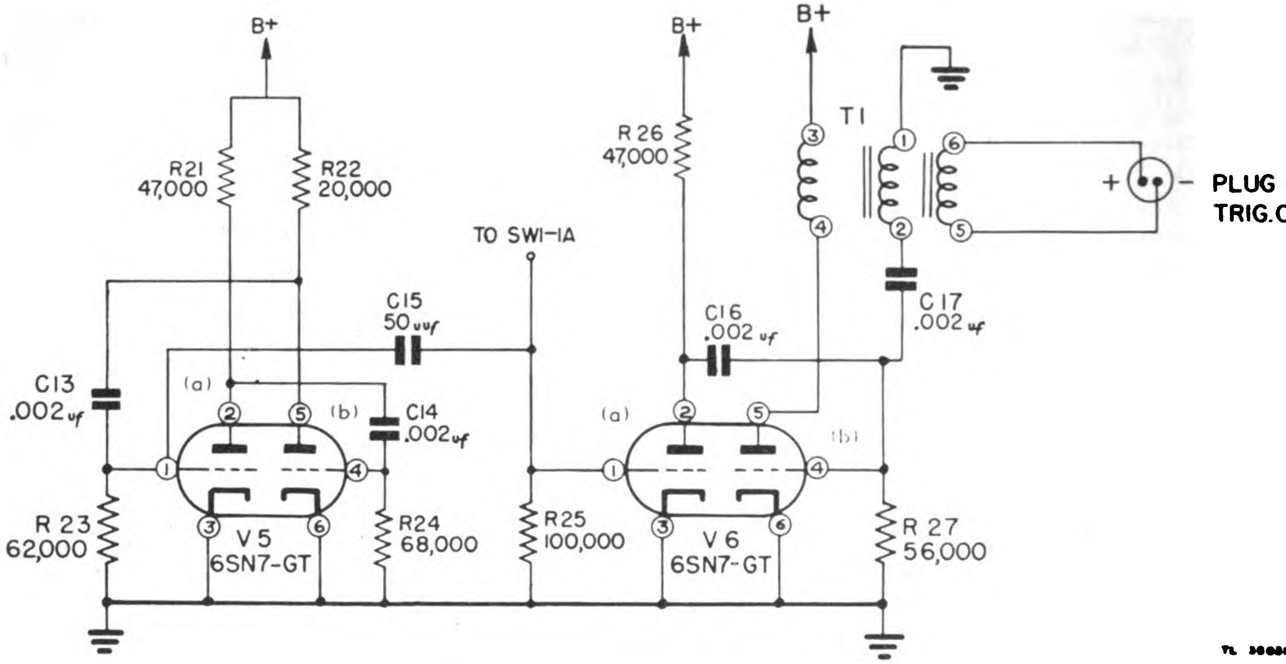


Figure 267. Synchroscope internal trigger circuit, simplified schematic diagram.

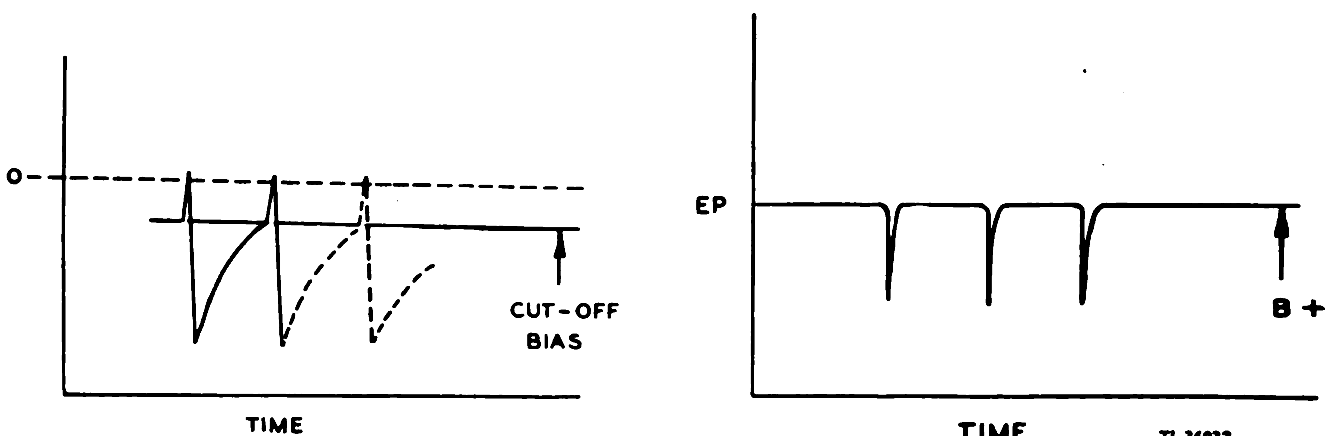


Figure 268. Triggered blocking oscillator, grid voltage waveforms.

TRIG. OUT jack with polarities marked. This 2,000-cycle trigger is available for test application.

h. Synchroscope Sweep Circuits. (1) A functional block diagram of the synchroscope sweep circuit is shown in figure 269. The rectangular gate from multivibrator V5 is applied through the contacts of switch SW1-1A to the differentiating network C5 and R8, which presents it as a series of sharp pulses of alternately negative and positive voltages to the grid of V2(a).

(2) The synchroscope sweep circuit develops a linear horizontal sweep for the cathode-ray tube, which is variable in five steps of 2.5, 7, 15, 85, and 250 microseconds. A short blanking pulse is generated for application to the control grid of cathode-ray tube V11. This short pulse blanks the CRT during the return trace so that it is not visible on the tube screen. The sweep developed must be synchronized with the input signal.

(3) The input trigger, selected by SW1-2A (fig. 270), is applied to the grid of the first triode of V1 (6SN7-GT). If the input trigger is positive, an amplified negative trigger appears on the plate of V1(a) and is applied through the contacts of SW1-1A to the grid input circuit of V2(a). In this case V1(a) is cathode-biased beyond cutoff by use of resistor network R7 and R2 between B+ and ground, contact being made through switch SW1-1B. The contact is completed for the three positive trigger selection points, positions 3, 4, and 5 of SW1.

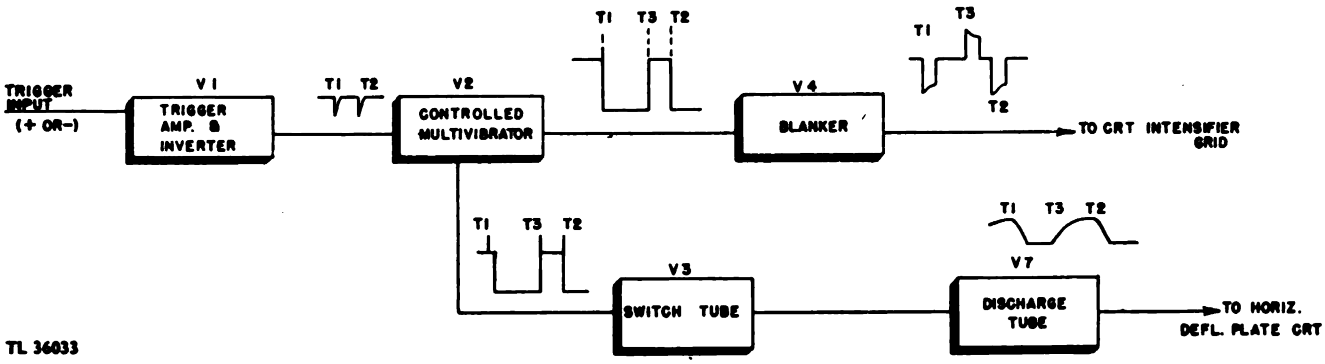


Figure 269. Synchroscope sweep circuit, functional block diagram.

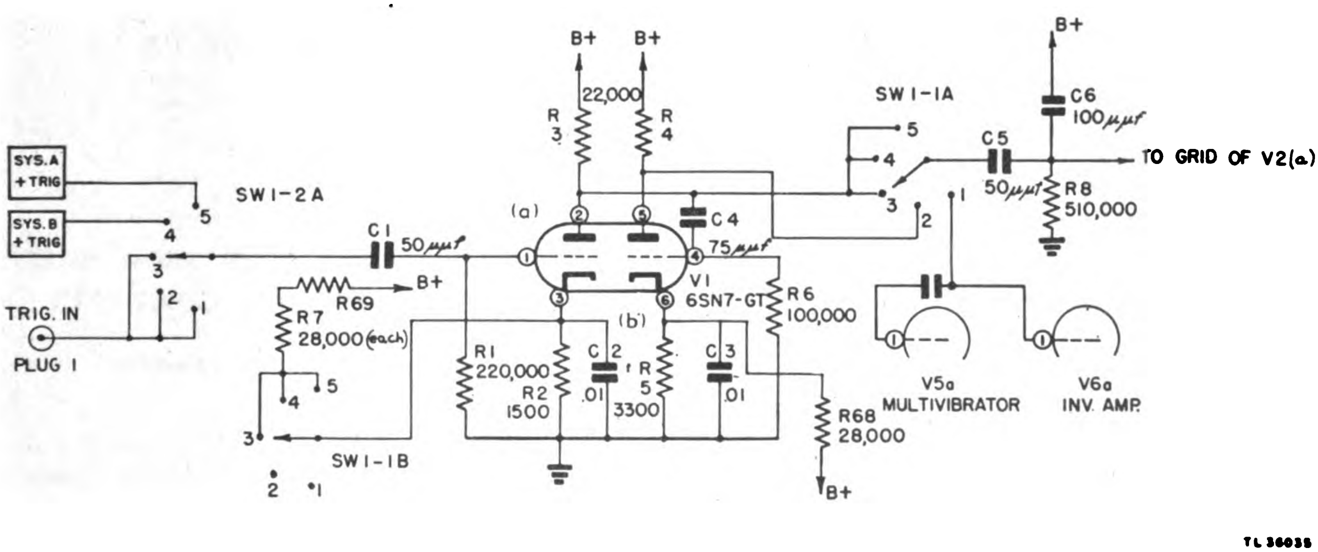


Figure 270. Synchroscope sweep trigger input circuit, simplified schematic diagram.

(4) If the input trigger is negative from a negative external source or from the internal trigger, SW1-1B is disconnected and the positive pulse appearing on the plate of V1(a) is coupled through C4 across R6 to the grid of V1(b). The sharp negative plate output is applied to the grid of V2(a) through the second contact of SW1-1A. The negative internal trigger from V5 is brought directly to contact 1 of switch SW1-1A for that position of the selector switch. V1 and SW1 are so connected that, regardless of the polarity of the input, a negative trigger is applied to the grid of V2(a).

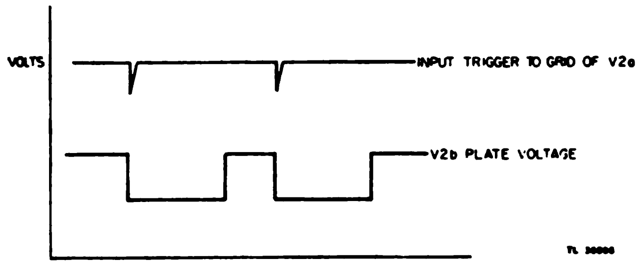


Figure 271. Controlled gating multivibrator output waveform and trigger input.

(5) Tube V2 and its associated network form an unbalanced free-running multivibrator with a long conducting period. The action of the multivibrator is triggered by the input negative trigger to the grid of V2(a) (fig. 271). The period of conduction in V2(a) is not critical in length, except that it must exceed 150 microseconds so that the multivibrator will not trigger itself. The output of V2(b) is a negative voltage gate during the 350-microsecond conduction period.

(6) The output of V2(b) serves as a gate for controlling the starting point of the synchroscope sweep and blanking pulse. The sweep occurs during the 350-microsecond portion of the wave and blanking occurs at the beginning of the 150-microsecond period. Since the starting point of this wave is controlled by the trigger which creates the wave being viewed, the CRT sweep is synchronized with the viewed signal pulse.

(7) The linear sweep voltage applied to the CRT through capacitor C25 is produced by the discharge of any one of the four capacitors C20, C21, C22, and C23, as selected by switch SW2-B, through discharge tube V7 (6SJ7-GT). Choice of sweep length is made by selection of the different sized capacitors. Since V7 is a pentode with a plate current inherently independent of plate voltage, the capacitor selected is discharged at a constant rate. Therefore the voltage across the capacitor decreases linearly to provide a linear CRT sweep.

(8) The cycle of charging and discharging the capacitor in the plate circuit of V7 is controlled by switch tube V3. Both triodes of V3 are connected together for parallel operation. The positive 150-microsecond gate applied to the grids of V3, which are normally biased to zero, causes the tube to conduct heavily and to charge the sweep capacitor connected to switch SW2-B. The negative 350-

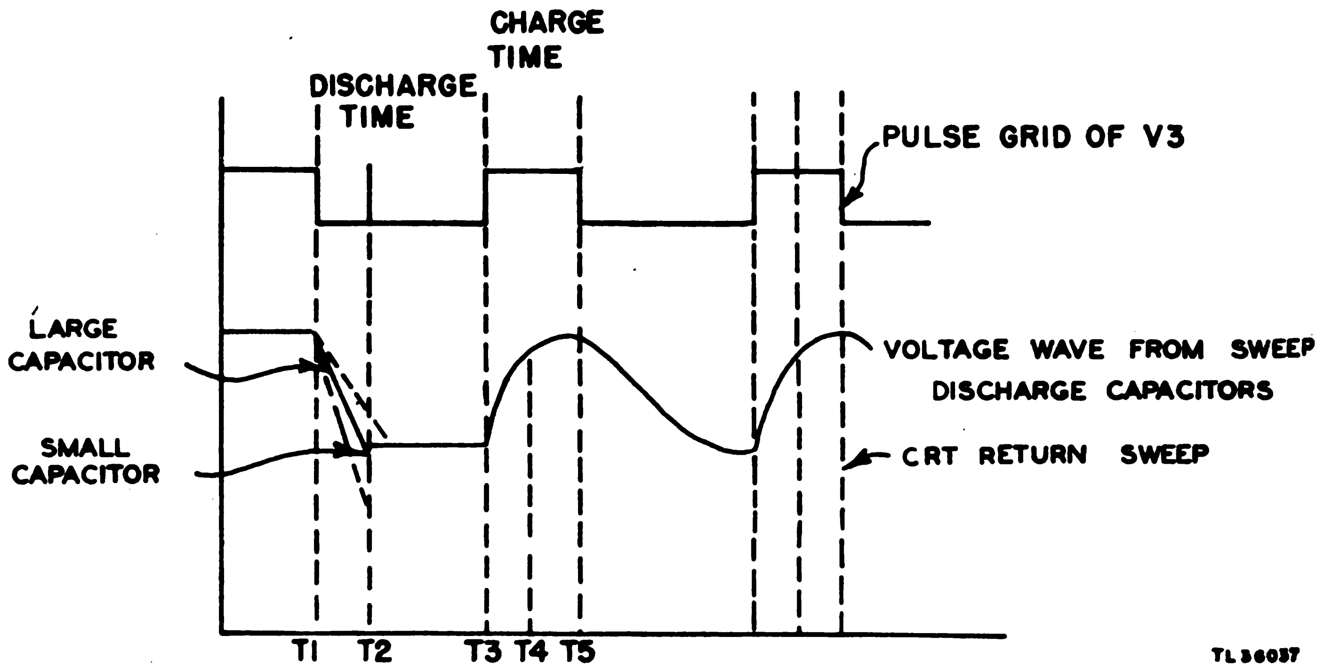


Figure 272. Synchroscope sweep waveform.

microsecond pulse from V2 then biases V3 to cutoff, allowing the sweep capacitor to discharge through V7. As the result of the sweep circuit action, the CRT sweep starts at the beginning of the 350-microsecond pulse and continues until the end of the pulse, its speed being regulated by the size of the discharge capacitor selected.

(9) Considering the cycle of the sweep, as shown by the solid line in figure 272, the sweep starts at time T1 and continues until T2, at which point the sweep voltage assumes a constant value and the spot remains at its maximum deflection. At T3, switch tube V3 allows the capacitor to begin its recharging cycle and the deflection voltage returns to its original value, allowing the spot to return to its origin until the next cycle begins. In order to eliminate the return trace from the CRT screen, blanking is applied to the intensifier grid of the CRT during the period between time T3 and T4.

(10) The blanking pulse is generated in blanking tube V4. It is controlled by a portion of the output of V2(b). The multivibrator pulse (fig. 273) is fed to the grid of V4 through a timed RC circuit composed of capacitor C9 and series resistors R13 through R17, placed in the circuit through switch SW2-A. The five positions of the switch correspond to the length of the CRT sweeps previously described.

(11) The length of the blanking pulse is determined by the value of resistance in the RC network, which sets the slope of the positive pulse applied to the grid of V4. A small value of resistance produces a narrow positive pulse and a short gate, while a larger resistance value widens the pulse and permits a longer period of conduction and hence a longer blanking gate to the intensifying grid of the CRT.

136. TROUBLE SHOOTING THE SYNCHROSCOPE.

a. Test Equipment. The test oscilloscope and the analyzer are used in the test procedure.

b. Test Conditions. (1) Terminals AB 7-1 and AB 7-2, or plug 5 connected to 117 volts ac (fig. 275).

(2) System trigger applied to terminal AB 7-4 or AB 7-8.

(3) Video signal from either A or B channel receiver applied to proper terminals, or a test waveform applied to plug 3.

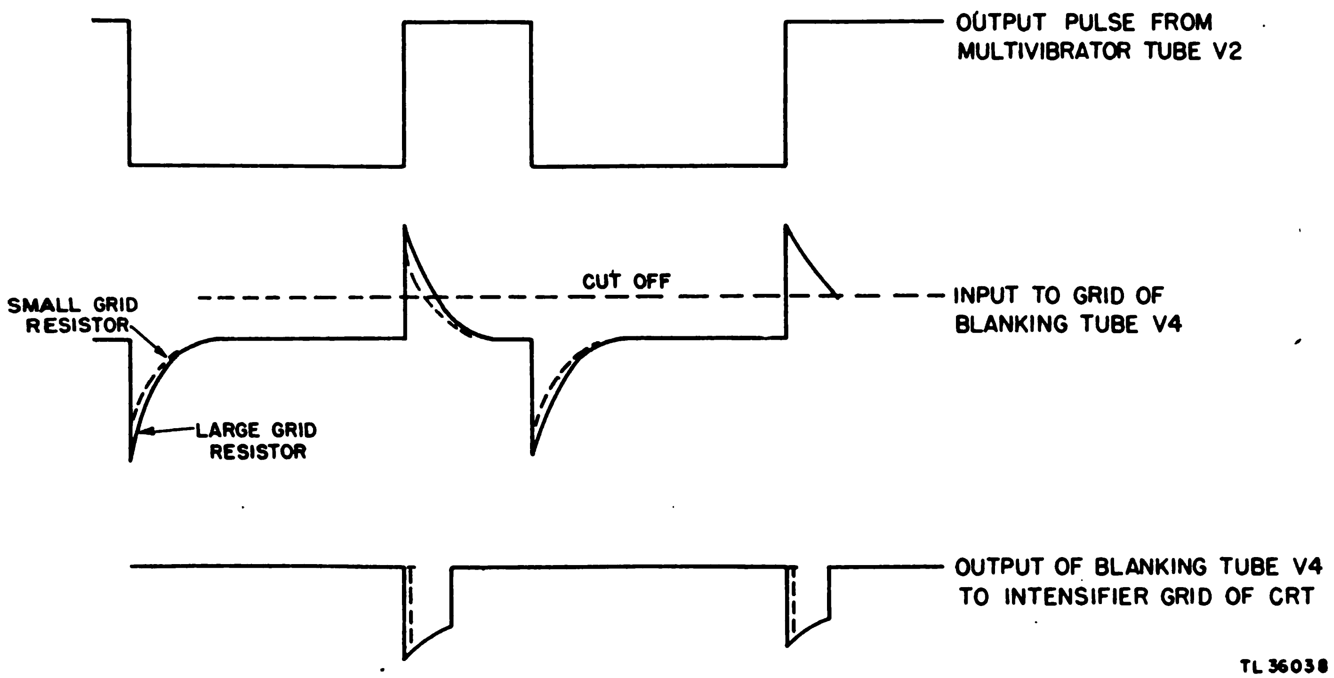


Figure 273. Blanking pulse generator waveform.

c. Test Procedure. For test purposes the synchroscope system should be divided into the following circuits:

(1) CATHODE-RAY TUBE AND POWER SUPPLIES. Tests for satisfactory operation of the CRT (cathode-ray tube) and the power supplies within the component will consist primarily of voltage and resistance checks, using figures 276-280 as references. Check the a-c and d-c volt-

ages on tubes V14 and V15, which supply the plate voltage to all tubes, and negative voltage for operation of CRT V11. Test the vertical sensitivity of CRT as follows: Connect the positive terminal of the analyzer to the SIG. IN jack, the negative terminal to chassis of the synchroscope. Adjust the analyzer to read positive voltages to ground. Set the synchroscope selector switch to SYNCH., the C.R.T. INPUT to DIR., and the power switch to ON. Turn CENTERING control UP and DOWN so as to move the trace 1 inch on the face of the CRT. Note the change in voltage on the analyzer for this 1-inch change in vertical position of the trace. The deflection sensitivity is then this change-in-voltage per inch.

CAUTION: The voltage at the plate cap of V15, at cathode and filament terminals 1 and 7, signal and focusing grids of V11, range between -500 and -1,250 volts dc. Use extreme caution when making tests at these points.

(2) INPUT SIGNAL CIRCUIT. Check switch SW3, SW4, and SW5 which select voltage inputs for application to the CRT. A mechanical inspection of the wiring for loose connections, and the switch contacts for cleanliness and corrosion should be adequate for these portions of the circuit. Check operation of the video amplifier stages V8, V9, and V10, by applying a known voltage waveform to plug 3 with SW5 set to the AMP. position. Compare the pattern on the CRT screen with the known waveform. If the waveform is abnormal, check the voltage and resistance at tubes V8, V9, and V10.

(3) OSCILLOSCOPE SWEEP CIRCUIT. Since the oscilloscope sweep voltage is generated by a relaxation oscillator V12 and the RC network as selected by switch SW6, most faults in this circuit can generally be traced to a defective tube V12 or to leakage in one of the capacitors selected by SW6. If the oscilloscope sweep will not lock in properly, check the resistance of P2, R41, and R53. Check capacitor C31 for leakage. If the above tests do not locate the defect, make voltage and resistance tests on tubes V12 and V13.

(4) INTERNAL TRIGGER CIRCUIT. Set selector switch SW3 to SYNCH., and INPUT TRIG. switch to INT. Check the waveform at pin 1 of V2 and V6 as shown in figure 274. Connect the vertical plates of the test oscilloscope to the TRIG. OUT jack. The waveform at this point should be the same as pin 2 of V6. If no output is obtained at the TRIG. OUT jack, check the voltage and resistance at the socket pins of tubes V1, V5, and V6.

(5) SYNCHROSCOPE SWEEP CIRCUIT. Connect a test lead from the TRIG. IN jack on the synchroscope to terminal 4 of connector strip 7 on the synchronizer chassis. This applies a negative trigger voltage to switch SW2. Using the other synchroscope, observe the waveform at pin 1 of tube V2, as shown in figure 274. To check the operation of tubes V3 and V4, observe the waveform at pin 3 of tube V3. As the SYNCHROSCOPE SWEEP SPEED switch is moved from position 1 to 5, the leading edge of the waveform at pin 3 of tube V3, should become less steep. To check operation of tube V4, observe the waveform at pin 3. The width of this waveform should increase as the SYNCHROSCOPE SWEEP SPEED switch is moved from position 1 to 5.

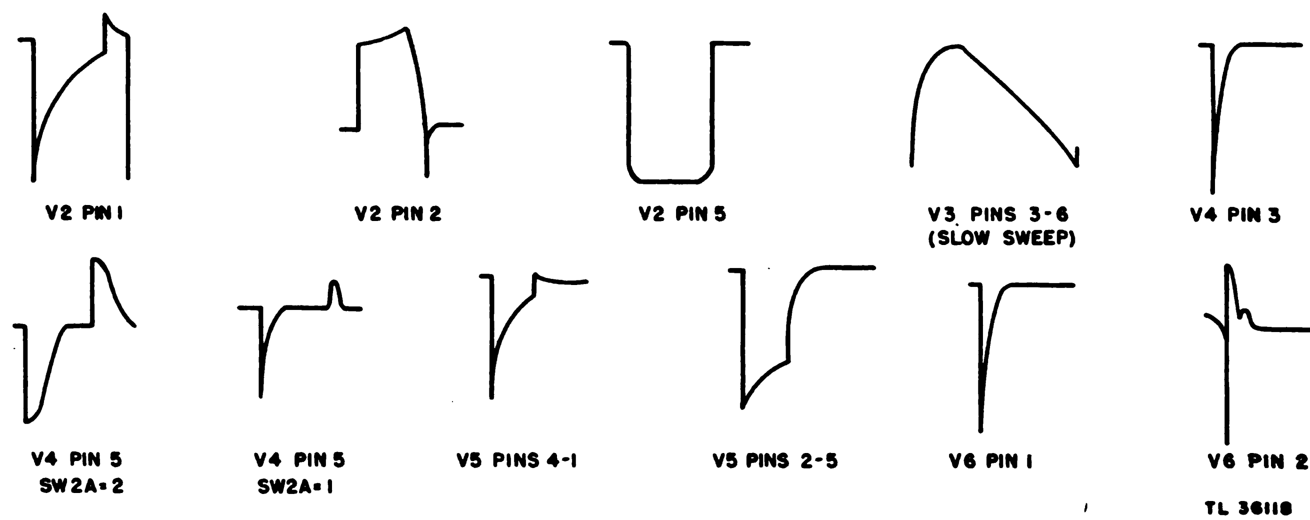


Figure 274. Synchroscope waveforms.

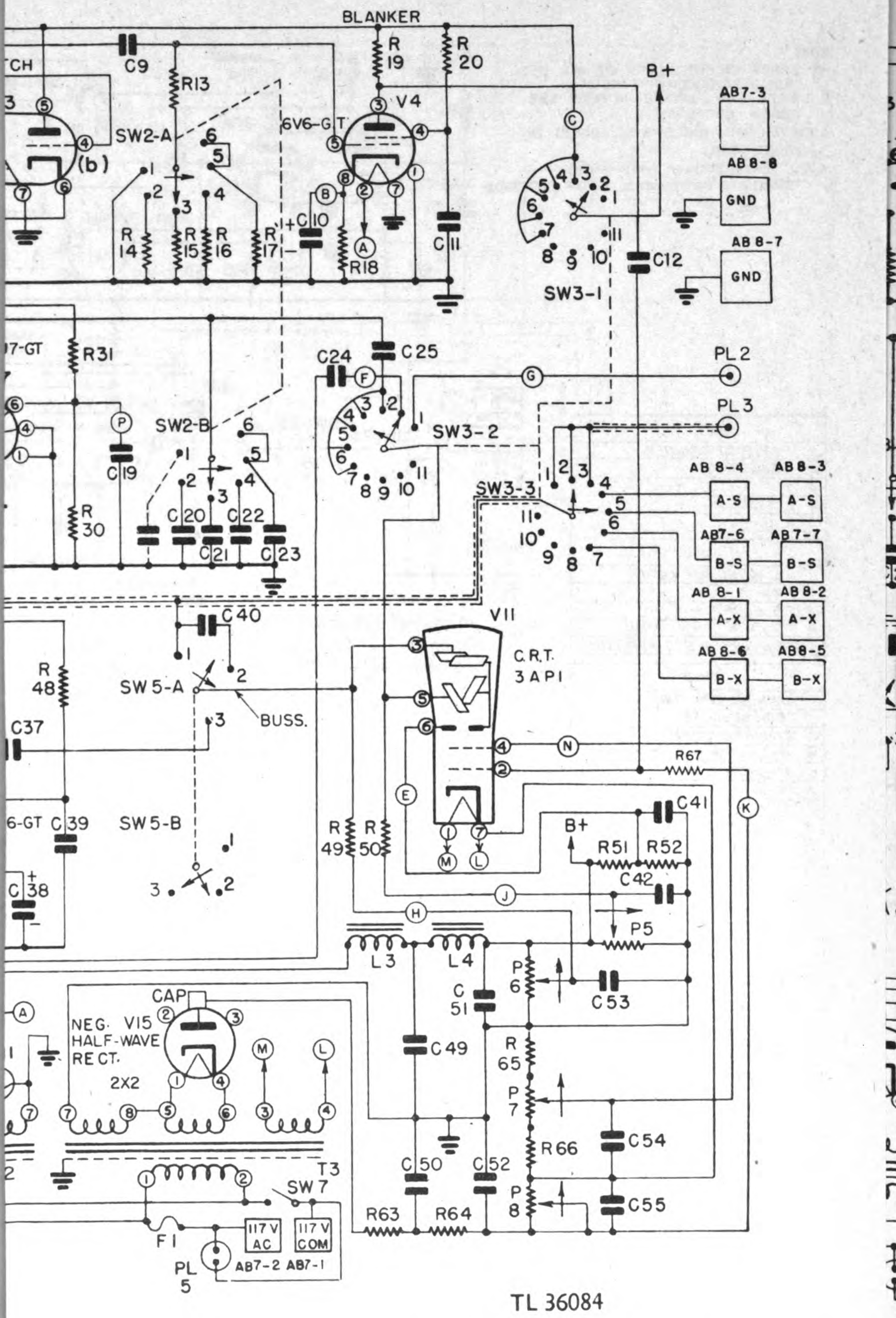


Figure 275. Synchroscope TS-64/MPN-1, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R36	20,000	½	5%
R37	1,000	½	20%
R38	47	½	20%
R39	100	½	20%
R40	22 Meg	½	20%
R41	100,000	½	20%
R42	68,000	1	20%
R43	2,200	1	20%
R44	4,700	2	20%
R45	510,000	½	5%
R46	2,500	25	5%
R47	300	2	5%
R48	10,000	½	20%
R49	1 Meg	½	5%
R50	1 Meg	½	5%
R51	220,000	½	20%
R52	220,000	½	20%
R53	22,000	½	20%
R54	270	½	10%
R55	510,000	½	5%
R56	1,500	½	5%
R57	100,000	2	20%
R58	100,000	½	20%
R59	220,000	1	20%
R60	4,300	½	5%
R61	680,000	½	20%
R62	470,000	½	20%
R63	22,000	½	20%
R64	220,000	1	20%
R65	330,000	2	20%
R66	100,000	½	20%
R67	240,000	½	5%
R68	28,000	2	10%
R69	28,000	2	10%
R70	28,000	2	5%
P1	1,000	2	10%
P2	250,000	2	10%
P3	2 Meg	2	10%
P4	500,000	2	10%
P5	1 Meg	2	10%
P6	1 Meg	2	10%
P7	500 000	2	10%
P8	100,000	2	10%
L1	CH-844-8	150 μh	
L2	CH-844-8	150 μh	
L3	15-2476	12 h	
L4	15-2476	12 h	
T1	5227D		
T2	15-3384		
T3	15-3377		
SW1	2515		
SW2	3226J		
SW3	1413		
SW4	3223J		
SW5	3223J		
SW6	3215J		
SW7	1GA1A1		

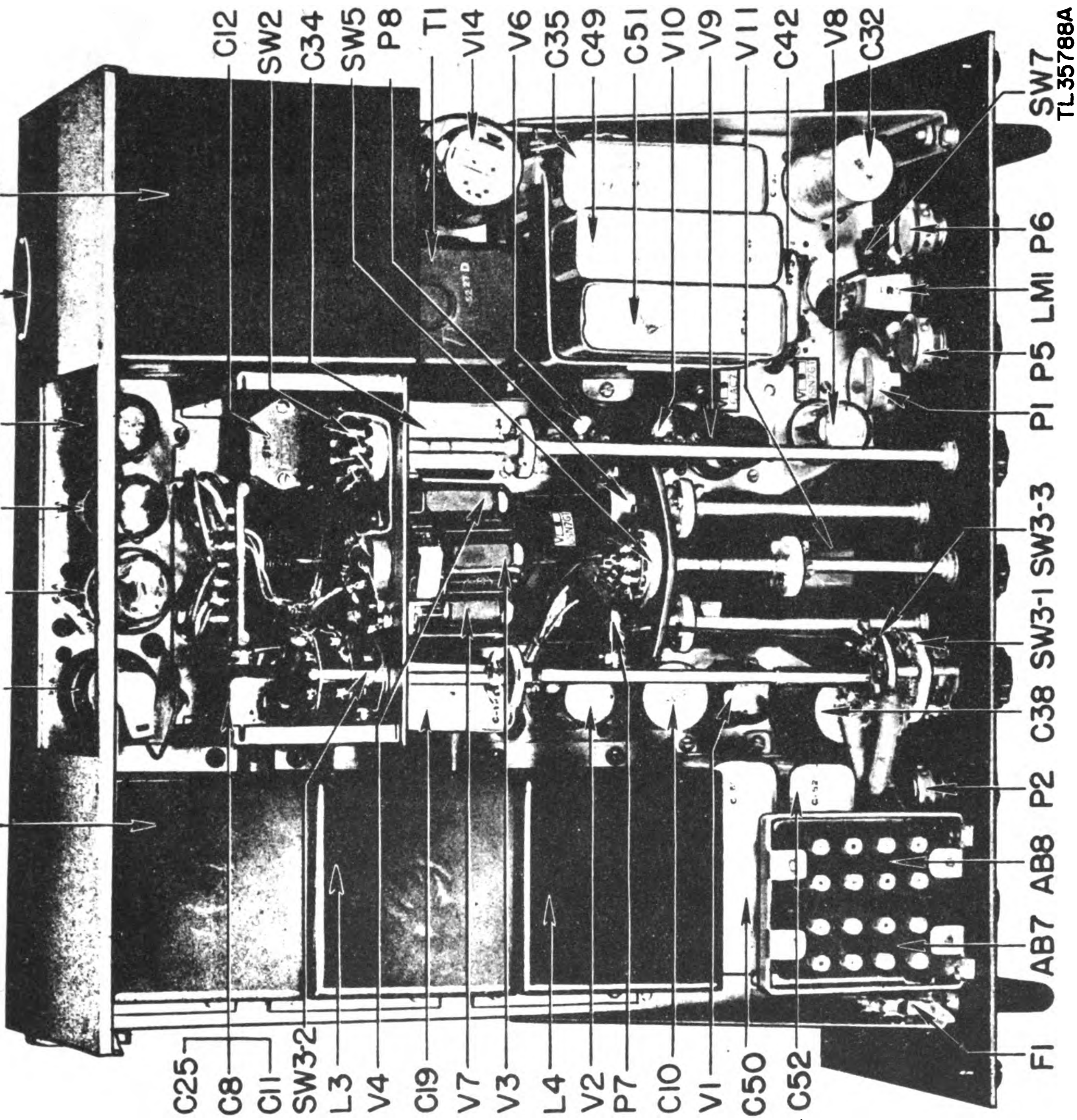


Figure 276. Synchroscope TS-64/MPN-1, top view.

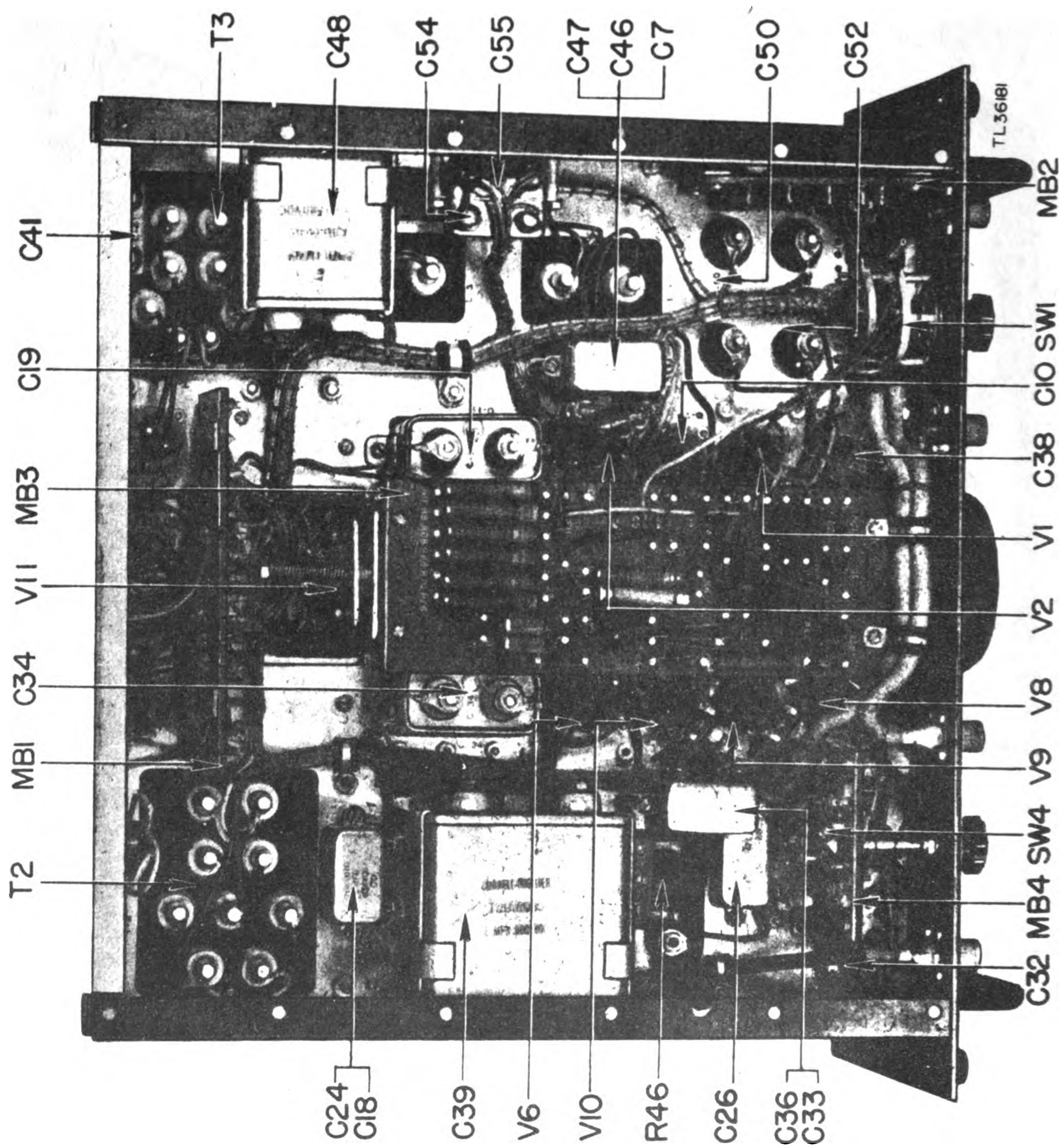
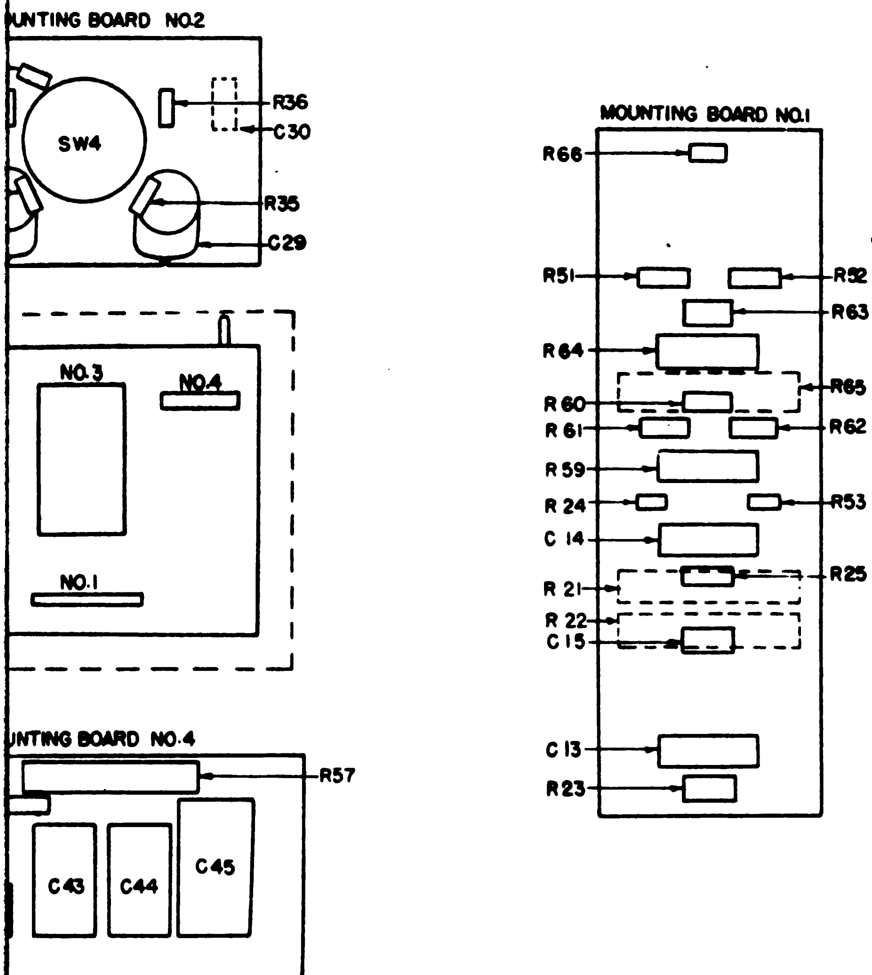
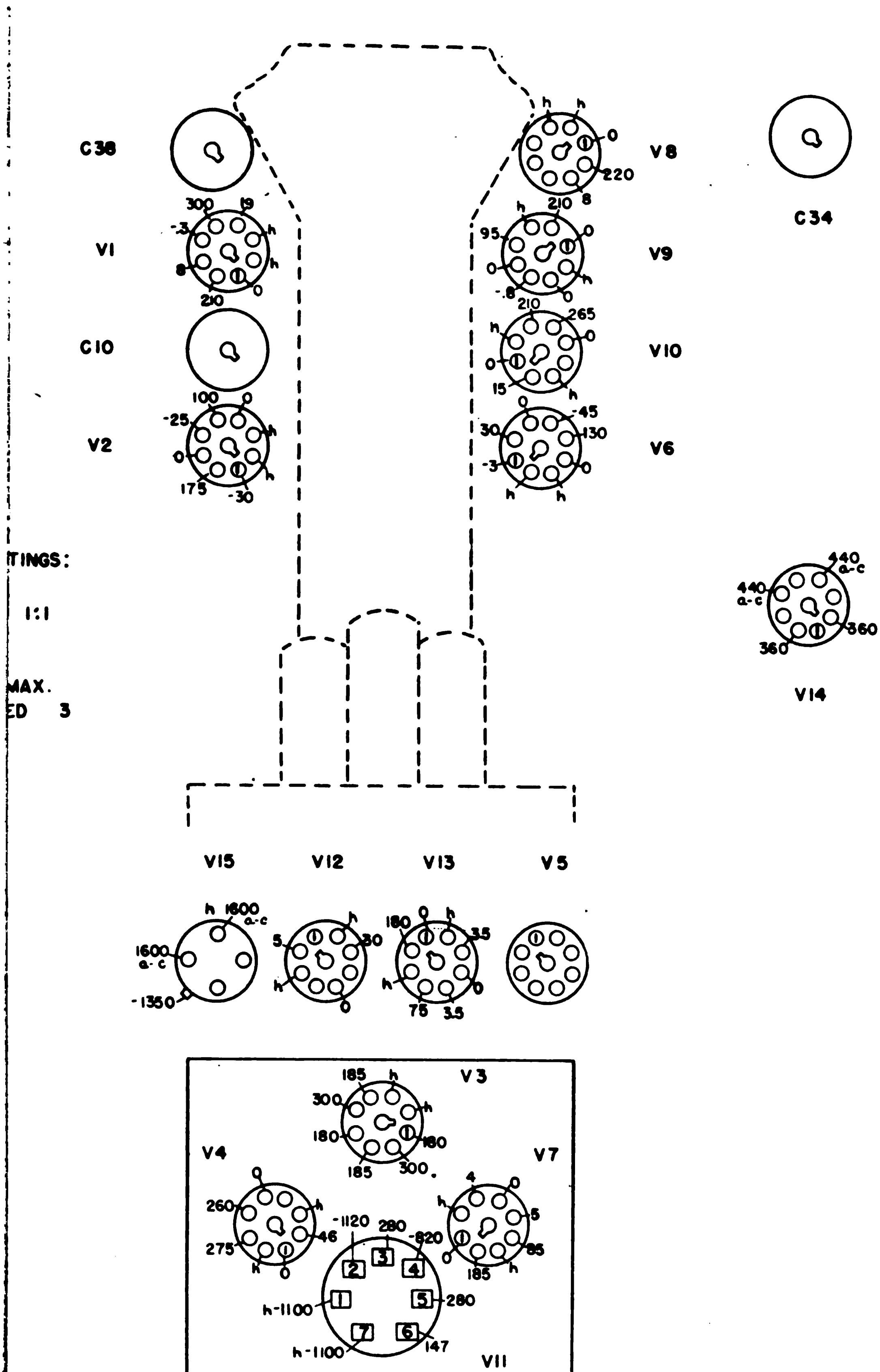


Figure 277. Synchroscope TS-64/MP, bottom view.



TL 36174

Figure 278. Synchroscope TS-64/MPN-1, mounting boards.



TL 35998

Figure 279. Synchroscope TS-64/MPN-1, voltage chart.

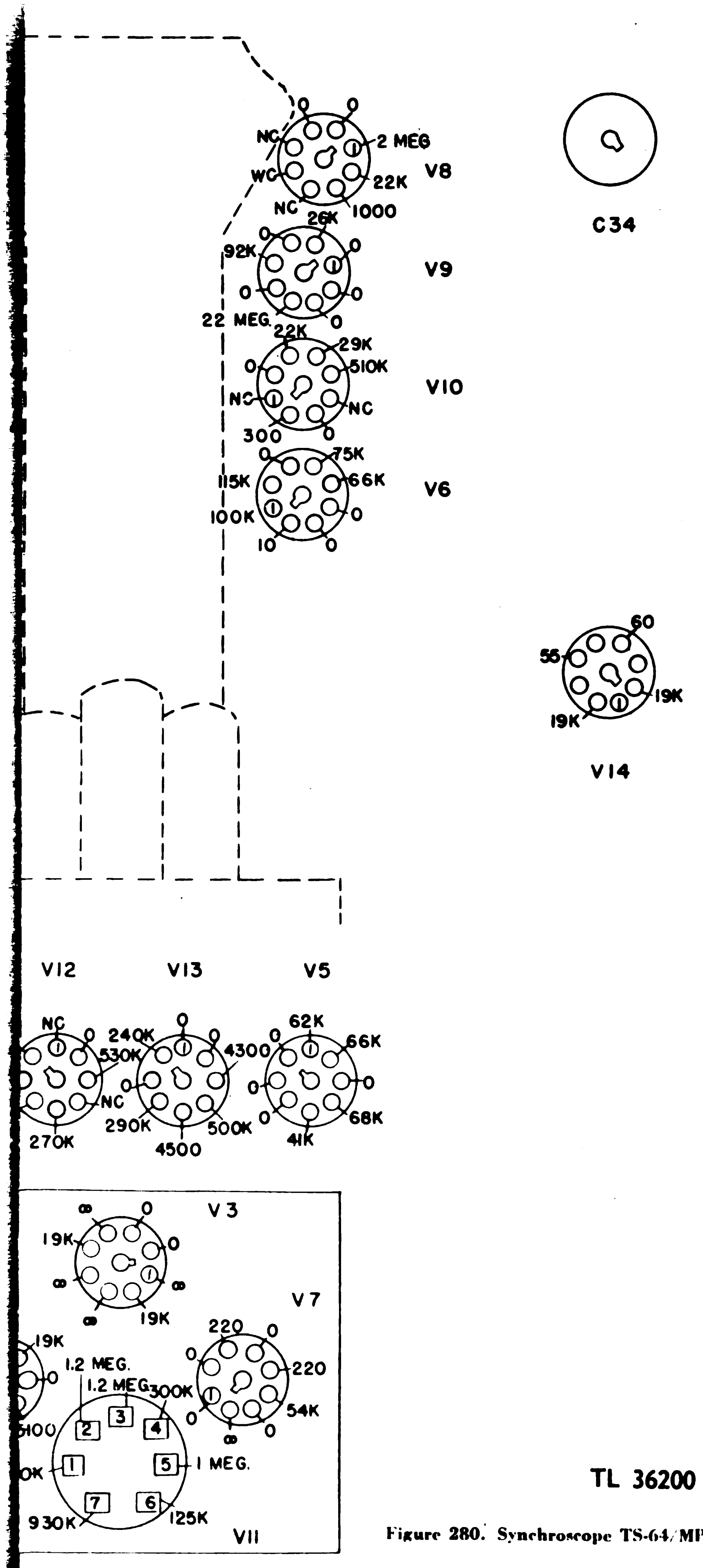


Figure 280. Synchroscope TS-64/MPN-1, resistance chart.

137. TEST SET TS-224/UP.

a. General Description. The test set (fig. 281) is designed for use in testing S-band radar equipment. It provides means for determining the power output of the transmitter, operating frequency of the transmitter and local oscillator, sensitivity of the receiver, and recovery of the T-R box. Power required is 70 watts at 117 volts ac, 50 to 800 cycles.

b. Circuit Analysis. (1) The test set may be used as a pulsed signal generator when an external trigger voltage is connected to plug P1 (figs. 282 and 284). Trigger inverter tube V1(a) permits the use of either a positive or negative trigger voltage. Switch SW1 cuts the inverter tube in or out so that a negative pulse will appear on the grid of V2(a). Tube V2 is a start-stop multivibrator in which the width of the gate can be controlled. R5 is a phase control mounted on the front panel; its adjustment determining the width of the waveform in the plate circuit of V2(b). The output of V2(b) is impressed across an RC network consisting of C6 and R10. The waveform across R10 is alternately positive and negative pulses. A large plate current flows through V3(b) and R11, causing V3(a) to be biased near cutoff; therefore, only the positive pulse on the grid causes plate current to flow. The output of V3(a) is impressed across the RC combination of C8, R15, and R16. Pulse width control R16, located on the front panel, controls the time that plate current of V3(b) is cut off, thereby controlling the pulse width. The output of the pulse multivibrator is impressed on the grid of cathode follower V1(b). The output of tube V1(b) appears across R18 and is then amplified by the pulse amplifier V4. The output of V4 is used to pulse modulate the r-f oscillator, V5.

(2) The test set becomes a special monitoring circuit when switch S4 is placed in position 1. Blocking oscillator tube V6(a) provides a pulse of fixed length and a recurrence frequency of approximately 600 cycles per second. These special pulsing characteristics are used in order to adjust the r-f oscillator tube voltage to correspond to reference levels of r-f power. The length of the pulse of V6(a) is factory adjusted so that a known amount of peak power is delivered at the antenna jack into a matched load. Tube V6(b) acts as a buffer amplifier between the blocking oscillator and the phasing multivibrator V2. Full-wave rectification is obtained through tube V8. This rectifier supplies all d-c operating voltages for the test set.

(3) The r-f system is a microwave cavity oscillator, V5, a type 446B lighthouse tube (fig. 283). The principal parts of the cavity are:

(*a*) The cavity proper, which comprises a silver-plated brass tube within which is located the type 446B tube.

(*b*) The cathode fingers, which contact the cathode ring of the tube and form one end of the cavity.

(*c*) The plunger, which is adjustable by means of the screwdriver adjustment.

(*d*) The plate cap fingers, which slide over the plate cap of the tube.

(*e*) The plate tuning shaft, to which the plate cap fingers are secured and which is actuated by the tuning dial.

(*f*) The grid cylinder and grid cylinder sleeve assembly which fits on the grid of the tube.

(*g*) The grid leak which is in a housing and which contacts the grid cylinder.

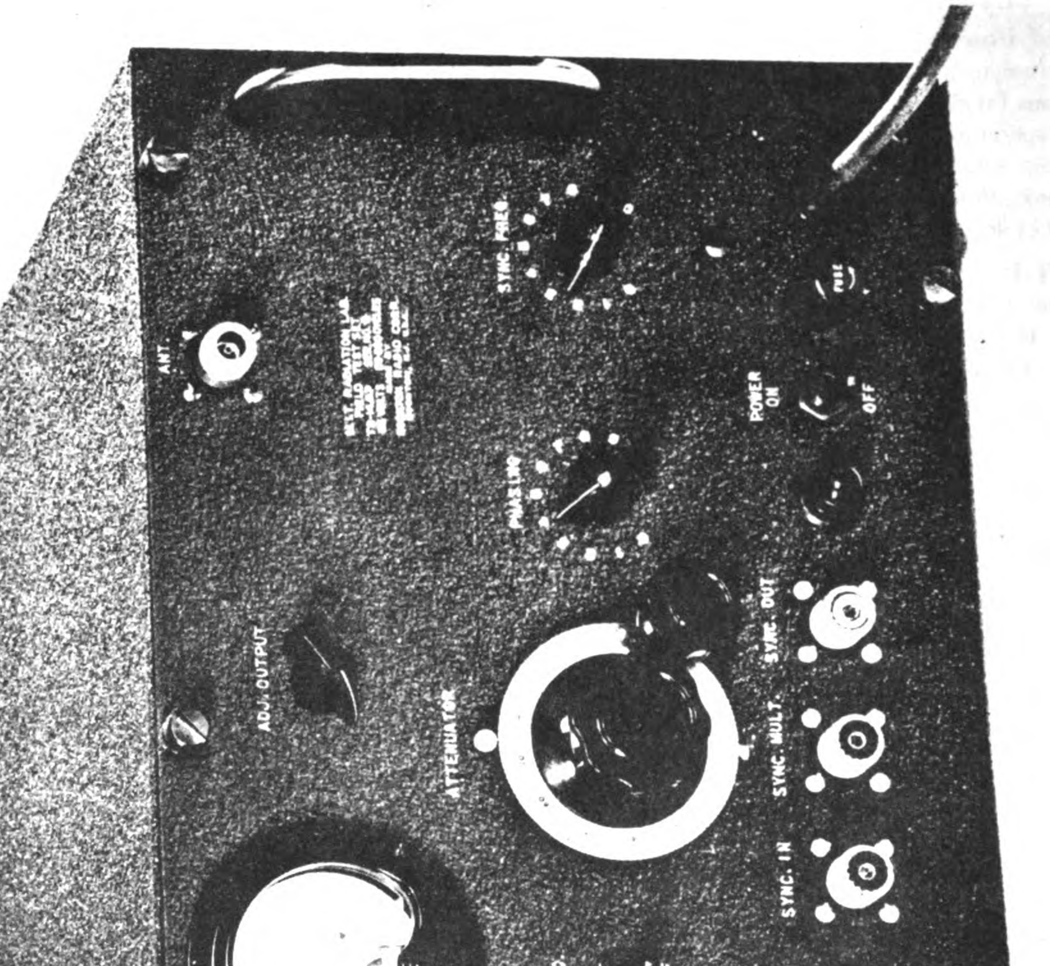
(*h*) The tailpiece which holds the tube, and the loop which serves to transfer r-f power from the cavity to the thermistor and to the attenuator.

(*i*) An r-f choke within the plate tuning shaft serves as an r-f filter. The r-f chokes on the end of the tailpiece serve to filter the cathode and filament supply voltages.

(*j*) One end of the cavity is formed by the plunger, which consists of an outer and inner ring of contacting fingers. The outer ring of fingers contacts the inner wall of the cavity. The inner ring of fingers contacts the plate tuning shaft. The other end of the cavity is formed by the ring holding the cathode fingers.

(*k*) A cone of mica which serves as a bypass capacitor also serves to insulate the plate cap fingers from the plate tuning shaft.

(4) The power monitoring system (fig. 284) consists of thermistor R51 connected in one arm of a Wheatstone bridge, and a meter and a source of voltage to balance the bridge. The thermistor is mounted directly in the r-f line between the cavity and the attenuator, so as to absorb a constant fraction of the power generated in the cavity. The resistance in the thermistor arm of the bridge varies with the r-f power absorbed by the thermistor. The resistance decreases as the thermistor temperature increases. The corresponding unbalance of the bridge is indicated by the meter, the readings being directly proportional to the r-f power absorbed by the thermistor. The normal resistance of thermistor R51 is above 200 ohms. The other three resistors of the bridge are each 200 ohms; therefore, the bridge is unbalanced. To balance the bridge, an alternating current is applied to the bridge circuit through capacitor C15. The alternating current flowing through resistor R29 and the thermistor causes the resistance of the thermistor to decrease to 200 ohms, thereby balancing the bridge. The a-c voltage is controlled by zero adjuster R31 which is mounted on the front panel of the test set. The bridge thermistor is also subject to resistance changes due to variation in ambient temperature and in the voltage applied to the bridge. Resistors R32 and R52



TL 35903

Figure 281. Test Set TS-221 UP, front view.

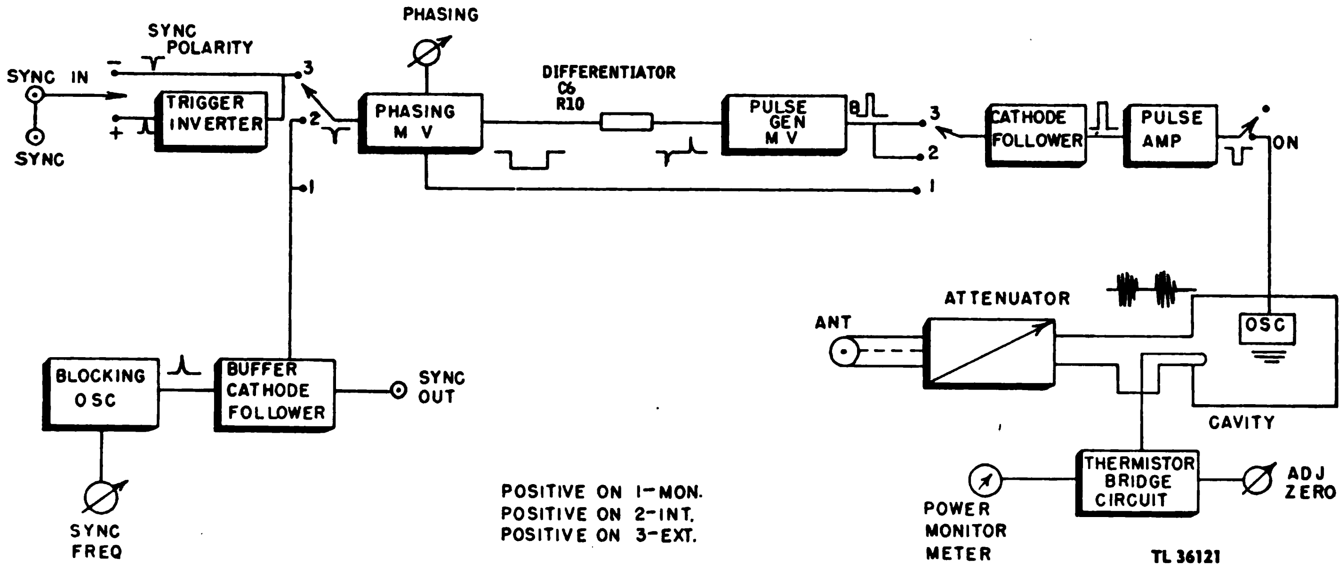


Figure 282. Test Set TS-224/UP, functional block diagram.

tend to hold the bridge balanced by compensating for the temperature changes. The action of tube V7 is to hold the voltage at a given value.

*c. **Placing Test Set in Operation.*** (1) MONITORING.

(*a*) Turn POWER ON-OFF switch and OSC. ON-OFF switch to OFF position.

(*b*) Connect power line cord to a 115-volt a-c outlet.

(*c*) Adjust the following controls to their midposition: PHASING, SYNC. FREQ., PULSE WIDTH, TUNING, and ADJ. OUTPUT.

(*d*) Set selector switch (lower left-hand corner of front panel) to MON. position.

(*e*) Turn POWER switch to ON position. The lamp adjacent to the POWER switch should now light.

(*f*) Turn ADJ. ZERO control until the monitoring meter reads zero.

(*g*) Turn OSC. switch to ON.

(*h*) The power monitoring meter should now indicate that r-f power is being generated. The meter deflection may be varied by the ADJ. OUTPUT control, and should be set for a meter reading of 200.

(2) INTERNAL SYNCHRONIZATION.

(*a*) Place the test set in operation as described in subparagraph *c* (1) above.

(*b*) Set selector switch to INT.

(*c*) Adjust SYNC. FREQ. control to vary repetition rate of r-f pulses as required by equipment under test.

(*d*) Adjust PULSE WIDTH control to vary r-f pulse width as required by equipment under test.

(*e*) Adjust TUNING control to set wavelength of r-f output to that of the equipment under test.

(*f*) Adjust ATTENUATOR control to provide desired r-f output.

(*g*) Adjust PHASING control to vary phase of r-f pulse with respect to trigger from SYNC. OUT jack as required by equipment under test.

(3) EXTERNAL SYNCHRONIZATION.

(*a*) Place test set in operation as described in subparagraph *c* (1) above.

(*b*) Connect one end of the video cable to SYNC. IN; the other end of the cable to either positive or negative trigger jacks on the synchronizer.

(*c*) Set MON/INT/EXT switch to EXT.

(*d*) The other controls will operate the same as for internal synchronization.

(4) ADJUSTING TEST SET TO S-BAND FREQUENCY.

(*a*) Connect power line cord to a 115-volt a-c outlet.

(*b*) Turn OSC. ON-OFF switch to OFF.

(*c*) Turn POWER switch ON.

(*d*) Turn ADJ. ZERO control until monitoring meter reads zero.

(*e*) Connect the r-f cable between ANT. jack on the test set and the pick-up dipole assembly. The dipole should be mounted a minimum distance of 4 feet from the search antenna, and oriented so that it is parallel with the dipoles of the antenna.

CAUTION: Never connect the test set directly into the r-f line of the radar system.

(*f*) Adjust ATTENUATOR to give a meter reading of approximately 160.

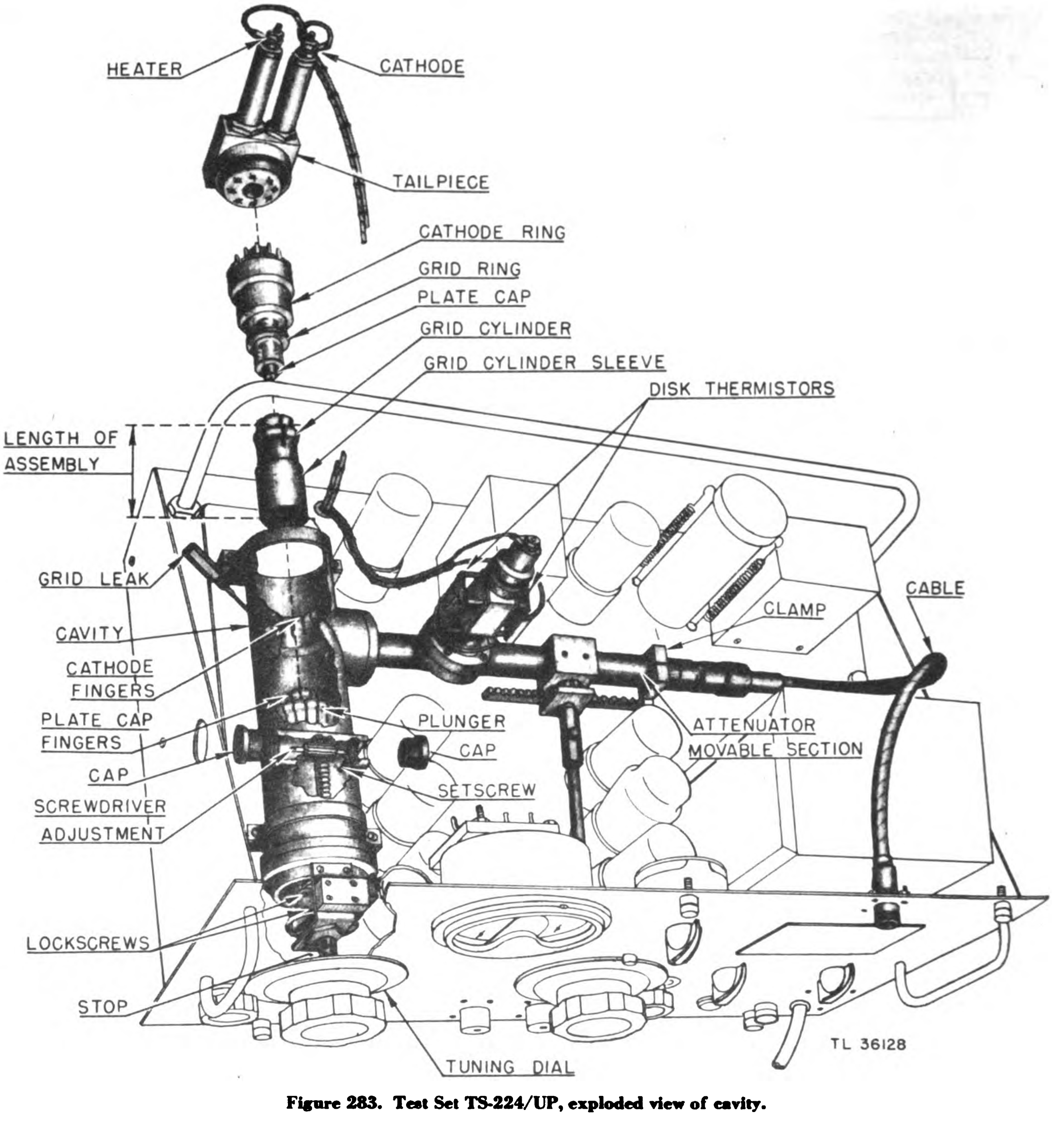


Figure 283. Test Set TS-224/UP, exploded view of cavity.

(*g*) Slowly turn TUNING dial until the meter deflection is at a minimum. This adjustment sets the cavity tuning to the same frequency as the radar S-band transmitter.

(5) MONITORING EXTERNAL POWER.

(*a*) Connect power line cord to a 115-volt a-c outlet.

(*b*) Turn OSC. ON-OFF switch to OFF.

(*c*) Turn POWER switch ON.

(*d*) Turn ADJ. ZERO control until monitoring meter reads zero.

(*e*) Connect r-f cable as in subparagraph (4) (*e*) above.

(*f*) Detune cavity by turning TUNING dial to 0 or 100, whichever is furthest removed from the frequency of the transmitter.

(*g*) Set red reference mark on ATTENUATOR dial to

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	100,000	½W	10%
R2	5,000	1W	10%
R3	50,000	1W	10%
R4	100,000	2W	10%
R5	1 Meg	2W	
R6	1,000	½W	5%
R7	10,000	2W	10%
R8	30,000	2W	10%
R9	1 Meg	½W	10%
R10	8,000	½W	10%
R11	1,000	2W	10%
R12	10,000	2W	10%
R13	5,000	2W	10%
R14	20,000	5W	10%
R15	75,000	1W	10%
R16	250,000	2W	10%
R17	100,000	½W	10%
R18	5,000	1W	10%
R19	30,000	1W	10%
R20	40,000	2W	10%
R21	500,000	½W	10%
R22	2,000	1W	10%
R23	500	1W	10%
R24	150,000	1W	10%
R25	20,000	2W	10%
R26	200,000	2W	10%
R27	200	1W	5%
R28	200	1W	5%
R29	200	1W	5%
R30	22,000	½W	10%
R31	500	2W	10%
R32		Thermistor	
R33	120	10W	10%
R34	120	10W	10%
R35		18V Mazda lamp	
R36		18V Mazda lamp	
R37	75,000	½W	5%
R38	1 Meg	2W	
R39	20,000	½W	5%
R40	75,000	1W	10%
R41	5,000	1W	10%
R42	10,000	1W	10%
R43	30,000	1W	10%
R44	50,000	2W	10%
R45	30,000	2W	10%
R46	2,000	20W	10%
R47	5,000	4W	10%
R48	10,000	2W	10%
R49	5,000	2W	10%
R50	600	1W	10%
R51		Bead thermistor	
R52		Bead thermistor	

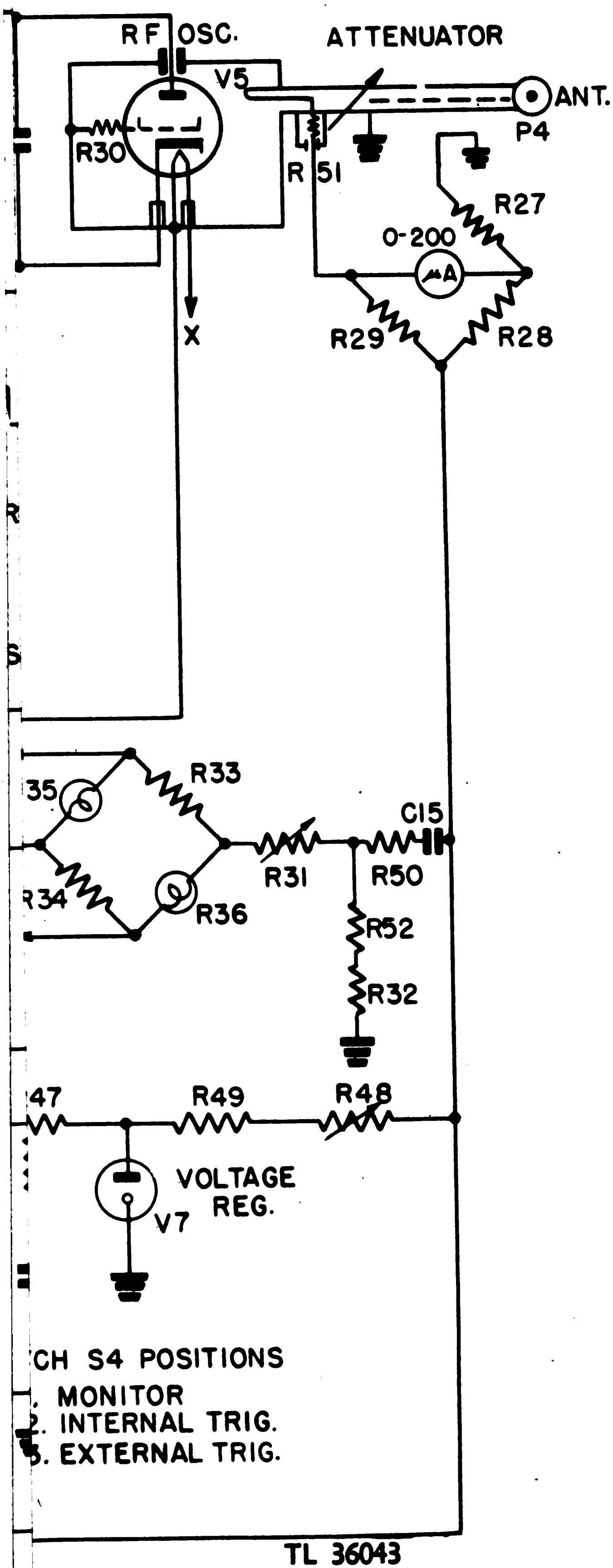


Figure 284. Test Set TS-224/UP, schematic diagram.

Symbol Designation	Description		
	Value	Rating	Tolerance
R1	100,000	½W	10%
R2	5,000	1W	10%
R3	50,000	1W	10%
R4	100,000	2W	10%
R5	1 Meg	2W	
R6	1,000	½W	5%
R7	10,000	2W	10%
R8	30,000	2W	10%
R9	1 Meg	½W	10%
R10	8,000	½W	10%
R11	1,000	2W	10%
R12	10,000	2W	10%
R13	5,000	2W	10%
R14	20,000	5W	10%
R15	75,000	1W	10%
R16	250,000	2W	10%
R17	100,000	¼W	10%
R18	5,000	1W	10%
R19	30,000	1W	10%
R20	40,000	2W	10%
R21	500,000	½W	10%
R22	2,000	1W	10%
R23	500	1W	10%
R24	150,000	1W	10%
R25	20,000	2W	10%
R26	200,000	2W	10%
R27	200	1W	5%
R28	200	1W	5%
R29	200	1W	5%
R30	22,000	¼W	10%
R31	500	2W	10%
R32		Thermistor	
R33	120	10W	10%
R34	120	10W	10%
R35		18V Mazda lamp	
R36		18V Mazda lamp	
R37	75,000	½W	5%
R38	1 Meg	2W	
R39	20,000	½W	5%
R40	75,000	1W	10%
R41	5,000	1W	10%
R42	10,000	1W	10%
R43	30,000	1W	10%
R44	50,000	2W	10%
R45	30,000	2W	10%
R46	2,000	20W	10%
R47	5,000	1W	10%
R48	10,000	2W	10%
R49	5,000	2W	10%
R50	600	1W	10%
R51		Bead thermistor	
R52		Bead thermistor	

Symbol Designation	Description		
	Value	Rating	Tolerance
C1	.001 mf	Mica	10%
C2	.1 mf	600 v	10%
C3	.0002 mf	Mica	10%
C4	.0015 mf	Mica	10%
C5	.1 mf	600 v	10%
C6	.00005 mf	Mica	10%
C7	.5 mf	600 v	10%
C8	.0001 mf	Mica	10%
C9	.1 mf	600 v	10%
C10	.25 mf	600 v	10%
C11	.25 mf	600 v	10%
C12	.1 mf	600 v	10%
C13	.5 mf	600 v	10%
C14	.5 mf	600 v	10%
C15	20. mf	20 v Electrolytic	
C16	.002 mf	Mica	5%
C17	.0025 mf	Mica	10%
C18	.001 mf	Mica	10%
C19	10. mf	450 wv Electrolytic	
C20	10. mf	450 wv Electrolytic	
C21	10. mf	450 wv Electrolytic	
CH	Filter Choke 10HY 75MA		
P1	Sync. in jack coaxial		
P2	Sync. mv jack coaxial		
P3	Sync. out jack coaxial		
P4	Ant. jack coaxial		
S1	Switch	DPST	
S2	"	SPST	
S3	"	SPST	
S4	"	3 Pole 3 Position	
T1	Power Transformer		
T2	Osc. Transformer 3 winding		
V1	VT231	6SN7	
V2	VT231	6SN7	
V3	VT231	6SN7	
V4		6AC7	
V5		446B	
V6	VT231	6SN7	
V7		VR/105/30	
V8		5Y3	

panel index. The monitoring meter now gives a direct reading in milliwatts of the average r-f power at ANT. jack.

(6) TEST SENSITIVITY OF RADAR RECEIVER.

(*a*) Place test set in operation as described in subparagraph *c* (1) above.

(*b*) Turn the MON/INT/EXT switch to the EXT. position.

(*c*) Connect the video cable between the SYNC. IN jack on the test set and a source of either positive or negative trigger voltage.

(*d*) Set SYNC. POLARITY switch to a position corresponding to polarity of the trigger voltage.

(*e*) Set the following switches to their midscale position: PHASING, PULSE WIDTH, and ATTENUATOR.

(*f*) Turn TUNING dial slowly until the test set signal appears on search indicator PPI tube.

(*g*) Turn ATTENUATOR dial clockwise until the test set signal is barely visible on the PPI tube. The accuracy of this setting can be improved by moving the test set pulse along the distance axis by means of the PHASING control.

(*h*) The reading of the ATTENUATOR dial at the disappearing point of the test set signal is an indication of the receiver sensitivity. The greater the reading the more sensitive the receiver.

d. Trouble Shooting the Test Set. (1) CHECKING THE PULSING CIRCUIT.

(*a*) Loosen the five captive screws that hold the chassis in the cabinet; remove the chassis and place in a position convenient for maintenance.

(*b*) Place the test set in operation as described in subparagraph *c* (1) above.

(*c*) Set the MON/INT/EXT switch to the MON. position.

(*d*) The circuit may be checked by connecting a synchroscope which is synchronized from the trigger at the SYNC. OUT jack. A square pulse of fixed width and recurrence rate should be observed. Next check the waveform at the plate of tube V4 (fig. 285); the pulse amplitude should be about 50 volts. The pulse should start at the beginning of the sweep on the synchroscope. If the pulse is distorted or no pulse appears, observe the waveform at pin 4 of tube V4, pin 4 of the tube V1, and at pin 2 of tube V2. Positive square pulses of approximately 70 volts should be seen at all these points. If no pulse appears at pin 2 of V2, the grid pin 1 of V2 should be checked. At this point a negative trigger from V6(b) should be seen. If this trigger does not appear, the blocking oscillator V6(a) is not functioning. In general, if the correct waveform is seen at the input of any stage, but an improper one at the output of the same stage, test the tube. If this does not clear the trouble make a voltage and resistance check (figs. 286-289).

(*e*) Set the MON/INT/EXT switch to the INT. position. In this type of operation, a positive trigger should be available at the SYNC. OUT jack. The recurrence rate can be varied by means of the SYNC. FREQ. control. When a synchroscope is synchronized from the jack, synchronization is indicated by varying brightness of the sweep trace as the SYNC. FREQ. control is varied.

(*f*) With the OSC. switch in the ON position, a short pulse, whose width is variable by the PULSE WIDTH control, should be observed at the cathode and on the plate of tube V5. If the pulse is distorted but its phase can be varied by the PHASING control, the search for trouble should proceed back through the circuit only as far as pin 1 of V3. If the pulse delay is made shorter than 5 microseconds, or longer than 200 microseconds, the pulses may occur erratically, or two pulses may appear together occasionally. This is normal. If no pulse appears at pin 1 of V3 or if the phasing cannot be controlled, the waveforms at plate pins 2 and 5, and grid pin 1 of tube V2 should be checked and compared with those in figure 283. The trailing edges of the gates found at pins 2 and 5 of V2 should be movable by means of the PHASING control. If these waveforms do not appear or if they are somewhat distorted, a plate voltage and a tube check should be made on the abnormal stage.

(*g*) Set the MON/INT/EXT switch to the EXT. position.

(*h*) The SYNC. POLARITY switch is set to correspond to the polarity of the external trigger fed into the SYNC. IN jack. The operation of the circuit is similar to that of the internal position except that tube V1(a) is used to invert positive external triggers, and that tube V6(a) does not put out pulses. Therefore, testing may be performed in a manner similar to that used for internal triggering.

(2) CHECKING THE THERMISTOR BRIDGE.

(*a*) Set the MON/INT/EXT switch to INT. and connect the test set as described in subparagraph *c* (1) above.

(*b*) It should be possible to zero set the monitoring meter by means of the ADJ. ZERO control. If this cannot be done, new regulator lamps R35 and R36 should be installed. If with this change it is still impossible to set the monitoring meter to zero, the voltage between ground and the junction of resistors R28 and R29 should be checked. This voltage should be about 2.5 volts. The variable resistor, R48, on the chassis, should be adjusted until it is possible to zero set the meter. If it is not possible to do this, the voltage at the plate of tube V7 should be checked (maximum voltage should not be over 120 volts), and a continuity check should be made on the thermistor bridge circuit.

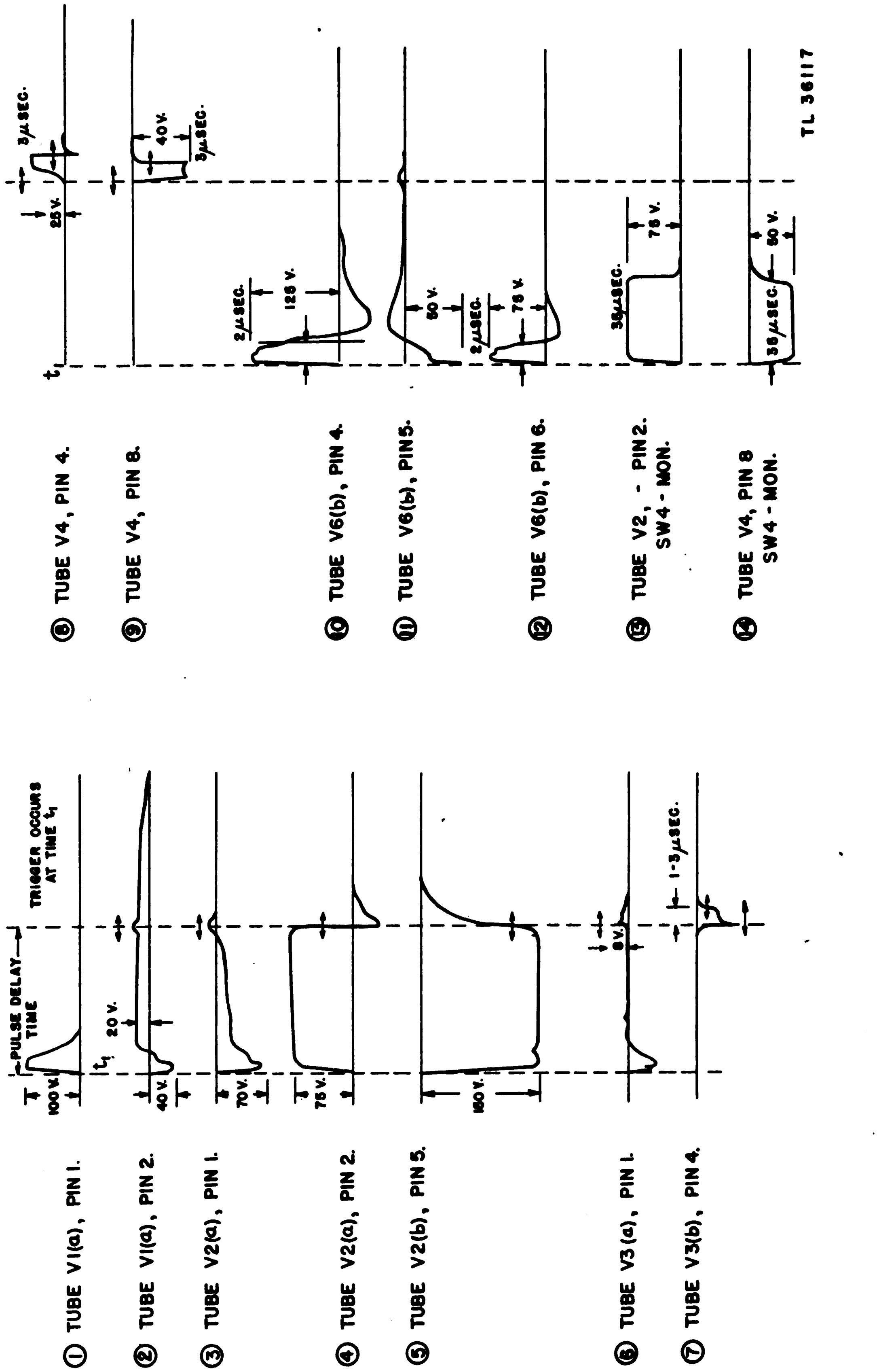


Figure 285. Test Set TS-224/UP, waveforms.

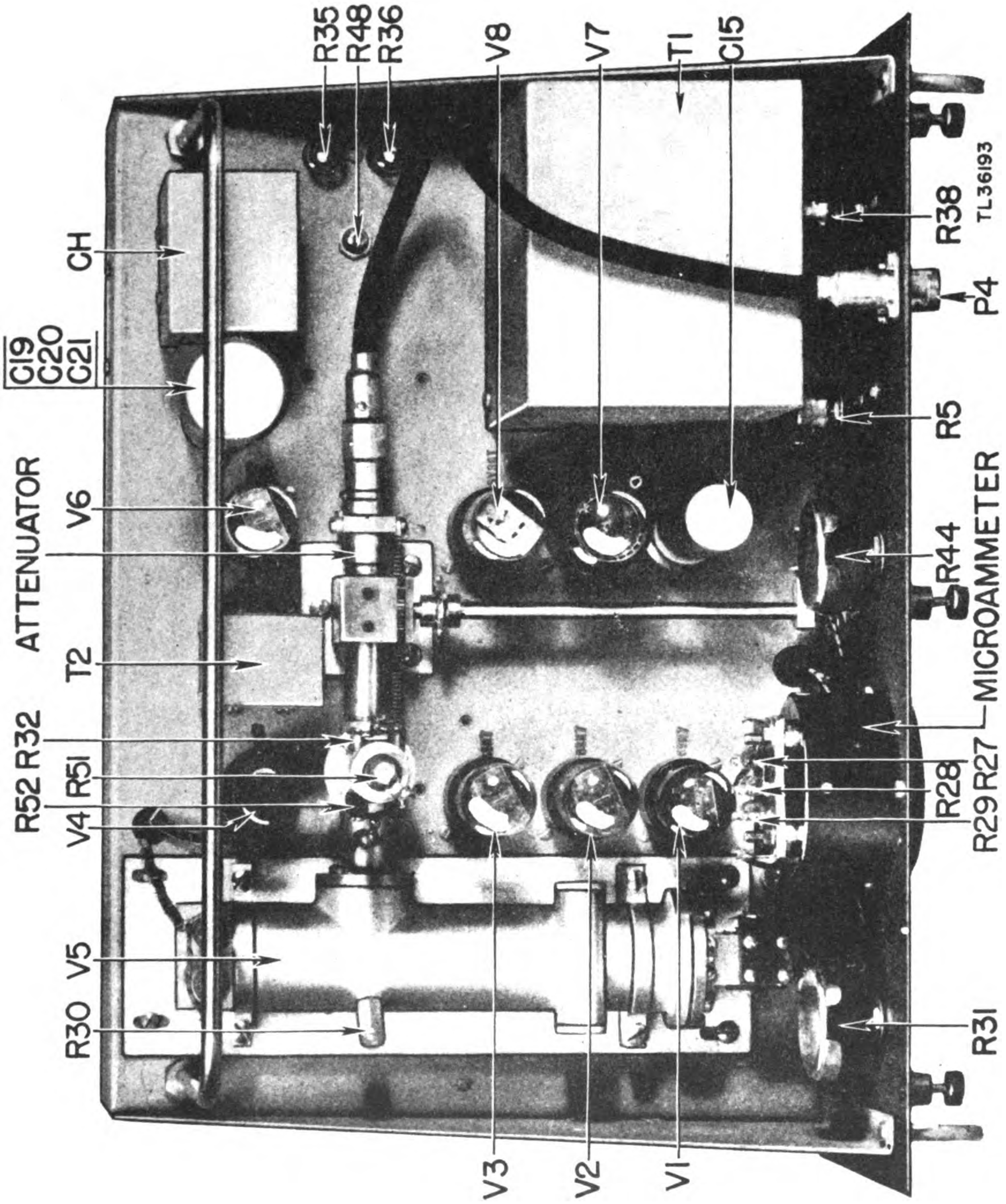


Figure 286. Test Set TS-224/UP, top view.

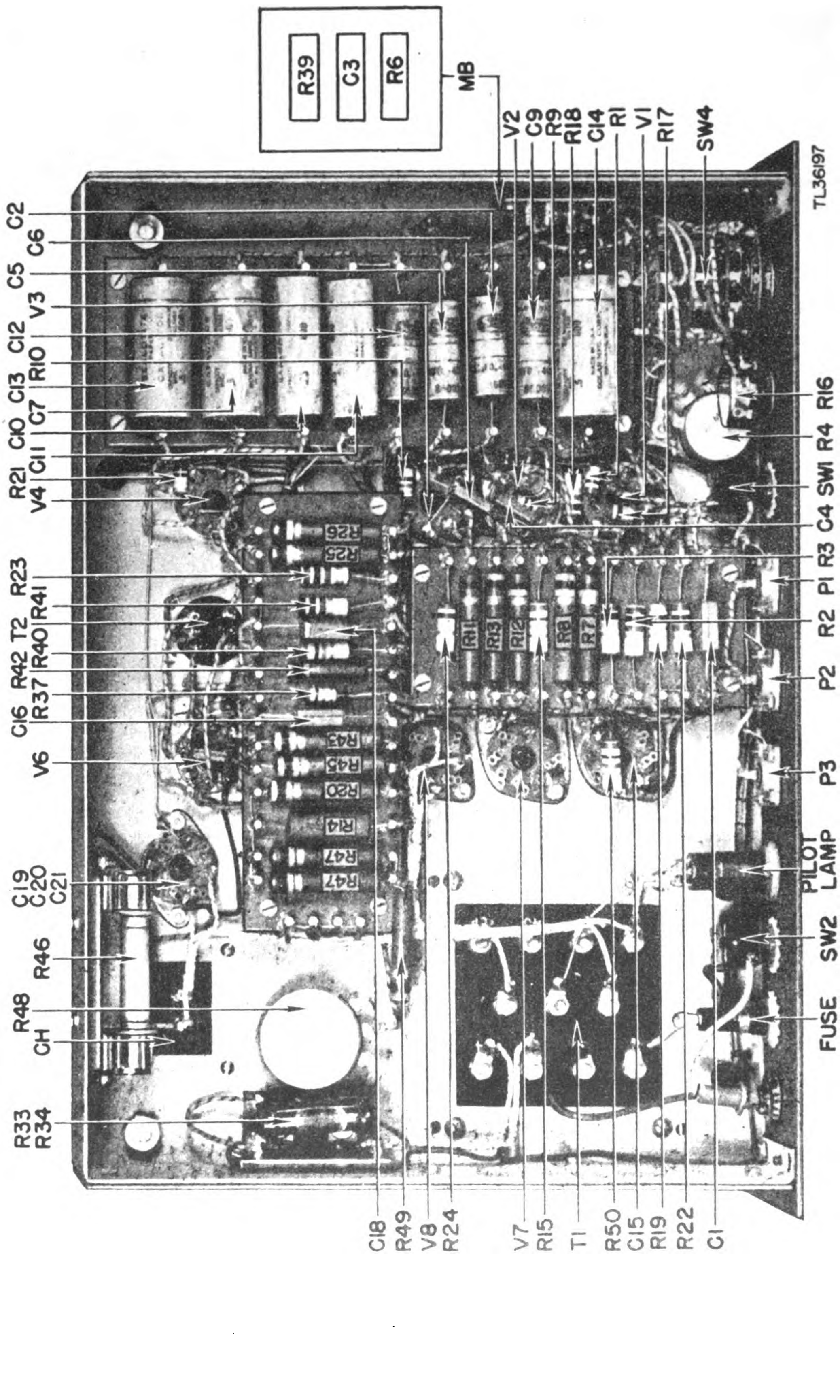


Figure 287. Test Set TS-224/UP, bottom view.

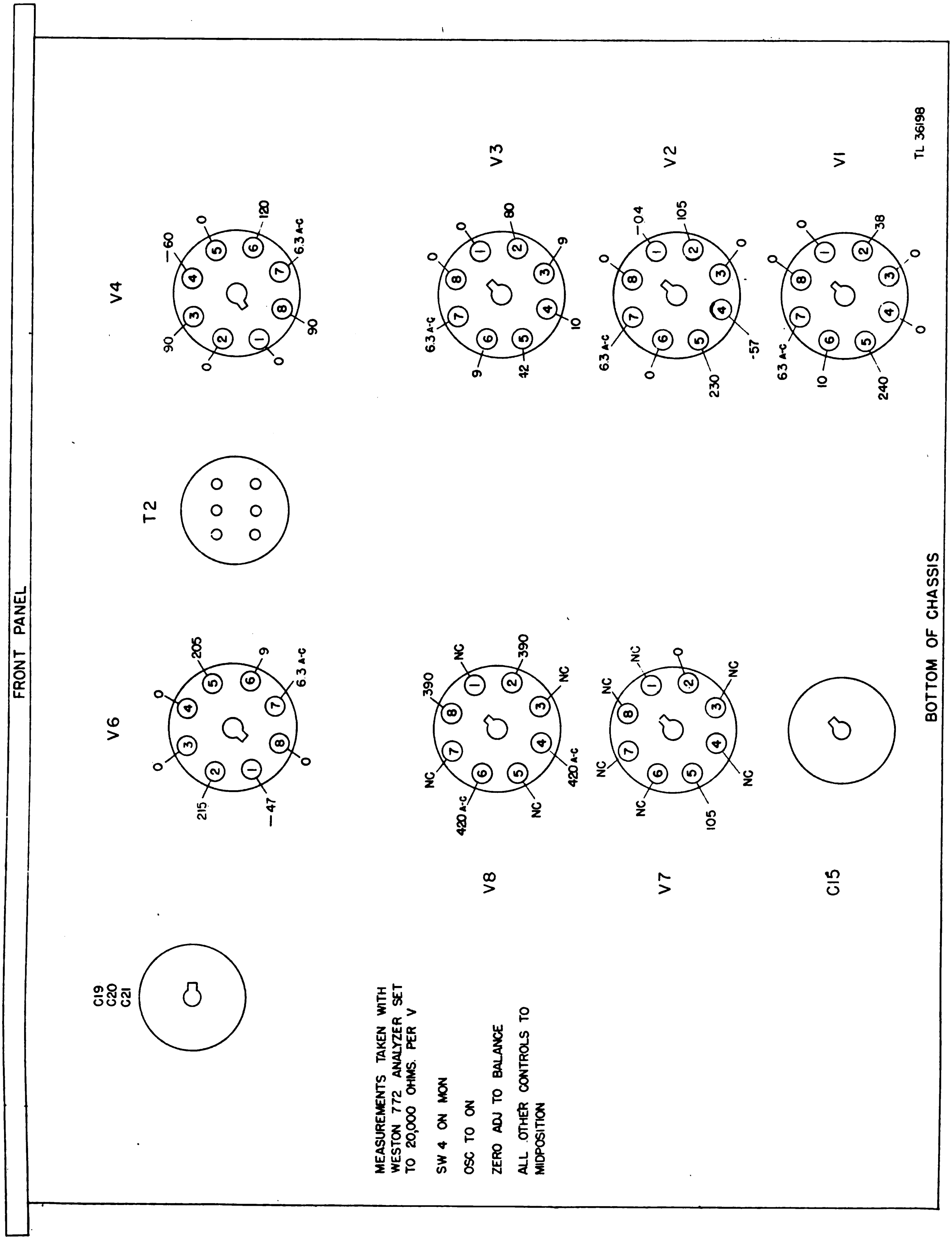


Figure 288. Test Set TS-224/UP, voltage chart.

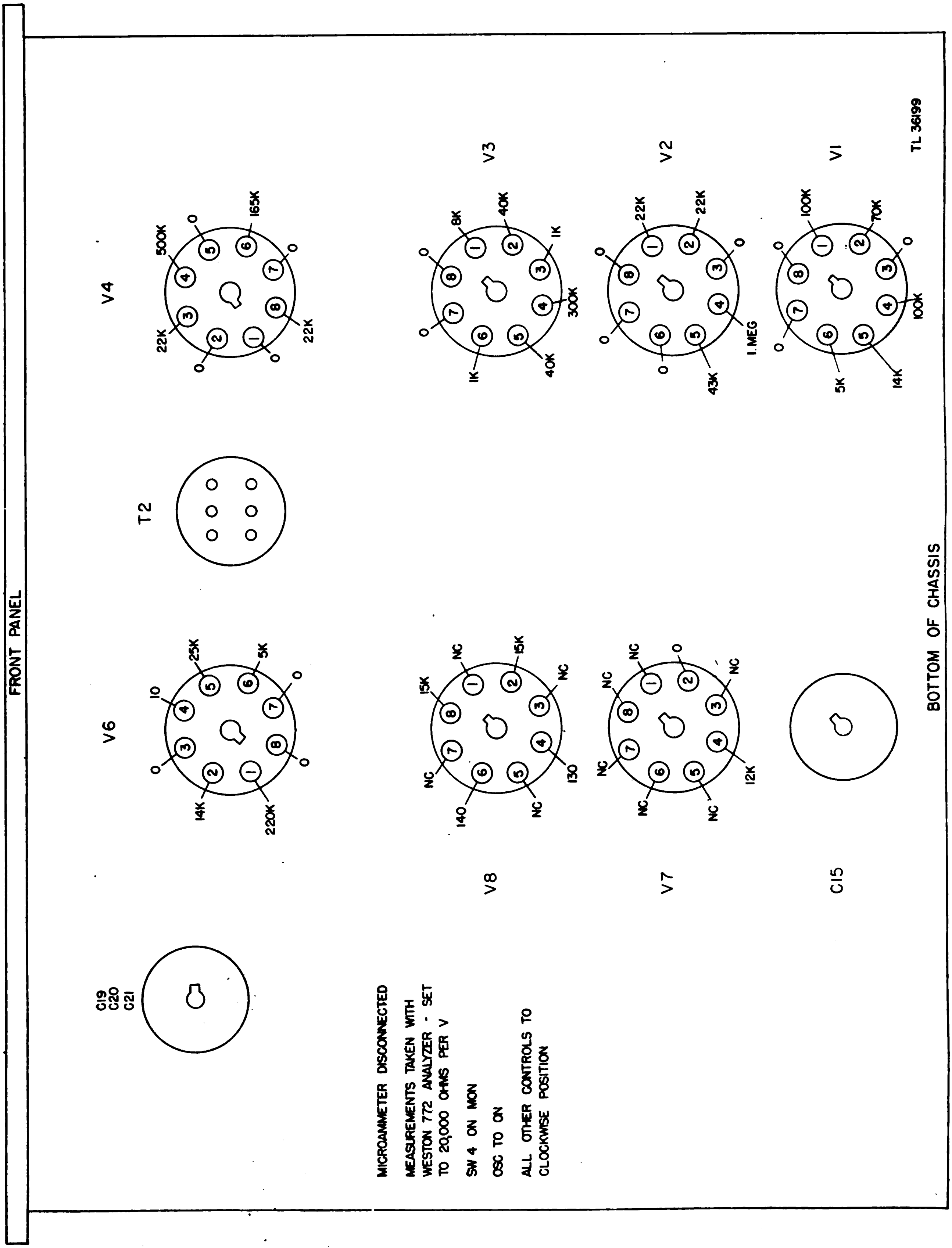


Figure 289. Test Set TS-224/UP, resistance chart.

CAUTION: Do not apply more than a few volts across the thermistor.

(3) CHECKING THE CAVITY OSCILLATOR.

(*a*) Should the electrical operation of the cavity and its associated parts become unsatisfactory, the simple causes of failure should first be checked, such as, the supply voltages and the various connections within the cavity.

(*b*) If insufficient power output is obtained on the monitoring meter it is due generally to a defective tube, poor contact to the tube by the plate or cathode fingers, or to an open grid resistor.

(*c*) Access to the cavity may be had by removing the plate tuning shaft assembly. To do this, remove the securing screws which hold the yoke on the front end to the body of the cavity. This assembly may then be pulled out. Do this carefully to avoid distorting the inner ring of plunger fingers. The plunger may be removed by moving the screwdriver adjustment in a counterclockwise direction. The fingers may then be bent in slightly, the surface of the plate tuning shaft cleaned, and the unit reassembled.

(4) REMOVAL OF CAVITY OSCILLATOR TUBE.

(*a*) Disconnect the power cord from the power source.

(*b*) Remove the grid leak (fig. 283).

(*c*) Turn the TUNING dial to read 100. This moves the plate cap fingers to a position close to the end of the plate cap of the tube and minimizes the possibility of breaking the tube when it is removed.

(*d*) Remove the six securing screws in the tailpiece.

(*e*) Remove the tailpiece by rotating slightly and pulling back.

(*f*) Remove the tube from its socket.

(*g*) Remove the grid cylinder and grid cylinder sleeve.

(5) TO INSTALL NEW TUBE IN CAVITY.

(*a*) Insert tube in socket in tailpiece.

(*b*) Install grid cylinder and grid cylinder sleeve on grid ring of tube.

(*c*) Loosen the tube socket securing nut in rear end of the tailpiece sufficiently so that the tube socket is free to move slightly.

(*d*) Insert the tailpiece in the cavity, using care to insure that the plate cap is entering the plate cap fingers without undue strain.

(*e*) Replace the six securing screws and tighten them progressively to insure that the tailpiece is seating properly. This must be carefully done to prevent distortion of the cavity and to insure complete electrical shielding of the cavity end.

(*f*) Install the grid leak.

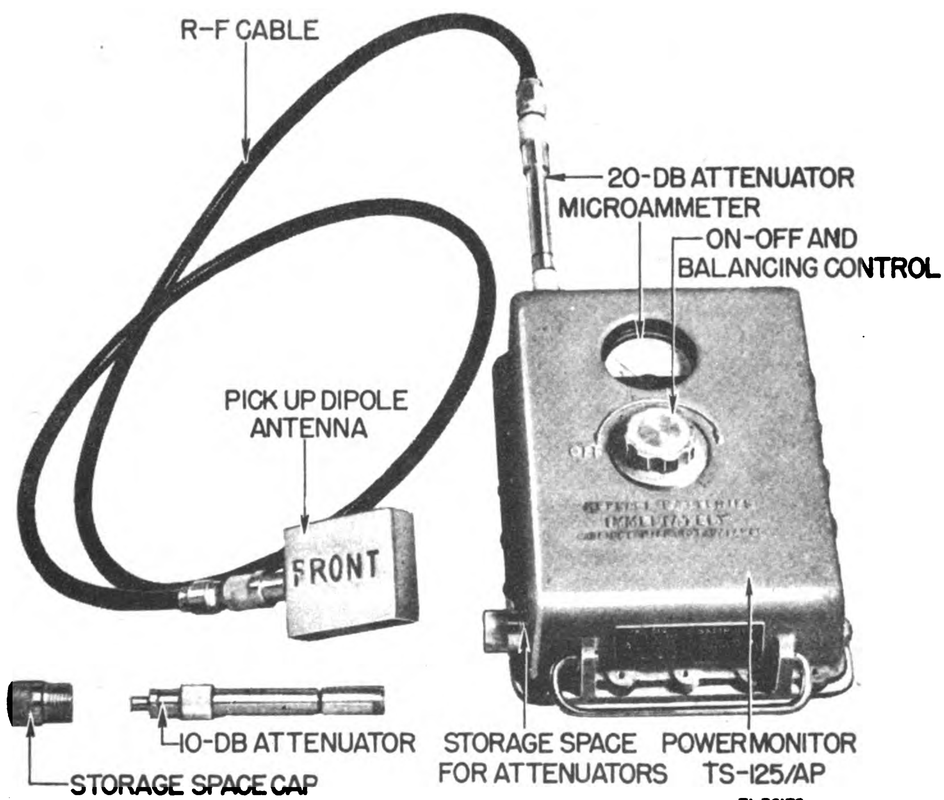


Figure 290. Power Monitor TS-125/AP.

(*g*) The TUNING dial and the vernier drive must now be removed to permit the adjustment of the operating position of the plate tuning shaft, unless the new tube is exactly the same height as the old tube.

(*h*) Loosen the lockscrew.

(*i*) Turn the tuning shaft clockwise until the plate cap fingers stop against the plate cap disk of the tube. Be sure that the tube socket securing nut (in rear of the tail-piece) is sufficiently loose to permit the tube to adjust itself, then tighten the nut. If this latter adjustment is properly made, the plate cap fingers should run smoothly over the plate cap of the tube and no binding will occur. Under these conditions it will be possible to rotate the tuning shaft with the fingers before the dial is mounted.

(*j*) With the tuning shaft at the full clockwise position, set the dial STOP so that the tuning shaft cannot be moved clockwise beyond this point, and tighten the lock-screw.

(*k*) Replace the TUNING dial and vernier drive, setting the tuning dial to read 0 and tightening its setscrews. Test the tuning control for binding. If necessary, loosen and readjust the tube socket and tighten its securing nut.

138. POWER MONITOR TS-125/AP.

a. General. Power Monitor TS-125/AP is a compact. battery operated wattmeter for measuring r-f power in the S-band system. The wattmeter consists of a cast aluminum box (fig. 290) in which are 10 and 20 decible (db) attenuators. a thermistor mount. temperature compensating thermistor disks. a bridge with a meter and a balancing potentiometer. three standard flashlight batteries: a pick-up dipole antenna: and an r-f cable. The meter reading is directly proportional to the amount of r-f power fed into the power monitor. Average power is indicated. The meter is calibrated to read full scale when 2 milliwatts of r-f power is applied. The meter also has a dbm scale. with 0 dbm being 1 milliwatt. hence the name dbm scale (decibles above or below 1 milliwatt).

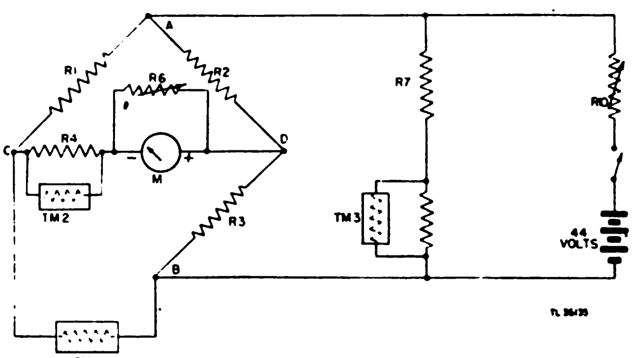


Figure 291.[a] Power Monitor TS-125/AP, simplified schematic diagram.

b. Theory of Operation. (1) The wattmeter operates on the bead-thermistor bridge principle. A thermistor is a circuit element having a negative resistance coefficient; that is, an increase in thermistor temperature causes a decrease in its resistance, and vice versa. Variations in thermistor temperature, and consequently the resistance, may be caused by thermal changes in the thermistor environment, by direct current flowing through the thermistor, or by absorbed r-f power. All these changes occur in the power monitor.

(2) Resistors R1, R2, R3, and thermistor TM1, form the arms of a bridge circuit (fig. 291). The normal or "cold" resistance of the thermistor is above 250 ohms; therefore, the bridge is unbalanced. When switch SW1 is closed, a current flows from the battery through variable resistor R10 to point A where it divides, part of the current flowing through R2 and R3, then back to the battery. The other portion of current flows through R1 and TM1, then back to the battery. Point C is now positive with respect to point D so the meter will read backwards. The current flowing through TM1 causes TM1 to heat, thereby reducing its value of resistance. When the resistance of TM1 decreases to 250 ohms. the meter will read zero because points C and D are at the same potential. Current through the bridge is adjusted by resistor R10 to a value which heats TM1 just enough to cause its resistance to rest at 250 ohms. When this condition exists. the bridge is balanced.

(3) The thermistor is mounted in a section of r-f coaxial line inside the instrument. When r-f power is fed into the coaxial section. a small amount of power is absorbed by TM1. This absorbed power causes the resistance of TM1 to further decrease. which unbalances the bridge. This unbalance is in the opposite direction as that when TM1 is "cold." Point C now becomes negative with respect to point D. therefore the meter will read directly the amount of bridge unbalance. The resulting unbalance current flowing through the meter is closely proportional to the r-f power causing the unbalance.

(4) The thermistor is also subject to resistance changes due to variations in ambient temperature and in the voltage applied to the bridge. Temperature compensating elements TM2 and TM3 are mounted near TM1 but on the outside of the r-f coaxial line. If the temperature at TM1 should change after the bridge has been balanced, the resistance of TM3 will also vary inversely proportional to the temperature change. TM3 is connected across resistor R8 and with R7 constitutes a variable shunt across bridge points A and B. The change in load, due to variation in resistance. across points A and B cause a proportional change in current through TM1. This action tends to hold the bridge balanced for small temperature changes in the environment of TM1. Resistors R5 and R6 are used to calibrate the meter, and should not be changed unless

a new meter is installed. Disk thermistor TM2, which is in parallel with R4 and connected in series with the meter, tends to reduce fluctuations in the meter reading also caused by temperature changes.

c. Installation. (1) R-f coupling between the wattmeter and the radar system must be done through high attenuation, preferably with space attenuation such as

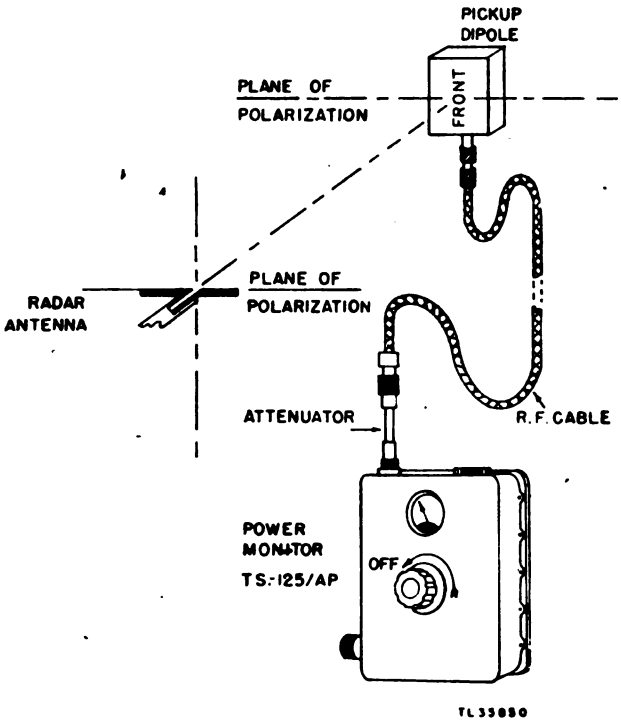


Figure 292. Space-coupling power monitor to radar antenna.

shown in figure 292. or through a wave selector as shown in detail B, figure 35.

(2) If the coupling system shown in figure 292 is to be used, a wooden strip and mounting bracket to support the pick-up dipole, should be installed. The distance and position of the pick-up dipole should be found by trial. If an unknown amount of power is to be measured, turn on the wattmeter, balance it, and then approach the radar antenna with the dipole, while watching the meter. No "lossy" or conducting material should be between the dipole and the radar antenna. The pick-up dipole should be mounted with the word FRONT facing the radar antenna and perpendicular to the plane of polarization.

CAUTION: Never connect the input cable directly to the r-f plumbing.

(3) A wave selector couples out about 1 percent of the power in the waveguide. A probe is mounted inside the wave selector and brought out through a coaxial socket. This is the best method of coupling as the degree of coupling is constant.

d. Operation. (1) PLACING POWER MONITOR IN OPERATION.

(*a*) Turn the switch ON by turning the balancing control clockwise.

(*b*) Advance the balancing control slowly until the meter needle moves up scale.

(*c*) Balance the meter to zero.

(*d*) Connect one end of r-f Cable CG-92/U to either the pick-up dipole or to the S-band wave selector, depending on the test to be made.

(*e*) If the power level is not known, first insert the 20-db pad between the free end of the cable and the power monitor. If no reading is obtained with the radar set operating, remove the 20-db pad and insert the 10-db pad. If the power is very low, the instrument may be connected directly.

CAUTION: Never connect both attenuator pads together because two watts would be dissipated in the first pad for full-scale meter deflection. To do so will damage the pad.

(2) MEASURING POWER OUTPUT.

(*a*) Balance the wattmeter.

(*b*) Using the proper pad, connect the power monitor to the system.

(*c*) To the dbm reading may be added the db attenuation of the pad to determine power above 1 milliwatt into the pick-up dipole. If the space attenuation is known, this may be added to get average system power in db above 1 milliwatt.

(3) MEASURING ANTENNA PATTERN.

(*a*) Balance the wattmeter.

(*b*) Mount the pick-up dipole on a pole so that it will be on a level with that of the center of the search antenna, and at least 15 feet from the antenna.

(*c*) Rotate the antenna in steps of a few degrees at a time, recording the meter reading at each step. The meter readings can then be plotted against the angle in degrees, from the axis. This shows the variations between the power of radiation and the direction.

(4) MEASURING LOCAL OSCILLATOR OUTPUT.

(*a*) Balance the wattmeter.

(*b*) Connect the wattmeter to the S-band local oscillator, plug PL4, through the 10-db pad: if the meter reading is below −7 dbm, remove the pad.

NOTE: The best method to determine the normal power output of the local oscillator is to make the above measurement when the set is known to be operating properly.

(c) If the radar crystal current is abnormally low and yet has normal local oscillator coupling and output, it is an almost certain indication of a poor crystal detector.

e. Trouble Shooting. (1) If the meter will not balance, or slowly drifts off balance, new batteries should be installed.

CAUTION: Never make any resistance measurements within the wattmeter without first disconnecting the bridge meter.

(2) The power monitor is mounted in a watertight case, therefore, the back should not be removed unless absolutely necessary. If a resistor is to be replaced, the new part should have the same resistance value and the wattage rating should be at least as high as the part being replaced.

(3) The bridge meter or thermistors should not be replaced in the field as this operation requires a readjustment of resistor R6 (fig. 293).

139. POWER MONITOR TS-36/AP.

a. General. (1) Power Monitor TS-36/AP is a portable test set designed to measure average power levels in the X-band frequency range. The power limits are between 0.1 and 1,000 milliwatts (–10 to +30 dbm). The power measured may be either continuous as from a signal generator or pulsed as from a radar transmitter.

(2) The power monitor is contained in a rectangular wooden case. A removable cover protects the panel equipment when not in use (fig. 294). All controls and meters are mounted on the front panel. The r-f connection is on the right side of the case and is protected by a removable cover.

(3) The d-c power required to operate the instrument is usually obtained from four dry batteries, Signal Corps type BA-30, which are mounted internally. At low temperatures, an external source of 25 to 30 volts may be required. Connection to an external battery is made through a jack on the front panel, labeled EXT BAT.

b. Accessory Equipment. The following equipment is furnished with the power monitor:

(1) A 5-foot coaxial-to-waveguide patch cable. One end is equipped with a type N coaxial jack; the other end, with a flange coupling.

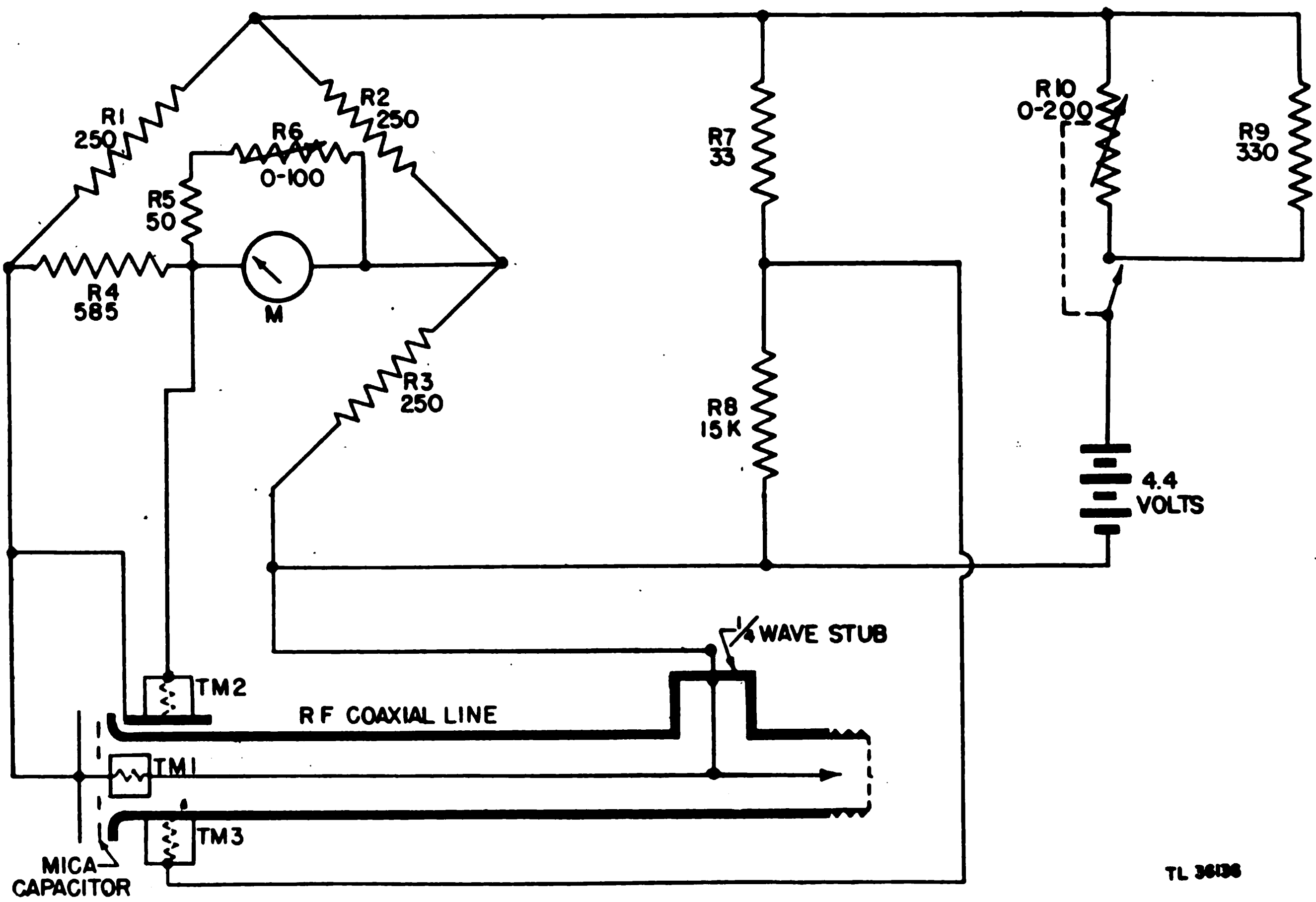


Figure 293. Power Monitor TS-125/AP, schematic diagram.

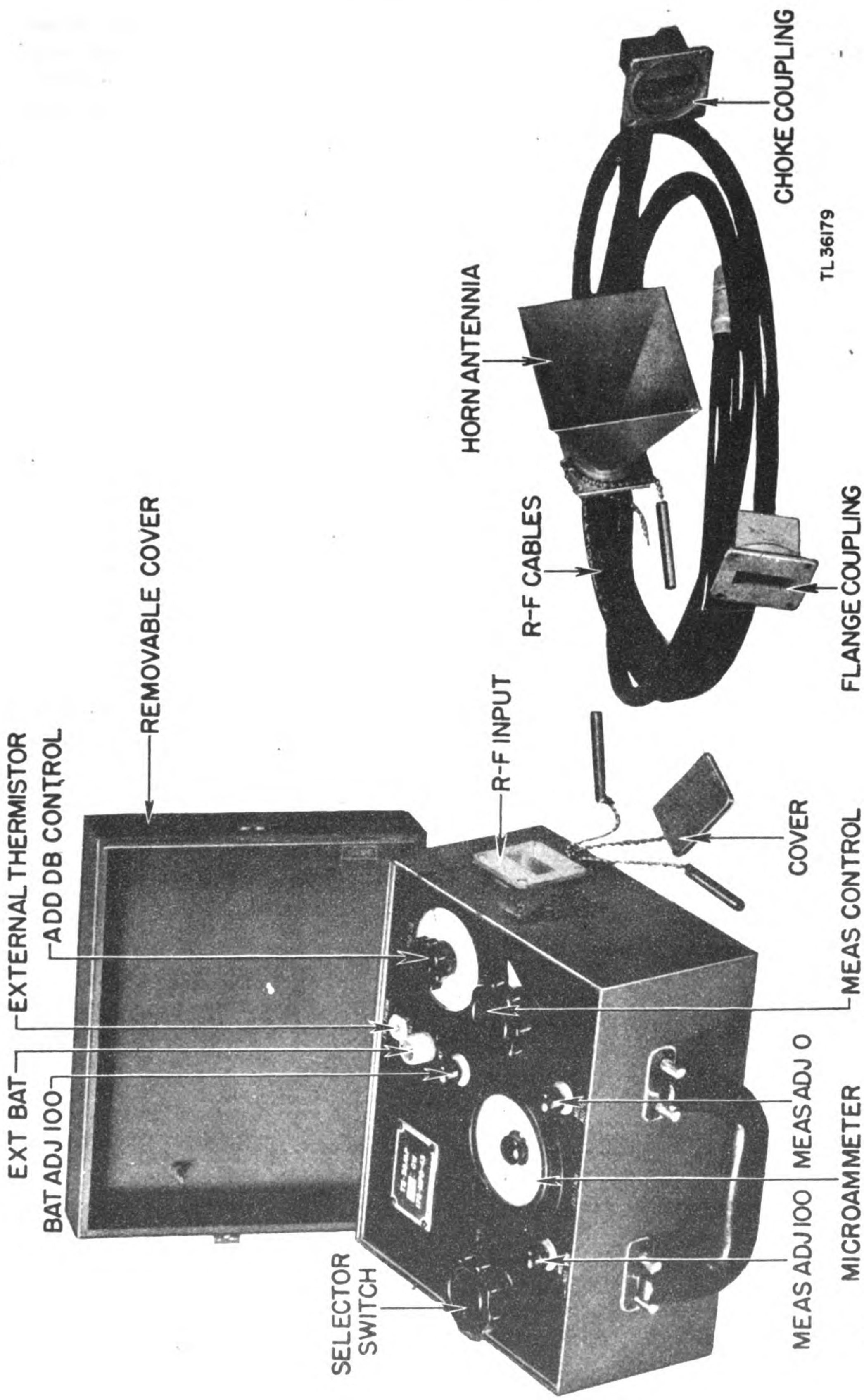


Figure 294. Power Monitor TS-36/AP.

(2) A 5-foot coaxial-to-waveguide patch cable. One end is equipped with a type N coaxial plug; the other end with a choke coupling.

NOTE: The two above-mentioned cables may be connected to form a waveguide-to-waveguide cable, 10 feet long.

(3) A horn-type test antenna with a waveguide connection.

c. Theory of Operation. (1) The power monitor consists of a power measuring head, an r-f attenuator, and a d-c bridge circuit.

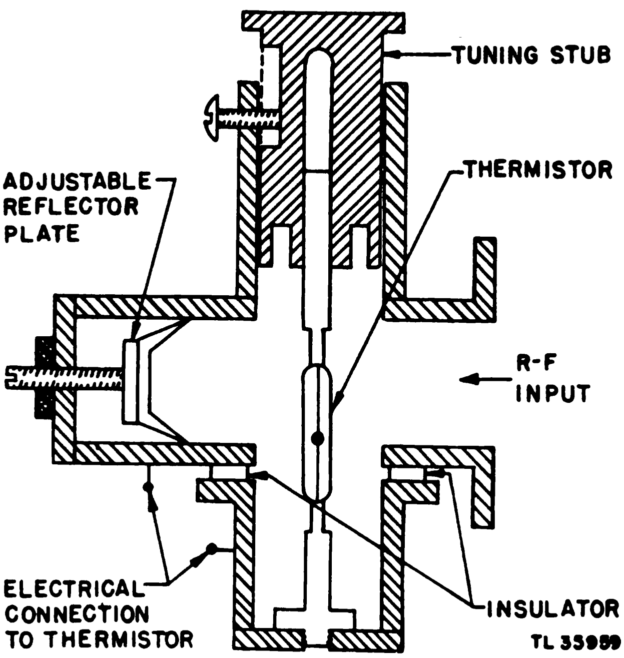
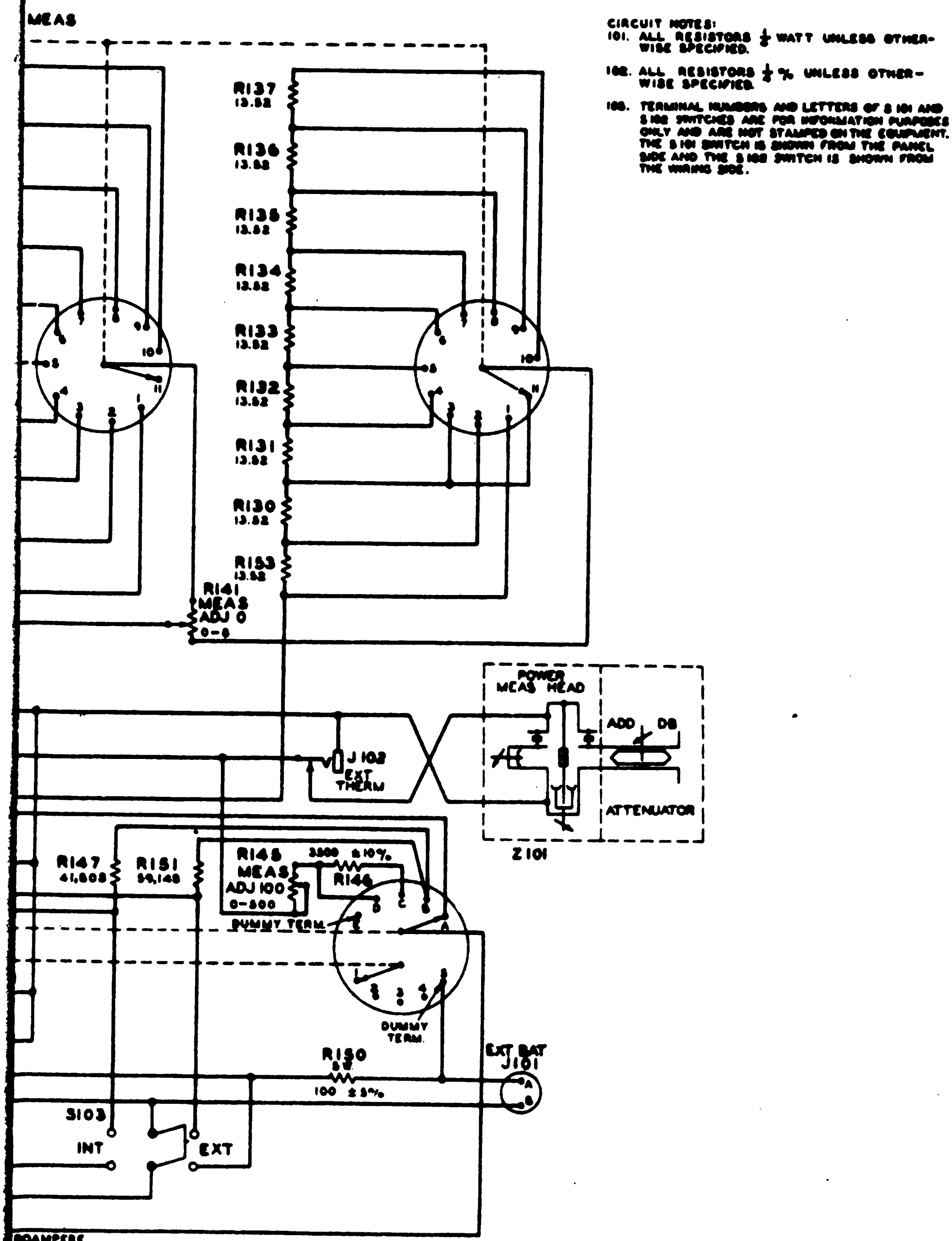


Figure 295. Power measuring head.

(2) The power measuring head (fig. 295) is a short section of waveguide in which a thermistor is mounted. The thermistor consists of a small semiconducting bead enclosed in a low-loss glass bulb and is terminated in two wires extending from the ends of the bulb. These wires are in turn fastened into two silver rods. One of these rods is threaded and screws into the fixed stub. The other silver rod forms the central conductor of the coaxial tuning stub and extends into the plunger with a friction fit which permits movement of the stub during the tuning process. The thermistor assembly forms a short coaxial line running through the waveguide, with the thermistor parallel to the short dimension of the waveguide. The end of the waveguide terminates in an adjustable reflector plate. This plate, together with the adjustable stub, is used to compensate for the reactance of the thermistor assembly and helps to match it to the waveguide. The lower fixed coaxial stub is insulated from the waveguide to provide a way for applying d-c power to the thermistor. The capacity coupling afforded by the insulator provides a low impedance path for r-f currents. Refer to paragraph 138 *b* for thermistor operation. The power measuring head is designed to measure the power level at the head.

(3) The purpose of the attenuator is to reduce the r-f power to 1 milliwatt at the power measuring head. The attenuator consists of two movable vanes in a section of waveguide and a control to adjust the vanes. The principle of operation is that the electric lines of force are greatest in the center of the waveguide. The attenuator mechanism serves to move energy absorbing elements from each side toward the center of the waveguide. The energy absorbing elements are carbon-coated bakelite vanes. As the vanes simultaneously approach the center of the guide, the power absorption, and hence the loss, increases to a maximum of 30 db, which is the highest calibrated point on the dial. The ends of the vanes are tapered to keep the standing wave ratio low. This minimizes reflection losses and affords a good impedance condition looking either way through the attenuator. The control is connected to the vanes through a rack and pinion movement having an anti-backlash construction so that the vane motion is reproducible and can be calibrated in terms of decible loss. The dial scale, ADD DB, is hand calibrated in steps of 2 db for the attenuator associated with it. ADD DB means that the indicated number of db should be added to the power applied to the measuring head in order to arrive at the power level present at the input of the instrument. The input end of the attenuator has a flange which is one element of a choke coupling. This type of coupling is readily separable yet prevents leakage in or out of the waveguide and introduces no loss to the desired transmission. The principle of the coupling is that of a real short circuit being reflected to the junction of the two guides by a half-wavelength cavity. The physical contact between the two coupling elements is at a point of high impedance in the half-wave cavity and therefore need not be perfect.

(4) The purpose of the d-c circuit (fig. 296) is to drive the thermistor resistance to its operating value, which for this bridge is 125 ohms. With no d-c power, the resistance is high. As power is applied and increased, the resistance of thermistor T101 decreases proportionately. In order to drive the thermistor to its operating value and to give an accurate indication of this value, T101 has been placed in one arm of a Wheatstone bridge circuit. The other arms consist of precision ohmic resis-



TL 36180

Figure 296. Power Monitor TS-36/AP, schematic diagram.

tors R138, R139, and R140. Meter M101 is a microammeter connected across the arms of the bridge. When the proper amount of power has been applied to the bridge, and hence to T101 to balance the bridge, the resistance of T101 is decreased to 125 ohms. The bridge circuit is set up when selector switch SW102 is in the CHECK and MEAS positions. In the CHECK position, R146 limits the current through M101 until an approximate balance is obtained. R146 is cut out when SW102 is in the MEAS position where an accurate balance can be obtained. The bridge arm ratios are such that exactly one-half of the total power applied to the bridge goes into T101. Thus, a change of 1 milliwatt (mw) into T101 requires a 2 mw change into the bridge as a whole. This affords more economical use of battery power than would be the case if all arms were equal. Another purpose of the d-c circuit is to provide a means of varying the power applied to the bridge circuit in definite steps. The steps chosen are 1 mw each for the majority of operating conditions. When an external battery is used, each step is 2 mw. When an internal battery is used, each step is ½ mw. The thermistor used in this instrument requires 6 to 23 mw to drive it to its operating resistance. This would require that 12 to 16 mw is delivered to the bridge. This requirement is fulfilled by a variable loss network.

(5) The variable loss network (fig. 296) is composed of all resistors which are under the control of the MEAS dial. The MEAS switch applies 18 to 36 mw to the bridge in 2 mw steps. These powers are obtained with the MEAS ADJ O control turned to the extreme clockwise position; that is, all resistance is in series with rheostat C. The MEAS ADJ O control provides a continuous adjustment of power between steps and serves to extend the lower power limit to 16 mw. This gives a total range of 8 to 18 mw at the thermistor. In order that the steps of the MEAS switch will always be of the required constant value, the voltage applied to the bridge must be a definite value, called the standard value. The standard voltage value is set up with SW102 on BAT. The meter indicates the voltage applied to the B rheostat contacts. In this position. with SW101 on BAT. the normal network load is on the battery. then dropping resistor R145 is adjusted until the correct meter reading is established. A reading of 100 microamperes on the meter represents 4.19 volts when using an internal battery and 5.92 volts with an external battery. In order to maintain a constant voltage during measurement, the load on the battery must be the same for all settings of the MEAS switch except the extreme clockwise position. Rheostats A, B, C, and D accomplish this. The current from the battery is fed through rheostat B to the slider of R141. From this point. half the current flows through the bridge circuit and half through a branch containing rheostat C and resistor R121. This later branch balances the network so that the load on the battery and rheostat B is constant and so that a 1-mw change can be effected in thermistor power regardless of the setting of R141. Rheostats C and D serve to pad out R141 as the power output increases so that its control range remains constant at 1 mw. Rheostat A compensates for changes in the useful load so that the total battery load remains constant for all positions of the MEAS switch.

d. Internal Battery Installation. To install the internal battery, do the following:

(1) Remove the two screws on the bottom of meter case and the cap from the waveguide connection.

(2) Lift chassis from case.

(3) Loosen the knurled screw on top of battery box and remove cover.

(4) Place batteries in the four holes of the battery block in accordance with markings on the box.

(5) Replace cover and tighten knurled screw.

(6) Set switch SW103 to INT position.

(7) Carefully replace chassis in case and tighten screws.

e. External Battery Connection. (1) Remove chassis from case and set SW103 to EXT.

(2) Replace chassis in case.

(3) Using the battery cable, connect it from the EXT BAT jack to terminals 5 and 8 on terminal board AB2-37 in communications rack A. Terminal 5 is negative and grounded. terminal 8 is positive.

> NOTE: Other sources of external battery may be used, provided the voltage is between 25 and 30 volts and the source is ungrounded or grounded on the negative side.

f. R-f Connections. (1) USING TEST HORN ANTENNA. The test horn antenna may be coupled directly to the input of the power monitor. In order to couple the horn to the radar antenna it is necessary to place the entire instrument in front of and on the same level as the radar antenna. The large end of the horn must point directly toward the radar antenna. If the waves are horizontally polarized, such as the waves from the azimuth antenna, place the short dimension of the large end of the horn horizontal. The radiation from the elevation antenna is vertical, therefore the short dimension should be vertical. The above method is to be used only when a quick check of transmitter power is desired. For more lengthy tests, mount the horn on some convenient support in the field of the radar antenna. If no support is available, set a pole in the ground. The pole should be high enough to permit placing the horn in the field of the radar antenna. The clamping of the horn to the support should provide adjustment for the horn to receive maximum power. The location of the horn with respect to the radar antenna must be found by trial. Connection between horn and power monitor is made with the r-f cables. The cable having the plain flanged end must be connected to the horn, the other cable having the choke coupling must be connected to the power monitor. The free ends of the cables are then connected together by means of type N connectors.

(2) USING WAVE SELECTOR. The X-band transmission line is equipped with a wave selector (fig. 105). The wave selector is equipped with a probe and type N socket. Use the coaxial-to-waveguide cable to connect the power monitor to the wave selector.

g. Bridge Balancing Procedure. (1) In locations where the average temperature is above 32° F, use the internal battery and the following procedure:

> CAUTION: Do not connect r-f power to the power monitor until the following steps have been completed.

(*a*) Turn the selector switch to BAT.

(*b*) Turn the BAT ADJ 100 control until meter indicates 100 microamperes. The panel should be in a horizontal plane.

(*c*) Turn selector knob to CHECK.

(*d*) Adjust MEAS knob to a position which causes the meter to read as near zero as possible.

> NOTE: Make the following adjustments with the panel in the same plane in which it will be used to make r-f measurements.

(*e*) Turn selector knob to MEAS.

(*f*) Adjust MEAS ADJ O control until meter reads zero. If the meter cannot be made to read exactly zero, shift MEAS knob one position forward or backward until the MEAS ADJ O control sets the meter to zero.

(*g*) Turn MEAS knob one position clockwise. The meter needle will swing up scale to approximately 100 microamperes.

(*h*) Adjust the MEAS ADJ 100 control until meter indicates exactly 100 microamperes.

(*i*) Turn the MEAS control one position counterclockwise. The meter needle will return to zero.

(*j*) The bridge is now balanced. Power measurement should be made immediately after the bridge has been balanced.

(2) If the temperature is below 32°F, use an external battery and set switch SW103 to EXT. Balance the bridge as follows:

(*a*) Complete steps as described in subparagraph *g* and subparagraphs (*a*) through (*f*) above.

(*b*) Turn MEAS knob one position clockwise. The meter needle will swing up scale to approximately 200 microamperes.

(*c*) Adjust the MEAS ADJ 100 control until the meter indicates exactly 200 microamperes.

(*d*) Complete operations as described in subparagraphs (*i*) and (*j*) above.

h. Measurement of Average R-f Power. Power measurements may be made by a direct reading method or by a balanced bridge method. The direct reading method alone can be used to measure average power less than 1 milliwatt; it is advisable to make the first reading of an unknown power by this method. The balanced bridge method is more accurate, but cannot be used for average powers less than 1 milliwatt.

(1) DIRECT READING METHOD.

(*a*) Complete the procedure for balancing the bridge as described in subparagraph *g* above, and leave the MEAS knob set to give a zero reading on the meter.

(*b*) Turn ADD DB control to extreme counterclockwise position.

> CAUTION: Avoid the application of average r-f power which has a level higher than 1 watt (+30 dbm) to the power monitor.

(*c*) Connect the source of r-f power to the meter as described in subparagraph *f* above. The wave selector is the best method. If the test horn antenna is used, be sure it is facing the radar antenna squarely.

(*d*) Turn on the radar system.

(*e*) Adjust the ADD DB dial so that the meter reads 100 microamperes.

(*f*) The loss as indicated by the reading on the ADD DB dial indicates the average power level at the input to the power meter. The reading is in terms of +dbm (db above 1 milliwatt).

(*g*) If the unknown power is less than 1 milliwatt, a meter reading of less than 100 microamperes will result even with the attenuator set at zero. In this case, the meter indicates directly the fraction of a milliwatt corresponding to the power level present. For example: a reading of 65 microamperes indicates the presence of 0.65 milliwatts r-f power at the input of the power monitor.

(2) BALANCED BRIDGE METHOD. In order to minimize measurement errors, the bridge circuit should be used on the basis of balancing it with the r-f power as well as with it off. Power less than 1 milliwatt cannot be measured by this method.

(*a*) Complete the procedure for balancing the bridge as described in subparagraph *g* above and leave MEAS knob set to give a meter reading of zero.

(*b*) Turn MEAS knob one position counterclockwise.

(*c*) Connect the power monitor to the source of r-f power as described above.

(*d*) Turn on the radar system.

(*e*) Adjust the ADD DB control so that a zero reading is obtained on the meter. This indicates that 1 milliwatt of r-f power is now being applied to the thermistor as a substitute for 1 milliwatt of d-c power removed from it in step (*b*) immediately above. The setting of ADD DB dial indicates the level of power in +dbm at the input connection.

i. Trouble Shooting the Power Monitor. (1) TEST EQUIPMENT REQUIRED.

(*a*) Analyzer, Weston Model 772.

(*b*) Precision resistor, 125 ohms (±0.25%).

(2) ATTENUATOR. The attenuator on each power monitor has been hand calibrated. Do not remove the knob unless it has been damaged. If there is mechanical damage to any part of the attenuator or a change in its calibration, the whole attenuator should be replaced with another factory calibrated unit. To replace the attenuator proceed as follows:

(*a*) Remove the two screws on the bottom of meter case and the cap from the waveguide connection.

(*b*) Lift the chassis from the case.

(*c*) Remove the screws holding the attenuator to the panel.

(*d*) In separating the attenuator from the power head, first remove two screws whose heads are toward the attenuator.

(*e*) Stand the assembly on the cover plate so that the junction of the attenuator and power head is horizontal. This permits careful handling of the copper gasket in the junction.

(*f*) Remove the last two screws.

(*g*) Detach the attenuator, being careful not to damage the gasket.

(*h*) In joining the new attenuator to the power head follow the above procedure in reverse order, being careful to centrally locate the gasket in the junction.

(3) POWER HEAD. Install a new power head if a thermistor burns out or requires replacement. Removal of the thermistor from a power head always requires a new impedance match. The thermistor, or its associated tuning stub, should never be changed or disturbed unless there is conclusive evidence of trouble, then the entire head should be replaced. To replace a power head, proceed in the same manner as described for the removal of the attenuator.

(4) BRIDGE CIRCUIT. In case of trouble in the bridge circuit, make a general inspection of wiring and switches.

> WARNING: Before using an analyzer to measure resistance or to detect open or short circuits, disconnect wires from the microammeter terminals, to protect the meter. Do not measure resistance of the microammeter.

(*a*) If resistance develops in the switch contacts, the resistance will have the same effect on the circuit as an abnormal value in a resistor unit which is wired to that switch. Such contacts may be checked by adjusting the analyzer as an ohmmeter and connecting it directly across the switch contacts. Use the ohmmeter on its lowest range. A zero resistance reading should be obtained; if not, the switch contacts should be cleaned with fine sandpaper, and then burnished with a strip of canvas.

(*b*) By turning the MEAS switch to its extreme clockwise position, the selector switch to OFF, and by opening the normally closed contacts on the tip of EXT THERM jack, all resistors become free of parallel paths and may be readily measured. The accuracy of resistor values in the power monitor is 0.25 percent. The analyzer has an accuracy of 15 percent, therefore it will show only large changes in resistance. If the value of a resistor is doubtful, a new one should be installed.

(*c*) To make a general test on the bridge network, remove all batteries from the power monitor and substitute a 125-ohm test resistor for the thermistor by connecting the resistor to a phone plug and inserting plug in EXT THERM jack. Then turn selector switch to CHECK or MEAS position and turn the BAT ADJ 100 control to extreme clockwise position. Using the analyzer, measure the resistance of the network between positive and negative terminals of the battery box. The resistance should be exactly 125 ohms and should be the same for positions 1 through 10 of the MEAS control.

(*d*) If the bridge balance is disturbed by changing position or by handling the power monitor, look for poor contacts on the springs in the battery box.

140. VOLTAGE DIVIDER TS-222/MPN-1.

a. General. (1) Voltage Divider TS-222 consists of a capacity voltage divider circuit and a selector switch so arranged that voltage attenuations of 10:1 or 100:1 may be obtained. All parts are contained in a metal box (fig. 297). The only control is a HI-LO switch mounted on the side of the box. The terminal on the left side of the unit is for a ground connection. Output is taken out through a socket below the HI-LO switch. High voltage to be measured is connected to the terminal which is mounted on top of the voltage divider.

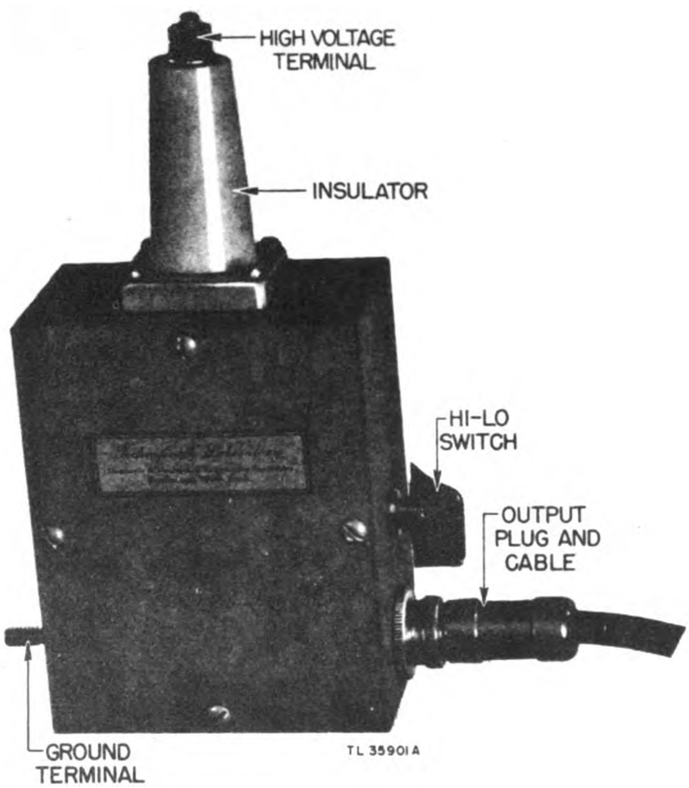


Figure 297. Voltage Divider TS-222/MPN-1.

(2) Two test cables are furnished with the voltage divider. A capacity divider cable is used to connect the capacity divider to a test oscilloscope. The high-voltage cable is used to connect the high-voltage terminal of the capacity divider to the point being measured.

b. Operation. Voltages above 150 volts should not be applied to the input circuit of a test oscilloscope. By connecting the voltage divider between the oscilloscope and the high voltage being checked, the high voltage can be attenuated to a safe level for application to the oscilloscope. The voltage divider is a capacity network, therefore d-c voltages cannot be measured. To use the voltage divider proceed as follows:

(1) Connect a heavy wire between ground and the ground terminal of the voltage divider. This connection should always be made first.

(2) Connect the test cable between the socket on the voltage divider and the test oscilloscope.

CAUTION: Be sure all power is removed and all capacitors have been discharged in the component being tested before the following connection is made.

(3) Connect the high-voltage test cable between the high-voltage terminal on the voltage divider and the point at which the test is to be made.

(4) Set HI-LO switch on voltage divider to HI or LO, depending on attenuation desired.

(5) The oscilloscope and radar system may now be turned on and the test made.

CAUTION: Turn off all power and discharge all high-voltage capacitors before removing the high-voltage cable or ground connections.

c. Circuit Description. The circuit of the voltage divider (fig. 298) consists of a resistor and capacitor network. C1 is a special high-voltage capacitor. With switch SW1 in the HI position, capacitors C3 and C4 form a shunt across the output. This shunt is adjusted so that only 1/100th of the voltage across the high-voltage terminal and ground is applied to the output plug. When switch SW1 is in the LO position, the shunting effect is much lower and allows 1/10th of the input voltage to appear at the output plug.

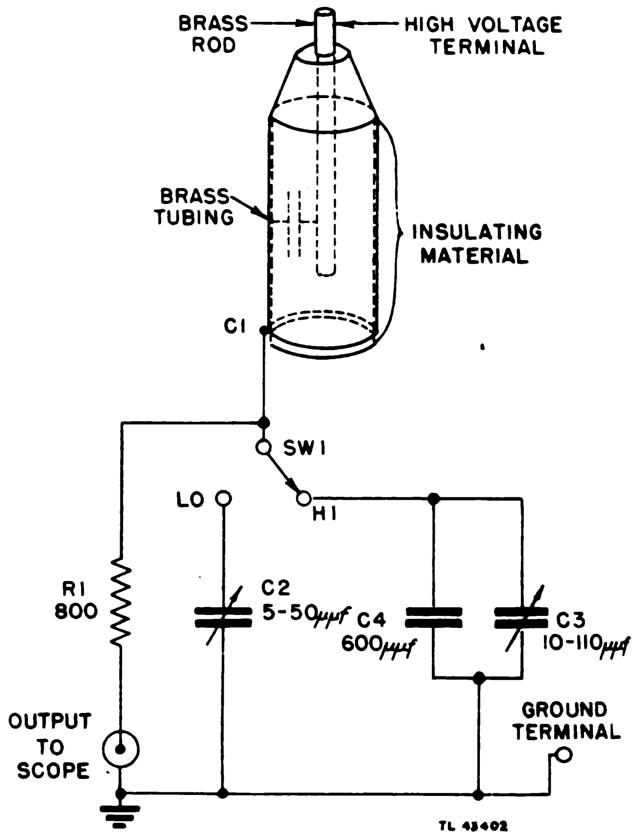


Figure 298. Voltage Divider TS-222/MPN-1, schematic diagram.

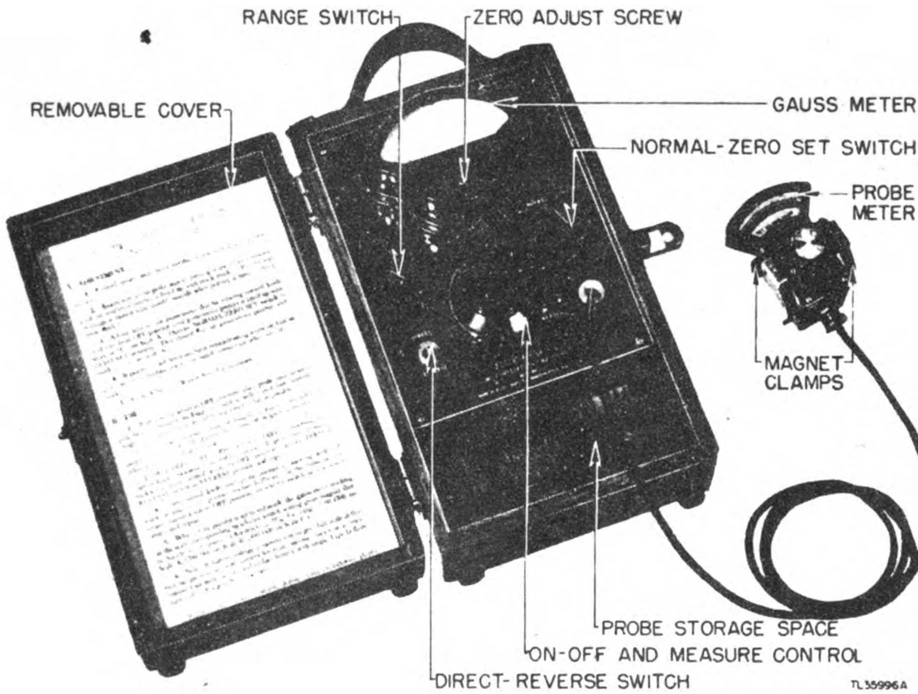


Figure 299. Flux Meter TS-15/AP.

d. Trouble Shooting the Voltage Divider. If it is impossible to obtain the correct output, remove the front panel and make an examination of the wiring and switch contacts. Do not change the adjustment of capacitors C2 or C3. If any part of the circuit requires removal. its exact value must be used as a replacement.

141. FLUX METER TS-15/AP.

a. General. (1) Flux Meter TS-15/AP is a test set designed to measure the magnetic flux density of permanent magnets in the X-band and S-band transmitters. The flux meter is contained in a rectangular wooden case (fig. 299). A removable cover protects the panel equipment when not in use. The panel equipment consists of a triple-range gauss meter; a three-position range switch labeled A, B, and C; a NORMAL and ZERO SET switch; a DIRECT-REVERSE switch; and a MEASURE control. An ON-OFF switch is a part of the MEASURE control. A probe meter is permanently connected to the test set through a shielded cable. One end of the wooden case forms storage space for the probe meter and cable. The gauss meter is calibrated for three ranges; A-range, 1,200 to 2,300; B-range, 1,700 to 3,200; and C-range, 2,400 to 4,500 gauss.

(2) Power to operate the flux meter is furnished by a 1.5-volt dry cell carried in the case back of the panel.

b. Battery Installation. To install a battery in the flux meter do the following:

(1) Remove the screw in each corner of the panel.

(2) Lift the panel a few inches and insert a battery, type BA-30, between the two clips. Observe polarity markings. Be careful not to damage any wiring.

(3) Replace panel and tighten screws.

c. Adjustment Check. To check meter adjustment and battery, proceed as follows:

(1) Remove probe meter from storage space and place it on a flat surface.

(2) Adjust probe meter pointer by turning the screw located beneath the knob on unit until pointer is lined up with the black mark. The pointer and its image in mirror scale should coincide when pointer is directly above black mark.

(3) Set range switch to A.

(4) Rotate MEASURE control clockwise from OFF position until the pointer on gauss meter is lined up with mark at 12 on scale A.

(5) Hold NORMAL-ZERO switch in ZERO SET position. The gauss meter pointer should now line up with mark at 23 on scale A.

(6) If the gauss meter pointer is not lined up with 23 on scale A, turn zero adjust screw (fig. 299) to displace the pointer an equal amount on the other side of the 23 mark.

(7) Recheck step (4) above.

(8) Repeat step (5) above if necessary.

(9) The flux meter is now ready for use.

d. Use of Flux Meter. To measure the flux density of the magnetron magnet proceed as follows:

(1) With MEASURE control in the OFF position, place probe unit between pole faces of magnet, making sure probe is clamped firmly on the magnet. Place the magnet and probe as far from the gauss meter as the cable will permit.

(2) Unless approximate value of the magnet is known, set range switch to position C. If approximate value of the magnet is known, set range switch to desired range.

(3) With DIRECT-REVERSE switch set to DIRECT, turn MEASURE control clockwise from OFF position. If the probe pointer moves backward, turn MEASURE control to OFF position, and set DIRECT-REVERSE switch to REVERSE.

(4) Advance MEASURE control clockwise until probe pointer is lined up with red mark, or the gauss meter pointer reaches full scale. If the latter occurs, return MEASURE control to OFF position, set the range switch to the next lower range, and repeat.

(5) When the probe pointer is set to red mark, the gauss meter reading on the scale corresponding to range switch position gives magnet flux in hundreds of gauss.

(6) Return MEASURE control knob to OFF.

e. Circuit Analysis. The circuit of the flux meter (fig. 300) is designed to measure the current required for full-scale deflection of the probe meter when placed in the field of an external magnet. When a current is applied to the moving coil in the probe meter, the coil tends to rotate so that its magnetic field will line up with that of the permanent magnet. A pointer is attached to the coil. The current required for full-scale deflection of the pointer is inversely proportional to the flux density of the permanent magnet. The gauss meter is a milliammeter which has been calibrated in gauss. Gauss is a term used to indicate magnetic lines per square centimeter (1 gauss being 1 line per sq cm). The gauss meter is connected in series with the battery, current adjusting resistor R4, and the probe meter. Resistor R4 adjusts the

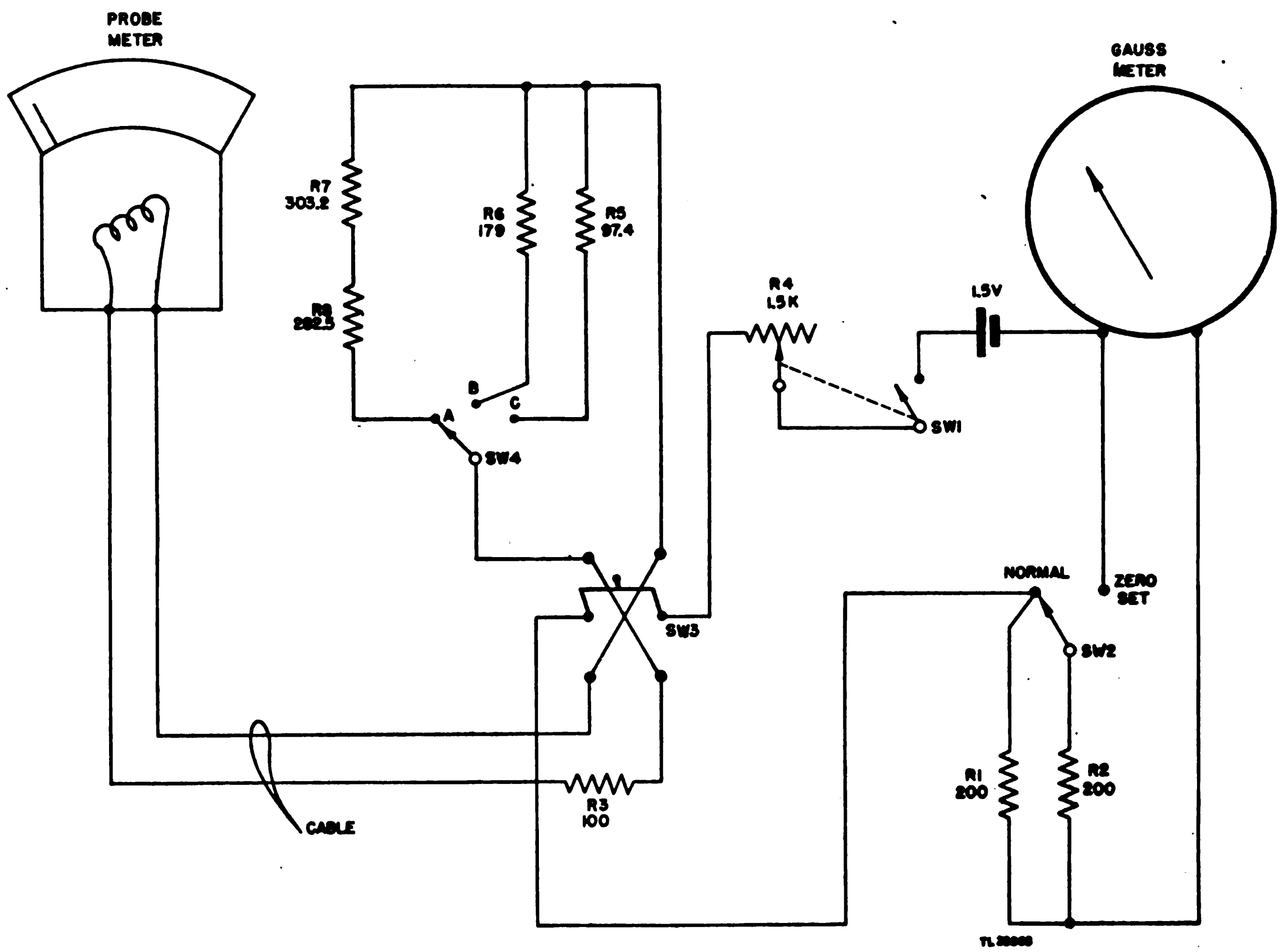


Figure 300. Flux Meter TS-15/AP, schematic diagram.

current so that the probe meter indicates full-scale deflection. When this condition exists, the gauss meter indicates the flux density of the magnet in gauss. Switch SW4 connects the proper resistor across the probe meter to correspond with the scale on the gauss meter. Most magnets are not marked as to their magnetic polarity, therefore the probe meter may read backwards. Instead of reversing the position of the probe on the magnet, switch SW3 is used to reverse the current flowing through the probe meter. When switch SW2 is in the NORMAL position, resistors R1 and R2 are in parallel, and with resistor R3, form a calibrating circuit for the gauss meter. With the probe meter disconnected from an external magnet, and the current adjusted by R4 until the gauss meter reads 12 on scale A, a zero check may be made by setting SW2 to ZERO SET. The gauss meter pointer should rest at 23 on scale A. This is because resistor R2 now becomes a shunt across the gauss meter and reduces the current through the meter to the same value required for a magnet having a flux density of 23 gauss. Switch SW2 is spring operated and remains on NORMAL unless held in the ZERO SET position while making the zero check.

f. Trouble Shooting the Flux Meter. (1) Install a new battery if the gauss meter pointer does not line up with 12 on scale A when the MEASURE control is turned to its full clockwise position. If the meter readings are unsteady, clean the battery contacts.

CAUTION: Before using an analyzer for circuit testing, disconnect the gauss meter and probe meter from the circuit. Do not attempt to measure resistance of either meter.

(2) If the flux meter fails to operate, make an inspection of all wiring and cable connections. The analyzer may be used to check for open or short circuits, but it is not capable of resistance measurements within the tolerances allowed for all resistors, except R4. If a resistor is suspected of having the wrong valve, a new one should be tried in its place. All resistors are wire wound; therefore, it is not likely that they will vary in resistance. Keep the flux meter in a dry place when not in use.

142. ECHO BOX TS-217/MPN-1.

a. General. Echo Box TS-217/MPN-1 is a resonant cavity system designed for use with the S-band transmitter of Radio Set AN/MPN-1. A frequency control knob, an indicating meter, and a range switch are mounted on the front of a steel panel (fig. 301). All other parts are mounted on the back of the panel (fig. 302). A coaxial input line approximately 3 feet long is brought out through the front lower righthand corner of the panel and is terminated in a type N connector. When not in use, the coaxial line is arranged to fold back behind the panel. The echo box is located in bay 9 of the transmitter rack (fig. 10).

b. Circuit Analysis. (1) The echo box is a cylindrical cavity approximately 6 inches in diameter, 5½ inches long, and has both ends covered. Inside the cylinder is a movable partition, which moves axially to vary the length of the cavity. When its knob is turn clockwise, the partition moves into the cylinder and decreases the cavity length. The frequency to which the cavity is resonant depends on the inside length of the cavity. When this length is decreased, the resonant frequency is raised, and vice versa. R-f energy is fed into the cavity through the coaxial line (fig. 301) and into a coupling loop

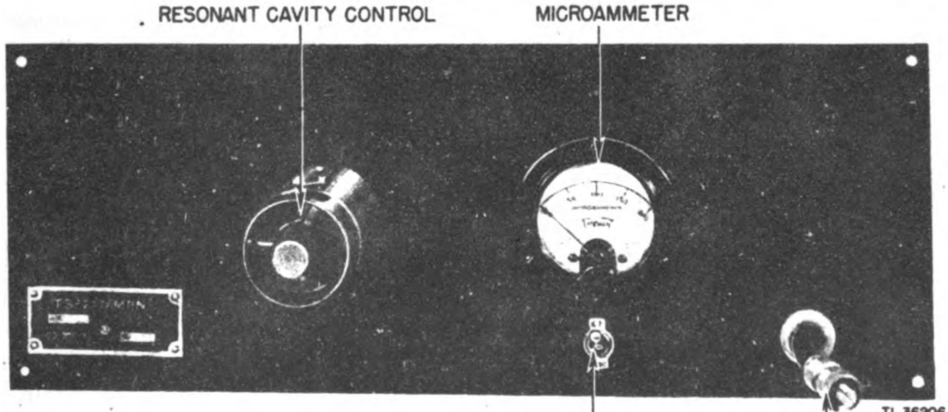


Figure 301. Echo Box TS-217/MPN-1, front view.

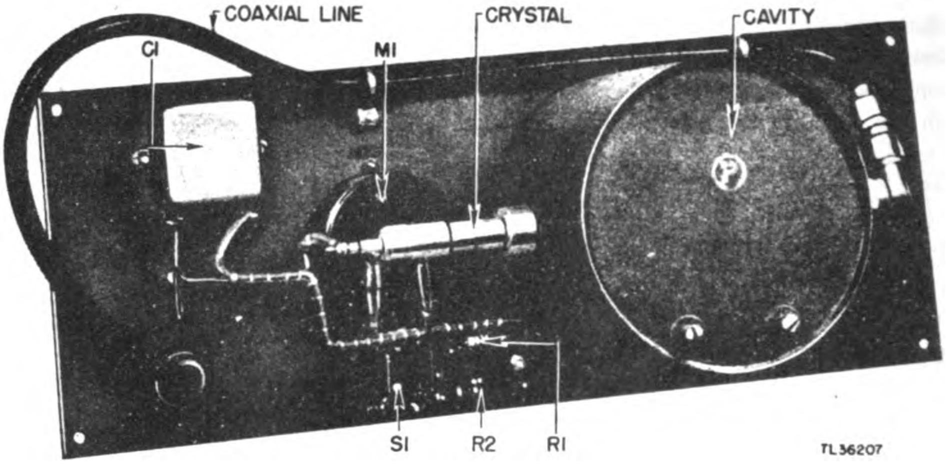


Figure 302. Echo Box TS-217/MPN-1, rear view.

inside the cavity. During the radar pulse, the resonant cavity accepts r-f energy, and oscillations build up for the duration of the pulse. After the radar pulse, the oscillations in the cavity continue but gradually die out because some of the energy is dissipated in the cavity, some is coupled out to the indicator system, and some goes out through the input line.

(2) The energy coupled out to the indicator system is rectified by the crystal. The crystal current is filtered by capacitor C1 (fig. 303), and is measured by microammeter M1. The crystal current, as measured by M1, indicates the amount of energy absorbed by the cavity. With switch SW1 in the X1 position, the meter indicates the amount of current being rectified by the crystal. The rectified current may be higher than 200 microamperes: therefore, a shunt resistor may be connected across M1 by placing SW1 in the X10 position. Resistor R2 serves as a dropping resistor. When SW1 is in the X10 position, the meter reading must be multiplied by 10 to find the value of rectified current.

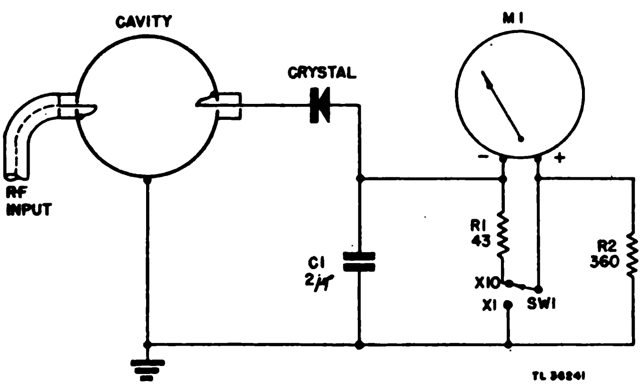


Figure 303. Echo Box TS-217/MPN-1, schematic diagram.

(3) After the radar pulse has shock-excited the cavity into oscillation, the cavity will continue to oscillate with an amplitude which decreases exponentially with time, reradiating the absorbed energy out through the r-f input line. The time required for the oscillations in the cavity to die out is called "ringing time." The ringing time is from 10 to 30 microseconds. The output from the cavity may be used as an aid in tuning the radar system.

*c. **Operation.*** To connect the echo box to the radar system, withdraw the coaxial input line and connect it to the cable leading to the S-band wave selector. When the echo box is not in use the cable should be disconnected.

(1) TO CHECK SYSTEM SENSITIVITY. All controls on the radar receiver and indicators must be in the same position each time a sensitivity check is made. Optimum or peak sensitivity is determined by experience with a particular radar set, and it represents maximum performance of the equipment. The search system sensitivity is obtained by the following procedure.

(*a*) Connect the echo box to the S-band wave selector.

(*b*) With the search system in operation, tune the echo box control until maximum deflection is obtained on the echo box meter.

(*c*) With the search central operating on the 7½-mile range, observe on the indicator the ringing time of the echo box. The reading can be taken directly in miles on the indicator scale. The echo will appear as a large bright spot with a radius of 3 to 4 miles, when the set is functioning normally. As an example: if the radius of the observed spot is 3 miles and that obtained at peak sensitivity is 4 miles, the system sensitivity is 75 percent.

(*d*) Detune echo box and disconnect the input cable.

(2) MEASUREMENT OF TRANSMITTER FREQUENCY. In general, measurement of the S-band transmitter frequency is not necessary as the frequency is fixed by the design of the transmitter tube and cannot be changed. If it is desired to measure the frequency, proceed as follows:

(*a*) Connect the echo box to the S-band wave selector.

(*b*) With the radar system in operation, tune the echo box control until maximum deflection is obtained on the echo box meter. Be sure that the maximum center is read. Two smaller peaks are usually found on either side close to the main peak.

(*c*) Read the scale and note the control knob position. The first two significant figures are found by the position of the indicator under the lucite scale on the control knob barrel. The third division is read off the circumference of the control knob.

(*d*) Determine the frequency by using the dial division calibration chart furnished with each echo box.

d. Trouble Shooting the Echo Box. (1) If the echo box fails to ring, check the cable for continuity and shorting and the wiring for broken or loose connections.

> CAUTION: Before using an ohmmeter to check the circuit, remove crystal and microammeter from the circuit.

(2) If the crystal needs to be replaced unscrew the crystal holder (fig. 302) and withdraw the crystal. Install the new crystal and replace the holder. Whenever the crystal is being installed, or when it is out of its holder, it must be kept away from the transmitting antennas if they are radiating. It is best to have the radar set off the air whenever crystals are removed from their capsules. Crystals are very delicate and should always be wrapped in tinfoil to protect them from being burned out, and if possible they should be kept in metal boxes. In dry or cold climates it is advisable, when inserting crystals, to ground out any static electricity by touching the finger to the echo box before the crystal makes contact.

143. TEST SET TS-13/AP.

a. General. Test Set TS-13/AP is a portable r-f signal generator with self-contained wavemeter and power supply. It has been designed to operate in the X-band frequency range covered by Radio Set AN/MPN-1. The test set is used to measure the radar system power output, system frequency, local oscillator frequency, and receiver sensitivity. It will generate either pulsed or continuous wave r-f power. The test set is designed to operate on 117-volt, 60-cycle power, and consumes approximately 150 watts. All controls for operating the test set are mounted on a front panel (fig. 304). The connection for r-f input and output is located on the left end of the unit. A frequency calibration chart is mounted in the cover.

b. R-f Connections. There are two connections between the test set and the radar system under test; a trigger line and an r-f line. The trigger line is a synchronizing cable, which connects between the INPUT SYNC connector on the test set and any available trigger such as that from the TRIG OUT jack on the synchroscope. The r-f line effects the transfer of r-f energy from the system to the test set or vice versa. This is accomplished in either of two ways. The first method is to connect the test set to the X-band wave selector through a low loss r-f cable. In the other method of coupling, the r-f connector of the test set is coupled by a length of r-f cable to the test horn antenna. The horn antenna is then mounted at a convenient distance in front of the system antenna. The distance is not critical and may be 15 or 20 feet, but once the distance is established, it must be maintained for future comparison, and care must be taken to orient the horn so that the feed probe in the horn is parallel to the dipole of the radar antenna. In this method, r-f energy may be transferred in either direction, depending on the type of test to be made.

> CAUTION: Never connect the test set directly into the waveguide except through the wave selector. To do so will damage the test set.

c. Operation. The test set should be placed so that the radar system controls and those of the test set may be adjusted simultaneously. To place the test set in operation proceed as follows.

(1) PRELIMINARY ADJUSTMENTS.

(*a*) Connect the line cord to a source of 117-volt, 60-cycle power and turn the POWER ON/OFF switch to ON.

(*b*) Connect either a positive or a negative trigger from the radar system to the INPUT SYNC jack. The trigger may be taken from the TRIG OUT jack on the synchroscope which is located in the transmitter rack.

(*c*) Turn the INPUT SEL to +TRIG or -TRIG depending on the polarity of the trigger taken from the synchroscope.

(*d*) Connect one end of a length of r-f coaxial cable to the waveguide-coax adapter on the end of the test set.

(*e*) Depending on the type of test, connect the other end of the coaxial cable to either the X-band wave selector or to the test horn antenna.

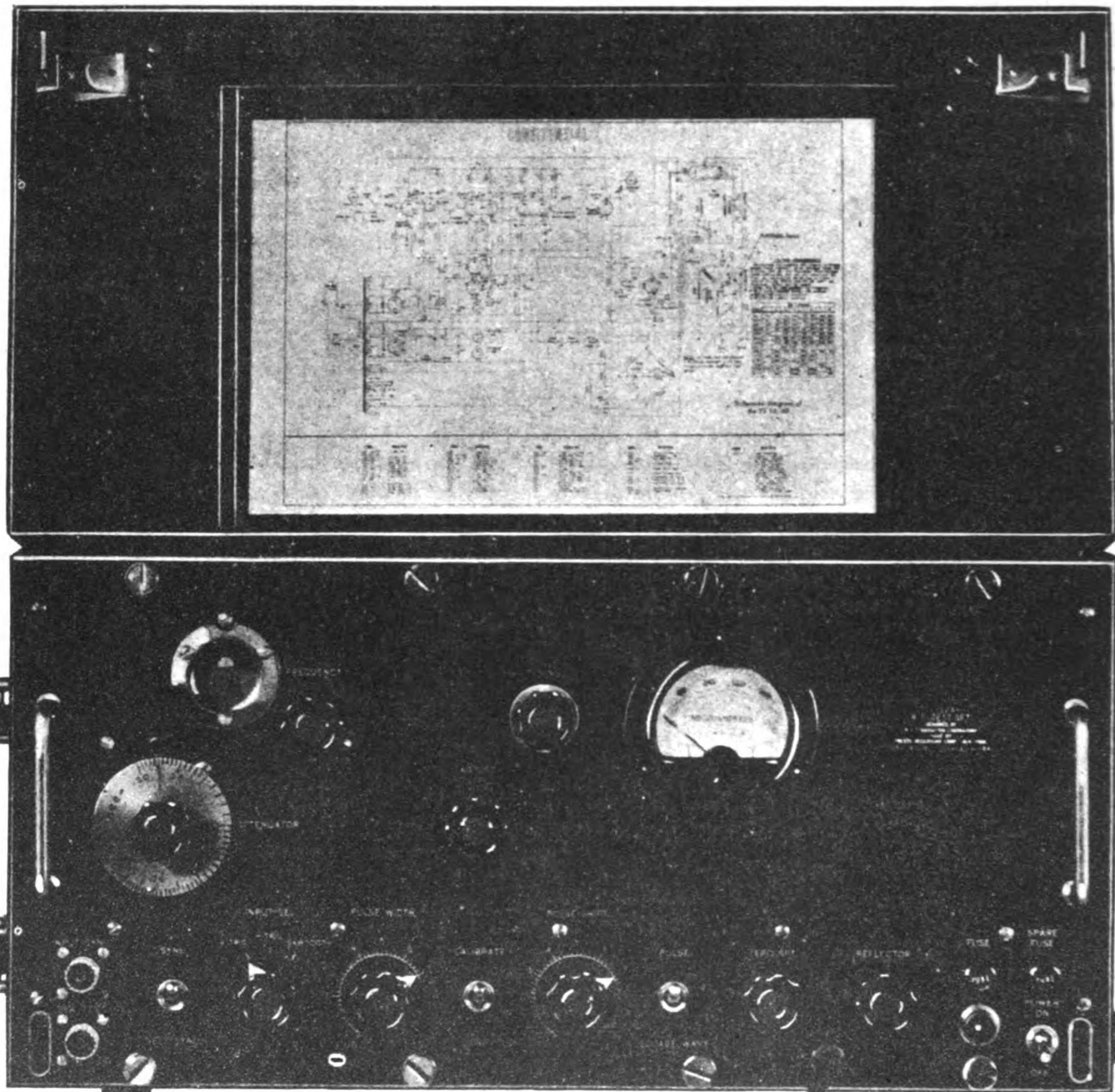


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Figure 304. Test Set TS-13/AP, front view.

(2) CW OPERATION.

(*a*) Make the adjustments as described in subparagraph (1) above.

(*b*) Turn the CALIBRATE-USE switch to the CALIBRATE position, the SYNC-SELF SYNC switch to the SYNC position and the PULSE-SQUARE WAVE switch to the PULSE position. Balance the thermistor bridge by varying the ZERO SET control until zero current is shown on the meter.

(*c*) Vary the REFLECTOR control throughout its range. Note the number of points throughout this range which start the test set generating r-f power, as evidenced by a deflection upon the meter. Choose the point on the REFLECTOR control which gives maximum deflection on the meter. If, through the course of the preceding adjustments, the meter deflects off scale, this indicates that too much power is being applied to the bridge. This can be remedied by varying the ADJUST OUTPUT control to bring the meter to approximately ¾ of full scale.

(3) SYNCHRONIZED PULSE OPERATION.

(*a*) Complete all steps as described in subparagraphs (1) and (2) above.

(*b*) Turn the CALIBRATE-USE switch to the USE position; the test set is now ready for pulsed operation.

(*c*) Adjust the PULSE WIDTH and PULSE SHIFT controls to give the desired r-f pulse width and r-f pulse time delay, respectively.

(4) SELF-SYNCHRONIZED PULSED OPERATION.

(*a*) Complete all steps as described in subparagraphs (1) and (2) above.

(*b*) For self-synchronized short pulses, place the PULSE-SQUARE WAVE switch in the PULSE position.

(*c*) For self-synchronized long pulses or square wave operation, place the PULSE-SQUARE WAVE switch in the SQUARE WAVE position.

(5) FREQUENCY MODULATION OPERATION.

(*a*) Complete all steps described in subparagraphs (1) and (2) above. Check to see that the thermistor bridge is balanced.

(*b*) Set the INPUT SEL switch to SAWTOOTH.

(*c*) Connect a saw-tooth voltage of 100 to 300 volts amplitude to the SYNC INPUT connector.

(*d*) Vary the REFLECTOR control to get maximum deflection on the meter. Now adjust until the deflection on the meter is about ¾ of full scale by varying the ADJUST OUTPUT control.

(6) TO MEASURE POWER OUTPUT OF TRANSMITTER.

(*a*) Complete all steps as described in subparagraphs (1) and (2) above.

(*b*) Connect a coaxial cable between the waveguide-coax adapter and the X-band wave selector.

(*c*) Turn the ATTENUATOR and ADJUST OUTPUT controls fully counterclockwise.

(*d*) Adjust ZERO SET control until meter reads zero. This should be repeated from time to time if the test set drifts off zero.

(*e*) Turn the ATTENUATOR control clockwise to the red reference mark.

(*f*) Turn on the radar system.

(*g*) The test set meter now indicates the amount of power in milliwatts.

(7) TO MEASURE TRANSMITTER FREQUENCY.

(*a*) Complete all steps as described in subparagraphs (1) and (2) above.

(*b*) Make the test as described in subparagraph (6) above.

(*c*) Very slowly, turn the FREQUENCY control through the range of 0 to 18 on the dial.

(*d*) When the FREQUENCY control is tuned through the frequency of the radar system, a sharp dip will be observed in the reading of the test set meter. Tune for the minimum meter reading.

(*e*) Read the scale on the FREQUENCY dial. The frequency is then found on the calibration chart.

(8) TO TEST X-BAND RECEIVER SENSITIVITY.

(*a*) Carry out steps as described in subparagraph (7), (*a*) through (*c*).

(*b*) Turn the ATTENUATOR to midrange and the ADJUST OUTPUT knob nearly all the way clockwise.

(*c*) Turn the CALIBRATE USE switch to CALIBRATE.

(*d*) Adjust the REFLECTOR control to obtain a maximum reading on the meter. If necessary, reset the ADJUST OUTPUT control to keep the meter reading on the scale.

(*e*) Slowly turn the FREQUENCY control until a dip is observed on the meter. Read the frequency as described in subparagraph (7) above.

(*f*) Make a small adjustment of the TUNING control and then readjust the REFLECTOR control until the meter reading is at a maximum. Turning the TUNING control clockwise lowers the frequency and vice versa.

(*g*) Again read the frequency as in (*e*) above.

(*h*) Repeat steps (*f*) and (*g*) above as many times as necessary, until the frequency is very close to that of the radar system.

(*i*) Adjust the synchroscope in the transmitter rack to indicate the output of the receiver under test. Adjust the receiver sensitivity control to its full clockwise position and the synchroscope video amplifier gain so that about ½ inch of noise is showing on the CRT.

(*j*) Adjust the test set ADJUST OUTPUT to give a reading of 100 on the meter.

(*k*) Recheck the power meter reading and, if necessary, reset the ADJUST OUTPUT control slightly to restore the meter reading to 100.

(*l*) Throw the CALIBRATE-USE switch to USE. At this point, an artificial signal or pip should appear on the CRT of the synchroscope. The signal may be moved in range by use of the PULSE SHIFT control.

(*m*) Make a fine adjustment of the TUNING control to obtain a maximum signal on the CRT. To do this, it may be necessary to retard the video amplifier gain of the synchroscope just long enough to peak the artificial signal.

(*n*) Check to see that the power meter still reads zero when the ADJUST OUTPUT control is in the extreme counterclockwise position. If it has drifted off zero, reset with the ZERO SET control; set the CALIBRATE-USE switch to CALIBRATE; reset ADJUST OUTPUT to give a power meter reading of 100; and then turn the CALIBRATE-USE switch back to USE again.

(*o*) Turn the ATTENUATOR control clockwise until the artificial signal on the CRT is barely visible in the noise. Moving the PULSE SHIFT control on the test set will improve the accuracy to which this can be done.

(*p*) The reading of the ATTENUATOR dial at the point of disappearance of the signal into the noise is an indication of the receiver sensitivity.

NOTE: The above sensitivity test should be made on each X-band receiver when they are known to be in a good operating condition, then all future tests should be based on the results obtained.

d. Circuit Description. Basically, the test set consists of a pulsing and phasing circuit; a regulated power supply system; an r-f oscillator and associated plumbing; and a direct reading thermistor bridge circuit.

(1) PULSING AND PHASING CIRCUIT.

(*a*) *Inverter.* A negative trigger is required to operate the phasing multivibrator V102 (figs. 305 and 306). If only a positive trigger is available, it is necessary to resort to a phase inverter to convert to a negative trigger. The positive trigger from the INPUT SYNC jack passes through the INPUT SEL switch, which would be set for a +TRIG applied to the grid of V101(a) through grid coupling capacitor C102 (fig. 307). V101(a) is close to cutoff and therefore the plate is slightly below ground potential. When a positive pulse is applied to the grid, the tube is immediately driven to increased conduction. The increased plate current causes a large voltage drop across R101. Point A is then at a much lower negative potential than the quiescent condition and will remain so for the duration of the applied pulse. The resulting negative pulse is applied through the plate coupling capacitor C104, to the grid of the phasing multivibrator. It can be seen that as the grid potential is made more positive, the plate potential is made more negative. Consequently a 180-degree phase shift has been accomplished. The use of a grounded positive voltage supply in this circuit in no way affects the normal circuit theory of the vacuum tube. R128 is a B-supply limiting resistor; R102 is a grid resistor; R103 provides the cathode bias; and C103 is a cathode bypass capacitor when a negative trigger is applied with the INPUT SEL switch in the –TRIG position. The trigger is passed directly on to the phasing multivibrator through capacitors C101 and C104.

(*b*) *Phasing Multivibrator.* The function of the multivibrator is to generate square waves. It is a relaxation type oscillator consisting of two resistance coupled stages in which the output of the second stage supplies the input to the first stage (fig. 308). Each stage gives a phase inversion of 180 degrees. Thus a total phase shift of 360 degrees is obtained. The output of the second stage is in phase with the signal on the grid of the first stage, therefore the conditions for an oscillatory circuit are satisfied. When tube V102(a) is conducting, the grid bias on tube V102(b) is made less negative as capacitor C106 is charged. When the grid voltage of tube V102(b) becomes positive with respect to the cathode, tube V102(b) begins conducting and V102(a) is nonconducting. The plate voltages are approximately square waves when the circuit constants are adjusted properly. The periods of half-cycles TA and TB (fig. 309) vary with the time constants consisting of RA, R109, C106, and the operating condition of the tube. RA and RB are varied by the PULSE-SQUARE WAVE and SYNC-SELF SYNC switches and the PULSE SHIFT control R104, to vary the time constants for different types of operation. When the PULSE-SQUARE WAVE switch is in the SQUARE

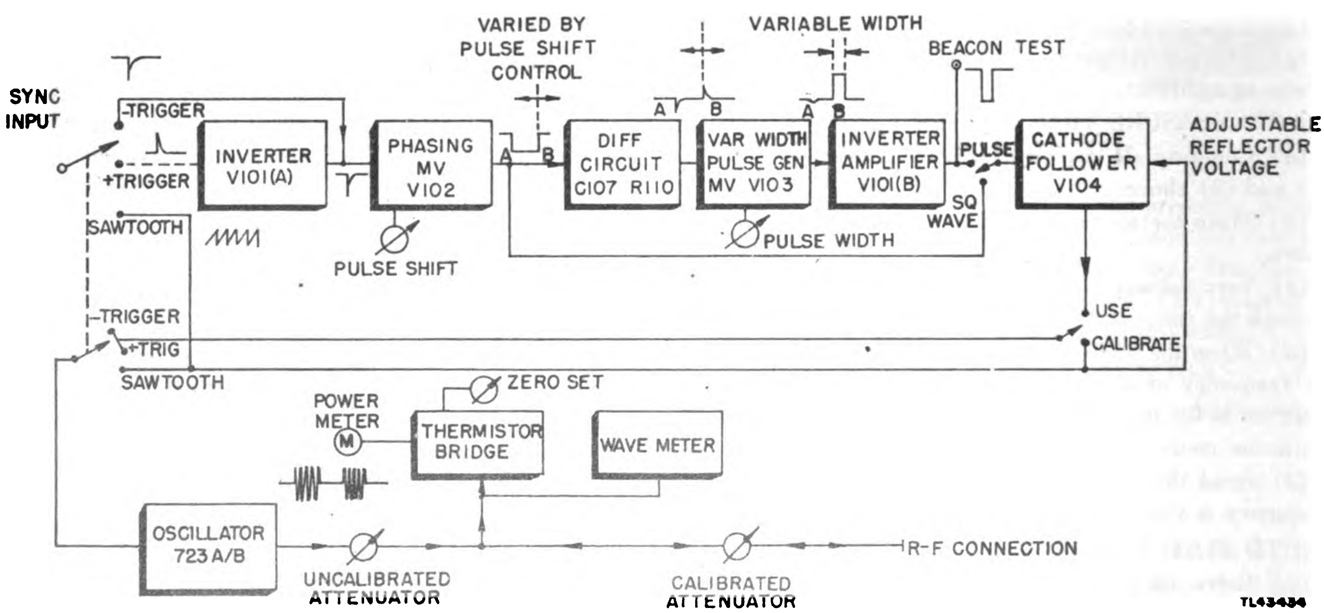

Figure 305. Test Set TS-13/AP, functional block diagram.

Symbol Designati[on]
C101
C102
C103
C104
C105
C106
C107
C108
C109
C110
C111
C112
C113
C114
C115
C116
C117
C118
C119
C120
C121
C122
C123
C124
C125
C126
F101
F102
I101
L101
L102
L103
M101
R101
R102
R103
R104
R105
R106
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R117
R118
R119
R120

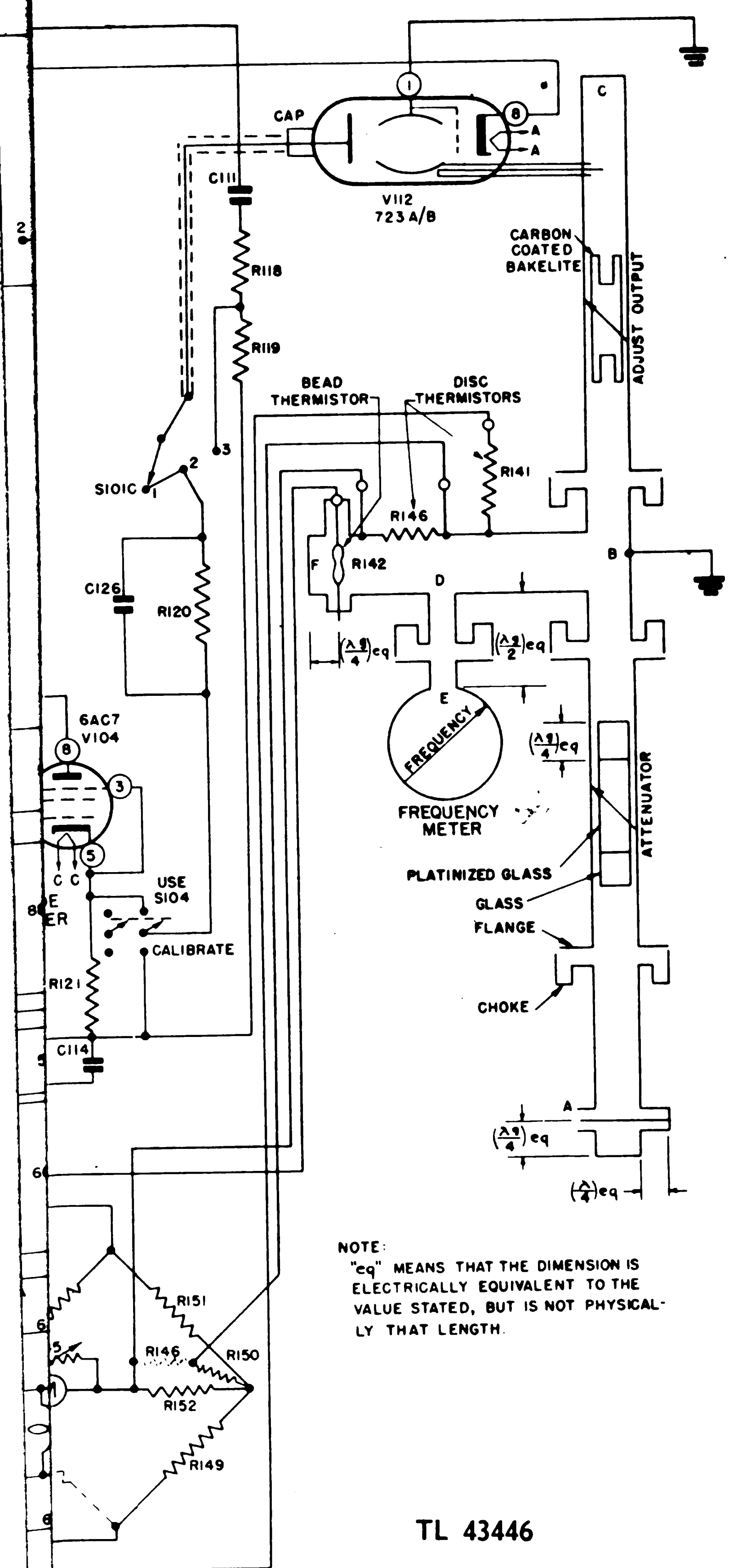

Figure 306. Test Set TS-13/AP, schematic diagram.

...escription	
Rating	Tolerance
600V d-c	10%
500V d-c	10%
600V d-c	10%
500V d-c	10%
500V d-c	10%
600V d-c	10%
500V d-c	10%
500V d-c	10%
600V d-c	10%
600V d-c	10%
600V d-c	10%
500V d-c	10%
600V d-c	10%
1,000V d-c	10%
1,000V d-c	10%
600V d-c	10%
1,000V d-c	10%
1,000V d-c	10%
600V d-c	10%
1,000V d-c	10%
1,000V d-c	10%
600V d-c	10%
600V d-c	10%
1,000V d-c	10%
500V d-c	10%
250V	
250V	
6-8V	
45 ohms	
450 ohms	
210 ohms	
68 ohms	
1 watt	10%
.5 watt	10%
.5 watt	10%
1 watt	10%
.5 watt	10%
.5 watt	10%
.5 watt	10%
10 watt	10%
10 watt	10%
.5 watt	10%
2 watt	5%
1 watt	10%
2 watt	10%
.5 watt	10%
1 watt	10%
.5 watt	10%
1 watt	10%
.5 watt	10%
.5 watt	10%
.5 watt	10%

Symbol Designation	Description		
	Value	Rating	Tolerance
R121	2,000	1 watt	10%
R122	100,000	.5 watt	10%
R123	10,000	2 watt	10%
R124	10,000	4 watt	10%
R125	10,000	4 watt	10%
R126	5,000	.5 watt	10%
R127	1 meg	.5 watt	10%
R128	6,000	20 watt	10%
R129	2 meg	1 watt	10%
R130	80,000	2 watt	10%
R131	30,000	1 watt	10%
R132	50,000	1 watt	10%
R133	50,000	1 watt	10%
R134	100,000	1 watt	10%
R135	1 meg	.5 watt	10%
R136	5,500	10 watt	10%
R137	38	.5 watt	5%
R138	38	.5 watt	5%
R139	3,000	4 watt	10%
R140	3,000	4 watt	10%
R141	THERMISTOR		
R142	THERMISTOR		
R143	475	.5 watt	5%
R144	8,000	15 watt	5%
R145	500	2 watt	10%
R146	THERMISTOR		
R147	6,000	20 watt	10%
R148	5,000	.5 watt	10%
R149	250	.5 watt	5%
R150	20	.5 watt	5%
R151	250	.5 watt	5%
R152	250	.5 watt	5%
R153	250	.5 watt	5%

	Type
T101	Power transformer Type 78077
S101	Rotary, 3 pole 3 position, 3 section
S102	Toggle, DPDT
S103	Toggle, DPDT
S104	Toggle, DPDT
S105	Toggle, DPDT
V101	6 SN7GT
V102	6 SN7GT
V103	6 SN7GT
V104	6AC7
V105	6Y6G
V106	6AC7
V107	VR105/30
V108	VR105/30
V109	VR105/30
V110	5U4G
V111	5Y3GT-G
V112	723A/B

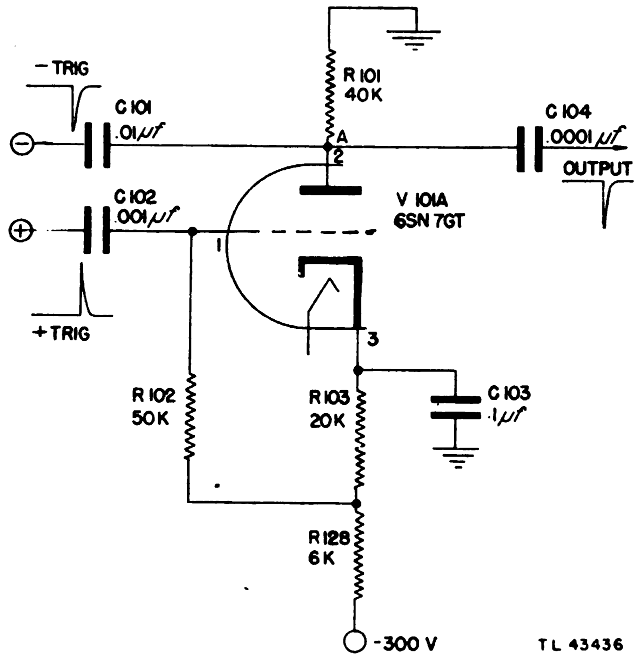

Figure 307. Trigger inverter, simplified schematic diagram.

WAVE position, and the SYNC-SELF SYNC switch in the SELF SYNC position, the recurrence frequency is still 1,000 cps but square waves of short duration are developed. If the PULSE-SQUARE WAVE switch is set to PULSE, and the SYNC-SELF SYNC switch is in the SYNC position, the output waves are synchronized at the trigger frequency. When a trigger pulse is applied to the grid of V102(a), the change from nonconducting to conducting state of V102(b) is made to come ahead of its

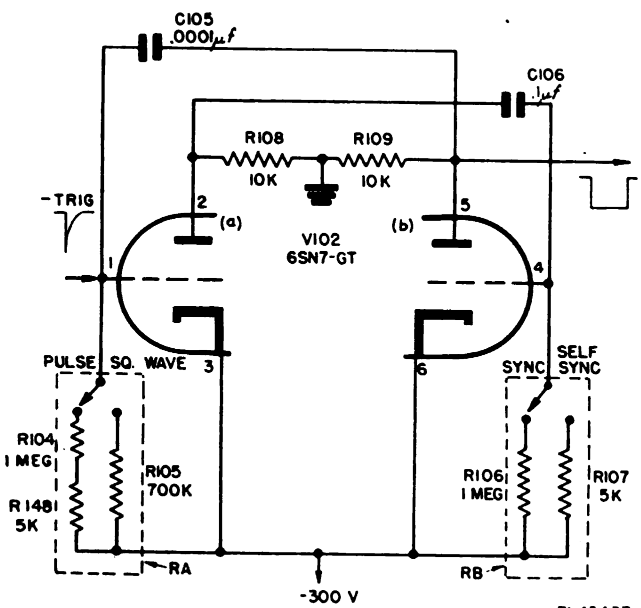

Figure 308. Phasing multivibrator, simplified schematic diagram.

natural time by application of the trigger. The synchronized negative square wave output of V102(b) is passed to a differentiator for phasing the pulse which is to be applied to the r-f oscillator.

(*c*) *Differentiator.* Sharp pulses are produced by an RC circuit (fig. 310) when abrupt changes occur in the d-c potential applied. Capacitor C107 charges or discharges exponentially until its voltage equals the new value of impressed voltage. A negative pulse is produced at the beginning of the negative square wave from the plate of V102(b), and a positive pulse at the end of the square wave. The time between the negative and positive pulses is adjusted by the PULSE SHIFT control R104, in the phasing multivibrator.

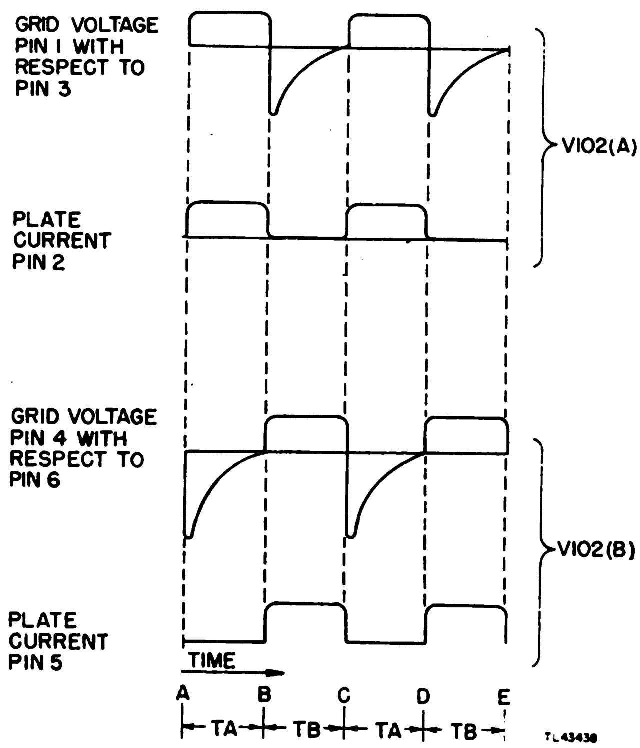

Figure 309. Phasing multivibrator waveforms.

(*d*) *Variable Pulse-Width Generator.* This circuit is a modified multivibrator in which the capacitor coupling between the first grid and the second plate is omitted so that the circuit will not oscillate, but will go through one half-cycle when triggered (fig. 311). The first triode, V103(a), is normally nonconducting and the second triode, V103(b), is normally conducting. Since V103(a) is already biased beyond cutoff, the negative trigger has no effect. The positive trigger from the differentiator circuit causes V103(a) to become conducting as shown in figure 312. The grid voltage of V103(b) rises exponentially at a rate dependent upon the time constant of R114, R115, R112, and C108. The width of the output pulse is varied by the PULSE WIDTH control R115, which varies the time constant. In figure 312, point A corresponds to the time of the input trigger; the time from A to B is time delay, and the time B to C is the width of the pulse. Inductance L101 is added to peak the rise of the pulse.

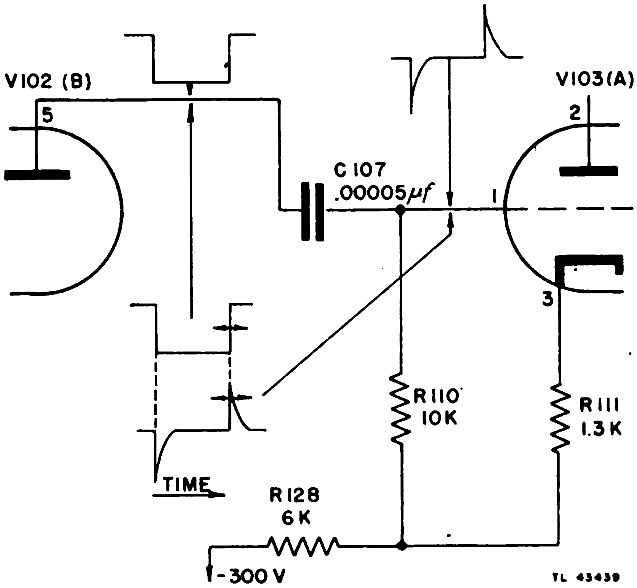

Figure 310. Differentiator, simplified diagram.

(*e*) *Inverter Amplifier.* Tube V101(b) (fig. 306) is used as an inverter amplifier to invert the positive pulse in a similar manner as V101(a) is used to invert positive trigger voltages. The output pulse of V101(b) is coupled to the grid of a cathode follower V104, when the PULSE-SQUARE WAVE switch is in the PULSE position.

(*f*) *Cathode Follower Stage.* Tube V104 is a cathode follower. It is used because it has a low output impedance and introduces negative feedback. The output is taken from across the cathode resistor and is used to modulate the r-f oscillator V112.

(2) POWER SUPPLY SYSTEM. The power supply operates entirely from one transformer. T101 (fig. 306). It uses two full-wave rectifiers, V110 and V111, both operating from separate high-voltage secondary windings. The two rectifiers actually form two power supplies whose voltages are additive. All voltages are negative with respect to ground. D-c voltage for the thermistor bridge and the cathode voltage for the oscillator tube are electronically stabilized while the reflector voltage, whose current drain is slight, is obtained by connecting the electronically regulated power supply in series with the VR stabilized power supply. The total reflector voltage is about -500 volts. V105 is a current regulator tube and tube V106 is a control tube for V105. Any change in voltage between ground and the cathode of V112 is fed to the grid of the control tube. V106 then operates the current regulator in such a way as to compensate for the change; that is, to increase or decrease the internal impedance of the supply. R133 controls the cathode voltage of V112. This voltage can be varied over 100 volts, but is normally about 300 volts. R132 controls the amount of feedback to the control tube. If R132 is adjusted to give too small an amount of feedback, the regulating ability of the supply drops; if too much feedback is used, the regulation is inverse; that is, a change in low voltage will be magnified.

(3) R-F OSCILLATOR. The oscillator, V112 (723A/B) is a velocity modulated tube of the reflex type. The oscillator is tuned for CW oscillation with the CALIBRATE-USE switch S104 (fig. 306) in the CALIBRATE position, by adjusting the reflector control R124 and R125. When the CALIBRATE-USE switch is thrown to the USE position, the reflector voltage of V112 is taken through the cathode resistor R121 of V104. This makes the reflector voltage less negative so that V112 stops oscillating. When a negative pulse is applied to the grid of V104, the tube becomes nonconducting. The IR drops across resistor R121 decreases to zero, returning the reflector of V112 to the proper voltage for oscillation for the duration of

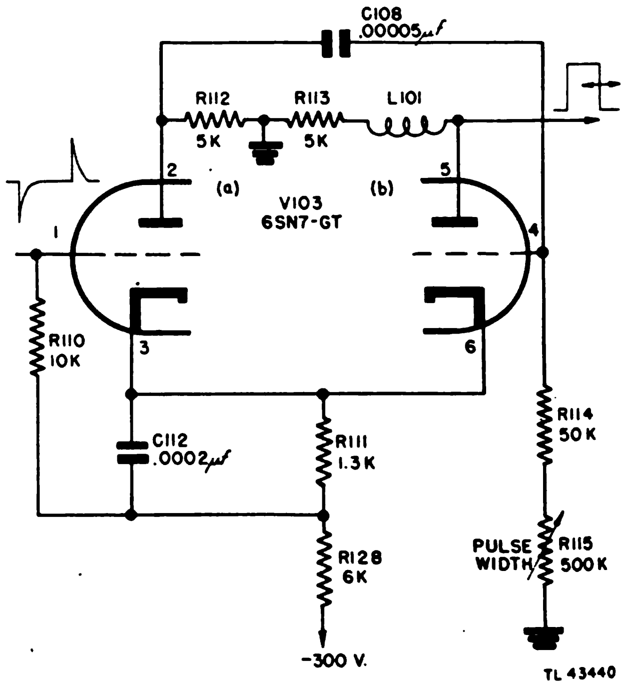

Figure 311. Pulse width generator, simplified schematic diagram.

the pulse applied to V104. When the PULSE-SQUARE WAVE switch is in the SQUARE WAVE position, the square wave output from V102 is applied to the grid of V104. When the INPUT SEL switch S101 is in the SAW-TOOTH position, tube V104 is not used. The external

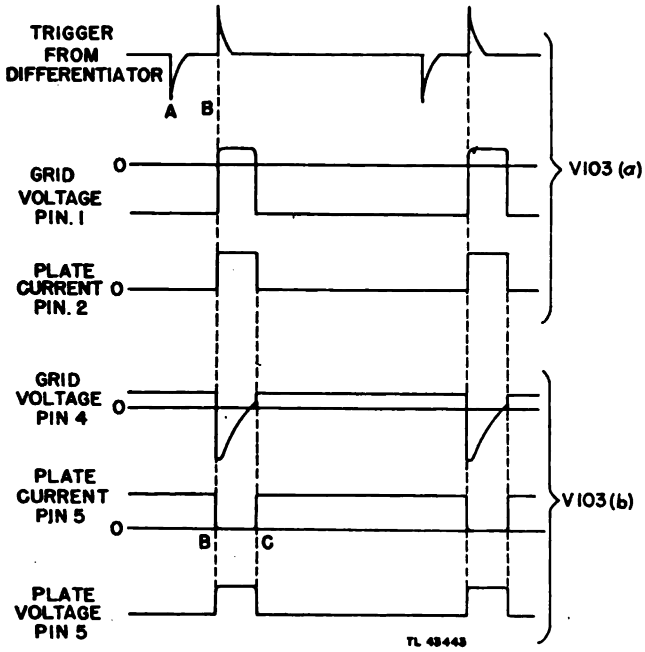

Figure 312. Pulse width generator waveforms.

saw-tooth voltage applied to the INPUT SYNC jack is coupled through capacitor C111 and a voltage divider consisting of R118 and R119, to the reflector of V112. R-f energy is taken from the oscillator by a probe extending into the cavity of the tube.

(4) R-F PLUMBING. The r-f plumbing of the test set (fig. 313) consists of a resonant cavity-type frequency meter; a power measuring head; a calibrated attenuator; an uncalibrated attenuator; a waveguide-coax adapter; and an r-f oscillator whose output is connected into a section of waveguide on which these units are mounted. Figure 306 includes a schematic diagram of the r-f plumbing.

(*a*) *Frequency Meter.* The frequency meter is a cylindrical cavity with the length adjustable by the FREQUENCY control. Energy is coupled from the rectangular waveguide to the frequency meter through a circular coupling hole.

(*b*) *Waveguide-coax Adapter.* The waveguide-coax adapter matches the impedance of a coaxial transmission line to that of the waveguide. They may be thought of as an antenna radiating into the waveguide, with a reflector which is a quarter-wavelength behind the antenna. The dimensions are not exact quarter-wavelengths, but are adjusted for matching the waveguide transition to the 50-ohm coaxial line impedance.

(*c*) *Calibrated Attenuator.* The calibrated attenuator consists of a rectangular glass strip that has a platinum coating. The strip is adjustable from one side of the waveguide to the center by means of a pair of rods controlled by the ATTENUATOR dial through a gear box. The attenuation is increased as the strip is moved toward the center of the waveguide. This is because the electric field strength is greatest in the center of the waveguide.

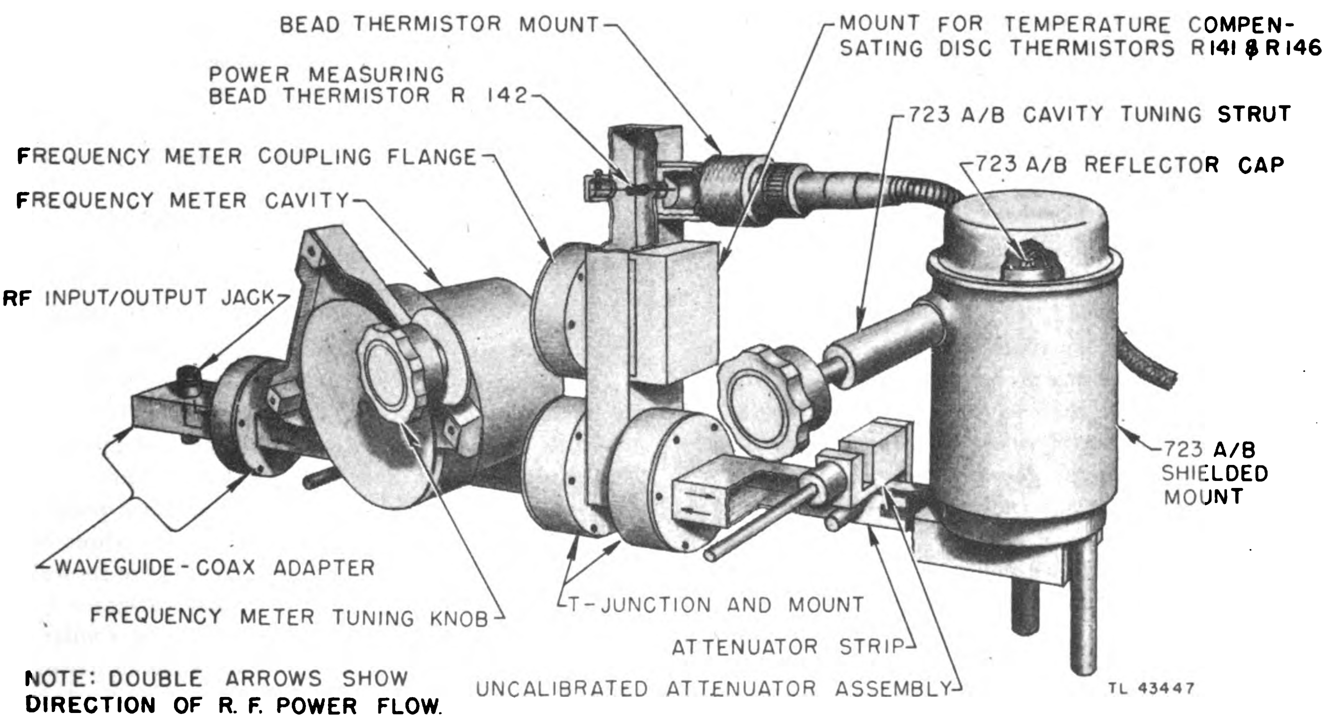

Figure 313. Test Set TS-13/AP, r-f plumbing.

The presence of the platinized glass strip changes the characteristic impedance of that part of the waveguide. The ends of the glass strip are left bare for the equivalent of a quarter-wavelength. The quarter-wave section acts as a transformer to transform from the characteristic impedance of empty waveguide to the characteristic impedance of the waveguide with the attenuator strip.

(*d*) *T-junction Mount.* The T-junction mount consists of a T-junction inserted between the r-f oscillator and the r-f input-output jack. The frequency meter and the power monitoring head are mounted on the waveguide branching off from the T (point B in fig. 306). This is an E-plane type T-junction, in which the branch is effectively in series with the main waveguide. In measuring the transmitted power, when the waveguide is matched, looking from B to C and from B to D, approximately half the power transmitted past B is dissipated in each branch. Similarly, approximately half of the oscillator power transmitted past point B from the oscillator (point C) goes through the calibrated attenuator toward the r-f input-output jack, and half goes up the power monitoring branch. The distance from the junction at point D to the frequency meter coupling hole (point E) is equivalent to a half-wavelength in the waveguide, so that when the frequency meter is tuned off resonance, the impedance, looking from D to E, is almost a short circuit. The hole at point D is effectively closed when the frequency meter is off resonance.

(*e*) *Power Measuring Head.* A bead thermistor, R142, is mounted across the waveguide at point F (fig. 306), and is essentially equivalent to a resistance in parallel with the waveguide. For a description of the operation of a thermistor and power measuring head see paragraph 139*c* on Power Monitor TS-36/AP. The two compensating disk thermistors, R146 and R141, are mounted on the waveguide so that they will be at the same temperature as the bead thermistor.

(*f*) *Oscillator Tube Mount and Attenuator.* R-f energy from the oscillator, V112, is coupled into the waveguide through a coaxial probe which acts as an antenna. The distance from the antenna probe (point C) to the shorted end of the waveguide is close to a quarter-wavelength so that energy initially traveling to the right is reflected back in phase with the energy going to the left. The uncalibrated attenuator is used to adjust the fraction of power that is transmitted to point E. The attenuator consists of a bakelite strip having a carbon coating. As the strip is moved toward the center of the waveguide by the ADJUST OUTPUT control, the power dissipated in the resistance strip increases. The resistance strip is partially matched to the characteristic impedance of the waveguide by notches in the ends. These notches are approximately one quarter-wavelength long so that they act as a quarter-wave transformer.

e. Trouble Shooting the Test Set. (1) PROCEDURE. Causes of incorrect operation should be determined by following an orderly and systematic procedure. The test set, and hence the location of faults, may conveniently be broken down into four circuits:

(*a*) Pulsing and phasing circuit; consisting of the inverter, multivibrator, and cathode follower tubes.

(*b*) R-f and oscillator circuit; consisting of the oscillator tube and associated plumbing.

(*c*) Thermistor bridge; consisting of the power measuring head, and two disk thermistors in a d-c bridge circuit.

(*d*) Power supply; including the voltage regulator and control tubes.

(2) NO C-W POWER. This will be evidenced by not being able to obtain a reading on the meter when in the CALIBRATE position. If the bridge had been previously balanced for CW, this would eliminate the bridge and its power source as a possible cause of trouble. The steps to be taken are as follows:

(*a*) Check to see that there are proper reflector and cathode voltages on tube V112 and that the voltages are both available when tuning the REFLECTOR control.

(*b*) Feel the shell of tube V112. It should be fairly hot, indicating that at least the filament is heated.

(*c*) If the preceding tests are made and found to be correct, install a new oscillator tube.

(3) NO R-F PULSE. If there is no r-f pulse output when on SYNC or SELF SYNC pulse operation, the following procedure should be followed:

(*a*) Make certain the test set is adjusted for CW operation. If CW output is obtained the trouble is probably in the pulsing circuit.

(*b*) Connect trigger cable between the TRIG OUT jack on the synchroscope and the INPUT SYNC jack on the test set.

(*c*) Adjust the synchroscope for SYNCH operation and the test set for synchronized PULSE operation.

(*d*) Using a test lead connected to the SIG IN jack on the synchroscope, check the waveform at the cathode of V104. If there is a modulating trigger at this point, check the output and input of the inverter amplifier. Then work back to the input circuit, noting at which point the trigger cannot be noticed on the CRT of the synchroscope. Typical waveforms in the different circuits are shown at their respective points in the schematic diagram (fig. 306). The trigger voltages viewed should be similar to those in the diagram. After the defective circuit has been located, use voltage and resistance measurements to locate the defective parts (figs. 314-317).

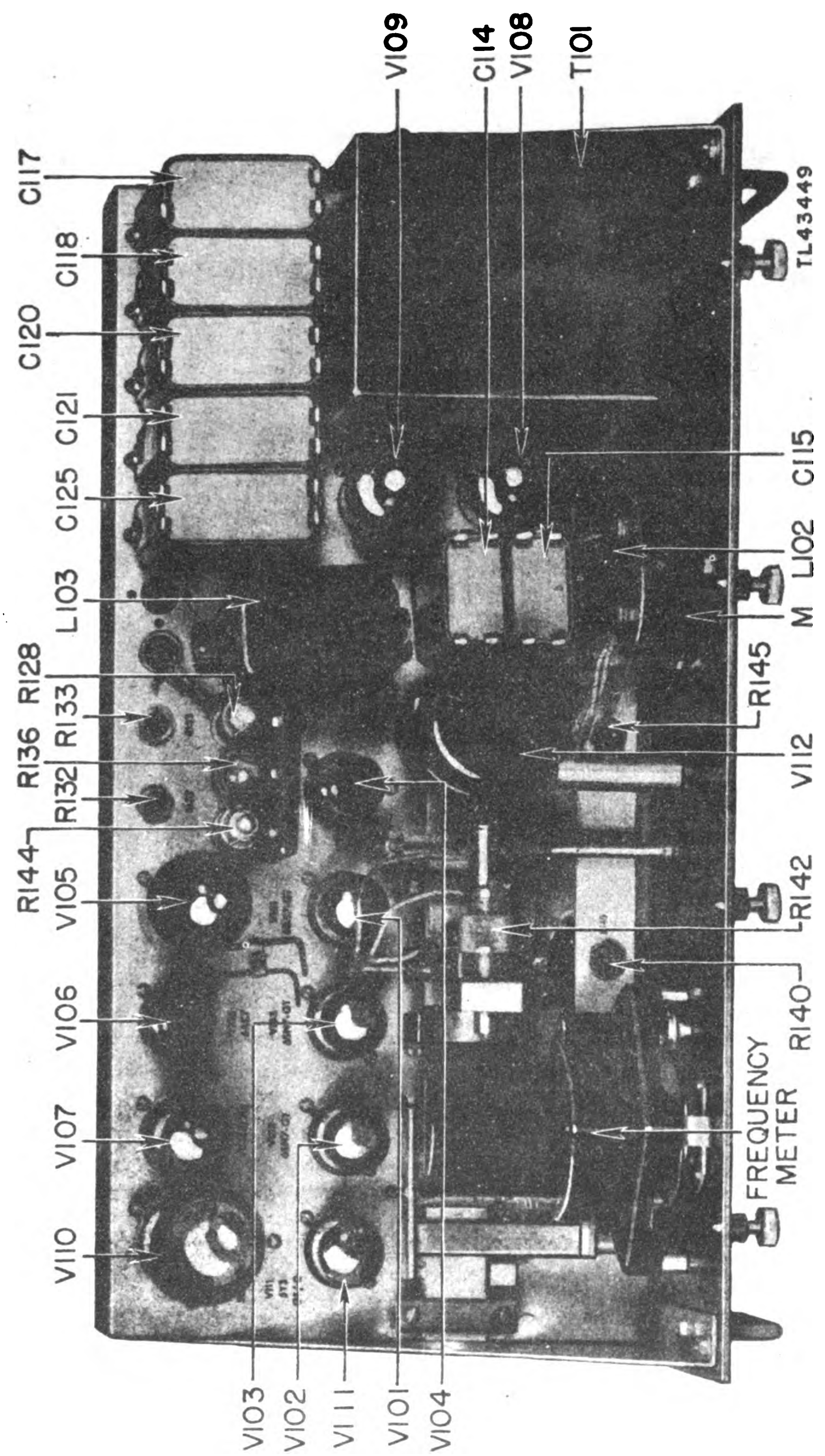

Figure 314. Test Set TS-13/AP, top view.

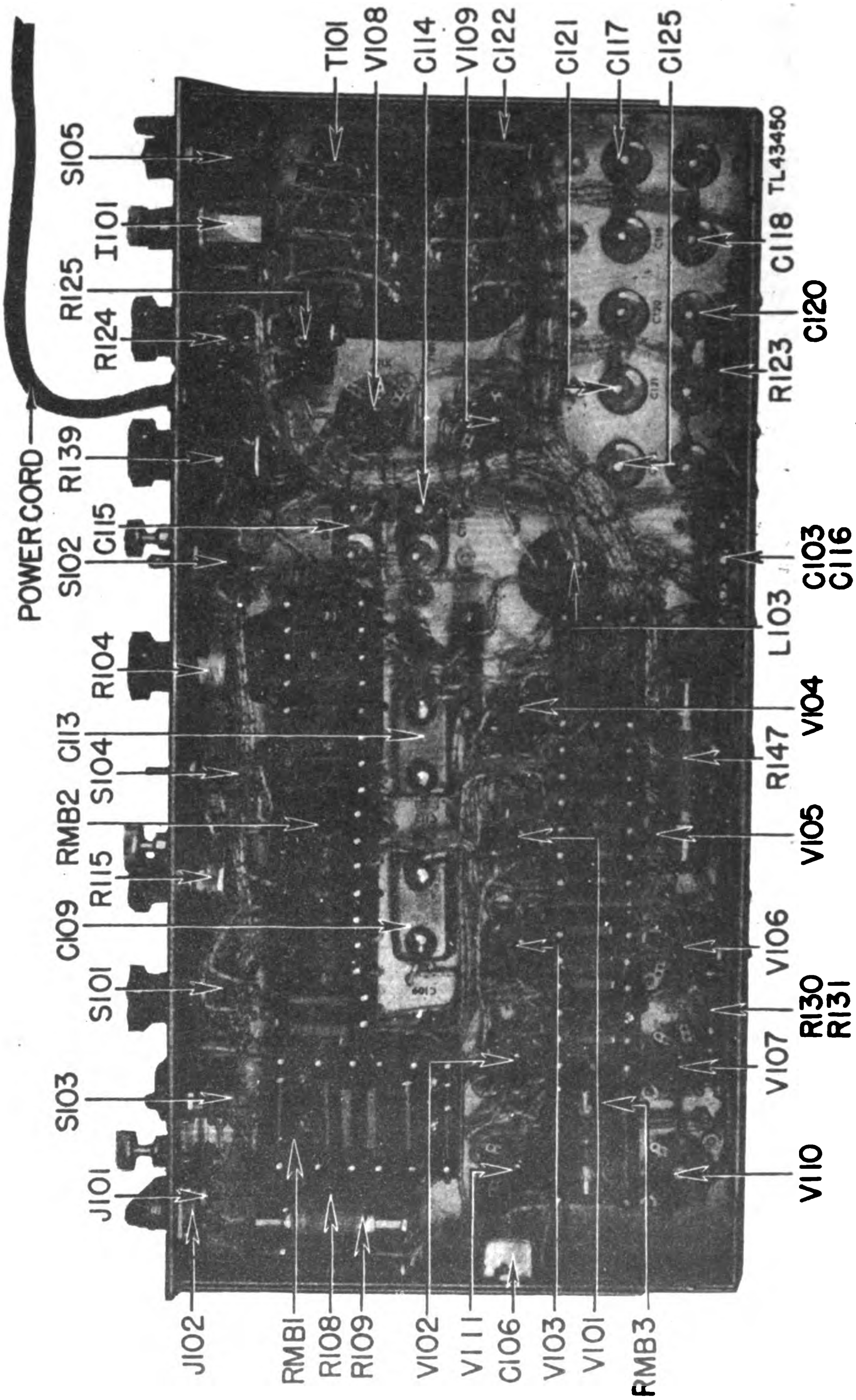

Figure 315. Test Set TS-13/AP, bottom view.

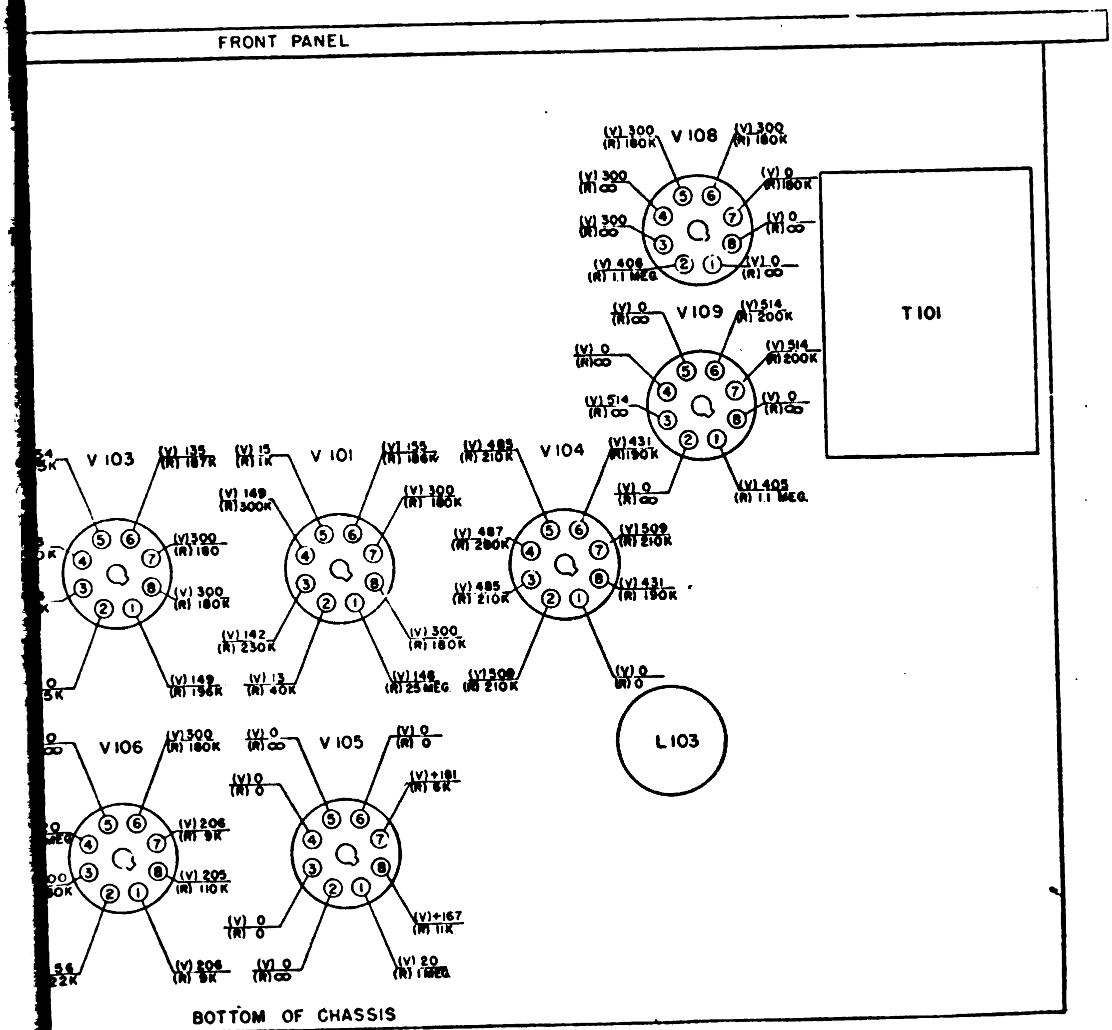

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Figure 316. Test Set TS-13/AP voltage and resistance.

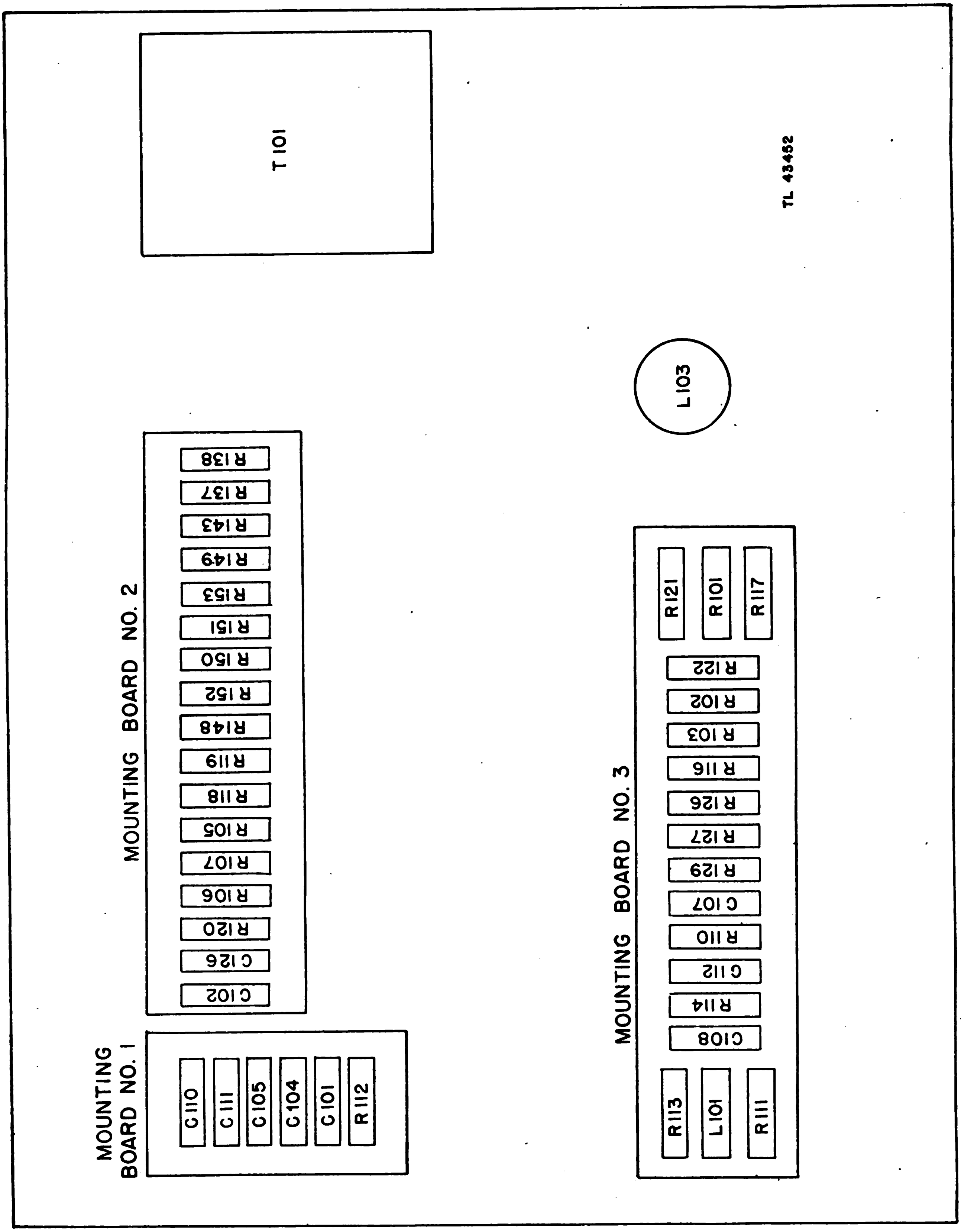


Figure 317. Test Set TS-13/AP, mounting boards.

(4) POOR FREQUENCY METER DIP. If it is impossible to obtain a dip of at least 25 percent when checking frequency, it will usually be found that this condition is caused by frequency modulation being present in the output of the r-f oscillator. The following steps should be taken:

(*a*) Replace the oscillator tube, V112. A defective tube can be the cause of excessive frequency modulation being present in the CW waveform.

(*b*) Using the test oscilloscope, check the ripple voltage present in the cathode and reflector voltage supplies. Excessive ripple voltage will cause a poor frequency meter dip. If a 60-cycle ripple appears on the CRT, check all filter capacitors in the power supply system.

(5) CHECKING VOLTAGE REGULATOR. It is possible for the regulator efficiency to become impaired after the test set has been in use for some time or due to tube changes. The procedure to be used in checking the voltage regulator action is as follows:

(*a*) It will be necessary to vary the line voltage several volts. This can be done when the radar set is off, by varying the line voltage control on the power plant.

(*b*) Connect the analyzer to measure the voltage between pin 2 of V107 and the chassis. Adjust the analyzer to the 1,000-volt d-c scale.

(*c*) If the adjustments of R132 and R133 are correct, varying the line voltage from 105 to 123 volts should not cause a change greater than 1 volt on the analyzer reading. The d-c voltage should remain constant at about 300 volts. If it is found that the d-c voltage does deviate too much, then potentiometers R132 and R133 should be adjusted until a constant voltage of 300 volts is obtained.

(6) CALIBRATED ATTENUATOR. The calibrated attenuator dial may slip. To reset, loosen the dial and turn the knob counterclockwise until it stops. Turn firmly but do not force it when it stops. At this point, the attenuator drive will be against the stop screw. Then set the dot on the calibrated dial under the indicator and tighten the dial screw.

144. TEST SET TS-225/MPN-1.

a. Description. Test Set TS-225 is a portable resonant cavity system designed for use in the X-band frequency range covered by Radio Set AN/MPN-1. The test set requires no external power supply, being operated by the energy picked up from the transmitter of the radar equipment under test. The test set (fig. 318) is contained in a metal carrying case which has a removable cover. The top of the test set serves as a control panel upon which are mounted two coaxial INPUT jacks; a TUNING control and tuning indicator; an output meter; a meter reading adjustment; and a SPARE CRYSTAL compartment. One end of the case provides storage space for a test dipole and coaxial connecting cords. On the under side of the panel (figs. 319 and 320) there is fastened a manually tuned ringing cavity, a smoothing capacitor, an input transducer and crystal assembly, and a microammeter.

b. R-f Connection. There are two methods of coupling the test set to the radar system. They are: a dipole antenna method, and a wave selector method.

(1) DIPOLE ANTENNA METHOD. When the dipole antenna is used it should be located approximately 30 feet from the radar antenna. Ordinarily, it is secured to a smooth surface by means of the attached suction cups. The dipole antenna elements will be properly oriented when the axis of the cord, which is connected to the re-

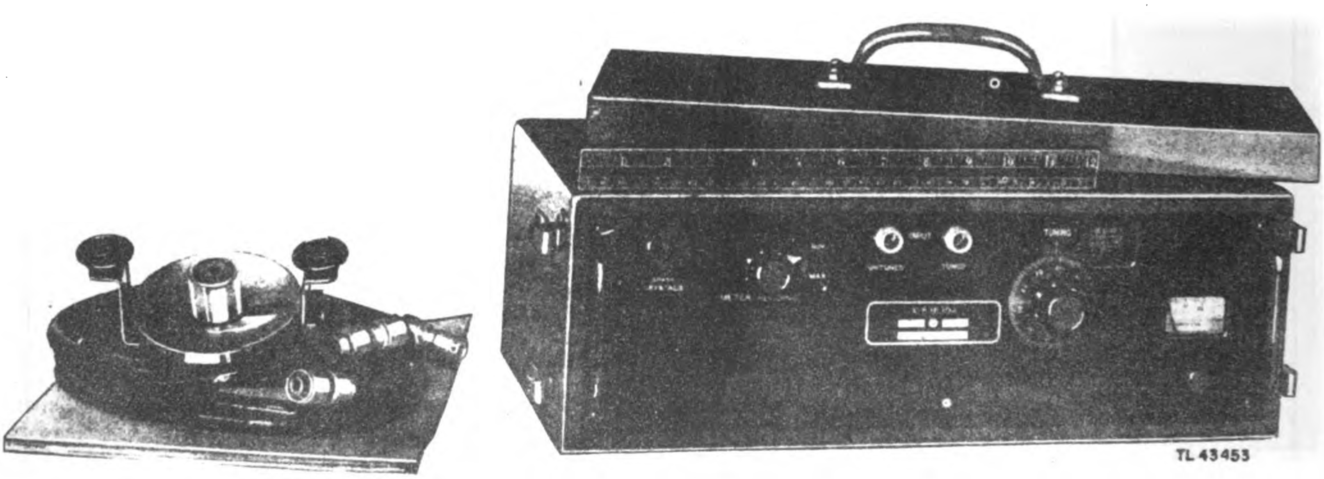


Figure 318. Test Set TS-225/MPN-1.

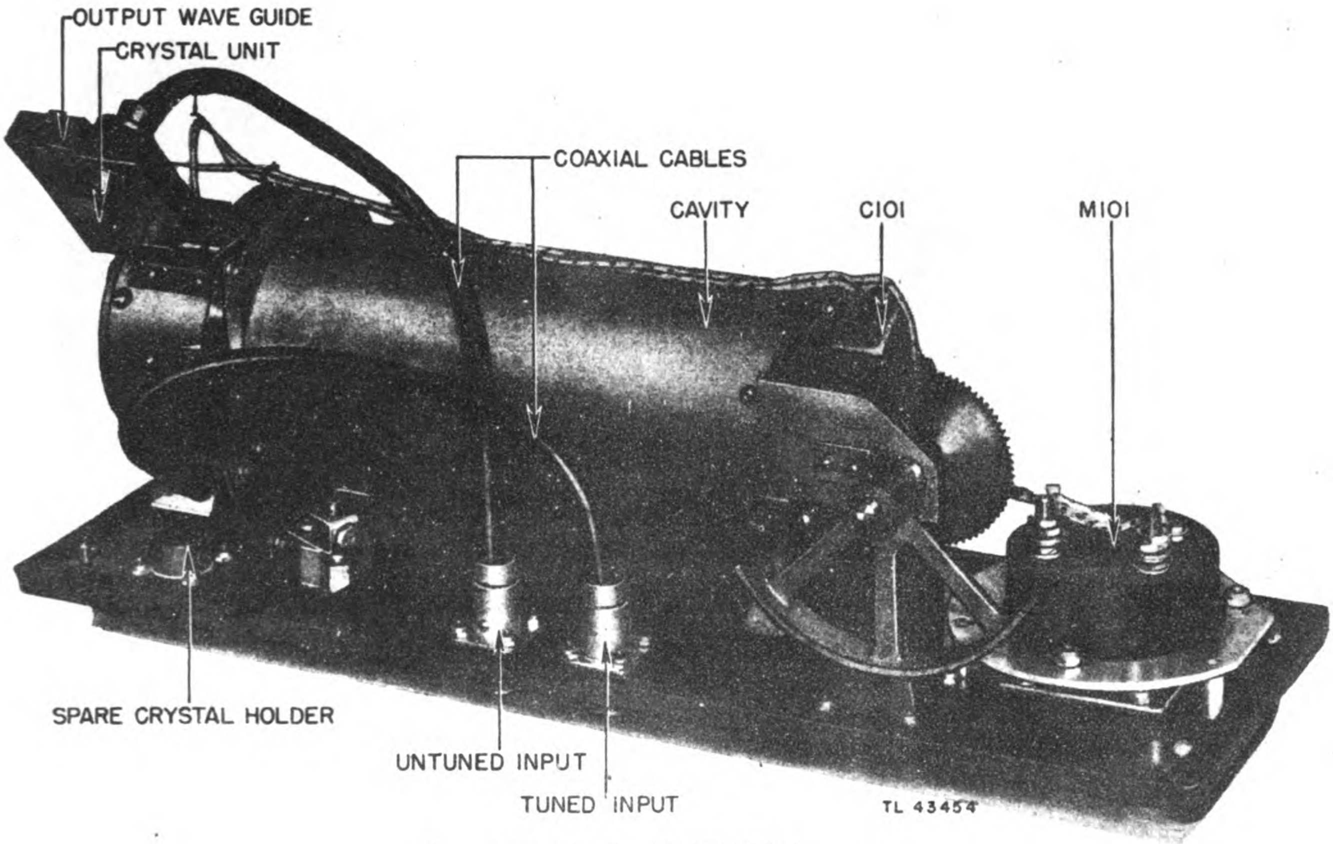


Figure 319. Test Set TS-225/MPN-1, top view.

flector, is perpendicular to the plane of polarization of the system antenna. A fixed location should be decided upon and adhered to in all future tests so that results of the tests will be directly comparable. It is important to avoid locations where interference patterns are formed by large reflecting surfaces.

(2) WAVE SELECTOR METHOD. Radio Set AN/MPN-1 is equipped with a wave selector (fig. 105), which is located behind the elevation antenna. The wave selector couples out a small percentage of power in the waveguide. Connection between the test set and wave selector is done through a coaxial cable furnished with the test set.

c. General Operating Procedure. Keep a permanent record of the radar equipment performance showing the results of each test. Such a record will serve as a life history of the installation; it will show up any progressive deterioration in radar performance and will be a useful guide in locating defective apparatus or improper adjustments.

(1) OVER-ALL PERFORMANCE TEST.

(*a*) Place the radar equipment in operation and allow it to warm up.

(*b*) Locate the test set dipole in its standard position relative to the radar system under test.

(*c*) Turn the test set METER READING control to MIN position and connect the dipole to the UNTUNED INPUT jack (using the patch cord provided).

(*d*) After the radar equipment has warmed up to normal operating temperature, adjust the azimuth and tilt of its antenna and, if necessary, move the dipole slightly to obtain maximum pickup as indicated by the test set meter reading. During this process, readjust the METER READING control as necessary to obtain adequate deflection without overloading the crystal and the meter. The approximate setting for the tilt and azimuth of the system antenna should have been determined so that only small shifts from a reference location of the dipole will be required to obtain maximum pickup.

(*e*) Move the dipole connection from the UNTUNED INPUT to the TUNED INPUT jack.

(*f*) Adjust the TUNING control for a maximum reading as indicated on the meter, and at the same time adjust the METER READING control to obtain adequate deflection without overloading the crystal and the meter. The range on the radar indicator should be set so that maximum deflection will be obtained on the system indicator.

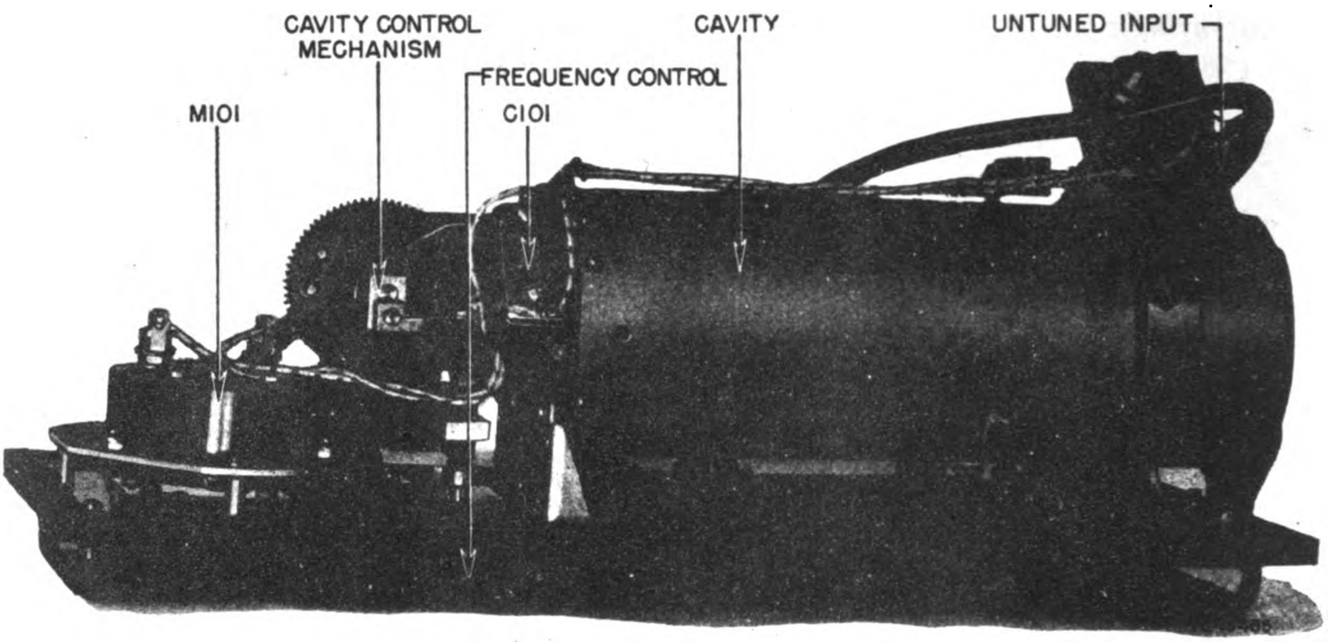


Figure 320. Test Set TS-225/MPN-1, bottom view.

(*g*) Note the ringtime to the nearest 1/10 mile.

(*h*) Compare this figure with corresponding values on previous tests to determine the over-all performance of the system.

(2) SPECTRUM ANALYSIS. A radar transmitter in good condition should give a spectrum curve similar to curve A or curve B of figure 321. A curve similar to curve C usually indicates that the transmitter output is frequency-modulated. This may be caused by a pulse which does not have a flat top or which has excessively sloping sides. It may also be due to a magnetron which is unstable or which is operating at improper voltage, current, or flux density. If two distinct peaks of comparable size are obtained, as in curve D, it is likely that the magnetron is subject to frequency "pulling" by standing waves in the waveguide. This may be caused by dents in the waveguide, defective waveguide choke couplings, or by a defective absorber unit. Procedure for making the above test is as follows:

(*a*) Turn the test set METER READING control to the MIN position.

(*b*) Connect a short coaxial cable between the X-band wave selector and the TUNED INPUT on the test set.

(*c*) With the radar set operating, turn METER READING control to the point that gives a usable meter reading.

(*d*) Adjust the TUNING control for maximum indication on the meter, readjusting the METER READING control as necessary to secure approximately full-scale deflection on the meter when the tuning is optimum. The tuning dial now indicates resonance.

(*e*) Rotate the TUNING control well below the point of resonance. Do not change the METER READING control.

(*f*) Turn the TUNING control slowly through the resonance point, noting the meter indication for various settings of the control. It is good practice to cover the frequency range by turning the TUNING control in the same direction, not by turning it in a back and forth movement. In this way, any error introduced because of backlash is eliminated.

(*g*) Construct a graph with the meter indications plotted against the readings on the 100-division TUNING dial. The resulting graph should resemble one of those in figure 321.

d. Theory of Operation. The circuit of Test Set TS-225/MPN-1 consists of a resonant cavity having a tuned and an untuned system, a rectifier, and a meter circuit (fig. 322).

(1) RESONANT CAVITY. The resonant cavity is a cylinder of aluminum alloy, within which a piston moves under the control of the frequency control gear mechanism, actuated by the TUNING control. The interior of the cavity is silver plated. The location of the fixed end is controlled by three screws which are adjusted at the factory. The piston is a bakelite disk with one side having a sheet of silver-plated copper foil cemented to it. The position of the piston within the cavity, and consequently the resonant frequency, is indicated by an engraved scale which is visible through a plexiglas window. The lower scale is divided into 33 equal parts and covers a range

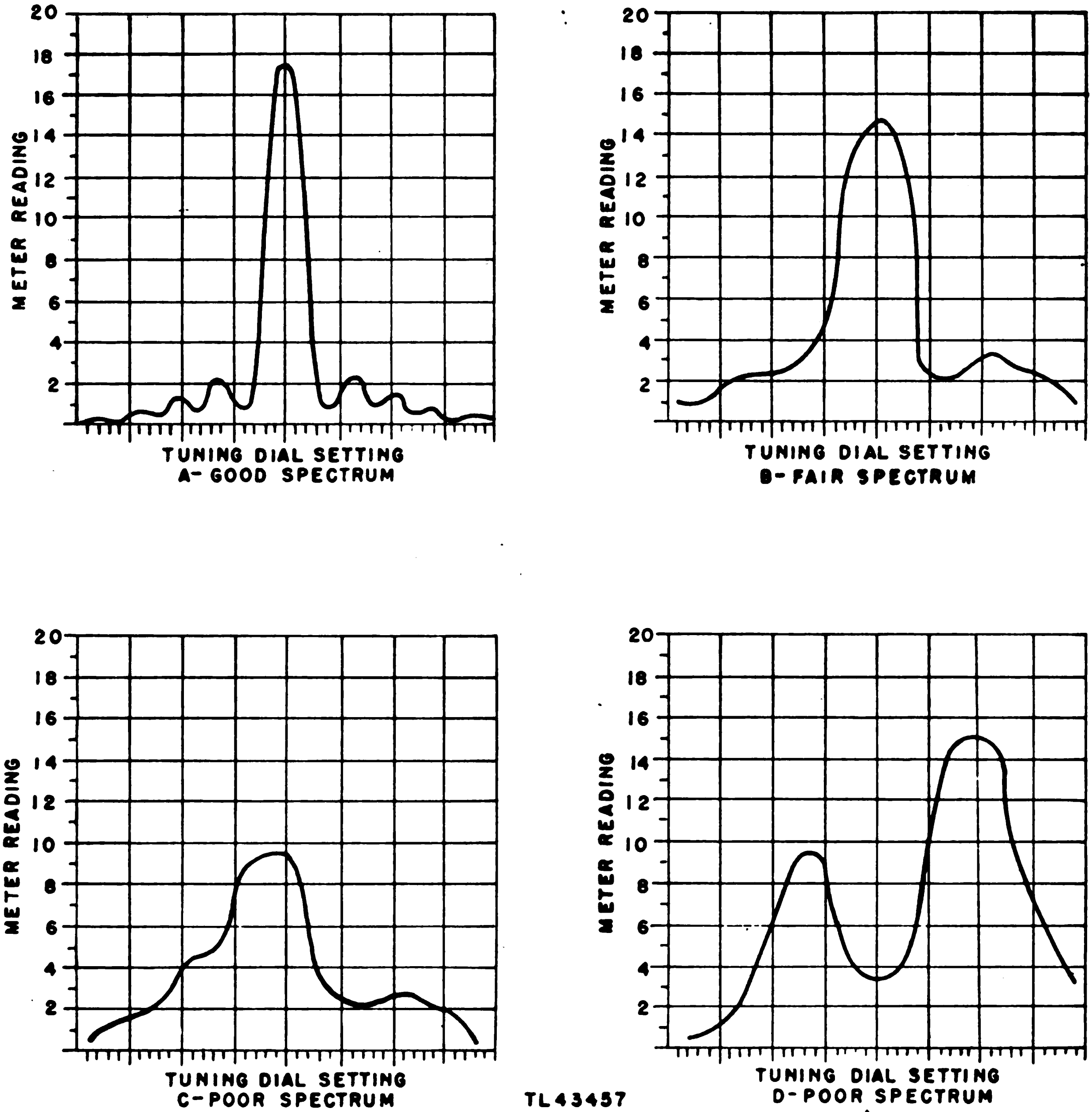


Figure 321. Spectrum analysis charts.

of 330 megacycles. Thus, each division represents 10 mc. Zero on the lower scale represents 8,920 mc. The frequency in mc corresponding to any setting on the lower scale is 8,920 + 10 times the dial reading. For example, if the lower scale reads 17.5, then the frequency for that setting is 8,920 + (10 x 17.5) or 9,095 mc. The upper scale is divided into 18 parts, each part corresponding to 1 full rotation of the TUNING control. This scale is useful for spectrum analysis and for recording the dial setting which represents the frequency of the radar transmitter. This reading consists of the reading on the upper scale which is a whole number representing hundreds, plus the reading on the lower dial. For example, if the upper scale reads between 9 and 10, and the lower scale reads 62, the setting is 962.

(2) INPUT TRANSDUCER. R-f power is fed into the input transducer through a coaxial cable from the TUNED INPUT jack J101 (fig. 322). The central conductor of the cable extends as a probe into the input transducer. The transfer of energy into the tuned cavity is through an orifice in the tuned cavity.

(3) UNTUNED INPUT CIRCUIT. R-f power is fed to a section of waveguide through a coaxial cable from the UNTUNED INPUT jack J102. From the waveguide section, the r-f power goes through a directional coupler window to the crystal unit assembly. The crystal rectifier and meter circuit must work with either the TUNED INPUT or the UNTUNED INPUT circuit. An output coupling orifice in the cavity (fig. 322) allows r-f energy to enter the crystal chamber. The amount of r-f energy reaching the crystal is controlled by the METER READING control which introduces attenuation in the common transmission path.

(4) The r-f energy reaching the crystal unit assembly is rectified by the crystal. The rectified current is then measured by the microammeter M101. The characteristics of the crystal and meter circuit are such that the meter deflection is approximately proportional to the power at the input jack. Two special bypass capacitors complete the r-f circuit through the rectifier. Capacitor C101 is used to smooth out the current pulses going to the meter and makes the reading more steady.

e. Variations of Ringtime with Temperature. (1) The electrical resistance of the walls of the resonant cavity varies with temperature. This causes a slight change in the Q of the cavity which, in turn, alters the ringtime. The ringtime increases at low temperatures and decreases at high temperatures. Approximate changes in a cavity are given below:

Temperature	Change in ringtime
— 40°F	+0.23-mile
— 20°F	+0.2 -mile
0°F	+0.15-mile
+ 20°F	+0.1 -mile
+ 40°F	+0.07-mile
+ 60°F	+0.02-mile
+ 70°F	0.00-mile
+ 80°F	—0.02-mile
+100°F	—0.07-mile
+120°F	—0.1 -mile
+140°F	—0.15-mile

(2) Even under extreme changes of temperature, the variation of ringtime due to changes in the characteristics of the test set is relatively small. Any change in observed ringtime larger than those shown above indicates that the variation is probably in the performance of the radar equipment itself.

f. Trouble Shooting. The adjustments of the resonant cavity and waveguides should not be altered under any conditions. To do so will change the constants which determine the ringtime and the frequency calibration. Periodical inspection should be made by removing the test set from the case and by checking for loose wires and mechanical tightness. The most frequent cause of trouble is a damaged or burned-out crystal.

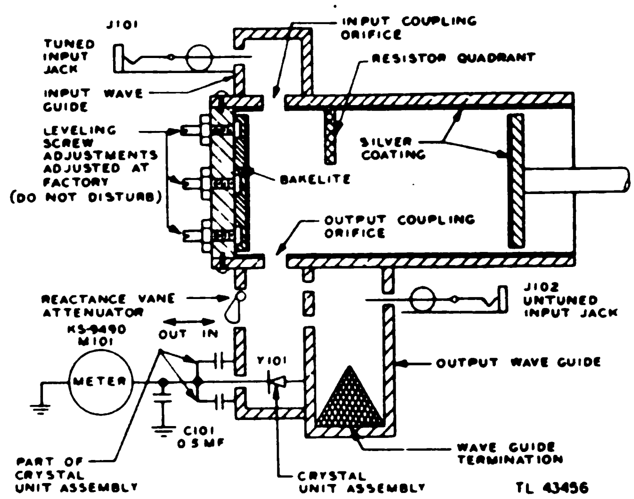


Figure 322. Test Set TS-225/MPN-1, schematic diagram.

(1) PRECAUTIONS. The electrical characteristics of the cartridge-type crystal will be impaired seriously if excessive electrical currents pass through the unit. Minute static charges are sufficient to cause damage. Therefore the possibility of a static discharge through the crystal should be prevented. Static may be accumulated, particularly in dry weather, by the motion of the operator's feet across an insulated floor. If the apparatus into which the crystal is to be inserted is not grounded, the apparatus may have accumulated a static charge. THE POSSIBILITY OF DAMAGE MAY BE AVOIDED BY TOUCHING THE CRYSTAL BLOCK WITH THE HAND WHICH HOLDS THE NEW CRYSTAL, BEFORE AND WHILE INSERTING THE NEW CRYSTAL IN THE BLOCK. The power absorbed by a crystal from a strong electromagnetic field may be sufficient to overload and damage it. Units, therefore, should never be exposed to strong fields. If it is necessary to remove the crystal from the crystal holder or from the spare crystal container when in the vicinity of a radar transmitter. THE OPERATION OF THE TRANSMITTER SHOULD FIRST BE STOPPED. Crystals not mounted in the set should be kept wrapped in lead foil or stored in a metal box.

(2) PROCEDURE. To replace the crystal proceed as follows:

(*a*) Remove the four panel screws and lift the test set from the case.

(*b*) Unscrew the crystal extractor (fig. 319) from the assembly.

(*c*) Unscrew the knurled cap from the extractor, then the crystal is readily removed.

(*d*) To install a new crystal, reverse the above procedure.

SECTION III

TROUBLE SHOOTING BY USE OF STARTING PROCEDURE

145. INTRODUCTION. The following analysis of trouble symptoms in Radio Set AN/MPN-1 and the trouble-shooting information which follows the analysis (chs. 7 and 8) have been prepared to aid the repairman in isolating the faults which may occur during the operation of the set.

a. The trouble-shooting procedure for Radio Set AN/MPN-1 is as follows:

(1) When a fault occurs that cannot be readily located by observation, the set should be completely shut down and then restarted according to the starting procedure outlined in TM 11-1343. This starting procedure has been repeated in the following paragraphs along with the indications of normal functioning, certain abnormal indications that may occur, and the probable location of the fault causing the abnormality.

(2) In steps 1 through 12, the majority of abnormal indications will occur in the power distribution system and will be caused by faulty switches, terminal strip connections, and power supplies. These faults can best be located by referring to the power distribution diagram (fig. 198) and checking voltages or continuity at successive points from the input end.

(3) Steps 13 and 15 can be used to isolate faults in the indicating system and in the receiving or transmitting systems, respectively. By the use of these steps, abnormalities can be located to a system, or in some cases, to a defective component. References are given under the probable location of fault which refer the repairman to the system trouble-shooting charts in chapters 7, 8, and 9. By means of this chart and the component waveform, voltage, and resistance charts, the fault can be traced to a faulty stage and hence to the defective resistance or capacitor causing the abnormality.

b. To aid in the trouble shooting, two test oscilloscopes (synchroscopes) have been incorporated into the radio set. One synchroscope is located in the transmitter rack and can be used to monitor the output of the search and precision receivers as well as to check certain critical waveforms in the transmitting and receiving systems. The second synchroscope is mounted in the indicator rack and is equipped with test leads for use in checking waveforms at the test point jacks mounted on the various indicator components. Typical waveforms obtained with the set operating normally are given in chapters 7 and 8 and should be used with the component trouble-shooting charts to isolate faults to a particular stage. A normal waveshape at the input of a stage and an abnormal waveshape at the output is usually an indication of trouble in that stage. Frequently, however, a fault in the succeeding stage will cause the abnormal waveshape; thus voltage and resistance measurements should not be confined to the single stage in question.

c. The final paragraph in this section (par. 161) provides an outline of the adjustment procedure for Radio Set AN/MPN-1 and gives references to the paragraphs where the complete alignment procedure for the particular item can be found. In many cases an abnormal indication may be only the result of a maladjusted component which must be corrected before logical trouble shooting can be attempted.

146. STEP 1. The TRANSMIT switch should be in its midposition, disconnecting both channels. All switches and circuit breakers should be in the OFF position. All indicator brilliance adjustments should be turned completely counterclockwise.

NORMAL INDICATION: Preparatory step, no indications.

147. STEP 2. Close the main switch to either GENERATOR or COMMERCIAL, depending upon the type of power being fed into the trailer. Check the line voltage with the distribution panel meter. If on generator power, check the output of each generator by throwing the voltmeter switch to the proper position, 1 or 2. The reading should be 117 ± 2 volts.

NORMAL INDICATIONS:

1. Both amber indicator lamps glow.
2. Distribution panel meter should read 117 ± 2 volts in both GEN-1 and GEN-2 positions.
3. Blower motors in trailer may be heard to operate.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No indications of power.	1*a*. Main circuit breakers on generators in OFF position. *b*. Defective power cables or connectors. *c*. Main switch defective or in wrong position.
2. One or both indicator lamps do not glow, other indications normal.	2*a*. Defective pilot light or wiring. *b*. Pilot light transformer T3 or T4 faulty.
3. No meter indication in either switch position, other indications normal.	3*a*. Defective meter. *b*. Defective switch SW20 or associated wiring.
4. All blowers inoperative, other indications normal.	4*a*. Switch SW15 off or defective. *b*. Defective wiring to distribution panel.
5. One or two blowers inoperative, other indications normal.	5*a*. Defective blower motor. *b*. Defective wiring to inoperative blower.

148. STEP 3. Close circuit breaker SW16 for trailer lights. If the ceiling lights do not come on, an individual snap switch of a unit may be turned off or a door may be open. Circuit breaker SW16 also feeds power to the convenience outlets.

NORMAL INDICATIONS: 1. Ceiling lights in trailer come on.
2. Power is available at convenience outlets.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. All ceiling lights remain off, no power at convenience outlets.	1*a*. Either or both door interlocks open. *b*. Defective switch SW16 or associated wiring.
2. One or more ceiling lights inoperative.	2*a*. Individual light switch in off position. *b*. Defective bulb or wiring in light.
3. One or more convenience outlets inoperative.	3. Defective outlet or wiring.

149. STEP 4. Check circuit breaker SW15 which starts the rack blowers and feeds power to the hydraulic pump motor switch located on the azimuth antenna housing. This circuit breaker should be in the ON position at all times. The wall switch for the pump motor is turned on only during trailer leveling operations.

NORMAL INDICATION: Hydraulic pump motor can be heard to operate when wall switch is turned on.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Hydraulic pump motor does not operate when wall switch is turned on, indications of STEP 2 are normal.	1*a*. Defective wall switch or associated wiring. *b*. Defective pump motor.

150. STEP 5. Close circuit breaker SW14. This feeds power to switch SW18 which feeds the IFF equipment. It also provides power for the two synchroscopes.

NORMAL INDICATION: Red jewel lamps on both synchroscopes glow.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Red jewel lamp does not glow and timebase cannot be obtained on either synchroscope.	1*a*. Power switch on front panel of both synchroscopes in OFF position. *b*. Circuit breaker SW14 or associated wiring defective.

2. Red jewel lamp does not glow and time-base cannot be obtained on one synchroscope, other synchroscope normal.	2*a*. Power switch on front panel of faulty synchroscope in OFF position. *b*. Fuse F1 defective in faulty synchroscope. *c*. If the above faults are OK, refer to trouble shooting the synchroscope (par. 136).

151. STEP 6. Close circuit breaker SW13. This feeds power to the communications receivers, power supplies, intercommunications system, and the pilot lights of the approach indicators. Operation of any communications circuit is now possible. Turn on the individual switches of each unit.

NORMAL INDICATIONS:

1. Approach indicator errormeters and course card lamps glow.
2. Green REC. lamp on approach indicator glows with switch in center position.
3. Aural signal pilot light on approach indicator glows with switch in lower position.
4. Selector switch pilot lights on approach indicator and intercommunications panel glow.
5. Tower receiver and PP-100 filaments light.
6. Receiver BC-342-N dial light on if power switch on receiver front panel is in MVC or AVC position.
7. Dial lights on SCR-522 control boxes.
8. Filaments on SCR-522 power supplies light.
9. Filaments on SCR-274 transmitters and power supplies light.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No indications of power in above circuits.	1. Switch SW13 or associated wiring faulty.
2. Dial lights and pilot lamps on approach indicator do not glow. All other indications normal.	2*a*. MIC. SUPPLY switch SW4 or associated wiring defective. *b*. Fuses F1 and F2 both defective (indicator lamps NE1 and NE2 will glow). *c*. Refer to trouble shooting in approach indicator (par. 225).
3. Tower receiver and PP-100 filaments do not glow, all other indications normal.	3*a*. Switch on power supply PP-100 defective or in off position. *b*. Power supply PP-100 fuse F1 defective (indicator lamp NE1 will glow). *c*. Rack wiring defective. *d*. Power supply PP-100 faulty, refer to trouble shooting in communications system power supplies (par. 245).
4. Dial light on one of three Receivers BC-342-N does not glow, other indications normal.	4*a*. Switch on front panel of receiver in OFF position. *b*. Fuse F3 on receiver front panel defective. *c*. Dial light defective. *d*. Switch at rear of receiver in OFF position. *e*. Rack wiring defective. *f*. Receiver BC-342-N defective, refer to trouble shooting in manual TM 11-850.
5. Dial lights on SCR-522 receivers do not light, filaments on power supply RA-62 do not glow, all other indications normal.	5*a*. Switch on power supply RA-62 defective or in off position. *b*. Fuses in power supply RA-62 defective. *c*. Rack wiring defective. *d*. Power supply RA-62 faulty, refer to trouble shooting in the communications system power supplies (par. 245).
6. Filaments on SCR-274 receivers and power supply PP-28 do not glow.	6*a*. Switch SW3 on power supply PP-28 defective or in off position. *b*. Fuse F2 defective (neon indicator lamps NE2 will glow).

c. Rack wiring defective.
d. Power supply PP-28 faulty, refer to trouble shooting the communications system power supplies (par. 245).

152. STEP 7. Close circuit breaker SW12. This feeds power to the channel switching relays through the TRANSMIT SWITCH which should be in the OFF position.

NORMAL INDICATION: No indications until TRANSMIT SWITCH is operated.

153. STEP 8. Close circuit breaker SW11. This feeds power to the 4,000-volt power supplies.

NORMAL INDICATION: With 4-kv channel A-B change-over switch in the midposition, filaments of both PP-23 power supplies will glow.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Filaments do not light on either 4-kv power supply.	1*a.* Switch SW11 defective. *b.* Defective rack wiring or wiring to 4-kv channel A-B switch.
2. Filaments do not light on one power supply, other supply normal.	2*a.* 4-kv channel A-B switch not in midposition. *b.* Defective fuse F2 in PP-23 (neon indicator lamp NE2 will glow).

154. STEP 9. Check to see that switch SW19 is in the OFF position. Close circuit breaker SW10. This feeds power to the search indicators, scan motor switch SW19, and search centrals.

NORMAL INDICATIONS:
1. Focused spot appears on both search indicator CTR's with intensity control turned clockwise.
2. Map lights and rose lights on search indicators glow.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No spot on either CRT, map and rose lights on both search indicators do not glow when associated illumination controls are turned fully clockwise.	1*a.* Defective switch SW10. *b.* Rack wiring defective.
2. No spot on either CRT, other indications normal.	2*a.* Throw 4-kv channel A-B switch SW1 to up position. If spot appears, 4-kv power supply PP-23 (#2) is defective (par. 243). *b.* Fuse F1 in power supply (#2) defective (neon indicator lamp NE1 will glow). *c.* Interlock switch on 4-kv power supply (#2) open or defective. *d.* Time delay relay on 4-kv power supply chassis defective. *e.* Refer to trouble shooting in the 4-kv power supplies (par. 243).
3. Defocused spot appears on one CRT, map and rose lights on associated search central do not glow, other indications normal.	3*a.* Fuse F1 on search central defective (neon indicator lamp NE will glow). *b.* Faulty connection at terminal 26-2 on search central.
4. No spot appears on one CRT, other indications normal.	4*a.* Plug PL1 on search indicator disconnected or defective. *b.* No filament voltage at pins 2 and 8 of CRT, transformer T1 defective or bad contact at terminals 1 and 2 on panel 20. *c.* CRT filament open, check continuity between pins 2 and 8.
5. Defocused spot on one CRT, other indications normal.	5*a.* 300-volt power supply PP-27 defective (par. 242) or faulty connection at terminal 22-4. *b.* Defective focus control P3 on search indicator. *c.* CRT defective.

6. Defocused spot on both CRT's, other indications normal.	6a. Throw 4-kv channel A-B switch SW1 up to position. If spot focuses, power supply PP-23 (#2) voltage is low.
	b. Faulty connection at RECPT. 1 (B+) on PP-23 (#2) or at plug SK1 on Relay Switching Unit RE-3/MPN-1.

155. STEP 10. Check to see that switch SW17 is in the OFF position. Close circuit breaker SW9. This feeds power to the precision indicators, directors, and precision scan motor switch SW17.

NORMAL INDICATIONS:
1. Large unfocused spot appears on all precision indicator tubes.
2. Cursor illumination and map light circuits energized.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No spot on any indicator tube, cursor and map lights do not glow with associated illumination controls turned fully clockwise.	1a. Defective switch SW9. b. Rack wiring defective.
2. No spot on any indicator tube, other indications normal.	2a. Throw 4-kv channel A-B switch SW1 to down position. If spot appears on all tubes, 4-kv power supply PP-23 (#1) is defective. b. Fuse F1 in power supply (#1) defective (neon indicator lamp NE1 will glow). c. Interlock switch on 4-kv power supply (#1) open or defective. d. Time delay relay on 4-kv power supply chassis defective. e. Refer to trouble shooting in 4-kv power supplies (par. 243).
3. Cursor and map lights on either director do not glow, other indications normal.	3a. Defective connections at panel AB5 on faulty indicator. b. Transformer T1 or associated wiring in indicator defective.
4. No spot on both tubes of either precision indicator and indications normal.	4a. Defective connection at PL1 on faulty indicator. b. Transformer T1 defective. c. Defective connections at terminals 1 and 2 on panel AB1 of faulty indicator.
5. No spot on either tube of one indicator, other indicator tubes and indications normal.	5a. Defective filament of faulty tube, check continuity between pins 2 and 8. b. 4-kv power disconnected from faulty tube at electrodes PL2 or PL3.

156. STEP 11. Before closing switches SW19 and SW17 check to see that no one will be injured and that no equipment will be damaged by running either of the two scan motors. Close switches SW19 and SW17; this starts the search and precision scanning motors.

NORMAL INDICATIONS:
1. Search antenna rotates and search antenna drive motor can be heard to operate when switch SW19 is closed.
2. Precision scanning motor starts and can be heard running when switch SW17 is closed.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Search antenna does not rotate when circuit breaker SW19 is closed.	1a. Search antenna switch on tower receiver control panel, located in bay 5 below intercommunications panel, in OFF position or defective. b. Safety switch on trailer roof near search antenna in OFF position or defective. c. Switch SW19 or distribution panel wiring defective. d. RELAY 1 in distribution panel defective. Test by opening panel and manually closing RELAY 1. e. Search antenna motor defective.

2. Precision scanning motor does not operate when circuit breaker SW17 is closed.	2*a*. Inside safety switch in OFF position or defective. *b*. Outside safety switch in OFF position or defective. *c*. Circuit breaker SW17 or distribution panel wiring defective. *d*. Precision scanning motor defective. Throw antenna scan speed control switch SW1 to opposite position, other precision scanning motor should operate.

157. STEP 12. Throw on channel A preheat switch. The green light indicates that the switch is on. Assuming channel A is to be put into operation, circuit breakers SW7 and SW5 should be turned on. They feed preheat power to the channel A preheat components in the transmitter and indicator racks, respectively.

NORMAL INDICATIONS:

1. Green light above "A" PREHEAT switch glows when switch is in ON position.
2. With circuit breaker SW7 closed:
   - *a*. Filaments light on both X- and S-band channel A receivers.
   - *b*. Both S and X meters in the control box register crystal current (0.6 ma) with the selector switches set at I XTAL "S" and I XTAL "X", respectively. Current meter plug must be inserted in jack on both channel A preamplifiers.
   - *c*. Filaments light on channel A power supply PP-26 in bay 7.
   - *d*. Channel A modulator filaments light.
   - *e*. Channel A S- and X-band magnetron blowers can be seen to operate in Radio Frequency Units RF-7 and RF-6, respectively.
3. With circuit breaker SW5 closed:
   - *a*. Channel A aural signal unit filaments go on.
   - *b*. Channel A synchronizer filaments light.
   - *c*. Filaments light on channel A 300-volt power supply PP-22, 500-volt power supply PP-24, and negative power supply PP-25.
   - *d*. Filaments light on channel A azimuth and elevation sweep amplifiers.
   - *e*. Filaments light in channel A azimuth and elevations angle coupling units and in commutator unit.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Green indicator lamp does not glow when preheat switch is in ON position.	1*a*. Channel A preheat switch or associated distribution panel wiring defective. *b*. Pilot light LM1 defective. *c*. Pilot light transformer T1 defective.
2. No indications of power when circuit breaker SW7 is operated.	2. Circuit breaker SW7 or associated wiring in distribution panel defective.
3. No indications of power when circuit breaker SW5 is operated.	3. Circuit breaker SW5 or associated wiring in distribution panel defective.
4. Filaments in S- or X-band receiver do not light, no crystal current meter reading, other indications normal.	4*a*. Switch SW6 on front panel of faulty receiver in OFF position (neon indicator lamp NE2 will glow). *b*. Fuse F1 on front panel of faulty receiver defective (neon indicator lamp NE1 will glow). *c*. Interlock switch on faulty receiver open or defective. *d*. Regulator tube V21, V22, or V23 removed from its socket.
5. No crystal current registered on S meter with selector switch in I XTAL "S" position, other indications normal.	5*a*. Crystal current metering plug out of JACK 1 on preamplifier unit in RF-7 unit. *b*. Refer to trouble shooting in the receiving system (par. 177).
6. No crystal current registered on X meter with. selector switch in I XTAL "X" position, other indications normal.	6*a*. Crystal current metering plug out of JACK 1 on preamplifier unit in RF-6 unit. *b*. Refer to trouble shooting in the receiving system (par. 208).

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
7. High-voltage power supply or modulator filaments do not light, all other indications normal.	7a. Defective wiring in transmitter rack. b. Power supply connector CS13 defective or modulator connector CS2 defective.
8. Channel A aural signal unit filaments do not light, other indications normal.	8a. Fuse F1 on front panel or aural signal unit defective (neon indicator lamp NE1 will glow). b. Voltage regulator tubes V5 or V6 out of sockets. c. Transformer T2 defective.
9. Channel A synchronizer or sweep amplifier filaments do not light, other indications normal.	9a. Connector strips to faulty component defective. b. Associated filament transformer defective.
10. Channel A angle coupling unts or commutator unit filaments do not light, other indications normal.	10a. Connector strip CS30 to angle coupling unit defective. b. Commutator unit connector PL1 defective or out of socket. c. Associated wiring in trailer defective.

158. STEP 13. Close circuit breakers SW3 and SW1. Throw the TRANSMIT switch to the A position. CAUTION: Before throwing the TRANSMIT switch, make sure both variacs in the transmitter control box are turned down.

NORMAL INDICATIONS:
1. Red indicator lamp on distribution panel will glow when TRANSMIT switch is operated.
2. Channel A indicator lamp on transmitter control box will glow.
3. Rotating trace appears on both search indicators. Noise or grass can be observed on trace but no signal echoes will appear.
4. Trace appears on all four precision indicator tubes and sweeps across tube faces in synchronism with the precision antenna scan. Noise or grass can be observed on traces but no signal echoes will appear.
5. Neon indicator lamp on channel A Radio Frequency Unit RF-7 glows.
6. Neon indicator lamp on channel A Radio Frequency Unit RF-6 glows.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Red indicator lamp does not glow, no traces appear on any search or precision indicator tube.	1a. Defective TRANSMIT switch. b. Defective wiring in distribution panel.
2. Red indicator lamp does not glow, other indications normal.	2a. Indicator lamp LM2 defective. b. Transformer T2 in distribution panel defective.
3. Channel A indicator lamp on transmitter control box does not glow.	3a. Overload RELAY 5 in control box tripped. Reset by pressing RESET A switch below S-band meter. b. Channel A indicator lamp LM1 defective (with selector switches in HV (S) and HV (X) positions, both S and X meters should indicate when channel A variac is turned slightly clockwise). c. One or more of the following channel A interlock switches open or defective: (1) Modulator interlock. (2) Radio Frequency Unit RF-7 interlock. (3) Radio Frequency Unit RF-6 interlock. (4) High-voltage power supply PP-26 interlock. d. Circuit breaker SW3 or associated wiring defective. e. Time delay RELAY 5 in control box defective. f. Overcurrent RELAY 3 in control box defective. g. Plate contact RELAY 1 in control box defective. h. Variac T1 in control box defective.

4. No timebase on search or precision indicator, focused spot on search indicators, defocused spot on precision indicators, other indications normal.	4*a*. Circuit breaker SW1 or associated wiring defective. *b*. Interlock switch on 500-volt power supply PP-24 open or defective. *c*. Fuse F1 on PP-24 defective (neon indicator lamp NE1 will glow). *d*. 300-volt power supply PP-22 defective. Refer to trouble shooting the power supplies (par. 242).
5. Focused spot but no timebase on all search and precision indicator tubes.	5*a*. No 300-volt d-c input at terminal 6-3 in the synchronizer. *b*. Fuse F1 on –102-volt power supply PP-25 defective (neon indicator lamp NE1 will glow). *c*. Synchronizer defective, no negative trigger pulse at terminal 7-4. Refer to trouble shooting in the synchronizer (par. 212).
6. No timebase on either search indicator, precision indicator normal.	6*a*. No negative trigger pulse at either search central. *b*. Sine potentiometer power supply PP-27 defective. Switch to other PP-27 at SINE POT POWER SUPPLY switch on intercommunications panel. *c*. Sine potentiometer defective. Refer to trouble shooting in the search indicating system (par. 187).
7. No timebase on one search indicator, other search indicator and precision indicators normal.	7*a*. No negative trigger pulse at terminal 23-4 of the associated search central. *b*. Associated search central defective, refer to trouble shooting in the search indicating system (par. 187). *c*. Sine potentiometer connection at associated search central terminal strip 24 defective.
8. Distorted PPI display on both search indicators, precision indicators normal.	8. Sine potentiometer or connections defective (par. 187).
9. Distorted PPI display on one search indicator, other search indicator and precision indicators normal.	9*a*. Associated search central defective (par. 187). *b*. Defective deflection coil in search indicator.
10. No noise or grass on either search indicator tube, precision indicator tubes normal.	10. S-band receiver defective or misaligned, check receiver noise level on synchroscope.
11. Focused spot but no timebase on either precision indicator, search indicators normal.	11. 500-volt power supply PP-24 defective (par. 242).
12. No timebase or spot on precision indicators, search indicators normal.	12*a*. Lamp LM1 in commutator unit defective. *b*. Commutator unit or wiring to synchronizer defective.
13. Defocused timebase on all precision indicator tubes, search indicator normal.	13. RELAY 1 on azimuth indicator defective.
14. Focused spot but no timebase on both tubes of one precision indicator.	14*a*. No 300-volt dc at terminal 10-5 on associated sweep amplifier. *b*. No 500-volt dc at terminal 11-8 on associated sweep amplifier. *c*. No trigger pulse at terminal 10-4 on associated sweep amplifier. *d*. Associated sweep amplifier defective (par. 223).
15. No timebase or spot on both tubes of one precision indicator, other precision indicator and search indicators normal.	15*a*. Defective photoelectric cell in commutator unit. *b*. Defective connection to synchronizer. *c*. Blanking circuit in synchronizer defective (par. 212). *d*. Blanker blades on switching unit not rotating.
16. Focused spot but no timebase on one tube of either precision indicator, other precision indicator tubes and search indicators normal.	16*a*. Associated sweep amplifier channel defective (par. 223). *b*. Faulty connections to indicator tube.

17. Timebase present but no scanning action on both scopes of one precision indicator, other precision and search indicators normal.
    - 17*a*. Associated angle coupling unit defective (par. 235).
    - *b*. Associated antenna scanning mechanism defective (par. 200).
    - *c*. Defective connection at terminal 10-3 of associated sweep amplifier.
18. Timebase present but no scanning action on one scope of one precision indicator, other indicator normal.
    - 18*a*. Associated sweep amplifier defective (par. 223).
    - *b*. Defective deflection coil in faulty precision indicator (par. 224).
19. Distorted display on all precision indicator tubes (range marks not properly spaced, etc.), search indicators normal.
    - 19*a*. Synchronizer defective (par. 212).
    - b. Synchronizer power supply voltage low.
        - (1) +300 volts at terminal 9-8.
        - (2) +500 volts at terminal 1-8.
        - (3) -210 volts at terminal 2-7.
        - (4) -102 volts at terminal 2-8.
20. Distorted display on both tubes of one precision indicator (sweep too short, range marker lines distorted, etc.), other indicators normal.
    - 20*a*. Associated angle coupling unit defective (par. 235).
    - *b*. Synchronizer defective (par. 212).
21. Distorted display on one tube of one precision indicator (sweep too short or bowed, etc.) other indicator tubes normal.
    - 21*a*. Corresponding channel of associated sweep amplifier defective (par. 223).
    - *b*. Precision indicator defective (par. 224).
    - *c*. Associated switching tube in synchronizer defective (par. 212).
22. No noise or grass on precision indicator tubes, search indicator normal.
    - 22. X-band defective or misaligned, check receiver noise level on synchroscope.

159. STEP 14. Channel B preheat circuit breakers SW8 and SW6 should be turned on so that this channel can stabilize and be ready for operation.

CAUTION: At least 15 minutes should be allowed after preheat power is turned on before the equipment is operated. This is to allow the units to become fairly stable.

If a change is to be made from channel A to channel B, the B circuit breakers SW4 and SW2 should be turned on and the A-B TRANSMIT switch moved to the B position. Circuit breakers SW4 and SW2 can be thrown to the ON position at any time prior to throwing the TRANSMIT switch to the B position.

NORMAL INDICATIONS:

1. Green light above "B" PREHEAT switch glows when switch is in ON position.
2. With circuit breaker SW8 closed, normal indications for channel B components are the same as for circuit breaker SW7 in STEP 12 (par. 157).
3. With circuit breaker SW6 closed, normal indications for channel B components are the same for circuit breaker SW5 in STEP 12 (par. 157).
4. With circuit breakers SW4 and SW2 closed and with the TRANSMIT switch in the B position, normal indications are the same as in STEP 13 (par. 158).

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. Abnormal indications for channel B components with circuit breakers SW8 and SW6 closed are the same as for channel A components in STEP 12 (par. 157).	1. Same as STEP 12 (par. 157).

2. Abnormal indications with circuit breaker SW4 and SW2 closed are the same as in STEP 13 (par. 158).	2. Same as STEP 13 (par. 158).

160. STEP 15. Turn up the transmitter high voltage by means of the channel A or B variac (behind the drop door of the transmitter control box) depending upon which channel has been selected. Raise the transmitter voltage slowly until the proper operating value has been reached (14kv for S-band and 12kv for X-band).

NORMAL INDICATIONS:
1. S-band meter on control box should read 18 to 22ma with selector switch in I MAG "S" position, and should read 14kv with selector switch in H.V. "S" position.
2. X-band meter on control box should read 12 to 16ma with selector switch in I MAG "X" position, and should read 12kv with selector switch in H.V. "X" position.
3. Main transmitted pulse and normal target echoes (if any) will appear on all indicator tubes.

ABNORMAL INDICATIONS	PROBABLE LOCATION OF FAULT
1. No voltage or current readings on either S or X meters with selector switches in normal positions.	1*a*. Sliding contact on variac T1 defective. *b*. Wiring to high-voltage power supply PP-26 defective. Voltage reading at terminal 6 on connector CS13 (PP-26) should be 117 volts with variac fully clockwise. *c*. Rectifier Power Unit PP-26 defective.
2. No S- or X-meter readings with selector switches in I MAG "S" and I MAG "X" positions, meter readings in H.V. "S" and H.V. "X" positions normal.	2*a*. No trigger pulse at terminal 1 on connector CS1 of the modulator. *b*. Modulator blocking oscillator circuit defective.
3. Abnormal S-meter readings: I RECTIFIER ....low H.V. "S" ....low I MAG "S" ....low Abnormal X-meter readings: H.V. "X" ....low I MAG "X" ....low	3*a*. Defective variac T1 in control box, voltage readings at terminal 6 on connector CS13 (PP-26) should be 117 volts with variac fully clockwise. *b*. Power Rectifier Unit PP-26 defective (par. 244).
4. Abnormal S-meter readings: I RECTIFIER ....high H.V. "S" ....low I MAG "S" ....low Abnormal X-meter readings: H.V. "X" ....low I MAG "X" ....low	4. Modulator defective (par. 166).
5. Abnormal S-meter readings: I RECTIFIER ....high H.V. "S" ....low I MAG "S" ....high Abnormal X-meter readings: H.V. "X" ....low I MAG "X" ....low	5*a*. Defective S-band magnetron in RF-7 unit. *b*. Radio Frequency Unit RF-7 defective (par. 167).
6. Abnormal S-meter readings: I RECTIFIER ....high H.V. "S" ....low I MAG "S" ....low	6*a*. Defective X-band magnetron in RF-6 unit. *b*. Radio Frequency Unit RF-6 defective (par. 195).

Abnormal X-meter readings: H.V. "X" ....low I MAG "X" ....high	
7. Abnormal S-meter readings: I RECTIFIER ....low H.V. "X" ....normal I MAG "S" ....normal Abnormal X-meter readings: H.V. "X" ....high or low I MAG "X" ......high or low	7. Voltage dropping network in PP-26 defective (par. 244).
8. No signal echoes or weak signal echoes on both search indicators.	8*a*. T-R switch in RF-7 unit mistuned (par. 173). *b*. Preamplifier in RF-7 unit defective or mistuned (pars. 177 and 184). *c*. S-band receiver defective or mistuned (pars. 178 and 184). *d*. S-band r-f system defective (par. 172). *e*. S-band r-f channel switch not properly aligned with transmission line.
9. No signal echoes or weak signal echoes on precision indicator tubes. Search system and transmitter meter readings normal.	9*a*. R-T or T-R switches in RF-6 unit mistuned (par. 204). *b*. Preamplifier in RF-6 unit defective or mistuned (pars. 184 and 208). *c*. X-band receiver defective or mistuned (pars. 178 and 184). *d*. Video stages in synchronizer defective (par. 212). *e*. X-band r-f system defective (par. 199). *f*. RELAY 1 on the elevation indicator defective.
10. No signal echoes or weak signal echoes on one search indicator, other search indicator and precision indicators normal.	10*a*. Clamping diode V1 on the search indicator defective (par. 187). *b*. Associated search indicator defective (par. 187).
11. No signal echoes or weak signal echoes on both tubes of one precision indicator. Other precision indicator and search indicator normal.	11. Defective precision indicator (par. 224).

161. ALIGNMENT AND TUNE-UP PROCEDURE OUTLINE.

a. Search System. The following outline gives a complete list of the major steps necessary for tuning and aligning the search system for Radio Set AN/MPN-1. Detailed instructions for the procedure in performing each step are given in chapter 7 under the section covering trouble shooting for the particular component under consideration. For example, the first step is adjusting the regulated power supply of the radar receiver. The instruction procedure for these adjustments are given in paragraph 179 and are indicated under the column headed REFERENCES in the outline below. Because the search system is triggered from the synchronizer in the precision system it is not possible to independently adjust the pulse recurrence frequency of the system. Thus, the prf adjustment is not considered as a factor in the adjustment of the search system, but should nevertheless be considered in the over-all operation of the radio set. Instructions for this adjustment are given in paragraph 214. The magnetron used in channel A and channel B of the search system should be so chosen that their frequencies are very nearly equal. Otherwise, trouble will result when switching from one channel to another. Further details on this subject are given in paragraph 168. The S-shaped section of waveguide which rotates to connect either the channel A or the channel B magnetron to the r-f system must stop directly over the magnetron output conection in use. Failure to do so is a mechanical fault and not an alignment adjustment. However, the r-f channel switch should be checked before alignment for tuning is attempted. See paragraph 173 for further details on the r-f channel switching mechanism.

OPERATION	REFERENCES
1. Adjustment of radar receiver regulated power supply.	1. Paragraph 179.
2. Tuning the local oscillator.	2. Paragraph 180.

OPERATION	REFERENCES
3. Tuning the AFC circuit.	3. Paragraph 181.
4. Tuning the T-R box.	4. Paragraph 173.
5. Adjustment of the STC circuit.	5. Paragraph 182.
6. I-f alignment.	6. Paragraph 184.
7. Adjustment of the search indicating system.	7. Paragraph 188; TM11-1343, paragraph 61.
8. Adjustment of Rectifier Power Unit PP-27/MPN-1.	8. Paragraph 241.
9. Synchronizing of the search system.	9. TM11-1343, paragraph 62.
10. Adjustment of the search antenna tilt.	10. Paragraph 173.

*b. **Precision System.*** In order to have the precision system operate with maximum efficiency and to obtain the highest possible accuracy, a number of alignments and adjustments are necessary. A complete list of the major steps necessary for proper operation of the precision system is given below. While a number of these steps are entirely independent and may be performed at any time, certain other steps must be performed in a definite order to prevent one adjustment from destroying a previously made adjustment.

OPERATION	REFERENCES
1. Adjustment of output voltage of all regulated power supplies.	1. Paragraph 241.
2. Adjustment of pulse recurrence frequency to 2,000 cps.	2. Paragraph 214.
3. Adjustment of transmitter HVPS output for proper precision magnetron current.	3. Paragraph 192.
4. Alignment of antenna switching blades in r-f system.	4. Paragraph 201.
5. Adjustment of variable waveguide width for proper angle of antenna scan as determined by magnetron frequency.	5. Paragraph 200.
6. Phasing at precision scanners.	6. Paragraph 202.
7. Tuning of T-R cavity for maximum sensitivity.	7. Paragraph 204.
8. Tuning of R-T cavity for maximum sensitivity.	8. Paragraph 204.
9. Adjustment of local oscillator frequency (cavity), AFC tuning (repeller voltage), and oscillator coupling (crystal current).	9. Paragraph 209.
10. I-f system tuning.	10. Paragraph 184.
11. Adjustment of STC circuit.	11. Paragraph 182.
12. Video gain control adjustment (receiver).	12. Paragraph 184.
13. Video gain control adjustment (synchronizer).	13. Paragraph 218.
14. Alignment of angle coupling unit outputs with antenna beam angles.	14. Paragraph 236.
15. Adjustment of indicator blanking blades on commutator units.	15. Paragraph 201.
16. Adjustment of indicator blanking control and gain commutation.	16. Paragraph 217.
17. Indicator mirror alignment.	17. Paragraph 230.
18. Alignment of indicator sweeps with phenolic maps.	18. TM11-1343, paragraph 63.
19. Adjustment of 2-volt sweeps on indicator tubes, and rotation of tubes for proper orientation of displays.	19. TM11-1343, addendum I.
20. Alignment of indicator displays on phenolic maps by means of radar signals.	20. TM11-1343, paragraphs 64 and 66.
21. Alignment of tracking cursors with glidepath.	21. TM11-1343, paragraphs 65 and 67.
22. Alignment of error meters with glidepath.	22. Paragraph 232.
23. Calibration of range marker timing oscillator.	23. Paragraph 216.
24. Adjustment of negative trigger delay.	24. Paragraph 216.
25. Adjustment of count-down blocked oscillator producing 10,000-foot range markers.	25. Paragraph 215.
26. Alignment of servo cursors in antenna follower system.	26. Paragraph 236; TM11-1343, paragraph 68.
27. Adjustment of aural signal unit.	27. TM11-1343, paragraph 69.

CHAPTER 7

TROUBLE SHOOTING IN THE SEARCH SYSTEM

SECTION I

TRANSMITTING SYSTEM

WARNING: ***Voltages sufficient to cause death on contact are exposed at many points in Rectifier Power Unit PP-26/MPN-1, Modulator MD-11/-MPN-1, and Radio Frequency Unit RF-7/MPN-1. Do not place hands or arms within these units with the high voltage on. Do not make any connections into these circuits which bring high voltages out to exposed points. Make all tests with high voltages off. Always ground high-voltage capacitors before touching them or their associated equipment.***

162. REFERENCE DATA.

a. Modulator MD-11/MPN-1.

(1) Figure 324. Front view.
(2) Figure 325. Right oblique view.
(3) Figure 326. Rear view.
(4) Figure 327. Subchassis, bottom view.
(5) Figure 25. Schematic diagram.
(6) Figure 328. Waveforms.
(7) Figure 329. Voltage and resistance chart.

b. Radio Frequency Unit RF-7/MPN-1.

(1) Figure 330. Front view.
(2) Figure 331. Right oblique view.
(3) Figure 332. Rear oblique view.
(4) Figure 28. Schematic diagram.

c. General.

(1) Figure 217. Rectifier Power Unit PP-26/MPN-1. (transmitter HVPS), schematic diagram.
(2) Figure 85. Intercommunications Panel SB-2/MPN-1, radar control circuit.
(3) Figure 214. Control Box C-61–MPN-1, schematic diagram.
(4) Figure 253. Capacitor color code.
(5) Figure 254. Resistor color code.
(6) Figure 255. Tube base chart.

163. SPECIAL INFORMATION.

a. Overload Relay Adjustment. Two overload relays are located in Control Box C-61 and are in the ground return side of the high-voltage power supply. Overload relay RY3 is in the channel A circuit and relay RY4 is in the channel B circuit (fig. 214). They are set to trip when the high-voltage Rectifier Power Unit PP-26 furnishes a current greater than 60 milliamperes. When the overload relay trips, it breaks the circuit to the plate contactor relays RY1 or RY2 also located in Control Box C-61 and they, in turn, open the primary circuit to the high-voltage power supply. When the overload relay trips, it can be reset by pushing the RESET button on the front of the Control Box C-61 panel. They can also be reset by reaching inside the control box panel door and pushing the mechanical reset button which extends through the glass cover incasing the overload relay. All power should be shut off from the transmitter rack before attempting to reach inside the control box. Should the overload relay frequently trip at a current value of less than 60 ma, the relay should be adjusted by setting the pointer on the relay so that it trips at 60 ma. The current can be read on the S-band meter in Control Box C-61 with the selector switch set to position I RECTIFIER X 100. Detailed instructions for the adjustment of this relay are given in paragraph 94.

b. Test Points. Only three test points in each channel are provided in the search transmitting system, all of which are located on the modulator unit. Two coaxial connections are located on the front panel of the modulator and serve as monitoring test points for the high-voltage output pulse to the S and X magnetrons. The modulator output waveforms may be monitored by connecting either the S- and X-test point to the SIG IN connection on the synchroscope in the transmitter rack. The third test point is an insulated bushing located on the modulator subchassis. It is accessible by opening the modulator front panel door and is behind and slightly to the left of driver tube V1. This test point provides a means of monitoring the positive trigger pulse which starts the modulator action.

c. Metering Circuits. Two meters are provided in Control Box C-61 (fig. 323) for measuring critical voltage and current values of both the S and X systems. They can be switched to either the channel A or the channel B circuit by means of a switch on the front panel.

(1) S-BAND METER. The S-band meter will read the following voltages and currents that are pertinent to the search transmitting system:

(*a*) High-voltage power supply output voltage with the selector switch in position H.V. "S" X 20K.

(*b*) High-voltage power supply current with the selector switch in position I RECTIFIER X 100.

(*c*) The S-band magnetron current with the selector switch in position I MAG "S" X40.

(*d*) Grid current of modulator switch tube V4 with a selector switch in position I GRID S1.

(*e*) Grid current of modulator switch tube V5 with a selector switch in position I GRID S2.

(2) X-BAND METER. Because the same modulator is used for both the search and precision systems and trouble shooting for the modulator unit is covered only under the search system, the following readings on the X meter will also be needed in isolating modulator faults:

(*a*) High-voltage output to the modulator X-band switch tubes read with the selector switch in position H.V. "X" X 20K.

(*b*) The grid current of modulator tube V6 read with the selector switch in position I GRID X1.

(*c*) The grid current of modulator switch tube V7 read with the selector switch in position I GRID X2.

(*d*) The X-band magnetron current with the selector switch in position I MAG "X" X40.

(3) METER READINGS. These meter readings give a quick check on the operation of the transmitting system. In general, abnormal meter readings are an indication of trouble in the transmitting system and are used as symptoms in isolating trouble to a particular component. They are used not only in the stop-start trouble-shooting chart (ch. 6, sec. 3), but also in the detailed trouble-shooting charts that follow on the transmitting system.

164. PROCEDURE.

a. Use of Trouble-shooting Charts. The start procedure on the trouble-shooting chart in chapter 6, section III, is used to isolate transmitting system faults to either the search or the precision transmitting system and to individual components if possible. Because a common modulator and a high-voltage power supply are used in

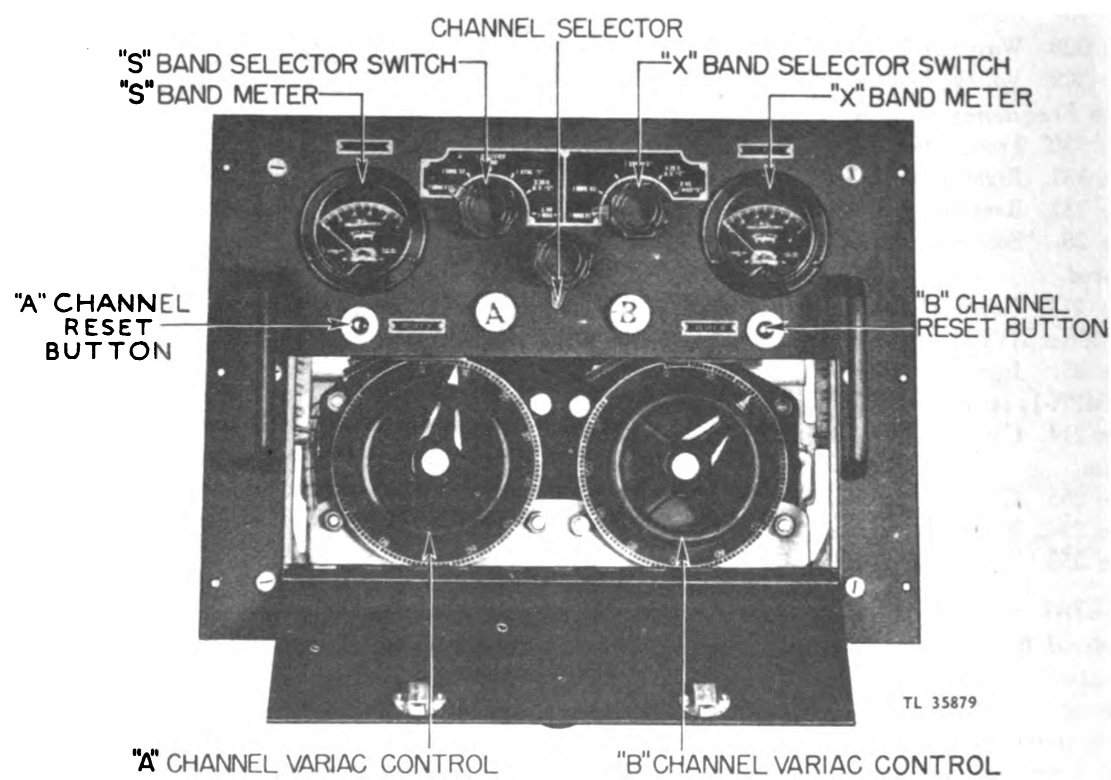


Figure 323. Control Box C-61/MPN-1.

both the search and precision system, it is often difficult to completely isolate a fault by use of the start procedure trouble-shooting chart alone. Therefore an additional chart has been included in the transmitter trouble-shooting section for the isolation of a fault to a particular component. The following discussion indicates the manner in which the trouble-shooting charts should be used.

(1) When a fault is detected, first refer to the starting procedure trouble-shooting chart, chapter 6, section III. The procedure given in this chart will in many cases isolate a fault to a particular component in which the trouble lies. In the search transmitting system, this will be either the high-voltage Rectifier Power Unit PP-26, Modulator Unit MD-11, or Radio Frequency Unit RF-7. In other cases, it will not be possible to isolate the fault directly to a component but merely to the transmitting system. When this occurs, refer to the transmitting system trouble-shooting chart for isolating the fault to a particular component within that system. This chart is given in paragraph 165.

(2) Additional tests are made in the transmitting system trouble-shooting procedure to insure that the fault actually is in the transmitting system. The step-by-step procedure systematically isolates the fault to a particular component. In most cases additional checks will have to be made, such as monitoring the modulator high-voltage output pulses, checking the power output of the transmitting system, and taking additional voltage, current, or resistance readings not practical in the start trouble-shooting procedure.

(3) The second and third trouble-shooting charts included in the search transmitting system are for Modulator Unit MD-11 (par. 166) and for the magnetron oscillator of the Radio Frequency Unit RF-7 (par. 167). The high-voltage Rectifier Power Unit PP-26 is covered in chapter 9, together with the other power supplies. If the fault is definitely isolated in the start trouble-shooting procedure, it is not necessary to refer to the transmitting system trouble-shooting chart. Merely refer directly to the chart for the defective component. If it is necessary to use the transmitting system trouble-shooting chart to isolate a fault, reference is made to the component trouble-shooting chart as soon as the fault has been traced directly to that component.

b. Test Equipment. The use of test equipment is fully discussed in chapter 6. Before using any test equipment for trouble shooting, become thoroughly familiar with its operation and capabilities. In addition to Test Synchroscope TS-64/MPN-1, the following test equipment will be required:

(1) Weston analyzer model 772, including 4-kv multiplier.

(2) Power Monitor TS-125/AP.

(3) Dumount test oscilloscope.

(4) Voltage Divider TS-222/MPN-1.

c. Use of Supplementary Data. Several views of each search transmitting system component are included as supplementary data for trouble shooting. All visible parts and circuit elements are called out on each picture. The picture showing the bottom view of the modulator subchassis and resistor mounting board will be useful in saving time when trying to locate a particular circuit element. Figure 328 shows all the critical waveforms of the transmitting system. While the waveforms will differ slightly with each individual Radio Set AN/MPN-1, their forms in general will be very much like the typical waveforms shown. In each case the setting of the test synchroscope or oscilloscope controls is given. In dealing with pulses, the only satisfactory method of checking a stage or component is by viewing the waveforms and this procedure should be used whenever possible. Because of the extremely high voltages used in the transmitting system, it is dangerous to check the tube socket voltages in the transmitting system with the exception of the driver stage V1 in the modulator unit. These voltages are given. When a modulator fault has been isolated to a defective stage by the use of the component trouble-shooting chart, the fault can be further isolated by checking the resistance reading as given on the tube socket resistance chart. All transmitter rack power must be off before taking resistance readings.

165. TROUBLE-SHOOTING CHART FOR TRANSMITTING SYSTEM (Isolation of faults to components).

A. SYMPTOMS:

1. No main pulse or signal echoes on the test synchroscope for both the search and the precision systems.
2. The high-voltage rectifier output voltage and current zero, or low, for both the X and the S system on the meter in Control Box C-61.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Input circuit to high-voltage Rectifier Power Unit PP-26 defective.	1*a*. Measure voltage (117 volts ac) between terminals 1 and 6 of connector CS13 on PP-26. *b*. Check continuity of interlock in modulator, RF-7, RF-6, and PP-26. *c*. Measure the supply voltage at variac terminals and trace circuit back until fault is determined.
2. High-voltage Rectifier Power Unit PP-26.	2. Refer to paragraph 244 for trouble shooting in the high-voltage power supply.

B. SYMPTOMS:

1. No main pulse or signal on the test synchroscope for both the search and precision systems.
2. Normal noise and grass appears on the synchroscope for both systems.
3. High-voltage output is normal as read on the S and X meters.
4. Magnetron current low on both S and X meters.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Modulator.	1. Check the modulator output waveforms with the synchroscope at the pulse test monitoring points (fig. 16) on the front panel of the modulator unit. The output waveforms for both the S and X system should appear as shown in figure 328. When output waveforms are not present at the test points, the trouble is in the modulator unit. See modulator trouble-shooting chart (par. 166) for isolation of the fault to a circuit element.

C. SYMPTOMS:

1. No main pulse or signals on the search indicators.
2. Normal main pulse and signals on the precision indicators.
3. S-band magnetron current zero or low (I MAG "S").

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Modulator.	1*a*. Check the modulator output waveform (fig. 328) with the synchroscope on the S-pulse test monitoring point. *b*. If the pulse is distorted, or does not appear, turn off the power from the transmitter rack and remove the plug from jack JK4 in the modulator unit. This is the line that connects the high-voltage output pulse to the magnetron. Turn the power on and again check the S-pulse waveform with the synchroscope. If the pulse is normal see item 2 below. *c*. If the pulse is still absent or distorted, refer to the modulator trouble-shooting chart (par. 166).
2. Radio Frequency Unit RF-7.	2. If the pulse waveshape is normal when the magnetron is disconnected, the trouble is in the RF-7 transmitter unit (par. 167).

D. SYMPTOMS:

1. Weak, unsteady, or abnormal signals on the search system indicators and test synchroscope.
2. Overload relay may or may not kick out repeatedly.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Search transmitting system.	1a. Check the high-voltage power supply meter reading (H.V. "S"). If it is low, or unsteady, refer to Rectifier Power Unit PP-26 (par. 244). b. Check the waveform on the S-pulse test monitoring point (fig. 328). If the output pulse waveform is not normal, refer to the Modulator MD-11 trouble-shooting chart (par. 166). c. Check magnetron current (I MAG "S"). If it is abnormal, refer to the transmitting magnetron trouble-shooting chart (par. 167). d. Measure the power output of the search system at the S-band wave selector connection (par. 138). Low output indicates trouble in the magnetron oscillator.
2. Search r-f system.	2. Measure the r-f power output from the search system by setting up the dipole antenna and using Power Monitor TS-125/AP as described in paragraph 138. Low r-f power output from the antenna with normal power output at the S-band wave selector connection indicates trouble in the search r-f and antenna system. Refer to the r-f system trouble-shooting chart (par. 172).
3. Search receiving system.	3. If the power output from the search antenna is normal, check the search receiving system (pars. 177 and 178).
4. Interference.	4. Check for other radar equipment operating near the same frequency and in the vicinity of Radio Set AN/MPN-1.

E. SYMPTOMS:

1. Grid current meter reading zero for either V4 or V5 in the modulator unit.
2. Search and precision system operating normally.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Grid current metering circuit.	1a. Check for open resistor, inductance, or broken connection in the modulator grid metering circuit. b. Check the meter circuit in Control Box C-61.

F. SYMPTOMS:

1. Magnetron current low (I MAG "S").
2. High-voltage readings normal.
3. Weak echoes on both search and precision indicators.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. High-voltage metering circuit.	1. The high-voltage meter reading is incorrect. Check resistor R23 in Rectifier Power Unit PP-26. This resistor should have a value of 20 megohms with a tolerance of ±10 percent.

166. TROUBLE-SHOOTING CHART FOR MODULATOR.

A. SYMPTOMS:

1. No output pulse on either the S- or the X-pulse test monitoring point.
2. Driver tube V1 in the modulator running at a normal temperature.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No trigger pulse to the modulator.	1*a*. Turn the TRIG. SEL switch on the intercommunications panel to the No. 1 or No. 2 search central. If the fault is cleared, the pulse from the synchronizer unit is not coming through to the modulator. Refer to section IV of chapter 8 for the trouble-shooting procedure. *b*. If the fault is still present see item 2 below.
2. Relay RY1 on intercommunications panel not functioning.	2. Check the operation and the contacts of relay RY1. This relay switches the trigger pulse voltages to the modulator unit and should operate when the transmit switch is thrown to channel B.
3. Transformer T1 defective.	3*a*. Using the test synchroscope, check the trigger pulse waveform at test point TP1 in the modulator. The variac high-voltage control should be turned down. *b*. If the trigger pulse is present at TP1 proceed to item 4. *c*. If the trigger pulse does not appear on TP1, check for its presence on terminal 1 of connector strip CS1. If the normal trigger pulse of about 50 volts amplitude appears at this terminal, transformer T1 is opened or defective.
4. Delay line network opened.	4. Check the waveform on the grid of V1 with a test synchroscope (fig. 328). If the trigger pulse does not lift the grid bias, replace the delay line network.
5. Modulator internal power supply.	5*a*. Check primary input power (117 volts ac) on terminals 1 and 2 and 1 and 3 of connector strip CS1. If the primary power is not correct, check the interlock system and the power distribution wiring system. *b*. Check the output of the modulator power supply. There should be approximately +1,200 volts dc on terminal 1 of connector strip CS4 and –750 volts dc on terminal 3 of connector strip CS4. *c*. If the power supply is not working, replace the rectifier tubes V2 and V3. If this does not clear the fault, check capacitors C5 and C6.
6. Primary of pulse transformer T2 is opened.	6. Check continuity between terminals 1 and 2 of pulse transformer T2, with all power off the transmitter rack.

B. SYMPTOMS:

1. No output pulse on either the S- or X-pulse monitoring test point.
2. The plate of driver tube V1 running hot.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Delay line network shorted.	1. Check the grid to ground resistance of tube V1 (fig. 329).
2. Capacitor C8 shorted.	2. Check capacitor C8 for a d-c short.

3. Incorrect grid bias on tube V1.	3*a*. Check grid bias voltage on pins 2 and 6 of V1. See tube socket voltage diagram (fig. 329). *b*. If the grid bias voltage is incorrect, check resistor R5 and resistor network R17 through R20.

C. SYMPTOMS:

1. No output pulse on either S- or X-test pulse monitoring point.
2. Driver tube V1 operating at a normal temperature.
3. Plates of modulator switch tubes operating very hot.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Relay RY1 not operating.	1*a*. Check contacts on relay RY1. *b*. Check relay windings for an open circuit.

D. SYMPTOMS:

1. No output pulse on either the S or X system.
2. Plates of driver tube V1 and modulator switch tubes operating very hot.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Negative 750-volt power supply.	1*a*. Check the voltage on terminal 3 of connector strip CS4. It should be –750 volts. *b*. If the output is zero or low, replace rectifier tube V3. *c*. Check filter capacitor C6.
2. Driver tube V1 gassy.	2. Replace the 3E29 driver tube.

E. SYMPTOMS:

1. Poor output pulse shape.
2. One or more modulator switch tubes has a blue glow.
3. Switch tube shows negative grid current.
4. Magnetron currents may be low (I "S" MAG or I "X" MAG).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. One or more switch tube soft or gassy.	1. Replace any switch tubes showing the above symptoms when pulse shape is affected.

F. SYMPTOM:

1. Main pulse and signals doubled for both the search and precision indicators.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Inductance L6.	1. Check continuity of inductance L6. With inductance L6 open, the pulse from the plate of the driver tube is not damped, and the switch tubes are triggered twice.

G. SYMPTOMS:

1. Pulse width greater than ½ microsecond.
2. Magnetron currents low (I "S" MAG and I "X" MAG).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Delay line network.	1. Replace defective delay line network.
2. Pulse transformer T2 defective.	2. Replace pulse transformer T2.
3. Incorrect grid bias.	3. Check the grid bias voltage of driver tube V1 and the modulator switch tubes.

H. SYMPTOM:

1. Low or irregular modulator output pulse.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Modulator switch tubes.	1. One or more of the modulator switch tubes has reduced emission or is mechanically unstable. Replace defective tubes.
2. Driver stage defective.	2*a*. Replace the 3E29 driver tube. *b*. Check the driver stage for defective circuit element.
3. Trigger circuit.	3*a*. Check the trigger pulse waveform at test point TP1 in the modulator. *b*. Trigger pulse from the synchronizer too low in amplitude. It should be about 50 volts. If it is incorrect, see section 4 of chapter 8. *c*. Trigger pulse step-up transformer defective. If the input trigger to the transformer is of the correct amplitude, while the output on test point TP1 is low, replace the pulse step-up transformer.
4. Defective high-voltage charging capacitor.	4. Check capacitors C17 for the S system and C18 for the X system. If they show signs of defects, replace the capacitors.

I. SYMPTOM:

1. Modulator tubes arc over.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Plate voltage supply too high.	1. Check variac setting and the meter voltage reading from Rectifier Power Unit PP-26.
2. Dirty, moist, or defective installation.	2. Clean all dirt or moisture from high-voltage insulators. Any defective insulators should be replaced.
3. No trigger voltage.	3. Oscillator is self-triggering. Check the input trigger voltage and the driver stage.

167. TROUBLE-SHOOTING CHART FOR TRANSMITTING MAGNETRON.

A. SYMPTOMS:

1. Magnetron current zero (I MAG "S").
2. Output pulse from the modulator unit normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Magnetron filament open.	1. Turn off all high voltage from the transmitter rack. Remove the banana plug filament connection from the magnetron filament continuity with the ohmeter. Replace the magnetron tube if the filament circuit is opened. The search system must be relined when the magnetron tube is replaced.
2. Magnetron filament transformer, T1 or T2.	2*a*. Turn off all high voltage from the transmitter rack (filament circuits energized) and measure the filament voltage at the magnetron terminals. *b*. If filament voltage is low or zero, measure voltage on primary of filament transformer. Replace transformer if defective.

B. SYMPTOMS:

1. Low or unsteady output from the transmitter magnetron.
2. Output pulse from the modulator unit normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective magnetron tube.	1. Magnetron arcing over internally. Replace the magnetron and reline the search system. See paragraph 168 for "aging" a new magnetron.

C. SYMPTOMS:

1. High magnetron current (I MAG "S").
2. Output pulse from the modulator normal.
3. Overload relay may operate repeatedly.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Variac high-voltage control set too high.	1. Adjust the variac to the proper high-voltage settings as indicated on the meter.
2. Magnetron filament voltage high.	2*a*. Check the magnetron filament voltage (6.3 volts ac) with the high-voltage power off from the transmitter rack. *b*. If the filament voltage is high, check with the primary input to the magnetron filament transformer T1 or T2 (117 volts ac). *c*. If the primary input voltage is high, check that the regulators on Power Units PE-127A (or the commercial power supply regulator) are regulating.
3. Low permanent magnet field strength.	3. Test the magnet field strength with Flux Meter TS-15/AP. See paragraph 141 for procedure. The magnetic field strength should be between 1,250 and 1,325 gauss. Replace the magnet if the field strength is low.
4. Magnetron tubes defective.	4. The magnetron may be gassy or defective. Replace the magnetron tube. The search system should be relined when the new magnetron is installed.
5. PRF is too high.	5*a*. Check the magnetron current when using the No. 1 or No. 2 search central to trigger the modulator. *b*. If the fault is cleared, see section IV of chapter 8 for checking the synchronizer master oscillator.

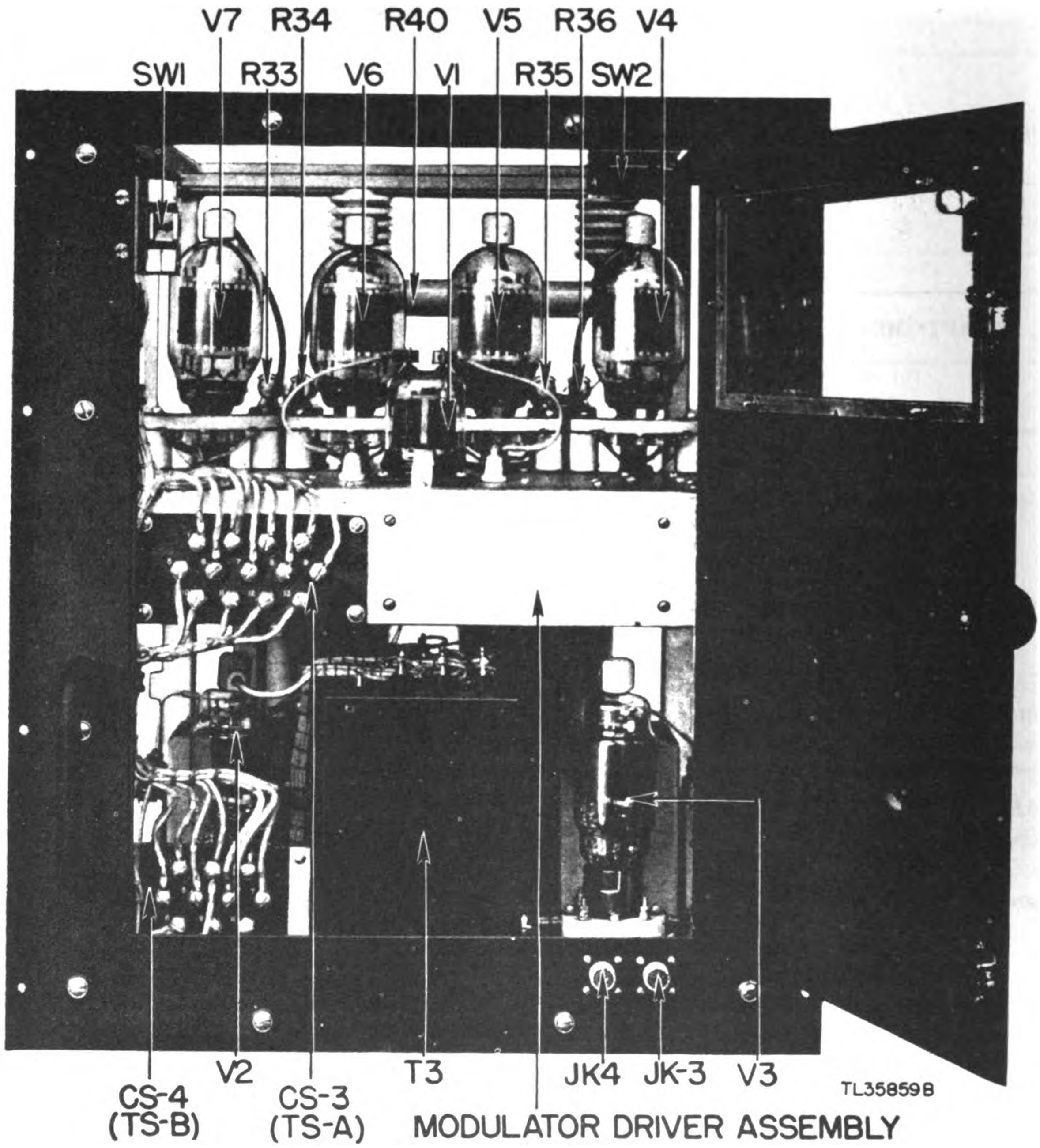


Figure 324. Modulator MD-11/MPN-1, front view.

D. SYMPTOMS:

1. Magnetron current low (I MAG "S").
2. Output pulse from modulator normal.

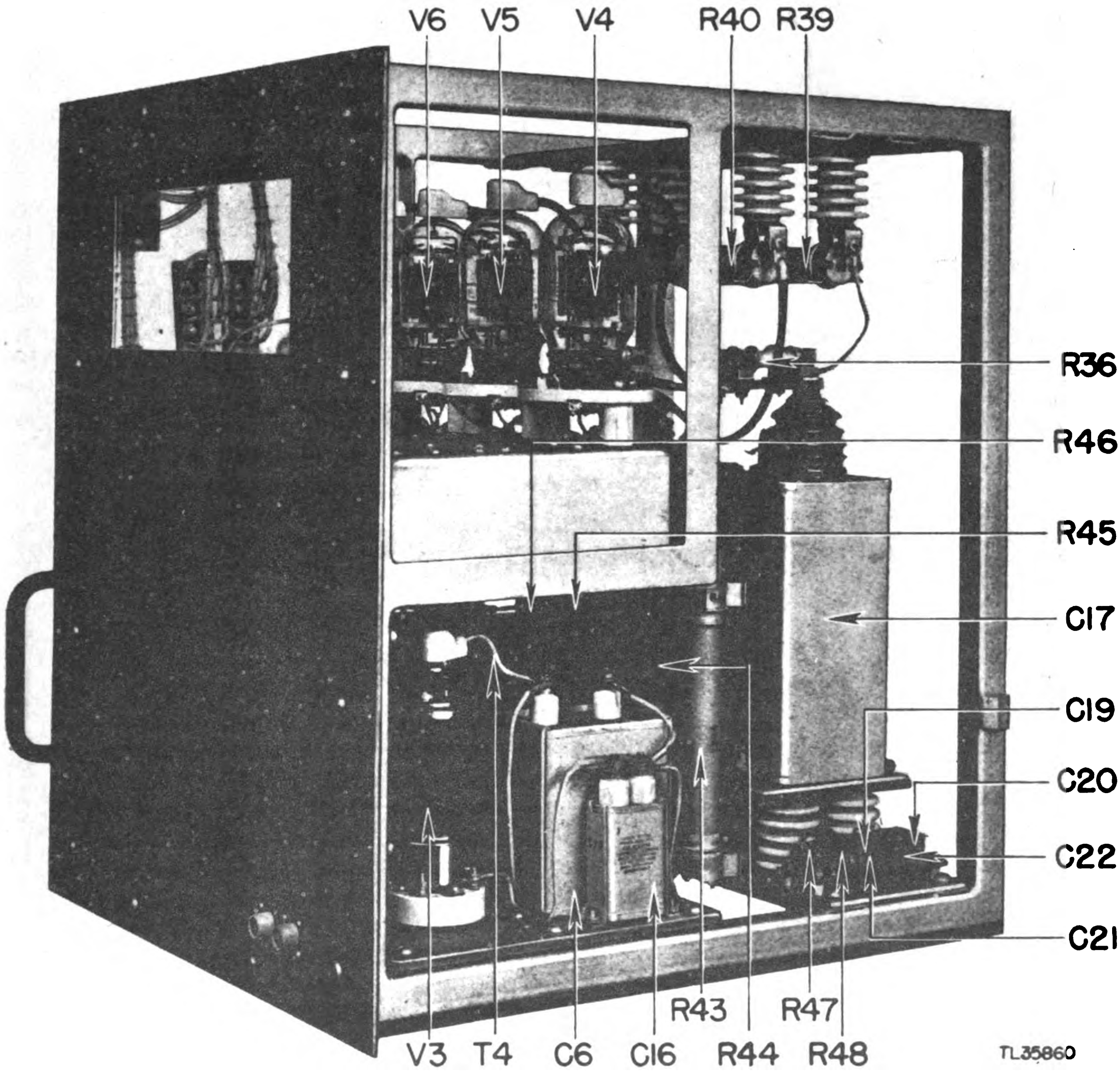


Figure 325. Modulator MD-11/MPN-1, right oblique view.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Magnetron filament voltage low.	1a. Check the magnetron filament voltage (6.3 volts ac) with the high-voltage power turned off from the transmitter rack.

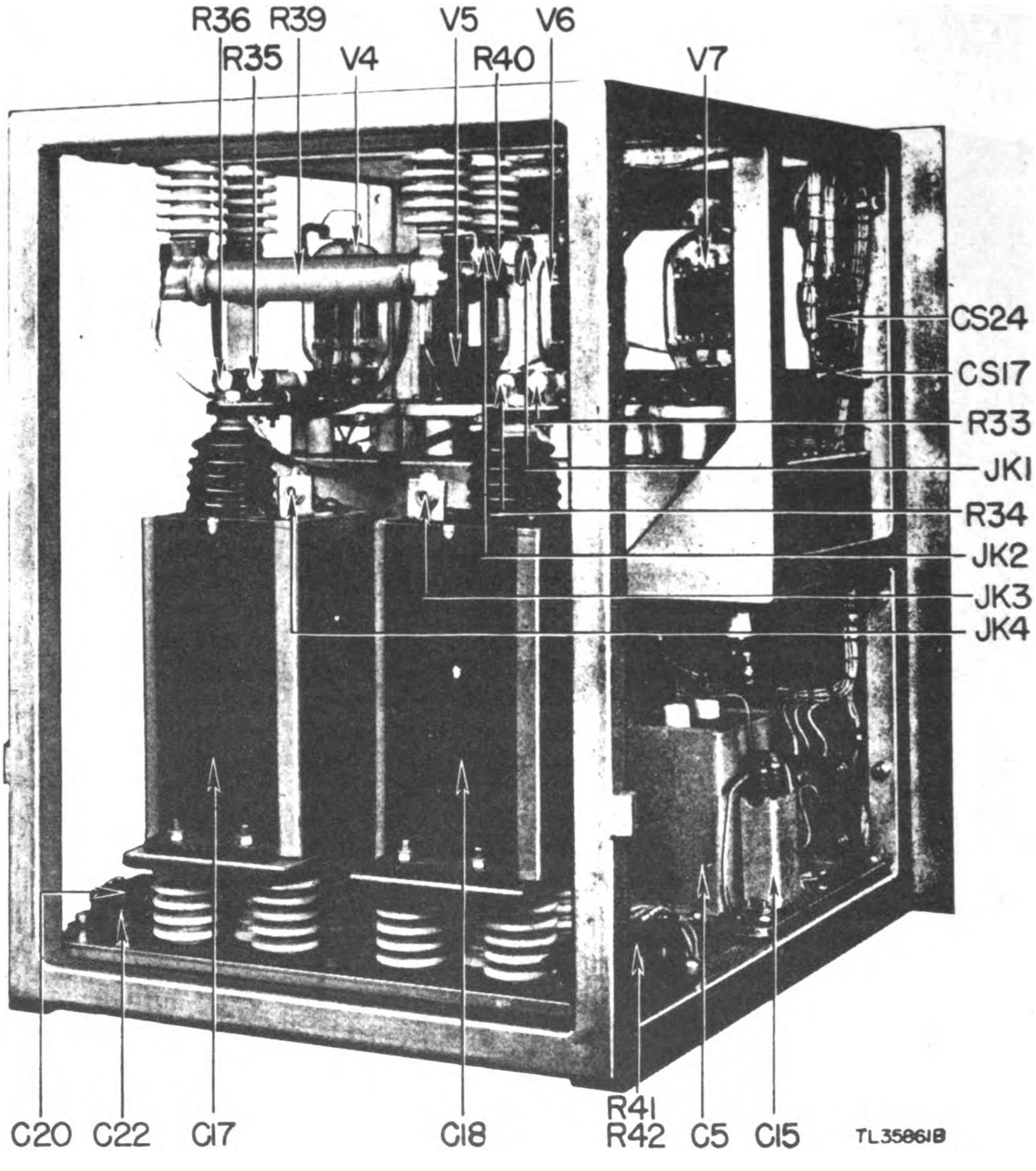


Figure 326. Modulator MD-11/MPN-1, rear view.

b. If the filament voltage is low, check the primary voltage (117 volts ac) applied to magnetron filament transformer, T1 or T2. Low primary indicates trouble in Power Units PE-127A or in the commercial power supply.

c. Normal primary voltage and low filament voltage indicates a defective filament transformer.

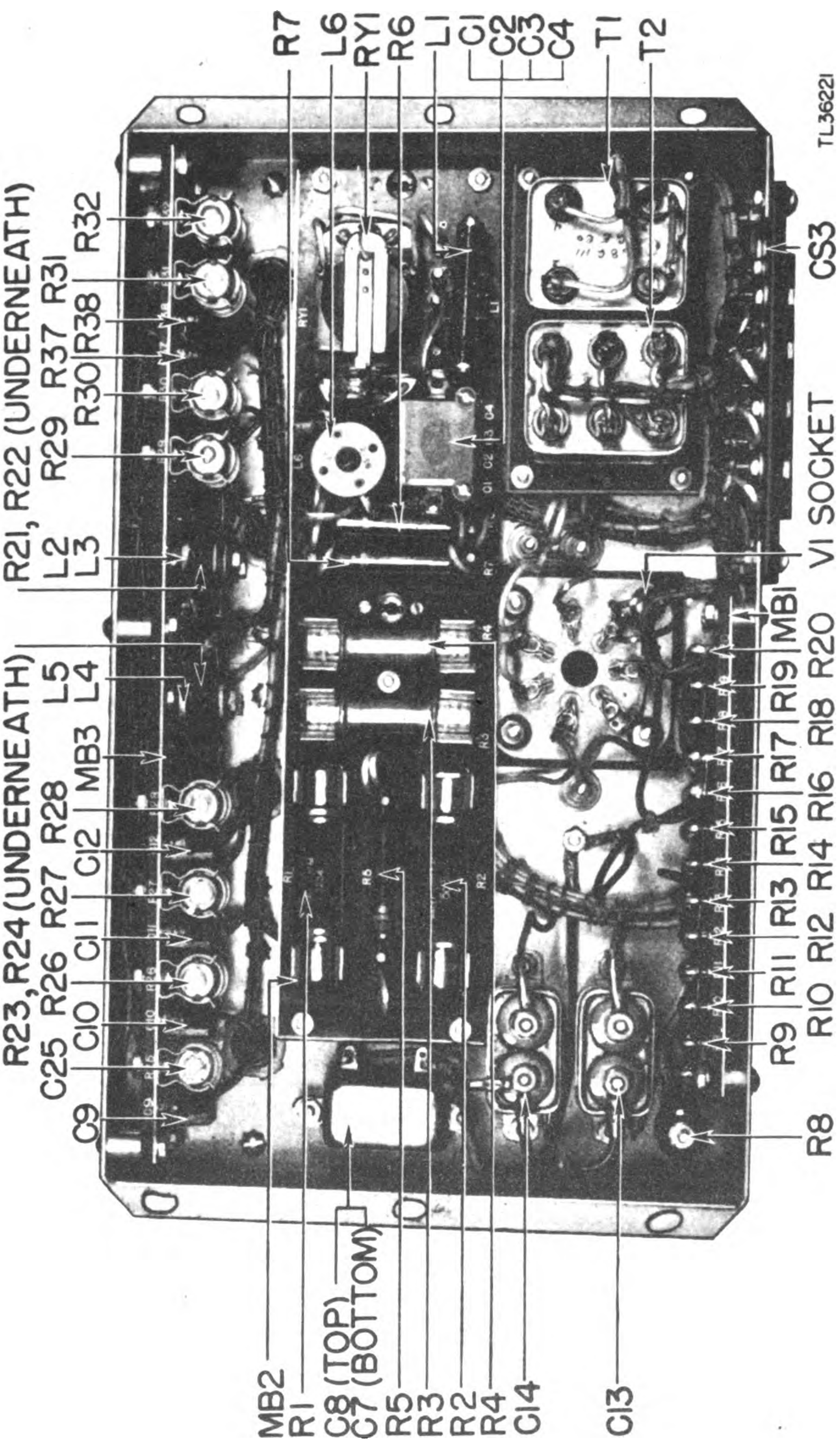


Figure 327. Modulator subchassis, bottom view.

2. Magnetron tube defective.	2. Replace the magnetron tube.
3. High-voltage Rectifier Power Unit PP-26.	3*a*. Check high-voltage meter reading (H.V. "S"). *b*. Arc-over of bleeder or voltage divider resistors will cause low high-voltage output (par. 244).
4. Defective high-voltage metering circuits.	4. The high-voltage metering circuit is reading too high. Check resistor R23 in Rectifier Power Unit PP-26. This resistor should have a value of 20 megohms with a tolerance of ± 10 percent.

E. SYMPTOMS:

1. Magnetron current (I MAG "S") unstable.
2. Signals on test synchroscope suddenly disappear as the high-voltage variac is turned down.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective magnetron tube.	1*a*. Signals should decrease gradually. A sudden disappearance of signals indicates very sharp magnetron spectrum and makes tuning difficult. A small change in primary voltage will stop the magnetron from oscillating. *b*. Magnetron tube should be changed and the system returned.

F. SYMPTOM:

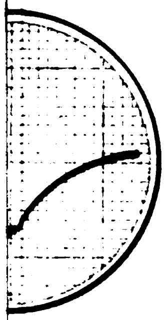
1. Magnetron blower motor does not operate.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No power input to the motor.	1*a*. Check input voltage (117 volts ac) on terminals 1 and 2 of connectors strip CS19A for the channel A blower motor, and terminal 1 and 2 of connector strip CS19B for the channel B blower motor. *b*. If there is no voltage across these terminals, check power distribution system.
2. Blower motor defective.	2*a*. Check voltage (117 volts ac) at plug PL1 for the channel A blower motor and plug PL2 for the channel B blower motor. *b*. If voltage is normal, remove plug and check continuity of blower motor. If open or shorted, replace blower motor.

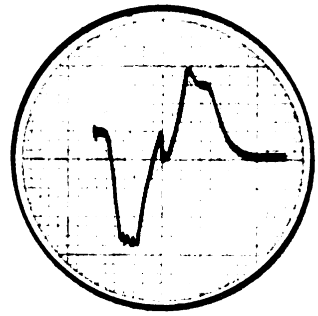
G. SYMPTOMS:

1. Low power output to the r-f system.
2. Modulator output normal.

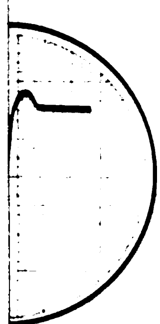
PROBABLE LOCATION OF FAULT	PROCEDURE
1. Arcing in the magnetron output connection.	1*a*. If the silver-plated bullet in the magnetron output connection becomes corroded, arcing will result. *b*. Clean the silver-plated bullet and the magnetron anode from the connection. *c*. Any part badly burned by r-f should be replaced.
2. Filament transformer arcing over.	2*a*. Clean and check secondary winding insulators of the filaments transformers. *b*. Replace any insulators suspected of being defective.



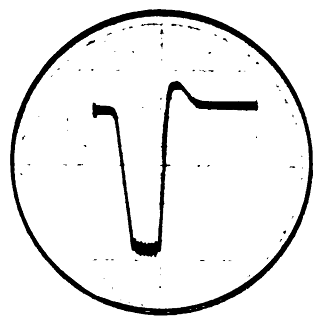
1 GRID
EEP SPEED 4
GAIN 1/3 maximum
ATTENUATOR 100:1



3
DRIVER TUBE V1 PLATE
SYNCHROSCOPE SWEEP SPEED 1
VIDEO AMPLIFIER GAIN 1/4 maximum
VIDEO AMPLIFIER ATTENUATOR 100:1



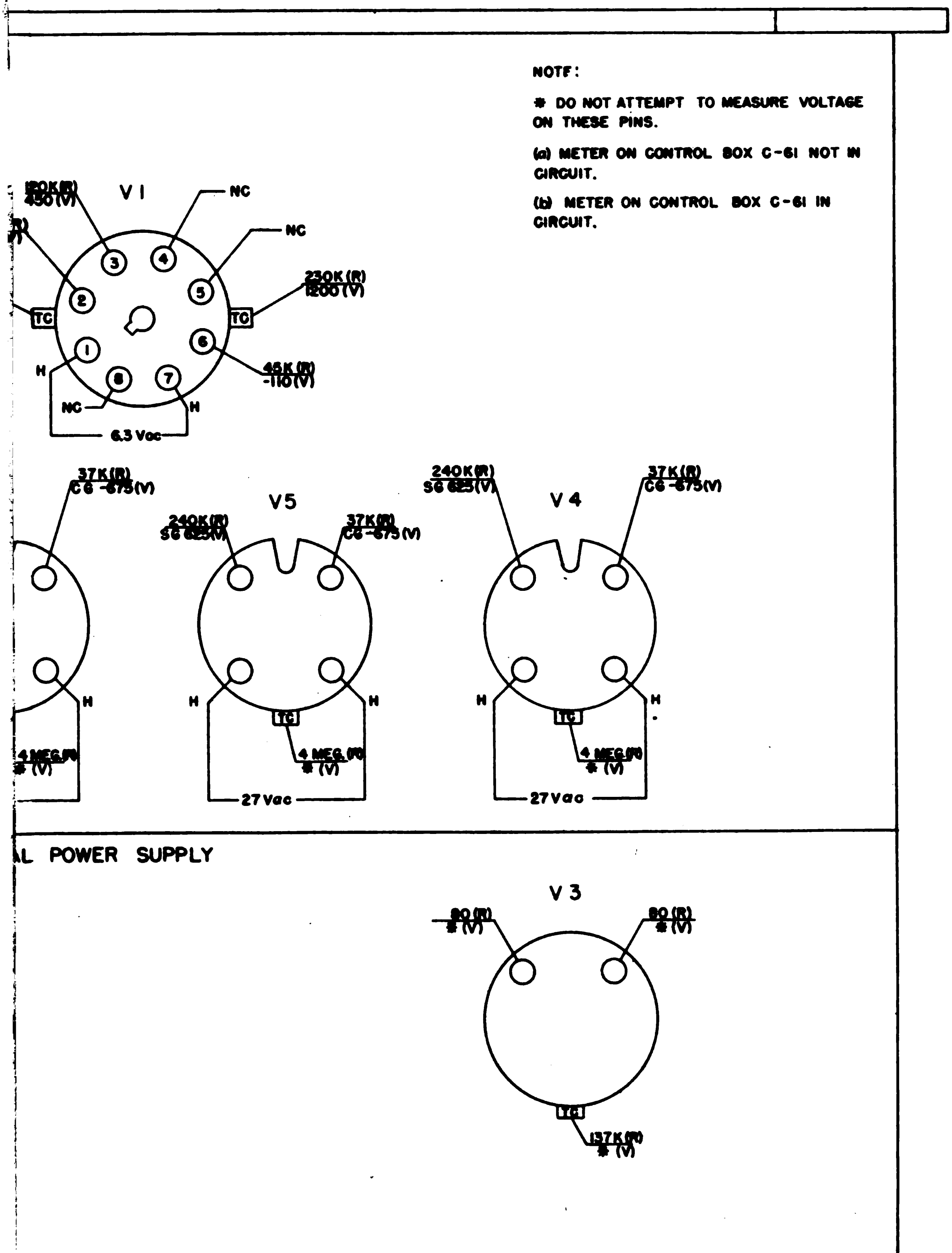
T PULSE
EEP SPEED 1
GAIN 1/4 maximum
ATTENUATOR 10:1



6
S-BAND OUTPUT PULSE
SYNCHROSCOPE SWEEP SPEED 1
VIDEO AMPLIFIER GAIN 1/4 maximum
VIDEO AMPLIFIER ATTENUATOR 10:1

TL 43467

Figure 328. Modulator MD-11/MPN-1, waveforms.



TL 35997A

Figure 329. Modulator MD-11/MPN-1, voltage and resistance chart.

168. SUPPLEMENTARY DATA.

a. Removal of Components. Wherever possible, the components of the search transmitting system should be repaired without removing them from the transmitter rack. In Modulator MD-11 the subchassis can be removed without taking the entire compartment out of the transmitter rack. In Radio Frequency Unit RF-7, either the channel A or the channel B magnetron subchassis assembly can be easily removed by taking out the six bolts that hold it in place.

b. Replacement of Magnetron Tubes. To take out a magnetron tube, it is necessary to have the r-f subchassis assembly removed from the transmitter rack. Before removing the subchassis assembly be sure the magnetron filament leads are disconnected. Pull the banana plug connectors directly out from their sockets and place them so they will be out of the way. Loosen the knurled knob on the magnetron coupler assembly. Take out the bolts which hold the magnetron to the supporting shoulder member at the point of the glass filament lead seal. This should leave the magnetron free to be removed from between the poles of the permanent magnet. With extreme caution, remove the magnetron itself by pushing it in a

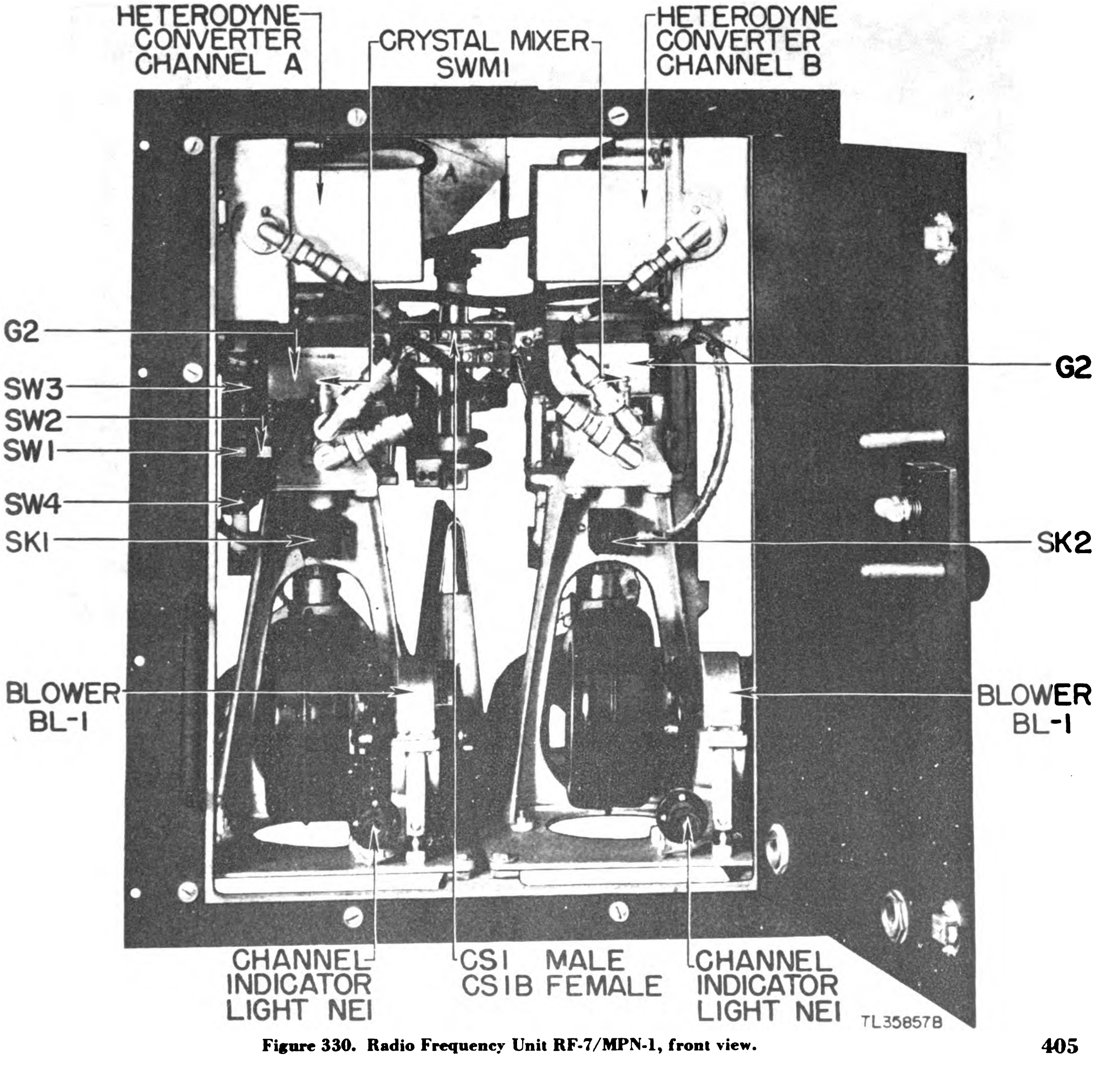


Figure 330. Radio Frequency Unit RF-7/MPN-1, front view.

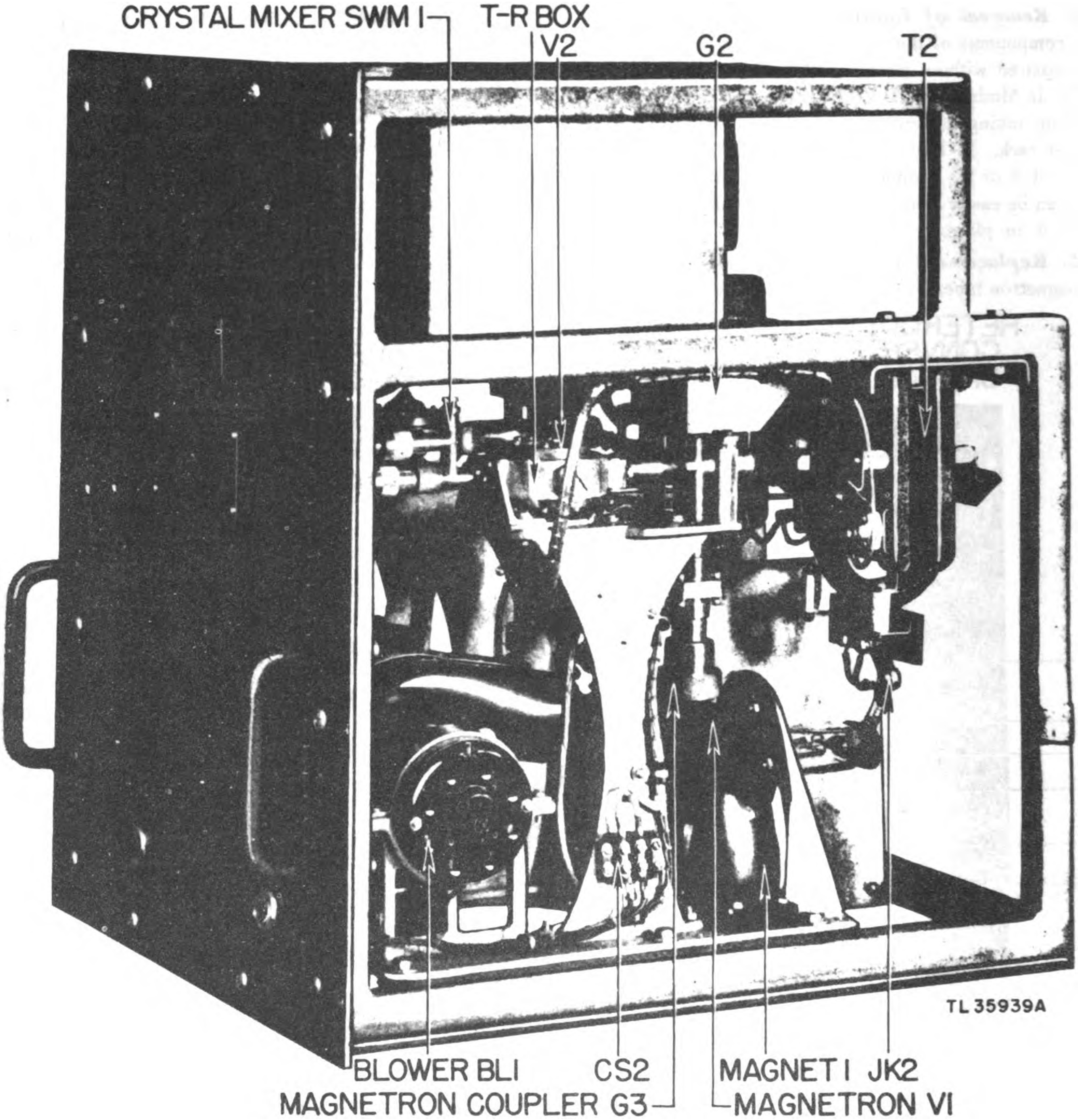


Figure 331. Radio Frequency Unit RF-7/MPN-1, right oblique view.

downward direction until it comes loose from the magnetron connector. Take care at all times so that no metallic objects strike the magnet or a loss of field intensity may result. With the magnetron removed, it is advisable to test the field strength of the magnet, using Test Set TS-15/AP. Follow the instructions given in paragraph 141. To install a new magnetron, follow the reverse of the above procedure. Be absolutely certain that the magnetron is centered between the poles of the magnet and that all fittings line up perfectly before inserting and tightening the mounting screws. Reconnect the filament leads and proceed to "age" the magnetron.

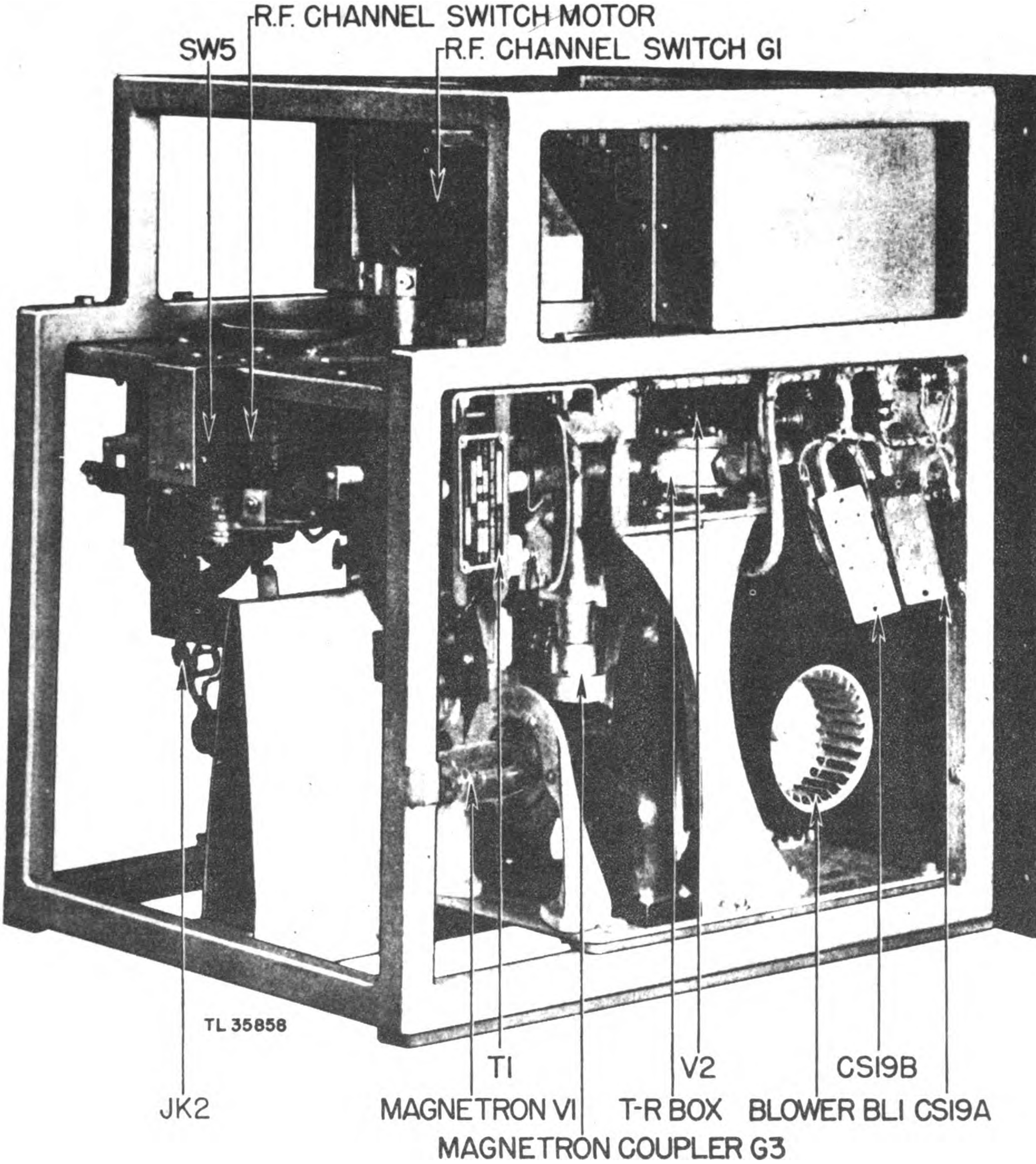


Figure 332. Radio Frequency Unit RF-7/MPN-1, rear oblique view.

c. Aging Newly Installed Magnetrons. New magnetrons are frequently unsteady when first put into operation. This unsteadiness may be due to the gassiness of the tube or to voltage breakdown from other causes. In either case the unsteadiness may be only temporary. After reinserting the magnetron subchassis assembly in the rack and connecting the various leads, turn on the system in the normal fashion and observe the magnetron current reading. The following symptoms may be observed:

(1) ABNORMALLY LARGE CURRENTS. This may last only a second or two, or it may continue. This indicates that the tube is gassy. It is assumed that the permanent magnet field strength has been tested before the new magnetron was installed. The magnetic field intensity

reading should be up to the minimum standard of 1,325 gauss, otherwise a large magnetron current may result.
(2) UNSTEADY CURRENT. This indicates gas bursts or voltage breakdown, or both.
(3) SHARP CURRENT RISES. An occasional kick or sharp rise of the magnetron current indicates voltage breakdown.
(4) AGING. If any of the above symptoms exist, it will be necessary to turn the high voltage, which is applied to the magnetron, on and off several times for an interval of 10 to 15 seconds. Rapidly bring the variac in Control Box C-61 up to the operating point, hold for the proper period of time, and reduce sharply to zero. If no improvement in the operation is apparent, the magnetron is probably defective and should be replaced. If there is some improvement noted, the symptoms should clear up completely in 15 minutes of either continuous or intermittent operation.

d. Matching Magnetron Frequencies. When the new magnetron is properly installed, determine its exact operating frequency within the limits of the test set accuracy. This must agree within narrow limits with the operating frequency of the magnetron being used in the other channel. If it does not, the pattern of the antenna beam will be changed considerably when channels are switched. It is advisable to use magnetrons in pairs matched as closely as possible. If considerable discrepancy is observed between the two channels on replacing one magnetron, replace the other one as well.

e. Aging New Modulator Switch Tubes. When replacing type 715A/B modulator switch tubes it is recommended that they be aged in accordance with the following instructions:

(1) Remove the plugs on the high-voltage pulse cables that connect the modulator jacks, JK3 and JK4, to the magnetrons.

(2) Operate the modulator in the normal way and raise the high voltage to the upper limits of the variac adjustment.

(3) If the overload relay trips, reapply the power and continue operation until the modulator will operate for 2 or 3 minutes without the overload relay tripping.

(4) Shut off the high voltage and reconnect the plugs on the high-voltage pulse cables that connect the modulator jacks, JK3 and JK4, to the magnetrons.

SECTION II

R-F SYSTEM

WARNING: ***Voltages sufficient to cause death on contact are exposed at many points in Radio Frequency Unit RF-7/MPN-1. Do not place hands or arms within this unit with the high voltages on. Do not make any connection into this unit which brings high voltages out to exposed points. Make all tests with the high voltages off. Always ground the high-voltage capacitors before touching them or their associated equipment.***

169. REFERENCE DATA.

a. Search Antenna and Transmission Line Assembly.

(1) Figure 30. Search antenna array.

(2) Figure 34. Transmission Line CG-31/MPN-1, search antenna feed.

(3) Figure 35. S-band transmission line.

(4) Figure 44. Search antenna elevation field pattern.

b. Radio Frequency Unit RF-7/MPN-1.

(1) Figure 28. Schematic diagram.

(2) Figure 33. R-f channel switching assembly.

c. General.

(1) Figure 333. T-R box recovery time test.

(2) Figure 334. R-f rotary joint.

170. MEASUREMENT OF T-R BOX RECOVERY TIME.

a. The recovery time of the T-R box is important in the reception of near-by echo signals. If the recovery time is prolonged, i.e., the spark across the gap is not extinguished immediately, a partial short circuit will appear across the input to the heterodyne converter which will attenuate the received echo signals during the first few microseconds of reception. Prolonged recovery time is usually caused by a defective T-R tube which should be replaced (par. 173).

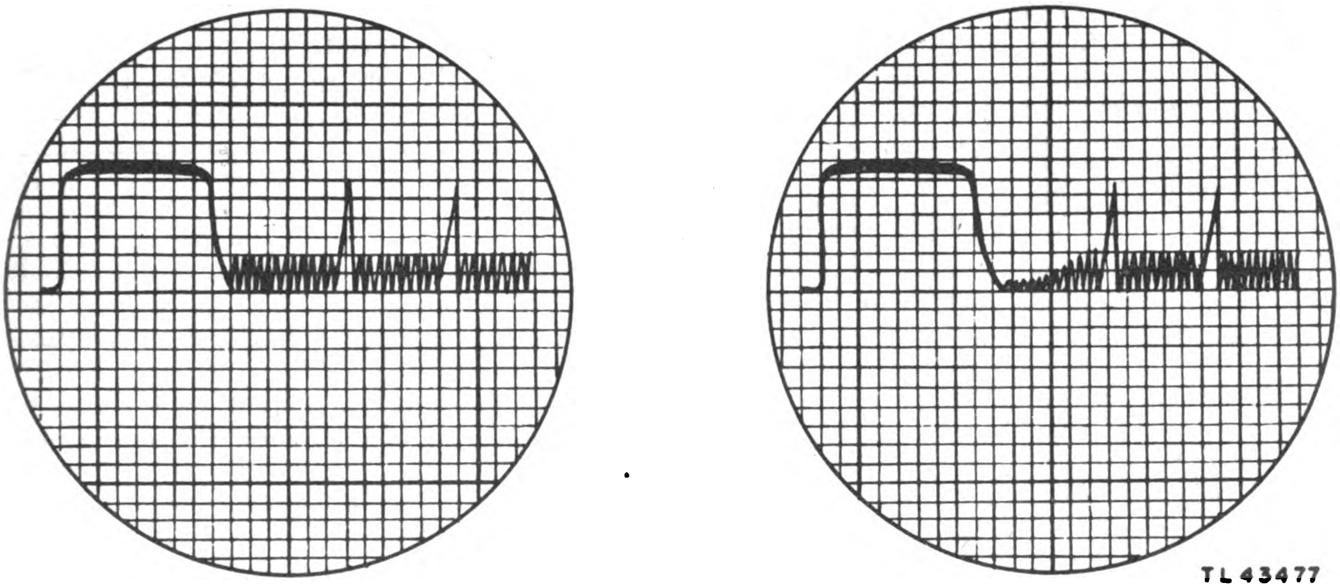


Figure 333. T-R box recovery time test.

b. To check the T-R box recovery time, first connect the echo to the selector line connection and tune the echo box for maximum meter deflection. Observe the receiver output on the synchroscope in the transmitter rack. If the T-R box recovery time is normal, noise will be visible immediately following the end of the echo box pulse (fig. 333a). If the recovery time is not normal, noise or grass will not be immediately visible following the end of the echo box pulse, but will start at zero and gradually increase to the normal value (fig. 333b).

171. PROCEDURE.

a. Very few electrical faults will occur in the search r-f system because of the nature of the construction of r-f equipment for S-band operation. The majority of the faults will be of a mechanical nature which can best be located by observation. These faults include bent or broken waveguides and coaxial line connections, a misaligned r-f channel switch, and mechanical breakage or wear in the search antenna drive assembly. The electrical faults will, in general, lie in the T-R box in Radio Frequency Unit RF-7 or in the r-f rotary joint. The latter fault can usually be traced to mechanical trouble causing arc-over within the rotary joint.

b. A trouble-shooting chart for the r-f system is included in paragraph 172 to aid in locating electrical faults that may occur. To insure that faults, such as weak echo signals, are actually located in the r-f system, it will be necessary to make an over-all check of the receiving system sensitivity with Test Set TS-224/UP, using the small dipole antenna mounted outside of the trailer (par. 137). If this test shows low sensitivity, connect Test Set TS-224/UP to the S-band selector connection as described in paragraph 137. If the sensitivity is normal at this point, it can be assumed that the fault lies in the r-f system. However, this test excludes the possibility that the T-R box is not operating properly. In order to obtain normal sensitivity at the S-band selector connection, the signal must pass through the T-R box which consequently must be in good working order. Faults in the T-R box can usually be isolated to a mistuned cavity or the absence of the –750-volt "keep alive" voltage.

172. TROUBLE-SHOOTING CHART FOR SEARCH R-F SYSTEM.

A. SYMPTOMS:

1. Weak echo signals observed on the synchroscope.
2. Receiver sensitivity normal as measured at the input to the preamplifier unit.
3. Crystal current normal.
4. Transmitter power output normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. T-R box.	1. Retune the T-R box cavity (par. 173).
2. Defective T-R tube.	2. Check the T-R box recovery time (par. 170). Replace tube if defective (par. 173).

B. SYMPTOM:

1. Crystal burns out repeatedly.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. T-R tube.	1. T-R tube defective, check T-R recovery time (par. 170) and discharge glow. Replace defective T-R tube.
2. Low keep alive voltage.	2. Measure voltage on top cap of T-R tube (–750 volts). If low or absence, check continuity of keep alive circuit and power supply in the modulator.

C. SYMPTOMS:

1. Low power output from search antenna as measured on Power Monitor TS-125/AP.
2. Normal power at S-band selector line.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. S-band transmission line.	1. Check the S-band waveguide visually for defective sections and choke joints.
2. R-f channel switch.	2. Check that the r-f channel switch is stopped directly over the magnetron output section for the channel in use. See paragraph 173 for adjustment.
3. Absorber Unit CG-32/MPN-1.	3. Replace absorber unit and note results.
4. Arc-over in transmission line.	4*a*. Check r-f rotary joint. See paragraph 173 for procedure. *b*. Arc-over in transmission line. See symptom D.

D. SYMPTOM:

1. Arc-over in r-f transmission system is indicated by a high-pitched singing noise.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Arc-over in r-f rotary joint.	1*a*. Remove the sound-insulated box and listen for signs of arc-over in r-f rotary joint. *b*. If arc-over is detected, see paragraph 173 for procedure.
2. R-f arc at some point inside transmission line.	2*a*. Locate the origin of the sound by ear or by feeling for any "hot spots" along the transmission line. *b*. Check for moisture inside transmission lines. They must be dried out thoroughly using a warm air blast if necessary. *c*. Check couplings between coaxial lines. See that bullet connectors are properly spread. *d*. Check the alignment of the r-f choke joints between the waveguide sections. *e*. Check that coupling loops inside T-R box have not become unsoldered. *f*. Any parts of the r-f transmission system that have been burned should be replaced unless burn is very slight.

173. SUPPLEMENTARY DATA.

a. Tuning T-R Box. (1) The complete tuning and alignment procedure for the receiving system requires that the T-R box be tuned for optimum performance of the system. This is normally done after the local oscillator and AFC circuit have been aligned. Care must be taken to see that the T-R box is tuned to resonate at the magnetron frequency and not at the local oscillator frequency. Otherwise, the T-R box will absorb power from the local oscillator.

(2) With both the receiving and transmitting systems turned on and operating, use the synchroscope to monitor the video output of the channel under test. Rotate the search rotoflector by hand until a good fixed echo is located on the synchroscope that is suitable for tuning. Turn the radar receiver gain control down so that the amplitude of the echo does not saturate the receiver or synchroscope. Adjust the T-R box cavity tuning plugs for maximum amplitude of the fixed echo by screwing them in or out of the cavity. Each tuning plug should be adjusted an equal amount and penetration into the cavity must be uniform.

b. Alignment of the R-f Channel Switch. The only way that the r-f channel switching mechanism can become completely out of alignment is for some of the Allen head setscrews to become loose on the rotating parts. Minor alignment adjustments can be made by shifting the magnetron S-band subchassis slightly in any direction in a horizontal plane. The holes, through which the subchassis assembly is bolted to the framework, are large enough to permit this movement. Should the r-f channel switching mechanism become out of line, proceed in the following manner:

(1) See that the crank wheel is tight on the motor shaft.

(2) See that the slotted crank arm which moves the S-shaped waveguide section comes firmly against the spring stop on the chassis in both positions of its travel.

(3) See that the slotted crank arm is tight on the shaft.

(4) Loosen the Allen head setscrew that fastens the movable S-shaped section of waveguide on the vertical shaft. With the setscrew loose, the S-shaped section of waveguide is free to rotate independently of the shaft. Rotate the S-shaped waveguide section until its rectangular cross-section in the r-f choke joint lines up exactly with the waveguide cross-section above. In this position, the long side of the rectangular cross-section will be parallel to the front panel of the radio frequency unit. Tighten the Allen head setscrew to lock the rotatable waveguide section in this position. Tighten the locknut on the Allen head setscrew.

(5) Move the magnetron subchassis assemblies until they line up with the rotatable section of waveguide on the r-f channel switch and tighten the six bolts to hold them securely in place.

(6) Test the operation of the r-f channel switch by switching from channel A to channel B several times while observing the switching operation. If the r-f channel switch does not stop at exactly the same place each time, it is an indication of worn parts which should be replaced.

c. Service of R-f Rotary Joint (fig. 334). (1) It is important that both rotating joints have no external side forces on them. The lower rotary joint may be forced off the center line of the spinner base by the short length of coaxial line that feeds it. This can be corrected by the use of shims and by adjusting the waveguide at the clamp and brackets which hold the waveguide to the spinner base. The parts of the rotating joint assembly have been checked and adjusted to very close tolerances at the factory, and should not require service except under unusual circumstances. If the rotating and stationary parts of the coaxial assembly become out of alignment, an internal arc-over will result. The arc-over will occur at the point in which the rotating member of the coaxial assembly comes closest to the stationary member during rotation. It can be checked in the following manner:

(*a*) Turn on the transmitting and receiving system and tune the S-band echo box to the magnetron frequency.

(*b*) Turn on the search rotoflector and observe any variation in current on the microammeter in the S-band echo box. Variation should not be over 2 percent.

(*c*) If there are signs of considerable variation, turn off the rotoflector and rotate it slowly by hand. Any point at which arc-over occurs in the rotary joint will be indicated by a sharp drop in the echo box microammeter reading and by the absence of signal on the synchroscope.

(*d*) Unless the arc-over is very slight, the parts making up the coaxial line within the rotary joint are usually burned and replacement is necessary.

(2) The rotary joint may be disassembled for inspection and lubrication of the ball bearings as follows:

(*a*) Remove the four screws that hold the brass end plate in place. The stationary section of the rotary joint, which mounts the ball bearings, is removed from the rotating section by pulling it out of the cylinder-shaped case. The outer bearing sleeve and the outer bearing can be removed from the coaxial line by pulling them off by hand. Do not use excessive pressure as these parts may be easily forced out of alignment.

(*b*) To remove the inner bearing, take out the Allen head setscrew and locknut. The inner bearing sleeve will then slide off of the stationary coaxial line assembly and the inner ball bearing will be free to slide off. The ball bearings have been packed (with Lubriplate) at the factory and do not require frequent lubrication. Any lubricant used should be non-corrosive, have a high melting point, and be of the type used on switches and contacts of electrical equipment.

(*c*) When assembling the rotating joint use the reverse order of procedure given above. Care should be taken that the Allen head setscrew seats exactly in the hole provided for this purpose in the outer conductor of the stationary coaxial assembly.

the mounting rings and bolt down securely. If the mounting rings are not bolted down securely, considerable loss of received signal energy will result. The T-R box should be retuned as described in subparagraph *a* above.

e. Adjustment of the Search Antenna Tilt. (1) The shift in the beam peak of the S-band search antenna array for a wavelength change of 0.20 centimeter is about 1.6 degrees. The search antenna is tilted to the angle read on the protractor which is fastened to the tilt arm on the

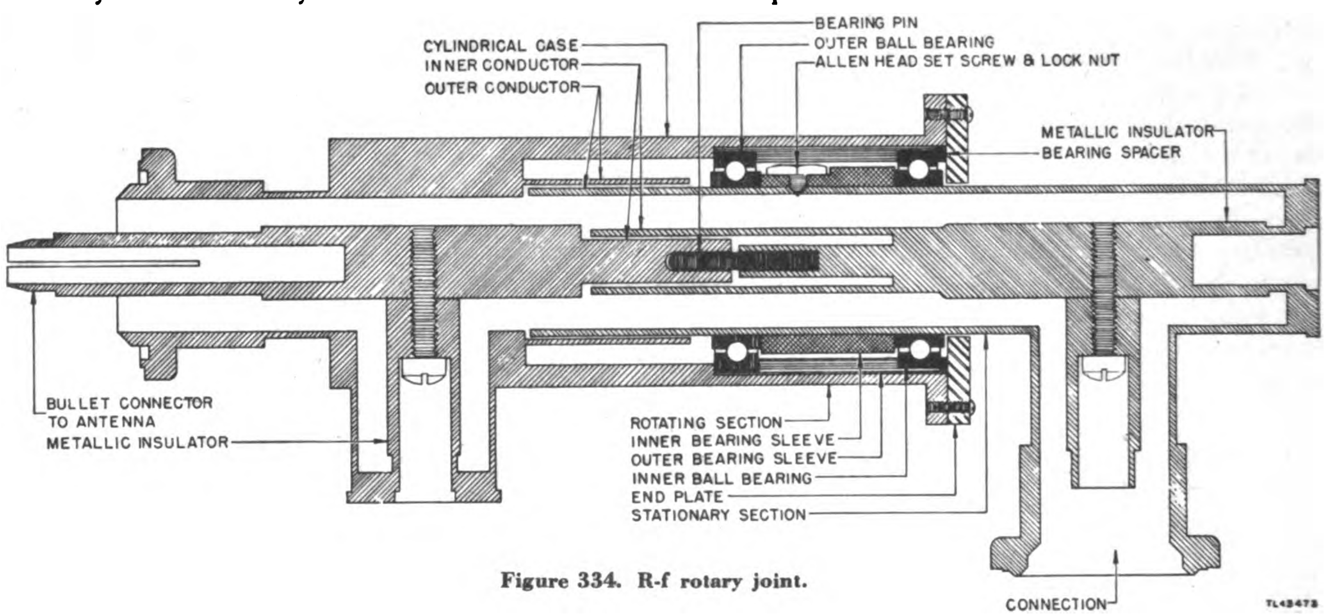


Figure 334. R-f rotary joint.

d. Replacing T-R Tubes. The performance characteristics of the T-R tubes within the r-f unit must be watched carefully because, as indicated in the trouble-shooting charts, they may cause repeated crystal failure and loss of sensitivity to near-by signals. To check the T-R tube operation, follow the procedure given in paragraph 170. To replace the T-R tube, proceed in the following manner:

(1) Remove the bolts holding both the top and bottom mounting rings in place. Using hand pressure only, take apart the two halves of the T-R cavity in which the tube is contained, and remove the T-R tube from the half of the cavity with which it remains. This will take considerable pressure. Do not use a screwdriver or other tools as they may slip and mar the interior surface of the cavity, thus affecting its electrical characteristics.

(2) Place the new T-R tube so that its flanges, extending out firmly from the tube wall, are firmly on the seating shoulder. Carefully match the two halves of the cavities together over the tube, so that the flanges make equal contact on the entire circumference. Again, using hand pressure only, force the cavity halves together as tightly as possible until there is no gap between sections. Replace search antenna rotoflector assembly. The following table can be used to set the tilt of the rotoflector:

MAGNETRON WAVELENGTH	ANTENNA TILT FROM HORIZONTAL
10.60 - 10.67 cm	0.4°
10.68 - 10.73 cm	1.2°
10.73 - 10.80 cm	2.0°

(2) These angles might need to be changed slightly, depending on the terrain and the type of aircraft being worked. For example, some fighter planes use a 4½ degree glidepath, hence it would be advantageous to raise the tilt of the search antenna rotoflector slightly to decrease ground clutter. As a general rule the above angles should be used. The proper angle of tilt for the rotoflector depends on the transmitter magnetron frequency. In general, the frequencies of channel A and B will differ. To make a rapid change from one channel to the other possible, a compromise beam angle tilt will have to be chosen. Trouble develops if the channel A wavelength is in the lower region and the channel B wavelength is in the upper region or vice versa. The magnetrons for both channels should be so chosen as to have frequencies close together.

SECTION III

RECEIVING SYSTEM

WARNING: ***Voltages sufficient to cause death on contact are exposed at many points in Radio Frequency Unit RF-7/MPN-1. Do not place hands or arms in this unit with the high voltage on. Do not make any connection into this unit which brings high voltages out to an exposed point. Make all tests with high voltage off. Always ground the high-voltage capacitors before touching their associated circuits.***

174. REFERENCE DATA.

a. S-band Preamplifier and Heterodyne Converter.

(1) Figure 335. Bottom view.
(2) Figure 330. Radio Frequency Unit RF-7/MPN-1, front view.
(3) Figure 49. Crystal mixer cross-sectional diagram.
(4) Figure 52. Schematic diagram.
(5) Figure 28. Radio Frequency Unit RF-7/MPN-1, schematic diagram.

b. Radar Receiver R-38/MPN-1.

(1) Figure 336. Top view.
(2) Figure 337. Bottom view.
(3) Figure 338. Bottom view of i-f strip.
(4) Figure 339. Mounting boards.
(5) Figure 56. Schematic diagram.
(6) Figure 340. Waveforms.
(7) Figure 341. Voltage and resistance chart.

c. General.

(1) Figure 85. Intercommunications Panel SB-2/MPN-1, radar control circuit.
(2) Figure 214. Control Box C-61/MPN-1, schematic diagram.
(3) Figure 253. Capacity color code.
(4) Figure 254. Resistor color code.
(5) Figure 255. Tube base chart.

175. SPECIAL INFORMATION.

a. Synchroscope. Synchroscope TS-64/MPN-1, which is mounted in the transmitter rack, is very useful in making quick tests on the search receiving system. The SELECTOR switch on the front panel of the synchroscope is set to position AS when monitoring the video output of channel A and to position BS when monitoring the channel B video output of the search receiver. Because the synchroscope is a type *A* display, it is much more useful for trouble shooting than the PPI display indicators of the search system. By observing the shape of the main transmitter pulse, amplitude of echo signals, receiver noise or grass, absence of echo signals, or interference shown on the synchroscope screen, considerable information on the condition and sensitivity of the receiving system can be obtained. Use of the synchroscope is also required in tuning the local oscillator (par. 180), tuning the AFC circuit (par. 181), and adjusting the STC circuit (par. 182).

b. Test Points. Six test points are located on the radar receiver subpanel and are accessible by opening the front panel door. These test points provide convenient connections for monitoring or testing waveforms and voltages critical to the receiver operation. They are connected in the receiver circuit as follows:

(1) Test point TP1 is in the discriminator output circuit and is used in tuning the AFC circuit and checking its operation.

(2) Test point TP2 is in the receiver gain control circuit which feeds the plate voltage to tubes V1 and V2. With the STC circuit off, voltages measured at this test point will check the operation of the receiver gain control circuit. When the STC circuit is switched on, the saw-tooth output waveform from the STC circuit is superimposed upon the d-c voltage from the manual receiver gain control. The waveform taken at this test point is a check on the operation of the STC circuit and is also used in its adjustment.

(3) Test point TP3 provides a point for monitoring the saw-tooth output of the STC circuit.

(4) Test point TP4 provides a point for monitoring the negative square-wave output of the multivibrator in the STC circuit.

(5) Test point TP5 is used when checking or adjusting the output of the regulated 300-volt receiver power supply.

(6) Test point TP6 is used when checking or adjusting the output of the regulated 220-volt receiver power supply.

c. Testing Crystals. The crystal under test should be removed from the mixer before making any continuity checks on it with an ohmmeter. A meter with at least 20,000 ohms-per-volt sensitivity should be used. Place the ohmmeter test leads directly across the crystal and observe the reading. Reverse the test leads and again observe the reading. The crystal resistance should change from about 50 to 500 ohms when the leads are reversed giving a front-to-back ratio of 10 to 1. The minimum front-to-back ratio at which a crystal will give satisfactory operation is usually about 5 to 1. If the ohmmeter shows no change of resistance with a change of polarity, or if the resistance is infinite or zero, the crystal is defective and should be replaced.

CAUTION: The crystals used are extremely sensitive and will be damaged if not treated carefully. Any of the following actions will burn out the crystals:

(1) Excessive local oscillator output.
(2) T-R box failure.
(3) Static discharge.
(4) Mechanical shock.
(5) Strong magnetic fields resulting in induced current in the crystal leads.

176. PROCEDURE.

a. The trouble-shooting procedure in the search receiving system of Radio Set AN/MPN-1 is divided into two parts. Paragraph 177 deals with the trouble shooting on the S-band heterodyne converter and preamplifier unit. Paragraph 178 covers the trouble-shooting procedure on the radar receiver proper. The heterodyne converter and radar receiver are so interrelated that it is often difficult to isolate a fault to either of them except by process of elimination. The trouble-shooting procedure in the two charts carries out this elimination process in a systematic manner. In general, faults involving abnormal crystal currents are first treated in the heterodyne converter and preamplifier trouble-shooting chart (par. 177). However, when there is a possibility that these faults could also be caused by one of the common circuits in the receiver proper, a cross-reference or corrective procedure is given. The procedure given under a particular symptom in either of the two charts will automatically trace the source of trouble in either component of the search receiving system. Because two separate channels are used in Radio Set AN/MPN-1, there are two complete search receiving systems. In addition, the search radar receivers are interchangeable with the precision receivers. This makes it possible to interchange a component suspected of being faulty with one known to be in good operating condition. In the case of intermittent faults, or low sensitivity, this is often a helpful check. A tube socket voltage and resistance chart is not included for the heterodyne converter and preamplifier unit. When the unit is in place in the Radio Frequency Unit RF-7 compartment, these readings cannot be taken readily because of the physical construction of the set. When the heterodyne converter and preamplifier unit is removed to the test bench, tube socket readings will have little or no value. The circuit elements should be checked against the values given on the schematic diagram (fig. 56). It is possible, however, to check the voltage on the local oscillator shell and repeller plate by opening the hinged cover on the heterodyne converter and preamplifier unit while it is in operating position.

b. Faults in the search receiving system will, in general, appear as a reduction or absence of target echoes on the search indicater tubes and test synchroscopes. This type of fault is common not only to the search receiving system but also to the transmitting system and the r-f system. Before attempting to locate the fault in the receiving system, it will be necessary to make certain that the particular fault is in the receiving system and not in either the r-f or transmitting system. In most cases, a quick check to see if the magnetron current and voltage readings are normal will eliminate the possibility of the fault being in either the r-f or transmitting system. Reference to steps 12 and 15 in the start procedure trouble-shooting section (pars. 157-160) will serve to isolate trouble to the receiving system and, in some cases, to a defective component. It will then be necessary only to isolate trouble to a particular component within the system. Many times this can be accomplished merely by observing the crystal current meter reading or the video output of the receiver as displayed on the synchroscope.

c. If a faulty component cannot be located as described above, it will be necessary to check the system sensitivity at the S-band wave selector connection, at the preamplifier input, and at the receiver input, by means of the signal generator (TS-224/UP), included with the test equipment. Its operation is described in paragraph 137. The following sensitivity checks will isolate faulty components:

(1) Low sensitivity with the r-f signal applied to the S-band wave selector connection and normal sensitivity with a 30-megacycle signal applied to the input of the preamplifier, indicates trouble in the local oscillator, crystal mixer, or the T-R box (if the crystal current is normal). Refer to the S-band heterodyne converter and preamplifier trouble-shooting chart (par. 177).

(2) Low sensitivity with a 30-megacycle signal applied to the input of the preamplifier and normal sensitivity with a 30-megacycle signal applied to Radar Receiver R-38 indicates trouble in the preamplifier unit. Refer to the S-band heterodyne converter and preamplifier trouble-shooting chart (par. 177).

(3) Low sensitivity with a 30-megacycle signal applied to Radar Receiver R-38 (receiver output measured on synchroscope) indicates trouble in the receiver. Refer to the radar receiver trouble-shooting chart (par. 178).

(4) If the video output, as viewed on the test synchroscope for the search system, is normal while that on the search indicators is not, the trouble is not in the receiving system. Refer to paragraph 187 for search indicator faults.

177. TROUBLE-SHOOTING CHART FOR S-BAND HETERODYNE CONVERTER AND PREAMPLIFIER.

A. SYMPTOMS:

1. Crystal current zero (1 CRYSTAL "S").
2. Noise, no signals on the test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. AFC circuit.	1*a*. Turn AFC switch SW1 on the radar receiver off (down). Slowly turn potentiometer P2 through its range.
	b. If crystal current and signals appear, the AFC circuit is not functioning. Refer to the radar receiver trouble-shooting chart (par. 178).
2. No local oscillator output.	2*a*. Measure the local oscillator output power. Refer to paragraph 138, chapter 6, for procedure. If there is power output from the local oscillator, see item 3 below.
	b. If there is no output, check the local oscillator tube voltages. There should be +300 volts on the shell, about –100 volts on the reflector plate, 6.3 volts ac on the filament, and ground potential on the cathode. Check the power plug connections and cables. Refer to the radar receiver trouble-shooting chart (par. 178) for power supply troubles.
	c. Check to see that the local oscillator is not shorted to ground. If it is, find the cause of the short. Check capacitor C14 and check that crystal mixer probe adjustment is not shorted to ground. When the shell of the local oscillator shorts to ground, resistor R13 is often burned out.
	d. Replace the local oscillator tube V3.
3. Defective crystal.	3*a*. Check the crystal and replace if necessary (par. 175).
	b. Before turning on the transmitter after a crystal has been replaced, check the T-R tube and "keep alive" voltage.
4. The local oscillator off frequency.	4*a*. Tune and adjust the local oscillator.
	b. Refer to paragraph 180 for procedure.

B. SYMPTOMS:

1. Crystal current zero.
2. Normal signals on test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Crystal metering plug not in place.	1. Check that the crystal metering plug is in jack JK1 of the heterodyne unit in use.
2. Crystal current metering circuit.	2*a*. Check the crystal current metering plug for internal broken connections or shorts.
	b. Check the metering circuits in Control Box C-61.

C. SYMPTOMS:

1. Crystal current sweeps too high when AFC circuit is hunting.
2. When the AFC circuit locks in, the crystal current is around 0.2 ma.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator unstable.	1*a*. The local oscillator is mistuned. Refer to paragraph 180 for tuning procedure.
	b. T-R box mistuned. Refer to paragraph 173 for tuning procedure.
2. AFC circuit.	2*a*. The AFC circuit is locked in on the wrong mode of the local oscillator. Check local oscillator coupling and adjust for correct crystal current.
	b. Align the AFC circuit. Refer to paragraph 173 for tuning procedure.

D. SYMPTOM:

1. Crystal current low (0.2 ma or below) even when the AFC circuit is sweeping.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Repeller voltage not correctly adjusted.	1. Adjust the receiver tuning control, potentiometers P2 and P9.
2. The AFC circuit is not correctly tuned.	2. Refer to the AFC tuning procedure (par. 181).
3. Loose local oscillator coupling.	3. Increase the local oscillator coupling. This is done by increasing the probe penetration depth in the crystal mixer.
4. The T-R box tuned to the local oscillator frequency.	4. Check the T-R box tuning (par. 173). If the T-R box is tuned near the local oscillator frequency, it will absorb power.

E. SYMPTOM:

1. Crystal current too high (above 0.8 ma) when the AFC is locked in.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator is too closely coupled.	1*a*. Reduce the local oscillator coupling by decreasing the probe penetration depth in the crystal mixer.
	b. Adjust the position of the coupling loop in the local oscillator cavity for less pickup.

F. SYMPTOM:

1. Intermittent crystal current.
2. Intermittent signals on the test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Loose crystal holder.	1. Clean and tighten the crystal holder surfaces.
2. Intermittent troubles of the type described under symptom A.	2. Follow the check procedure used under symptom A.

G. SYMPTOM:

1. Excessive grass on the test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator coupling too tight.	1*a*. Reduce the local oscillator coupling. *b*. Adjust coupling for correct value of crystal current.
2. Noisy crystals.	2. Replace the crystal.

H. SYMPTOMS:

1. No signals on the test synchroscope.
2. Low noise value on test synchroscope.
3. Crystal current normal.
4. AFC circuit does not lock in.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Preamplifier.	1*a*. As a check in isolating the trouble to the preamplifier stages, refer to the procedure given in paragraph 176. If the trouble is found to be in the receiver unit see the trouble-shooting chart on Radar Receiver R-38 (par. 178). *b*. Check that +105 volts is reaching pin C of power input plug PL1. *c*. Replace first and second i-f tubes V1 and V2, one at a time, and note the results. *d*. Remove the search heterodyne converter unit from the transmitter compartment and check the preamplifier circuit element against the schematic diagram (fig. 52). *e*. Check the preamplifier i-f alignment. Refer to paragraph 184 for procedure.

I. SYMPTOM:

1. The receiver breaks into oscillations.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator.	1*a*. The local oscillator is operating on an unstable mode. Tune and align the local oscillator and AFC circuits. Refer to paragraphs 180 and 181 for procedure. *b*. Reduce the local oscillator coupling by partially withdrawing the output coupling loop from the oscillator cavity. This will reduce the local oscillator loading. *c*. The heterodyne converter assembly is not properly grounded. Check ground connections and fasten down securely. *d*. Replace the first and second i-f tubes (stages V1 and V2) and note results.
2. Receiver.	2. Refer to the trouble-shooting chart on Radar Receiver R-38 (par. 178).

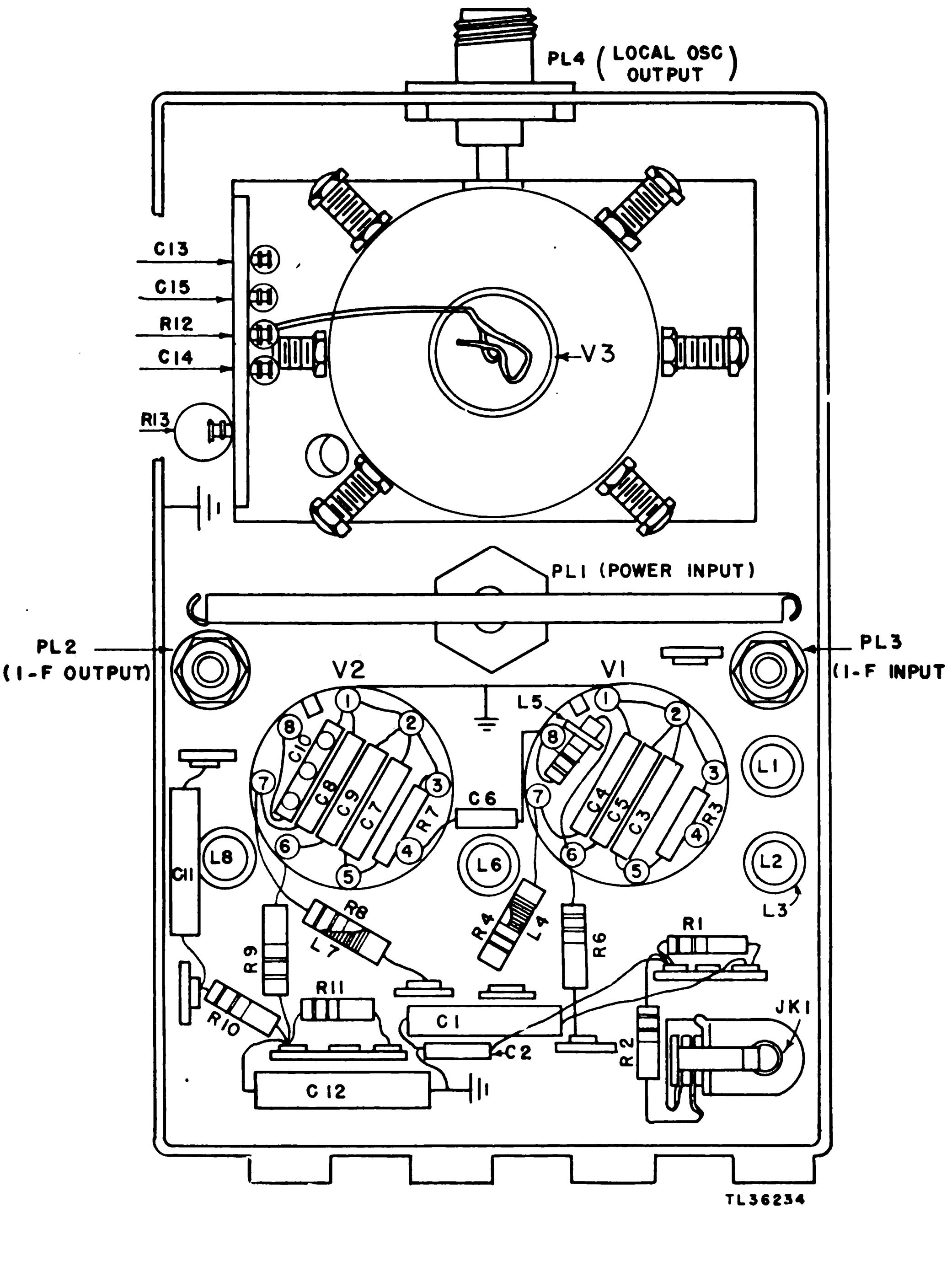


Figure 335. S-band heterodyne converter and preamplifier, bottom view.

178. TROUBLE-SHOOTING CHART FOR RADAR RECEIVER.

A. SYMPTOMS:

1. No noise or signals on the test synchroscope.
2. Crystal current zero (I CRYSTAL "S").

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Receiver fuse blown.	1*a*. Neon fuse indicator light should be lit if fuse is blown.
	b. Check the continuity of the fuse and replace with a 5-ampere fuse if it is open.
2. Positive power supply defective.	2. See symptom N.

B. SYMPTOMS:

1. No noise or signals on test synchroscope.
2. Crystal current normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 220-volt regulated power supply.	1. See symptom P.
2. Positive 105-volt power supply.	2. See symptom R.
3. Preamplifier unit.	3*a*. Check to see if the AFC circuit locks in and holds. If it does, the preamplifier unit is working normally.
	b. If the AFC circuit will not lock in, check the preamplifier unit. Refer to paragraph 177.
4. Defective i-f strip.	4*a*. Check tubes V1, V2, V3, V4, V5, V6, V7, and V8. Replace any found defective.
	b. Make a stage-by-stage test of the tube socket voltages for the i-f strip on tubes V1 through V8 (fig. 341).
	c. Locate the faulty circuit elements by the aid of the resistance chart (fig. 341).
5. Receiver gain control circuit.	5*a*. Try both the local and remote positions of switch SW3. If either position clears the fault, see symptoms E or F below.
	b. Check the voltage at test point TP2 with switch SW2 off. Vary the receiver gain control between maximum and minimum positions. The voltage on the test point TP2 should vary between 0 and +105 volts. If not, see symptom H.

C. SYMPTOMS:

1. Video output weak on test oscilloscope in one channel only.
2. Crystal current normal.
3. Transmitter meter readings and modulator pulse shape normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Adjustment of video control.	1*a*. Turn potentiometer P1 fully clockwise for maximum video output.
	b. Receiver gain control should be fully clockwise for maximum output. Be sure that switch SW3 is not set in a remote position when the local gain control is being used.

PROBABLE LOCATION OF FAULT	PROCEDURE
2. Low power supply voltage.	2*a*. Check that +300 volts is on test point TP5. If not, refer to symptoms N and O. *b*. Check that +220 volts is on test point TP6. If not, refer to symptoms P and Q. *c*. Check that +105 volts is on terminal 6 of connector strip 12. If not, refer to symptom R. *d*. Check that -105 volts is on terminal 5 of connector strip 12. If not, refer to symptoms S, T, or U.
3. Preamplifier unit.	3*a*. Check the preamplifier unit gain by feeding a modulated 30-megacycle signal from a signal generator into plug P13 of the preamplifier unit. Next, feed the same signal directly into the receiver and compare the output signal amplitude. The modulated pattern is shown in figure 340-8. *b*. If in doubt about the preamplifier unit, run a similar check on the spare channel preamplifier. *c*. Refer to paragraph 177 for preamplifier trouble.
4. Defective i-f strip.	4*a*. Check tubes V1 through V8. Replace any showing signs of poor emission or high resistance shorts. *b*. Check i-f strip tube socket voltages and resistance readings (fig. 341). Investigate the cause of any abnormal reading.
5. I-f band pass width too narrow.	5*a*. Check the band pass width of the i-f strip at the preamplifier unit (par. 183). *b*. For i-f alignment procedure refer to paragraph 184.

D. SYMPTOM:

1. Receiver breaks into oscillations.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Preamplifier unit.	1. Refer to symptom I (par. 177).
2. Poor ground connections in the receiver.	2*a*. Check to see that the i-f strip is securely screwed down. *b*. Check all ground connections in the i-f strip. Check that terminal 3 on connector strip 12 is making a good connection.
3. Defective i-f amplifier tube.	3. Replace tubes V1 through V5 one at a time, and note results.

E. SYMPTOMS:

1. Receiver gain control circuit does not work in the LOCAL position.
2. Receiver gain control circuit is normal in the REMOTE position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local gain control circuit.	1. Check the gain control resistor network consisting of R63, P4 and R62.

F. SYMPTOMS:

1. Receiver gain control circuit does not work in the REMOTE position.
2. Receiver gain control circuit is normal in the LOCAL position.

PROBABLE LOCATION OF FAULT

1. Remote gain control circuit (located on the intercommunications panel, figure 85).

PROCEDURE

1*a*. Check that +105 volts and –105 volts are on terminals 8 and 6 respectively for the channel A receiver and on terminals 4 and 2 respectively for the channel B receiver (connector strip CS31).

b. If either voltage is incorrect, check the interrack wiring of these leads between the intercommunications panel and the radar receiver.

c. Check the gain control resistor network consisting of R1, P5, and R3 for the channel A receiver and R2, P6, and R4, for the channel B receiver.

G. SYMPTOMS:

1. Gain control has no effect in either the LOCAL or the REMOTE position.
2. Signal and noise levels on test synchroscope high.

PROBABLE LOCATION OF FAULT

1. The –105-volt supply.

PROCEDURE

1. Refer to symptoms S and U.

H. SYMPTOMS:

1. No signals on test synchroscope.
2. No voltage at test point TP2.

PROBABLE LOCATION OF FAULT

1. Cathode follower stage V14.

PROCEDURE

1*a*. Check tube V14 and replace if necessary.

b. Check the resistance and voltage tube sockets measurements for V14 (fig. 341). Find the cause of any abnormal reading.

I. SYMPTOMS:

1. Noise but no signals on the test synchroscope.
2. AFC circuit does not sweep the crystal current (indicated by the meter reading).

PROBABLE LOCATION OF FAULT

1. AFC circuit alignment.

PROCEDURE

1*a*. Check the waveforms at test point TP1 with the AFC switch SW1 in an off position. It should appear as shown in figure 340.

b. If the waveform is not correct, refer to the alignment procedure given in paragraph 181. Check that the waveform is not distorted when the AFC circuit is switched on.

c. If the AFC circuit is impossible to tune, see item 2 below.

PROBABLE LOCATION OF FAULT

2. Discriminator circuit.

PROCEDURE

2*a*. Check tubes V9, V10, and V11. Replace any found defective.

b. Check coupling capacitor C43. If it is shorted, tube V12 fires continuously and tube V13 cannot sweep. Check the bias of tube V11. Too much gain on V11 causes V12 to fire on noise alone.

c. Check the tube socket voltages and resistance reading for tubes V11, V10, and V9 (fig. 341). Trace the cause of any abnormal reading.

. Stages V12 or V13 nonoperative.	3*a*. Replace tubes V12 and V13, one at a time, and note the results when the AFC circuit is switched on.
	b. Check the tube socket voltages of V12. Note especially the bias on pin 8 of V12. High bias on V12 causes low sensitivity.
	c. Check the tube socket voltages of V13. Note the range of the AFC sweep and trace the cause of abnormal readings.

J. SYMPTOM:

1. AFC circuit sweeps, but does not lock in.

ROBABLE LOCATION OF FAULT	PROCEDURE
AFC circuit alignment.	1. Tune up the AFC circuit. Refer to paragraph 181 for procedure.
The AFC circuit sensitivity too high.	2*a*. Check the bias of V12 (fig. 341). *b*. If bias is incorrect, check resistors R45 and R46.
Magnetron.	3*a*. Check the magnetron output frequency. *b*. If the magnetron is out of the operating band, it must be replaced.

K. SYMPTOM:

1. The AFC circuit will not lock in and hold.

ROBABLE LOCATION OF FAULT	PROCEDURE
. Discriminator improperly tuned.	1. Tune the AFC circuit. Refer to paragraph 181 for procedure.
. Tube V13 does not produce the proper hunting cycle.	2*a*. With the transmitter off, switch on the AFC circuit and observe the sweep of crystal current. It should rise from 0 to about 0.8 ma in approximately ¾ second, and then drop to 0 and repeat. *b*. If the sweep of the crystal current is not correct, check tube V13 and replace if necessary. *c*. Check capacitors C44 and C46. These are the sweep capacitors and, if leaky, will cause an erratic sweep of the crystal current. *d*. Check the –255-volt power supply and bias of V13. See symptoms T and U.
. Local oscillator tuned below the magnetron frequency.	3*a*. Retune the local oscillator to 30 megacycles above the magnetron. Refer to paragraph 180 for procedure.
. Unstable magnetron.	4*a*. Replace the magnetron as a check on its operation. *b*. Check the strength of the permanent magnet (par. 141).
. Local oscillator too tightly coupled.	5. Reduce the local oscillator coupling. The main transmitter pulse draws the local oscillator off frequency.
. Local oscillator improperly shielded.	6. Check the shielding on the local oscillator unit. The system may be picking up rf present because of inadequate shielding.

L. SYMPTOMS:

1. Distance signals cut off.
2. STC circuit switch SW2 on.

   NOTE: Some units of Radio Set AN/MPN-1 have the trigger pulse wired to the receiver of both the search and precision systems. In such cases, symptoms L and M apply to both the search and precision receivers. If the positive trigger pulse is wired only to the precision receivers, symptoms L and M will not apply to the search receiver.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. The STC gate length is too short.	1*a*. Adjust potentiometer P8 to increase multivibrator V15 gate length. *b*. Waveforms on TP3 and TP4 should be similar to that shown in figure 340.

M. SYMPTOMS:

(See note under symptom L.)

1. Near-by signals saturate the receiver and test synchroscope.
2. The STC circuit is on (switch SW2 in up position).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. STC circuit defective.	1*a*. Check the waveform at test point TP2. It should be similar to that shown in figure 340. *b*. Check positive trigger input pulse from the synchronizer at terminal 4 of connector strip CS12 with an oscilloscope. If it is absent on units wired for STC use, trace the pulse wiring circuit. (All precision receivers, and in some units the search receivers, are connected for STC operation.) *c*. Check for a square wave pulse at test point TP4. It should be similar to that shown in figure 340. If the square wave pulse is not present, check tubes V15 and V16. Replace if necessary. *d*. Check tube socket voltage and resistance readings for tubes V15 and V16 (fig. 341). Trace the cause of any abnormal reading. *e*. Check the waveform at test point TP3. This waveform is shown in figure 340. *f*. If the waveform is present at test point TP3 and not at TP2 check, L27 and T3.
2. Receiver gain control circuit defective.	2. See symptoms G and H.

N. SYMPTOM:

1. Zero or low 300-volt on test point TP5.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Adjustment.	1. Adjust P5 for 300-volt output on test point TP5.
2. Main full-wave rectifier V17.	2. Check tube V17. Replace if necessary.
3. Tube V18 defective.	3. Check series regulator tube V18. Replace if necessary.
4. Transformer T1.	4a. Check the primary voltage of transformer T1 on terminals 1 and 2. It should be 117 volts ac. Check the secondary voltage of transformer T1. This can be done most easily on pins 4 and 6 of tube V17. Each should have 575 volts ac to ground.
	b. Should the transformer be burned out, determine the cause before replacing. Check L28, R64, R60, and C54 for short to ground. Inspect fuse F1. It should be rated at 5 amperes.
5. Filter circuit.	5. Check L28 for an open circuit. Check capacitor C54 for leakage.

O. SYMPTOM:

1. 300-volt power supply does not regulate.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Adjustment.	1. Adjust potentiometer P5 for 300-volt output on test point TP5.
2. Tube V18, V19, and V21 defective.	2. Check tubes V18, V19, and V21. Replace if necessary.
3. Regulator circuit.	3a. Check resistance network R68, P5 and R69.
	b. Check the tube sockets voltage and resistance readings of tubes V18, V19, and V21 (fig. 341). Determine the cause of any abnormal reading.

P. SYMPTOMS:

1. Zero or low 220-volt output at test point TP6.
2. 300-volt power supply output normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Adjustment.	1. Adjust P7 for 220-volt output on test point TP6.
2. Tubes V24 and V25 defective.	2. Check series regulator tubes V24 and V25 and replace if necessary.
3. Control stage V26.	3. Check tube V26 and replace if necessary.

Q. SYMPTOMS:

1. 220-volt power supply will not regulate.
2. 300-volt power supply normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Tube V24, V25, and V26 defective.	1. Check tubes V24, V25, and V26. Replace any found defective.
2. Regulator circuit.	2a. Check resistance network R78, P7, and R79.
	b. Check the tube socket voltage and resistance readings (fig. 341) for V26 and determine the cause of any abnormal readings.

R. SYMPTOMS:

1. Zero or low output from the positive 105-volt power supply.
2. 220-volt power supply normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Adjustment.	1. Adjust potentiometer P6 for +105 volts as measured on terminal 6 of connector strip CS12.
2. Potentiometer P6 defective.	2. Check the continuity of potentiometer P6. Replace if necessary.

S. SYMPTOM:

1. Zero or low output for both the 255 and the –105-volt supply.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Rectifier V20.	1. Check half-wave rectifier tube V20. Replace if necessary.
2. Transformer T2.	2*a*. Check to see that filament lights on V20.
	b. Check the primary input voltage on terminals 1 and 2 of transformer T2.
	c. No filament voltage with normal primary input voltage indicates defective transformer T2.
3. Filter network.	3*a*. Check inductance L29 for open circuit.
	b. Check filter capacitor C58 for short circuit or leakage.
	c. Check resistance R72 for open circuit.

T. SYMPTOMS:

1. Negative power supply does not regulate.
2. Both the –225-volt and the –105-volt supplies deliver an output voltage.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Tube V23.	1. Replace regulator tube V23.

U. SYMPTOMS:

1. No –105-volt output.
2. The –225-volt supply does not regulate.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Regulator tube V23.	1. Replace regulator tube V23.

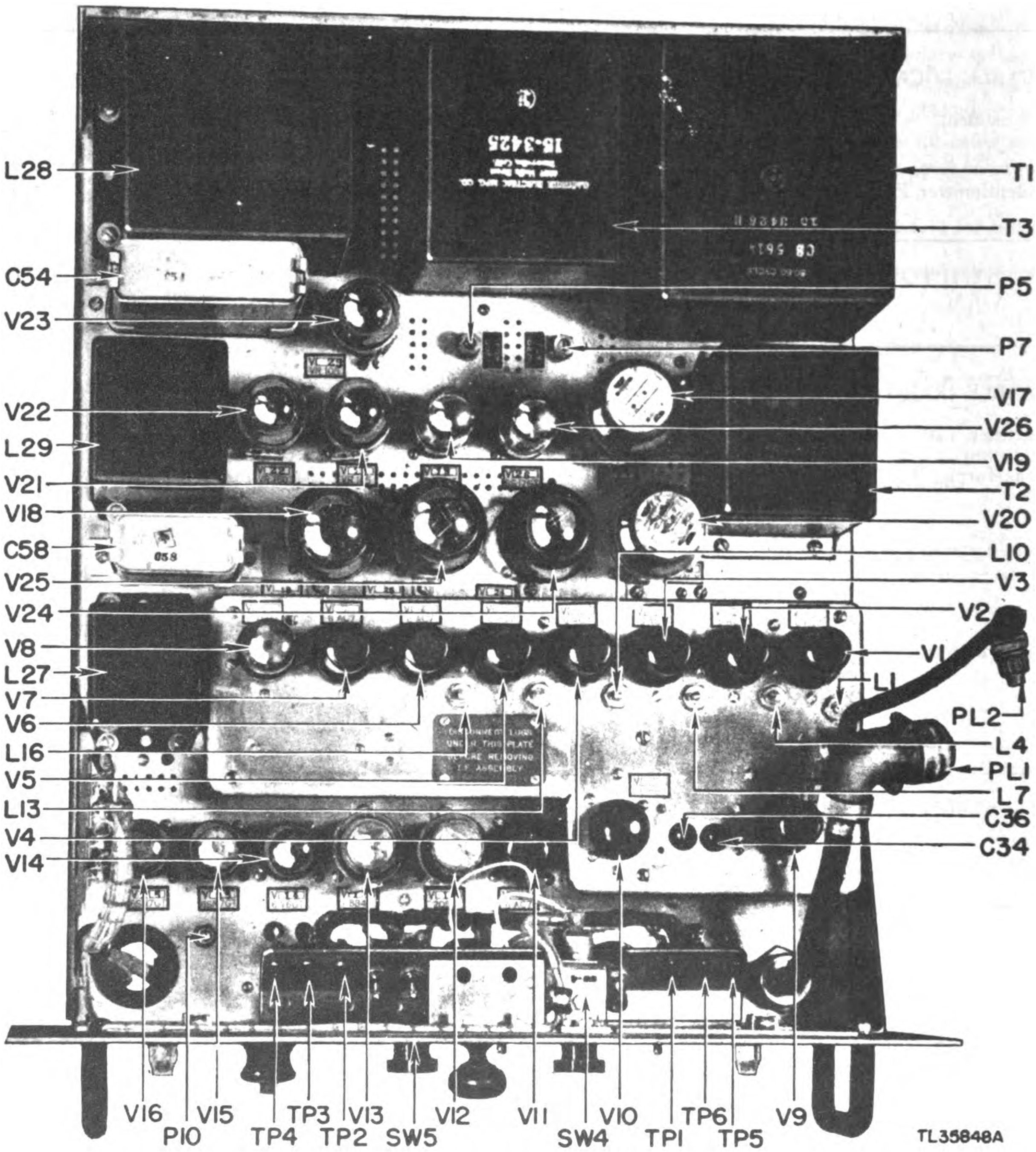


Figure 336. Radar Receiver R-38/MPN-1, top view.

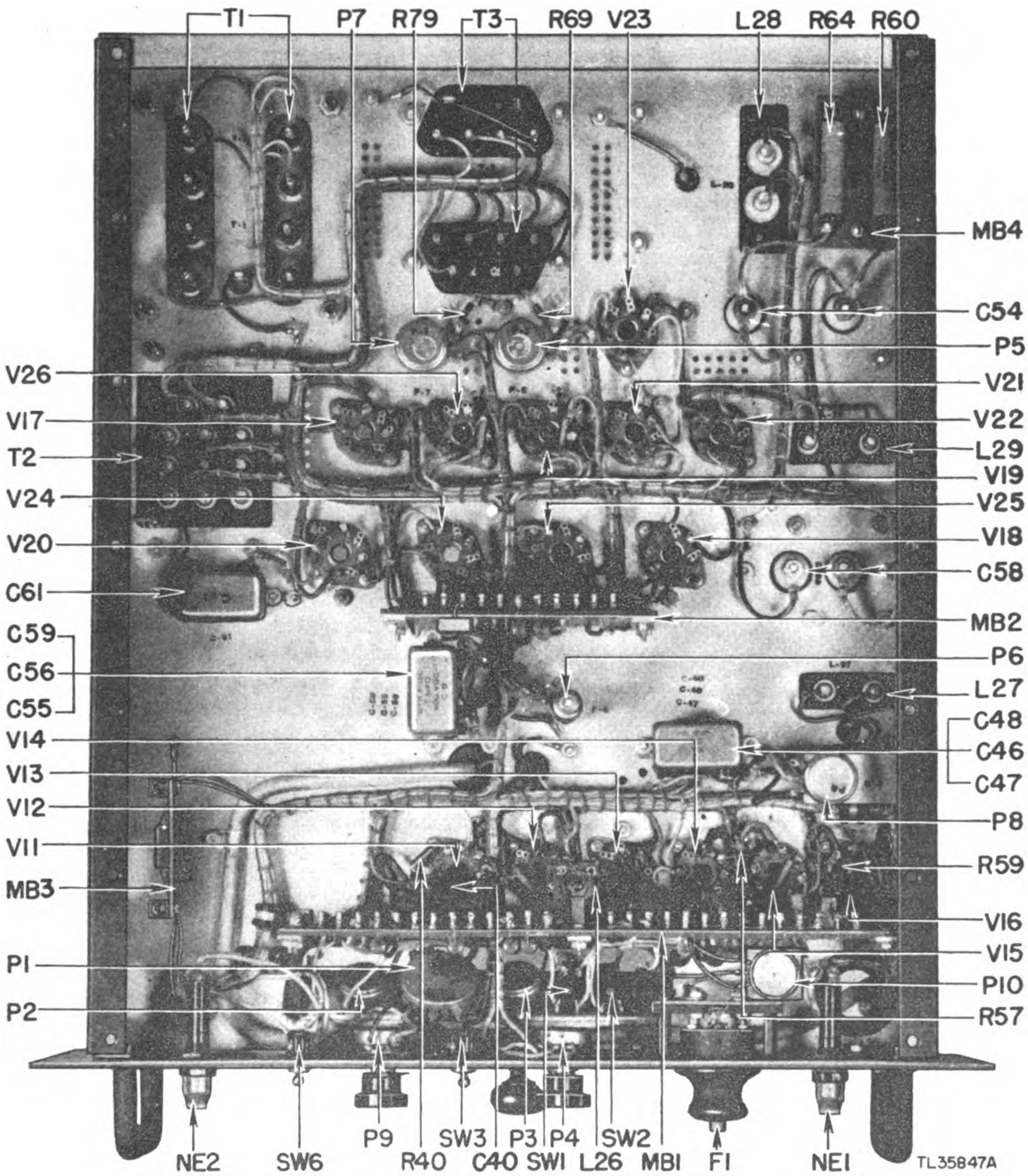


Figure 337. Radar Receiver R-38/MPN-1, bottom view.

179. ADJUSTMENT OF RECEIVER POWER SUPPLIES. Before attempting to tune or align the search system, the regulated power supplies in the radar receiver should be adjusted to give the proper output voltages. This is done in the following manner:

a. Adjust P5 to obtain 300-volt output on test point TP5.

b. Adjust P7 to obtain 220-volt output on test point TP6. Switch SW3 should be set to the LOCAL position and gain control P4 fully advanced.

c. Adjust P6 to obtain +105-volt output as measured on terminal 6 of connector strip CS12. Do not disconnect the preamplifier unit when making this measurement. P4 should be fully clockwise.

180. TUNING SEARCH SYSTEM LOCAL OSCILLATOR.

a. Set the controls on Synchroscope TS-64 as follows:

(1) SELECTOR SWITCH to position AS when checking the channel A system and to position BS when checking the channel B system.

(2) SYNCHROSCOPE SWEEP SPEED to position 4.

(3) CRT INPUT to AMP.

(4) INPUT TRIG. switch to A. SYS. when checking the channel A system and to B. SYS. when checking the channel B system.

(5) The VIDEO AMPLIFIER GAIN control so that the signals do not saturate the cathode-ray tube.

(6) The VIDEO AMPLIFIER ATTENUATOR switch to position 10:1.

(7) Adjust the FOCUS intensity (INT.) and CENTERING controls.

b. Adjust the radar receiver controls as follows:

(1) Turn the LOCAL-REMOTE switch SW3 on the radar receiver to the local position.

(2) Turn switch SW1 to manual (downwards).

(3) Turn switch SW2 to the off position (downwards).

(4) Turn potentiometer P1 to maximum (clockwise).

(5) Turn the receiver gain control P4 to maximum (clockwise).

(6) If the receiver is operating properly, grass should appear on the synchroscope.

> WARNING: The crystal current should not exceed 0.8 ma at any time during the adjustment of the local oscillator or the crystal may be damaged. Keep the crystal coupling probe adjusted so that this current value is not exceeded.

c. Turn off the radar receiver. Remove the local oscillator tube and its mounting from the chassis and adjust the six cavity slugs to a uniform depth fairly well into the cavity. Reinsert the local oscillator tube and its mounting on the chassis and see that the local oscillator mounting is pushed all the way to the rear of the chassis for maximum coupling with the output loop. Make certain that the cavity is not shorted to ground. Turn on the receiver.

d. Rotate potentiometer P2 from one extreme to the other, watching the crystal current meter. Set potentiometer P2 to the position where maximum crystal current occurs. If the crystal current is too high or too low, adjust the local oscillator coupling probe on the crystal mixer to give a crystal current of approximately 0.5 milliamperes.

e. Turn on the transmitter and adjust the control variac so that the magnetron current is 18 milliamperes. Swing the repeller voltage (adjusted by potentiometer P2) through its extreme range, watching for signals on the synchroscope. Note the crystal current. If no signals appear on the synchroscope, turn the receiver off, adjust the depth of the two front local oscillator cavity tuning plugs, and again turn on the receiver and continue to swing potentiometer P2 through its entire range.

> NOTE: When the crystal metering plug is in jack JK1 of the preamplifier unit for crystal current measurement, the signals may be attenuated or distorted.

f. When signals have been located, select the mode of oscillation which gives the best signals. This corresponds to the greatest crystal current, and the highest setting of potentiometer P2. From this point on, work with the minimum setting of receiver gain control P4 that will give satisfactory signals. If signals are not located, turn the receiver off. Open the local oscillator chassis and turn the four front cavity tuning plugs out one turn each. The plugs should be of uniform depth in the cavity. Repeat steps given in subparagraphs *d* through *f*.

g. If care has been taken to see that no signals were skipped in the steps given in subparagraphs *d* through *f*, the local oscillator frequency will be above the magnetron frequency.

h. By coordinating the tuning of potentiometer P2 and the local oscillator front two cavity tuning plugs, a combination which gives maximum signal strength and maximum crystal current at the same time should be obtained.

i. The local oscillator repeller plate voltage should now be varied by means of potentiometer P2, and the signals should gradually grow to a maximum and gradually decrease to a minimum. The crystal current should reach a maximum at the same time that the signals reach a

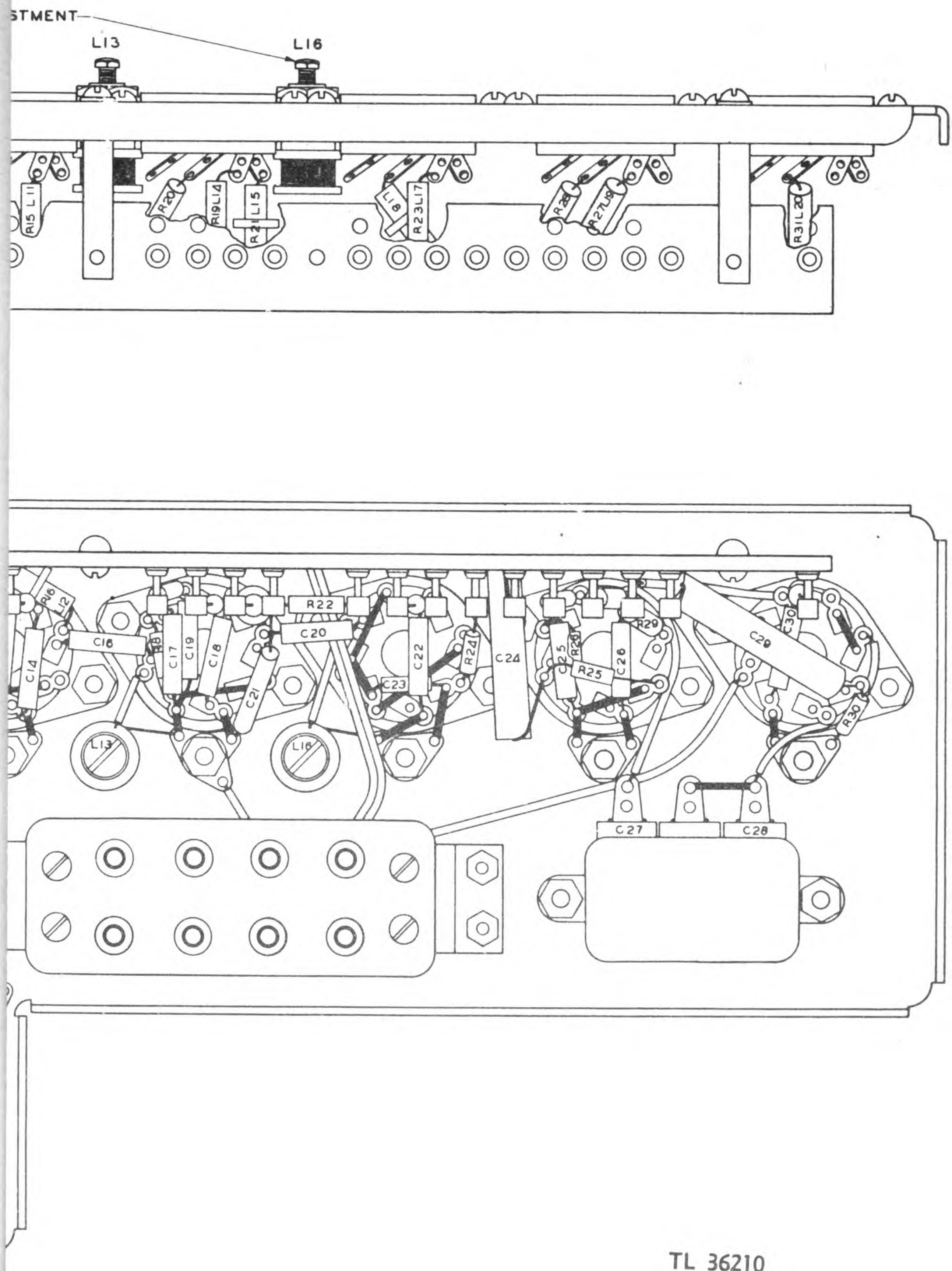


Figure 338. Radar Receiver i-f strip, bottom view.

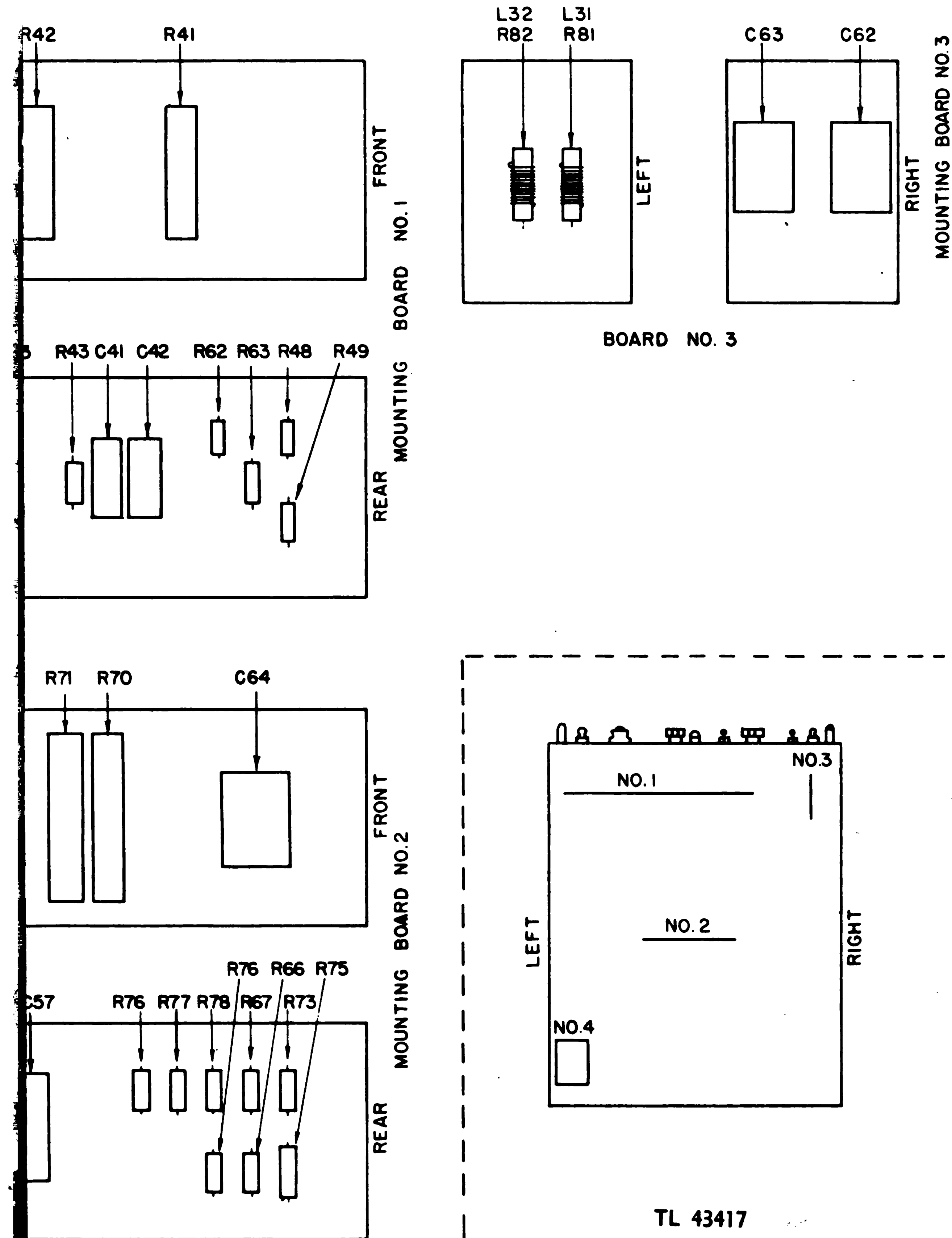
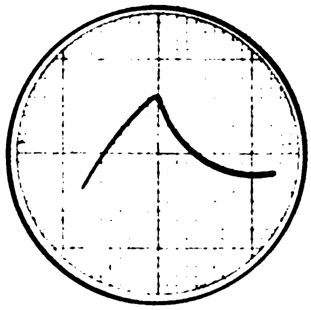
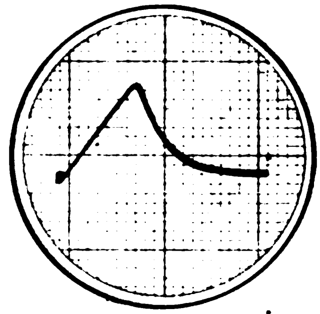


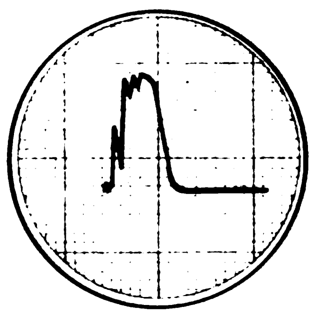
Figure 339. Radar Receiver R-38/MPN-1, mounting boards.



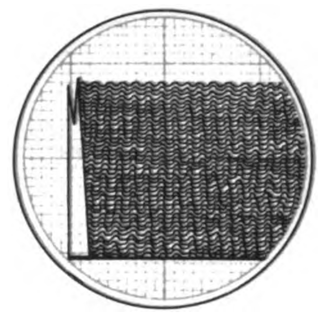
3
STC OUTPUT AT TP2
SYNCHROSCOPE SWEEP SPEED 4
VIDEO AMPLIFIER GAIN ⅔ maximum
VIDEO AMPLIFIER ATTENUATOR 10:1



4
PLATE OF STC SWITCH TUBE V16a AT TP3
SYNCHROSCOPE SWEEP SPEED 4
VIDEO AMPLIFIER GAIN ⅔ maximum
VIDEO AMPLIFIER ATTENUATOR 10:1



7
TRIGGER FROM SYNCHRONIZER ON CS12-4
SYNCHROSCOPE SWEEP SPEED 3
VIDEO AMPLIFIER GAIN ¼ maximum
VIDEO AMPLIFIER ATTENUATOR 1:1



8
MODULATION PATTERN DURING RECEIVER TEST
SYNCHROSCOPE SWEEP SPEED 3
VIDEO AMPLIFIER GAIN ⅛ maximum
VIDEO AMPLIFIER ATTENUATOR 10:1
SELECTOR switch to appropriate AS, BS, AX, or BX position for receiver under test.

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Figure 340. Radar Receiver R-38/MPN-1, waveforms.

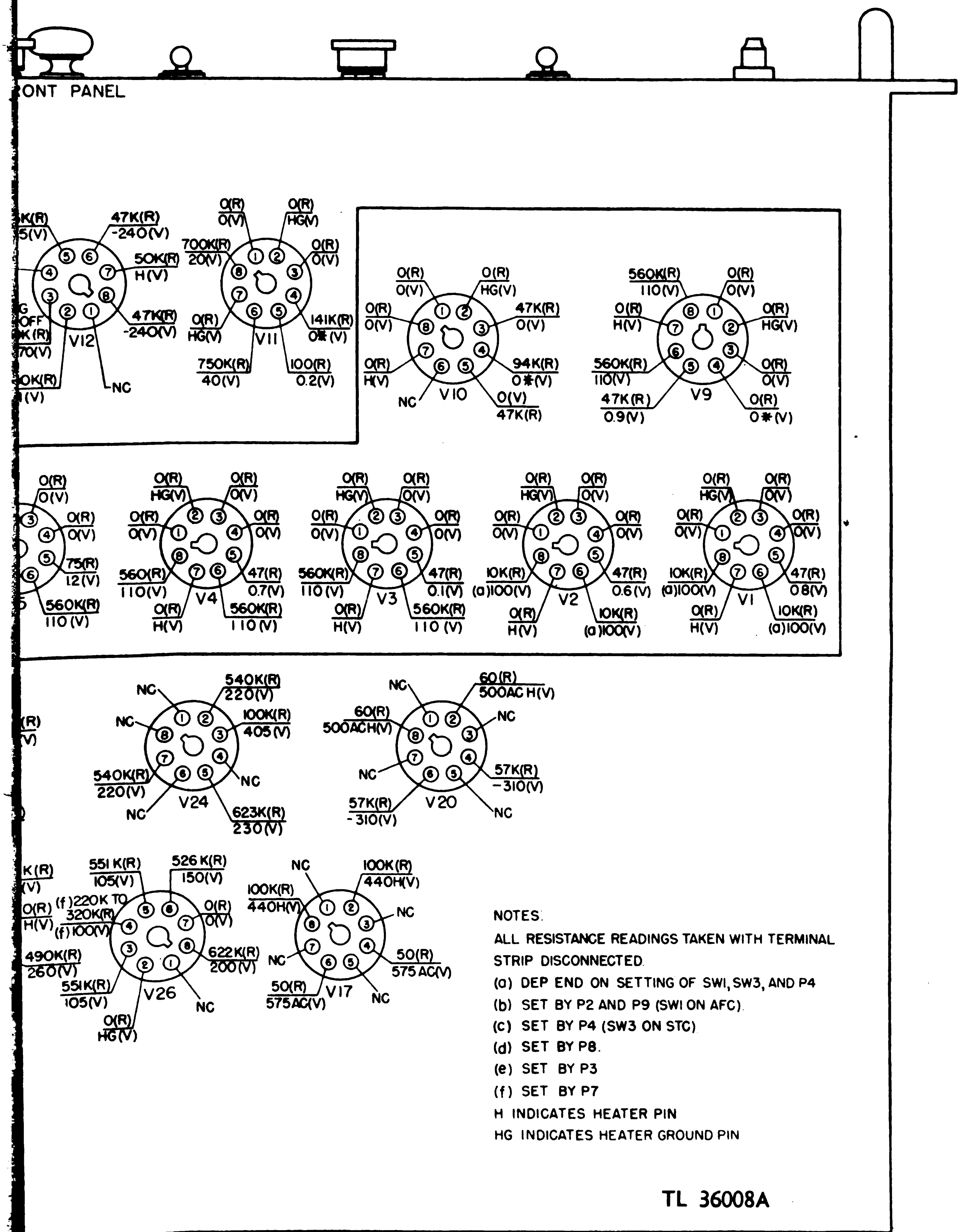


Figure 341. Radar Receiver R-38/MPN-1, voltage and resistance chart.

maximum. If the crystal current and the signals do not reach a maximum at the same time, turn the local oscillator coupling loop slightly clockwise and repeat the steps given in subparagraphs *e*, *f*, *h*, and *i*. Recheck the crystal current and adjust, if necessary, to 0.5 milliamperes. Repeat the procedure until the crystal current and signals reach a maximum at the same time. Do not reduce the coupling of the local oscillator to the extent that it materially reduces the signal strength. Note that changing the local oscillator coupling changes the tuning of the cavity.

j. Adjust the local oscillator coupling probe in the crystal mixer to give a crystal current of from 0.5 to 0.7 milliampere, and check the local oscillator wavelength with the S-band echo box in the following manner:

(1) Tune the S-band echo box to the magnetron wavelength and note the reading.
(2) Turn off the transmitter.
(3) Disconnect the local oscillator coupling cables from the crystal mixer.
(4) Connect the S-band echo box to the local oscillator.
(5) Turn the echo box tuning knob so that the pointer moves toward the left (higher numbers) of the dial reading from the magnetron frequency as measured in (1) above. The tuning knob should be turned so that the pointer moves approximately 3 or 4 divisions. If the local oscillator is tuned properly, a microammeter indication should be observed around that point. If no indication is found, move the calibration pointer 3 or 4 divisions toward the right of the dial setting found when measuring magnetron frequency. If an indication on the microammeter is observed at this point, the local oscillator is tuned to a frequency lower than that of the magnetron and it should be retuned.

k. Make a final adjustment of the repeller plate voltage by setting potentiometer P2 and the vernier control P9 for maximum signal strength.

181. TUNING THE AFC CIRCUIT.

a. Adjust potentiometers P2 and P9 in the radar receiver for maximum echo box signal response with the gain control switch SW3 on LOCAL. and switch SW1 AFC off. Connect test point TP1 to the SIG. IN jack on the synchroscope and set the controls as follows:

(1) SELECTOR switch to position SYNCH.
(2) CRT INPUT switch to AMP.
(3) SYNCHROSCOPE SWEEP SPEED to position 4.
(4) INPUT TRIG. switch to A. SYS. if the channel A system is being checked and to B. SYS. if the channel B system is being checked.
(5) VIDEO AMPLIFIER ATTENUATOR to position 10:1.
(6) Adjust the INTENSITY, FOCUS, and CENTERING controls.

b. Tune the secondary of the discriminator transformer by adjusting capacitor C36 to the main transmitter pulse. This will give a waveform on the synchroscope that is maximum in the downward direction (fig. 340). Use a nonmetallic screwdriver for all discriminator tuning adjustments. Tune the primary of the discriminator transformer by adjusting capacitor C34 so that it also makes the waveform maximum in the downward direction. Then tune capacitor C36 to a point where a few scattered pulses are upward but most of them are still downward as shown in figure 340.

c. Adjust potentiometer P2 for maximum signal strength, turn on switch SW1 AFC, and check that the echo box signals are at least equal to the maximum signal strength observed when the AFC circuit is off. The AFC circuit should lock in and hold.

d. To check the AFC circuit operation, turn potentiometer P2 slowly through its range. The AFC circuit should hold the signal at maximum strength for a variation in the setting of P2. After this check, turn off switch SW1 AFC and retune potentiometers P2 and P9 for maximum signal strength. Again turn on switch SW1 AFC and change the transmitter frequency by decreasing the voltage applied to the high-voltage power supply. This is done by slowly decreasing the setting of the variac control. The AFC circuit should hold the signals at near maximum strength through a variation in the magnetron current of 5 milliamperes or more.

182. ADJUSTMENT OF THE STC CIRCUIT.

Not all units of Radio Set AN/MPN-1 are equipped to use the STC circuit in search system. All precision receivers have a positive trigger pulse from the synchronizer wired to terminal 4 on the connector strip. On search receivers that do not have this input trigger pulse connection wired in, it will be necessary to run a jumper from terminal 4 on the connector strip of the precision receiver to terminal 4 on the search receiver. It is desirable to have the STC circuit lined up on all four radar receivers in Radio Set AN/MPN-1 so that they may be interchanged between the search and the precision systems.

a. The controls on the synchroscope should be set in the following manner:

(1) Connect test point TP4 on the radar receiver to the SIG. IN connection on the synchroscope.
(2) Set the SELECTOR switch to SYNCH.
(3) Set the SYNCHROSCOPE SWEEP SPEED to position 4.
(4) Set the CRT INPUT switch to AMP.
(5) Set VIDEO AMPLIFIER ATTENUATOR to 10:1.

(6) Set the INPUT TRIG. switch to A. SYS. when checking the channel A system and to B. SYS. when checking the channel B system.

(7) Set the VIDEO AMPLIFIER GAIN CONTROL so that the cathode-ray tube is not saturated.

b. (1) Check that a positive trigger pulse of approximately 50 volts amplitude is supplied to terminal 4 of the receiver. Observe the waveform at test point TP4, with switch SW2 in the ON position. The trace should appear as the negative gate or rectangular wave (fig. 340). For the precision system receiver, use a SYNCHROSCOPE SWEEP FEED setting of 4 and adjust the gate length with potentiometer P8 to approximately 108 microseconds. If the STC circuit is to be used for the search system receiver, use a SYNCHROSCOPE SWEEP SPEED setting of 5, and adjust the gate length to slightly over 300 microseconds.

(2) Next observe the waveform at receiver test point TP3, using the same synchroscope adjustments as above. The waveform should be a positive-going saw-tooth voltage wave of the same duration as the gate voltages observed at TP4. The slope of this saw-tooth wave may be adjusted by varying potentiometer P3. The setting of P3 will be determined by the conditions necessary to minimize near-by ground return appearing on the search and precision indicators.

c. Turn switch SW2 STC to the OFF position and measure the d-c voltage at test point TP2. Gain control switch SW3 should be on LOCAL so that local gain control can be used. Observe the voltage variations on TP2 as the gain control is varied from a counterclockwise to a full clockwise position. The voltage should vary from approximately 0 to 105 volts.

d. Turn switch SW2 STC on, and connect test point TP2 to the synchroscope. Observe the saw-tooth waveform output of the STC circuit superimposed upon the d-c voltage level of the gain control circuit (fig. 340). This is the form in which the STC voltage is applied to the plates and screen grids of tubes V1 and V2 in the i-f strip.

183. CHECKING RECEIVER BAND PASS WIDTH.

a. Use a Hickok 19X or similar signal generator and tune it to produce a 30-megacycle output. Because the dial setting may not be accurate, a signal generator should be used that has been checked against a standard signal generator. Disconnect the coaxial input cable to the preamplifier unit and connect the signal generator to the input of the preamplifier. Connect an oscilloscope to the video output of the receiver (terminal 8 on the connector strip). Keep the attenuation control on the signal generator as low as possible and still have signals of sufficient amplitude to overcome the noise level of the receiver. Amplitude modulate signal generator about 30 percent while keeping the receiver and oscilloscope gain controls low enough to prevent saturation. If the receiver has the proper band pass width (2 megacycles) the signal on the oscilloscope should remain approximately the same amplitude when the signal generator frequency is moved from 29 to 31 megacycles; 1 megacycle each side of the i-f frequency.

184. I-F ALIGNMENT OF RECEIVER AND VIDEO AMPLIFIER.

a. Test Equipment Required.

(1) Dumont test oscilloscope.

(2) Sweep frequency generator (f-m signal generator giving a center frequency of 30 mc with a frequency spread of 4 to 5 mc each side of center).

(3) Weston analyzer model 772.

b. Test Bench Requirements. The receiver and heterodyne converter should be mounted on a suitable test bench with adequate ground connection for both components. The Dumont oscilloscope vertical deflecting plates are connected to the video output of the i-f strip at pin 8 of tube V8 or to terminal 8 of the receiver connector strip. Connect 117 volts ac to the receiver input (terminals 1 and 2) on the connector strip. The receiver regulated power supplies should be adjusted as indicated in paragraph 179 before i-f alignment is attempted.

c. Test Procedure.

(1) Adjust the signal generator for an output of approximately 500 microvolts at 30 megacycles, with 30 percent 1,000-cycle modulation. Connect the output from the signal generator to the i-f input (PL1) of the radar receiver. When the receiver is turned on, the modulation pattern of the signal generator output should appear on the oscilloscope. If it does not, the output should be increased until the modulation waveform does appear. If no signal can be made to appear on the oscilloscope, the signal generator connection should be moved to the grid of a stage nearer the receiver output until signal detection is possible. When the modulation pattern appears on the oscilloscope, the tuning screws protruding from the i-f strip for each stage should be adjusted for maximum output. Using a nonmetallic screwdriver, first adjust L16 in the grid circuit of V6 for a maximum response signal on the oscilloscope. Then, in order, tune L13, L10, L7, and L4, for maximum output from each. As the tuning progresses from stage to stage, hold the oscilloscope vertical gain constant but reduce the input signal from the sweep generator. After final adjustment of these stages, the sweep generator input to the receiver should be approxi-

mately 100 microvolts. Reduce the sweep generator output after each coil is tuned in order to prevent saturation of the receiver.

CAUTION: As the i-f stages are rather broadly tuned (2-megacycle band width), it is necessary to use great care in adjusting the coils so that band width of each stage centers at 30 megacycles.

(2) To tune the input stage V1, it is necessary to take special steps, since the tuned inductance L1 is directly in series with the signal generator output and is shunted by the low resistance of R1 (75 ohms). Disconnect one end of R1, and place a noninductive resistor of 500 ohms value in series with the sweep generator output. Reconnect the sweep generator to the i-f input of the radar receiver and tune the first stage in the manner outlined above. When this stage is properly in tune, reconnect resistor R1 and connect the preamplifier unit i-f output coaxial line to the input of the receiver.

(3) To align the two preamplifier i-f stages, connect the generator to the preamplifier by removing the crystal and connecting the sweep generator leads across the coaxial crystal mixer output as follows: Place a 1,000-ohm resistor in series with the nongrounded output lead of the sweep generator. The 1,000-ohm resistor is so placed that its other pigtail lead makes contact at the bottom of the crystal socket. With the second sweep generator lead grounded, set the sweep generator frequency to 30 megacycles and adjust for 50 percent modulation at approximately 1,000 cycles.

(4) Tune the grid inductances in the two preamplifier stages in the same manner as outlined above for the receiver proper.

(5) To complete the i-f alignment of the receiver and preamplifier, make certain that the maximum signal output is obtained from all stages after they have been tuned.

d. Test Bench Alignment of the AFC Circuit. The AFC circuit of the radar receiver can be aligned by making use of the same test equipment and connections used for the i-f alignment procedure. It is done in the following manner:

(1) Tune capacitor C34 (using a nonmetallic screwdriver) for a maximum signal on the test oscilloscope. To observe this signal, place the oscilloscope test lead at test point TP1 in the radar receiver discriminator circuit. If tuning C34 produces no signals, detune C36 slightly until a signal appears, then set C34 to make the signal a maximum.

(2) Place one of the oscilloscope leads on the grid of V11 (pin 4) and the other lead to the chassis ground. Observe the peak output when the sweep generator frequency is changed gradually from 28 to 32 megacycles. Tune C34 so that the output is symmetrical above and below 30 megacycles. The sweep generator output must be kept low enough so that the grid of V11 is not driven positive at any time.

(3) When capacitor C34 has been correctly tuned, set the sweep generator output to 30 megacycles and tune C36 for zero signal. Tuning the signal generator through 30 megacycles should then give the zero signal at the 30-megacycle setting and a symmetrical output for frequencies above and below 30 megacycles as illustrated in figure 61.

(4) The final tuning of the AFC discriminator circuit should be done when the receiver is reinstalled in Radio Set AN/MPN-1. The complete field tuning procedure for the AFC circuit is given in paragraph 181.

SECTION IV

INDICATING SYSTEM

185. REFERENCE DATA.

a. Search Indicator ID-35/MPN-1.

(1) Figure 71. Front view, showing control panel.
(2) Figure 342. Rear view.
(3) Figure 72. Schematic diagram.
(4) Figure 346. Waveforms.
(5) Figure 348. Voltage chart.

b. Search Central SN-6/MPN-1.

(1) Figure 68. Front view, showing control panel.
(2) Figure 343. Top view.
(3) Figure 344. Bottom view.
(4) Figure 345. Mounting boards.
(5) Figure 86. Schematic diagram.
(6) Figure 347. Waveforms.
(7) Figure 349. Voltage chart.
(8) Figure 350. Resistance chart.

c. Intercommunications Panel SB-2/MPN-1.

(1) Figure 70. Front view.
(2) Figure 443. Top view.
(3) Figure 444. Bottom view.
(4) Figure 85. Radar control circuit.

d. General.

(1) Figure 400. Cabling diagram bays 4, 5, and 6.
(2) Figure 254. Resistor color code.
(3) Figure 253. Capacitor color code.

186. PROCEDURE. The search indicator system consists of two search indicators, two search centrals, and the radar control circuit of the intercommunications panel. By treating these components together, it has been possible to arrange trouble-shooting procedures into a logical sequence. In drawing up the chart, advantage was taken of the duplication of equipment which frequently makes it possible to locate a fault by merely flipping a switch. All of the faults considered occur as indications on the indicator cathode-ray tubes. There usually exist several possible causes of any fault appearing. The purpose of the trouble-shooting chart is to trace the fault first to a definite circuit and then to a particular stage. The isolation of a fault to a given stage will generally be followed by a systematic check of voltages and resistances to locate the defective component. Instructions for performing these tests will be found in chapter 6. Following the procedure of the chart will often lead logically to some circuit external to the search indicator system. Trouble shooting will then be continued by referring to the section on the particular system involved. Disassembly of units during trouble shooting will be held to a minimum. Cable connections are not to be removed until their removal is directed in the trouble-shooting chart. Be careful to avoid damaging the heads of the terminal screws or the threads of the terminal boards. The following subparagraphs give hints as to the best method for working on each of the component units.

a. The Search Indicator. Most of the tests that must be made on the search indicator can be performed without removing the unit. In general it will be necessary only to remove the panel section just over the unit. This gives access to the terminal board and to the filament transformer. If it is necessary to examine the connections to the resistor strips or potentiometers remove the front section of the top of the unit.

b. Search Central. Most of the trouble shooting work that will be required on the search central may be performed without removing the unit. By removing the section of the operating desk in front of the search central, the unit may be slid out far enough to give access to the wiring and components under the chassis. Access to the four terminal strips may be had by lifting out the removable section at the center of the search central panel. It is not necessary to remove the terminal strips. Many troubles may be diagnosed by checking the terminals of the search central with the oscilloscope or volt-ohmmeter. The principal waveforms are obtained from test points located on the chassis. Many faults will be traceable to poorly adjusted controls. Controls most frequently needed are adjusted by knobs on the search central, search indicator, or intercommunications panel. Controls less frequently adjusted, whose setting are semipermanent in nature, have screwdriver adjustments accessible at the panel or on the floor of the chassis. Such controls generally require readjustment only when some change has been made in the circuit such as the installation of a new tube or the replacement of a circuit component. Typical controls of this type are the circularity and centering controls on the search central panel. Direction for setting up controls on the search central will be found in paragraph 188.

c. Intercommunications Panel. The complete removal of the intercommunications panel is a job requiring hours of work. However, it will not be necessary to remove the panel for the performance of trouble-shooting checks. Sufficient access to the panel for trouble-shooting work may be had by removing the four screws which hold the panel in the rack and pulling it forward onto the operating desk. The intercommunications panel contains a complicated mass of wiring since it includes not only many of the controls related to the search indicator system, but those associated with the communications and intercommunications equipment at the search operating position as well.

187. TROUBLE-SHOOTING CHART FOR SEARCH INDICATING SYSTEM.

A. SYMPTOMS:

1. No spot or trace on one PPI.
2. Other PPI normal.
3. Precision scopes and transmitter normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Sweep intensity control.	1. Turn up the sweep intensity control to ascertain if a spot can be obtained by this means.

2. Line voltage supply.	2. Note if the map light on the search central and the compass rose lights on the indicator unit are operating. Failure of these lamps to light indicates trouble either in connections to the power line or in the filament transformers of the units.
3. CRT heater voltage supply.	3. Check voltage between terminals 6 and 8 on the filament transformer T1 in the indicator unit. This reading should be 6.3 volts.
4. CRT bias.	4. Check voltage at terminal 20-7 of the indicator unit. This reading should be 10 to 80 volts depending on the position of the SWEEP INTENSITY control. If voltage exceeds 80, check capacitor C17 in the search central for short circuit.
5. CRT anode high voltage.	5. Turn off switch SW11 on the main distribution panel and check to make sure plug PL1 is firm in its socket.
6. Open CRT heater.	6. Remove the metal cap from the top of the tube housing, disconnect the tube socket, and check continuity of heater.
7. Mechanical centering adjustments.	7. Check the adjustment of mechanical centering controls as explained in paragraph 188 of this section.
8. Defective CRT.	8. If none of the preceding steps has cleared the fault, replace the cathode-ray tube according to the instructions given in paragraph 189 of this section.

B. SYMPTOMS:

1. Intense uncontrollable spot on one PPI.
2. Other PPI normal.
3. Precision scopes and transmitter normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. CRT bias circuit.	1*a*. Check voltage at terminal 20-6 of the indicator unit. This reading should be 270 volts. *b*. Absence of this voltage indicates trouble in Rectifier Power Unit PP-27 or in the wiring which supplies this voltage from the search central to the indicator. *c*. Lift off removable section at the center of the search central panel and check for the presence of the 270-volt regulated supply at terminal 25-6 of the search central. *d*. Turn off the voltage supply to the search indicator system, remove terminal strip 20 and measure the resistance between terminal 20-6 and ground. The resistance should be approximately 93K. High resistance indicates an open resistor R1 or potentiometer P2. *e*. Check the resistance between terminal 20-7 and ground. This resistance should vary from 22K to 47K as the sweep intensity control is moved from maximum to minimum brilliance positions. A constant value of 25K indicates that capacitor C2 is shorted. A high value of resistance indicates an open resistor R3 or potentiometer P2, or a faulty sliding contact in potentiometer P2.

C. SYMPTOM:

1. Spot appears on PP1 but cannot be focused.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 300-volt supply to focus coil.	1*a*. Check voltage at terminal 20-5 of the indicator unit. This reading should be 300 volts. Absence of voltage at terminal 20-5 indicates trouble either in the wiring which supplies this voltage to the indicator unit or in Rectifier Power Unit PP-27. Low voltage indicates a probable short to ground in the focus or deflection coils.
	b. Check voltages at terminals 25-2 and 26-4 in the search central. Presence of the 300-volt supply at these terminals indicates an open circuit in the wiring which conveys this voltage to the indicator unit.
	c. If the 300-volt supply is not present at terminals 25-2 and 26-4, trouble shoot Rectifier Power Unit PP-27 according to the procedure given for that unit.
	d. Low voltage at terminal 20-5 indicates a possible short to ground in the deflection coils. Turn off voltage supply to the indicators and check resistance between terminals 21-3, 21-4, 21-7, and 21-8 and ground. A reading less than 20K on any of these indicates a grounded deflection coil.
	2. Turn off the voltage supply to the indicators at the main distribution panel, remove terminal strip 20, and check continuity between terminal 20-5 and ground. This reading should be 20K to 45K depending upon the position of the focus control. A reading greatly exceeding these values indicates that either the focus coil L1 or the focus control P3 is open.

D. SYMPTOM:

1. Spot off center.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Electrical centering control.	1. Adjust electrical centering control until the focused spot at the center of the screen appears superimposed upon the "main bang" pin on the search central panel.
2. Mechanical centering adjustments.	2. If the adjustment afforded by the electrical centering control is not sufficient to bring the focused spot to the center of the screen, further adjustment can be made by means of the three knurled screws which are equally spaced about the cathode-ray tubes housing. These should be adjusted as directed in paragraph 188 of this section.
3. Defective tubes in the sweep circuit.	3. An off-centered sweep may indicate a defective tube in the sweep circuit. This however will give rise to additional indications of trouble. Either the sweep will be absent or it will be distorted, and the checks should be continued as directed under symptom G.

E. SYMPTOMS:

1. No sweep on either PPI.
2. Normal focused spots appear at centers of screens.
3. Precision scopes and transmitter normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Negative trigger pulse.	1*a*. Switch to internal triggering. *b*. If a sweep is obtained with internal triggering, check the external trigger line with an oscilloscope, beginning at terminal 23-4 of search central. Continue by checking for the trigger pulse at terminals 32-3 and 32-7 of the intercommunications panel. *c*. If the trigger appears at terminal 32-3 and not at terminal 32-7, examine trigger selector switch for faulty contact. *d*. If the trigger appears at all of the above mentioned points, there remains the possibility that it may be of insufficient amplitude. Check the wiring and continue trouble shooting in the synchronizer according to the procedure given for that unit.
2. Sine potentiometer.	2*a*. Reverse position of toggle switch on intercommunications panel which controls selection of sine potentiometer voltage supply. If sweep appears on one PPI, trouble is in the Rectifier Power Unit PP-27 which supplies the other PPI. Check at terminals 26-6 and 26-8 of the search central for the presence of the negative 150-volt and positive 270-volt supplies. *b*. Using a d-c meter, check the voltages at terminals 24-1, 24-2, 24-3, and 24-7 of the search central, with the search antenna running. These voltages vary continuously from 150 volts positive to 150 volts negative. Absence of any one of these voltages will cause distortion of the trace rather than a complete disappearance of the trace.

F. SYMPTOMS:

1. No sweep on one PPI; spot appears at center of screen.
2. Other PPI normal.
3. Precision scopes and transmitter normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 300-volt supply to deflection coils.	1*a*. Test operation of focus control. If electron spot cannot be focused, refer to symptom C. *b*. Check voltage at terminals 25-3, 25-4, 25-7, and 25-8. Each should measure 300 volts. *c*. The absence of all of the above voltages indicates an open connection to the center taps of the deflection coils. The absence of one or more of these voltages indicates an open deflection coil. The check should be continued by removing voltage from the unit and checking the deflection coils for continuity.
2. Negative trigger input.	2*a*. Check for the presence of the negative trigger pulse at terminal 23-4 of the search center. *b*. If the trigger pulse is absent, check the negative trigger line to the intercommunications panel. *c*. As an additional check, patch from terminal 23-3 to terminal 23-4 and switch to internal triggering, making sure that the trigger is taken from the search central which is apparently giving trouble. *d*. If the negative trigger pulse is present at terminal 23-4, proceed as directed below.

3. Gating multivibrator.

3a. Check the waveform at TP2. If the negative-going square wave is not obtained at this point, replace the gating multivibrator tube V5.

b. If replacing the tube fails to clear the fault, measure the voltages at the tube socket and check them against the tube socket voltage chart.

4. Sweep circuit.

4a. Check at the grids of switch tubes V9, V10, V11, and V12 for the presence of the negative-going square gating pulse.

b. Check socket pin voltages of switch tubes and sweep amplifiers.

G. SYMPTOMS:

1. Distorted sweep.
2. Range markers distorted or elliptical in shape.
3. Normal or abnormal sweeps appear on all indicators.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Circularity adjustments.	1. If the sweep is elliptical rather than circular, adjust the circularity controls which are located on the search central panel.
2. Input from sine potentiometer.	2a. Check at terminals 24-1, 24-2, 24-3, and 24-7 in the search central for the presence of the sinusoidally varying voltages from the sine potentiometer. The absence of any one of these components will cause severe distortion of the trace.
	b. If one or more of the sinusoidally varying voltages is absent, check the wiring to the sine potentiometer.
3. Sweep circuits.	3a. Check at the grids of the switch tubes for the presence of the negative-going gating pulse.
	b. With the antenna operating, check the waveforms obtained at terminals 25-3, 25-4, 25-7, and 25-8, noting the amplitude of each. If any of these voltages is noticeably greater or less than the others, replace the sweep amplifier tube in that stage.
	c. If replacing the sweep amplifier tube does not improve the waveform, replace the switch tube.
	d. If fault is not cleared by replacing tubes, make a systematic check of socket pin voltages and resistances.

H. SYMPTOM:

1. Return trace not properly blanked.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Intensifying voltage circuit.	1a. Turn down the sweep intensity control until the return trace disappears. Turn down the sweep intensity control until the outward moving trace is of normal intensity.
	b. If the return trace persists and is approximately the same intensity as the normal trace, measure the voltage at terminal 21-2 of the search indicator. This reading normally should be approximately 200 volts.

PROBABLE LOCATION OF FAULT	PROCEDURE
	c. If the voltage at terminal 21-2 is noticeably higher than 200, check this terminal with an oscilloscope for the presence at the positive-going square wave from the gating multivibrator.
	d. Check at terminal 24-8 of the search central for the positive-going square wave of the gating multivibrator. If the positive-going square wave is obtained at this terminal, check the wiring between the search central and the search indicator; that is, from terminal 24-8 to 21-2.
2. Gating multivibrator.	2*a.* Replace gating multivibrator tube V5 in the search central.
	b. If replacing the tube fails to clear the fault, measure the voltages at the socket pins of V5.

I. SYMPTOM:

1. Trace disappears following a strong signal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Clamping diode.	1. Replace clamping diode V1 in the indicator unit.

J. SYMPTOMS:

1. No echoes or very weak echoes on the PPI.
2. Synchroscope shows normal signal intensity.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Video brilliance control.	1. Turn up the video brilliance control to ascertain if signals can be brought to proper intensity.
2. Clamping diode.	2*a.* Replace clamping diode V1 in the indicator unit.
	b. Check the operation of potentiometer P1 for a defective sliding contact.
	c. Check the resistance from terminal 21-1 to ground. This should be 2,000 ohms. A high resistance recording indicates an open potentiometer P1.
3. Intercommunications panel.	3*a.* Remove the intercommunications panel and patch from terminal 33-3 to either 33-4 or 33-8, depending upon whether the channel A or the channel B receiver is being used.
	b. If signals are now obtained on the PPI, trouble in relay RY1 is indicated.
	c. Remove terminal strip 33 and check the continuity of the contacts of relay RY1 between terminal 33-3 and either terminal 33-4 or 33-8, depending upon which channel fails to work.
4. Wiring.	4. If none of the above procedures produces echoes on the screen of the PPI, check the wiring from terminal 33-3 of the intercommunications panel to terminal 21-1 of the search indicator. If these connections are found to be continuous check the wiring from terminals 33-4 and 33-8 to the receivers. This investigation may be made by stopping the search antenna on a strong permanent echo and tracing the signal by means of an oscilloscope.

K. SYMPTOM:

1. Range markers do not appear; sweep trace otherwise normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Range marker brilliance control.	1. Turn up the range marker brilliance control on the search central panel to ascertain if range markers may be obtained by this means.
2. Cathode circuit of CRT.	2. Using an oscilloscope, check at terminal 20-7 of the search indicator for the presence of the range markers. Similarly, check terminal 24-4 of the search central. If range markers appear at either of these two points, the wiring is defective.
3. Mixer amplifier circuit.	3*a*. Check test point TP4 on the search central chassis with the oscilloscope. If range markers appear at this point, trouble in the mixer amplifier circuit is indicated. *b*. Replace V6, the mixer amplifier, and recheck terminal 24-4. *c*. If replacing V6 fails to clear the fault, continue with a check of socket pin voltages and resistances to locate defective component.
4. Range marker circuit.	4*a*. If no output was obtained at TP4 in the tests made above, check TP3 in a similar manner. *b*. If an output of the proper amplitude and form is obtained at TP3, replace V4 and again check for output. If replacing the tube fails to clear the fault, continue with a detailed check of voltages and resistances at the socket pins of V4, paying particular attention to the possibility of an open coil L2 or a defective potentiometer P2. *c*. If no output was obtained at TP3, check at the grid (pin 1) of V3 for the negative-going gating pulse. If the gating pulse appears at this point, replace V3. If replacing the tube fails to clear the fault, continue with a detailed voltage and resistance check, paying particular attention to the adjustment of the 270-volt regulated supply. If this voltage is not of the proper value, ringing oscillator will not operate.

L. SYMPTOM:

1. Too few or too many range markers.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Expansion voltage applied to sine potentiometer.	1*a*. If too few range markers appear on the screen it may be due to too great expansion voltage, causing the trace to extend off the edge of the tube. *b*. Adjust the expansion voltage if necessary by means of R46 in the search central.
2. Gating pulse.	2*a*. If too many or too few range markers appear on the PPI screen, the difficulty may be due to a gating pulse of improper width. *b*. Width of the gating pulse of the 30-mile range may be adjusted by means of P10 in the search central. There is no control provided for varying the width of the gating pulse when using the 7.5- or 15-mile timebases.

3. Range marker frequency adjustments.	3. By using a fixed echo at a known distance, check the frequency of the range marker oscillator. If the distance of the fixed echo is not accurately known, it may be determined roughly by checking on the precision system.

M. SYMPTOM:

1. No identification strobe pulse.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Identification strobe intensity and position controls.	1*a*. Turn up the identification strobe intensity control, making sure that the strobe has been switched to the proper position at the intercommunications panel. Adjust the position control to bring the strobe within the sweep range being used. *b*. If this fails to bring the strobe onto the screen, proceed as directed below.
2. Mixer amplifier circuit.	2. Using an oscilloscope, check for the presence of the strobe pulse at terminal 23-6 of the search central. If the pulse is obtained at this terminal, trouble is indicated in the mixer amplifier circuit.
3. Identification strobe circuit.	3*a*. Check for the strobe pulse at terminal 23-5 of the search central. *b*. If the strobe pulse is obtained at terminal 23-5, proceed to item 4 below. *c*. If the pulse is not obtained at terminal 23-5, check the output of test point TP5. This test point should show a positive-going square wave variable in width by means of the strobe position control. *d*. If the variable square wave is not obtained at TP5, trouble is in the variable multivibrator V7. Continue with a detailed check of socket pin voltages and resistances. *e*. If the variable square wave is present at TP5, trouble is indicated in the circuit of V8. Check the waveforms obtained at socket pins 1 and 4, and continue if necessary, with a detailed voltage and resistance check.
4. Intercommunications panel.	4*a*. If in checking the output of terminal 23-5 as directed in 3*a*, the strobe pulse was found to be present, it will be necessary to check the switching circuits in the intercommunications panel. *b*. Check the operation of the four identification mark switches on the intercommunications panel by attempting to switch the strobe outputs of the two search centrals and various precision indicators. *c*. Remove the rack mounting screws and pull the intercommunications panel out onto the operating desk as far as possible without removing the cables. Check at terminals 30-8 and 30-1 for the strobe pulses from search centrals 1 and 2, respectively. Absence of either of the pulses at these terminals indicates trouble in the wiring external to the intercommunications panel. If the strobe pulses are present at terminals 30-8 and 30-1, remove line voltage and check continuity of switch contacts.

N. SYMPTOM:

1. **Identification strobe intensity is unequal.**

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Mixer amplifier tubes.	1. Since there is no control governing the outputs of the strobe intensities from the two search centrals, the only way of balancing these outputs is to properly match the tubes used in the mixer amplifier circuit. This is done by trial, exchanging tubes until a suitable balance is obtained.

O. SYMPTOMS:

1. No PPI trace with internal trigger from one search central.
2. Normal operation with internal trigger from other search central.
3. Normal operation with external trigger.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Trigger circuit voltage supply.	1*a*. Check at terminal 23-7 in the search central for the presence of the 270-volt regulated supply.
	b. If the 270-volt supply does not appear at terminal 23-7, refer to item 3*a* below.
2. Auxiliary trigger circuit.	2*a*. Check at terminal 23-3 for the presence of the negative-going trigger pulse.
	b. If the negative-going pulse is obtained at terminal 23-3, check for the same pulse at terminal 23-4. If the pulse is not present at terminal 23-4, proceed to item 3*d* below.
	c. If the negative-going pulse was not found at terminal 23-3, check terminal 23-8 in the search central with an oscilloscope for the presence of the positive-going trigger pulse. The presence of this pulse indicates that the oscillator and positive trigger amplifier are operating normally, and trouble is indicated in the negative-going pulse amplifier, V1(b). Make a voltage and resistance check to isolate the defective component.
	d. If no positive-going pulse is obtained at terminal 23-8, the fault is probably in the oscillator circuit. Replace V1 and, if replacing the tube fails to clear the fault, continue with a detailed voltage and resistance check at the socket pins of V1.
3. Intercommunications panel.	3*a*. If in the check made in 1*a* above, the 270-volt supply is not found at terminal 23-7 with the trigger selector switch in the proper position, trouble is indicated in the trigger selector switch on the intercommunications panel.
	b. Unfasten the intercommunications panel from the rack and pull it as far out onto the operating desk as the cables permit. Check at terminals 32-6 and 32-4 for the presence of the 270-volt supply from search centrals 1 and 2, respectively. If either voltage supply fails to appear, trouble is indicated in wiring external to the intercommunications panel.

c. If both 270-volt supplies are present at terminal strip 32, check the voltage at either terminal 33-5 or terminal 32-8, depending upon whether search central 1 or search central 2 is being used. During this measurement, be sure that the trigger selector switch is in the proper position. Failure of the voltage to appear at terminal 33-5 or 32-8 with the trigger selector switch in the proper position indicates a faulty switch contact.

d. If in 2*b* above, the trigger appears at terminal 23-4 in the search central and not at 23-3, place the trigger selector switch in the proper position and check at each of terminals 33-6 and 33-7 for the presence of the negative-going trigger pulse.

e. Absence of the negative-going pulse at these terminals indicates trouble in the wiring between the search central and the intercommunications panel.

f. If the negative-going pulse is obtained at terminals 33-6 and 33-7, check for it at terminal 32-7 with the trigger selector switch in the proper position. If the trigger pulse appears at terminals 33-6 and 33-7 and not at terminal 32-7, trouble in the selector switch is indicated.

188. ALIGNMENT OF CONTROLS.

a. Mirror. The semitransparent mirror must be aligned so that the reflected image of the PPI screen appears to lie in the plane of the map which is mounted on the search central panel. An improper adjustment results in parallax and the reflected image appears to shift its position relative to the map as the observer shifts his head. To adjust the mirror, loosen the locknuts on the three adjusting screws, and turns the screws by means of the knurled head until the position of the reflected image appears satisfactory.

b. Main Bang Pin. The main bang pin, located near the center of the search central panel, is adjustable in position. Loosen the two locking screws which hold the metal slide upon which the pin is mounted, and move the pin until it appears to lie on the center line of the fuselage and about two-thirds of the way back on the wing surface of the airplane image on the navigating head.

c. Centering Controls. The vertical and horizontal centering controls are accessible by means of a screwdriver from the front of the search central panel. These controls should be adjusted until the transmitter pulse appears superimposed upon the main bang pin on the search central panel.

d. Circularity Control. A circularity control for each of the three ranges available with the search system is accessible by means of a screwdriver at the front of the search central panel. These controls are set by switching to each range in turn and adjusting the control until the range marker circles appear perfectly circular.

e. Mechanical Centering Controls. If the sweep cannot be centered by means of the two centering adjustments on the search central panel, it will be necessary to remove the indicators from the rack, patch into the terminal board with long leads, and make adjustments by means of the focus coil mounting screws. Before beginning this adjustment both centering controls should be set to their midpositions. Loosen the knurled mounting screws and move the focus coil until the spot appears centered. Tighten the screws. If this adjustment is made properly, the sweep should be nearly enough centered to permit the adjustment to be completed by means of the electrical centering controls.

f. Sweep Intensity Controls. The sweep intensity control should be adjusted so that the sweep trace is just visible on the screen.

g. Range Marker Brilliance Control. The range marker brilliance control, located on the search central panel, should be adjusted so that the range markers have a brilliance sufficient to paint continuous circles on the screen of the PPI.

h. Focus Control. The focus control should be adjusted so that the range markers appear sharp and distinct. To achieve the proper focus, it may be necessary to readjust the sweep intensity and range marker brilliance controls.

i. Video Brilliance Control. The video brilliance control is set to give echoes the proper intensity. Its setting will depend largely on the choice of the operator.

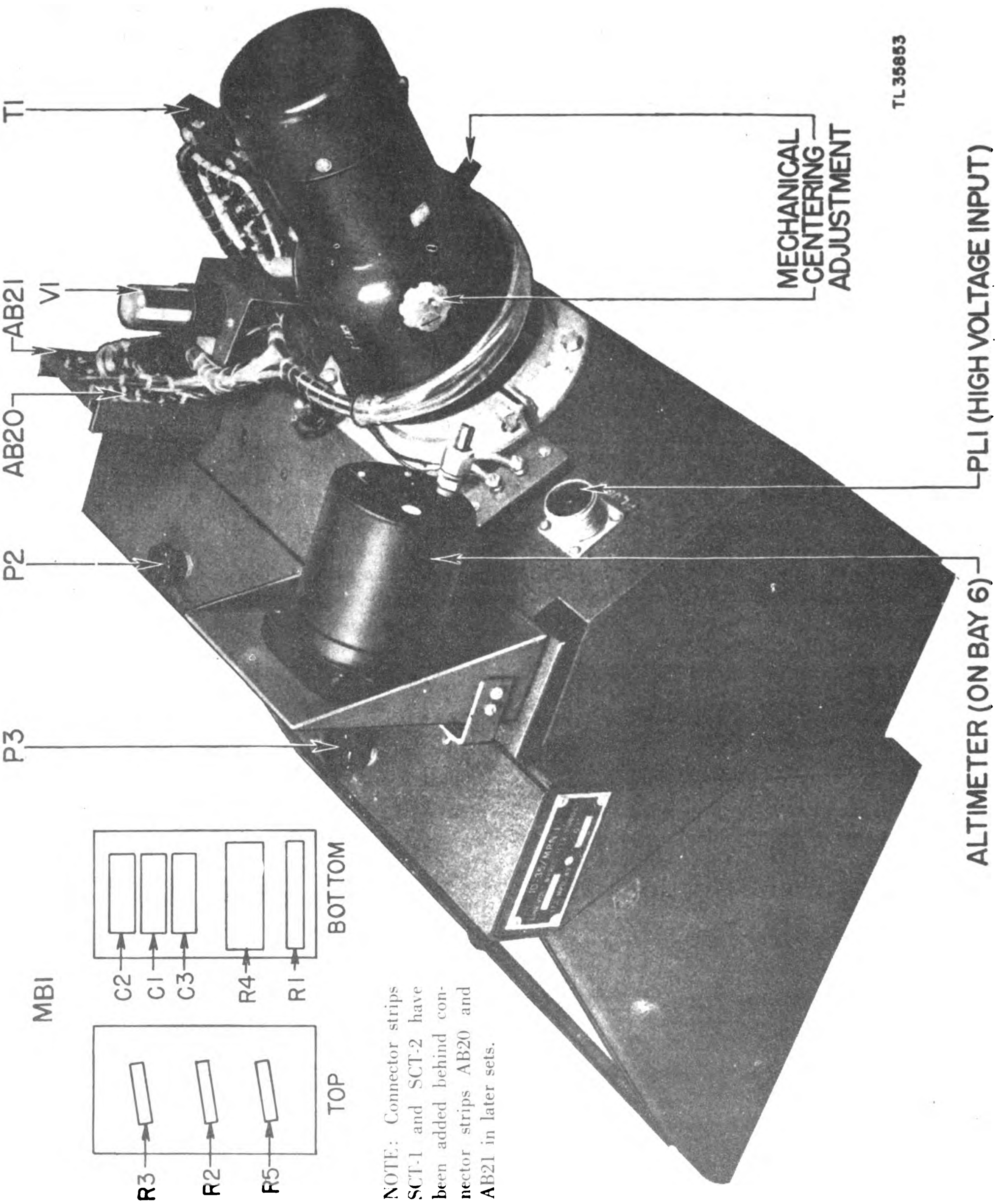


Figure 342. Search Indicator ID-35/MPN-1, rear view.

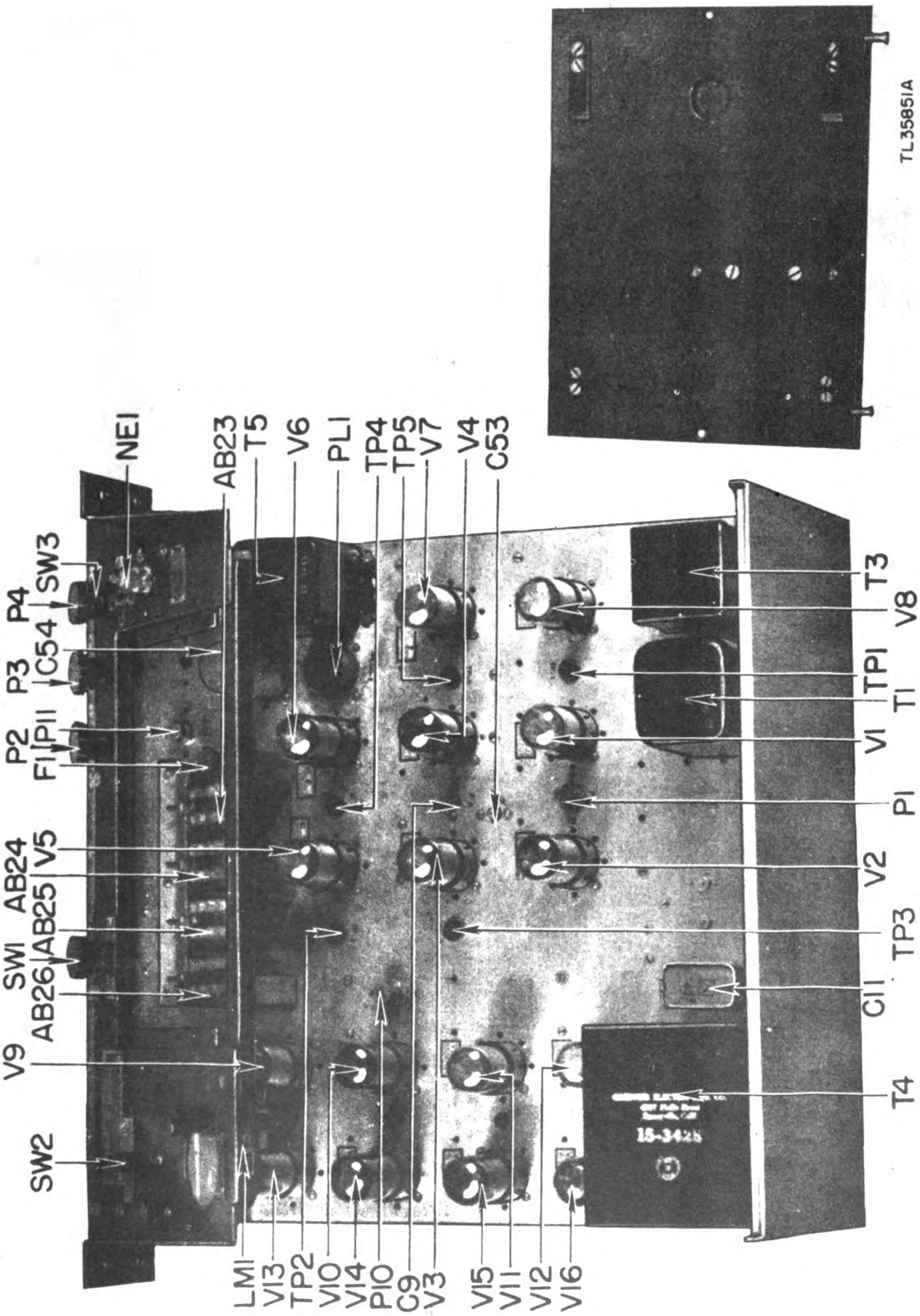


Figure 343. Search Central SN-6/MPN-1, top view.

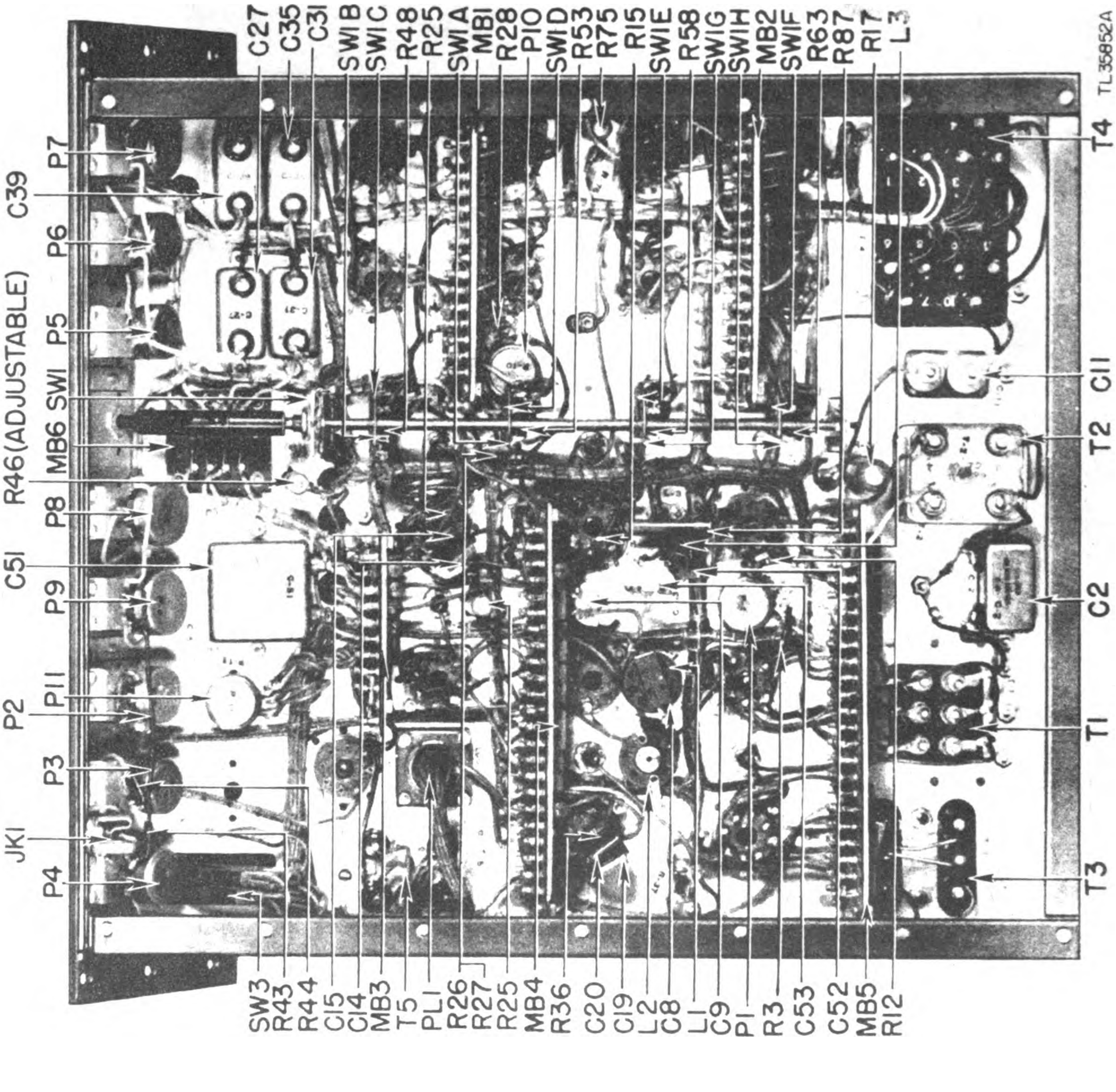


Figure 344. Search Central SN-6/MPN-1, bottom view.

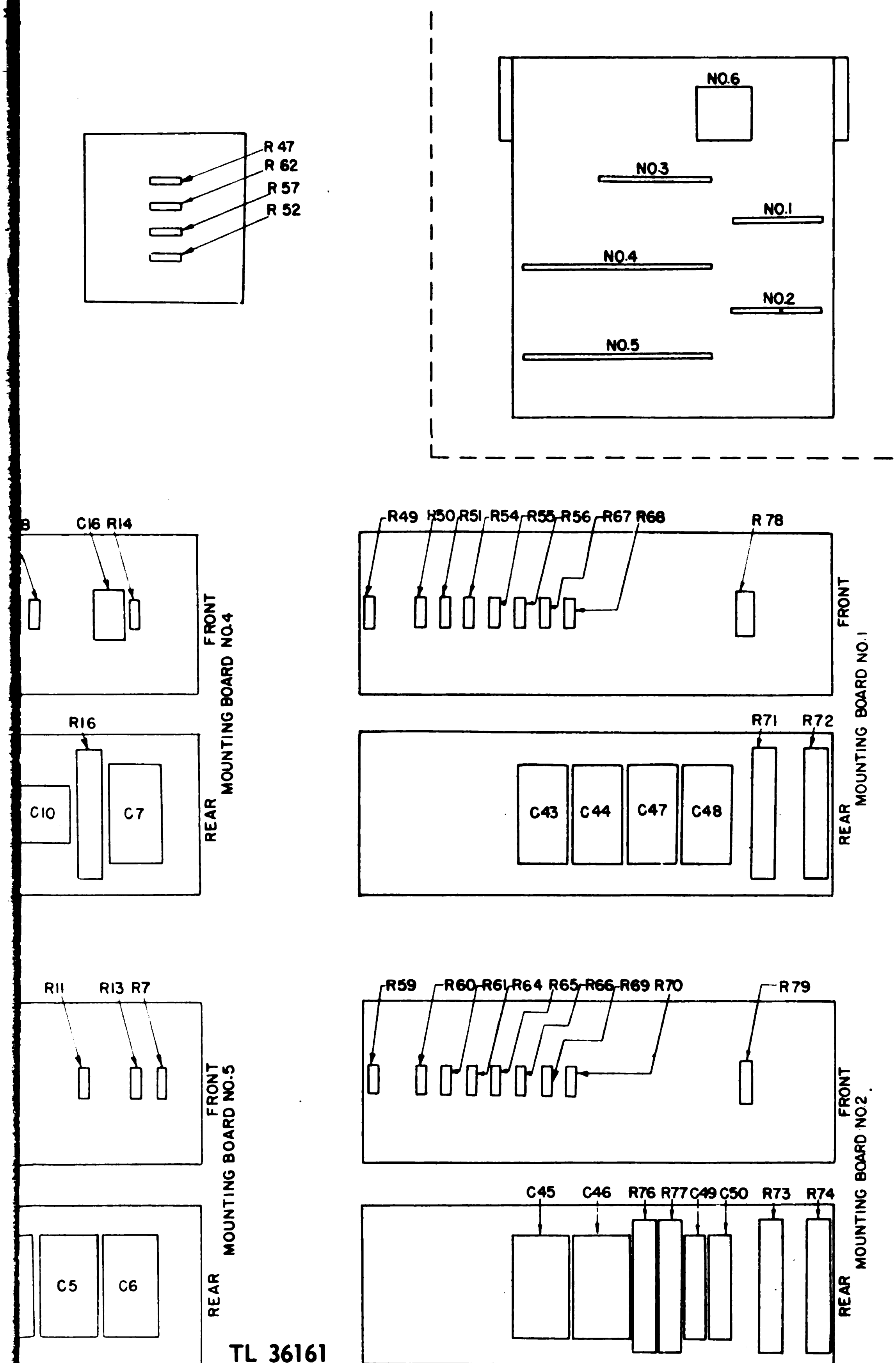
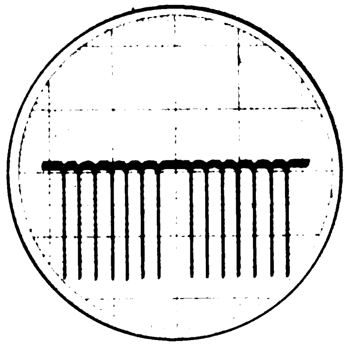
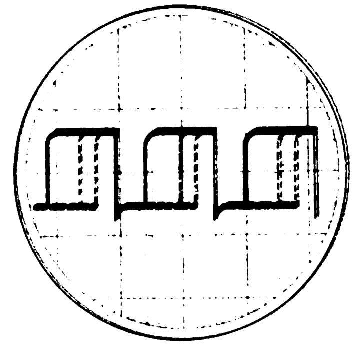


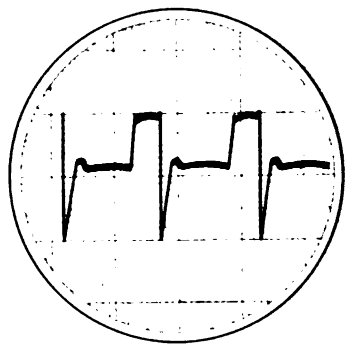
Figure 345. Search Central SN-6/MPN-1, mounting boards.



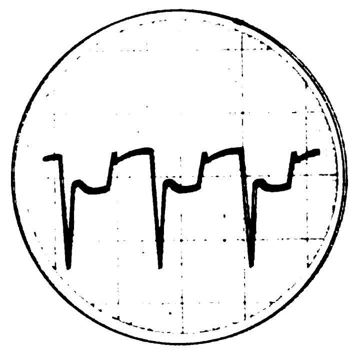
1
RANGE MARKERS, V6(a)
30-mile range
Terminal 20-7
Y ATTENUATOR 10:1
Y GAIN 10



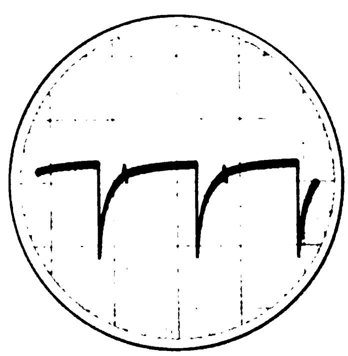
2
GATING MULTIVIBRATOR, V5(b)
Terminal 21-2
Y ATTENUATOR 100:1
Y GAIN 10



3
SWEEP CIRCUIT, V13, V14, V15, and V16
7.5-mile range
Terminals 21-3, 21-4, 21-7, and 21-8
Y ATTENUATOR 100:1
Y GAIN 10



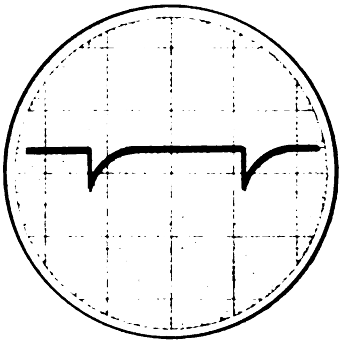
4
SWEEP CIRCUIT, V13, V14, V15, and V16
15-mile range
Terminals 21-3, 21-4, 21-7, and 21-8
Y ATTENUATOR 100:1
Y GAIN 10



5
SWEEP CIRCUIT, V13, V14, V15, and V16
30-mile range
Terminals 21-3, 21-4, 21-7, and 21-8.
Y ATTENUATOR 100:1
Y GAIN 10

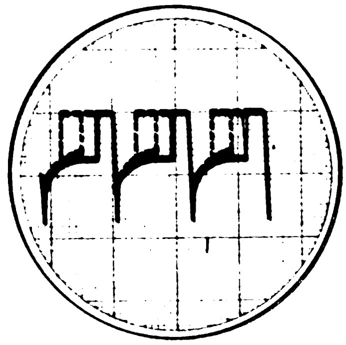
TL 43480

Figure 346. Search Indicator ID-35/MPN-1, waveforms.



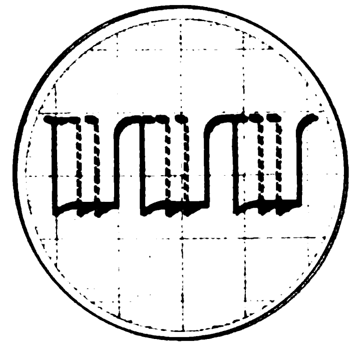
4

V2 **EXTERNAL TRIGGER**
Terminal 23-4
Y ATTENUATOR 100:1
Y GAIN 10



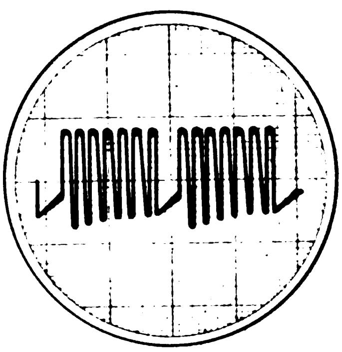
5

GATING MULTIVIBRATOR, V5(a)
Pin 1
Y ATTENUATOR 100:1
Y GAIN 20



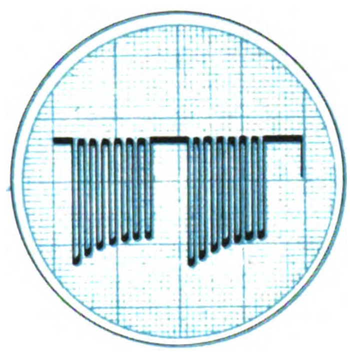
6

GATING MULTIVIBRATOR, V5(b)
Pin 2, TP2
Y ATTENUATOR 100:1
Y GAIN 15



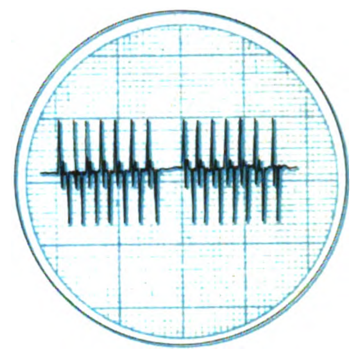
10

RANGE MARKER CIRCUIT, V4(a)
30-mile range
Pin 1, TP3
Y ATTENUATOR 100:1
Y GAIN 50



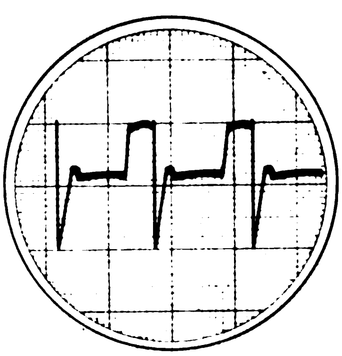
11

RANGE MARKER CIRCUIT, V4(b)
30-mile range
Pin 4
Y ATTENUATOR 100:1
Y GAIN 50



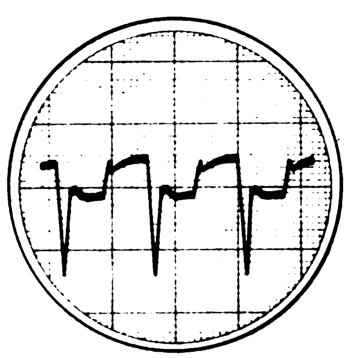
12

RANGE MARKER CIRCUIT, V6(a)
30-mile range
Pin 1, TP4
Y ATTENUATOR 100:1
Y GAIN 50



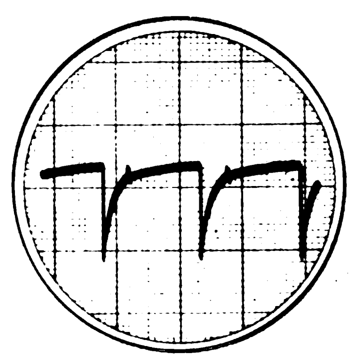
16

SWEEP CIRCUIT, V13, V14, V15, and V16
7.5-mile range
Pin 3, terminals 25-3, 25-4, 25-7, and 25-8
Y ATTENUATOR 100:1
Y GAIN 10



17

SWEEP CIRCUIT, V13, V14, V15, and V16
15-mile range
Pin 3, terminals 25-3, 25-4, 25-7, and 25-8
Y ATTENUATOR 100:1
Y GAIN 10



18

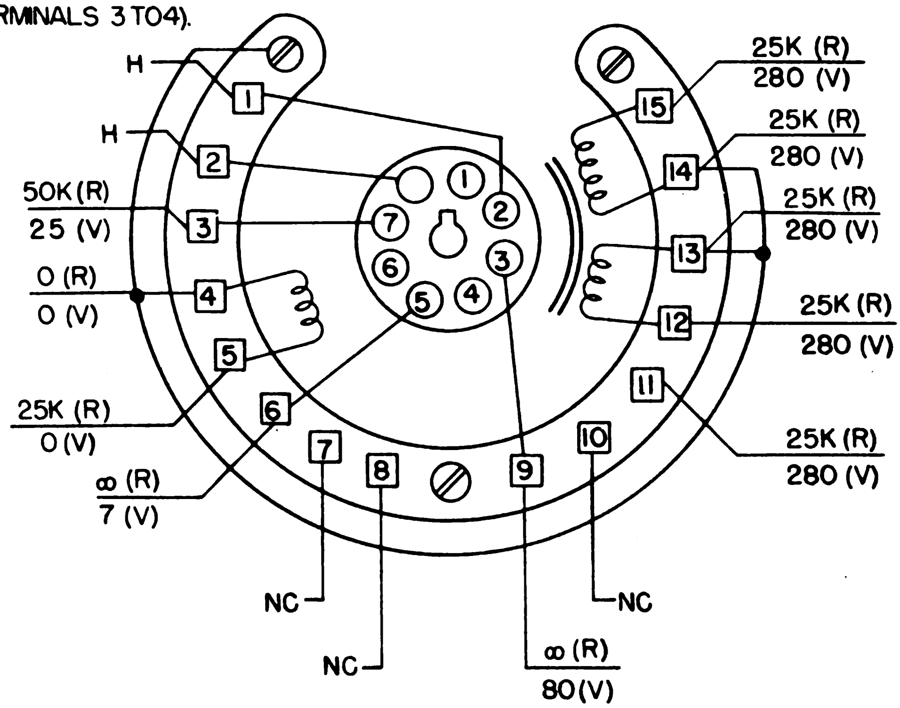
SWEEP CIRCUIT, V13, V14, V15, and V16
30-mile range
Pin 3, terminals 25-3, 25-4, 25-7, and 25-8
Y ATTENUATOR 100:1
Y GAIN 10

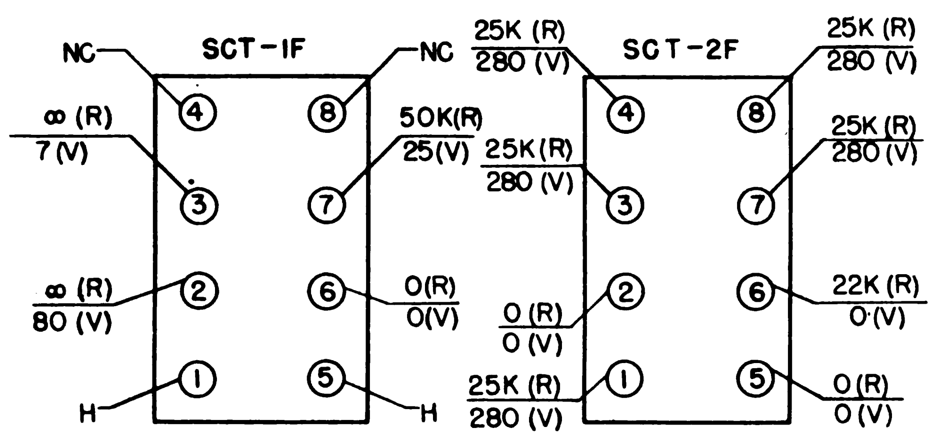
TL 43479

Figure 347. Search Central SN-6/MPN-1, waveforms.

NOTE:

ALL CONTROLS FULLY CLOCKWISE.
MALE AND FEMALE CONNECTOR STRIPS ATTACHED
– i.e. SCT-1F TO SCT-1M AND SCT-2F TO SCT-2M.
FOCUS COIL RESISTANCE 22K.
DEFLECTION COILS RESISTANCE 750 OHMS (TERMINALS 7 TO 8
AND TERMINALS 3 TO 4).





TL 36016A

Figure 348. Search Indicator ID-35/MPN-1, voltage and resistance chart.

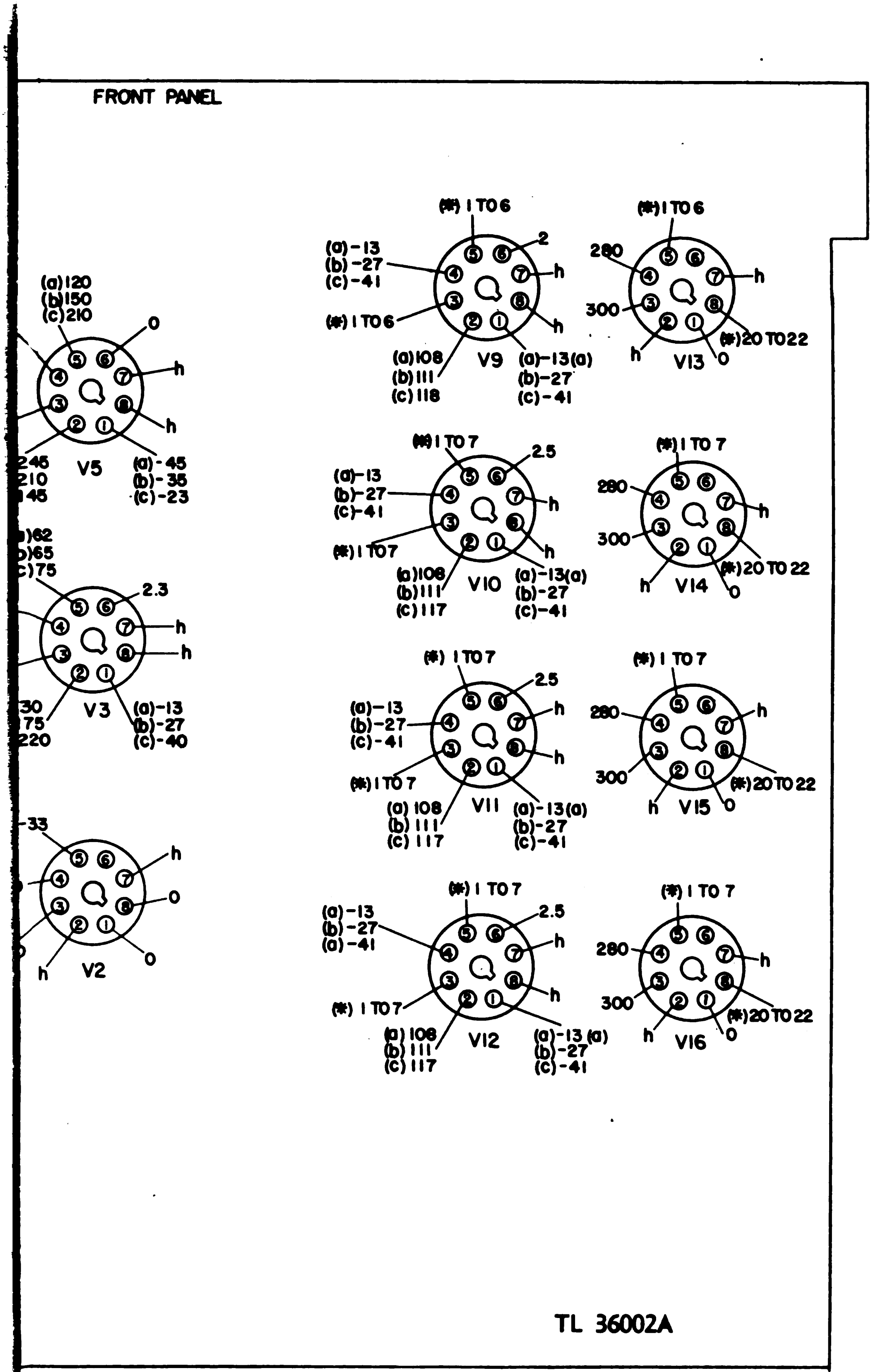


Figure 349. Search Central SN-6/MPN-1, voltage chart.

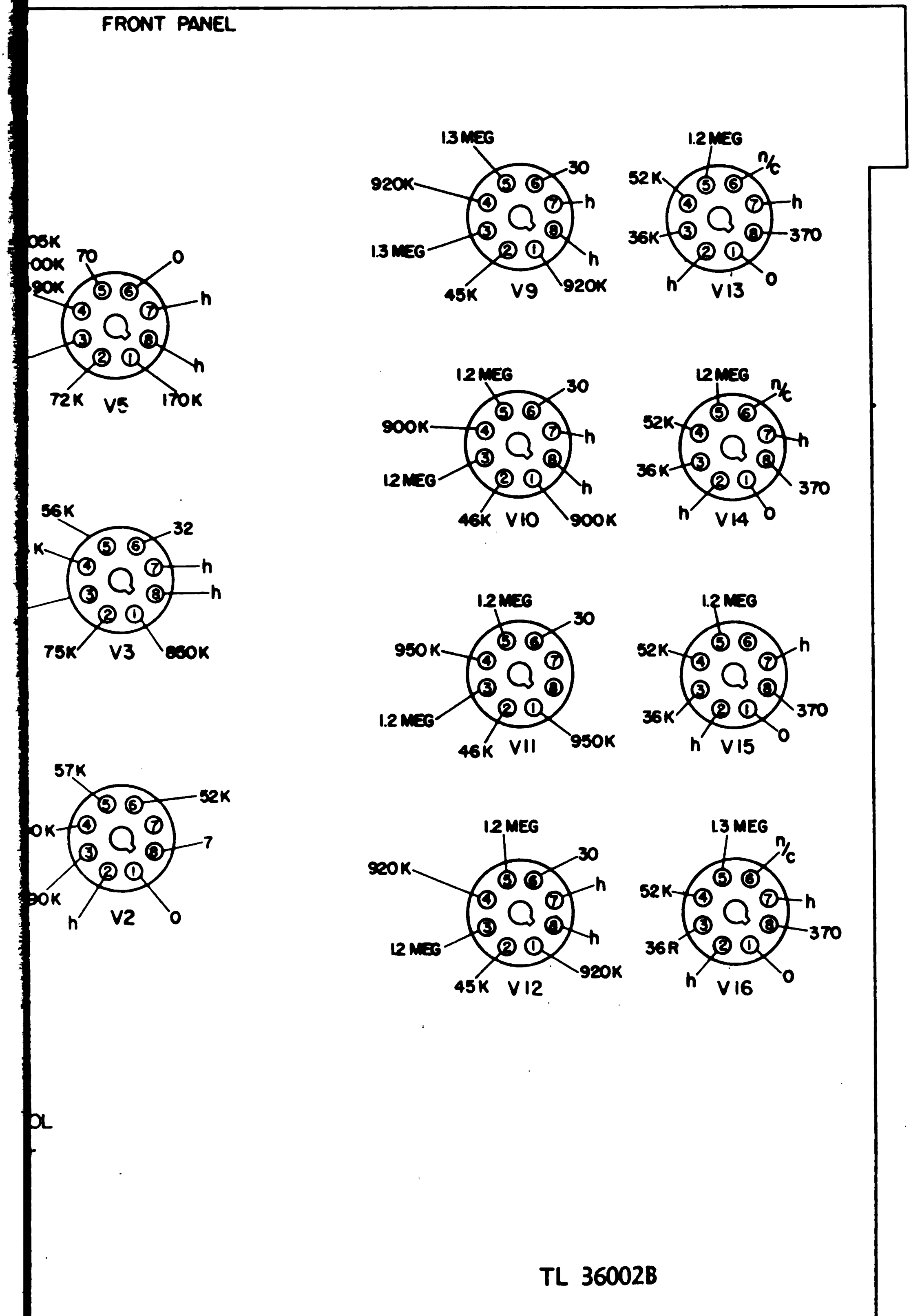


Figure 350. Search Central SN-6/MPN-1, resistance chart.

189. REPLACING CATHODE-RAY TUBE. To remove an indicator cathode-ray tube, it will first be necessary to remove the semitransparent mirror. Be careful, during the removal of the mirror, to avoid disturbing the positions of the three knurled adjusting screws. Remove the two round-headed screws which hold each of the three metal strips through which the adjusting screws pass. Carefully lower the mirror from its position in the unit and set it aside. Remove the shield which surrounds the indicator tube screen, and dismantle the compass rose and navigating head assemblies. To gain access to the rear of the unit, remove the section of the rack panel which is just above the indicator unit. Loosen the screws which hold the metal cap of the cathode-ray tube housing, and remove the cap. Remove the cathode-ray tube socket. Pull the cathode-ray tube out through the front of the unit. To install the new tube, repeat the above operations in the reverse order.

190. ADJUSTMENT OF TRACE EXPANSION. The length of the trace which appears on the cathode-ray tube depends on the adjustments of the following:

a. Expansion Control in Search Central. Adjustable resistor R46 in the search central determines the value of the positive voltage fed to the sine potentiometer. This resistor, which may require adjustment when a new cathode-ray tube is installed, is mounted under the search central chassis.

b. 4-kv Power Supply. The anode high voltage applied to the cathode-ray tube determines the axial velocity of the electrons composing the cathode-ray beam, and thus determines the deflection produced by a given deflecting force. Consequently, the voltage provided by the 4-kv power supply, Rectifier Power Unit PP-23, determines the length of the PPI trace. This voltage may be controlled by potentiometer P1, which is adjustable by means of a screwdriver through a hole in the top of the power supply chassis.

c. Deflection Coils. Expansion is also determined by the position of the deflection coils between the cathode and screen. The position of the deflection coils may be adjusted in the following two ways:

(1) Remove the screws which secure the deflection coil yoke to the tube housing. Move the yoke forward or back to the desired position and reinsert the screws. This adjustment permits the deflection coils to be mounted in any one of three definite positions. If intermediate positions are required, use the procedure given immediately below.

(2) Loosen the retaining ring which holds the tube housing to the rest of the unit. Move the tube housing in or out to the position required. Tighten the retaining ring.

CHAPTER 8

TROUBLE SHOOTING IN THE PRECISION SYSTEM

SECTION I

TRANSMITTING SYSTEM

> WARNING: *Voltages sufficient to cause death on contact are exposed at many points in Radio Frequency Unit RF-6/MPN-1 and in Modulator MD-11/MPN-1. Do not place hands or arms within these units with the high voltage on. Do not make any connections into these units which bring high voltages out to an exposed point. Make all tests with high voltage off. Always ground high-voltage capacitors before touching them or their associated parts.*

191. REFERENCE DATA.

a. Modulator MD-11/MPN-1.

(1) Figure 324. Front view.
(2) Figure 325. Right oblique view.
(3) Figure 326. Rear view.
(4) Figure 327. Subchassis, bottom view.
(5) Figure 25. Schematic diagram.
(6) Figure 328. Waveforms.
(7) Figure 329. Voltage and resistance chart.

b. Radio Frequency Unit RF-6/MPN-1.

(1) Figure 351. Front view.
(2) Figure 352. Front oblique view.
(3) Figure 353. Rear oblique view.
(4) Figure 95. Subchassis assembly.
(5) Figure 96. Schematic diagram.

c. General.

(1) Figure 217. Rectifier Power Unit PP-26/MPN-1 (transmitter HVPS), schematic diagram.
(2) Figure 85. Intercommunications panel, radar control circuit.
(3) Figure 214. Control Box C-61/MPN-1, schematic diagram.
(4) Figure 253. Capacitor color code.
(5) Figure 254. Resistor color code.
(6) Figure 255. Tube base chart.

192. SPECIAL INFORMATION.

a. Overload Relay Adjustment. An overload relay is located in Control Box C-61 and is common to both the search and precision transmitting systems. The overload relay (relay RY3 in channel A and relay RY4 in channel B) is so designed that it will trip on an overcurrent greater than 60 ma. Should the overcurrent relay trip continually at a lower current value, the relay should be adjusted by setting the pointer on the relay to 60 ma (refer to pars. 94 and 163).

b. Test Points. Two test points are provided on the front panel of the modulator unit. At these test points should appear the S and X modulator output waveforms. These waveforms may be monitored by connecting the test jacks to the synchroscope in the transmitter rack.

c. Metering Circuit. An S and an X meter are provided in Control Box C-61, the latter of which can be utilized to aid in the location of faults in the X-band transmitting system. The X-band magnetron current can be read with the control box selector switch in the I MAG "X" position. In this position, the X meter will read 12 to 16 ma under normal operating conditions. With the selector switch in the H.V. "X" position, the X meter will read the high-voltage output (12 kv) of Rectifier Power Unit PP-26 which is applied to the X-band switch tubes in the modulator. Abnormal meter readings are, in general, an indication of trouble in the transmitting system and are used as such in the start procedure trouble-shooting chart (ch. 6, sec. III) to isolate troubles to either the search or precision transmitting systems, and in some cases to certain components within these systems.

d. High-voltage Power Supply Adjustment. The high voltage applied to the X-band switch tubes is dropped from the full output of PP-26 by means of a voltage divider network across the output of the high-voltage power supply. Twenty taps are provided on the voltage divider and the X-band high voltage can be varied by changing the location of plug SW3. The location of the plug in the jacks (1-20) should be varied until the X-band high-voltage reading (H.V. "X") is 12 kv at the same time that the S-band high-voltage reading (H.V. "S") is 14 kv. In some cases the magnetron may not oscillate properly at 12 kv and it will be necessary to slightly raise or lower the X-band high voltage in order to obtain the proper magnetron current (12 to 16 ma).

WARNING: Make certain the high voltage is turned off and the capacitors in PP-26 are fully discharged before making the foregoing adjustment.

193. PROCEDURE.

a. In Radio Set AN/MPN-1 the search and precision transmitting systems are closely interrelated by the common high-voltage power supply and modulator unit which feed both the S- and X-band magnetrons. Because of this close relation, faults which occur in one system will be reflected as abnormal indications in the other system. The start procedure trouble-shooting chart (ch. 6, sec. III) is used to isolate faults to either of the two transmitting systems or to the common power supply or modulator unit. Once a fault has been isolated to the precision transmitting system, the system trouble-shooting chart in paragraph 194 can be used to further trace the fault to a defective component. The modulator trouble-shooting chart will not be repeated under the precision system, as a complete chart is contained in the search transmitting system trouble-shooting data (par. 166). References to this chart will be made in the probable location of fault column in the following trouble-shooting chart.

b. Frequently a fault in the transmitting system, such as a soft magnetron tube, will result in weak received echo signals which could also be caused by both the r-f system and the receiving system. In order to definitely determine that the fault is in the transmitter, it may be necessary to make a power measurement of the output of the magnetron. This is accomplished by means of Power Monitor TS-36. Instructions for the use of the power monitor are given in paragraph 139. Low power output as measured at the X-band selector line indicates trouble in the precision transmitting system, while normal power output at the selector line and low power output as measured at a point 30 to 50 feet in front of the radio set (par. 139) indicates trouble in the r-f system. In the latter case, the waveguide transmission line and antenna arrays should be closely inspected for damaged sections or faulty connections.

c. After the fault has been isolated to a defective stage, by use of the component trouble-shooting chart, the fault can be further isolated by checking the voltage and resistance readings as given on the voltage and resistance charts.

194. TROUBLE-SHOOTING CHART FOR TRANSMITTING SYSTEM (Isolation of faults to components).

A. SYMPTOMS:

1. No main pulse or signal echoes on search or precision indicator scopes.
2. High-voltage rectifier output voltage and current zero or low, as read on S and X meters.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Input circuit to high-voltage Rectifier Power Unit PP-26 defective.	1*a*. Measure voltage (117 volts ac) between terminals 1 and 6 of connector CS 13 on PP-26. *b*. Check continuity of interlock switches in modulator, RF-7, RF-6, and PP-26. *c*. Measure the supply voltage at variac terminals and trace circuit back until fault is determined.
2. High-voltage Rectifier Power Unit PP-26.	2. Refer to paragraph 244 for trouble shooting in the high-voltage power supply.

B. SYMPTOMS:

1. No main pulse or signal echoes on search or precision indicator scopes.
2. High-voltage output is normal as read on S and X meters.
3. Magnetron current zero or low on both S and X meters.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Trigger pulse input circuit to modulator defective.	1*a*. Check trigger pulse waveform at modulator input (CS-1, terminal 1) with test oscilloscope. *b*. Check trigger pulse waveform output at synchronizer terminal 7-4.
2. Modulator.	2. Check modulator output waveforms with synchroscope at the pulse test monitoring points (fig. 16) on the front panel of the modulator. If output waveform is distorted or not present and input waveform is normal, trouble is in modulator (par. 16).

C. SYMPTOMS:

1. No main pulse or signals on precision indicators.
2. Normal display on search indicators.
3. X-band magnetron current (I MAG "X") zero or low.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Modulator.	1*a*. Check the modulator output waveform with the synchroscope at the X-pulse test monitoring point. *b*. If the pulse is distorted or does not appear, turn off the power from the transmitter rack and remove the plug from jack JK3 in the modulator unit. This is the line that connects the high-voltage output pulse to the magnetron. Turn the power on and again check the X-output waveform. If the pulse is still distorted, refer to the modulator trouble-shooting chart (par. 166).
2. Radio Frequency Unit RF-6.	2. In *b* above, if the pulse returns to normal when plug is removed from jack JK3, the fault is in the RF-6 unit (par. 195).

D. SYMPTOMS:

1. Weak, unsteady, or abnormal signals on precision indicators and test synchroscope.
2. Overload relay may or may not kick out repeatedly.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Precision transmitting system	1*a*. Check the high-voltage power supply meter reading (H.V. "X"). If it is low or unsteady, refer to the high-voltage Rectifier Power Unit PP-26 (par. 89). *b*. Check the waveform at the X-pulse test monitoring point. If the output pulse waveform is not normal, refer to Modulator MD-11 (par. 166). *c*. Check the magnetron current (I MAG "X"). If it is abnormal, refer to the magnetron trouble-shooting chart (par. 195). *d*. Measure the power output of the precision magnetron at the X-band selector line (par. 139). Low output indicates trouble in the magnetron oscillator.
2. Precision r-f system.	2*a*. Measure the power output from the precision antennas with the power meter (par. 139). Low r-f power output from the antenna with normal power at the X-band selector line indicates trouble in the search r-f system. Refer to the r-f system trouble-shooting chart (par. 199). *b*. If the power output from the precision antennas is normal, fault may be in the T-R or R-T switch in the RF-6 unit (par. 199).

PROBABLE LOCATION OF FAULT	PROCEDURE
3. Precision receiving system.	3. If the power output from the precision antennas is normal, check the receiving system sensitivity (par. 207).
4. Interference.	4. Check for other radar equipment operating in the vicinity, near the same frequency as Radio Set AN/MPN-1.

E. SYMPTOMS:

1. Grid current meter reading zero for either V6 or V7 in the modulator unit
2. Search and precision system operating normally.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Grid current metering circuit.	1*a*. Check for open resistor, inductor, or broken connection in the modulator grid metering circuit. *b*. Check the meter circuit in Control Box C-61.

F. SYMPTOMS:

1. Magnetron current (I MAG "X") low.
2. High-voltage readings normal.
3. Weak echoes on both search and precision indicators.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. High-voltage metering circuit.	1. The high-voltage meter reading is incorrect. Check resistor R22 in Rectifier Power Unit PP-26. This resistor should have a value of 20 megohms with a tolerance of ±10 percent.

195. TROUBLE-SHOOTING CHART FOR TRANSMITTING MAGNETRON.

A. SYMPTOMS:

1. X-band magnetron current (I MAG "X") zero.
2. Output pulse from modulator unit normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Magnetron filament transformer, T1 or T2.	1*a*. Turn off all high voltage from the transmitter rack (filament circuits energized), measure filament voltage at magnetron terminals (6.3 volts ac). *b*. If filament voltage is zero or low, measure voltage on primary winding of T1 or T2 (117 volts ac).
2. Magnetron filament open.	2. Turn off all high voltage and filament voltage from the transmitter rack. Disconnect the filament leads from the faulty magnetron and check continuity between magnetron terminals. Replace the magnetron tube if filament is open and check alignment of angle coupling units (par. 236).

B. SYMPTOMS:

1. Low or unsteady output from the transmitting magnetron.
2. Output pulse from the modulator unit normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective magnetron tube.	1. Magnetron arcing over internally. Replace the magnetron and realign the precision system. See paragraph 196 for aging a new magnetron.

C. SYMPTOMS:

1. High magnetron current (I MAG "X").
2. Output pulse width from modulator unit normal.
3. Overload relay may trip repeatedly.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Tap on PP-26 misadjusted.	1. Readjust position of tap on high-voltage power supply to obtain normal current.
2. Magnetron filament voltage high.	2*a*. Measure the magnetron filament voltage (6.3 volts ac) with the high voltage disconnected from the transmitter rack.
	b. If the filament voltage is high, measure the primary input to filament transformer T1 or T2 (117 volts ac).
	c. If the primary input voltage is high, check that the regulators on Power Units PE-27-A or the commercial power supply regulator is operating.
3. Magnetron permanent magnet field strength low.	3. Test the magnetron permanent magnet field strength with Flux Meter TS-15/AP. Refer to paragraph 141 in chapter 6 for the test procedure. The normal field strength should be between 2,300 and 2,500 gauss. Replace the magnet if field strength is low.
4. Magnetron tube defective.	4. The magnetron may be gassy or defective. Replace the magnetron tube. Check alignment of precision system with new magnetron.
5. PRF is too high.	5*a*. Check the magnetron current (I MAG "X") when using the No. 1 or No. 2 search central to trigger the modulator.
	b. If the fault is cleared, see section IV of chapter 8 for checking the synchronizer master oscillator.

D. SYMPTOMS:

1. Magnetron current low (I MAG "X").
2. Output pulse from modulator normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Magnetron filament voltage low.	1*a*. Measure the magnetron filament voltage (6.3 volts ac) with the high voltage disconnected from the transmitter rack.
	b. If the filament voltage is low, measure the primary voltage on transformer T1 or T2 (117 volts ac). A low primary voltage indicates trouble in the regulators on Power Units PE-127-A or the commercial power supply regulator.
	c. Normal primary voltage and low filament voltage indicates a defective filament transformer.
2. Magnetron tube defective.	2. Replace the magnetron tube (par. 196).
3. High-voltage Rectifier Unit PP-26.	3*a*. Check high-voltage meter reading (H.V. "X").
	b. Arc-over of bleeder or voltage divider resistors will cause low high-voltage output (pars. 89 and 244).

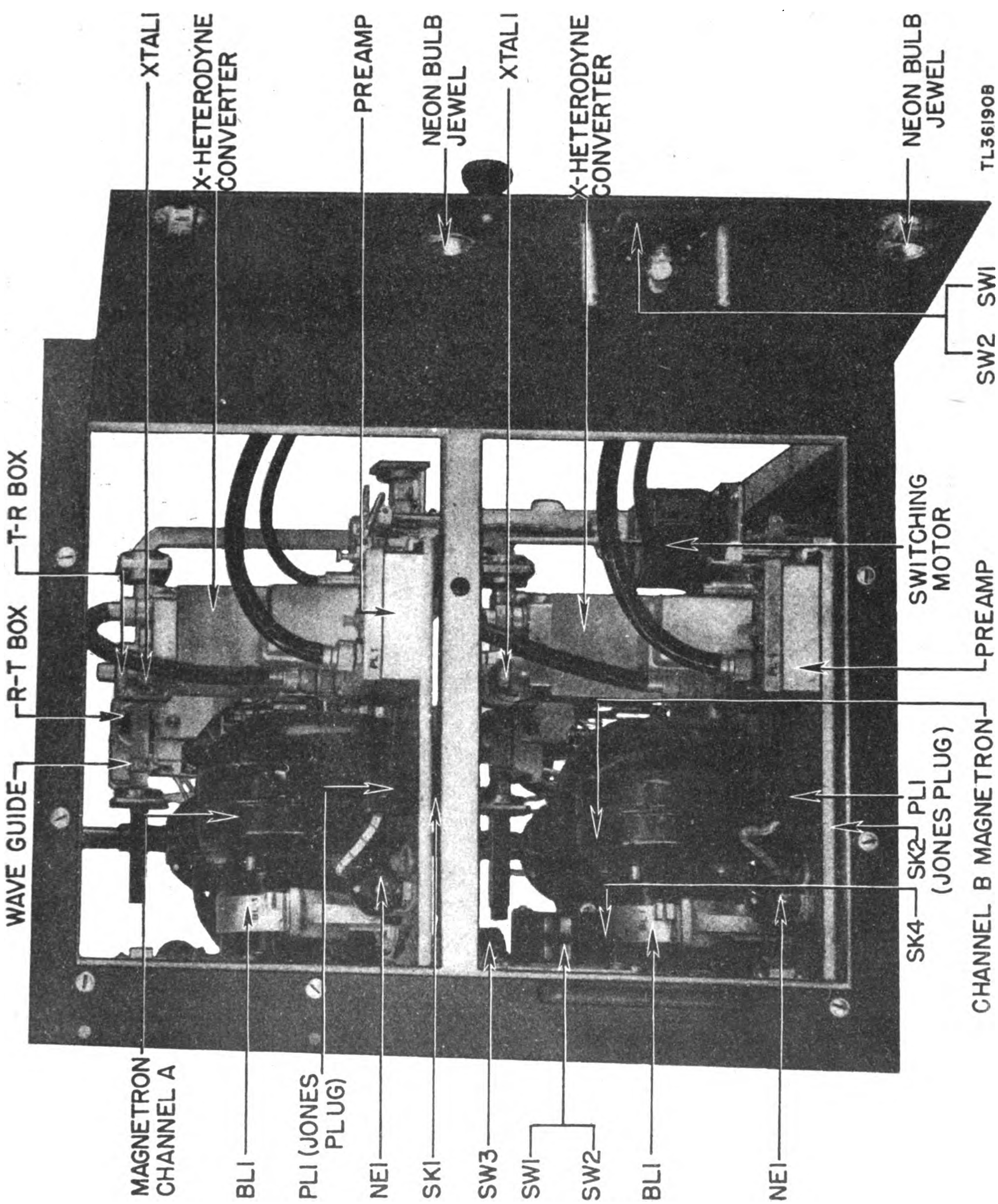


Figure 351. Radio Frequency Unit RF-6/MPN-1, front view.

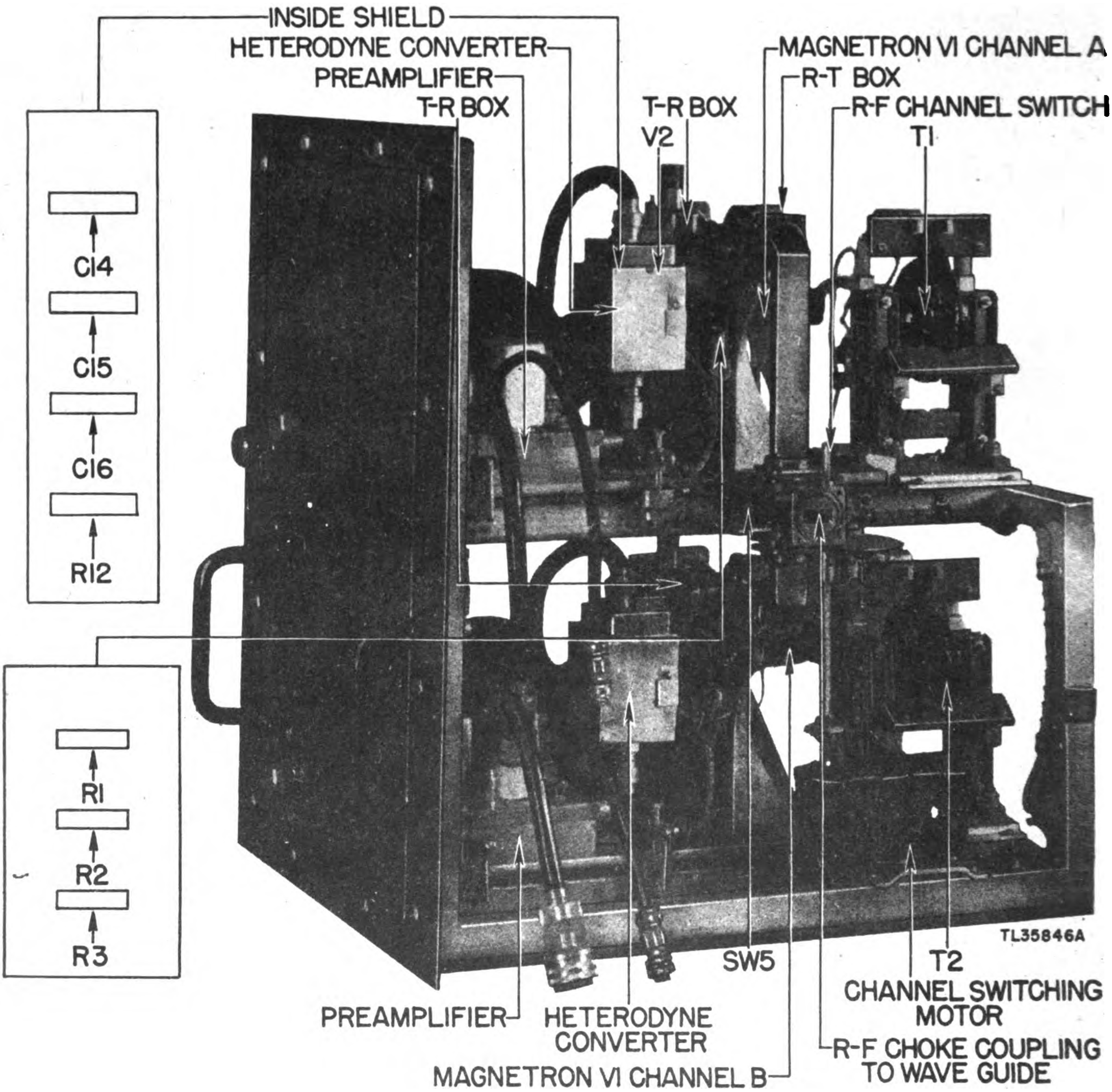


Figure 352. Radio Frequency Unit RF-6/MPN-1, front oblique view.

PROBABLE LOCATION OF FAULT	PROCEDURE
4. Defective high-voltage metering circuit.	4. The high-voltage metering circuit is reading too high. Check resistor R22 in PP-26. This resistor should have a value of 20 megohms with a tolerance of ±10 percent.

E. SYMPTOMS:

1. Magnetron current (I MAG "X") unstable.
2. Signals, as viewed on synchroscope, suddenly disappear as the high-voltage variac is turned down.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Magnetron tube defective.	1*a*. Signals should decrease gradually as high voltage is reduced. A sudden disappearance of signals indicates a very sharp magnetron spectrum and makes tuning difficult. *b*. Replace defective magnetron (par. 196).

F. SYMPTOM:

1. Magnetron blower motor does not operate.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No power input to the blower motor.	1*a*. Measure input voltage (117 volts ac) across terminals 1 and 2 of connector strip CS20A for the channel A motor, and connector strip CS20B for the channel S motor. *b*. If there is no voltage across these terminals, check power distribution system (par. 237).
2. Blower motor defective.	2*a*. Check voltage (117 volts ac) at plug SK1 for channel A blower and plug SK2 for channel B blower. *b*. If voltage is normal, remove plug and check continuity of blower motor. If open or shorted, replace blower motor.

196. SUPPLEMENTARY DATA.

a. Replacement of Magnetron. (1) To remove an X-band magnetron tube, it is first necessary to remove the chassis subassembly from Radio Frequency Unit RF-6. To do this, disconnect plug PL1, the preamplifier power cable and i-f output cable, and the filament leads to the magnetron. Loosen the five hold-down bolts along the side of the subchassis and slide the unit directly forward out of the rack. Care should be taken not to tilt the unit while removing it from the rack so as not to damage the waveguide transmission line.

(2) Loosen the four nuts on the magnetron mounting bolts holding the magnetron to the supporting shoulder. Lift the magnetron straight up, sliding it out from between the pole faces of the permanent magnet. Take care at all times that no metallic objects strike the magnet, or a loss of field strength may result. With the magnetron removed, it is advisable to test the field strength of the magnet with Flux Meter TS-15 AP (par. 111).

(3) To install a new magnetron, follow the reverse of the above procedure. Be absolutely certain that the magnetron is centered between the poles of the magnet and that all fittings line up perfectly before tightening the mounting bolts.

b. Aging Newly Installed Magnetrons. If the magnetron installed is new or has not been used in some time, it will be necessary to age the magnetron according to the procedure given in paragraph 168.

c. Matching Magnetron Frequencies. When the new magnetron is properly installed, determine its exact operating frequency within the limits of the test set accuracy. This must agree within narrow limits with the operating frequency of the magnetron being used in the other channel. If it does not, the scanning patterns of the precision antennas will be changed considerably when channels are switched. It is advisable to use magnetrons in pairs matched as closely as possible. If considerable discrepancy is observed between the two channels on replacing one magnetron, replace the other one as well.

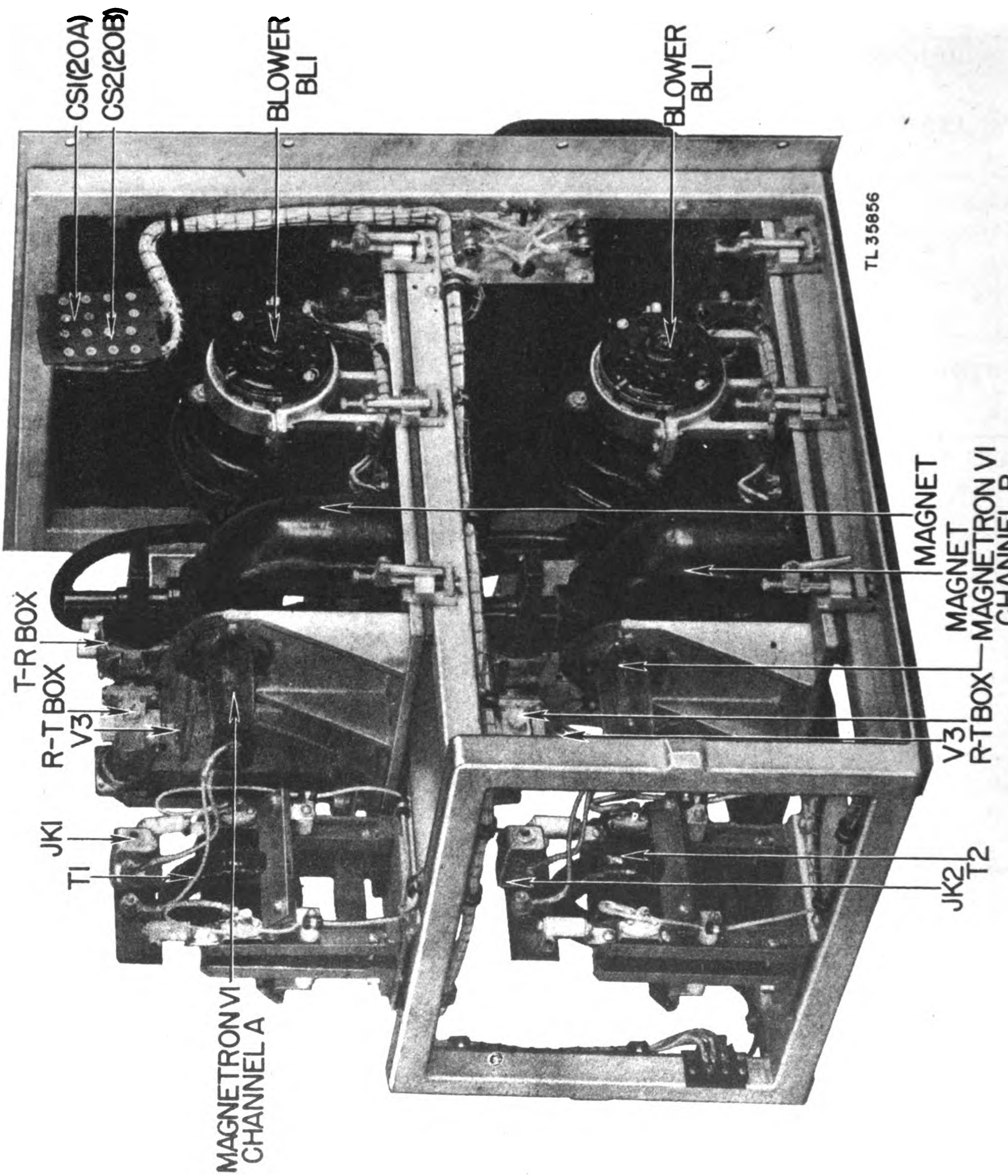


Figure 353. Radio Frequency Unit RF-6/MPN-1, rear oblique view.

SECTION H

R-F SYSTEM

WARNING: ***Voltages sufficient to cause death on contact are exposed at many points in Radio Frequency Unit RF-6/MPN-1. Do not place hands or arms within this unit with the high voltage on. Do not make any connection into this unit which brings high voltages out to an exposed point. Make all tests with high voltage off. Always ground high-voltage capacitors before touching them or their associated parts.***

197. REFERENCE DATA.

a. Antenna Arrays.

(1) Figure 98. Precision antenna assembly.
(2) Figure 109. Elevation antenna scanning pattern.
(3) Figure 112. Azimuth antenna scanning pattern.

b. R-f Switches.

(1) Figure 101. X-band and r-f channel switch.
(2) Figure 103. Switching Unit SA-8/MPN-1.

c. Radio Frequency Unit RF-6/MPN-1.

(1) Figure 351. Front view.
(2) Figure 352. Front oblique view.
(3) Figure 353. Rear oblique view.
(4) Figure 95. Subchassis assembly.
(5) Figure 96. Schematic diagram.

d. General.

(1) Figure 333. T-R box recovery time test.

198. PROCEDURE.

a. In general, very few faults will occur in the precision r-f system due to the nature of its construction. The majority of faults that do occur, however, will probably lie in the R-T or T-R switches in Radio Frequency Unit RF-6. The remainder of the faults will necessarily be of a mechanical nature that can best be located by observation. These faults include bent or broken waveguide sections and connections, misaligned r-f and channel switches, and mechanical breakage or wear in the precision scanning mechanism.

b. A trouble-shooting chart for the r-f system is included in the following paragraph to aid in locating any faults that may occur. To insure that faults, such as weak echo signals, are actually located in the r-f system, it will be necessary to check the over-all receiving sensitivity with Test Set TS-13/AP and a dipole, located in front of the trailer approximately 30 to 50 feet (par. 143). If this test shows low sensitivity, again check the over-all receiving sensitivity with the test set connected to the X-band selector line (par. 143). If the sensitivity is normal at this point, it can be assumed that the fault lies in the r-f system. This test, however, excludes the T-R and R-T switches which must be operating properly in order to obtain normal sensitivity at the selector line. Faults in the T-R and R-T switches can usually be isolated to a mistuned cavity or the absence of the –750-volt keep-alive potential.

199. TROUBLE-SHOOTING CHART FOR R-F SYSTEM.

A. SYMPTOMS:

1. Weak echo signals as observed on synchroscope.
2. Receiver sensitivity normal as measured at input of preamplifier unit.
3. Crystal current normal.
4. Transmitter power output normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. T-R box.	1. Retune T-R box cavity (par. 204).
2. R-T box.	2. Retune R-T box cavity (par. 204).

B. SYMPTOM:

1. Burned-out crystal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. T-R tube.	1. T-R tube defective, check T-R recovery time (par. 170) and discharge glow. Replace T-R tube if necessary.
2. Low keep-alive voltage.	2. Measure voltage on top cap of T-R tube (–750 volts dc). If low or absent, check continuity of keep-alive circuit and power supply in modulator.

C. SYMPTOMS:

1. Low power output from precision antennas as measured on Power Monitor TS-36/AP.
2. Normal power at X-band selector line.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. X-band transmission line.	1. Check the X-band waveguide visually for defects and loose joints.
2. R-f channel switch.	2*a*. Check that the switch blade completely blocks waveguide for channel not in use.
	b. Check double r-f choke joints at channel switch for misalignment or excessive spacing.
3. R-f antenna switch.	3*a*. Inspect r-f antenna switch blades and T-section spacing.
	b. Check alignment of switch blades (par. 201).
4. Absorber Unit CG-29/MPN-1.	4. If power output is normal for one precision antenna and is low for the other, replace absorber unit on faulty antenna.

200. ADJUSTMENT OF ANTENNA GUIDE WIDTH.

a. The eccentrics on both elevation and azimuth scanner drives have been designed to produce a little greater waveguide motion than is required to produce the desired scan. Thus the excess scan must be allowed to project beyond the desired scanning range. The placement of this excess scan is determined by the adjustment of the toggle bar connecting rod between the scanner drive box and the rigid linking bar. The toggle bar is so adjusted that the r-f switch opens for the azimuth scanner at –1 degree from the normal, at the long wavelength end of the band (X.330), and for the elevation scanner at +1 degree from the normal, at the short wavelength end of the band (X.270). This guarantees that the precision beams will always scan to at least 1 degree for both antennas; however, it also means that for frequencies at either end of the band, one of the antenas will be scanning through the normal to the array. At the short wavelength end of the band the azimuth antenna will scan through the normal, while at the long wavelength end the elevation antenna will scan through the normal. Although scanning through the normal may be an undesirable condition, it is necessitated by the fact that for both antennas the scan nearest to the normal is the most important region of the scanned area, and otherwise would not be receiving complete scan coverage at certain magnetron wavelengths.

b. The adjustment of the toggle bar is made at the factory and should not be touched by personnel in the field unless a readjustment is necessitated by a mechanical replacement in the scanning mechanism. If this adjustment is deemed necessary, the following procedure should be followed, using the waveguide width values determined for $\lambda = X.270$ and $\lambda = X.330$ which are stamped on the scanner data plates.

(1) It will first be necessary to construct a special indicator disk as shown in figure 354. This can be made of stiff cardboard or metal, with four indicator marks (1, 2, 5, and 6) etched or painted on the outer circumference. This disk is then attached to the pinion shaft of the 4:1 antenna gear reduction assembly and a fixed index marker is established.

(2) Insert the waveguide width dial indicator in the waveguide to be adjusted and determine the position of the drive eccentric corresponding to maximum throw towards the load end (maximum guide width) for the azimuth scanner, or towards the feed end (minimum guide width) for the elevation scanner. This position can best be determined for the azimuth antenna by setting the eccentric approximately for maximum throw towards the load end, then loosening the nut holding the indicator disk and turning it until point 1 coincides with the index mark. Tighten the nut and turn the disk to point 2 and note the reading of the dial indicator. Turn the disk in the opposite direction approximately 360 degrees towards

point 3 until the dial reading is the same. The disk position may not coincide exactly with point 3; for example, it may occur at position A on the diagram (fig. 354). Under these circumstances, loosen the nut and rotate the disk halfway between position A and point 3. Then tighten the nut and rotate the disk back to point 1. This procedure will exactly locate the positive of maximum throw. To insure accuracy, the above procedure should be repeated and care observed in making the settings and adjustments.

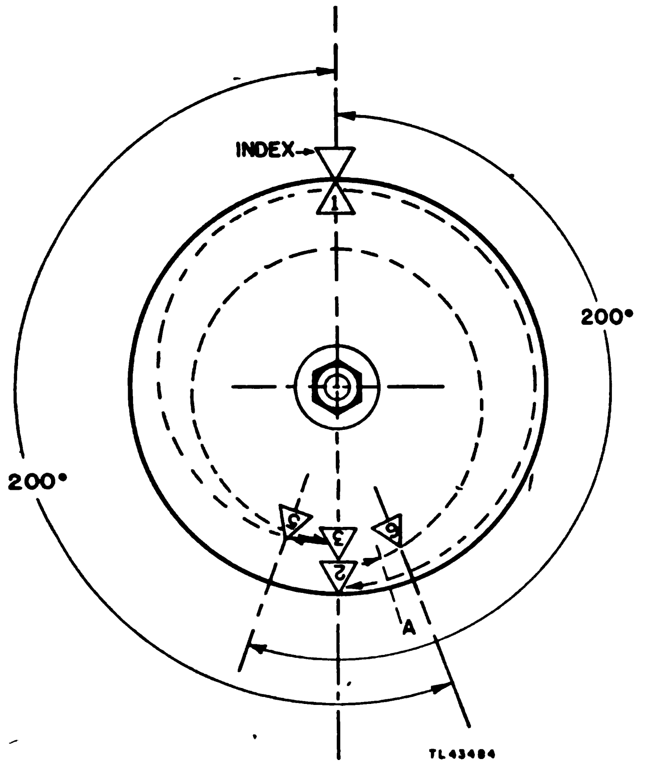


Figure 354. Special indicator disk.

(3) All gear and eccentric play must be eliminated by always approaching the desired settings in the correct direction of rotation as shown in figure 354. The same procedure applies to the elevation antenna, except that the eccentric position for maximum throw should be towards the feed end (narrow guide width) as mentioned above. In addition, the direction of disk rotation, as viewed from the pinion shaft end, will be clockwise instead of counterclockwise.

(4) When the exact point of maximum throw is located, rotate the disk in a counterclockwise direction exactly 200 degrees to point 5 for the azimuth antenna, or in a clockwise direction exactly 200 degrees to point 6 for the elevation antenna. This corresponds to exactly 50 degrees rotation of the drive eccentric and is the correct position for setting the waveguide width to comform to the values at $\lambda = X.330$ for the azimuth or at $\lambda = X.270$ for the elevation antenna as stamped on the scanner data plates. Adjust the length of the toggle drive connecting rod to obtain the proper dial reading. After the toggle rod length has been determined, securely tighten down the locknuts and insert a wire or cotter pin to prevent any change during future use.

(5) After completion of the above adjustments, the antenna should be checked to insure that the movable plate does not strike the channel section when the scanning motor is rotated.

201. ALIGNMENT OF R-F SWITCH BLADES.

a. Elevation. During the following alignment procedure all dial indicator readings must be taken only when the position is reached through a clockwise rotation of the scan motor as viewed from the azimuth side. The blades should first be aligned with respect to the elevation antenna according to the following procedure.

(1) Loosen the nuts which clamp the clutch holding the r-f switch blades.

(2) Loosen the clutch by striking the end of a large screwdriver held vertically along side of the shaft between the clutch and the azimuth blades. The blades should then rotate with each other but free from the shaft.

(3) Rotate scan motor by hand until elevation guide width is approximately at a minimum, and rotate the r-f blades to make the elevation blade take the position as shown in diagram (a) of figure 355. (Reference lines are scribed on blades and on center of waveguide.) Temporarily tighten nut locking the clutch.

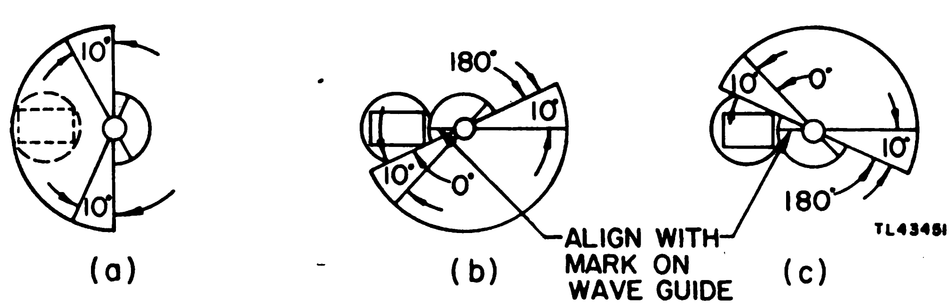


Figure 355. R-f switch blade alignment.

(4) Rotate the scan motor clockwise until the elevation blade is in the position shown in diagram (b) and the guide width is decreasing as viewed from azimuth side, i.e., until the 10-degree line in the open sector coincides with the mark on the waveguide. Take dial indicator reading on the elevation antenna in this position.

(5) Rotate the scan motor clockwise, causing the elevation r-f blade to rotate through 200 degrees (cutting off the r-f energy from the elevation antenna) to the position shown in diagram (c). Take dial indicator reading on the elevation antenna in this position.

(6) If the readings taken in steps (4) and (5) are not within 0.002 inch of each other, average the readings and rotate the scan motor clockwise to give a dial indicator reading of this average. Without allowing the r-f switch assembly shaft to turn, loosen the r-f blades and turn them slightly to make the 10-degree line in the open sector of the elevation blade coincide with the mark on the waveguide. Tighten the nut locking the clutch, making certain that while so doing the adjustment is not changed, and then repeat steps (4) and (5).

(7) Readings should then be within 0.002 of an inch. If not, repeat procedure beginning with step (4) until readings are within the desired tolerance.

(8) Rotate the scan motor clockwise until a precise micrometer or dial indicator reading is obtained corresponding to X-270 and to the 1-degree beam angle. This reading is obtained:

(*a*) With elevation r-f blade approximately in the diagram (b) position.

(*b*) With elevation r-f blade approximately in the diagram (c) position.

(9) The mark on the waveguide should fall for both positions in step (8) within 5 degrees of the 10-degree line in the open sector of the elevation r-f switch blade.

*b. **Azimuth.*** After the elevation blade has been properly aligned as above, the azimuth blade should be aligned according to the folowing procedure:

(1) Remove the four small bolts on the clutch between the r-f blades and the r-f switch assembly drive sprocket, and disengage the clutch. Replace the bolts but do not tighten.

(2) Rotate the scan motor clockwise by hand to obtain the maximum azimuth antenna guide width, and rotate the r-f blades to make the azimuth blade take the position shown in diagram (a). Temporarily tighten the bolts on the friction clutch.

(3) Rotate the scan motor clockwise until the azimuth blade is in the position shown in diagram (b) and the guide width is increasing. Take dial indicator reading on azimuth antenna in this position.

(4) Rotate assembly clockwise causing the azimuth r-f blade to rotate through 200 degrees (cutting off the r-f energy from azimuth antenna) to the diagram (c) position. Take dial indcator reading on the azimuth antenna in this position.

(5) If the readings taken in steps (3) and (4) are not within 0.002 inch of each other, average the readings and rotate the scan motor clockwise to give a micrometer or dial indicator reading of this average. Without allowing the r-f switch assembly drive sprocket to turn, loosen nuts on friction clutch and rotate r-f blades slightly to make the 10-degree line in the open sector of the azimuth blade coincide with the mark on the waveguide. Tighten the nuts locking the clutch, making certain that while so doing the adjustment is not changed, and then repeat steps (3) and (4).

(6) Readings should be within 0.002 of an inch. If not, repeat the procedure beginning with step (3) until the readings are within the desired tolerance.

(7) Rotate the scan motor clockwise by hand until a precise micrometer or dial indicator reading is obtained corresponding to X.330 and to the 1-degree beam angle. This reading is obtained:

(*a*) With azimuth r-f blade roughly in the diagram (b) position.

(*b*) With azimuth r-f blade roughly in the diagram (c) position.

(8) The mark on the waveguide should fall for both positions in step (7) within 5 degrees of the 10-degree line in the open sector of the azimuth r-f switch blade.

*c. **Blanker Blades.*** The following procedure should be used for the alignment of the blanker blades:

(1) Loosen the nuts holding the clutch for the blanker blades and loosen this clutch as under *a*(2).

(2) Rotate the r-f switch assembly by hand to the position shown in diagram (a) of figure 356.

(3) Holding the r-f switch blades in the diagram (a) position, rotate the blanker blades to the same position, adjusting them more exactly by seeing that the center of light beam is on the 2-degree line on the blades (diagram (b) of fig. 356).

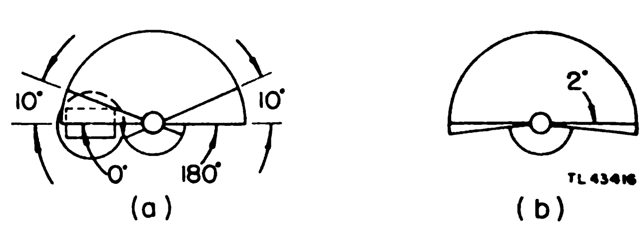


Figure 356. Blanker switch blade alignment.

(4) Semipermanently tighten nuts to clamp clutch.

(5) Make final adjustment of blanker blades position by adjusting so that the start of the elevation scope up-sweep coincides with the end of the down-sweep. Then finally tighten nuts to clamp clutch.

202. PHASING PRECISION SCANNERS. Since the precision antennas scan alternately through the operation of the variable waveguide scanner, their phasing is a matter of obtaining the correct relationships of the coupling shafts connecting the scanner drives to Switching Unit SA-8/MPN-1. Disks divided into quadrants painted alternately red and white have been installed in the two scanner drive boxes (fig. 357). When the elevation antenna is installed, its scanner drive box disk should be turned so that the color corresponds to the color showing on the azimuth scanner drive box disk. This insures proper phasing for the two antennas.

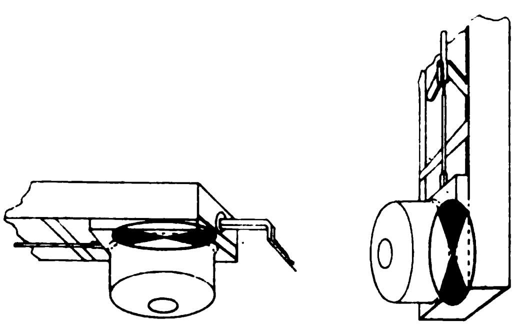


Figure 357. Phasing precision scanners.

203. T-R AND R-T TUBE REPLACEMENT. To replace either the T-R or R-T tube in Radio Frequency Unit RF-6 it will first be necessary to remove the transmitter subchassis from the compartment. Disconnect all cable connections to the subchassis and disconnect the filament leads to the magnetron. Loosen the five hold-down clamps and slide the subassembly straight out from the compartment, taking care not to damage the waveguide connections.

a. T-R Tube. To replace the T-R tube (1B24), first disconnect the coaxial cable at the bottom of the heterodyne converter unit. Loosen the four screws holding the converter unit and T-R box to the waveguide assembly and lift out the converter unit. Slide off the 1B24 tube and replace with a new tube. Reassemble the T-R box and heterodyne converter and reconnect the coaxial cable.

b. R-T Tube. To replace the R-T tube, first remove the top cap connection to the tube. Unscrew and remove the upper and lower knurled nuts from the R-T box. Remove the back section of the R-T box by pulling it diagonally out from the front section. Use finger pressure only and do not pry sections apart. These sections are machined to fit snugly together and any marring of the machined surfaces or of the cavity will alter the electrical characteristics of the R-T box. Remove the upper and lower tubular sections from around the R-T tube by lifting the sections out vertically. Gently remove the R-T tube, being careful not to damage the circular flanges about the tube. Insert the new R-T tube and reassemble the R-T box in the reverse order that it was disassembled.

204. ADJUSTMENT OF T-R AND R-T BOXES. The following procedure is recommended for use in tuning the X-band T-R and R-T boxes in Radio Frequency Unit RF-6/MPN-1. This procedure assumes that the local oscillator and receiver circuits have been previously tuned as explained in paragraphs 184 and 209, respectively.

a. Connect Test Set TS-13/AP to the X-band wave selector and tune the test set to the magnetron frequency (par. 143).

b. Turn down the magnetron high voltage and adjust the test set for synchronized pulse operation. An echo pulse should appear on the screen of the synchroscope in the transmitter rack (SELECTOR switch in AX or BX position).

c. Adjust the T-R box tuning plug on top of the T-R tube for maximum signal amplitude.

d. Unlock the knurled locknut on the side of the R-T box and adjust the knurled tuning screw for maximum signal amplitude on the synchroscope screen. If a maximum can not be obtained by means of this adjustment, set the tuning screw at the middle of its travel and adjust the slotted coarse adjustment for maximum signal amplitude. Tighten the locknut and make final adjustment by means of the knurled adjustment screw. Tighten the knurled locknut.

e. Check the adjustment of the T-R box tuning plug as in step *c*.

f. If the test set is not available or if a quick adjustment is required, the above procedure may be used with the magnetron operating normally and by tuning for maximum echo signal amplitude as observed on the synchroscope screen.

SECTION III

RECEIVING SYSTEM

> **WARNING:** ***Voltages sufficient to cause death on contact are exposed at many points in Radio Frequency Unit RF-6/MPN-1. Do not place hands or arms within this unit with the high voltage on. Do not make any connection into this unit which brings high voltages out to an exposed point. Make all tests with high voltage off. Always ground high-voltage capacitors before touching them or their associated parts.***

205. REFERENCE DATA.

a. X-band Preamplifier and Heterodyne Converter.

(1) Figure 358. Preamplifier, top view.
(2) Figure 359. Preamplifier, bottom view.
(3) Figure 117. X-band heterodyne converter, cutaway view.
(4) Figure 114. Precision heterodyne converter, schematic diagram.
(5) Figure 96. Radio Frequency Unit RF-6/MPN-1, schematic diagram.
(6) Figure 360. Voltage and resistance chart.

b. Radar Receiver R-38/MPN-1.

(1) Figure 336. Top view.
(2) Figure 337. Bottom view.
(3) Figure 338. Bottom view of i-f strip.
(4) Figure 339. Mounting boards.
(5) Figure 56. Schematic diagram.
(6) Figure 340. Waveforms.
(7) Figure 341. Voltage and resistance chart.

c. Synchronizer SN-5/MPN-1.

(1) Figure 361. Top view.
(2) Figure 362. Bottom view.
(3) Figure 123. Schematic diagram.
(4) Figure 120. Video amplifier circuit.
(5) Figure 365. Voltage chart.
(6) Figure 366. Resistance chart.

d. General.

(1) Figure 214. Control Box C-61/MPN-1, schematic diagram.
(2) Figure 253. Capacity color code.
(3) Figure 254. Resistor color code.
(4) Figure 255. Tube base chart.

206. SPECIAL INFORMATION.

a. Synchroscope. The synchroscope mounted in the transmitter rack can be used to advantage in making quick tests on the precision receiving system. With the SELECTOR switch on the front panel in the AX or BX position, the video output of the channel A or channel B precision receivers can be seen on the synchroscope display screen. By observing the shape or absence of signals on the synchroscope, the repairman can obtain a great deal of information on the behavior of the receiving system. Use of the synchroscope will also prove valuable in the alignment and adjustment of the receiving system components.

b. Test Points. Six test points are located behind the front door of the receiver unit. The first four of these test points can be used in conjunction with the synchroscope to measure certain critical waveforms in the AFC and STC circuits in the receiver unit. Test points 5 and 6 may be used to check the 300-volt and 220-volt plate supplies in the receiver.

207. PROCEDURE.

a. The trouble-shooting procedure in the precision receiving system of Radio Set AN/MPN-1 will be identical in most respects with the trouble-shooting procedure for the search receiving system given in section III of chapter 7. The main difference between the two systems lies in the local oscillator and mixer stages, and in the video section of the system. Since the heterodyne converter section (local oscillator and crystal mixer) of the precision system operates at the higher X-band frequencies, and since the physical arrangement of the converter is different, a separate trouble-shooting chart for the X-band heterodyne converter will be included in this section. The receivers in the two systems are identical, thus the trouble-shooting chart for the receiver will not be included; instead, reference will be made to the receiver information in the search system trouble-shooting section (par. 178).

b. Certain types of faults in the precision receiving system will, in general, appear as an absence or reduction of target echoes on the precision indicator tubes. These faults are common to both the precision r-f system and the precision transmitting system in addition to the receiving system. Thus, before attempting to locate the fault in the receiving system, it first will be necessary to ascertain that this particular fault lies in the receiving system and not in either the r-f or transmitting systems. In most cases, a quick check of the magnetron current and voltage readings will suffice, if readings are normal, to assume that the transmitting and r-f systems are operating normally. Reference to STEP 12 and STEP 15 in the start procedure trouble-shooting section (pars. 157 and 160) will serve to isolate troubles to the receiving system and, in some cases, to a defective component. It will then be necessary to isolate the trouble to a particular component within the system. This can oftentimes be accomplished merely by observations of the crystal current reading or of the video output of the receiver as displayed on the synchroscope.

c. If the faulty component cannot be located by observation, it will be necessary to check the system sensitivity at the X-band selector line, at the preamplifier input, and at the receiver input, by means of the signal generators included with the test equipment (par. 143). The following receiving system sensitivity checks indicate the faulty components:

(1) Low sensitivity with X-band r-f signal applied to X-band selector line and normal sensitivity with 30-mc signal applied to input of preamplifier indicates trouble in the local oscillator or crystal mixer stages. Refer to X-band heterodyne converter trouble-shooting chart (par. 208).

(2) Low sensitivity with 30-mc signal applied to input of preamplifier and normal sensitivity with 30-mc signal applied to input of Radar Receiver R-38 indicates trouble in the preamplifier unit. Refer to X-band heterodyne converter trouble-shooting chart (par. 208).

(3) Low sensitivity with 30-mc signal applied to Radar Receiver R-38, output measured on synchroscope in transmitter rack, indicates trouble in the receiver. Refer to radar receiver trouble-shooting chart (par. 178).

(4) Low sensitivity as measured at terminal 8-8 on synchronizer and normal sensitivity at output of receiver (terminal 8-4 on synchronizer), indicates trouble in the video stages located in the synchronizer unit. Faults in the synchronizer video stages may be located by checking the video signal at TP11 with the synchroscope. If the signal is abnormal at this point and normal at terminal 8-4, tube V22 or associated circuit is defective. If the signal is normal at TP11 and abnormal at terminal 8-8, the cathode follower stages, V23 and V24, are defective. Refer to the synchronizer voltage and resistance charts (figs. 365 and 366) for normal voltage and resistance readings on these stages.

208. TROUBLE-SHOOTING CHART FOR X-BAND HETERODYNE CONVERTER AND PREAMPLIFIER.

A. SYMPTOMS:

1. Crystal current zero (I CRYSTAL "X").
2. Noise, no signals on test synchroscope (AX or BX).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. AFC circuit.	1*a*. Turn the AFC switch SW1 on the radar receiver off (down). Slowly turn potentiometer P2 through its range.
	b. If crystal current and signals appear, the AFC circuit is not functioning. Refer to the receiver trouble-shooting chart (par. 178).
2. Mixer crystal defective.	2*a*. Remove the crystal and check the back-to-front resistance ratio (normal ratio 5:1). Replace crystal if necessary.
	b. Before turning on the transmitter after a crystal has been replaced, check the T-R tube and keep-alive voltage.
3. No local oscillator output.	3*a*. Check power plug connections to heterodyne converter.
	b. Measure local oscillator tube voltage; +300 volts at pin 1, approximately −100 volts at the top cap, 6.3 volts ac at pin 2. Power is obtained from the power supply in the radar receiver.

	c. Replace the local oscillator tube V3.
4. Local oscillator off frequency.	4. Tune and adjust the local oscillator (par. 209).

B. SYMPTOMS:

1. Crystal current zero (I CRYSTAL "X").
2. Normal signals on test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Crystal metering plug not in place.	1. Check that the crystal metering plug is in JACK 1 of the preamplifier in use.
2. Crystal current metering circuit.	2*a.* Check the crystal current metering plug for internal broken connections or shorts.
	b. Check the continuity of the metering circuit in the preamplifier.
	c. Check the metering circuits in Control Box C-61.

C. SYMPTOMS:

1. Crystal current sweeps too high when AFC circuit is hunting.
2. When the AFC circuit locks in, the crystal current is around 0.2 ma.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator unstable.	1*a.* Retune local oscillator (par. 209).
	b. Retune T-R box (par. 204).
2. AFC circuit.	2*a.* The AFC circuit is locked in on the wrong mode of the local oscillator. Check local oscillator coupling and adjust for correct crystal current.
	b. Align the AFC circuit. Refer to paragraph 181 for tuning procedure.

D. SYMPTOM:

1. Crystal current low (0.2 ma or below) even when the AFC circuit is sweeping.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Repeller voltage not correctly adjusted.	1. Adjust the receiver AFC tuning control potentiometers P2 and P9.
2. AFC circuit is not properly tuned.	2. Refer to the AFC tuning procedure (par. 181).
3. Loose local oscillator coupling.	3. Increase the local oscillator coupling by turning down adjustment setscrew on heterodyne converter.
4. T-R box tuned to the local oscillator frequency.	4. Retune the T-R box (par. 204). If the T-R box is tuned near the local oscillator frequency, it will absorb power.

E. SYMPTOM:

1. Crystal current too high (above 0.8 ma) when AFC is locked in.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator too closely coupled.	1. Reduce the local oscillator coupling to the crystal mixer by turning up the adjustment setscrew on the heterodyne converter.

F. SYMPTOMS:

1. Intermittent crystal current.
2. Intermittent signals on the test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Crystal loose in socket.	1. Clean and tighten crystal holder surfaces.
2. Intermittent troubles of the type described under symptom A.	2. Follow the check procedure used under symptom A.

G. SYMPTOM:

1. Excessive grass and noise on the test synchroscope.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator coupling too tight.	1. Adjust local oscillator coupling for correct value of crystal current by turning up the adjustment setscrew on the heterodyne converter.
2. Noisy crystal.	2. Replace the crystal.

H. SYMPTOMS:

1. No signals on the test synchroscope.
2. Low noise value on test synchroscope.
3. Crystal current normal.
4. AFC circuit does not lock in.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Preamplifier.	1*a*. Measure the receiving system sensitivity at the preamplifier input and at the receiver input (par. 207) to ascertain that the trouble lies in the preamplifier unit. *b*. Check that +105 volts is reaching pin C of power input plug 1. *c*. Replace the 1st and 2nd i-f tubes V1 and V2, one at a time, and note the results. *d*. Remove the preamplifier unit from Radio Frequency Unit RF-6 and check the resistors against the resistance chart (fig. 360) *e*. Check the preamplifier i-f alignment (par. 184).

I. SYMPTOM:

1. Receiver breaks into oscillations.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Local oscillator.	1*a*. Local oscillator is operating on an unstable mode. Tune and align the local oscillator and AFC circuits (pars. 209 and 181). *b*. Reduce the local oscillator coupling by turning up the adjustment setscrew on the heterodyne converter. *c*. The preamplifier unit is not properly grounded. Check ground connections and fasten down securely. *d*. Replace the 1st and 2nd i-f tubes V1 and V2 and note results.
2. Receiver.	2. Refer to receiver trouble-shooting chart (par. 178).

209. SUPPLEMENTARY DATA.

a. Replacement of Local Oscillator. (1) To remove the local oscillator tube, first disconnect the coaxial cable to the preamplifier at the bottom of the heterodyne converter. Remove the two screws holding the rectangular shield can to the mixer assembly and remove the shield. Make certain that the high voltage is not applied to any of the r-f system components.

(2) Remove the reflector cap lead from the 723A tube and carefully pull the tube straight down out of its socket.

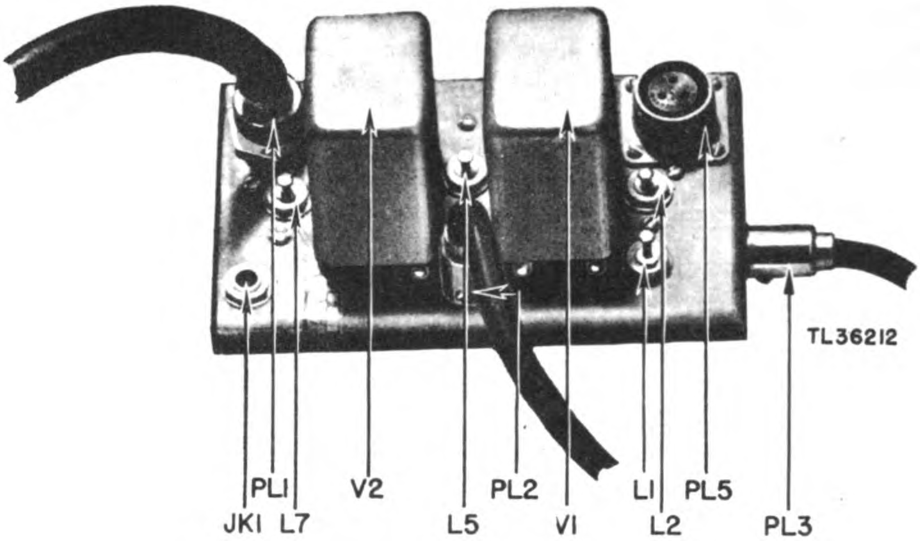


Figure 358. Preamplifier, top view.

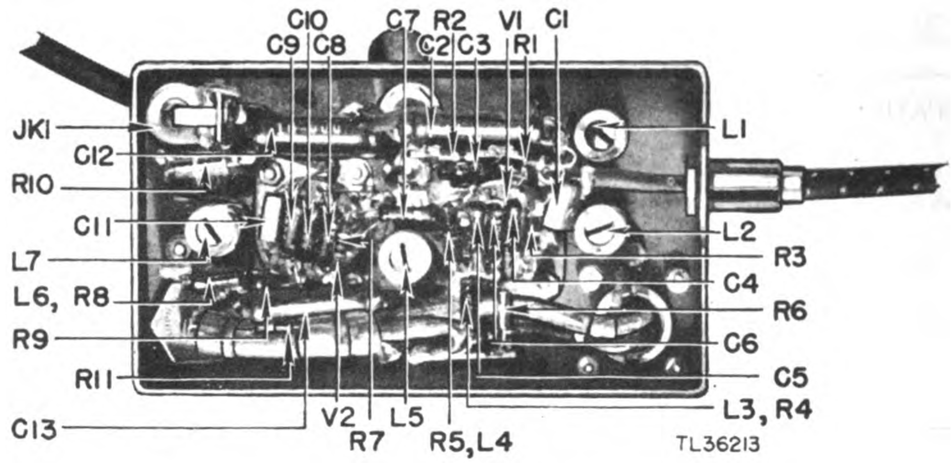


Figure 359. Preamplifier, bottom view.

Care should be taken not to damage the coupling probe which protudes from the base of the tube through one of the socket holes and into the mixer section.

(3) Place the new tube in the proper socket position and push into the socket. Since the probe length and tuning of the new tube will probably differ from the tube replaced, tuning and coupling adjustments will have to be made before the shield can is replaced. Reconnect the tube top cap, connect the preamplifier coaxial cable, and proceed with the local oscillator tuning procedure as described in the following subparagraph. In some cases it may be found that proper tuning can not be accomplished with the shield can removed. In these cases, it will be necessary to replace the shield can and then remove it each time a tuning adjustment is made.

b. Local Oscillator Tuning Procedure. (1) Turn on the receiver and insert the crystal metering plug into the jack in the preamplifier. Switch the receiver AFC switch SW1 off (down).

(2) Alternately tune the AFC potentiometer P2 (on the receiver front panel) and vary the local oscillator coupling adjustment (on the heterodyne converter unit) until 0.5 ma crystal current is indicated at the maximum output tuning position of P2.

(3) Mechanically tune the local oscillator cavity adjustment strut with the small insulated wrench supplied with the r-f unit. The recommended procedure is to adjust the AFC potentiometer so that noise on the synchroscope appears at a maximum (crystal current should be between 0.3 and 0.8 ma). Slowly turn the tuning strut adjustment until signals appear. Alternate between AFC tuning adjustment and tuning strut adjustment until maximum crystal current and maximum signal appear at the same setting. **This is a critical adjustment and should be carefully made.**

CAUTION: The shell of the local oscillator tube is maintained at +300 volts dc when the equipment is in operation. Be careful not to contact the tube when making tuning adjustments.

(4) Two settings that give maximum signals should be found separated by from 1/4 of a turn to 3 turns of the tuning strut. One setting produces a local oscillator frequency 30 megacycles above that of the magnetron, the other a frequency 30 megacycles below it. When both settings have been found, tune the local oscillator to the one which has the tuning strut bows closer together; i.e., to the higher oscillator frequency.

(5) Selection of the wrong tuning strut adjustment will reverse the discriminator output characteristic. To check the final selection, connect the synchroscope test lead to TP1 of the receiver and attach the negative lead of a d-c voltmeter to the local oscillator reflector cap, the positive lead being connected to ground. As the STC tuning potentiometer is turned through the range of oscillation of the local oscillator, in such direction that the reflector voltage becomes less negative, the discriminator pulses appearing on the synchroscope should be first negative and then positive. This indicates that the local oscillator is properly tuned 30 mc *above* the magnetron frequency.

(6) After tuning the local oscillator to its proper setting and adjusting for best signals, turn switch SW1 on the receiver to AFC. Observe that the signals appearing on the synchroscope retain at least the amplitude they had with switch SW1 in the off position. If the AFC circuit does not lock in, check the mean value of the reflector voltage; it should be near the value which gives a maximum output when the AFC is turned off. The voltage should be in the neighborhood of -100 volts dc. If this voltage is very far from the correct value, there is danger that the AFC will lock in on a lower mode of oscillation of the local oscillator, thereby producing less power output and less reliability in local oscillator frequency stability.

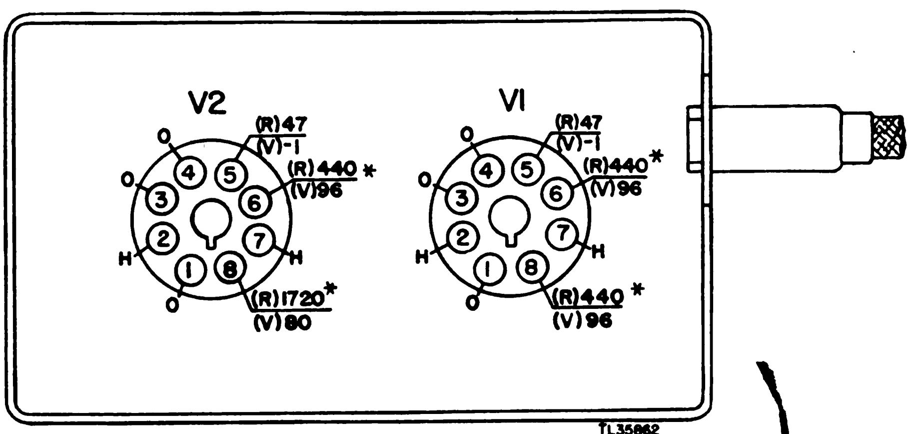
(7) With the AFC operating normally and signals showing on the synchroscope, set the local oscillator tuning strut for maximum crystal current. **This will be an extremely fine adjustment, requiring very light pressure on the adjustment wrench.** This setting should yield maximum signal reception. If it does, the local oscillator can be considered properly tuned.

(8) The local oscillator coupling should be examined critically before the system is considered ready to operate. The crystal current should be approximately 0.6 ma with no "pulling" or variation of frequency apparent at the time of the transmitter pulse.

(9) Replace the shield can on the heterodyne converter unit, making certain that all connections are tight and well made.

*c. **Preamplifier Alignment Procedure.*** Refer to i-f alignment procedure for S-band preamplifier (par. 184).

*d. **Receiver Alignment Procedure.*** Refer to alignment procedure for Radar Receiver R-38 (par. 184).



NOTE:
ALL VOLTAGES DC UNLESS OTHERWISE SHOWN.
RESISTANCE READINGS MADE WITH PLUG I REMOVED.
ALL VOLTAGE AND RESISTANCE READINGS MADE TO GROUND UNLESS OTHERWISE NOTED.
ALL VOLTAGE READINGS MADE WITH 20,000 OHMS PER VOLT METER.
* THESE READINGS TAKEN TO PIN C OF PLUG I INSTEAD OF TO GROUND.

Figure 360. Preamplifier, voltage and resistance chart.

SECTION IV

SYNCHRONIZER

210. REFERENCE DATA.

a. Synchronizer SN-5/MPN-1.

(1) Figure 361. Top view.
(2) Figure 362. Bottom view.
(3) Figure 363. Mounting board diagrams.
(4) Figure 123. Schematic diagram.
(5) Figure 364. Waveforms.
(6) Figure 365. Voltage chart.
(7) Figure 366. Resistance chart.

b. General.

(1) Figure 253. Capacitor color code.
(2) Figure 254. Resistor color code.
(3) Figure 255. Tube base chart.

211. PROCEDURE.

a. Since the synchronizer contains circuits from several systems of the radio set, troubles within the component will produce a wide variety of symptoms. Since no data is presented by the synchronizer within itself, these symptoms will appear at other points. For the most part, the symptoms will be apparent in the indicator displays since the indicating system presents the information obtained by the radio set.

b. In general, isolation of trouble to the synchronizer will have been accomplished by trouble-shooting procedures given in other sections of this manual. Once this has been done, reference to the applicable set of symptoms given in the trouble-shooting chart will give data for further isolation of trouble. The procedure given will generally permit isolation of trouble to individual stages, whereupon information given on the voltage, resistance, and waveform diagrams will present the necessary data for the location of the faulty circuit element or elements.

212. TROUBLE-SHOOTING CHART FOR SYNCHRONIZER.

A. SYMPTOMS:

1. No timebase sweep on any indicator tube.
2. No magnetron current.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Master blocking oscillator circuit.	1*a*. Observe waveform at TP2 on the synchroscope. It should be similar to the waveform shown in figure 364.
	b. If no waveform exists at TP2, measure 300-volt d-c plate supply at terminal 6-3.
	c. If plate voltage is correct, replace oscillator tube V1. If this does not correct the fault, refer to voltage and resistance charts (figs. 365 and 366) and check operation of oscillator stage.
2. 300-volt power supply.	2*a*. Low or no plate supply voltage indicates trouble in 300-volt power supply. Refer to chapter 9, section II.
	b. If voltage at terminal 6-3 is zero but spots on precision indicator may be focused, trouble is indicated in channel switching relay RY1 in the azimuth indicator or in the rack wiring.

B. SYMPTOMS:

1. No timebase sweep on all indicator tubes.
2. Magnetron voltage and output current normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Inoperative tubes.	1. Remove and test tubes V3, V4, and V17.
2. Gating multivibrator.	2*a*. Check waveform at TP3 on synchroscope. Waveform should be as shown in figure 364.
	b. If waveform is incorrect, check voltages, resistances, and waveforms on tubes V1 (b) and V3.

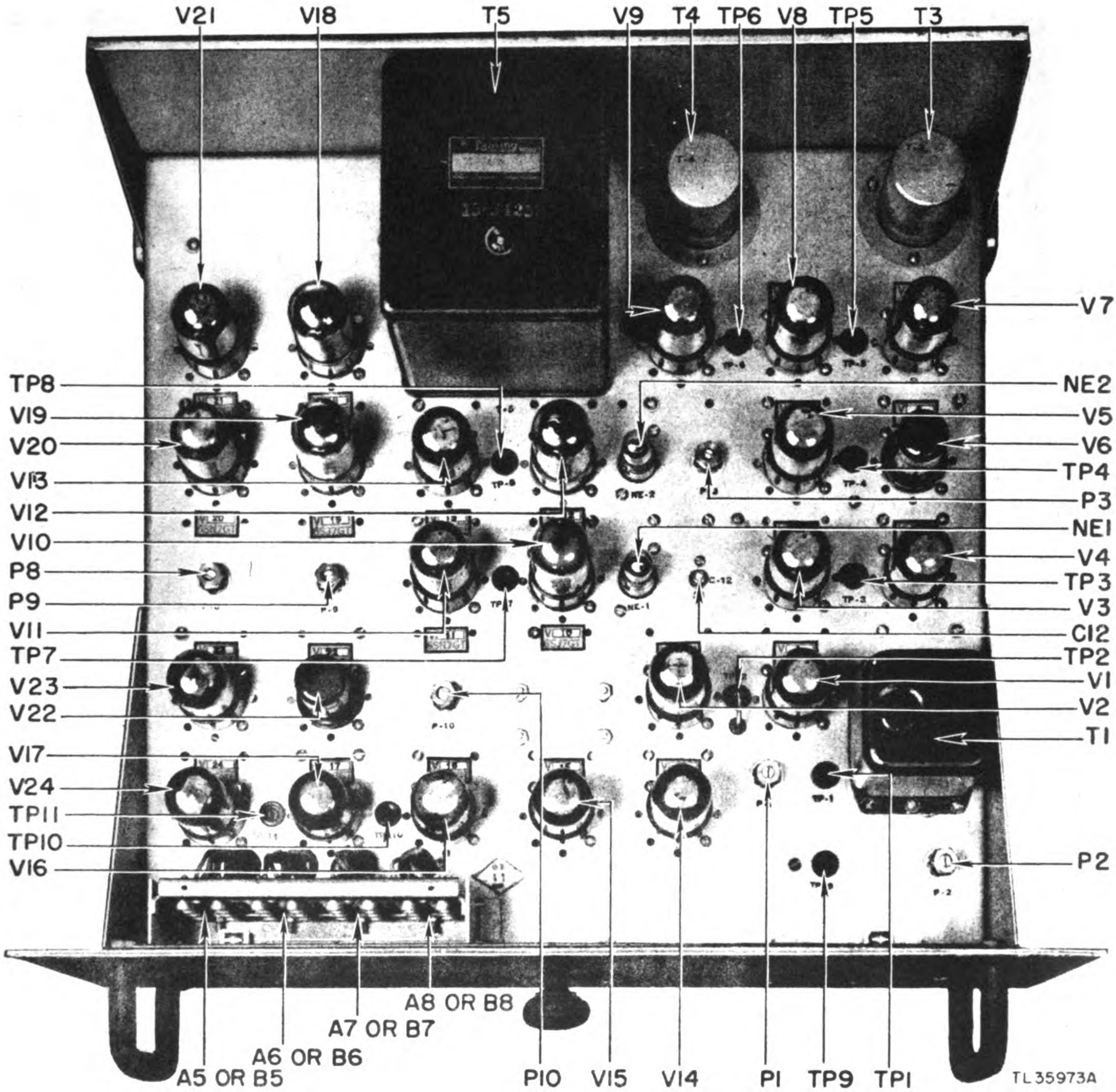


Figure 361. Synchronizer SN-5/MPN-1, top view.

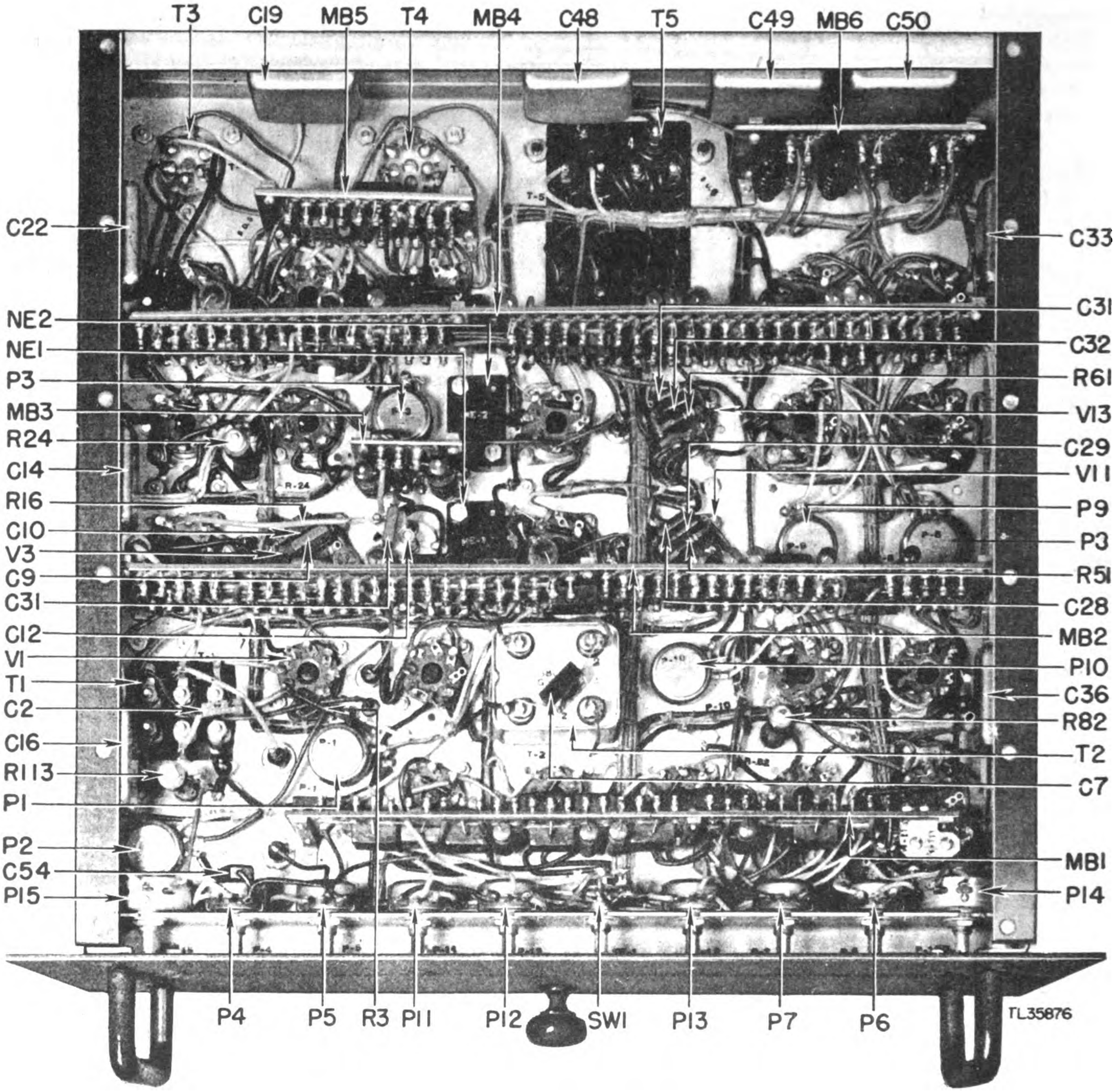


Figure 362. Synchronizer SN-5/MPN-1, bottom view.

3. Negative trigger amplifier.	3a. Observe negative trigger output at terminal 7-4 (fig. 364). If correct, refer to item 4. b. If negative trigger is faulty, trouble shoot stage V17(b).
4. Channel switching relays.	4. Proper negative trigger output at terminal 7-4 indicates a trouble in relay RY1 in approach indicator.

C. SYMPTOMS:

1. No timebase sweeps on all precision indicator tubes.
2. Timebase sweeps normal on search indicator tubes.
3. Magnetron output normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Same faults as in symptom B.	1a. Check TRIG. SEL. switch on intercommunications panel. Switch to X if not already set in that position. Symptoms of trouble should now be the same as given in symptom B. b. If, after throwing selector switch, sweeps on the search indicators are still satisfactory see item 2 below.
2. 500-volt supply to sweep amplifier.	2. Refer to chapter 9, section II.

D. SYMPTOMS:

1. No current indicated for either S- or X-band magnetron.
2. Output voltage of transmitter HVPS normal.
3. Timebase sweeps on all indicator tubes normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Positive trigger amplifier.	1a. Observe output waveform at terminal 7-8 and compare it with that shown on figure 364. If normal, refer to item 2. b. If waveform is abnormal, test tube V2. c. Make voltage and resistance measurement on tube V2.
2. Channel switching relay.	2. Check relays RY1 in approach indicator and RY1 in intercommunications panel. If waveform is normal at both these points refer to next item.
3. Modulator.	3. Refer to chapter 7, section I.

E. SYMPTOMS:

1. No range markers on all precision indicator tubes.
2. All other indications normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Range marker brilliancy controls turned down.	1. Turn 2 MILE RANGE MARK BRILL (P13) and 10 MILE RANGE MARK BRILL (P12) controls to the maximum clockwise position.
2. Range marker timing oscillator circuit.	2a. Observe waveforms at TP4 (fig. 364) with synchroscope. b. If observed waveform is correct, refer to item 3 below. c. If waveform is abnormal, test tubes V4, V5, and V6. d. Check voltages, resistances, and waveforms on the above three tubes.
3. Blocked oscillator.	3a. Observe waveform at TP5 on synchroscope. If normal, proceed to item 4. b. Test tube V7.

	c. Check voltage and resistance values and waveforms on blocking oscillator stage.
4. Tube V8.	4. Tube V8 is common to both 2-mile and 10-mile range marker circuits. Check with tube tester.

F. SYMPTOMS:

1. No range markers on both 2-mile indicator tubes.
2. Range markers on 10-mile indicator tubes normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 2,500-foot marker brilliance control low.	1. Turn 2 MILE RANGE MARK BRILL (P13) control to the maximum clockwise position.
2. Cathode follower V8(a).	2*a*. Turn RANGE MARK RATIO TEST (SW1) to clockwise position and observe sweep on 10-mile indicator tubes. If 2,500-foot markers appear, refer to item 3. *b.* If no markers appear, test tube V8 with tube tester. *c.* Check for normal spacing of range markers on 10-mile indicator tubes. Abnormal spacing indicates faults similar to those described in symptom E above with the exception that the count-down blocked oscillator V9(a) is free running. Refer to symptom E.
3. Faulty mixer V17(a).	3*a*. Check marker signal to 2-mile indicator tubes at either terminals 8-6 or 8-2 (fig. 364). *b.* If markers appear normal, refer to item 4. *c.* If no waveforms appear, check voltages and waveforms at terminals 1 and 2 of the mixer stage.
4. Channel switching relay.	4. Check for faulty points on channel switching relay RY2 in the elevation indicator and RY2 in the azimuth indicator.

G. SYMPTOMS:

1. No range markers on both 10-mile indicator tubes.
2. Range markers on 2-mile indicator tubes normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 10,000-foot marker brilliance control low.	1. Turn 10 MILE RANGE MARK BRILL control (P12) to the maximum clockwise position.
2. Count-down blocked oscillator.	2*a*. Check for proper waveform (fig. 364) at TP6 with synchroscope. If correct refer to item 3. *b.* If no signal appears at test point, check continuity of transformer T4. *c.* Check waveform at plate (terminal 2) of V9(a). *d.* No signal at plate of oscillator indicates open capacitor C25 or faulty inverter-amplifier tube V7(b).
3. Mixer circuits.	3*a*. Check tube V14 with tube tester. *b.* If tube is satisfactory, replace and check waveforms (fig. 364) at terminals 4 and 5. No signals at terminal 4 indicates a faulty coupling capacitor C39. *c.* Check voltage and resistance values (figs. 365 and 366) of mixer (V14) circuit. *d.* Check signals at terminals 8-7 and 8-3. If signals are satisfactory at these points, check channel switching relays in azimuth and elevation indicators.

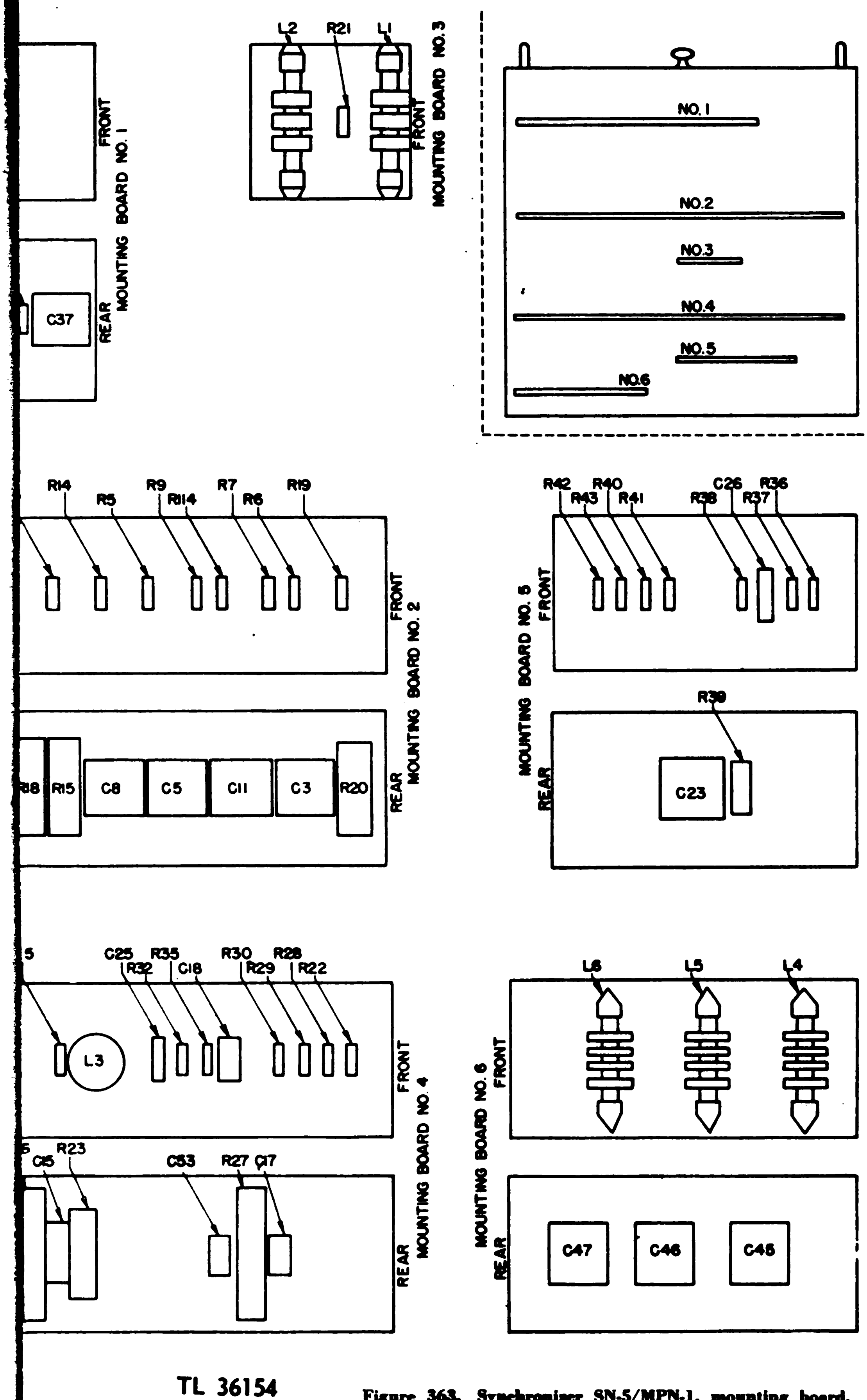
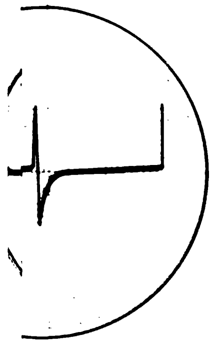
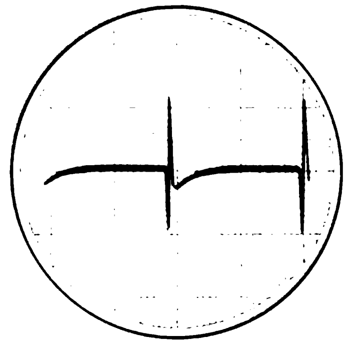


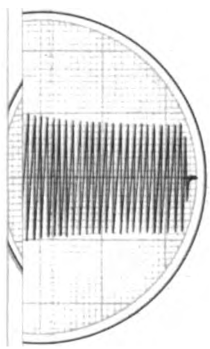
Figure 363. Synchronizer SN-5/MPN-1, mounting board.



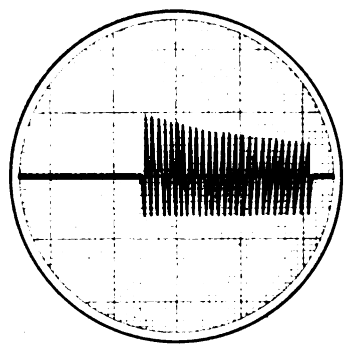
5
FIER, V2
N 40
N 40



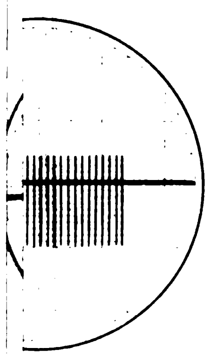
6
AMPLIFIER, V2
Pin 3
Y GAIN 0
X GAIN 40



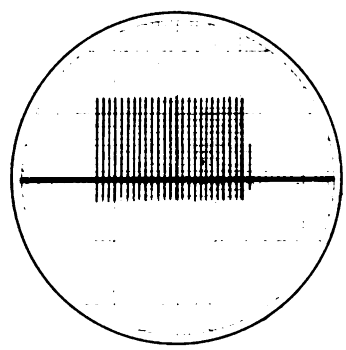
11
RKER TIMING
R, V4(b)



12
CLIPPER, V5(a)
Pin 3
Y GAIN 100
X GAIN 100



17
ILLATOR, V7(a)



18
CATHODE FOLLOWER, V8(a)
Pin 1
Y GAIN 40
X GAIN 100

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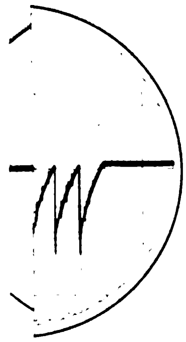
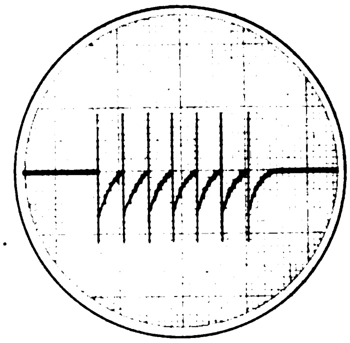
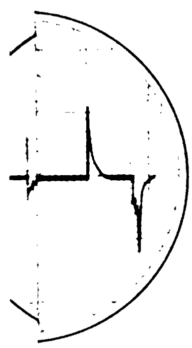
Figure 364A. Synchronizer SN-5/MPN-1, waveforms.



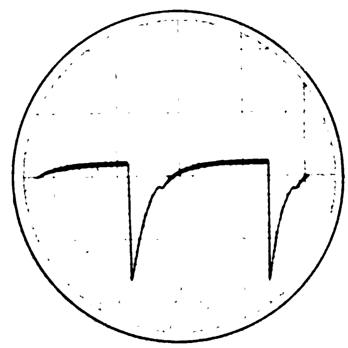
IBE, V8(b)*



24
COUNT-DOWN BLOCKED OSCILLATOR, V9(a)*
Pin 1
Y GAIN 20
X GAIN 100



HOIFIER, V17(b)
IN
IN



30
INVERTER AMPLIFIER, V17(b)
Pin 5
Y GAIN 30
X GAIN 40

IT-S
and
P10
N 1
N

imo
NG

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igra **Figure 364B. Synchronizer SN-5/MPN-1, waveforms.**

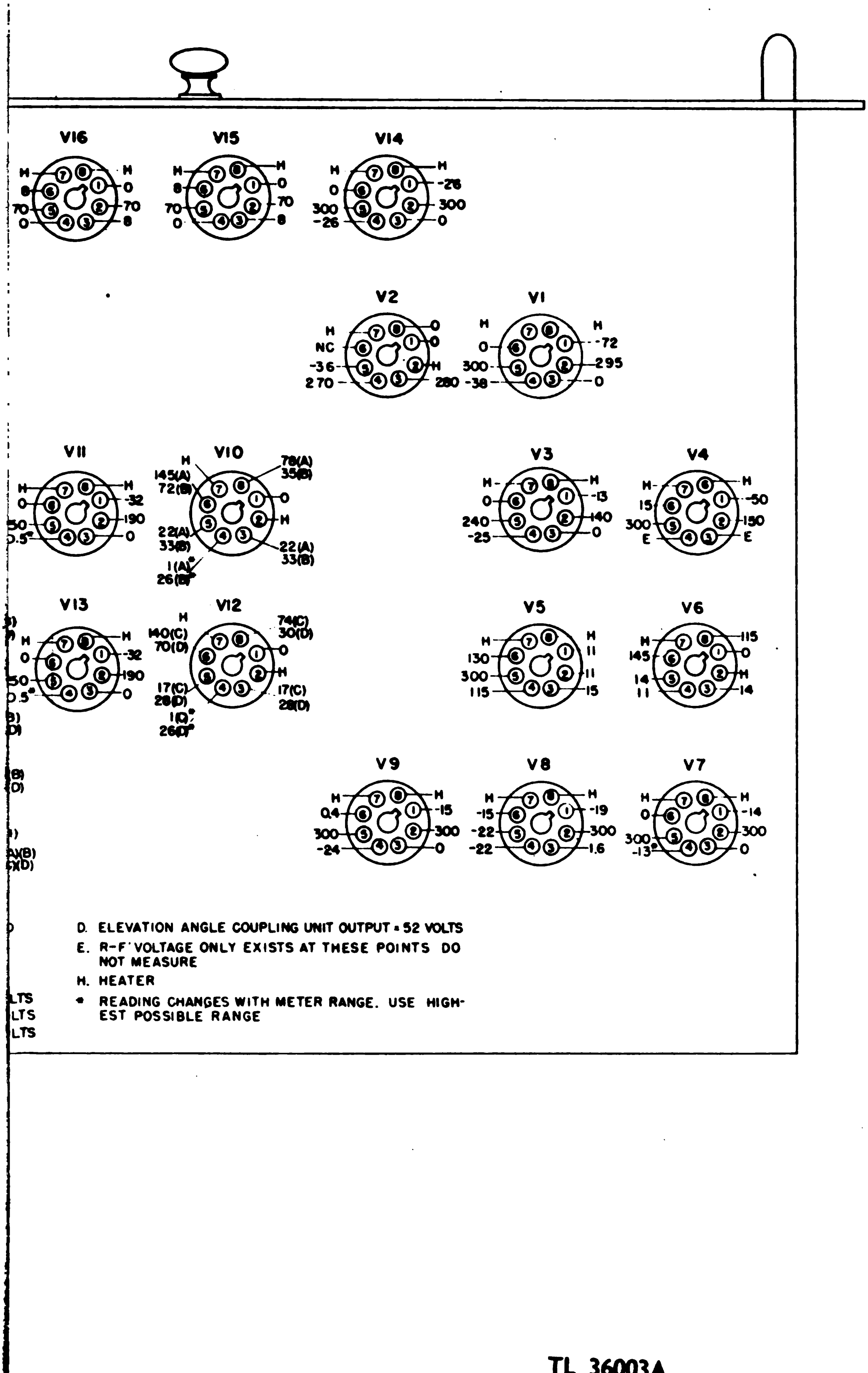

Figure 365. Synchronizer SN-5/MPN-1, voltage chart.

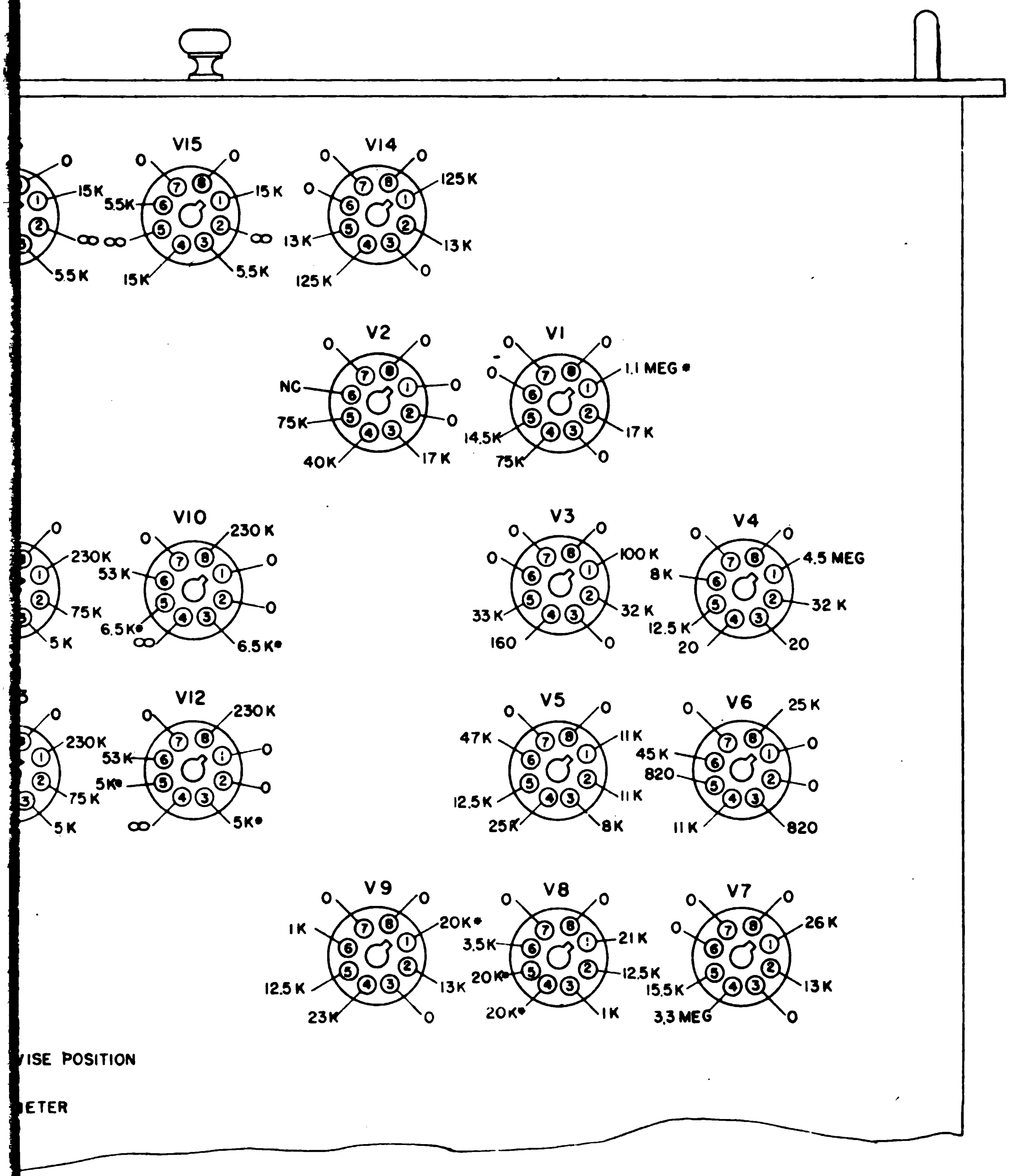

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Figure 366. Synchronizer SN-5/MPN-1, resistance chart

H. SYMPTOMS:

1. Improperly spaced range markers on all precision indicator tubes.
2. Wrong indications of range on known fixed targets.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Precision indicator alignment.	1. Proper number of range markers is 4 on the 2-mile indicator tube and 5 on the 10-mile indicator tube. Adjust amplitude, expansion, and tilt controls on associated sweep amplifiers until alignment is correct.
2. Improper negative trigger delay.	2*a*. Produces improper range markers spacing at beginning of sweep on both search and precision indicators. *b*. Adjust by procedure given in paragraph 216.
3. Range marker timing oscillator frequency.	3. Adjust oscillator frequency according to procedure given in paragraph 216.

I. SYMPTOMS:

1. Improperly spaced range markers on 10-mile indicator tubes.
2. Improper indications of range on known fixed targets on 10-mile tube.
3. Correct indications of range on 2-mile indicator tubes.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Count-down blocked oscillator frequency.	1*a*. Check ratio of 2,500 and 10,000-foot range markers by procedure described in paragraph 215. *b*. Adjust potentiometer P3 on top of synchronizer chassis until count-down ratio is correct.

J. SYMPTOMS:

1. Angle markers missing from azimuth indicator display.
2. All other indicators appear normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Azimuth angle marker circuit.	1*a*. Advance ANGLE MARK BRILL control (P5) to the maximum clockwise position. *b*. Check output at TP9 with synchroscope used as oscilloscope. If correct output is obtained, refer to item 2. *c*. If no output is obtained, trouble shoot angle marker circuit by means of procedure given in paragraph 213.
2. Mixer V15.	2*a*. Check V15 with tube tester. *b*. Make voltage, resistance, and waveform measurement on V15. *c*. No plate voltage on one or both sections of V15 is a symptom of trouble in the associated indicator, since these tubes obtain their plate voltage from the indicator. Refer to chapter 8, section 5.

K. SYMPTOMS:

1. Angle markers missing on elevation indicator.
2. All other indicators operating normally.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Same as symptom J.	1. Refer to symptom J.

L. SYMPTOMS:

1. No identification marker appearing on 10-mile indicator tube (abnormal).
2. No identification marker appearing on 2-mile indicator tube (normal).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No input.	1*a*. Check for presence of input signal at terminal 6-6. Lack of signal indicates trouble in the intercommunications panel or search central. Refer to chapter 7, section IV.
	b. If signal is similar to that shown in figure 347, refer to item 2.
2. Mixer V14.	2*a*. Turn STROBE BRILLIANCE control (P11) to maximum clockwise position.
	b. Check mixer tube V14 with tube tester.
	c. Check voltage, resistance, and waveforms on mixer tube.

M. SYMPTOMS:

1. No change in intensity of precision indicator sweep with antenna switching.
2. No control of precision receiver gain.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No input voltage.	1. Check input voltages at terminals 5-6 and 5-7 with voltmeter. Proper values are given in figure 365.
2. No –210-volt supply voltage.	2*a*. Voltage at terminal 5-8 should be –210 volts.
	b. If no voltages exist at this terminal, and the remainder of the radio set is operating normally, an open circuit between the negative power supply (PP-25) and the synchronizer is indicated.

N. SYMPTOMS:

1. No control of precision receiver gain from either azimuth or elevation indicator positions.
2. Blanking of both precision indicators normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Receiver gain control switch on LOCAL position.	1. Change the receiver gain control switch to REMOTE position.
2. Faulty d-c amplifier (V20).	2*a*. Check tube V20 with tube tester.
	b. Check voltage and rsistance values on V20.

O. SYMPTOMS:

1. No change of display intensity on either precision indicator as antennas are switched.
2. Control of receiver gain from both precision indicator positions is normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Faulty inverter V21.	1*a*. Check output of inverter at terminals 5-3 and 5-5 with voltmeter. Correct values are given on voltage chart (fig. 365).
	b. If output is normal see item 2.
	c. If no output exists, test tube V21 and check voltage and resistance values on the tube terminals.

2. Channel switching system.	2. Check for presence of blanking voltages at terminals 14-1 (channel A) or 14-2 (channel B) on the azimuth indicator and 2-1 (channel A) or 2-2 (channel B) on the elevation indicator. Lack of signals at the proper points indicates a fault in the channel switching relays or in the power system energizing these relays.

P. SYMPTOMS:

1. No change of display intensity on one precision indicator as antennas are switched.
2. No control of receiver gain from other precision indicator.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No input.	1*a*. Check input voltages at terminals 5-6 and 5-7. If these voltages do not correspond with those listed in figure 365, trouble is indicated in the commutator unit (pars. 72 and 235).
	b. If input voltages are normal, refer to item 2.
2. Faulty inverter (V18 or V19).	2*a*. If fault lies in elevation indicator blanking and azimuth indicator gain, check inverter V18. If faults occur in the opposite indicators check inverter V19.
	b. Check voltage and resistance values on proper inverter stage.
3. Gain control potentiometer.	3. Check for the presence of shorts to ground or across the potentiometer on the indicator where no control of gain is possible. Check interconnecting wiring between gain control on director and commutator circuit in synchronizer.

213. TROUBLE SHOOTING ANGLE MARKER CIRCUIT.

a. Purpose of Test. Circuits generating angle markers consist of tubes V10 and V11 for producing the azimuth angle markers and tubes V12 and V13 for producing the elevation angle markers. While each individual action in these circuits takes place in a relatively short time, the time interval between these actions is so long that waveforms of the circuit cannot be viewed on the oscilloscope. However, in case of trouble in these circuits, the use of the oscilloscope would greatly facilitate location of the fault. Reference to figure 137 shows that the input voltage to the circuit is approximately a sine wave with a frequency of approximately 0.5 (slow scanning) or 2.0 (fast scanning) cycles per second. By increasing the frequency of this input, the circuit action may be speeded up to a point obtainable on the oscilloscope sweep circuit. This is accomplished by utilizing a 60-input voltage.

b. Test Procedure. (1) Disconnect the input voltage to the faulty circuit. The leads may be broken at any one of three places. This is done most easily by disconnecting the angle coupling unit feeding the faulty circuit. (Be sure to disconnect the angle coupling unit in the proper channel as well as on the proper antenna.) Two other points at which the circuit may be disconnected are at terminal strip 6 on the synchronizer (by inserting an insulating material over the proper terminal and between the removable and fixed strips) or at the terminal strip on the indicator rack frame.

(2) Connect a 60-cps voltage of the order of 2 volts to the input terminal of the faulty circuit. This voltage may be obtained from an external source or from the filament terminal of one of the tubes of the synchronizer itself.

> CAUTION: Do not obtain this voltage from tubes V18, V19, V20, or V21 as the filaments on these stages have a d-c voltage of –210 volts superimposed on the filament voltage.

(3) Set the oscilloscope sweep frequency at the proper range and observe the circuit waveforms at the two test points provided. The oscilloscope display should be similar to the waveforms shown in figure 364.

(4) Because of the fact that the input voltage has a much higher frequency than the one for which the circuit was designed, the rate of change of voltage as the neon tube is extinguished may be sufficient to trigger the multivibrator following. This will be evidenced by the appearance of another pulse from the output of the multivibrator, and is shown by dotted lines on the waveform (TP9, TP10) in figure 364. The two pulses move toward or away from one another with variation of the angle marker control (P4 or P6) on the front panel of the synchronizer. The appearance of this extra pulse does not indicate a fault in the circuit.

214. ADJUSTMENT OF PULSE RECURRENCE FREQUENCY. When tube V1 or the circuit elements of the master blocking oscillator circuit are replaced, a readjustment of the pulse recurrence frequency must be made. This is accomplished by adjustment of potentiometer P1 on top of the synchronizer chassis (fig. 361). Two possible methods of making this adjustment are given below.

a. Using Standard Audio Oscillator. When an audio oscillator of known accuracy is available, the following procedure may be used to properly adjust the pulse recurrence frequency:

(1) Adjust the audio oscillator frequency to 2,000 cps and connect its output terminals to the Y-SIGNAL INPUT terminal of the test oscilloscope. Adjust the sweep frequency (with the SYNC. SIG. control set at zero) of the oscilloscope until a single sine wave cycle is approximately stationary on the scope screen.

(2) Connect either the positive or negative trigger (terminals 7-8 or 7-4) to the Y-SIGNAL INPUT terminals of the oscilloscope. Adjust potentiometer P1 until a single stationary pulse is visible on the scope screen.

> NOTE: In order that the master oscillator frequency will not be a submultiple of the sweep frequency, the timebase *must be broken* below (or above) the trigger pulse.

(3) Turn the frequency range selector switch on the oscilloscope to the X-SIGNAL INPUT and connect the output of the audio oscillator (2,000 cps) to the X-SIGNAL INPUT terminals. Make a fine adjustment of potentiometer P1 until the trigger is stationary on the oscilloscope screen.

b. Using Search Central Trigger. If an accurate audio oscillator is not available, and the blocking oscillator circuit in the search central (or in the synchronizer of the other channel) is known to be of the proper frequency, it may be used as a standard for calibration. The following procedure may be used in the adjustment:

(1) Connect the trigger output from the search central (or from the other synchronizer) to the Y-SIGNAL INPUT terminals of the test oscilloscope. Adjust the sweep frequency of the oscilloscope until the scope display is as described in subparagraph (2) above. The SYNC. SIG. control on the oscilloscope must be set at zero.

(2) Substitute either the positive or negative trigger output of the synchronizer to the test oscilloscope in place of the trigger from the search central. Adjust potentiometer P1 until the trigger is stationary on the scope screen, again with the SYNC. SIG. control at zero (midposition).

> NOTE: In order to obtain a trigger from the search central, the TRIG. SEL. switch on the intercommunications panel must be thrown to either position 1 or position 2, depending upon which search central is used as a standard.

215. COUNT-DOWN OSCILLATOR ADJUSTMENT.

a. Requirements. The output pulses from the count-down blocked oscillator are spaced and timed to represent 10,000-foot intervals of range. The input pulses which trigger this oscillator are spaced at 2,500-foot intervals. The count-down oscillator must be adjusted so that one output pulse is produced by every four input pulses.

b. Adjustment. Adjustment of the count-down blocked oscillator frequency (and control of ratio of 2,500-foot to 10,000-foot range markers) is made as follows:

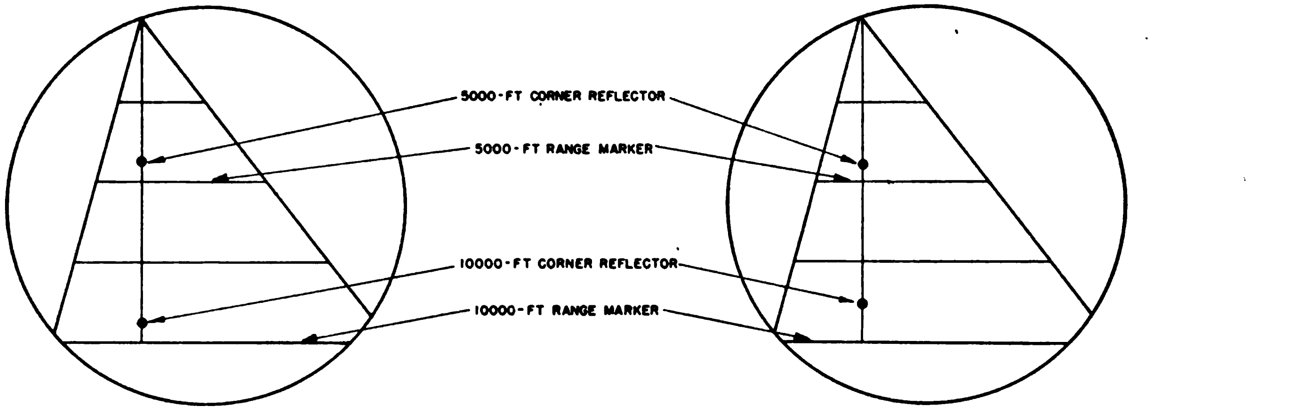
(1) With the radio set operating in a normal manner, reduce the VIDEO BRILLIANCE control on one of the precision indicators to the minimum position. The range markers should now be clear on both indicator tubes.

(2) Using a screwdriver, turn the RANGE MARK RATIO TEST switch on the front panel of the synchronizer to its clockwise position. Closely spaced range markers representing intervals of 2,500 feet will appear between the 10,000-foot markers on the 10-mile indicator tube. The 2,500-foot markers will normally be of a lesser intensity (and produce a finer line) than the 10,000-foot markers. If intensities are approximately equal, turning the test switch alternately on and off during the adjustment procedure will aid in differentiating between the two types of markers.

(3) Proper operation of the count-down blocked oscillator will produce one 10,000-foot range marker for every four 2,500-foot range markers. When the test switch is thrown on, three fine lines should appear *between* the heavy range marker lines on the 10-mile indicator tube. If this is not the case, adjust potentiometer P3 (fig. 361) on top of the synchronizer to give proper operation.

(4) The control will have an effect on oscillator frequency only at certain critical points. Alternately rotate the potentiometer in both directions and determine the limits of proper operation. Make a final setting of the potentiometer, midway between these two points.

(5) If proper operation cannot be obtained with the potentiometer, or the 10,000-foot range markers are unstable, try replacing tubes V8 and V9. If trouble is still present, it may be necessary to change the voltage at the cathode (pin 6) of stage V8(b). This may be accomplished by substituting a resistor of slightly different value for R38.



(a) **Figure 367. Errors in range measurement.** (b)

216. CORRECTION OF RANGE DATA.

a. Types of Error. Two types of errors occur in the determination of range. These two errors are due to improper operation of two separate circuits. Controls are provided for independent correction of the errors. Correction procedure is described in the following subparagraphs:

(1) The first error is one of a fixed distance throughout the range of the radio set. This type of error is illustrated by figure 367(a). It results from the fact that the indicator sweeps are started at a time other than that at which the main pulse is radiated. Correction is made by the delay of the negative trigger in the synchronizer.

(2) The other type of error is fixed percentage error. This means that if a given error occurs at a certain range, twice as large an error will occur at twice the range. This is illustrated in figure 367(b). The error is due to incorrect frequency of the range marker timing oscillator.

(3) One or both of these errors may occur in the radio set at the same time. While independent controls are provided for correction, the effects of the two controls are similar. Adjustments must be made in the proper order to obtain the required results.

b. Adjustment of Range Marker Timing Oscillator Frequency.

> WARNING: The oscillator frequency control is a factory preset adjustment and should be changed only when a change of damage oscillator circuit elements has altered the frequency or when range measurements errors have been definitely traced to improper oscillator frequency. Only experienced personnel should be permitted to make the adjustment.

(1) Install two or more corner reflectors in the region scanned by the precision antennas, along a line through the radio set running parallel to the runway. If only two reflectors are used, install them at distances of 5,000 feet and 10,000 feet from the radio set. If more reflectors are used, install at 2,500-foot intervals up to 10,000 feet and at 10,000-foot intervals thereafter.

(2) Graduate a narrow strip of paper into four divisions with spacing of graduations equal to the distance between range markers on the 2-mile indicator tube. Make a similar scale for the 10-mile tube if corner reflectors have been placed beyond 10,000 feet. The spacing of range markers must be measured along the line on which the corner reflectors are laid out.

(3) Lay the prepared scale on the face of the phenolic map and along the line of the corner reflectors. Carefully adjust capacitor C12 on top of the synchronizer chassis until the spacing of the corner signals is equal to the spacing of the graduations on the prepared scale (and equal to spacing of range markers). Tighten the locknut on the variable capacitor.

(4) While the frequency of the timing oscillator is now correct, errors may still be present in range measurements. If so, these errors will be due to improper negative trigger delay and will appear as shown in figure 367(a). Correct by the procedure outlined in subparagraph *d*.

c. Test-bench Adjustment of Timing Oscillator. If a crystal-controlled (196.6 kc) signal generator or a variable frequency generator with an accuracy of better than 1 percent is available, use the following procedure to calibrate the range marker timing oscillator frequency:

(1) Remove the gating multivibrator stage (V3) in the synchronizer.

(2) Connect a d-c voltage source of -30 volts to -50 volts to TP3. This voltage holds stage V4(a) at cutoff and allows the timing oscillator to oscillate freely.

(3) Set up the test oscilloscope with the sweep frequency

selector switch to the X-SIGNAL INPUT position, and the output of the standard signal generator fed to these terminals. Obtain the output of the range marker timing oscillator at terminal 3 of tube V5 in the synchronizer, and feed it to the Y-SIGNAL INPUT terminals of the scope.

(4) With the output of the standard signal generator set at 196.6 kc carefully adjust capacitor C12 until the oscilloscope display shows a circle, an ellipse, or a straight line running diagonally across the tube face. If the two signals differ slightly in frequency, the scope display pattern will appear to roll in a circle. Adjust C12 for a stationary display.

d. Adjustment of Negative Trigger Delay. If the frequency of the range mark timing oscillator is correct, or if it has been adjusted by either of the above procedures, error in negative trigger delay will cause range measurement errors to appear as shown in figure 367(a). If such an error is found to be present, make adjustments of trigger delay as follows:

(1) With spacing of corner reflector signals equal to spacing of range markers (as set by range marker timing oscillator frequency) adjust potentiometer P2 on top of synchronizer chassis until corner reflector signals coincide with range markers.

(2) Make any readjustments of amplitude, expansion, and tilt control on the associated sweep amplifiers that may be necessary.

217. ADJUSTMENT OF BLANKING CONTROLS.

a. Servicing Commutator Circuit. The input to the commutator circuit, consisting of stages V18, V19, V20, and V21, is in the form of a d-c voltage which periodically changes from one value to another and then back to the first. Therefore, circuit analysis through the use of the oscilloscope is not feasible. In trouble shooting the circuit, use the analyzer to measure voltage and resistance values. If the voltage values shown at pin 4 on stages V18 and V19 are not approximately equal to those shown on the voltage chart, trouble is indicated in the photoelectric commutator. Make all voltage measurements in this circuit with the antenna switching motors stopped. Make measurements first with the azimuth antenna energized and then with the elevation antenna energized in order to utilize all available voltage data.

b. Receiver Gain Circuit Adjustment. Adjustment of the blanking controls, P8 and P9, in the commutator circuit of the synchronizer is made by first adjusting for proper operation of the receiver gain control section and then checking for proper operation of the indicator blanking section. Make the adjustments as follows:

(1) Stop the precision antenna switching motor and rotate the motor by hand until the r-f energy is fed to the azimuth antenna. The azimuth indicator tubes should now have a more intense trace than those of the elevation indicator.

(2) Connect a voltmeter between the azimuth blanking terminal 5-5 and the ground. Turn potentiometer P9 to the region where the voltmeter reading is zero and rotate until the voltmeter just begins to indicate a negative voltage. Adjust potentiometer P9 to this point, which is the point at which stage V12(b) is exactly at cutoff.

(3) Rotate the antenna switching motors by hand until the elevation antenna is energized. Connect the voltmeter between receiver gain control terminal 6-1 and ground. Rotate the REMOTE GAIN CONTROL on the elevation director and note the range of meter reading. The range of voltage should be from −70 to −95 volts. A somewhat greater range is permissible provided the two limits mentioned fall within the range. If the required range is not covered, make a slight adjustment of potentiometer P9 until the required range is covered.

(4) Connect the voltmeter to elevation blanking terminal 5-3 and adjust potentiometer P8 for zero voltage at the terminal as explained in subparagraph (2).

(5) Again connect the voltmeters to receiver gain control terminal 6-1. Rotate the antenna switching motor until the azimuth antenna is energized. Note the range of voltage given at the terminal by complete rotation of the REMOTE GAIN CONTROL on the azimuth director. The required range is the same as previously specified. Make any slight adjustment of P8 necessary to obtain the required range.

(6) Rotate the receiver gain control on the elevation director to its complete range. There should be no apparent change in the voltmeter reading.

(7) Rotate the antenna switching motors until the elevation antenna is energized. Check that the azimuth gain control now has no effect on the voltmeter reading.

c. Indicator Blanking Circuit Adjustment. (1) After completing adjustment of the receiver gain circuit and with the elevation antenna energized, connect the voltmeter to the azimuth blanking terminal 5-5. A reading of −70 volts or lower (more negative) should be obtained. When the azimuth antenna is energized this voltage should rise to zero.

(2) Similar voltage readings should be obtained at elevation blanking terminal 5-3 when the opposite antennas are energized. The voltage range at both the above terminals may be slightly in excess of that given.

(3) If the proper range of blanking voltages is not produced, a study of the blanking action on the precision

indicators will indicate whether or not further adjustment of potentiometers P8 and P9 is necessary. If readjustments are made, check that remote receiver gain control action has not been impaired.

(4) If a ripple, or a periodic variation in intensity, is present in the indicator displays, it may sometimes be corrected by a slight adjustment of potentiometers P8 and P9. Again check receiver gain control action if readjustments are made.

218. VIDEO CIRCUIT ADJUSTMENT AND SERVICE.

a. Test Procedure. No rigorous test procedure is necessary except the customary check on circuit continuity and d-c socket voltages. If defects are suspected and video output from the receiver is not available, the circuit can be tested by applying the positive trigger from synchronizer terminal 7-8 to video input terminal 8-4, thru Voltage Divider TS-222/MPN-1 set to the 100:1 or HIGH position. Insert the test scope or synchroscope into TP11 and compare the plate output of V22 with the known trigger waveform. Note the amplitude as the measure of the gain of V22. Apply the test lead to video output terminal 8-8 to observe the output of the cathode followers V23 and V24. The waveform should be identical with that at TP11 except for a slight loss in amplitude. If video gain or waveshape at TP11 is not satisfactory, adjust video gain control P10. If no improvement is apparent, check the tubes and other circuit elements for defective operation.

b. Video Gain Control Adjustment. (1) The video gain control, P10, is adjusted for maximum amplifier gain with no limiting action.

(2) To properly adjust the control, stop the antenna switching motors in such a position that good fixed signals are obtained on the receiver. Connect the test rack synchroscope to terminal 8-4 on the synchronizer and adjust the receiver gain to the lowest value at which the signals are visible on the synchroscope.

(3) Connect the synchroscope test lead to terminal 8-8 and adjust P10 to the point of maximum output signals and a very slight decrease in noise. This setting will be approximately the cut-off point of the cathode injector stage V22. Keep the receiver gain at as low a value as possible during these adjustments.

(4) A rough adjustment of P10 may be made by connecting a d-c voltmeter to terminal 8-4 and adjusting P10 until the voltage read by the meter just reaches zero. During this adjustment the output of the receiver must be cut off by opening the receiver panel door. and the receiver video gain control must be at maximum.

219. SUPPLEMENTARY DATA.

a. Removal of Chassis from Rack. The synchronizer can be removed from the indicator rack after removing the four terminal boards inside the panel door and the four holding screws on the front panel. During removal be especially careful that the rear panel of the chassis does not cut the insulation on the connecting cables. When replacing the component. make a final check after connection is completed to verify the fact that all cables are connected to their proper terminal strips.

b. Use of Waveform Chart. All waveforms of the synchronizer are shown on figure 364. A Dumont type 241 oscilloscope was used to take all waveforms shown on the 5-inch grid background, while the synchroscope was used to obtain the waveforms with the 3-inch background. As an approximate indication of amplitude. the horizontal and vertical gain settings of the oscilloscope are given. Unless otherwise indicated, the Y attenuator is set at 100:1 and the sweep frequency control to the 900-3K position.

SECTION V

INDICATING SYSTEM

WARNING: ***Voltages sufficient to cause death on contact exist in Azimuth Indicator ID-36/MPN-1 and Elevation Indicator ID-37/MPN-1. Do not place hands or arms within these units with the high voltages on. Do not make any connections into these units which bring high voltages out to an exposed point. Make all tests with the high voltages off. Always ground high voltage capacitors before touching them or associated equipment.***

220. REFERENCE DATA.

a. Sweep Amplifier AM-15/MPN-1.

(1) Figure 368. Top view.
(2) Figure 369. Bottom view.
(3) Figure 370. Mounting boards.
(4) Figure 150. Schematic diagram.
(5) Figure 371. Waveforms.
(6) Figure 372. Voltage chart.

(7) Figure 373. Resistance chart.

b. Elevation Indicator ID-37/MPN-1.

(1) Figure 374. Front view.
(2) Figure 375. Rear view.
(3) Figure 160. Schematic diagram.
(4) Figure 376. Voltage chart.
(5) Figure 377. Resistance chart.

c. Azimuth Indicator ID-36/MPN-1.

(1) Figure 378. Front view.
(2) Figure 379. Rear view.
(3) Figure 164. Schematic diagram.
(4) Figure 380. Voltage chart.
(5) Figure 381. Resistance chart.

d. Elevation Director Assembly MX-33/MPN-1.

(1) Figure 165. Front view.
(2) Figure 166. Rear view.
(3) Figure 168. Schematic diagram.

e. Azimuth Director Assembly MX-32/MPN-1.

(1) Figure 169. Front view.
(2) Figure 382. Rear view.
(3) Figure 171. Schematic diagram.

f. Approach Indicator ID-38/MPN-1.

(1) Figure 172. Front view.
(2) Figure 383. Front view, with panel open.
(3) Figure 438. Top view.
(4) Figure 439. Bottom view.
(5) Figure 437. Front interior view, with panel open.
(6) Figure 174. Schematic diagram.
(7) Figure 440. Voltage and resistance chart.

g. Aural Signal Unit O-8/MPN-1.

(1) Figure 384. Top view.
(2) Figure 385. Bottom view.
(3) Figure 386. Mounting boards.
(4) Figure 179. Schematic diagram.
(5) Figure 387. Waveforms.
(6) Figure 388. Voltage and resistance charts.

h. General.

(1) Figure 253. Capacitor color code.
(2) Figure 254. Resistor color code.
(3) Figure 255. Tube base chart.

221. SPECIAL INFORMATION.

a. Removal of Precision Directors. (1) In contrast to other components of the radio set, the terminal boards on the precision directors must be removed after the components are removed from the rack. To take out either director, remove the operator's table, loosen the panel screws holding the director, and partially slide the component out of the rack. The terminal boards will then be available on the left side of the chassis behind the sloping panel.

(2) Use care in the removal of directors to prevent damage to map light. On certain types of precision indicators, the map light bulb is extended below the indicator. When such a unit is in use, sliding the associated director out of the indicator rack results in striking and breaking the map light bulb. Take out both bulbs before removing the director.

b. Adjustment of Precision Indicator Tubes. (1) In the alignment of the precision indicators it is often necessary to adjust the position of the cathode-ray tubes. Such adjustments require access to the rear of the indicator and to the clamp holding the tube mount.

(2) Access may be gained to the rear of certain early production indicators only by the removal of the channel B sweep amplifier. Later models, however, are provided with a removable relay panel. When this panel is loosened and moved to one side, sufficient space is provided for access to the tube mount clamp.

222. PROCEDURE.

a. Use of Trouble-shooting Chart. While faults may occur in any part of the radio set, nearly all will cause some symptom of trouble to appear in either the search or the precision indicating system. The trouble-shooting chart in chapter 6, section III, based on the starting procedure of the radio set, has been designed to isolate these troubles to a definite system or even a single component of the set. Therefore, when symptoms of trouble appear in the indicating system, use the following procedure to locate the source of the trouble:

(1) When trouble is detected, first refer to the starting procedure trouble-shooting chart, chapter 6, section III. Information given there will aid service personnel in isolating the trouble to a system.

(2) If the trouble has been found to exist in the indicating system, next refer to the trouble-shooting chart given in this section. Due to the complexity of certain systems in the radio set, system trouble-shooting charts are provided for isolation of trouble to components, and component trouble-shooting charts are then provided for final isolation of the fault.

(3) Since the components of the indicating system are not closely connected electrically, no system trouble-shooting chart has been provided with the exception of the sweep amplifier and associated indicator. The nature of any trouble that might occur will immediately disclose which component is faulty. In the case of the sweep amplifiers and precision directors, by far the greater number of troubles will occur in the sweep amplifier because of its greater complexity. Refer first to the sweep amplifier trouble-shooting chart, and if no trouble is found then check the associated indicator.

b. Test Equipment. The use of test equipment is fully discussed in chapter 6. Before using any test equipment for trouble shooting, become thoroughly familiar with its operation and capabilities. Except where noted, all test equipment used is provided with the radio set.

c. Use of Supplementary Data. In following the trouble-shooting charts for location of faults, references are often made to figures giving voltage, resistance, and waveform data. When checking waveforms, remember that while waveforms will differ slightly with each individual radio set, their forms in general will be very much like the typical waveforms shown. All voltages have been taken with a meter of 20,000 ohms-per-volt sensitivity. Meter range as well as sensitivity will affect the value of the readings. Always use the highest meter scale possible that will still give a readable indication. Operating positions of potentiometers will affect certain voltage and resistance values. Take this into account when comparing measured values with those specified. All voltage values are taken with the component in operation. Resistance measurements must be made with the component removed and cables disconnected.

223. TROUBLE-SHOOTING CHART FOR SWEEP AMPLIFIER.

a. 2-mile Channel.

A. SYMPTOMS:

1. No trace on 2-mile display tube.
2. Focused spot present on 2-mile tube.
3. Normal trace on 10-mile tube.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 2-mile multivibrator V1.	1*a*. Check waveform at TP1 on sweep amplifier. *b*. Replace tube V1 (6SN7-GT). *c*. Check voltages and resistances of stage V1 against charts (figs. 372 and 373).
2. Precision indicator.	2*a*. Check waveforms at terminals 2 and 3 of connector strip 11. *b*. Refer to indicator trouble-shooting chart (par. 224).

B. SYMPTOMS:

1. No angular sweep or distorted sweep on 2-mile tube.
2. Normal trace on 10-mile tube.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Square wave modulator stage or amplifier stage (waveform at TP1 normal, waveform at TP2 abnormal).	1*a*. Replace tube V2 (6SJ7-GT). *b*. Replace tube V3 (6SN7-GT). *c*. Check setting of P2, 2-mile EXPANSION control. *d*. Check voltage and resistance of the two stages against the charts (figs. 372 and 373).
2. Cathode follower stage V4 and V5 (waveform at TP2 normal, waveform at terminal 3 of connector strip 11 abnormal).	2*a*. Replace tubes V4 and V5 (807's). *b*. Check voltage and resistance of V4 and V5 stages against the charts (figs. 372 and 373).
3. Deflection coil in precision indicator.	3. Refer to indicator trouble-shooting chart (par. 224).

C. SYMPTOMS:

1. Distorted vertical sweep (azimuth) or distorted horizontal sweep (elevation) on 2-mile tube.
2. Normal trace on 10-mile tube.
3. Waveform normal at terminal 3 of connector strip 11.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Inverter stage V11(a), square wave modulator V6, or amplifier stage V7 (waveform at TP1 normal, waveform at TP3 abnormal).	1*a*. Replace tubes V6 (6SJ7-GT), V7 (6SN7-GT), and V11 (6SN7-GT) one at a time and note results. *b*. Check settings of P5, 2-MILE RANGE MARK TILT, and P6, 2-MILE TIMEBASE AMP controls. *c*. Isolate fault to a particular stage by checking waveforms (fig. 371A) and then check voltage and resistance of the defective stage (figs. 372 and 373).
2. Cathode follower stage V9 and V10 (waveform at TP3 normal, waveform at terminal 2 of connector strip 11 abnormal).	2*a*. Replace tubes V9 and V10 (807's). *b*. Check voltage and resistance values against charts (figs. 372 and 373).
3. Deflection coil in precision indicator.	3. Refer to indicator trouble-shooting chart (par. 224).

D. SYMPTOMS:

1. Return timebase sweep visible on 2-mile tube.
2. Trace on 10-mile tube normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Amplifier V11(b) and cathode follower V12.	1*a*. Replace tubes V11 (6SN7-GT) and V12 (6V6-GT). *b*. Measure voltage and resistance values and check against charts (figs. 372 and 373).
2. Precision indicator circuits.	2. Refer to indicator trouble-shooting chart (par. 224).

b. 10-mile Channel.

A. SYMPTOMS:

1. No trace on 10-mile display tube.
2. Focused spot present on 2-mile tube.
3. Normal trace on 2-mile tube.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. 10-mile multivibrator V13.	1*a*. Check waveform at TP5 on sweep amplifier. *b*. Replace tube V13 (6SN7-GT). *c*. Check voltage and resistance readings against charts (figs. 372 and 373).
2. Precision indicator.	2*a*. Check waveforms at terminals 6 and 7 of connector strip 10. *b*. Refer to indicator trouble-shooting chart (par. 224).

B. SYMPTOMS:

1. No angular sweep or distorted sweep on 10-mile tube.
2. Normal trace on 2-mile tube.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Square wave modulator V14 or amplifier V15 (waveform at TP5 normal, waveform at TP4 abnormal).	1*a*. Replace tube V14 (6SJ7-GT) or tube V15 (6V6-GT). *b*. Check setting of P8, 10-MILE EXPANSION control. *c*. Isolate fault to a particular stage by checking waveforms (fig. 371B) and then check voltage and resistance values of the defective stage (figs. 372 and 373).

2. Clamping tubes V8, V16, and V21.	2a. Replace V8 (6SN7-GT), V16 (6SN7-GT), and V21 (6SN7-GT), and note results.
	b. Check waveform at pin 1 of V8 and V16.
3. Cathode follower stage V17 (waveform at TP4 normal, waveform at terminal 7 of connector strip 10 abnormal).	3a. Replace tube V17 (807).
	b. Check voltage and resistance readings at V17 against charts (figs. 372 and 373).
4. Defective coil in precision indicator.	4. Refer to indicator trouble-shooting chart (par. 224).

C. SYMPTOMS:

1. Distorted vertical sweep (azimuth) or distorted horizontal sweep (elevation) on 10-mile tube.
2. Normal trace on 2-mile tube.
3. Waveform normal at terminal 7 of connector strip 10.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Inverter stage V24(a), square wave modulator V19, or amplifier stage. V20 (waveform at TP5 normal, waveform at TP6 abnormal).	1a. Replace tubes V19 (6SJ7-GT), V20 (6V6-GT), and V24 (6SN7-GT), and note results.
	b. Check settings of P11, 10-MILE RANGE MARK TILT, and P12, 10-MILE TIMEBASE AMP. controls.
	c. Isolate fault to a particular stage by checking waveforms (fig. 371B) and then check voltage and resistance values of the defective stage (figs. 372 and 373).
2. Clamping tubes V8 and V16.	2a. Replace V8 (6SN7-GT) and V16 (6SN7-GT), and note results.
	b. Check waveform at pin 4 of V8 and V16.
3. Cathode follower stage V22 (waveform at TP6 normal, waveform at terminal 6 of connector strip 10 abnormal).	3a. Replace tube V22 (807).
	b. Check voltage and resistance values against charts (figs. 372 and 373).
4. Deflection coil in precision indicator.	4. Refer to indicator trouble-shooting chart (par. 224).

D. SYMPTOMS:

1. Return timebase sweep visible on 10-mile tube.
2. Trace on 2-mile tube normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Amplifier V24(b) and cathode follower V25.	1a. Replace tubes V24 (6SN7-GT) and V25 (6V6-GT).
	b. Measure voltage and resistance values and check against charts (figs. 372 and 373).
2. Precision indicator circuits.	2. Refer to indicator trouble-shooting chart (par. 224).

E. SYMPTOMS:

1. Trace on 10-mile tube will not center properly.
2. Trace on 2-mile tube normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Centering tubes V18 or V23.	1a. Replace V18 and V23 (6V6-GT), and note results.
	b. Check setting of P9 and P10, 10-MILE CENTERING controls.
	c. Check voltage and resistance values of V18 and V23 against charts (figs. 372 and 373).

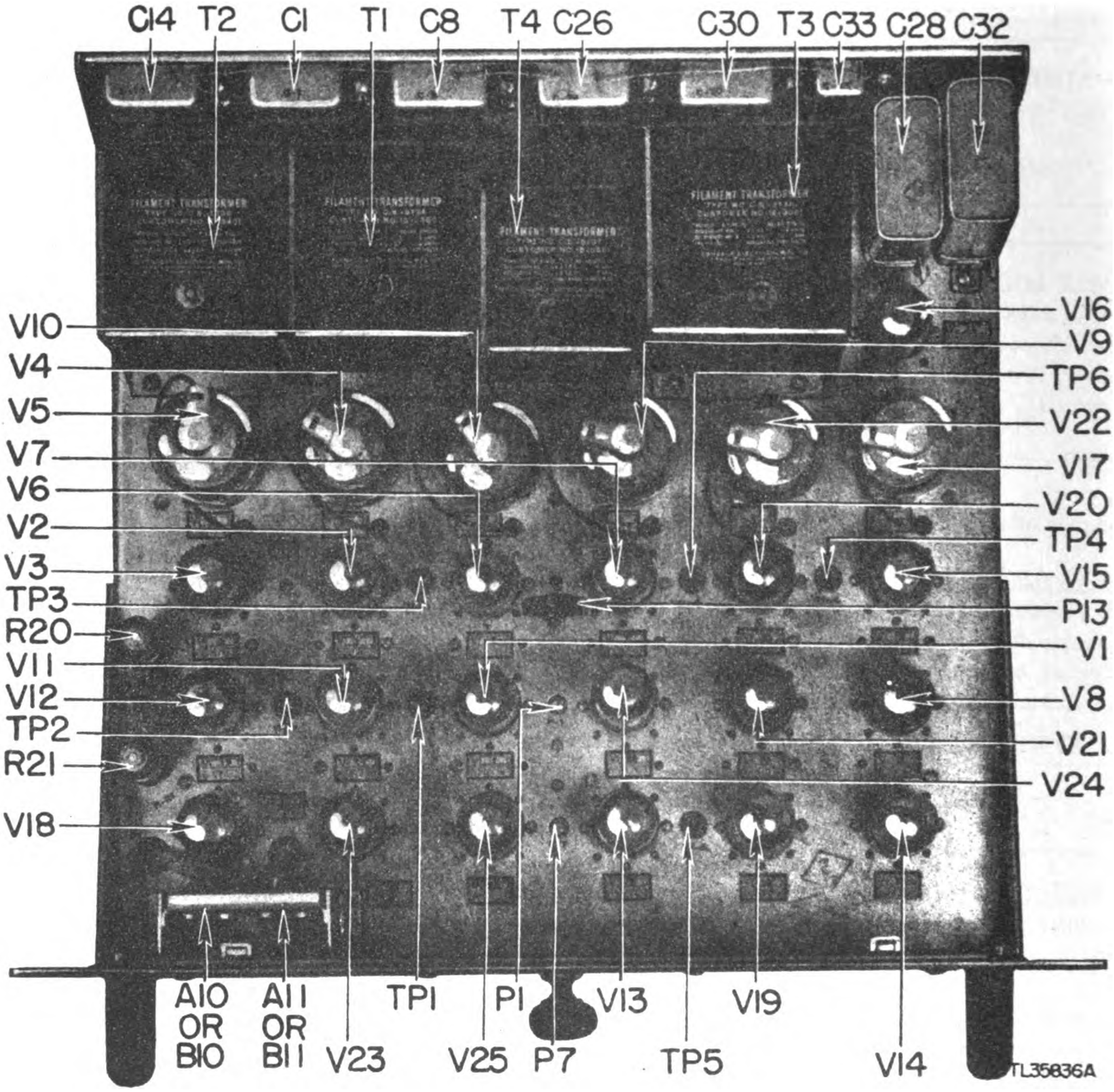


Figure 368. Sweep Amplifier AM-15/MPN-1, top view.

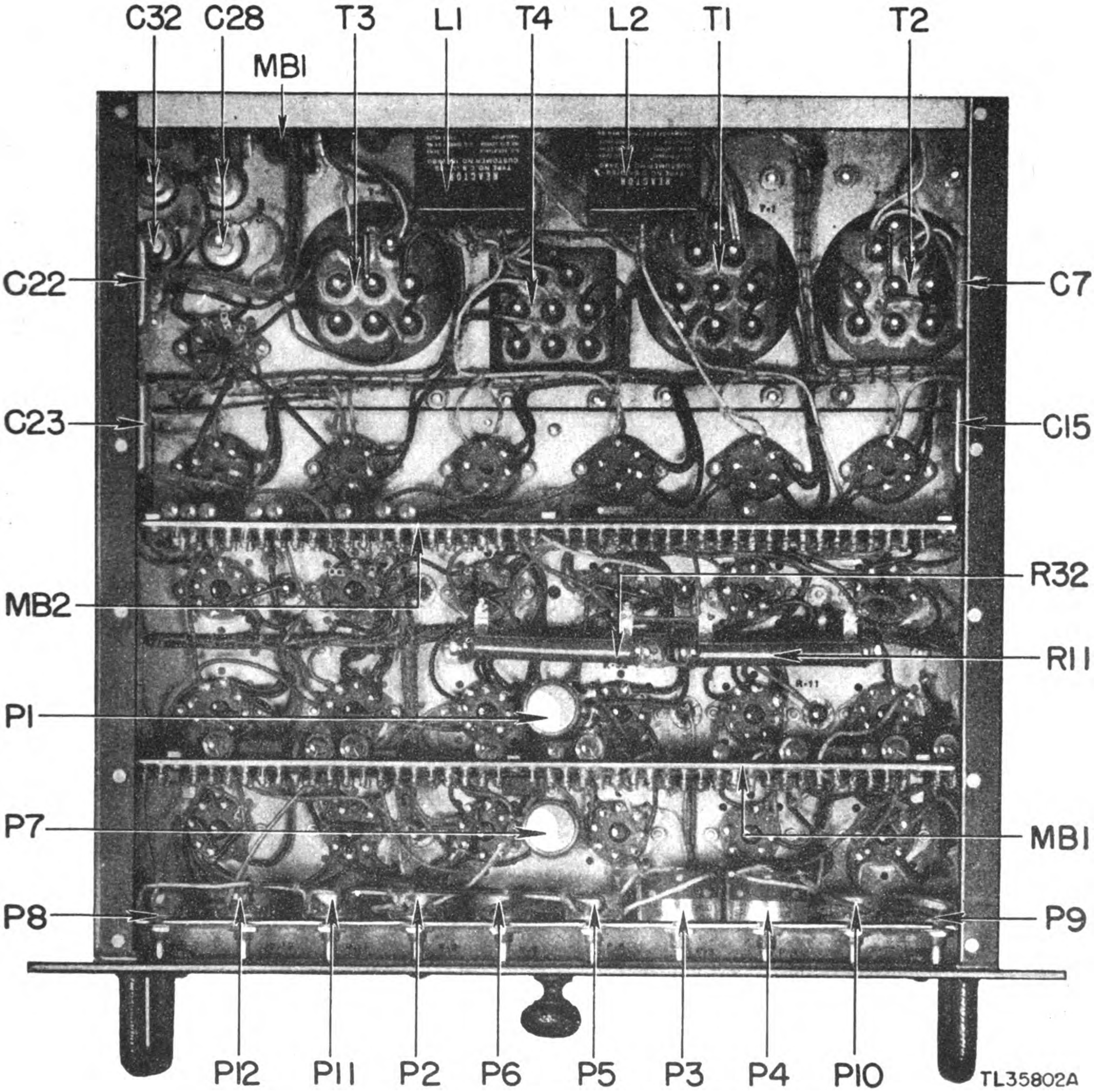


Figure 369. Sweep Amplifier AM-15/MPN-1, bottom view.

224. TROUBLE-SHOOTING CHART FOR PRECISION INDICATORS.

A. SYMPTOMS:

1. No sweep or spot on both tubes of one indicator.
2. Display on other precision indicator normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Improper reset controls.	1. Turn the TIME BASE INTENSITY controls on the indicator panel to the maximum clockwise position.
2. Indicator blanked by photoelectric commutator.	2. Start antenna switching motors with switch SW17 on the power distribution panel. If they do not start, check power distribution circuits.
3. Filament transformer.	3. Check voltage between terminal 3 and 5 of transformer T1. Proper value of voltage is 6.3 volts ac.
4. No 4-kv supply.	4. Turn off the high-voltage supplies with circuit breaker SW11 on the power distribution panel. Place a jumper from ground to the high-voltage terminal on all indicator tubes to discharge any capacitors. Check continuity from tube high-voltage to the high-voltage power supply in use by the precision system.

B. SYMPTOMS:

1. No sweep or spot on one precision indicator tube.
2. All other tubes operating normally.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Improper setting of controls.	1*a*. Turn the TIME BASE INTENSITY control on the indicator to its maximum clockwise position. *b*. Adjust the associated centering controls on the sweep amplifier.
2. Faulty indicator tube.	2. Check filament continuity. If no other source of trouble can be found, insert a new indicator tube.
3. No 4-kv supply.	3. Turn off 4-kv supplies (circuit breaker SW11 on power distribution panel). Place jumper between ground and indicator tube high-voltage terminal to discharge any high-voltage capacitor in the circuit. Check continuity of high-voltage terminal to other indicator tubes to high-voltage supply (PP-23) in use.

C. SYMPTOMS:

1. No sweep or a distorted sweep appears on one or both tubes on one precision indicator.
2. Spot which can be focused appears on indicator tubes.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Faulty sweep generating coils.	1. Measure resistance to ground on terminals leading to sweep coil. Infinite resistance indicates an open circuit and, as a result, no sweep.
2. Channel switching relays.	2. Check for presence of sweep voltage from sweep amplifier at sweep coil terminals. No voltage indicates faulty relays or faulty sweep amplifier. Check that relays are in proper position, depending on which channel is in use, and that contacts are good.

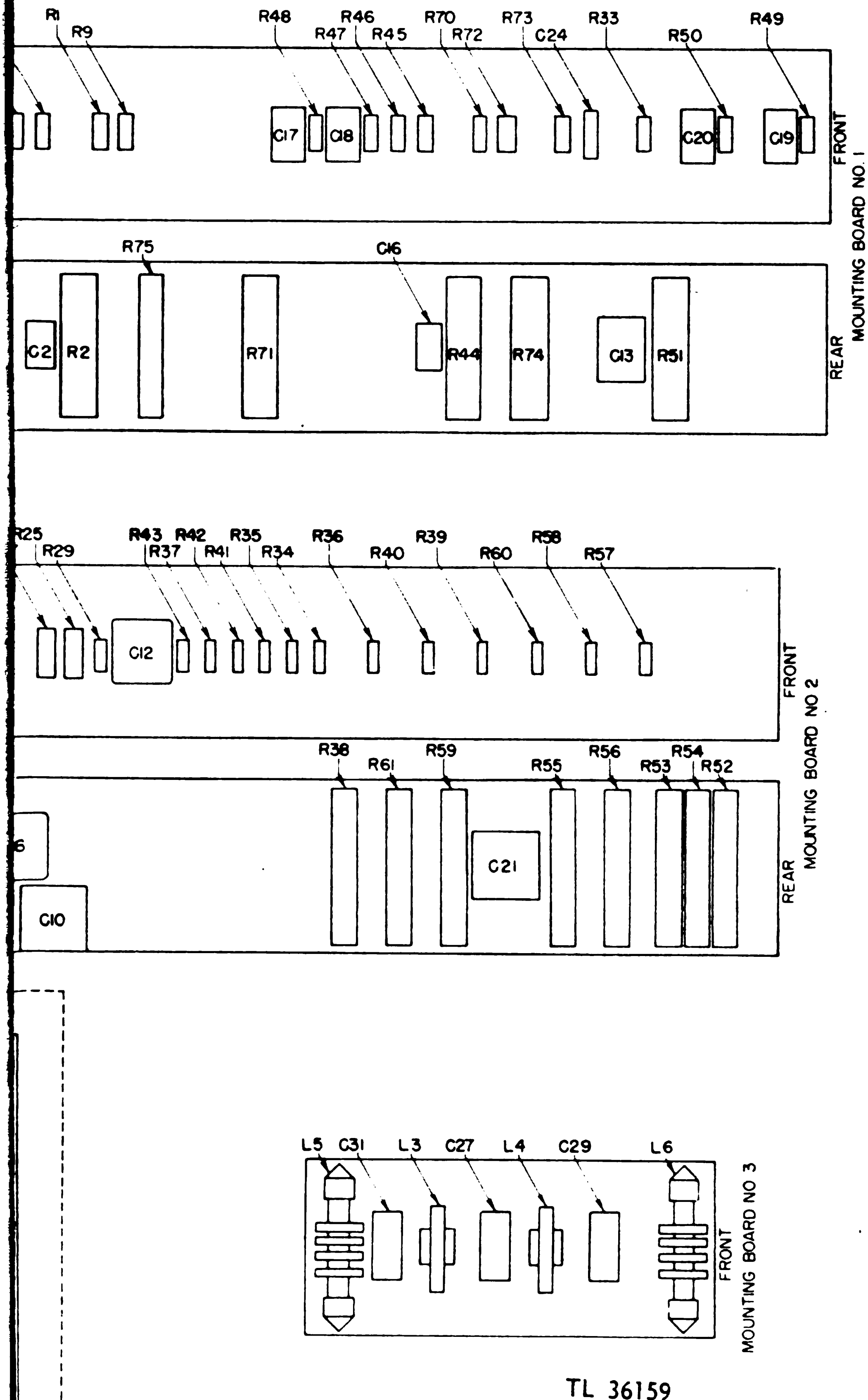
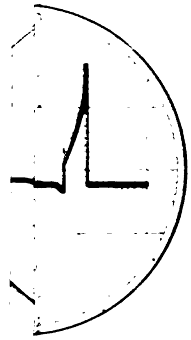
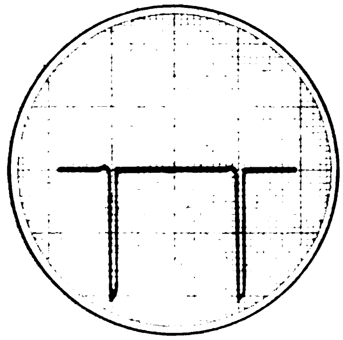


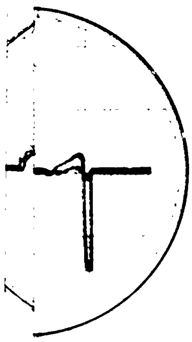
Figure 370. Sweep Amplifier AM-15/MPN-1, mounting boards.



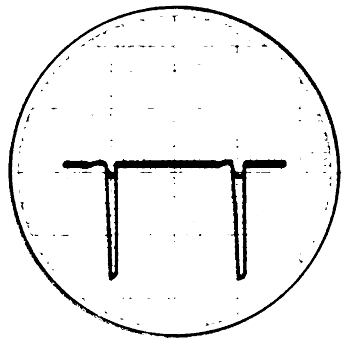
IIL ODULATOR, V2
2
AI
AI



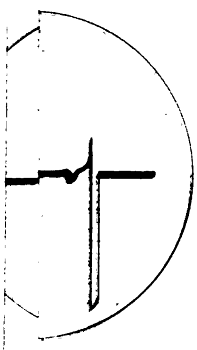
6
AMPLIFIER, V3
Pins 1, 4
Y GAIN 60
X GAIN 40



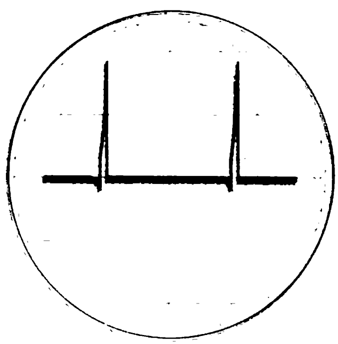
1
ODVERS, V9 and V10
Tern
5
40



12
AMPLIFIER, V11
Pin 4
Y GAIN 40
X GAIN 40



7
TO RATOR, V14
0
0



18
AMPLIFIER, V15
Pin 3
Y GAIN 5
X GAIN 40

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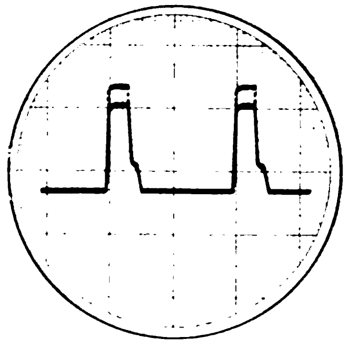
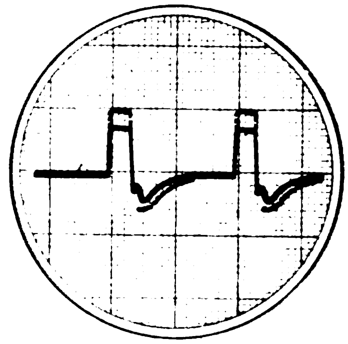
igure 371A. Sweep Amplifier AM-15/MPN-1, waveforms.



21
AMPLIFIER, V20
Pin 3
Y GAIN 5
X GAIN 40



22
CATHODE FOLLOWER, V22
Pin 4
Y GAIN 5
X GAIN 40

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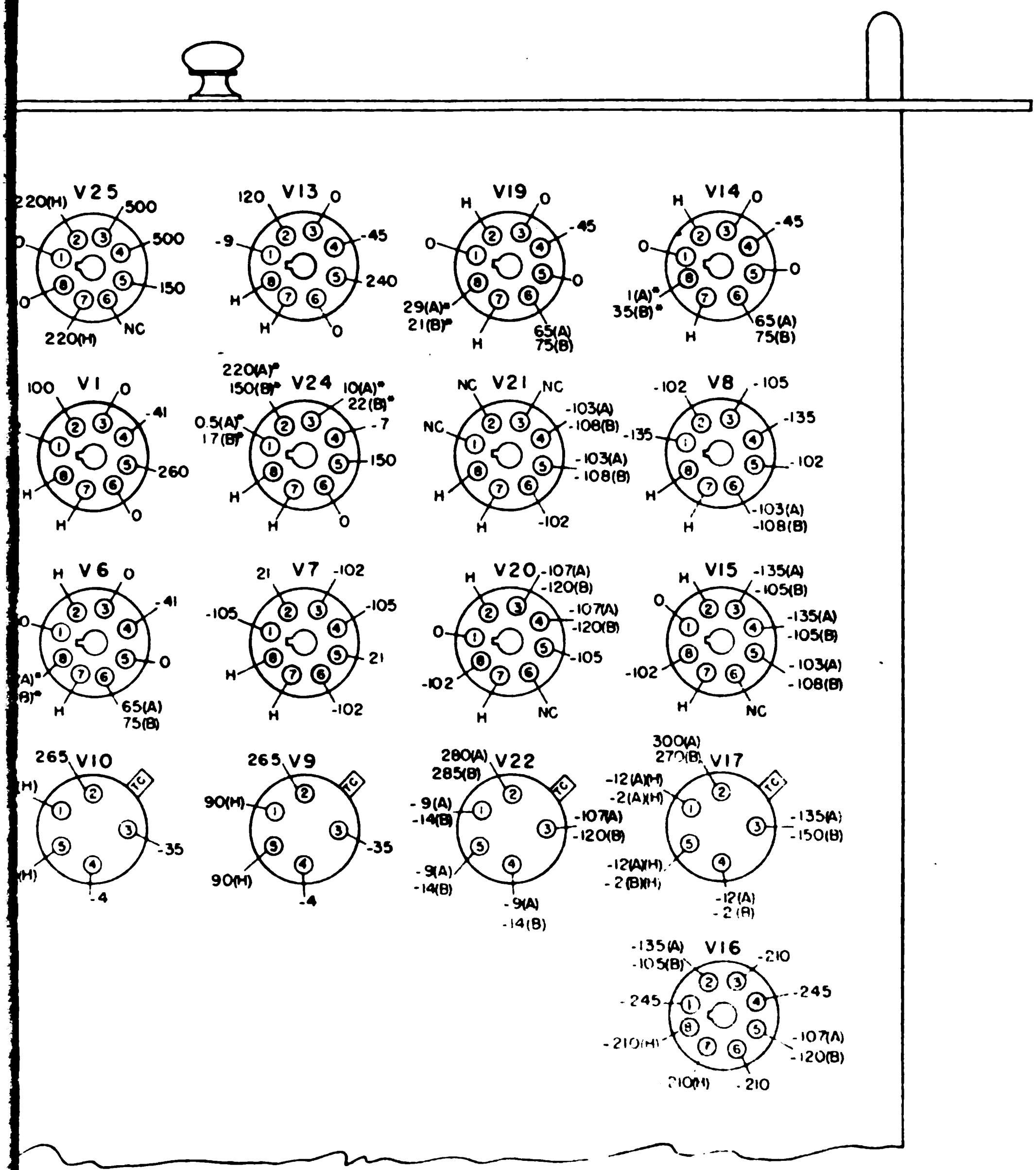
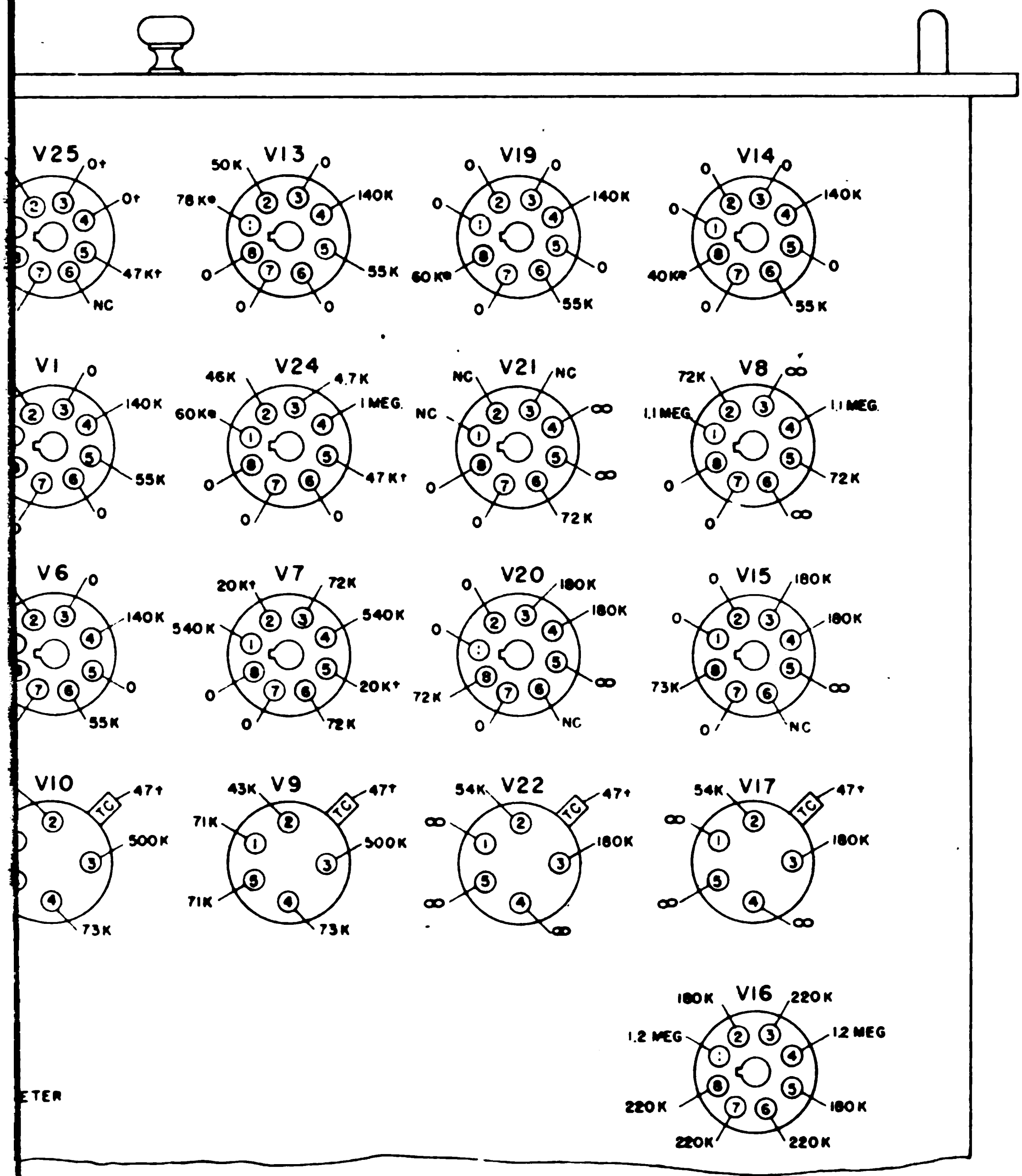
Figure 371B. Sweep Amplifier AM-15/MPN-1, waveforms.



TL 36004A

Figure 372. Sweep Amplifier AM-15/MPN-1, voltage chart.



TL 36144

Figure 373. Sweep Amplifier AM-15/MPN-1, resistance chart.

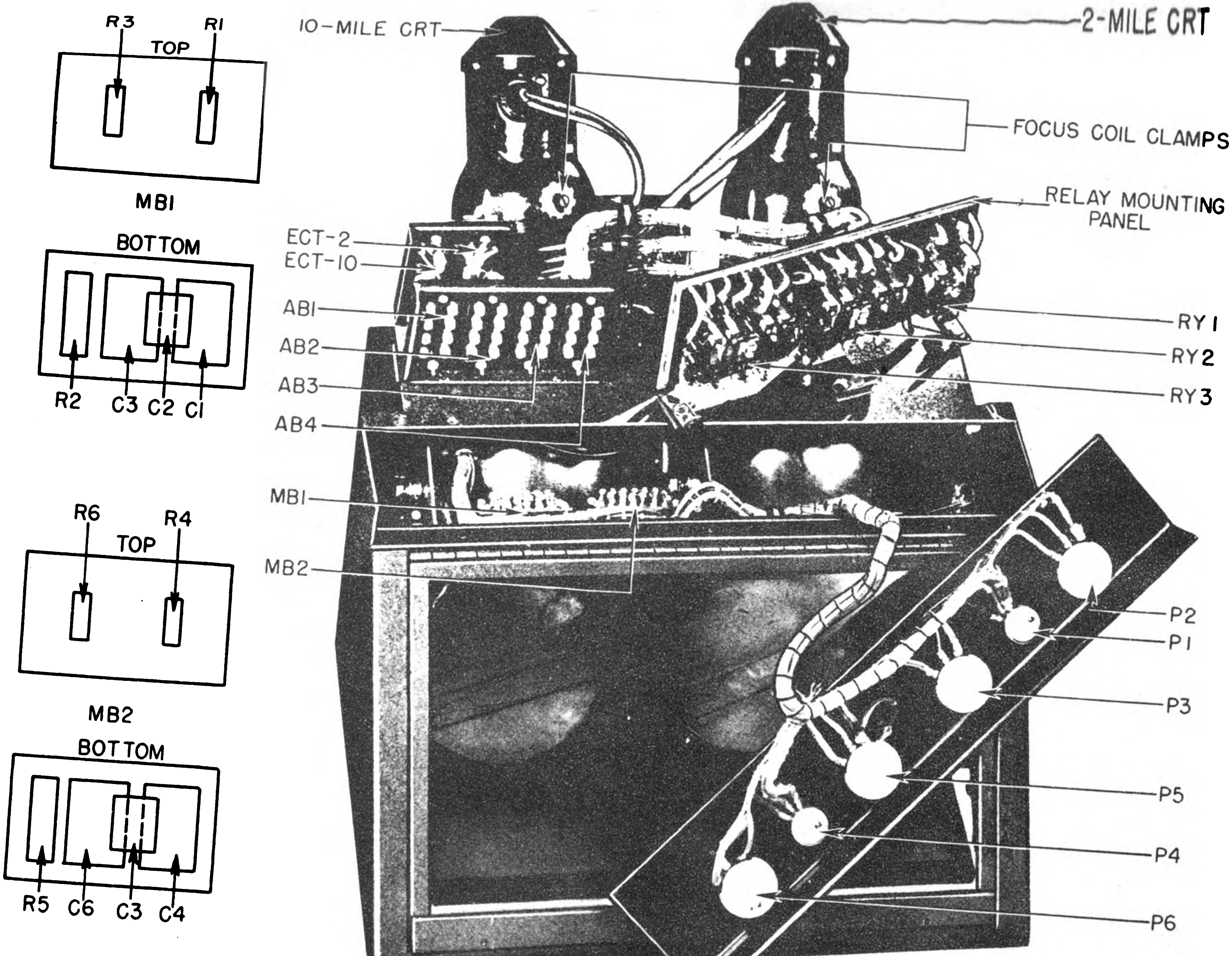


Figure 374. Elevation Indicator ID-37/MPN-1, front top view.

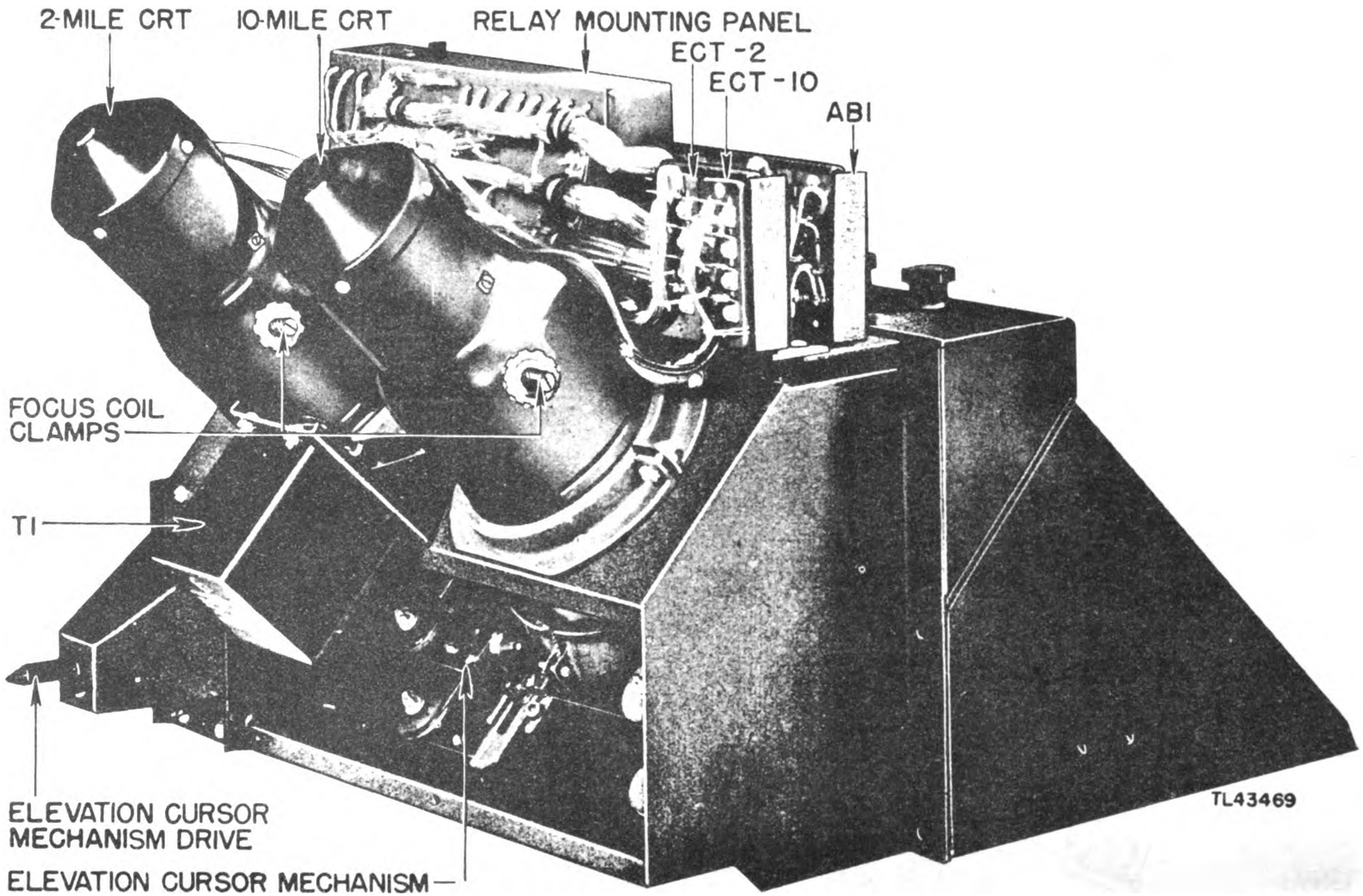
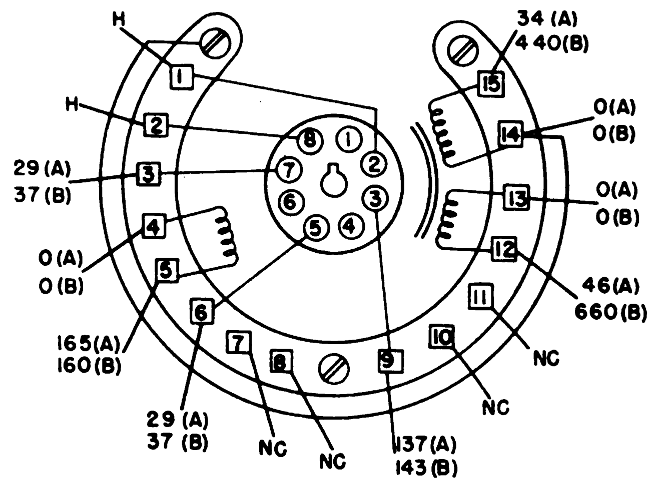
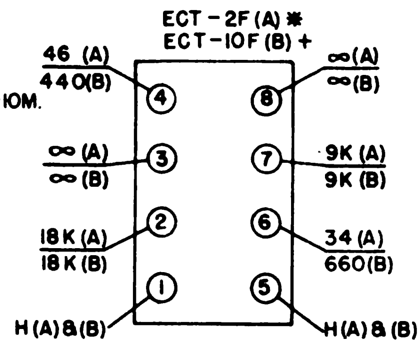


Figure 375. Elevation Indicator ID-37/MPN-1, rear side view.



DTE:
LL CONTROLS FULLY CLOCKWISE.
ALE AND FEMALE CONNECTER STRIP
TACHED –I.E. ECT-2F TO ECT-2M AND ECT-10F TO ECT-10M.
(A) 2-MILE CRT CONNECTOR STRIP VALUES.
(B) 10-MILE CRT CONNECTOR STRIP VALUES.
DCUS COIL RESISTANCE 22K.
DTAL DEFLECTION COILS RESISTANCE (TERMINALS
TO 6) 80 OHMS FOR 2-MILE CRT AND 1100
HMS FOR 10-MILE CRT.



TL 36015B

Figure 377. Elevation Indicator ID-37/MPN-1, resistance chart.

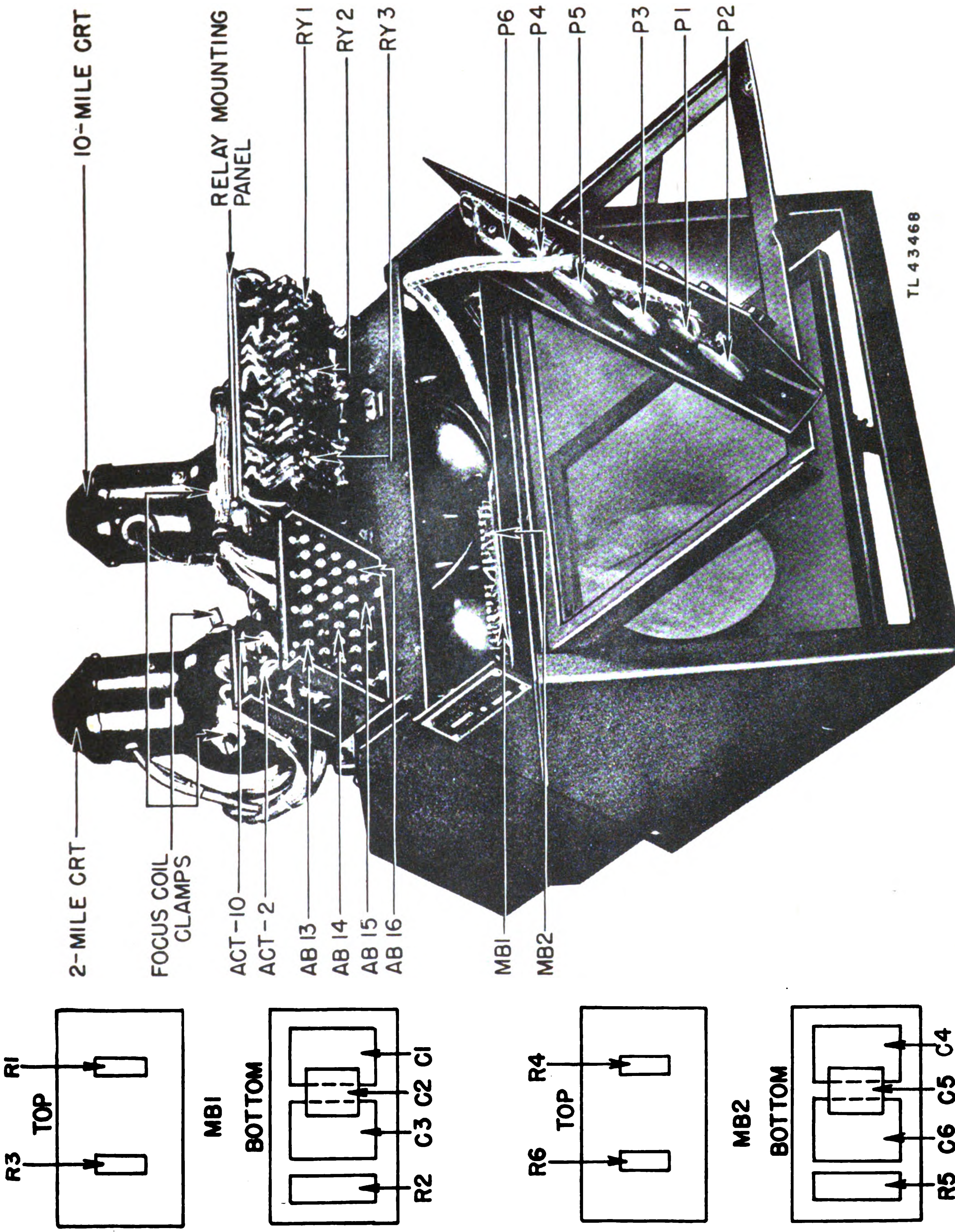


Figure 378. Azimuth Indicator ID-36/MPN-1, front top view.

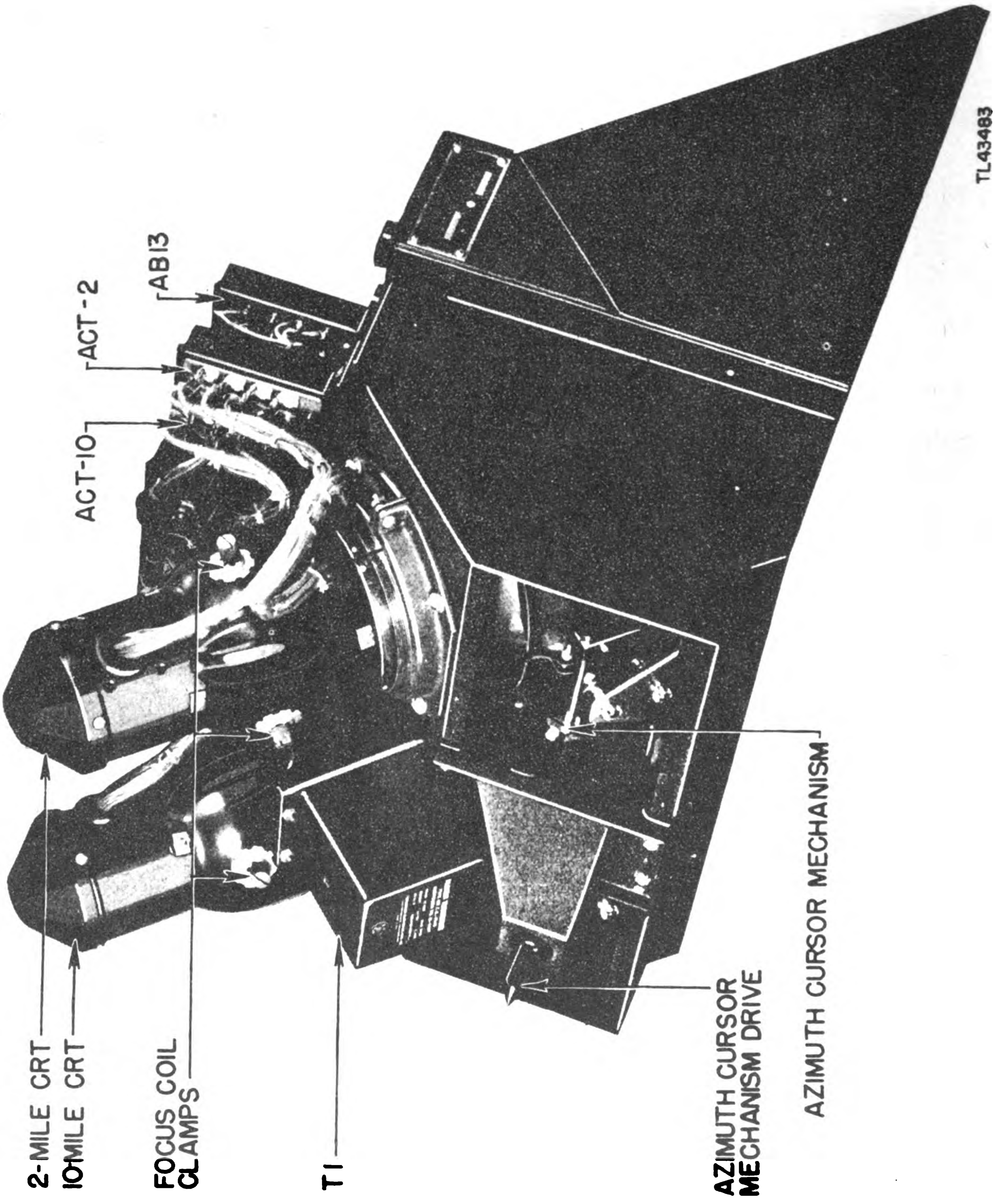
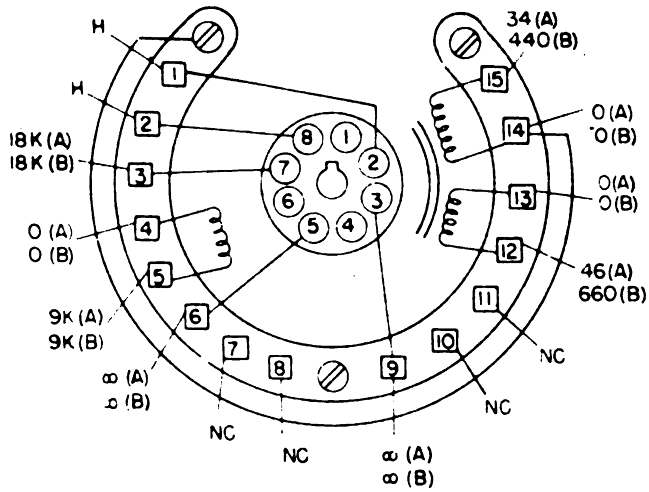
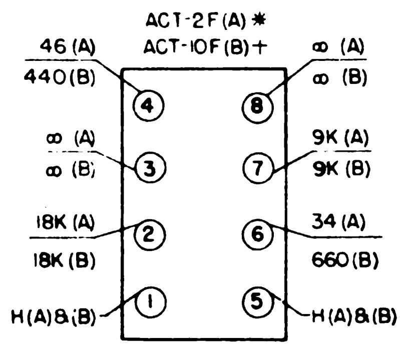


Figure 379. Azimuth Indicator ID-36/MPN-1, rear side view.



ROLS FULLY CLOCKWISE.
FEMALE CONNECTOR STRIPS ATTACHED — ι ε
O ACT-2M AND ACT-10F TO ACT-10M
LE CRT CONNECTOR STRIP VALUES.
LE CRT CONNECTOR STRIP VALUES.
L RESISTANCE 22K.
LECTION COILS RESISTANCE (TERMINALS 4 TO 6)
FOR 2-MILE CRT AND 1100 OHMS FOR 10-MILE CRT



TL 36013B

Figure 381. Azimuth Indicator ID-36/MPN-1, resistance chart.

3. Sweep amplifier.	3. Check output of associated sweep amplifier. If incorrect, refer to paragraph 223.

D. SYMPTOMS:

1. Unfocused sweeps appear on one or more precision indicator tubes.
2. All sweep patterns normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Improper setting of controls.	1. Adjust the FOCUS control on the faulty tube or tubes.
2. Faulty focus control or coil.	2. Measure the resistance of the focus potentiometer (P3 or P6). Check the resistance of the focus coil as given on the resistance chart.
3. Improper focusing voltage.	3*a*. If fault exists on elevation indicator only, check 300-volt lead between indicators. *b*. Check contacts on RY1 in the azimuth indicator. *c*. Loss of the 300-volt supply will also result in loss of control of indicator display intensity.

E. SYMPTOM:

1. Indicators improperly blanked.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Faulty circuit elements.	1. Check for grounded bypass capacitor or open series resistor to terminal 5 of the indicator tube. If fault occurs on all tubes, the shorted capacitor is the probable fault. If only one tube is affected, look for an open series resistor.
2. Channel switching relay.	2. Check RY1 in the affected indicator for proper position and operation of contact.
3. No blanking voltage.	3. Using d-c voltmeter, check for approximately 70-volt change on blanking terminal (5-3 or 5-5) of the synchronizer. Improper blanking voltage indicates fault in synchronizer or photoelectric commutator.

F. SYMPTOMS:

1. No video signals on precision indicators.
2. Transmitter rack synchroscope shows signals are present on precision system.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Improper trigger.	1*a*. Check that the TRIG. SEL. switch on the intercommunications panel is in the X position. *b*. If trouble is not cleared, refer to item 2.
2. Faulty circuit elements.	2. Check for faulty video brilliance control (P1 and P4) or coupling capacitor (C1 or C4). No signals on all tubes indicate a shorted brilliance control while a lack of signals on one tube indicates no coupling capacitor.
3. Video amplifier and synchronizer.	3. Check video output at terminal 8-8 of synchronizer. A lack of signal indicates a faulty synchronizer circuit or open connections to the transmitter rack. Refer to chapter 8, section IV.

225. TROUBLE-SHOOTING CHART FOR PRECISION DIRECTORS AND APPROACH INDICATOR.

A. SYMPTOM:

1. Azimuth or elevation meter does not indicate when tracking cursor is off glidepath.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Error potentiometer.	1*a*. Check voltage across terminals 2 and 3 of connector strip AB19, or across terminals 3 and 4 of connector strip AB5. This voltage should be 35 volts dc. *b*. If no voltage is present, check RECT. 2 in aural signal unit. *c*. If voltage is normal, disconnect connector and check continuity of error potentiometer.
2. Azimuth or elevation errormeter.	2. Check error voltage at terminal 4 of connector strip AB19 (azimuth) or terminal 1 of connector strip AB6 (elevation). If normal, check continuity of errormeter circuit in aproach indicator.

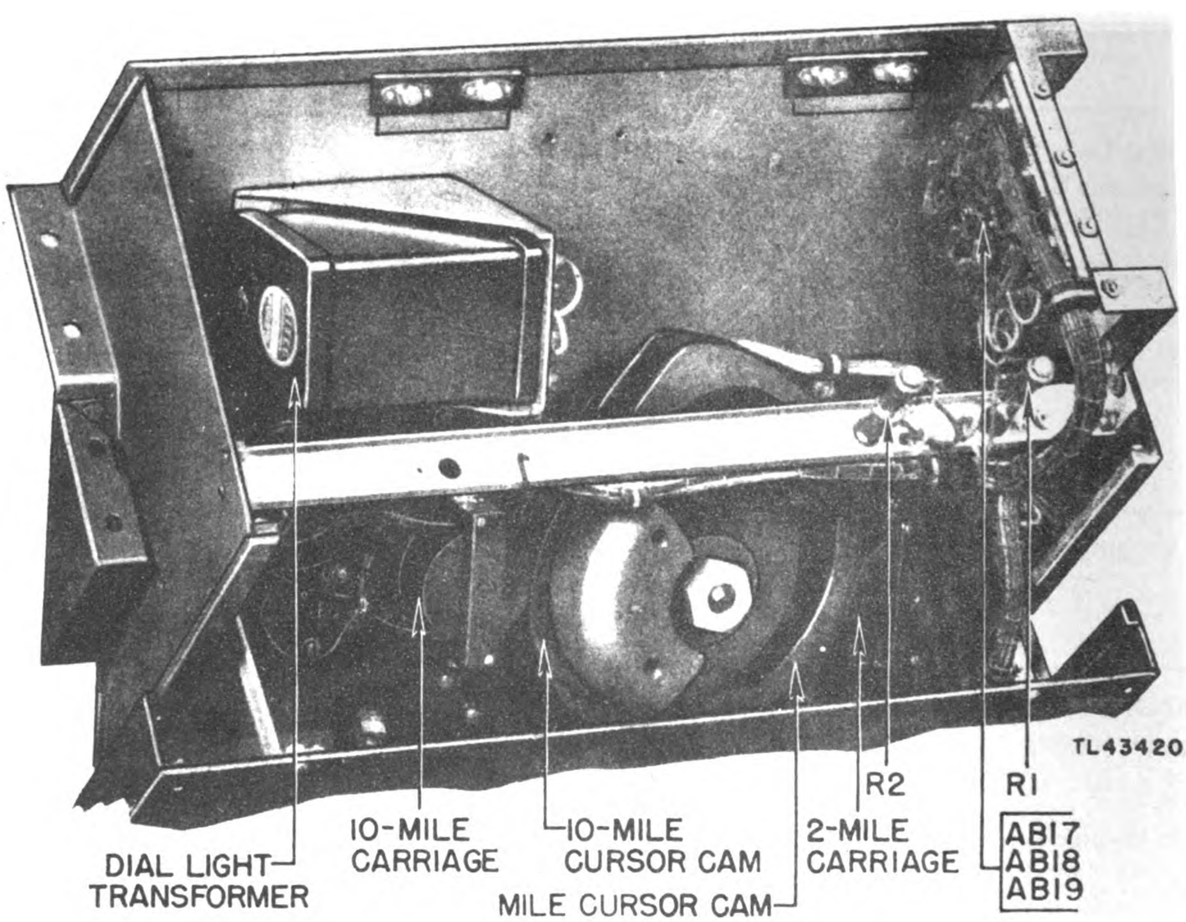


Figure 382. Azimuth Director Assembly MX-32/MPN-1, rear view.

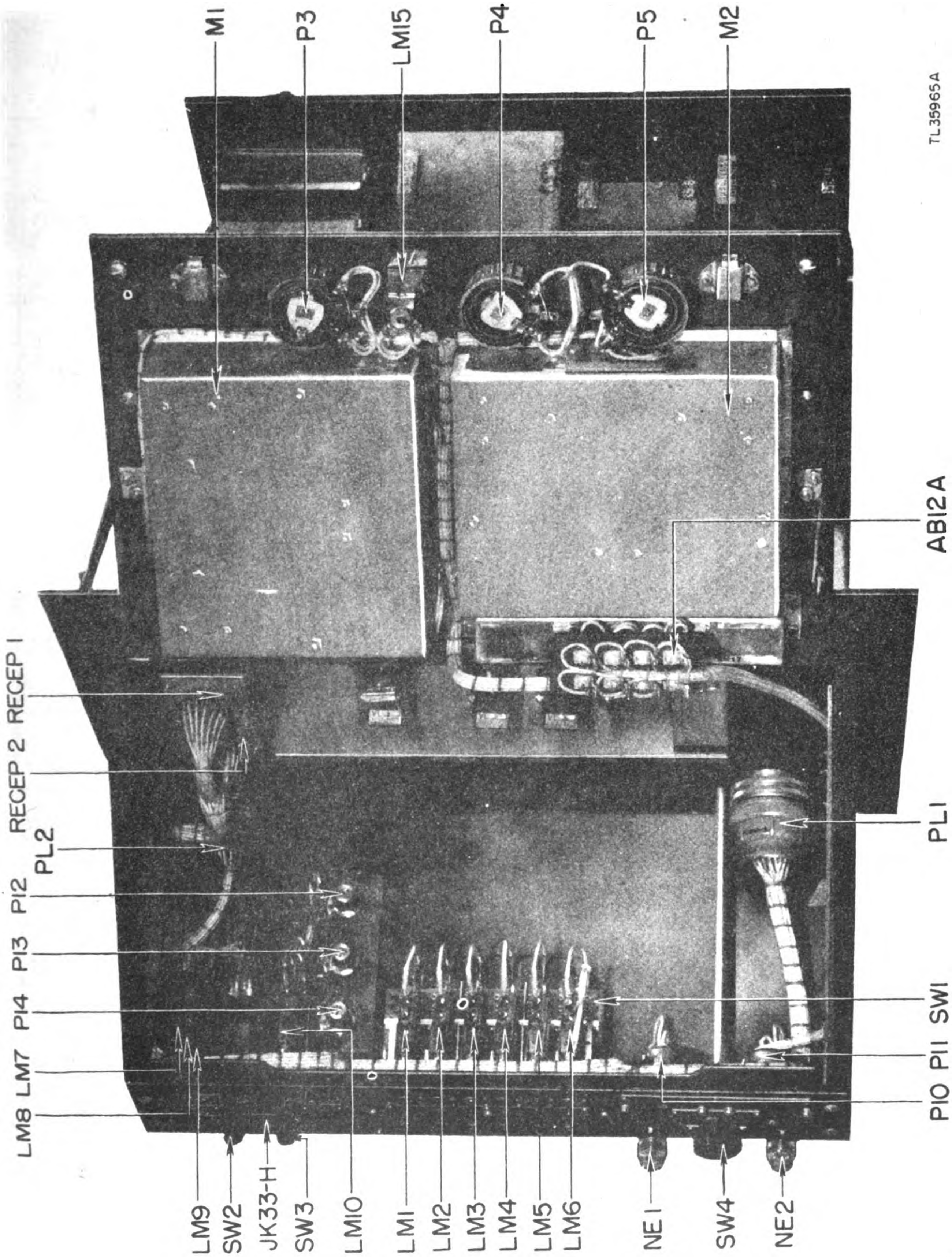


Figure 383. Approach Indicator ID-38/MPN-1, front view, with panel open.

B. SYMPTOM:

1. Map and cursor lights do not glow with illumination potentiometer turned fully clockwise.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Transformer T1.	1*a*. Measure voltage (117 volts ac) at terminals 1 and 2 of connector strip AB17 (azimuth) and connector strip AB5 (elevation). *b*. Check continuity of transformer and replace if necessary.
2. Illumination controls.	2. If either cursor or map lights fail to glow, check continuity of corresponding illumination potentiometer, P1 and P2 for azimuth director and P4 and P5 for elevation director.

C. SYMPTOMS:

1. Receiver remote gain control defective.
2. Local gain control normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Remote gain control potentiometer.	1*a*. Check continuity of potentiometer P4 (azimuth) or P3 (elevation). Replace if necessary. *b*. Check continuity of remote gain control circuit by reference to cabling diagrams.

226. TROUBLE-SHOOTING CHART FOR AURAL SIGNAL UNIT.

A. SYMPTOM:

1. No audio tone heard from aural signal unit in any position of azimuth tracking cursor.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Power supply circuit in aural signal unit.	1*a*. Check voltage at pin 5 of V5. *b*. Replace rectifier tube V7 (5R4GT) and voltage regulator tubes V5 (VR-105) and V6 (VR-150). *c*. Check continuity of rectifier circuit.
2. Relaxation oscillator V8 or cathode follower V10(b).	2*a*. Check waveform of audio output at terminal 4-5 with test oscilloscope. *b*. If waveform is normal, refer to trouble shooting in the communications system. *c*. If waveform is abnormal, replace tubes V8 (884) and V10 (6SN7-GT). *d*. Check waveform at pin 3 of V8 and measure voltage and resistance values (figs. 388A and 388B).
3. Keying multivibrator.	3. Capacitor C16 shorted.

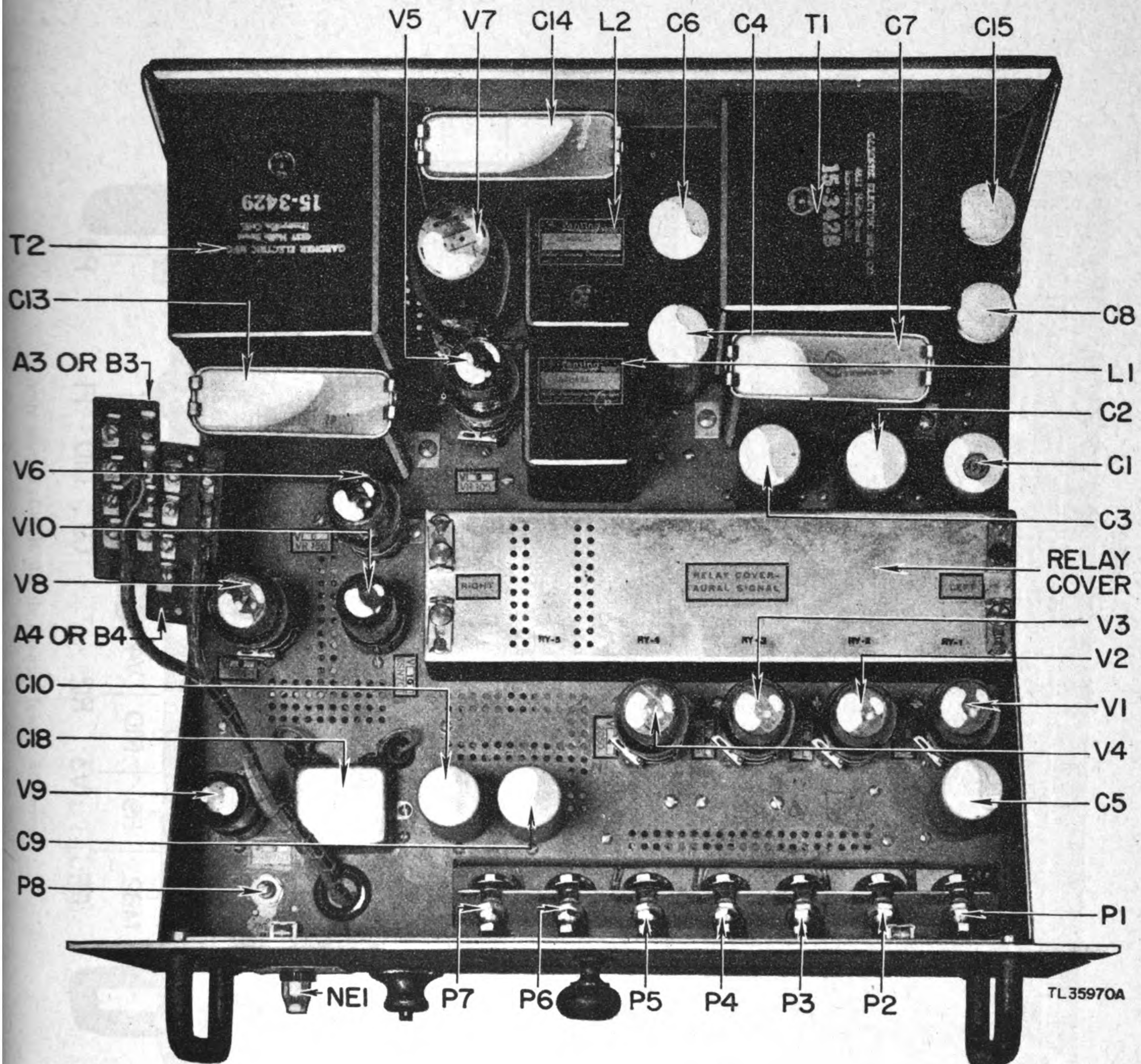


Figure 384. Aural Signal Unit 0-8/MPN-1, top view.

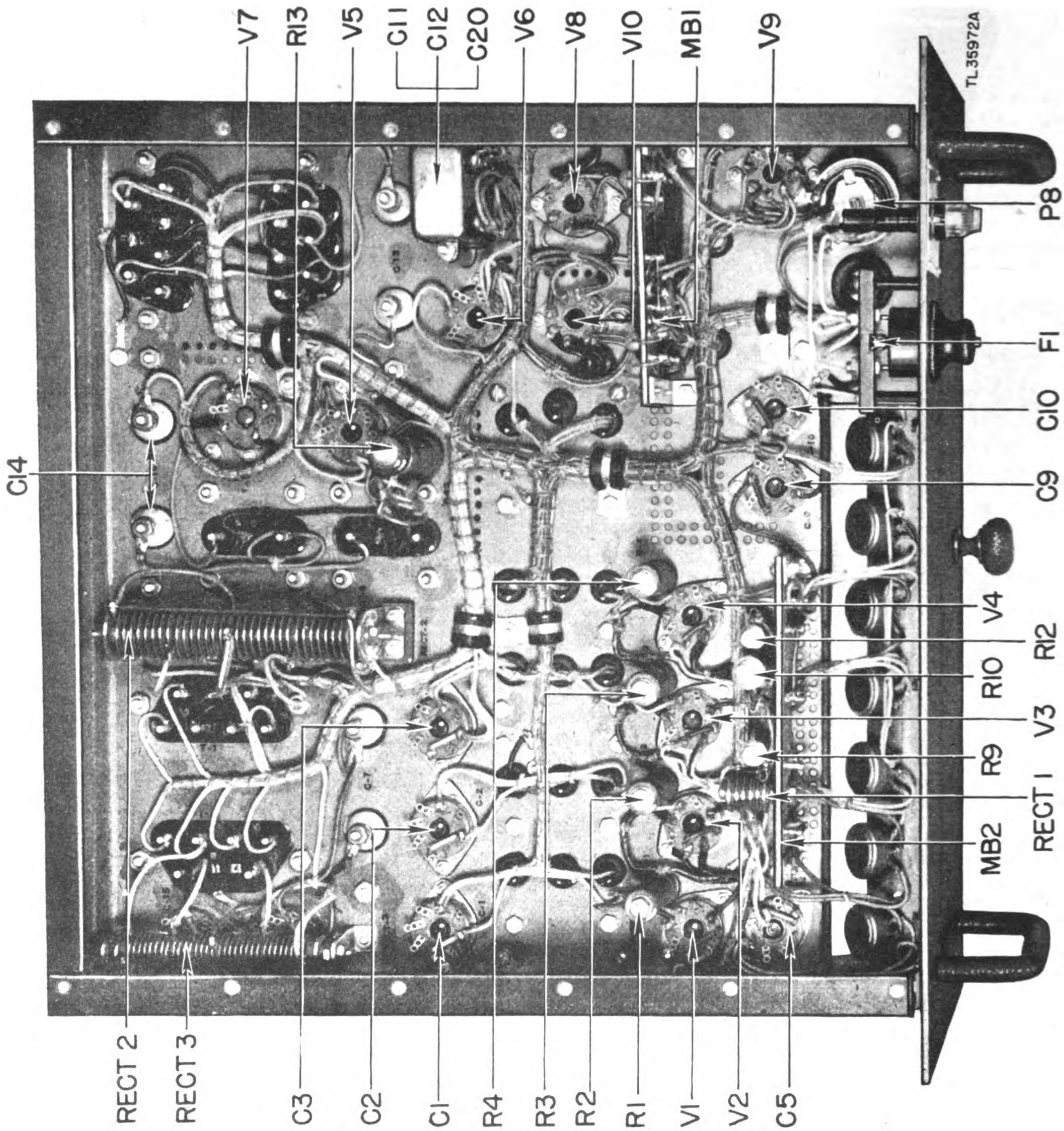


Figure 385. Aural Signal Unit O-8/MPN-1, bottom view.

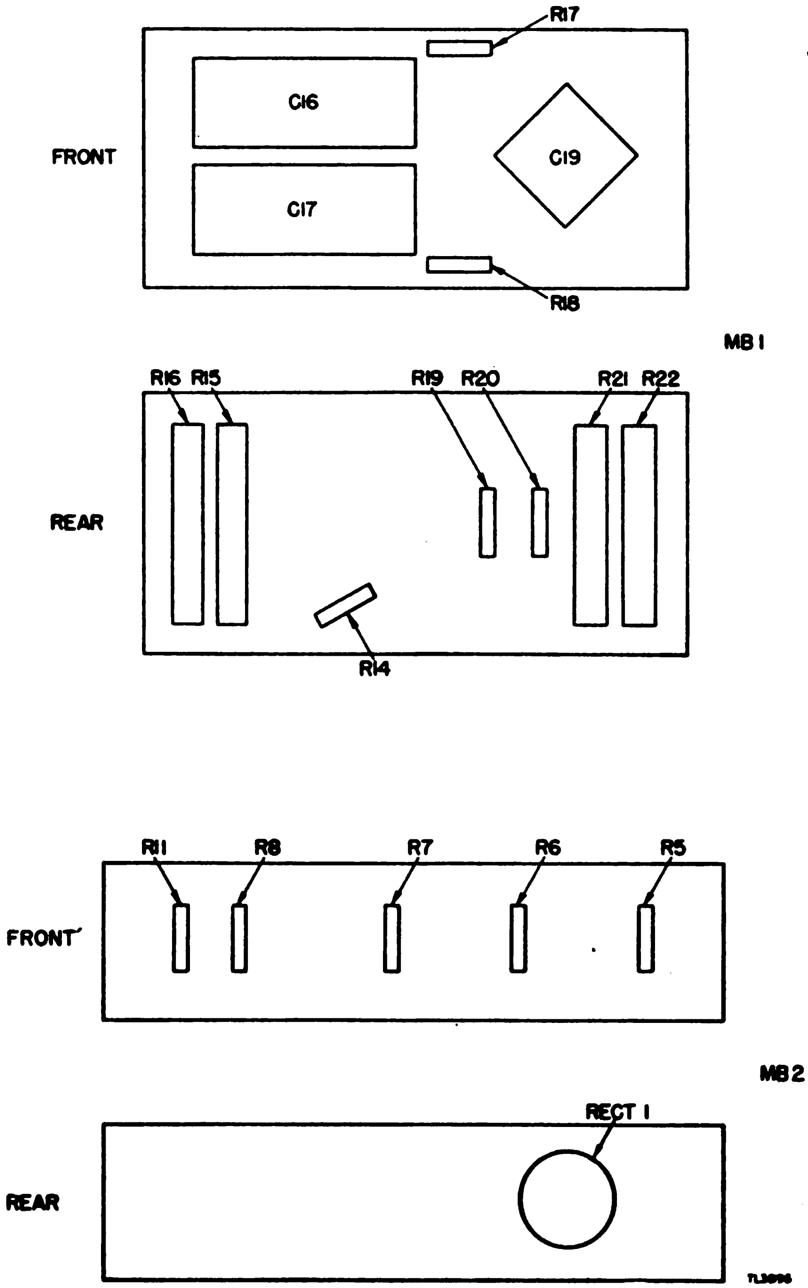


Figure 386. Aural Signal Unit 0-8/MPN-1, mounting boards.

B. SYMPTOMS:

1. Solid audio tone with azimuth tracking cursor on either side of glidepath.
2. Tone rises normally with increasing deviations from glidepath.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Keying multivibrator V9, or switch tube V10(a).	1*a*. Replace tubes V9 (6SN7-GT) and V10 (6SN7-GT).
	b. Check waveform (fig. 387) at pin 5 of V9, and pin 2 of V10.
	c. Measure voltage and resistance values and check against charts (figs. 388A and 388B).

C. SYMPTOMS:

1. Decreasing pitch or no tone audible as azimuth tracking handwheel is turned clockwise.
2. Normal broken rising pitch audible as handwheel is turned counterclockwise.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Reversing circuit, V1.	1*a*. Check adjustment of potentiometer P1.
	b. Replace tube V1 (2050).
	c. Relay RY1 defective.
	d. Bias rectifier, RECT. 1, circuit defective, check voltage output and replace if necessary.
2. Reversing relay RY5.	2. Relay RY5 does not operate, check continuity of winding and wiring through relay RY1.

D. SYMPTOMS:

1. Intermittent ON COURSE tone of rising pitch as tracking handwheel is turned counterclockwise.
2. Normal rising pitch as handwheel is turned clockwise.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Inner marker circuit, V3.	1*a*. Check setting of potentiometer P3.
	b. Replace tube V3 (2050).
	c. Check voltage and resistance values (figs. 388A and 388B).
2. Relay RY3.	2. Relay RY3 does not operate. Check continuity of winding.

E. SYMPTOMS:

1. No high warning tone as azimuth tracking handwheel is turned fully clockwise or counterclockwise.
2. Audio tone within outer marker limits normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Outer marker circuit, V4.	1a. Check setting of potentiometer P4.
	b. Replace tube V4(2050).
	c. Measure voltage and resistance values (figs. 388A and 388B).
2. Relay RY4.	2. Relay RY4 does not operate, check continuity of winding.

F. SYMPTOM:

1. Elevation warning light does not operate when azimuth tracking handwheel is turned fully clockwise or counterclockwise.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Elevation warning light circuit in approach indicator.	1. Refer to approach indicator trouble-shooting chart (par. 225).
2. Elevation warning circuit V2.	2a. Check setting of potentiometer P2.
	b. Replace tube V2 (2050).
	c. Measure voltage and resistance values (figs. 388A and 388B).
	d. Bias rectifier, RECT. 3, circuit defective, check voltage output and replace if necessary.
3. Relay RY2.	3. Relay RY2 does not operate, check continuity of winding.

227. SWEEP AMPLIFIER ADJUSTMENTS.

a. Indicator Alignment. All controls for alignment of the precision indicators are mounted on the front panel of the associated sweep amplifier, with the exception of potentiometer P13 which is mounted on the bracket on top of the sweep amplifier chassis. Complete instructions for the setting of these controls are given in paragraphs 63 to 67 and addendum I of TM-1343.

b. Adjustment of Gate Width. (1) Unless some object of special interest (such as trees, hills, etc.) exists just beyond 10 miles, adjust the 10-mile gate width control (P7) for a gate of exactly 50,000 feet. This adjustment will produce a display, with the sweep blanked immediately after the fifth 10,000-foot range marker.

(2) Since the maximum possible information is desired on the 2-mile indicator tube, adjust the 2-mile gate width for this condition. The maximum usable information will be obtained if the sweep is blanked approximately ½ inch beyond the fourth 2,500-foot marker.

228. ADJUSTMENT OF FOCUS COIL.

While the FOCUS controls on the indicators will ordinarily provide complete adjustment of the indicator tube focus, replacement of a cathode-ray tube or other service work may necessitate a resetting of the fous coil. The coil is clamped in position by the three knurled thumbnuts on the indicator tube mount. To adjust the coil, loosen the three nuts and move the coil to the desired position. The coil should be adjusted so that with the focus control at the center of its position, and with the sweep amplifier inoperative, the large unfocused spot changes to a focused spot without a shift in position when the 300-volt focusing voltage is supplied.

229. REMOVAL OF PRECISION CRT'S.

To replace a defective precision cathode-ray tube, proceed as follows:

WARNING: Make certain 4-kv power supply is off and all high-voltage capacitors are discharged before the CRT is removed. Handle the CRT with care.

a. Remove relay assembly from top of precision indicator to obtain access to CRT socket connection.

b. Remove tube cap from tube shield and disconnect tube base socket.

c. Remove potentiometer panel to obtain access to 4-kv plug connection to CRT. Disconnect 4-kv connector.

d. Take out the four retaining screws on front of indicator and remove the phenolic tube shield and cursor.

e. Pull out hinge plate, tube retainer, and CRT, being careful not to strike tube against side of indicator.

f. Loosen the three holding screws and remove tube retainer from defective CRT.

g. Replace tube retainer on new CRT and install new tube in the precision indicator following the reverse of the foregoing procedure.

230. MIRROR ALIGNMENT. A semitransparent mirror must be aligned so that the reflection image of the two precision indicator tubes appears to lie in the plane of the maps which are mounted on the associated director panel. An improper adjustment results in parallax, and the reflected image appears to shift its position relative to the map as the observer shifts his head. To adjust the mirror proceed as follows:

a. Three knurled thumbscrews are provided for adjustment of the mirror. Two of these thumbscrews are located at the two inner corners of the mirror, while the third is at the center of the outside edge. All are located under the mirror and are accessible to the operators.

b. Turn the map light to full brilliancy or use the fluorescent trouble lamp to provide additional lighting on the phenolic map. Start the radio set, with the exception of turning up the high voltage and stop the switching motors so that there is a stationary trace on the indicator whose mirror is to be adjusted.

c. Using the straight edge of a piece of white paper lay the paper on the phenolic map along the image of the indicator tube trace and with a spacing of approximately 1/64 inch between the trace and the paper.

d. Move from side to side and note if the spacing between paper and trace varies. A few minutes of observing the display will make it apparent as to whether the image is above or below the plane of the map.

e. If the indicator tube image is directly below the map, raise all parts of the mirror an equal amount with the three adjustment controls. Check for parallax on all parts of both indicator tubes to determine if the tilt of the mirror is correct. Readjust the thumbscrews individually to correct tilt if necessary.

f. During the mirror alignment make frequent readjustments of the "main bank" pin and the phenolic map on the director. Adjustment of the map, together with the tilt and height of the mirror, will give a final optimum of position. Some approximations will have to be made as some curvature on the indicator tube faces may prevent accurate alignment at all points with the phenolic maps (which are plane surfaces).

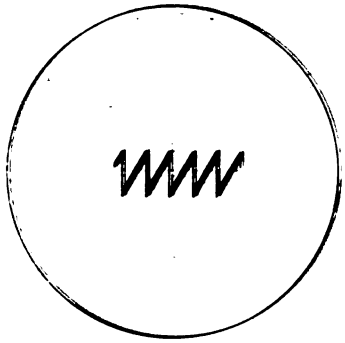
231. ADJUSTMENT OF AZIMUTH ERRORMETER.

a. A meter sensitivity adjustment, P11, is provided on the approach indicator to insure that the errormeter converts the error voltage into exact distance as indicated on the meter scale. In addition, two variable shunt resistors are connected across the ends of the azimuth error potentiometer to provide a contracted scale at the outer limits of the indicator needle travel. These shunt resistors, R1 and R2, are preset by the manufacturer and should not be tampered with in the field.

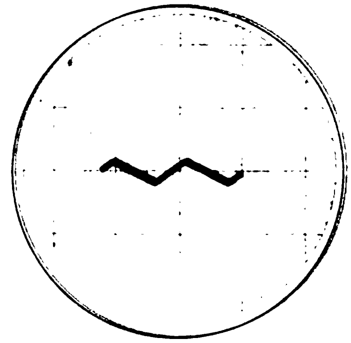
b. To adjust the azimuth errormeter sensitivity, first insure that the 2-mile and 10-mile display sweeps and tracking cursors are properly aligned with the phenolic maps as described in paragraphs 64 and 65 of TM 11-1343. Measure voltage between terminals 1 and 2 of connector strip 4 on the aural signal unit. This voltage should be 35 volts, if not, adjust P8 for correct voltage reading. With these alignments correct, move the tracking cursor to the angle marks along the base of the phenolic map and check the azimuth errormeter reading against the value given in the table below. The distances given in the chart are measured from the inscribed vertical line on the map. Thus, to determine the true deviation from the center line of the runway, it will be necessary to subtract a constant factor (X), equal to the actual distance between the center of the azimuth antenna and the center line of the runway, from the value given in the chart when the tracking cursors are on the runway side of the inscribed vertical line. Similarly, when the tracking cursors are on the opposite side of the inscribed vertical line from the runway, it will be necessary to add a constant factor (X) to the value given in the chart.

Tracking cursor setting	Azimuth errormeter reading	
	2-mile cursor (1″=666′)	10-mile cursor (1″=3,333′)
± 2° point	346 ∓ X feet	1,733 ∓ X feet
± 4° point	693 ∓ X feet	3,466 ∓ X feet
± 6° point	1,046 ∓ X feet	5,233 ∓ X feet
X = distance in feet between center line of runway and center of azimuth antenna.		

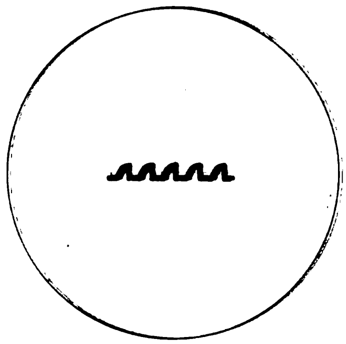
c. Any discrepancies between the values given in the chart and those as read on the azimuth errormeter for the corresponding tracking cursor settings can be corrected by a slight adjustment of the sensitivity control, P11, located on the front panel of the approach indicator.



3
RELAXATION OSCILLATOR, V8*
Pin 3 (V10, pin 4)
Y GAIN 30
X GAIN 40



4
CATHODE FOLLOWER, V10(b)*
Pin 6
Y GAIN 14
X GAIN 40



7
AUDIO OUTPUT*
Terminal 4-5
Y GAIN 100
X GAIN 40

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Figure 387. Aural Signal Unit 0-8/MPN-1, waveforms.

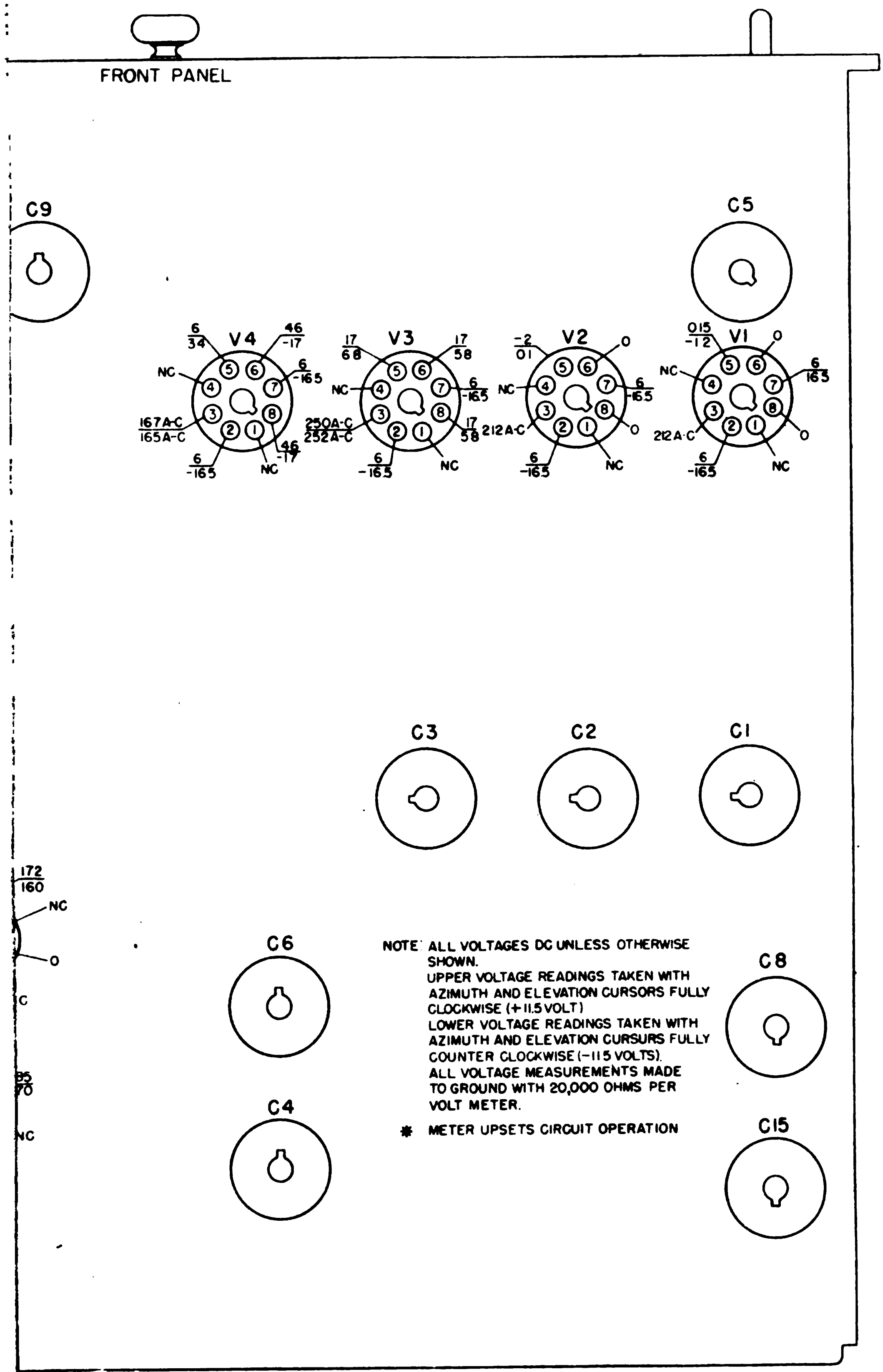


Figure 388A. Aural Signal Unit 0-8/MPN-1, voltage chart.

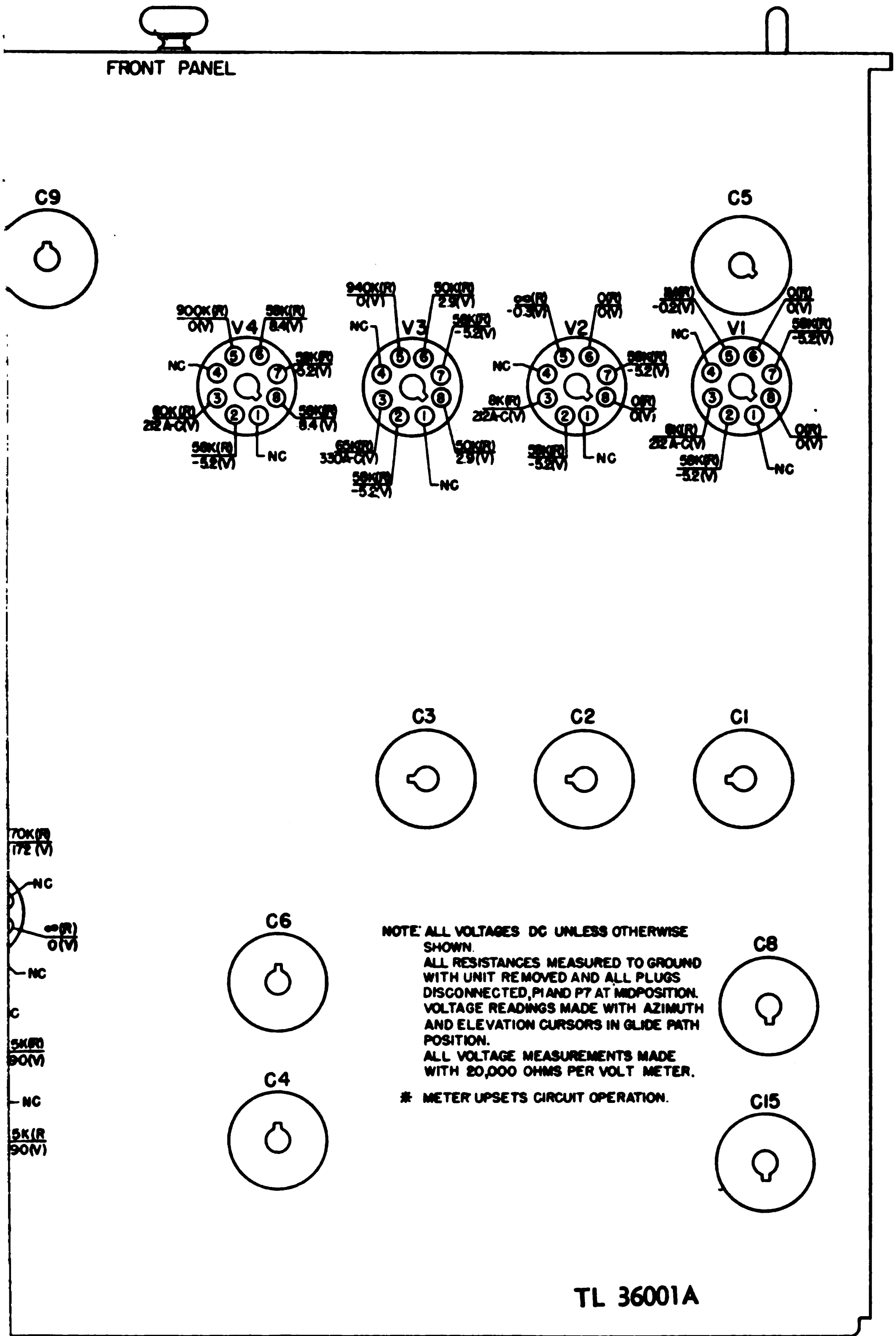


Figure 388B. Aural Signal Unit O-8/MPN-1, voltage and resistance chart.

232. ADJUSTMENT OF ELEVATION ERRORMETER.

a. A meter sensitivity adjustment is also provided on the approach indicator to insure that the elevation errormeter is properly calibrated. This control, P10, is adjusted in a manner similar to that for the azimuth sensitivity control. Two preset adjustments, R1 and P2, are associated with the elevation error potentiometer and are preset by the manufacturer. These adjustments should not be tampered with in the field.

b. To adjust the elevation errormeter sensitivity, first insure that the 2-mile and 10-mile elevation display sweeps and tracking cursors are properly aligned with the phenolic maps as described in paragraphs 66 and 67 of TM 11-1343. The following procedure should be used to check the calibration of the elevations errormeter:

(1) Rotate the elevation trackers' handwheel until the cursors are in the glidepath position (elevation errormeter reads zero feet deviation).

(2) Loosen the clamping nut on the 2-mile cursor and move the cursor in a vertical direction until it coincides with the nearest angle mark inscribed along the right-hand vertical line of the phenolic map. (Do not change the angular setting of the cursor.) Tighten the clamping nut.

(3) Move the 2-mile cursor either up or down, by means of the elevation handwheel, to the next angle mark. This corresponds to a vertical deviation of an approaching aircraft of 176 feet (1 inch on the 2-mile map represents 200 feet). Thus the elevation errormeter should indicate a deviation of 176 feet.

(4) Move the 2-mile cursor to the next angle mark. The elevation errormeter should now read 352 feet deviation.

(5) If the elevation errormeter does not correspond to the deviations in (3) and (4), slightly adjust the meter sensitivity control P10 on the front panel of the approach indicator until the correct reading is obtained.

(6) Rotate the elevation handwheel until the meter indicates zero deviation (glidepath position), and loosen the clamping nut on the 2-mile cursor. Move the cursor until it intersects the touchdown point and tighten the clamping nut.

SECTION VI

SCAN SYNCHRONIZING AND ANTENNA POSITIONING SYSTEM

233. REFERENCE DATA.

a. Angle Coupling Unit CU-14/MPN-1.

(1) Figure 389. Top view.
(2) Figure 390. Bottom view.
(3) Figure 188. Schematic diagram.
(4) Figure 394. Voltage chart.
(5) Figure 395. Resistance chart.

b. Commutator Unit SA-40/MPN-1.

(1) Figure 391. Front oblique view.
(2) Figure 392. Rear view.
(3) Figure 192. Schematic diagram.
(4) Figure 397. Voltage chart.
(5) Figure 398. Resistance chart.

c. General.

(1) Figure 396. Angle coupling and commutator junction box, schematic diagram.
(2) Figure 193. Precision antenna follower assemblies.
(3) Figure 253. Capacitor color code.
(4) Figure 254. Resistor color code.
(5) Figure 255. Tube base chart.

234. PROCEDURE.

a. Faults in the scan synchronizing system will, in general, appear as an absence of scan or as a distorted scan sweep on either the elevation or azimuth precision indicators. The majority of faults in this system will be caused either by circuit defects or faulty connections in the angle coupling unit or commutator unit, or by maladjustment of the preset adjustments in the angle coupling unit and synchronizer. Before attempting to locate faults in the scan synchronizing system, first insure that the angle coupling unit is properly aligned (par. 236). With this unit properly aligned, faults can be isolated by means of step 13 (par. 158) of the start procedure trouble-shooting chart to the scan synchronizing system. Reference should then be made to the scan synchronizing system trouble-shooting chart in the following paragraph, and to the voltage and resistance charts which can be used to isolate faults to a defective element.

b. Faults in the antenna positioning system will be of a mechanical nature, which can usually be located by inspection. The alignment of the antenna positioning cursors on the precision indicators should be checked frequently with the position of the precision antenna to insure that the antenna positioning system is functioning normally.

235. TROUBLE-SHOOTING CHART FOR SCAN SYNCHRONIZING SYSTEM.

A. SYMPTOMS:

1. No timebase scan on both tubes of one precision indicator, other indicator scan normal.
2. No angle voltage at terminal 10-3 on associated sweep amplifier.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Trailer wiring to angle coupling unit.	1. Check voltage at terminal 3 of conector strip CS30 on angle coupling unit (2-52 volts). If output is normal, check continuity of trailer wiring between synchronizer and angle coupling unit.
2. Angle coupling unit.	2*a*. If no output appears at terminal 3, measure plate supply voltages at terminals 4, 6, and 7 (–102, +300, and +500 volts, respectively).
	b. Replace tubes V1, V2, and V3, one at a time, and note if fault is cleared.
	c. If abnormally high voltage is present at terminal 3 but does not sweep, check cable connections between angle capacitor and angle coupling units.
	d. Check voltage and resistance values against the charts (figs. 394 and 395).

B. SYMPTOMS:

1. Brilliant line at edges of EPI scan.
2. Signals and timebase sweep normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Commutator unit.	1*a*. Lamp LM1 defective.
	b. Measure voltages at terminals E and G of plug PL1 on commutator unit (–210 and –102 volts, respectively).
	c. Replace tubes V1, and V2 or V3.
	d. Check voltages and resistances by means of the charts (figs. 397 and 398).
2. Commutator circuits in synchronizer defective.	2. Refer to synchronizer trouble-shooting chart (par. 212).

C. SYMPTOMS:

1. Brilliant line at edges of EPI scan.
2. Timebase backed out during normal scan.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switching Unit SA-8/MPN-1.	1. Check alignment of r-f and blanker switch blades (par. 201).

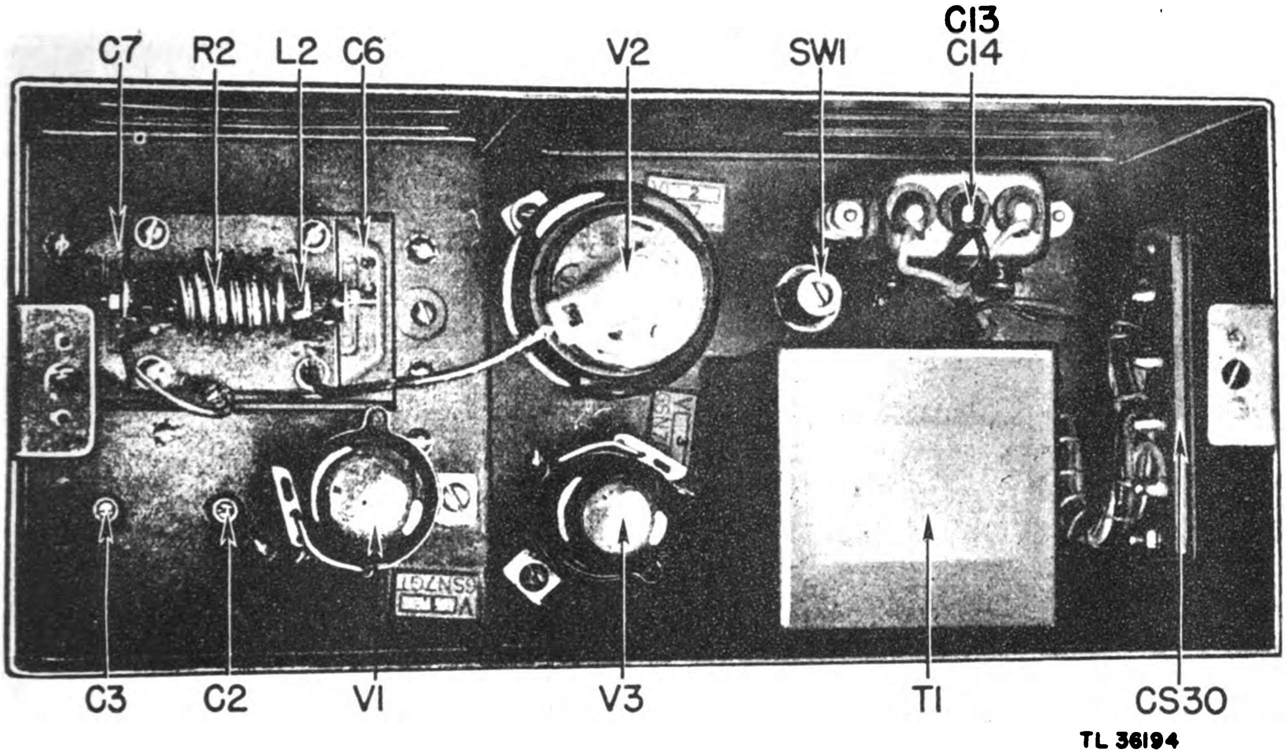


Figure 389. Angle Coupling Unit CU-14/MPN-1, top view.

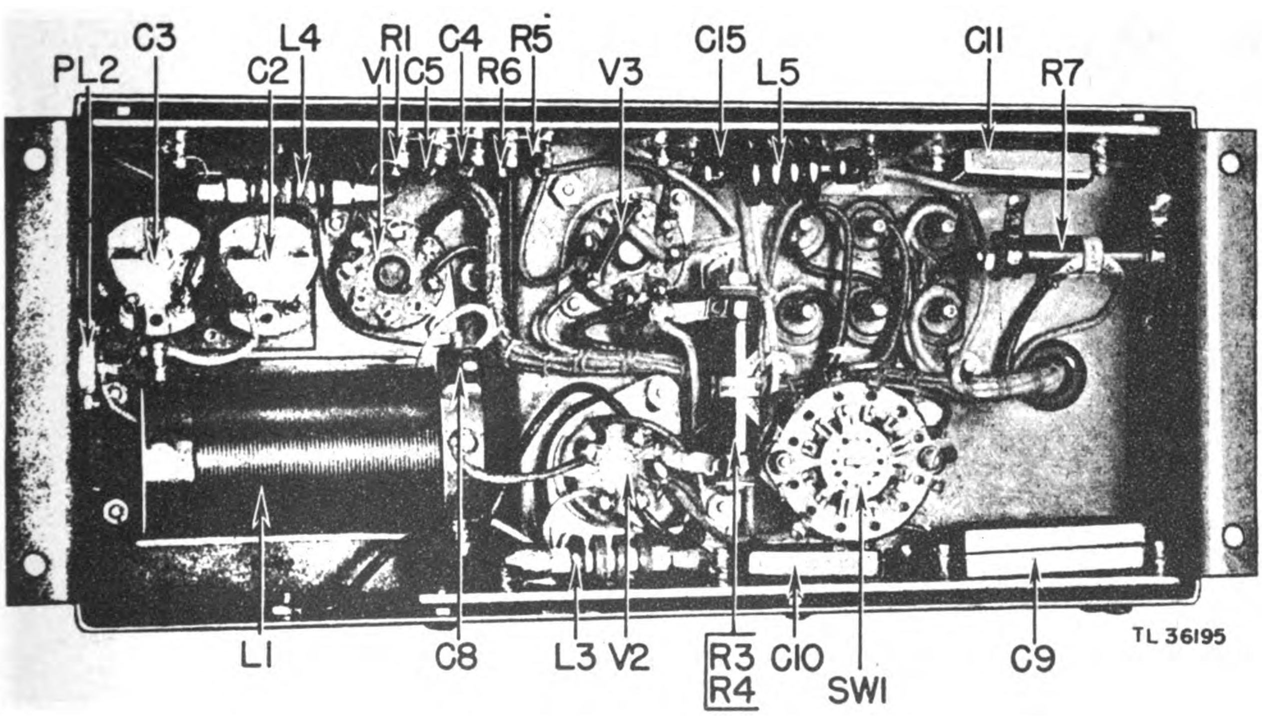


Figure 390. Angle Coupling Unit CU-14/MPN-1, bottom view.

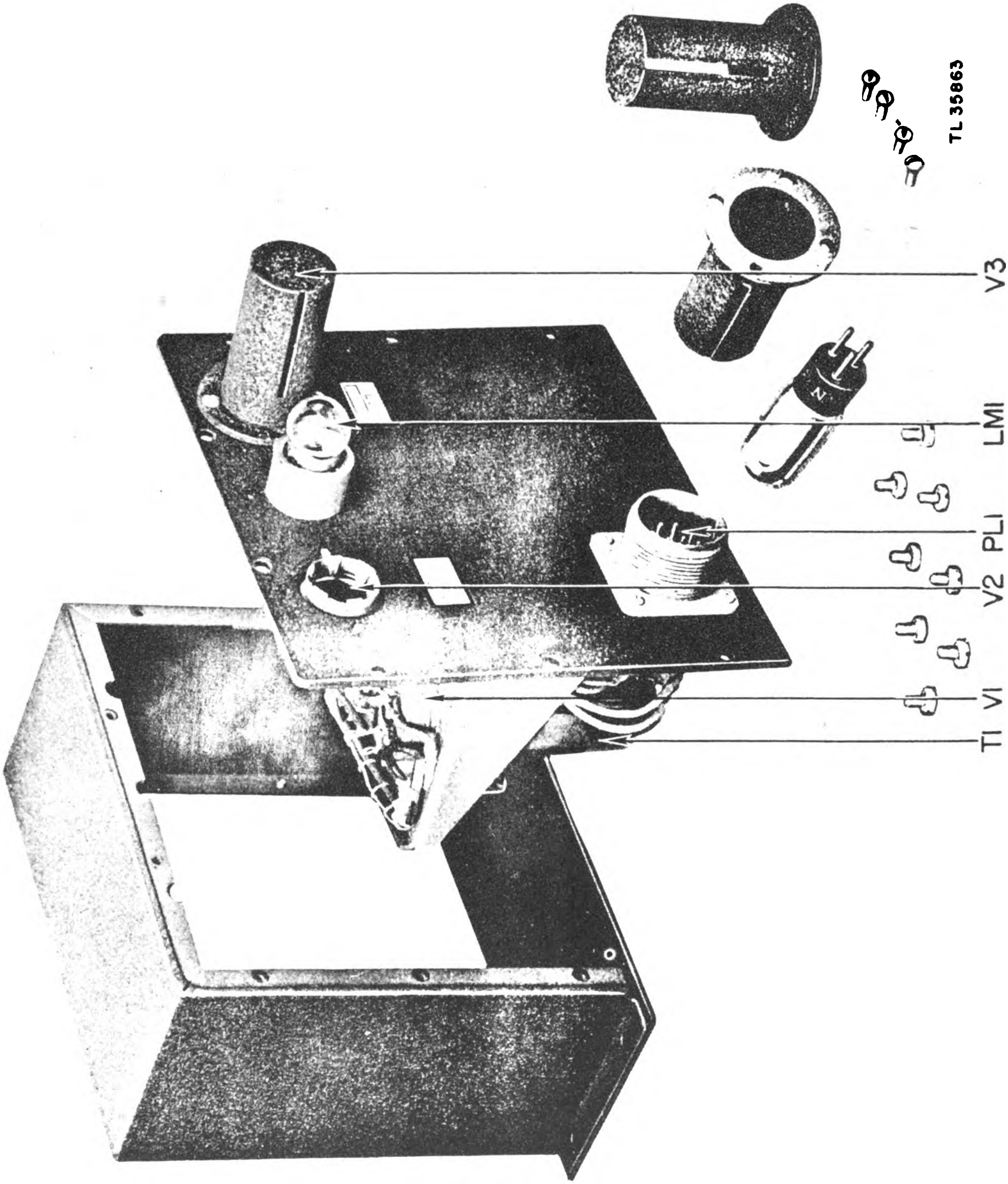


Figure 391. Commutator Unit SA-40/MPN-1, front oblique view.

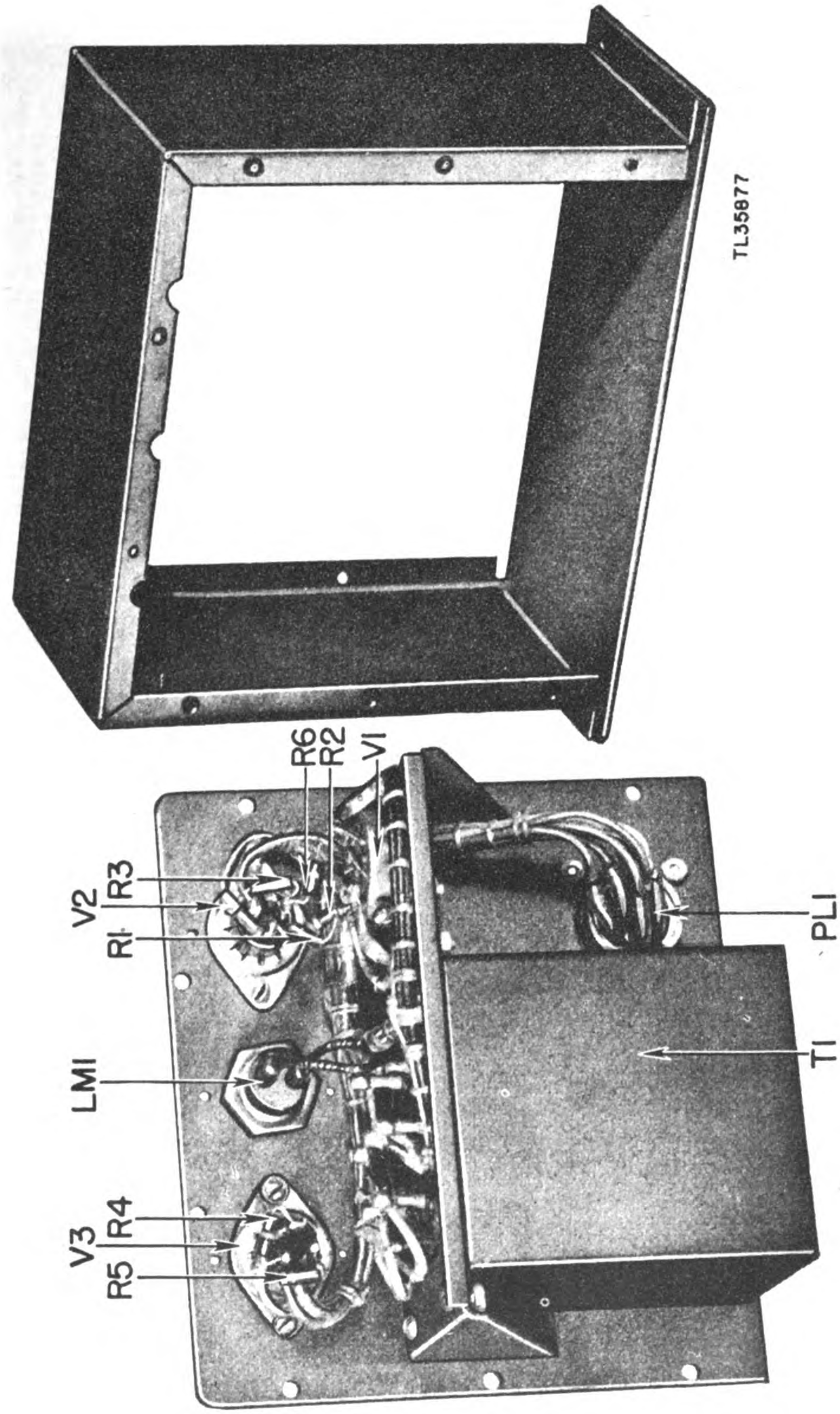


Figure 392. Commutator Unit SA-40/MPN-1, rear view.

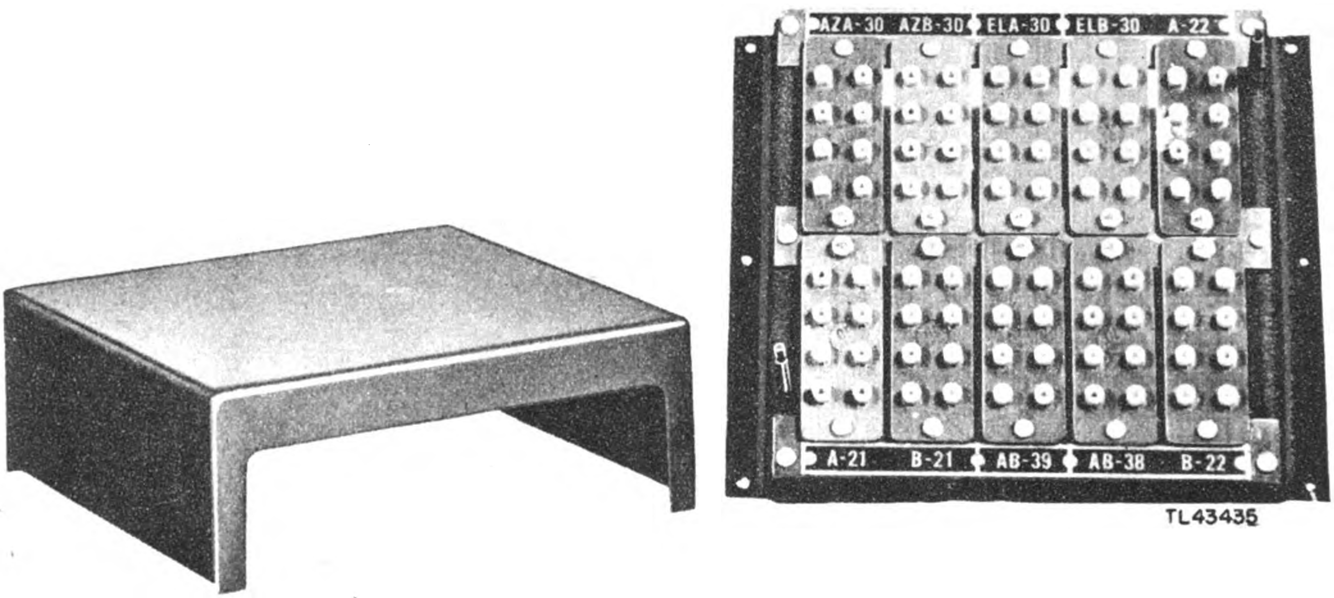


Figure 393. Angle coupling and commutator junction box.

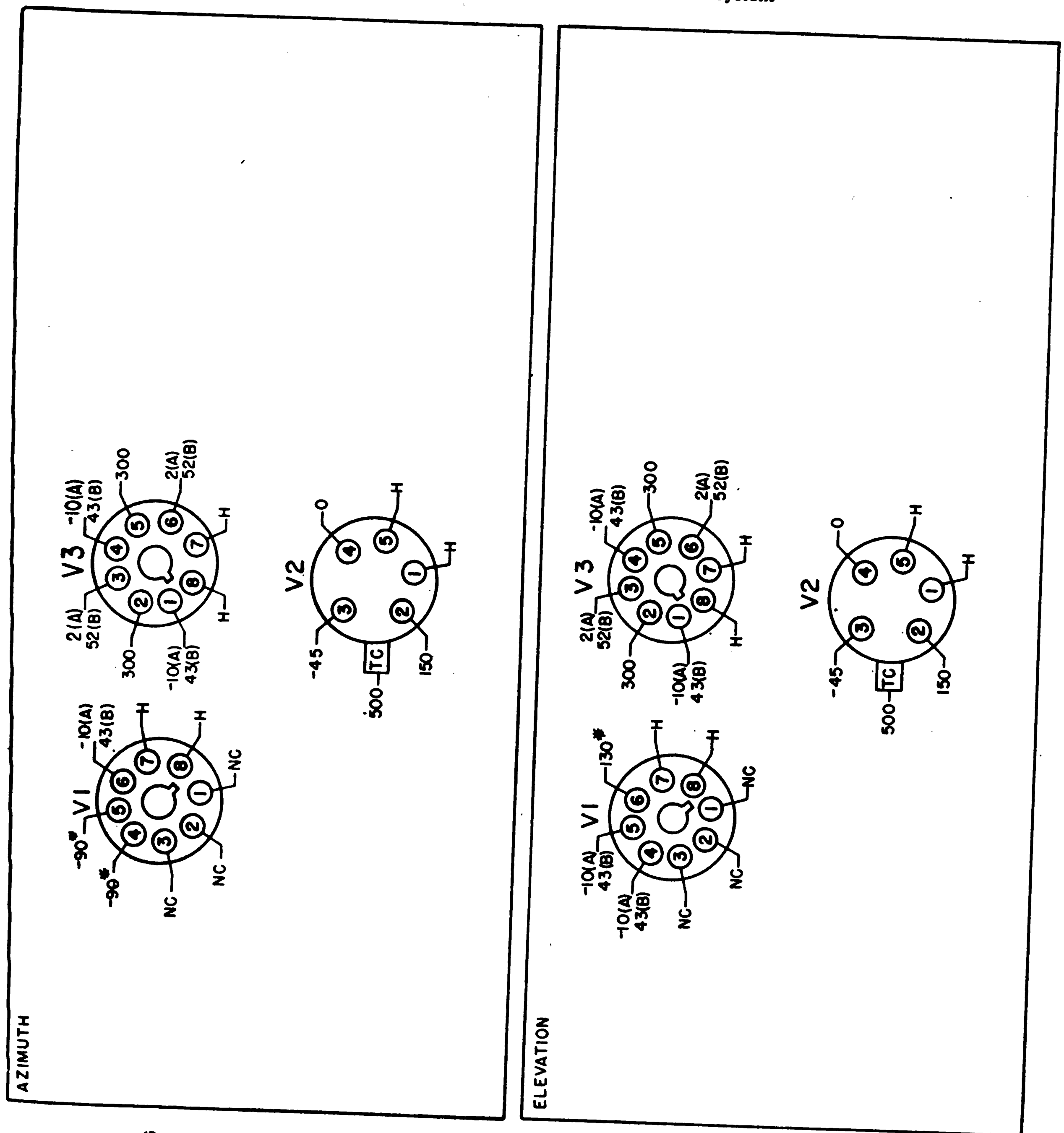
236. SUPPLEMENTARY DATA.

a. Alignment of Angle Coupling Units. (1) The alignment procedure for the azimuth and elevation angle coupling units is given in paragraphs 56 and 57, respectively, of TM 11-1343. Before proceeding with this alignment, however, it will be necessary to measure the frequency or wavelength of both channel A and channel B magnetrons in order to determine which of the three sets of waveguide widths to use during the alignment procedure. Waveguide width dial readings are stamped on the AZIMUTH SCANNER and ELEVATION SCANNER data plates on the antenna arrays for the following three wavelengths X.280, X.300, and X.320.

(2) For the azimuth angle coupling unit alignment, dial readings corresponding to the next *longer* wavelength should be used. For example, if the channel A magnetron wavelength measures X.295, and the channel B magnetron wavelength measures X.285, the angle coupling unit should be aligned using the dial readings corresponding to the X.300 frequency. This will insure that the longer wavelength beam will sweep to the 1-degree limit (the shorter wavelength beam will sweep to slightly below the 1-degree limit).

(3) For the elevation angle coupling unit alignment, dial readings corresponding to the next *shorter* wavelength should be used. With the magnetron wavelengths the same as in the above example, dial readings corresponding to the X.280 frequency should be used during the elevation alignment. This will insure that the shorter wavelength beam will sweep down to the 1-degree line.

b. Alignment of Servo Cursors. Final alignment of the servo cursors is described in paragraph 68 of TM 11-1343. In some cases, however, a larger degree of adjustment may be required. This larger adjustment can be obtained by means of the adjustable turnbuckles in the cables to the antennas (fig. 193). By loosening the turnbuckle in one side of the cable and tightening the one in the opposite cable, the position of the cursors may be altered with respect to the antenna. After this adjustment has been made, the tension in the servo cables must be adjusted to 150 pounds by means of the adjustment screw on the turnbuckle. In the event a cable is replaced, it may be necessary to remove a link in the chain connecting the cable to the foot pedals in order to obtain the proper tension.



ALL CONTROLS IN NORMAL OPERATING POSITION
A. OUTPUT VOLTAGE = 2 VOLTS
B. OUTPUT VOLTAGE = 52 VOLTS
VALUE DEPENDS ON OPERATING POSITION OF POTENTIOMETER

Figure 394. Angle Coupling Unit CU-14/MPN-1, voltage chart.

A. MEASURED TO 500 VOLT SUPPLY TERMINAL 30-7

B. MEASURED TO 300 VOLT SUPPLY TERMINAL 30-6

C. MEASURED TO -102 VOLT SUPPLY TERMINAL 30-4

D. MEASURED TO BIAS TERMINAL 30-8

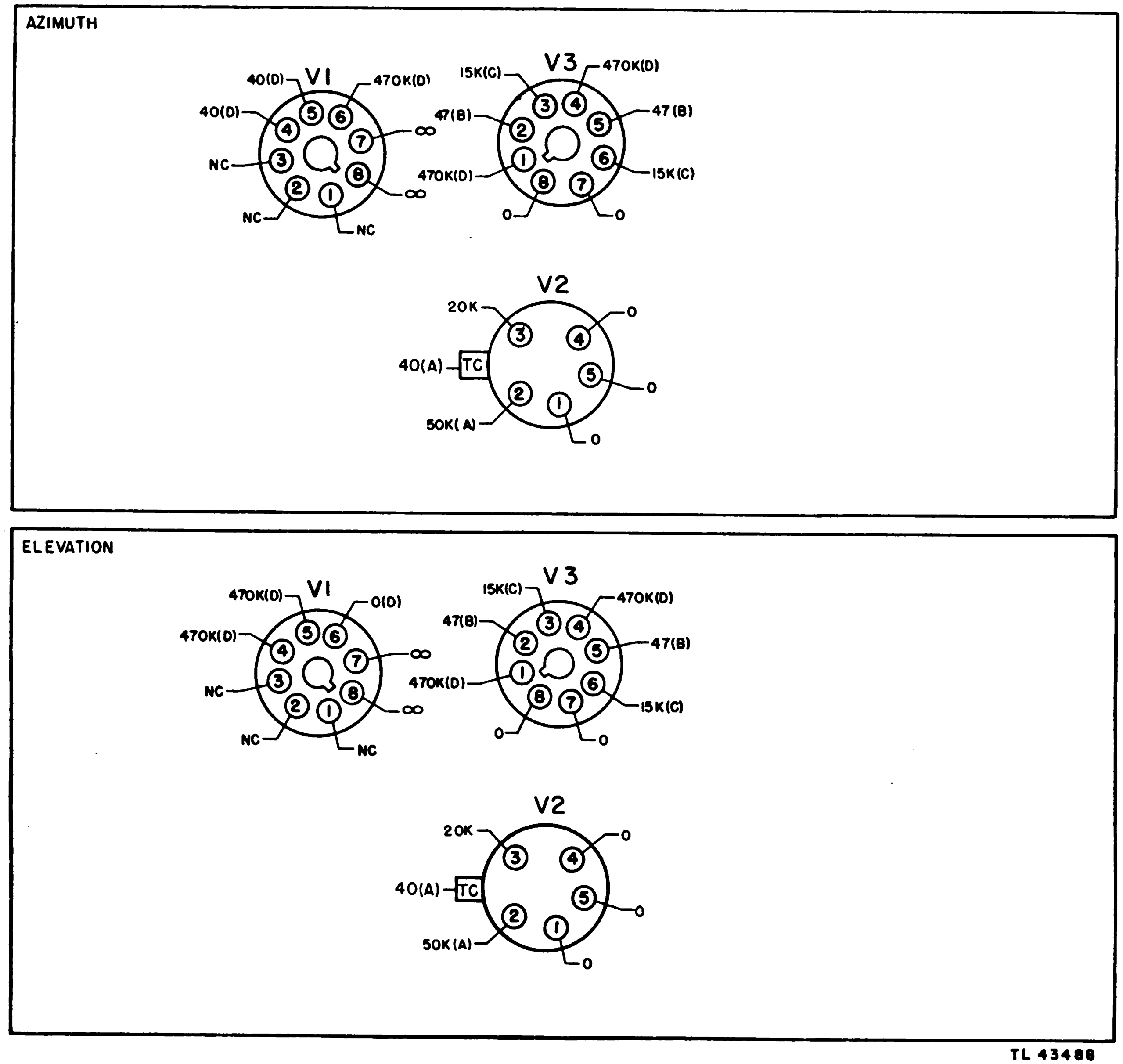


Figure 395. Angle Coupling Unit CU-14/MPN-1, resistance chart.

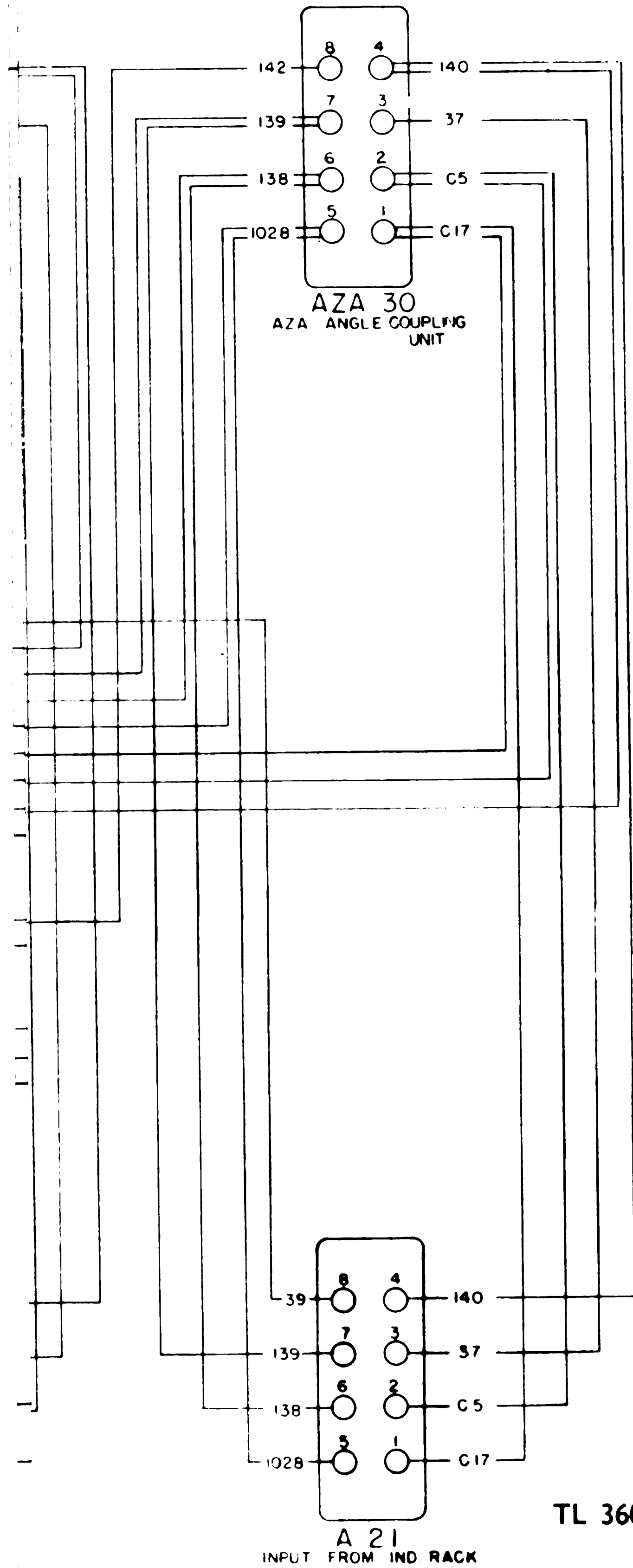


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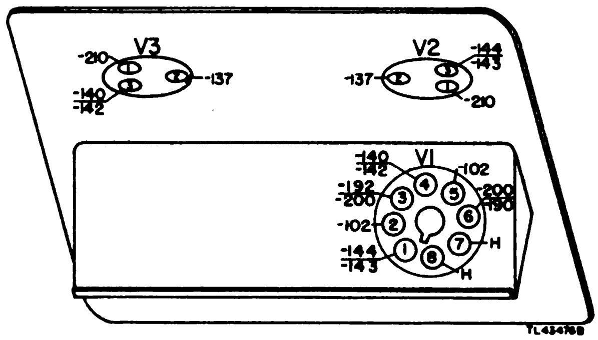
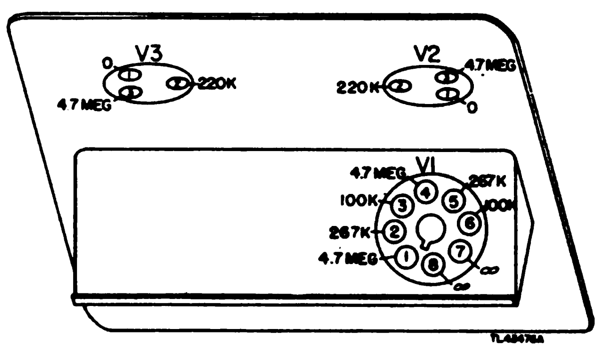
Figure 396. Angle coupling and commutator junction box, schematic diagram.



NOTE:
UPPER VOLTAGE READINGS WITH R-F SWITCH IN AZIMUTH POSITION. LOWER VOLTAGE READINGS WITH R-F SWITCH IN ELEVATION POSITION. ALL VOLTAGE READINGS TAKEN TO GROUND WITH 20,000 OHM PER VOLT METER.

Figure 397. Commutator Unit SA-40/MPN-1, voltage chart.



NOTE:
RESISTANCES MEASURED TO PIN E OF PLI WITH PLUG PLI REMOVED

Figure 398. Commutator Unit SA-40/MPN-1, resistance chart.

CHAPTER 9

TROUBLE SHOOTING ASSOCIATED EQUIPMENT

SECTION I

POWER DISTRIBUTION SYSTEM

237. REFERENCE DATA.

a. Cabling Diagram.

(1) Figure 399. Indicator Rack MT-118/MPN-1, bays 1, 2, and 3.
(2) Figure 400. Indicator Rack MT-118/MPN-1, bays 4, 5, and 6.
(3) Figure 401. Transmitter Rack MT-119/MPN-1.
(4) Figure 402. Communications Rack MT-121/MPN-1, (rack A).
(5) Figure 403. Communications Rack MT-120/MPN-1, (rack B).
(6) Figure 404. Indicator Rack MT-118/MPN-1, communications circuits.
(7) Figure 405. Inter-rack cabling diagram.
(8) Figure 406. Connector adaptation for SCR-274 transmitter, schematic diagram.
(9) Figure 228. Cabling block diagram of communications system.

b. General.

(1) Figure 194. Power Distribution Panel SB-1/MPN-1, schematic diagram.
(2) Figure 198. Power distribution control circuit.
(3) Figure 199. 4-kv relay control circuit.
(4) Figure 201. High-voltage relay and interlock system.
(5) Figure 249. Power supplies and associated components, block diagram.
(6) Figure 407. Contact-making voltmeter.
(7) Figure 408. Contact-making voltmeter contact assembly.

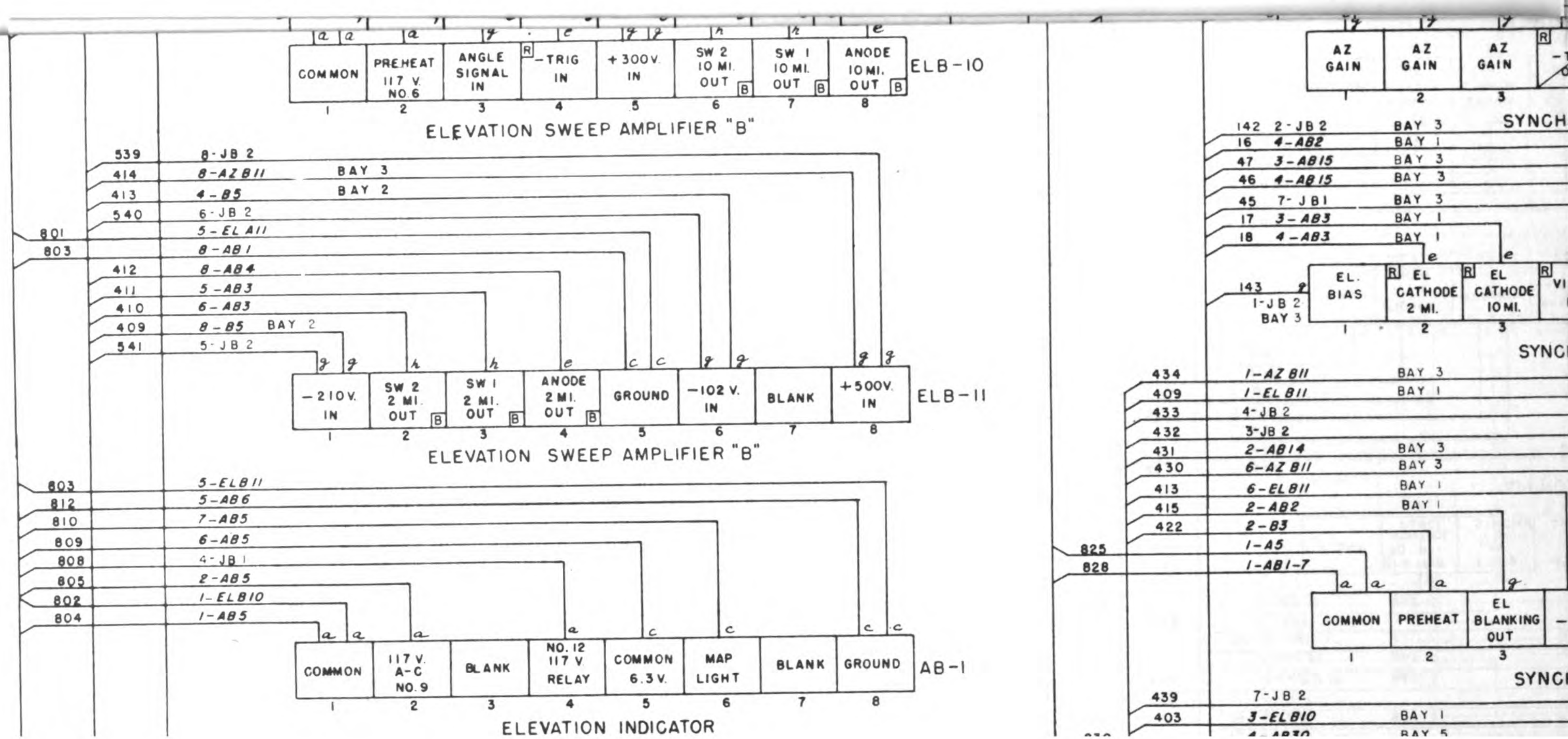
238. USE OF CABLING DIAGRAMS.

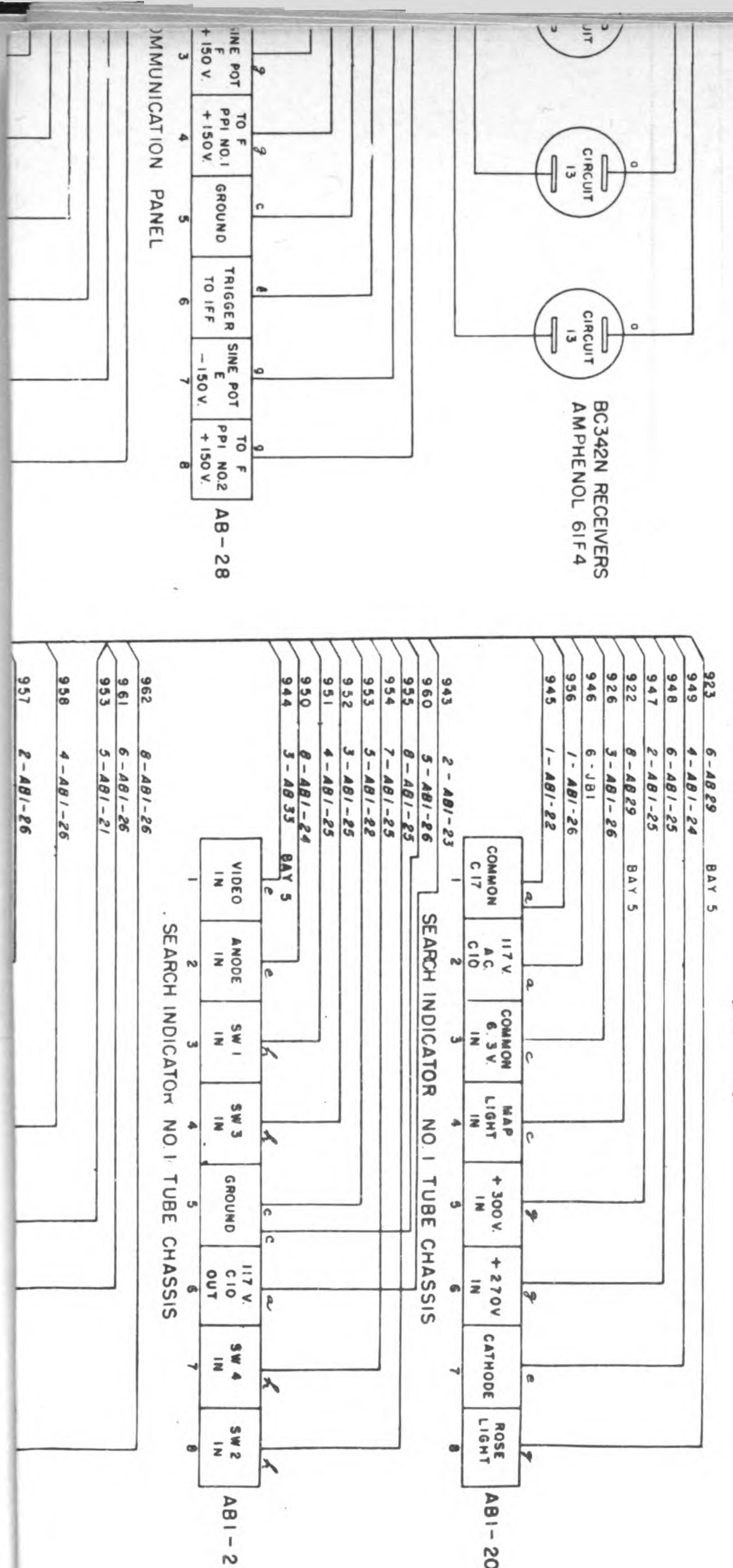
a. The majority of the faults occurring in the power distribution system can be isolated by means of the start procedure trouble-shooting chart in section III of chapter 6, and by reference to the power distribution control circuit diagram (fig. 198). When the fault has been isolated to the cabling between units or between switches and units, it will be necessary to check the continuity of the inter-cabling between successive connecting points. The path of the suspected cable and the location of successive points where continuity tests or voltage checks may be made, can be obtained by referring to the cabling chart of the particular rack involved.

b. Each connecting wire in the cabling system is numbered on the cabling diagram and its path may be traced by following the wire number. At each connector point, the terminal and connector designation of the terminating end of the inter-connecting wire is also given to aid in tracing the circuit.

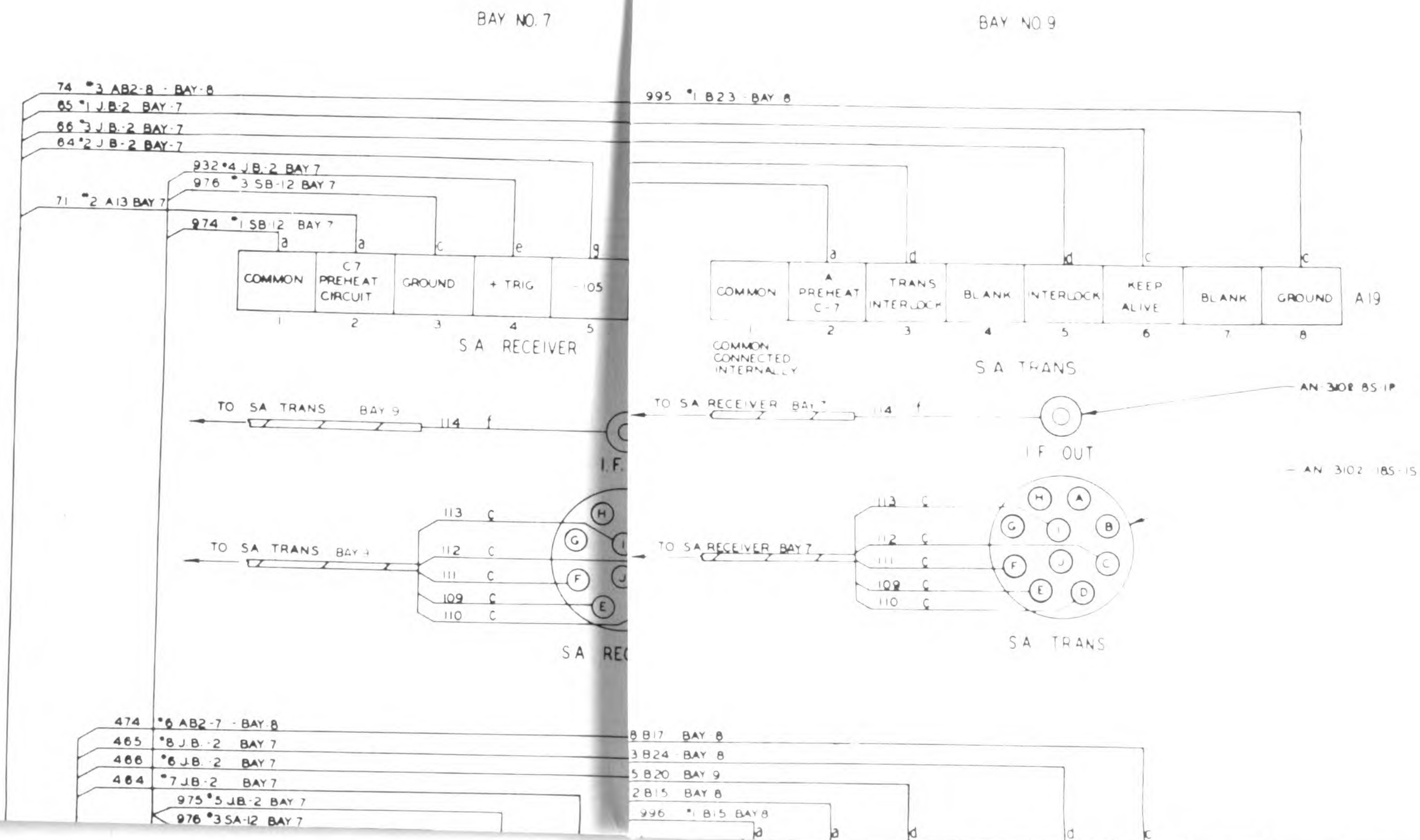
239. VOLTAGE REGULATOR ADJUSTMENTS.

a. Contact-making Voltmeter. The contact-making voltmeter has been adjusted at the factory for a normal load-center voltage of 120, with voltage-band limits of 119 and 121 volts. To check the output of the voltage regulator, connect an a-c voltmeter providing the proper range between the output voltage testing terminals (fig. 22, TM 11-1343). With the equipment operating in the usual manner, this voltmeter should now show the voltage for which the regulator is adjusted. To adjust the regulator, set the automatic-manual selector switch in the test position. By means of the manual RAISE or LOWER push-button switches, raise or lower the voltage until the voltmeter contact closes. At this point, the regulator will operate to return the voltage toward the normal voltage position. Next check the operation of the voltmeter contact by starting in the opposite direction in a similar manner, again noting the voltage at which contact closes. The two voltages thus determined by the making of the contact while approaching the normal voltage position from above and below, determine the voltage band width of the regulator. Ordinarily, the band width should be adjusted to provide limits of plus or minus 1 volt from the normal voltage position. The band width may be adjusted if necessary, by the stationary contact adjusting knob at the top of the stationary contact assembly (fig. 407). Turning this knob in a clockwise direction lowers and narrows the band width; turning it counterclockwise raises the contact and widens the band width. The normal voltage is the median of the voltages at which the raise and lower contacts are closed. At this voltage, the contact beam should balance in a horizontal position halfway between

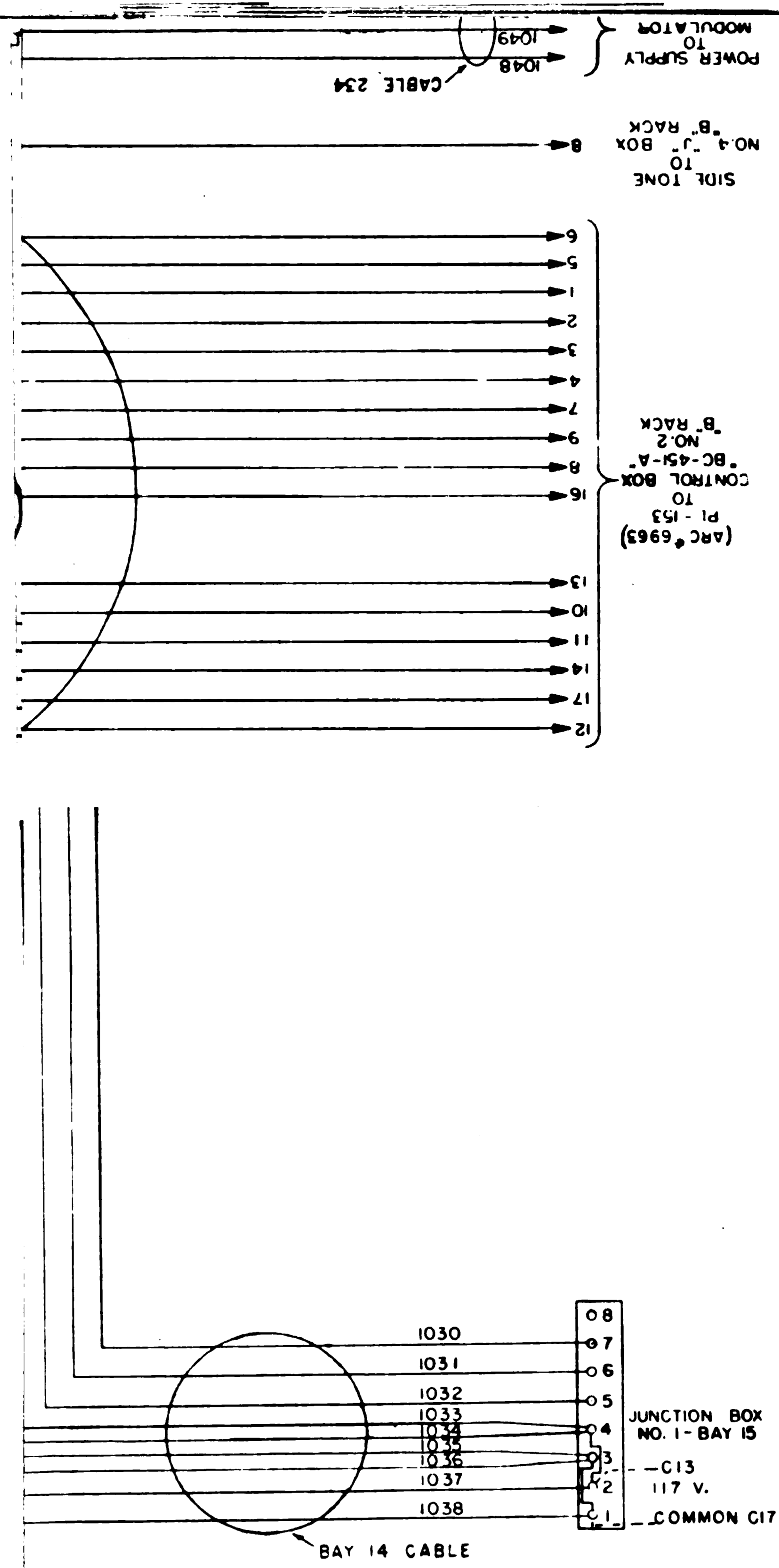

COMMON
PREHEAT 117 V. NO.6
ANGLE SIGNAL IN
-TRIG IN
+300V. IN
SW 2 10 MI. OUT
SW 1 10 MI. OUT
ANODE 10 MI. OUT
ELB-10
ELEVATION SWEEP AMPLIFIER "B"
539 8-JB 2
414 8-AZB11 BAY 3
413 4-B5 BAY 2
540 6-JB 2
801 5-EL A11
803 8-AB1
412 8-AB4
411 5-AB3
410 6-AB3
409 8-B5 BAY 2
541 5-JB 2
-210V. IN
SW 2 2 MI. OUT
SW 1 2 MI. OUT
ANODE 2 MI. OUT
GROUND
-102 V. IN
BLANK
+500V. IN
ELB-11
ELEVATION SWEEP AMPLIFIER "B"
803 5-ELB11
812 5-AB6
810 7-AB5
809 6-AB5
808 4-JB1
805 2-AB5
802 1-ELB10
804 1-AB5
COMMON
117 V. A-C NO.9
BLANK
NO. 12 117 V RELAY
COMMON 6.3 V.
MAP LIGHT
BLANK
GROUND
AB-1
ELEVATION INDICATOR
AZ GAIN
AZ GAIN
AZ GAIN
SYNCHR
142 2-JB 2 BAY 3
16 4-AB2 BAY 1
47 3-AB15 BAY 3
46 4-AB15 BAY 3
45 7-JB1 BAY 3
17 3-AB3 BAY 1
18 4-AB3 BAY 1
143 1-JB 2 BAY 3
EL. BIAS
EL CATHODE 2 MI.
EL CATHODE 10 MI.
VID IN
SYNCH
434 1-AZ B11 BAY 3
409 1-EL B11 BAY 1
433 4-JB 2
432 3-JB 2
431 2-AB14 BAY 3
430 6-AZ B11 BAY 3
413 6-EL B11 BAY 1
415 2-AB2 BAY 1
422 2-B3
825 1-A5
828 1-AB1-7
COMMON
PREHEAT
EL BLANKING OUT
SYNCH
439 7-JB 2
403 3-EL B10 BAY 1



cabling diagram, bays 4, 5, and 6.



BAY NO. 7
BAY NO. 9
74 *3 AB2-8 · BAY-8
65 *1 J.B-2 BAY-7
66 *3 J B-2 BAY-7
64 *2 J B-2 BAY-7
932 *4 J.B-2 BAY 7
976 *3 SB-12 BAY 7
71 *2 A13 BAY 7
974 *1 SB 12 BAY 7
COMMON
C7 PREHEAT CIRCUIT
GROUND
+ TRIG
S A RECEIVER
TO SA TRANS BAY 9
I.F.
SA REC
995 *1 B23 · BAY 8
COMMON
A PREHEAT C-7
TRANS INTERLOCK
BLANK
INTERLOCK
KEEP ALIVE
BLANK
GROUND
A19
COMMON CONNECTED INTERNALLY
S A TRANS
AN 3108 8S-1P
I F OUT
AN 3102 18S-1S
SA TRANS
474 *6 AB2-7 · BAY 8
465 *8 J B -2 BAY 7
466 *6 J B. 2 BAY 7
464 *7 J B-2 BAY 7
975 *5 J B-2 BAY 7
976 *3 SA-12 BAY 7
8 B17 BAY 8
3 B24 BAY 8
5 B20 BAY 9
2 B15 BAY 8
996 *1 B15 BAY 8



TL 36089A

Figure 402. Communications Rack MT-121/MPN-1, (rack A), cabling diagram.

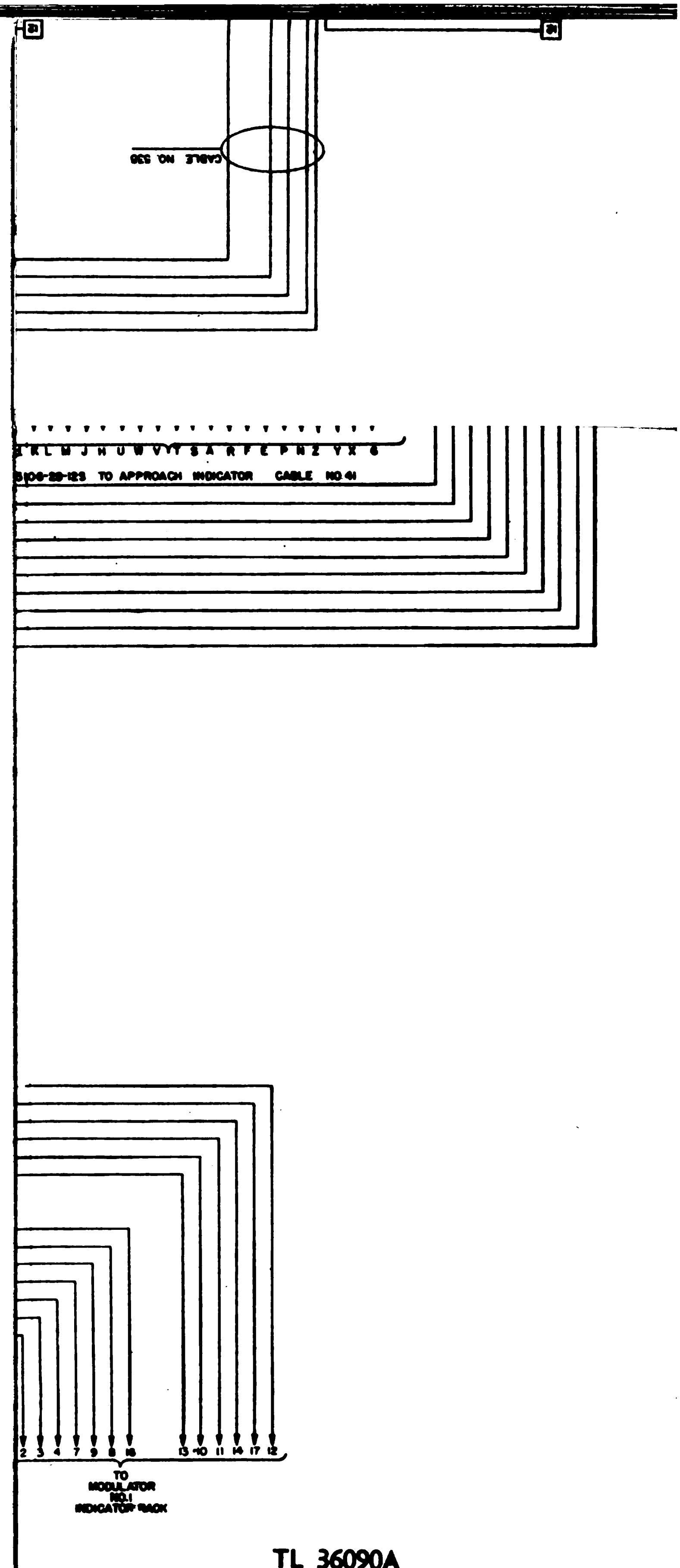
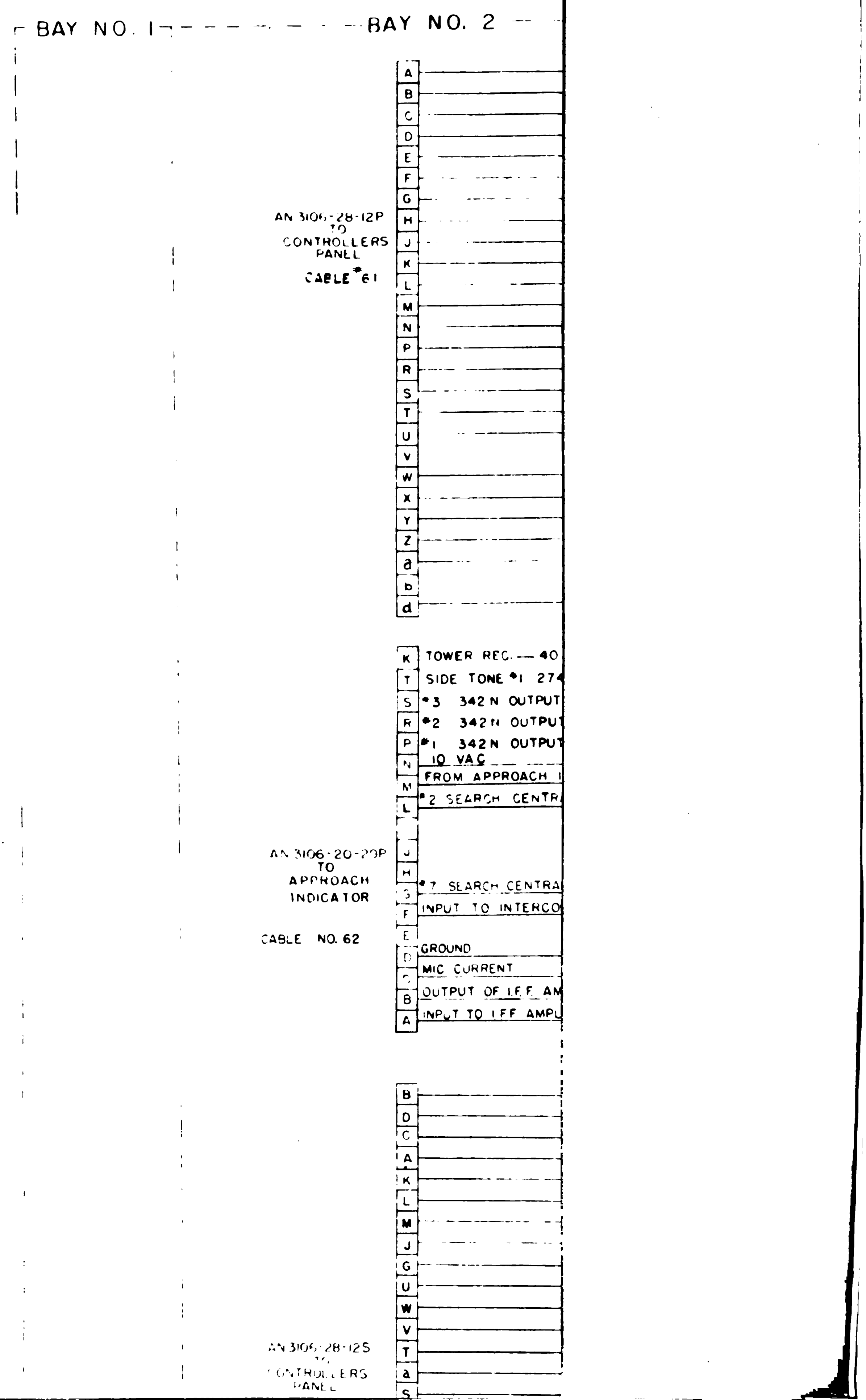
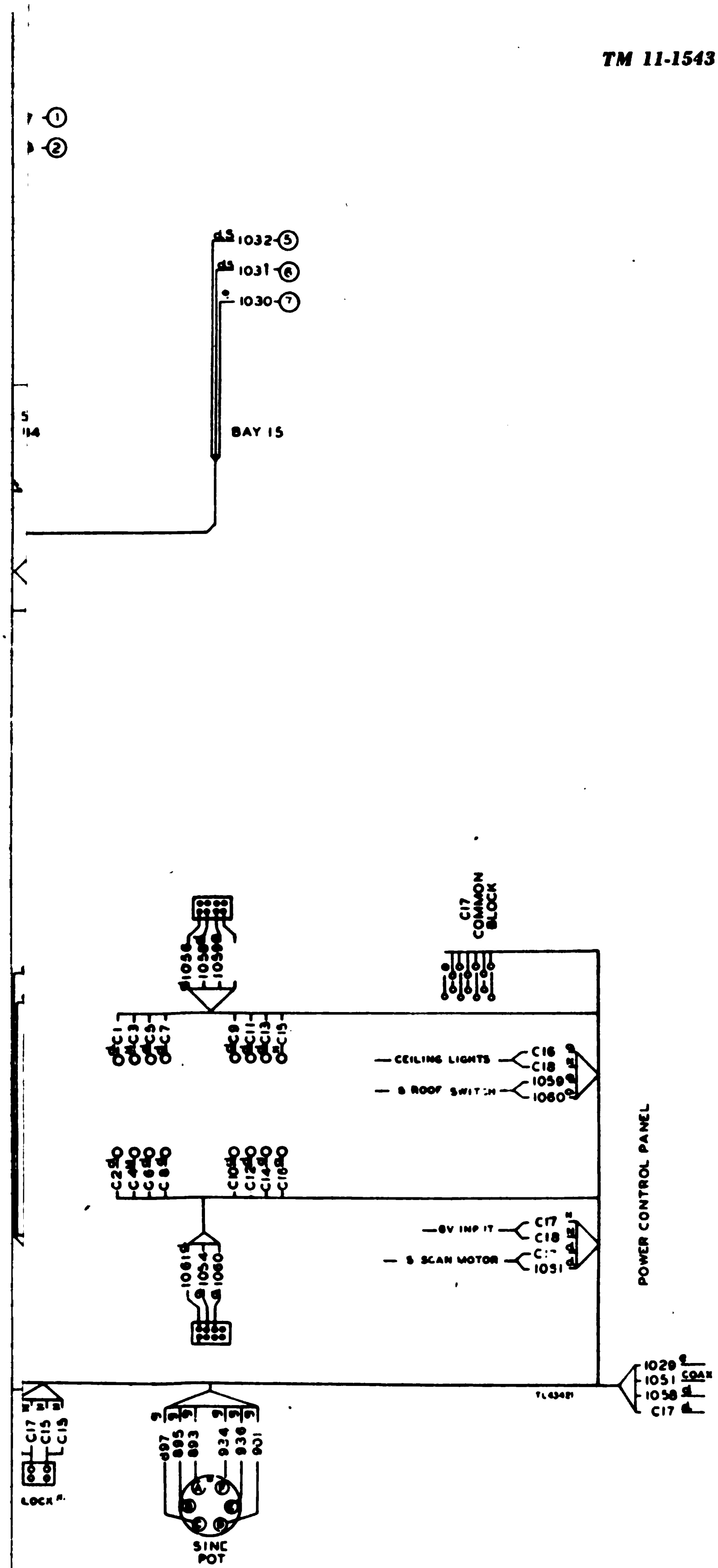


Figure 403. Communications Rack MT-120/MPN-1 (rack B), cabling diagram.



BAY NO. 1
BAY NO. 2
AN 3106-28-12P TO CONTROLLERS PANEL
CABLE #61
A B C D E F G H J K L M N P R S T U V W X Y Z a b d
K T S R P N M L J H G F E D C B A
TOWER REC. — 40
SIDE TONE #1 27
#3 342 N OUTPUT
#2 342 N OUTPUT
#1 342 N OUTPUT
10 VAC
FROM APPROACH I
#2 SEARCH CENTR
AN 3106-20-29P TO APPROACH INDICATOR
#7 SEARCH CENTRA
INPUT TO INTERCO
CABLE NO. 62
GROUND
MIC CURRENT
OUTPUT OF I.F.F. AM
INPUT TO I.F.F. AMPL
B D C A K L M J G U W V T a S
AN 3106-28-12S TO CONTROLLERS PANEL



TL 43421

Figure 405. Inter-rack cabling diagram.

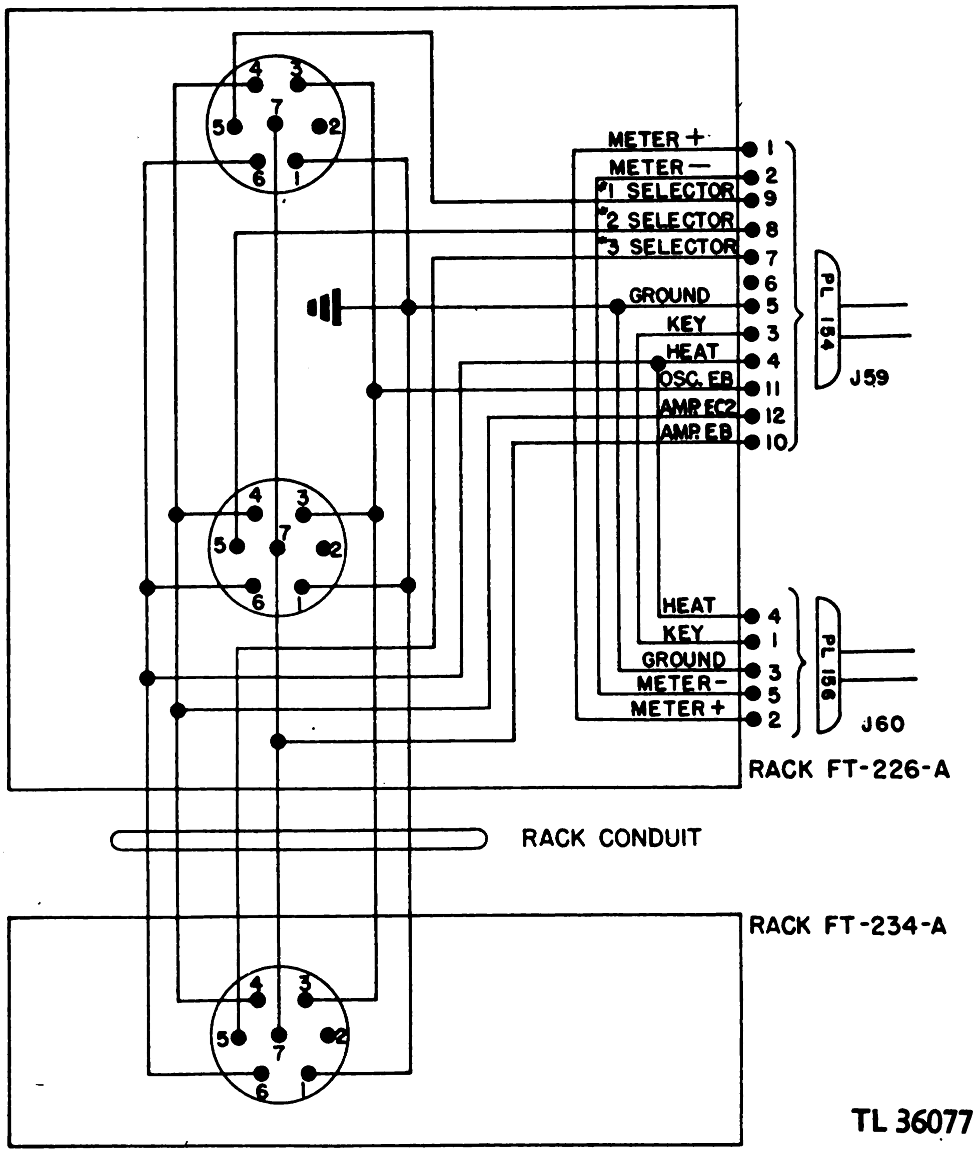


Figure 406. Connector adaption for SCR-274 transmitter, schematic diagram.

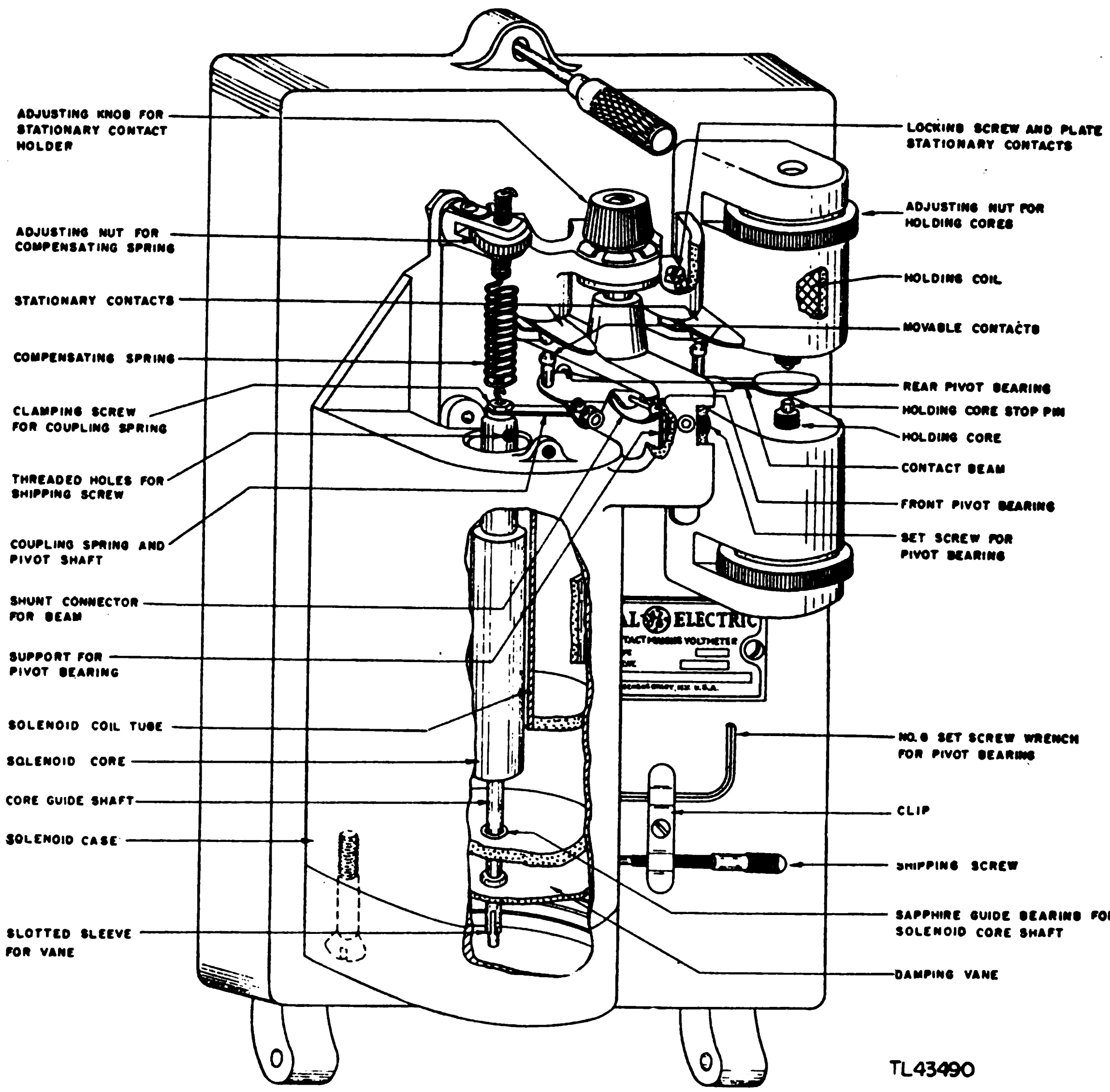
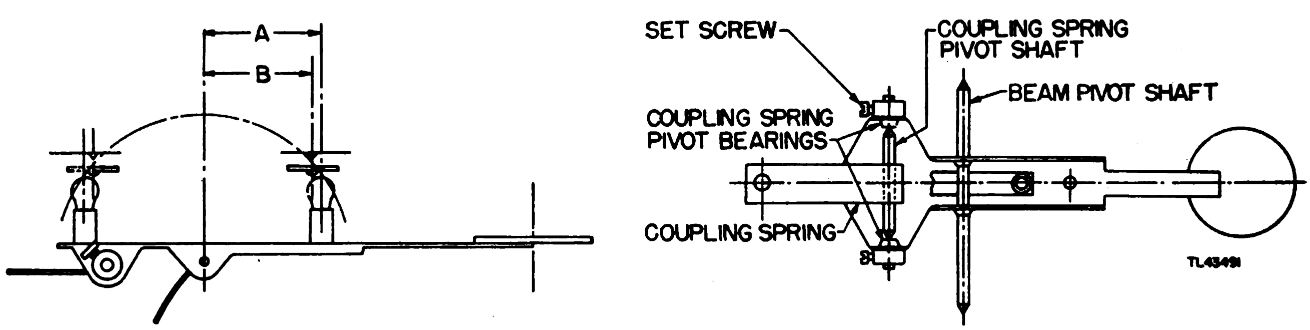


Figure 407. Contact-making voltmeter.



(a) ALIGNMENT OF CONTACT-MAKING-VOLTMETER CONTACTS (b) CONTACT-MAKING-VOLTMETER BEAM ASSEMBLY

Figure 408. Contact-making voltmeter contact assembly.

contact position. This condition may be obtained by adjusting the compensating spring adjusting nut, turning it clockwise to decrease the voltage and counterclockwise to increase the voltage. The holding coils should next be adjusted to give sufficient holding effect to return the regulator to normal voltage position after each operation. Holding effect is increased by moving the holding coil cores closer to the armature located on the end of moving contact beam, and is decreased by moving the cores away from the armature. These adjustments are made by the knurled nut on each holding coil assembly and are self-locking.

b. Alignment of Contacts. The spacing of contacts is shown in figure 408. The spacing (B) of contacts should always be less than (A). The amount of spacing depends on the voltage band width and is determined by the requirement that the contact centers coincide after the contact has been made and sufficient holding pressure developed. Stationary contacts can be adjusted to obtain this condition by moving these contacts by means of the extensions provided on the contact holder. It should be possible to make these adjustments without loosening the screws holding the stationary contacts in place.

SECTION II

POWER SUPPLIES

WARNING: *Voltages sufficient to cause death on contact are exposed at many points in the power supplies used in Radio Set AN/MPN-1. Do not place hands or arms in these units with the high voltages on. Do not make any connections into these units which bring high voltages out to an exposed point. Make all tests with high voltages off. Always ground high-voltage capacitors before touching them or their associated circuits.*

240. REFERENCE DATA.

a. Rectifier Power Unit PP-22/MPN-1.

(1) Figure 409. Top view.
(2) Figure 410. Bottom view.
(3) Figure 204. Schematic diagram.
(4) Figure 432. Voltage and resistance chart.

b. Rectifier Power Unit PP-23/MPN-1.

(1) Figure 418. Top view.
(2) Figure 419. Bottom view.
(3) Figure 210. Schematic diagram.
(4) Figure 433. Voltage and resistance chart.

c. Rectifier Power Unit PP-24/MPN-1.

(1) Figure 411. Top view.
(2) Figure 412. Bottom view.
(3) Figure 211. Schematic diagram.
(4) Figure 434. Voltage and resistance chart.

d. Rectifier Power Unit PP-25/MPN-1.

(1) Figure 413. Top view.
(2) Figure 414. Bottom view.
(3) Figure 415. Resistor mounting board.
(4) Figure 212. Schematic diagram.
(5) Figure 435. Voltage and resistance chart.

e. Rectifier Power Unit PP-26/MPN-1.

(1) Figure 422. Front view.
(2) Figure 423. Top view.
(3) Figure 424. Right rear oblique view.
(4) Figure 425. Left rear oblique view.
(5) Figure 217. Schematic diagram.

f. Rectifier Power Unit PP-27/MPN-1.

(1) Figure 416. Top View.
(2) Figure 417. Bottom view.
(3) Figure 218. Schematic diagram.
(4) Figure 436. Voltage and resistance chart.

g. Rectifier Power Unit PP-28/MPN-1.

(1) Figure 428. Top view.
(2) Figure 429. Bottom view.
(3) Figure 220. Schematic diagram.

h. Rectifier Power Unit PP-100/MPN-1.

(1) Figure 430. Top view.
(2) Figure 431. Bottom view.
(3) Figure 221. Schematic diagram.

i. Relay Assembly RE-3/MPN-1.

(1) Figure 421. Top view, and control panel.
(2) Figure 207. Schematic diagram.

j. Control Box C-61/MPN-1.

(1) Figure 426. Front oblique view.
(2) Figure 427. Rear oblique view.
(3) Figure 214. Schematic diagram.

k. Relays.

(1) Figure 222. HVPS time delay relay circuit.
(2) Figure 223. HVPS time delay relay, time setting mechanism.
(3) Figure 224. HVPS time delay relay, brake mechanism.
(4) Figure 225. Overcurrent relay, left side.
(5) Figure 226. Overcurrent relay, right side.

l. General.

(1) Figure 420. X-scanning motors relay assembly.
(2) Figure 198. Power distribution control circuit.
(3) Figure 254. Resistor color code.
(4) Figure 253. Capacitor color code.

241. PROCEDURE.

a. Regulated Power Supplies. (1) Most of the power supply units used with Radio Set AN/MPN-1 are voltage regulated to compensate for the variations in the load imposed by the radar circuits. The regulating circuits of Rectifier Power Units PP-22, PP-24, PP-25, and PP-27 are sufficiently alike to permit the use of the same trouble-shooting chart with all four units. A control tube whose grid bias is obtained from a tap on the output bleeder network provides control voltage to a bank of series regulator tubes which acts as a variable resistor. Where variable output voltages are required, variation is provided by means of a potentiometer forming part of the bleeder network and having its variable contact connected to the grid of the control tube. The settings of these controls will generally be determined by the requirements of the circuits served by the power units. For example, the control on PP-27 will be set to provide an output of approximately 270 volts; its exact setting will be that which is necessary to provide proper operation of the range marker circuit in the search centrals. In several cases, a second potentiometer control provides voltage feedback to the anodes of the series regulators. This potentiometer should be adjusted for minimum ripple.

(2) The trouble-shooting chart in paragraph 242 is to be used with Rectifier Power Units PP-22, PP-24, PP-25, and PP-27. Of these units, the first three supply power to the timing circuits of the precision system, and the fourth serves similarly in the search system. Trouble in the units will generally be indicated by the improper operation of one or more of the circuits supplied. Duplication of equipment, in each case, permits service to be carried out with little or no loss of operating efficiency. If the output controls on the units require adjusting, these may be located by referring to the illustrations listed in paragraph 240.

b. Rectifier Power Unit PP-23/MPN-1. With a few variations which are discussed in paragraph 243, the procedure given in the trouble-shooting chart, paragraph 242, may be aplied to Rectifier Power Unit PP-23. Two of these units provide 4 kv to the anodes of the search and precision indicator tubes. Under normal conditions, one of the 4-kv power units supplies anode high voltage to the search indicators while the other serves similarly in the precision system. However, since it is possible to operate the entire system from one power unit, service may be performed without interrupting operation. Some adjustment of the 4-kv output may be required to achieve proper expansion of the search indicator traces. The details of this adjustment, which is made by means of potentiometers P1 and P2, are given in paragraph 190 of chapter 7. The control circuits for the 4-kv power supplies are contained in Relay Assembly RE-3, which switches both the line supply and the 4-kv output.

c. Rectifier Power Unit PP-26/MPN-1. Rectifier Power Unit PP-26 supplies the high voltage for the modulator; consequently most of the faults appearing in this power supply will be indicated by some misbehavior on the part of the transmitting system. For purposes of trouble shooting, Control Box C-61 will be considered part of the high-voltage power supply system. Control Box C-61 contains the two variacs which control the line voltage supplied to the primaries of the channel A and channel B high-voltage transformers. The transmitting system metering circuit, also contained in the control box, is discussed with the transmitting system.

d. Communications Equipment Power Supplies. Besides the radar power supplies, discussed above, the set includes three Rectifier Power Units PP-28 and one Rectifier Power Unit PP-100. Rectifier Power Unit PP-28 consists of a vacuum tube rectifier circuit which supplies 550 volts to the HF transmitters, and a selenium rectifier circuit which supplies 26 volts to the HF receivers. Rectifier Power Unit PP-100 is a small selenium rectifier unit which supplies 26 volts for the operation of the tower receiver.

242. TROUBLE-SHOOTING CHART FOR REGULATED POWER SUPPLIES.

A. SYMPTOM:

1. No output.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Line voltage supply and primary circuit.	1. Inspect the fuses in the primary circuit of the high-voltage transformers. An open fuse is indicated by the glowing of a neon lamp on the panel. Remember that PP-22 and PP-24 have a common fuse and a common interlock circuit which are located in PP-24.
2. Rectifier filament.	2. Inspect rectifier tubes for burned-out filaments.
3. Open circuits in components or wiring.	3. Remove the power unit from the rack and check transformer secondaries and filter chokes for continuity. Continue checking the continuity of all wiring as far as the output terminals.

B. SYMPTOMS:

1. Smoke.
2. Overheating.
3. Erratic output.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Excessive load caused by shorted external circuit.	1*a*. Remove line voltage. *b*. Measure the resistance from one output terminal to the other. If this measurement shows low or zero resistance, disconnect the output terminal board, and check the resistance both at fixed and movable terminals to determine whether the short is in the power supply or in the external circuit. *c*. If the test made above indicates that the short is in the power unit, remove the unit and check for shorts in the bleeder network, filter capacitors, and wiring.

C. SYMPTOM:

1. Low output.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. One rectifier of bridge circuit burned out.	1. If the power supply uses a bridge circuit as in the case of PP-22 and PP-24, inspect the rectifier tubes to determine if one or more rectifiers have open filaments.
2. Regulator circuit improperly adjusted.	2. Check the adjustment of the voltage control potentiometer in the grid circuit of the control tube to make sure that it has not been improperly set.
3. Low resistance in bleeder network.	3. Remove the terminal strip and check the values of resistance between the output terminals. Compare these values with those shown on the circuit diagram to determine if reduced output is due to a shorted or low resistance bleeder network.

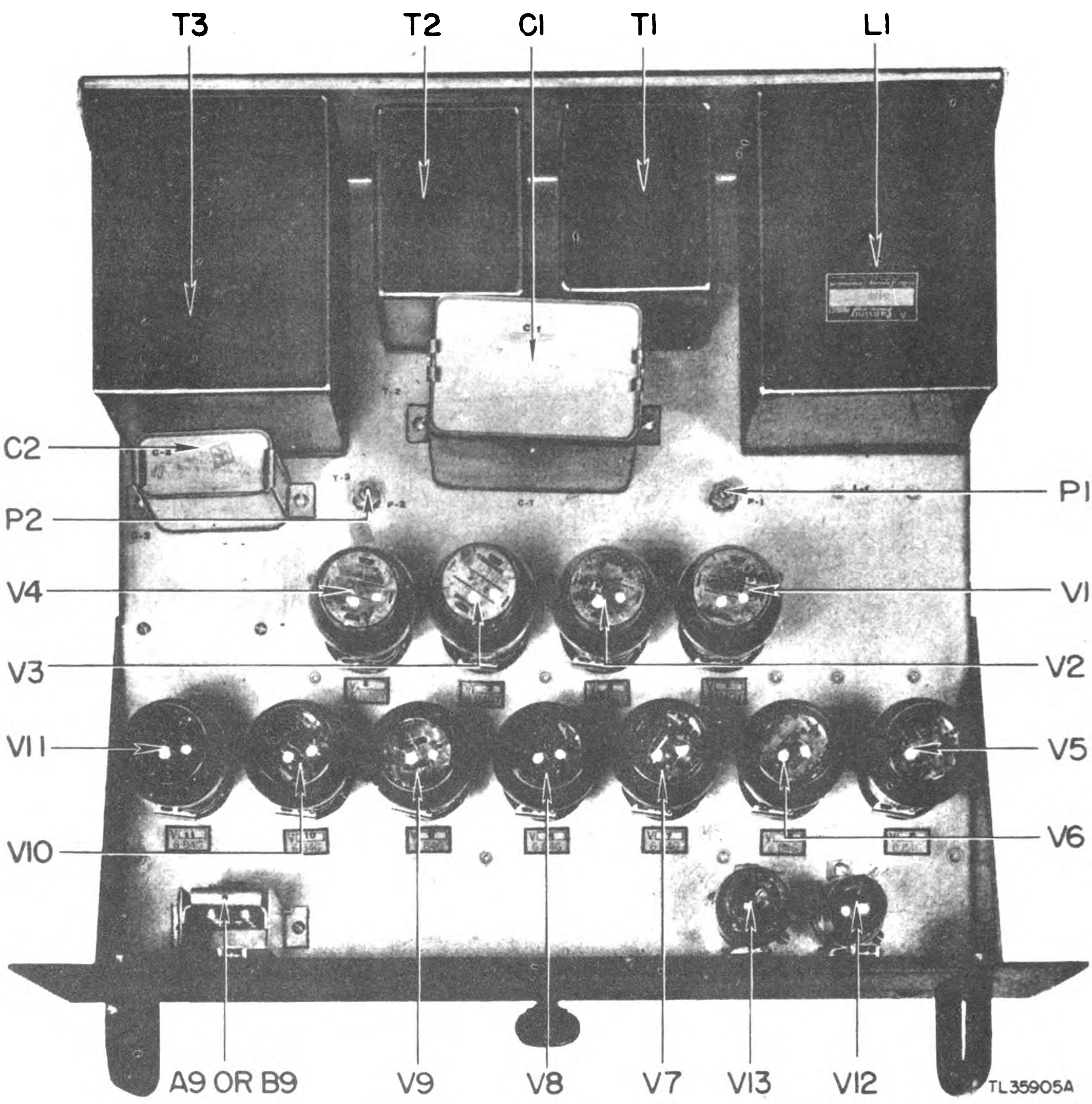
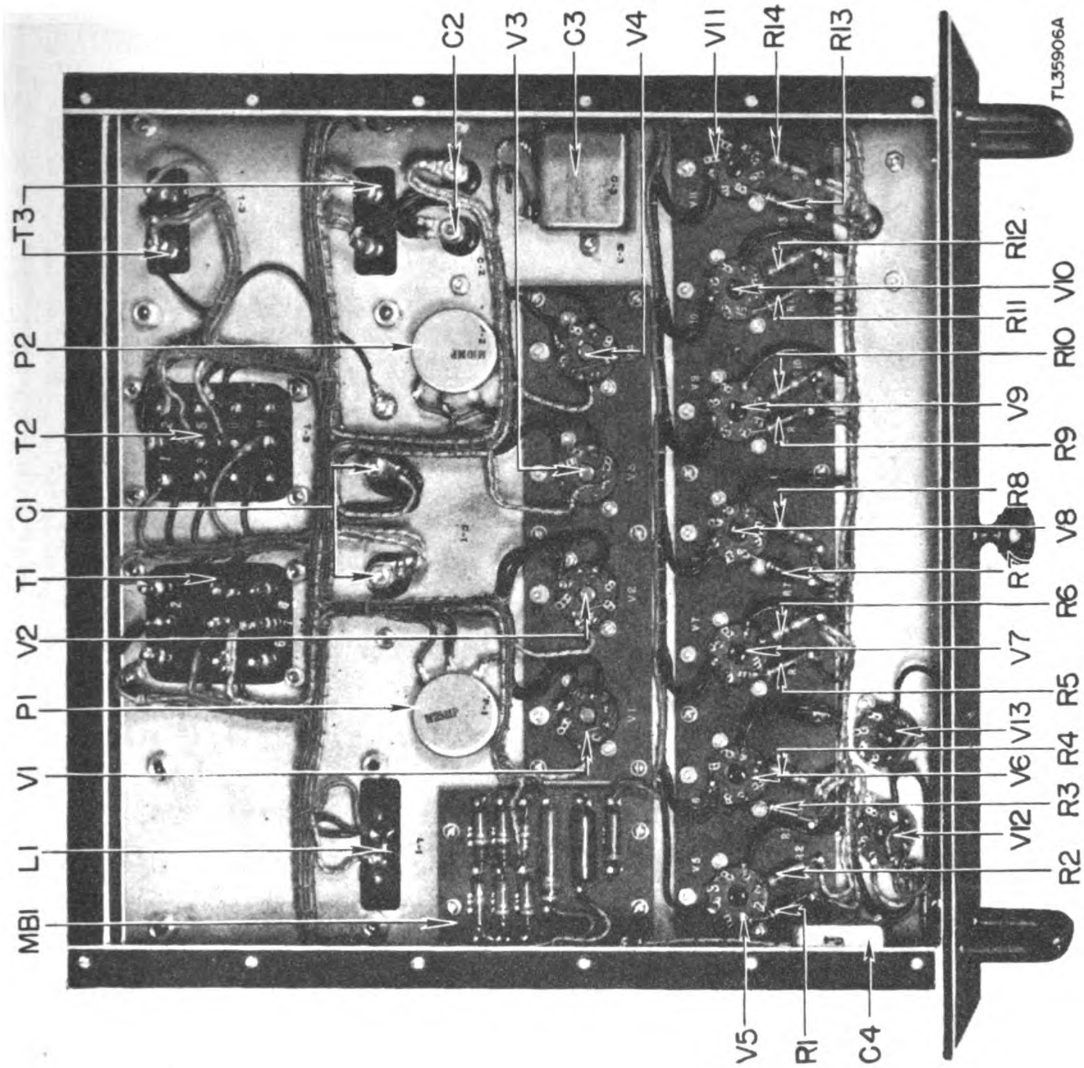


Figure 409. Rectifier Power Unit PP-22/MPN-1, top view.

4. Leaky filter capacitors.

4. Remove the power unit, disconnect the filter capacitors, and determine their resistance, bearing in mind that while the resistance of a filter capacitor may be high enough at the low voltage supplied by the ohmmeter it may not be high enough at the voltages encountered in the power unit. If any doubt exists, replace the filter capacitors.



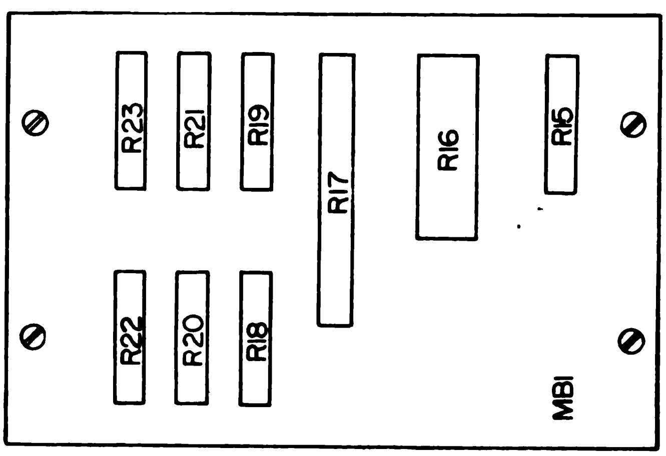


Figure 410. Rectifier Power Unit PP-22/MPN-1, bottom view.

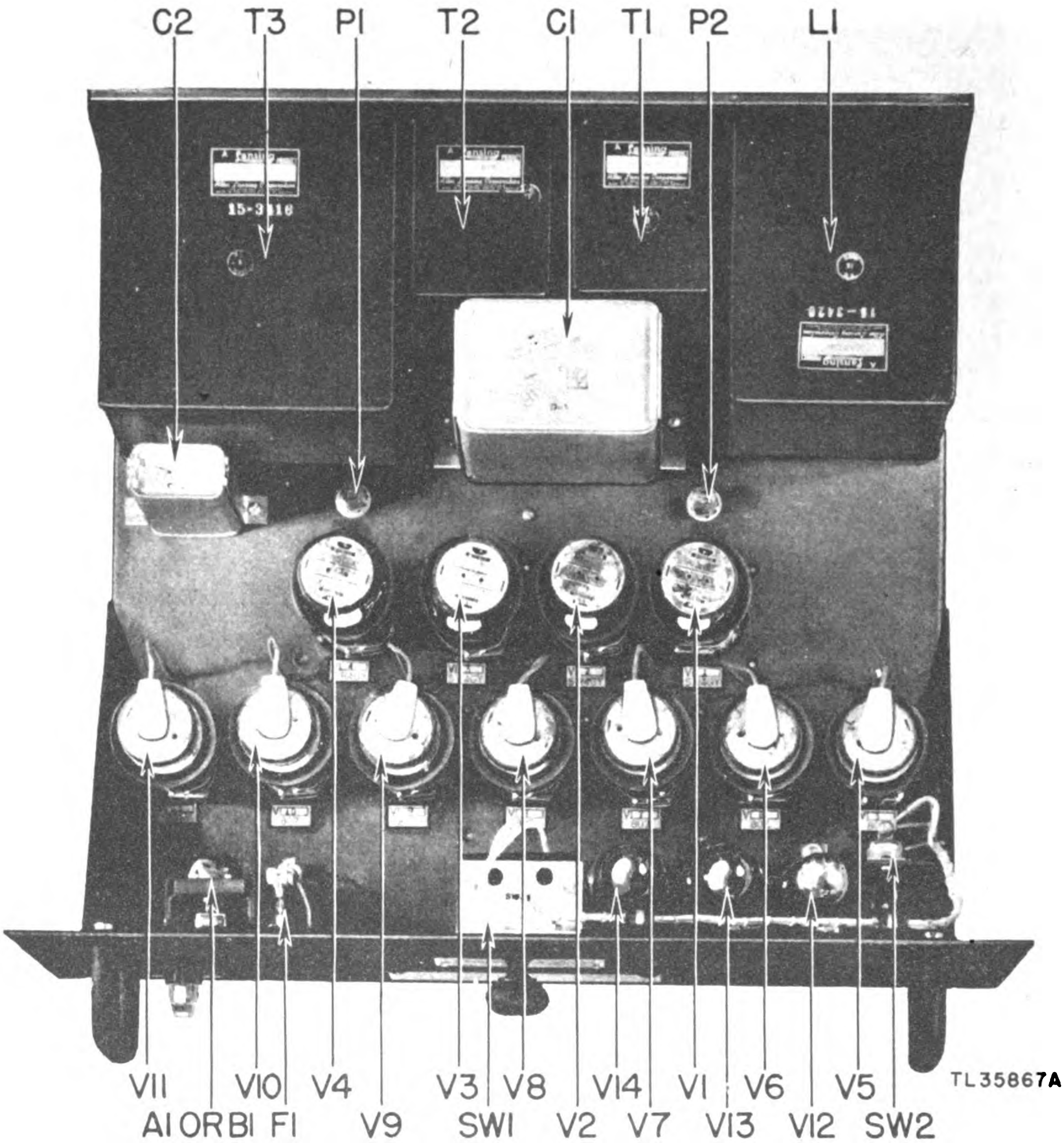


Figure 411. Rectifier Power Unit PP-24/MPN-1, top view.

D. SYMPTOMS:

1. Poor regulation.
2. Jitter or excessive ripple.

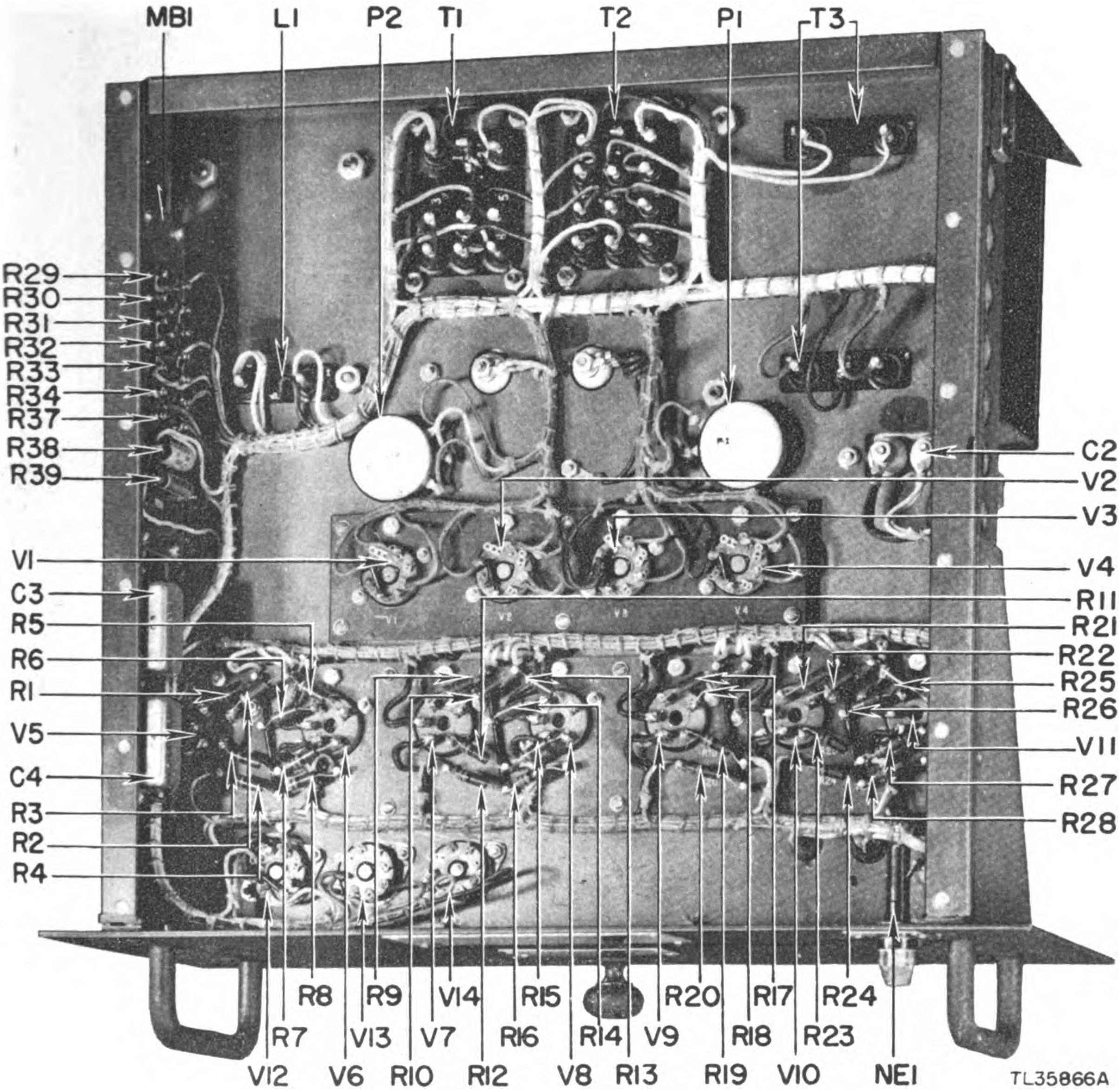


Figure 412. Rectifier Power Unit PP-24/MPN-1, bottom view.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Defective VR150 regulator tube.	1. Replace the VR150 tubes in the circuit one at a time, observing after each replacement if any improvement has been effected.
2. Poor adjustment of regulator circuit.	2. Check the settings of voltage controls to ascertain if any improvement can be effected by readjustment.

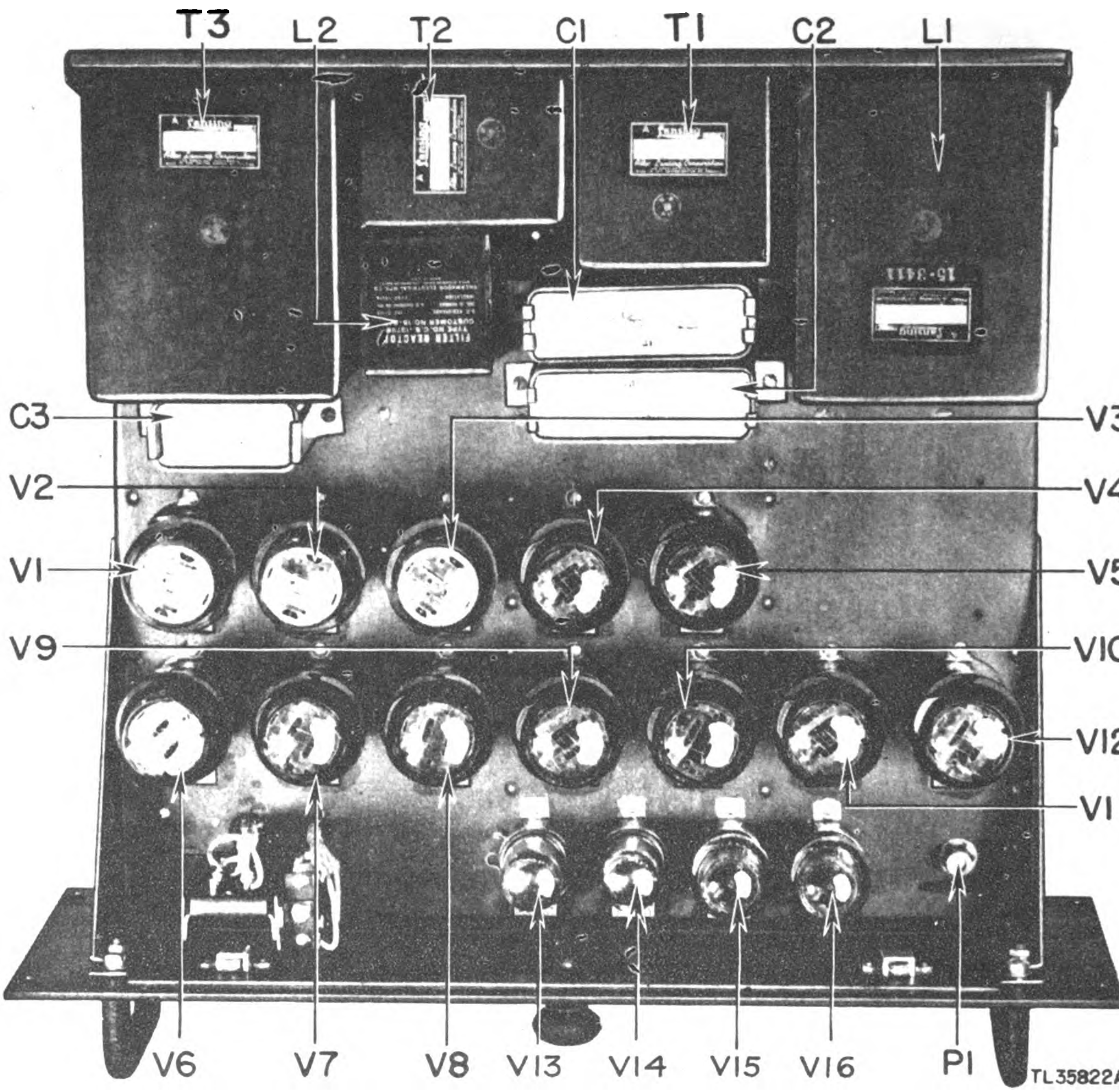


Figure 413. Rectifier Power Unit PP-25/MPN-1, top view.

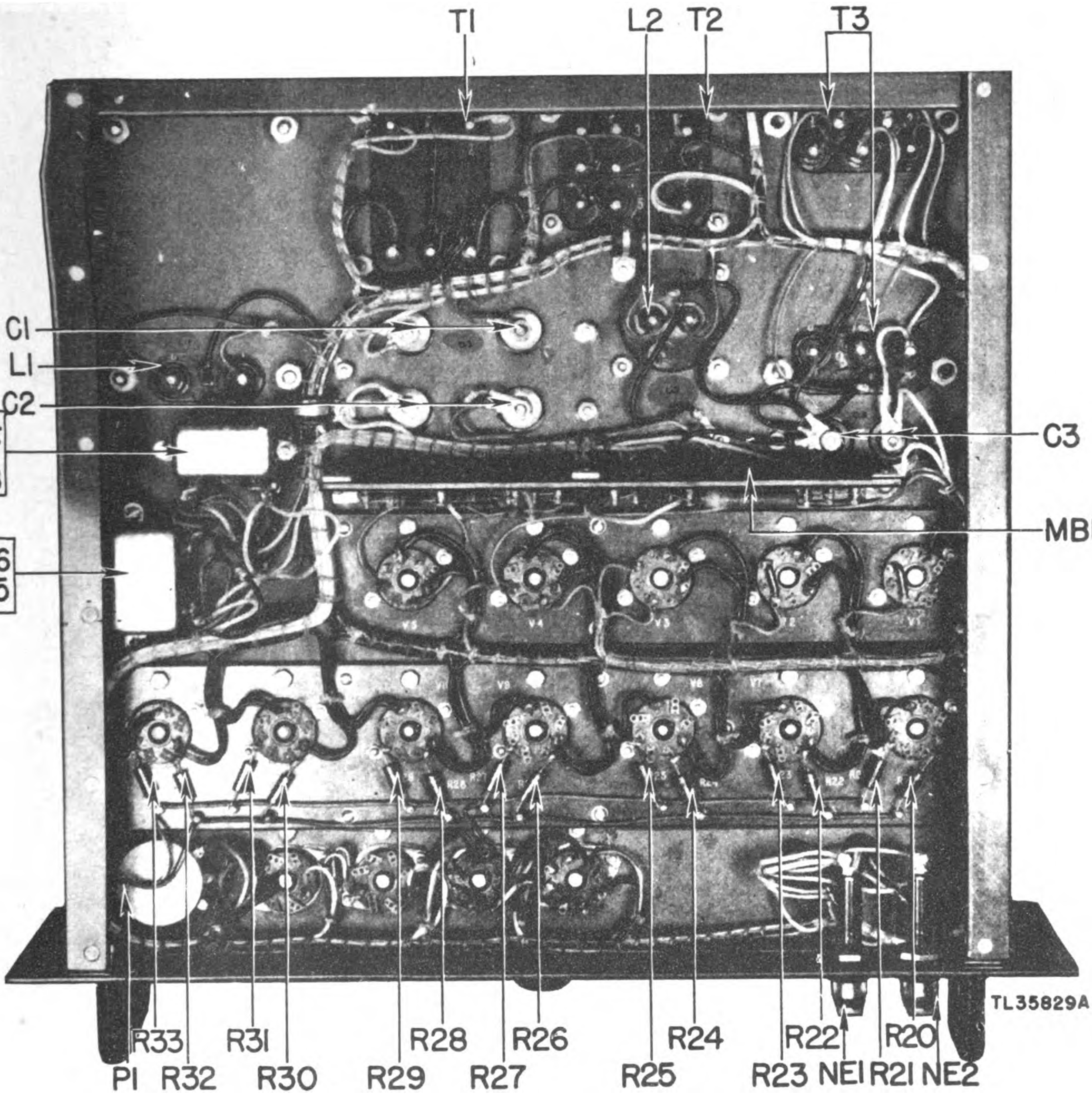


Figure 414. Rectifier Power Unit PP-25/MPN-1, bottom view.

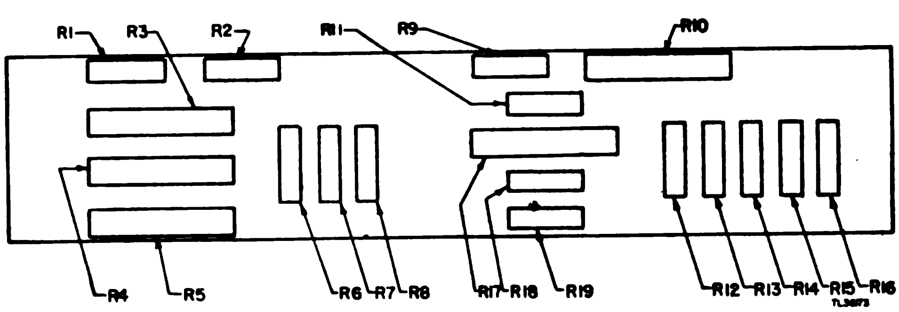


Figure 415. Rectifier Power Unit PP-25/MPN-1, mounting board.

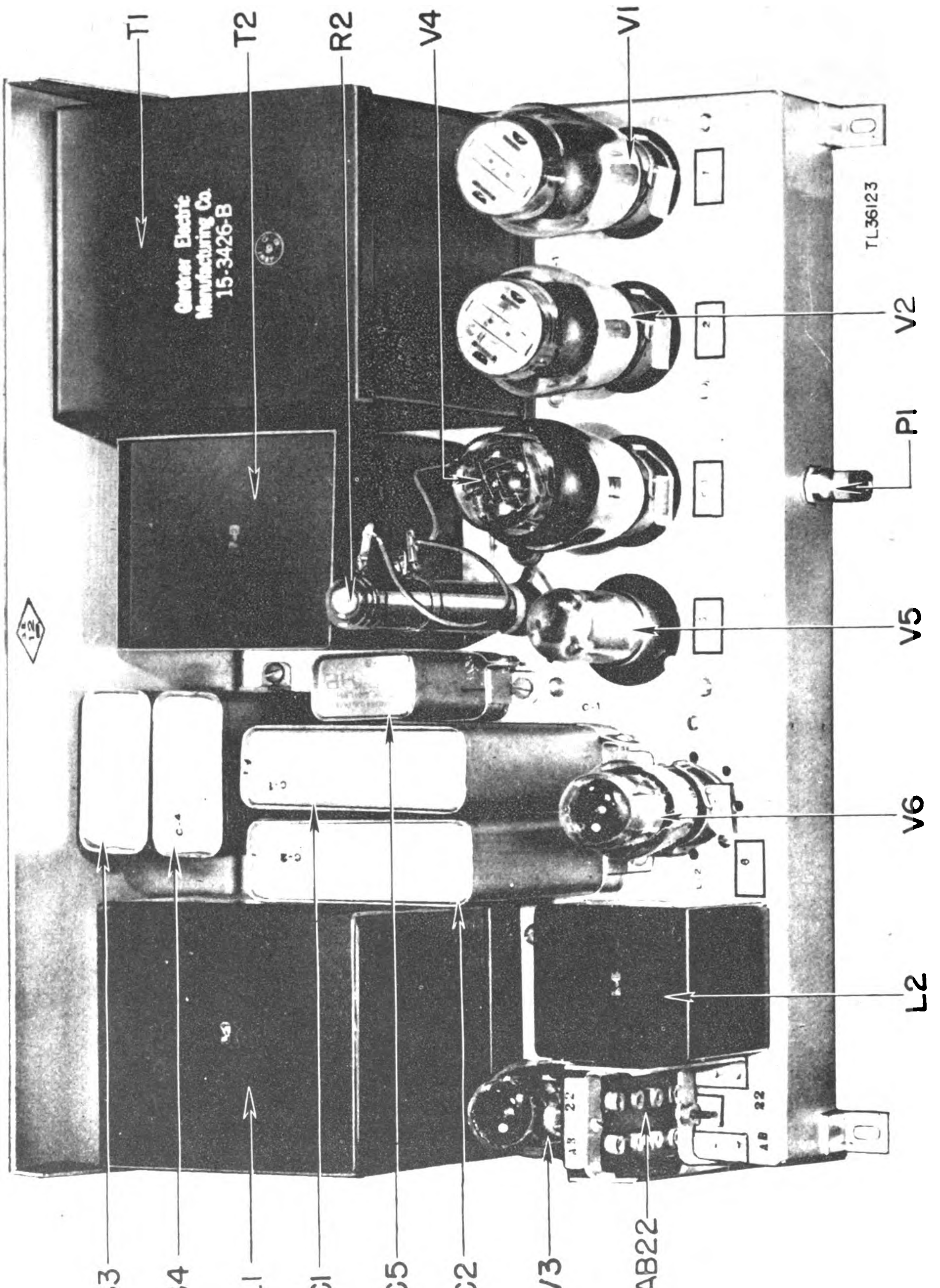


Figure 416. Rectifier Power Unit PP-27/MPN-1, top view.

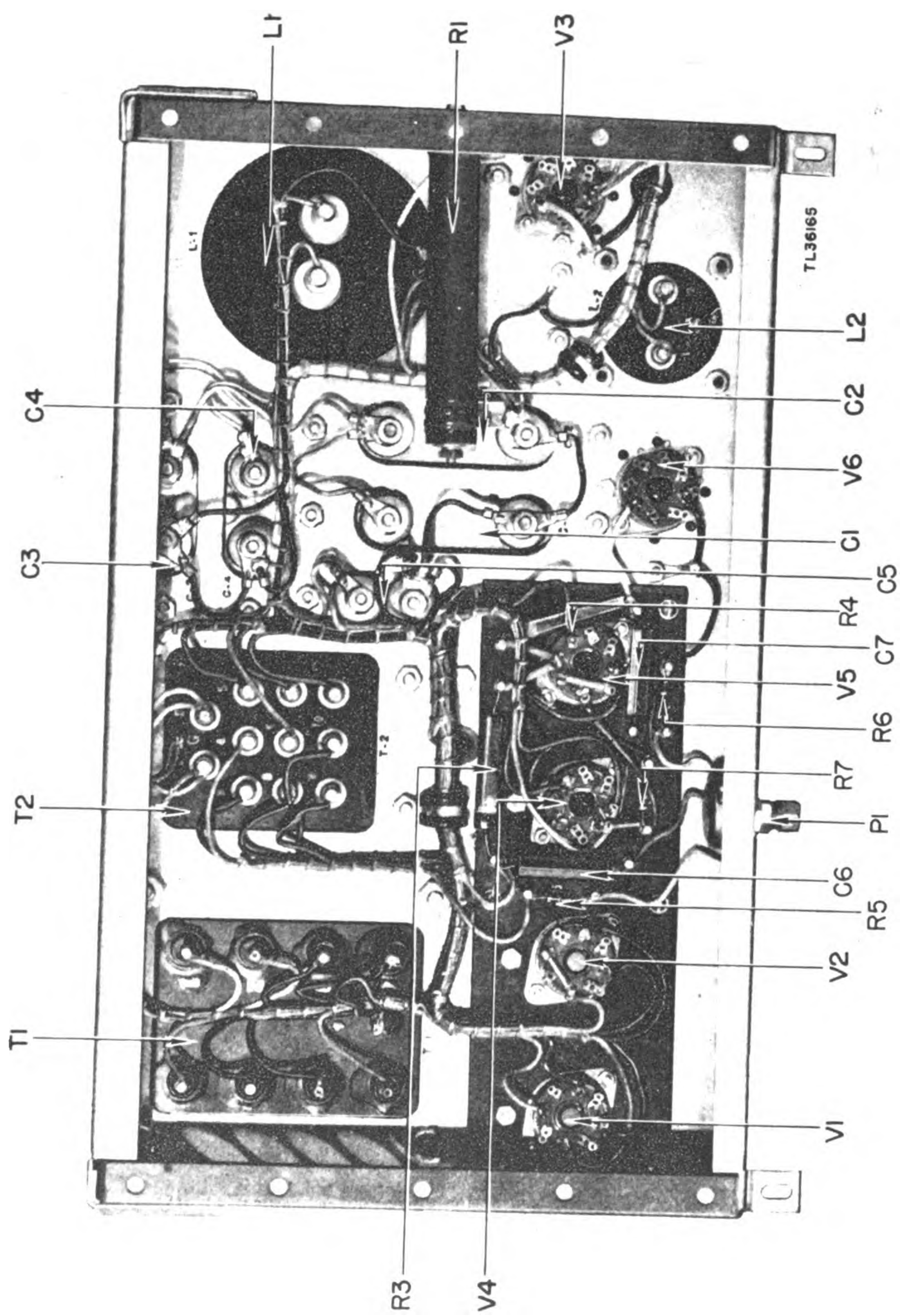


Figure 417. Rectifier Power Unit PP-27/MPN-1, bottom view.

3. Faulty voltage control tubes.	3. Replace the control tubes.
4. Faulty series regulator.	4. Test the series regulator tubes and replace any that appear doubtful.
5. Defective circuit components.	5a. Remove power supply unit from the rack. b. Check all wiring for possible bad connections. c. Replace the filter capacitor.

243. TROUBLE SHOOTING IN 4-KV POWER SUPPLIES.

WARNING: Voltages encountered in this unit are high enough to cause death on contact. Do not attempt to work on the interior of the unit without first turning off the line voltage. Discharge all high-voltage capacitors before touching the terminals. Do not attempt to check the high voltage with a voltmeter.

a. Rectifier Power Unit PP-23/MPN-1. Trouble shooting in Rectifier Power Unit PP-23 may be performed according to the procedure given in the trouble-shooting chart for regulated power supplies, paragraph 242. However, the high voltages encountered in this unit make it impossible to perform service checks with the power on. A large proportion of the troubles experienced with the 4-kv power units will probably occur in the primary circuits. Should either unit fail to operate, it will be well to begin by checking terminals 1 and 2 of the terminal strip to make sure that the line voltage is present. Absence of the line voltage at these terminals indicates trouble in Relay Assembly RE-3, which contains the control circuits of the 4-kv power supplies. The primary circuits of the power units are protected by fuses, shunted by neon bulbs which glow when the fuse is open. Repeated blowing of fuses indicates serious trouble either in the primaries of the transformers or in the rectifier circuits themselves. The lighting of all filaments, except that of the high-voltage rectifier, indicates either that the time delay relay has failed to operate or that an interlock is open. When it is necessary to remove one of the 4-kv power supplies for service, operation may be continued by switching both search and precision systems to the other 4-kv power supply. Thus, trouble shooting in these units need not interrupt operation. The voltage output of the 4-kv power supplies is adjusted by means of potentiometers P1 and P2.

b. Relay Assembly RE-3/MPN-1. Relay Assembly RE-3 contains the control circuit for the 4-kv power supplies. A multiple-pole toggle switch on the panel of the unit controls the application of line power to the 4-kv power supplies, and actuates the relays which switch the high-voltage circuits. The high-voltage relays are of the permanently sealed vacuum type. Trouble in these relays will generally necessitate replacement. The only other source of trouble in the relay unit is the multiple-pole switch.

WARNING: Avoid contact with the six high-voltage terminals on the front of the relay unit. Do not attempt to measure voltages at any of these terminals.

244. TROUBLE SHOOTING IN HIGH-VOLTAGE POWER SUPPLIES.

WARNING: Voltages sufficient to cause death on contact are exposed at many points in Rectifier Power Unit PP-26. Do not attempt to work on these units with the line voltage on. Do not make any connections which bring high voltages out to an exposed point. Always ground high-voltage capacitors before touching them or the associated parts.

a. Rectifier Power Unit PP-26/MPN-1. Faults arising in the high-voltage power supplies will generally give some indication in the transmitting system. Low or unsteady output from the power units will probably be traceable to arcing within the unit, a defective filter capacitor, or a defective rectifier. Low or unsteady X-band modulator voltage might result from a poor connection of the variable tap switch SW3 to the bleeder network. A complete disappearance of output will usually indicate some trouble in the line supply circuits, defective rectifiers, or burned-out transformer windings. In the event that the line voltage fails, interlocks, overload relays, and the variacs in the control box should be checked. Arcing taking place at the porcelain stand-off insulators is usually caused by moisture or dirt and will

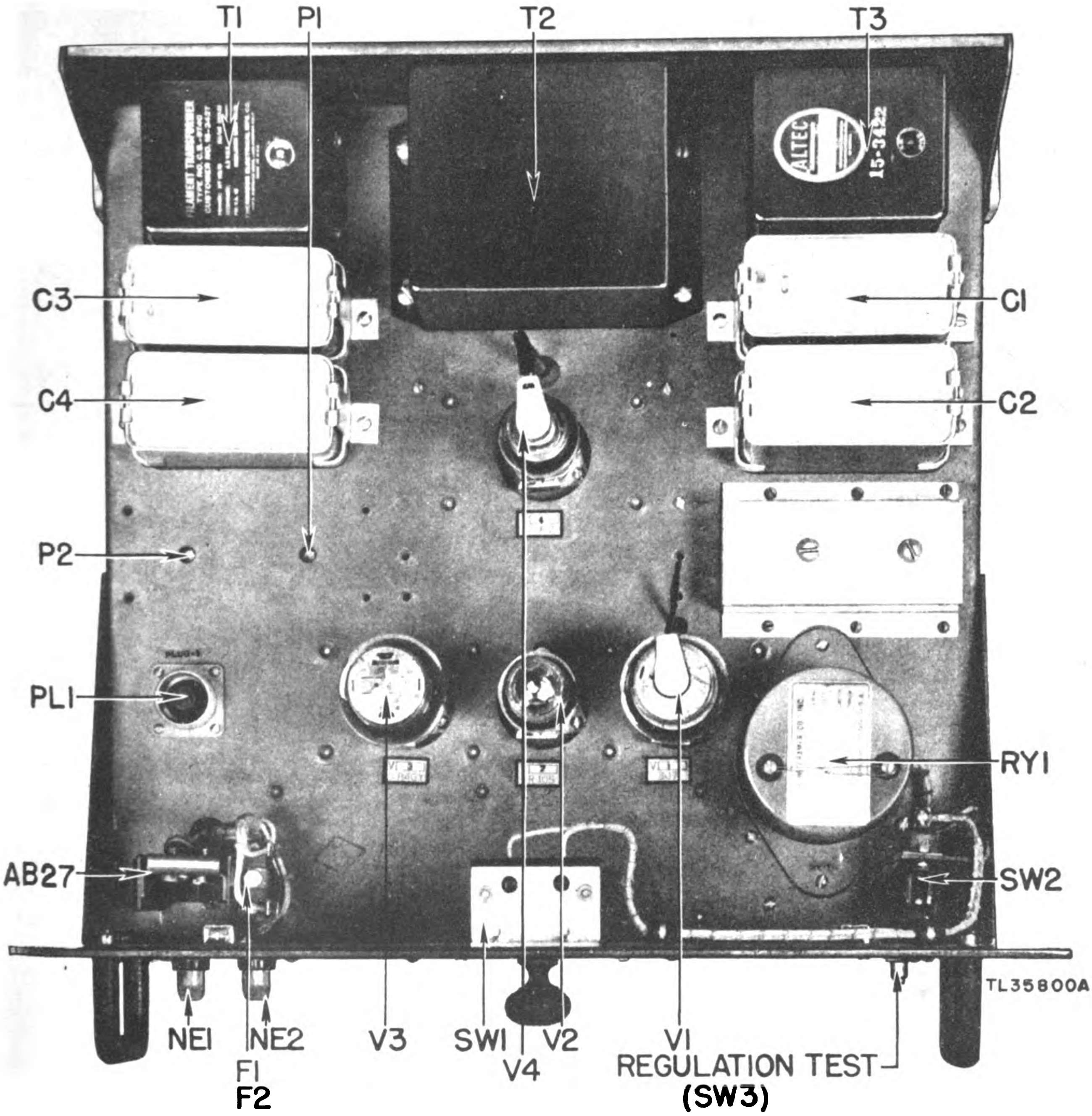


Figure 418. Rectifier Power Unit PP-23/MPN-1, top view.

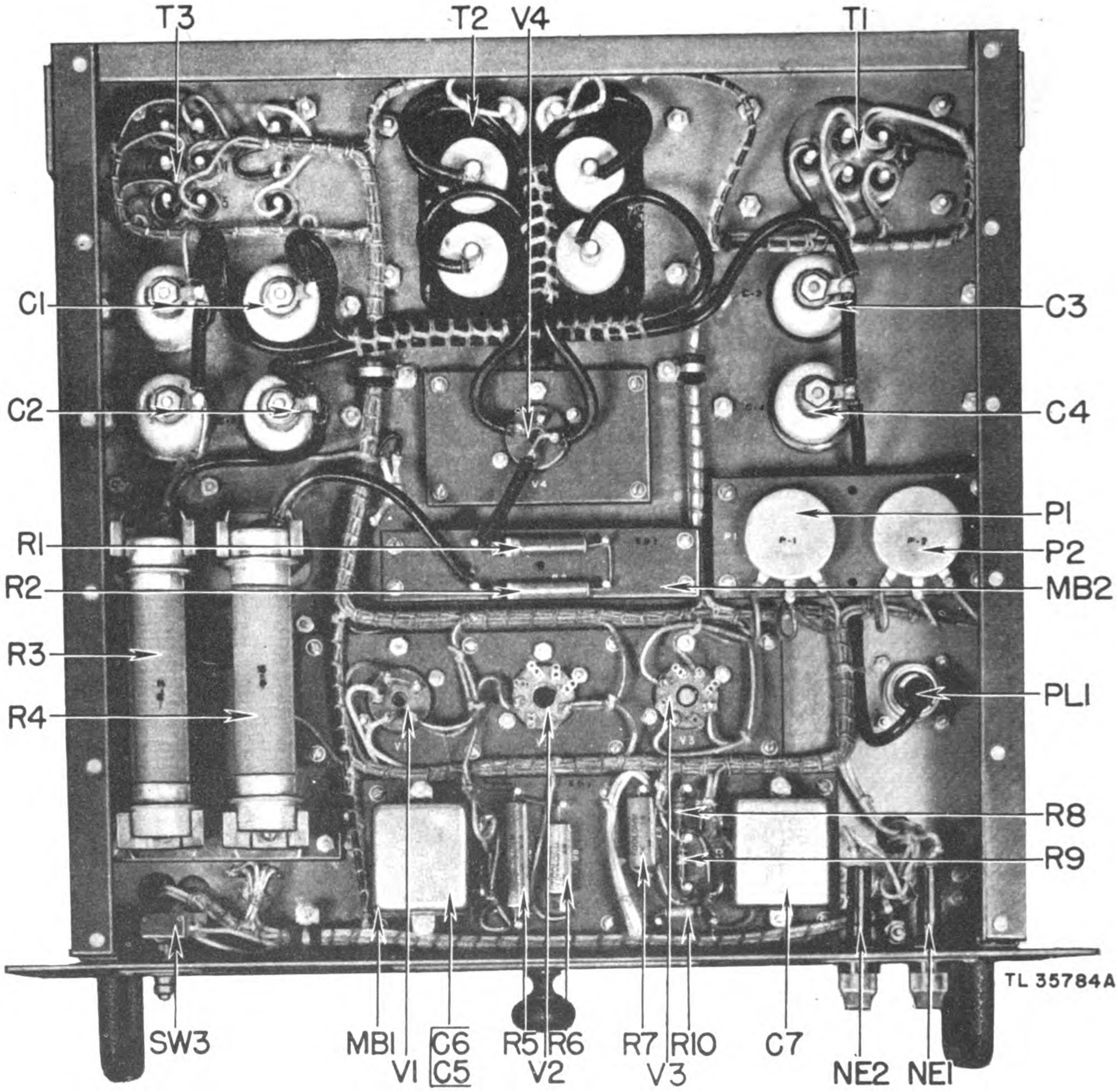


Figure 419. Rectifier Power Unit PP-23/MPN-1, bottom view.

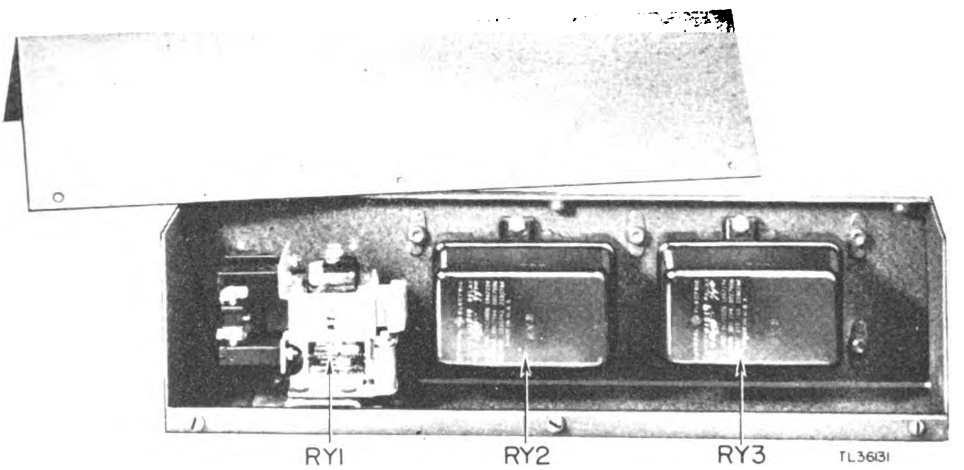


Figure 420. X-scanning motors relay assembly.

generally disappear when the insulators are given a thorough cleaning. If the arcing takes place between leads within the unit, it may be due either to poor insulation or to too little spacing between wires. Repeated opening of overload relays may indicate trouble in the power supply itself, but is more likely to be traceable to a defective external circuit which applies an excessive load.

b. Control Box C-61/MPN-1. The control circuit for the high-voltage power supplies which includes the A and B channel variacs, time delay relays, and overcurrent relays is contained in Control Box C-61. In addition, the control box contains the transmitter and mixer metering circuits for both the S and the X systems. Faults arising in the control circuit of the high-voltage power supplies will be of the type resulting from burned-out or defective variacs, and defective or poorly adjusted relays. Instructions for adjusting relays are given in paragraph 246.

245. TROUBLE SHOOTING IN COMMUNICATIONS SYSTEM POWER SUPPLIES.

a. Rectifier Power Unit PP-28/MPN-1. Three Rectifier Power Units PP-28 mounted in bay 15 of the communications rack, supply operating voltages to the HF communications equipment. Each of these units contains a full-wave vacuum tube rectifier circuit which supplies 550 volts dc to one of the HF transmitters, and a selenium bridge rectifier which supplies 26 volts to the associated receiver. The 550-volt circuit is of conventional design and is very similar to the power supply circuit of a broadcast receiver. The disappearance of the 550-volt output can usually be traced to a defective rectifier, open transformer secondary, or open filter choke in this circuit. Reduced output, accompanied by overheating of transformers and chokes, indicates the possibility of defective filter capacitors, shorted or gassy rectifiers, or short circuits in the wiring of the circuit. Normally the 26-volt circuit should give little trouble. However, there are likely to be occasional transformer or rectifier burn-outs caused by excessive external loads. Service in these cases will consist principally in the replacement of the damaged part.

b. Rectifier Power Unit PP-100/MPN-1. Rectifier Power Unit PP-100 is a selenium rectifier circuit similar to the 26-volt circuit of Rectifier Power Unit PP-28, which supplies power for the tower receiver. Provided it is not damaged by external overloads, it should operate indefinitely.

246. ADJUSTMENT OF RELAYS.

a. HVPS Time Delay Relay. When it is necessary to readjust the time delay relays on the high-voltage power supplies, the following procedure should be used:

(1) ADJUSTMENT OF TIME SETTING MECHANISM (fig. 223).

(a) Loosen the timing disk locking screw (1).

(b) Rotate the time indicator friction nut (2) clockwise until the timing disk stop (4) rests against the timing disk clamp (5). At this point, the motor switch lever (3) should be resting on the motor switch (6).

(c) Tighten the timing disk locking screw.

(d) With a wrench, rotate the time indicator friction nut until it registers zero.

(e) Loosen the timing disk locking screw and rotate the time indicator friction nut in a counterclockwise direction until the indicator registers 60.

(f) Tighten the timing disk locking screw.

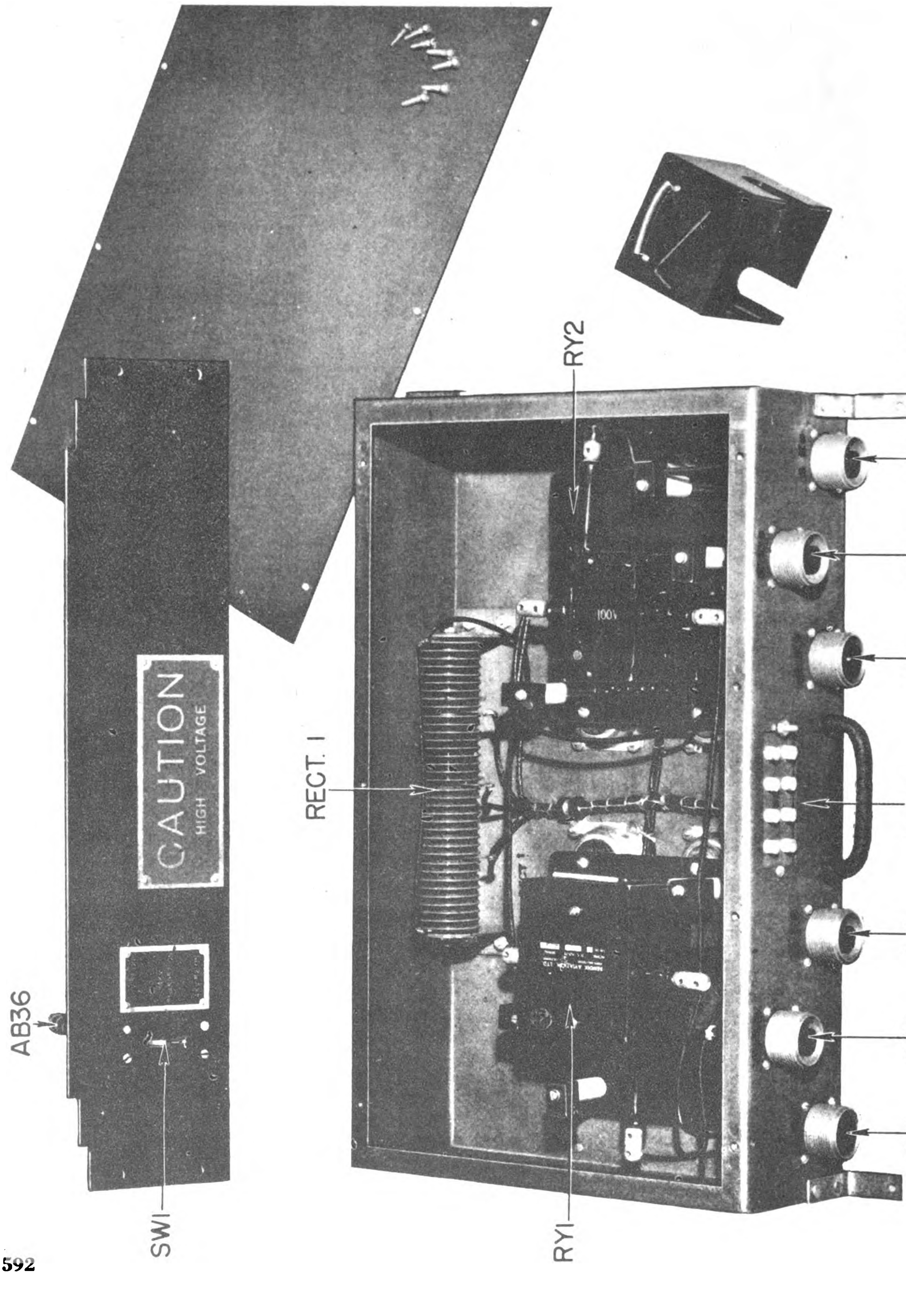


Figure 421. Relay Assembly RE-3/MPN-1, top view and control panel.

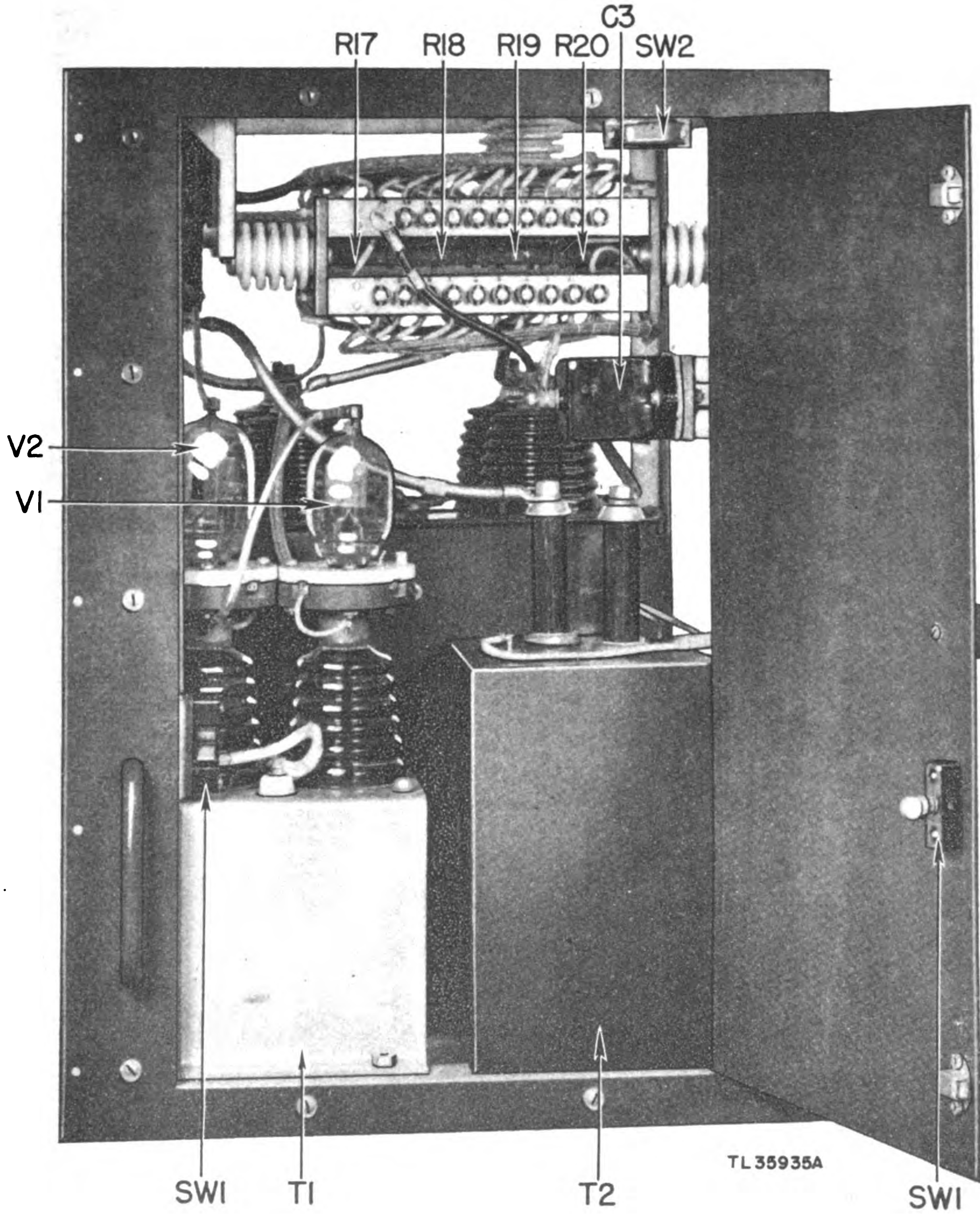


Figure 422. Rectifier Power Unit PP-26/MPN-1, front view.

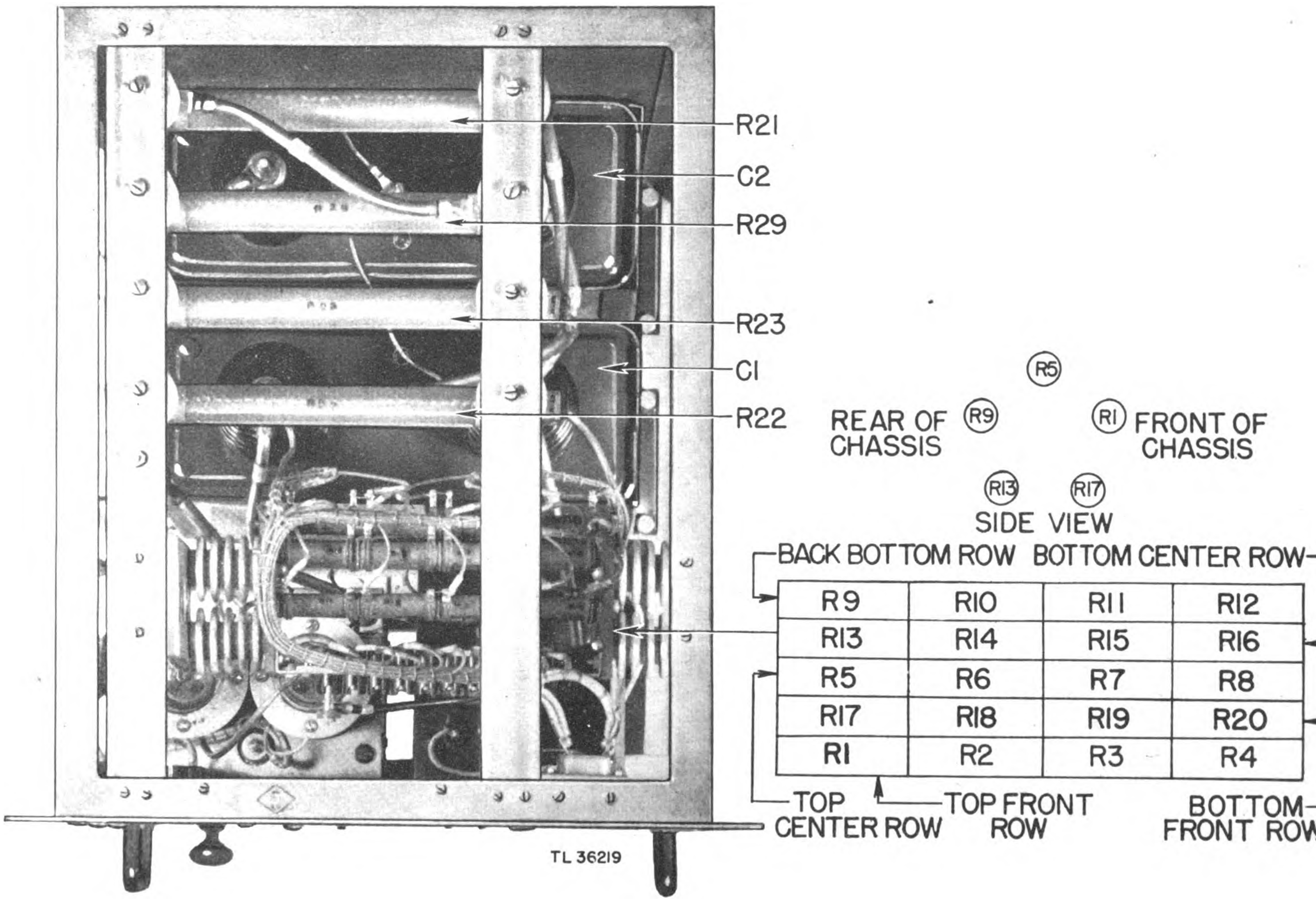


Figure 423. Rectifier Power Unit PP-26/MPN-1, top view.

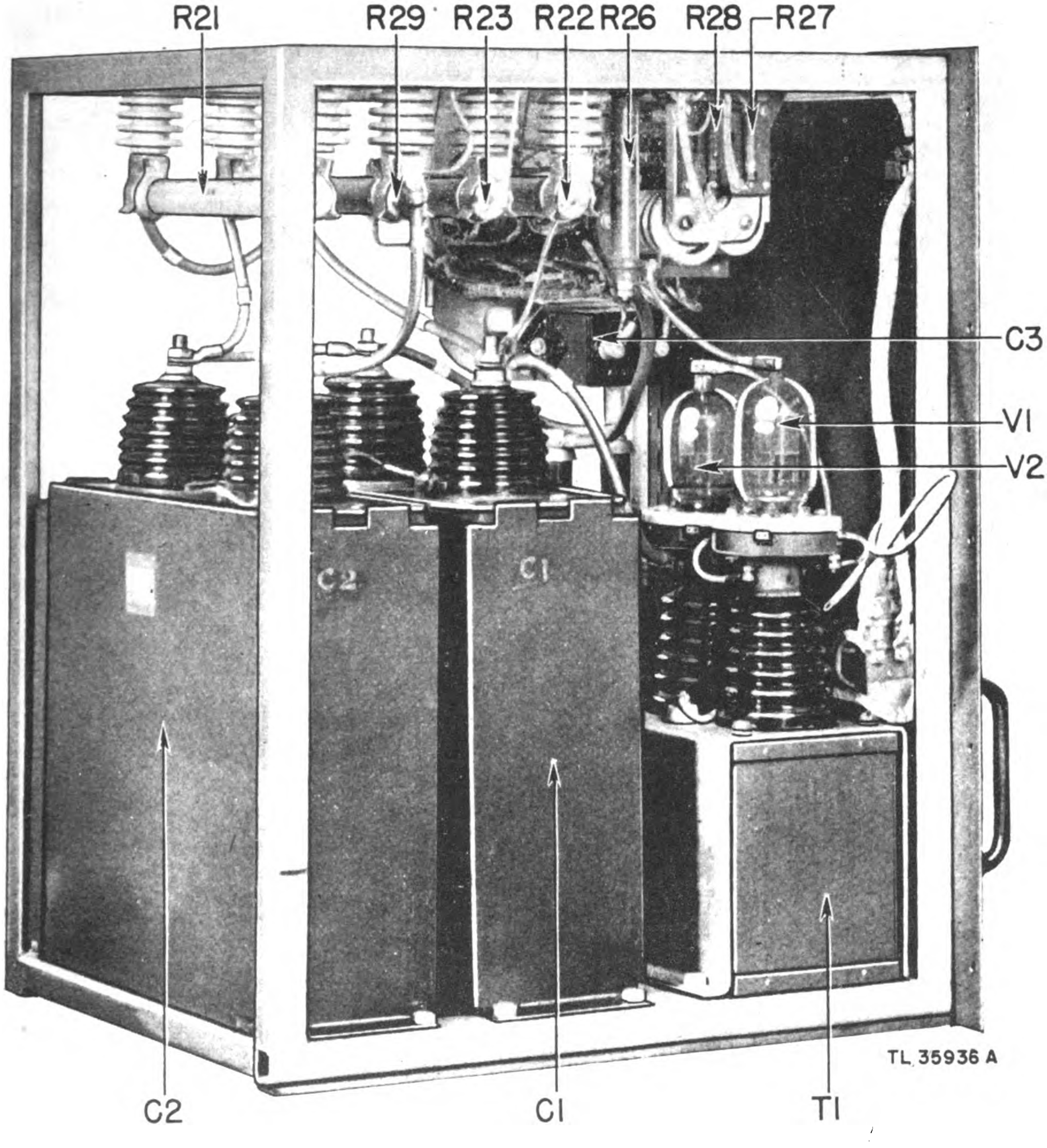


Figure 424. Rectifier Power Unit PP-26/MPN-1, right rear oblique view.

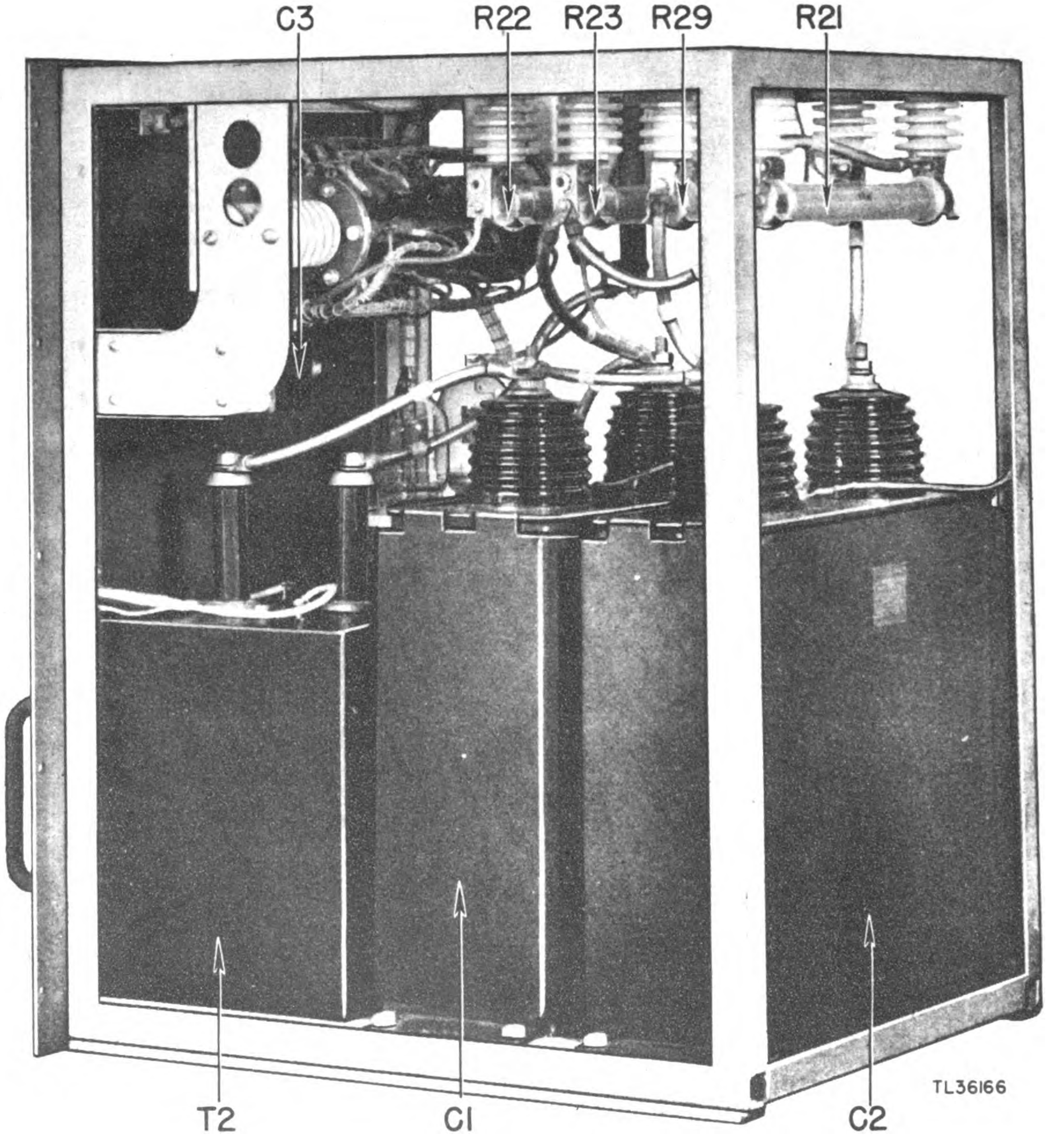


Figure 425. Rectifier Power Unit PP-26/MPN-1, left rear oblique view.

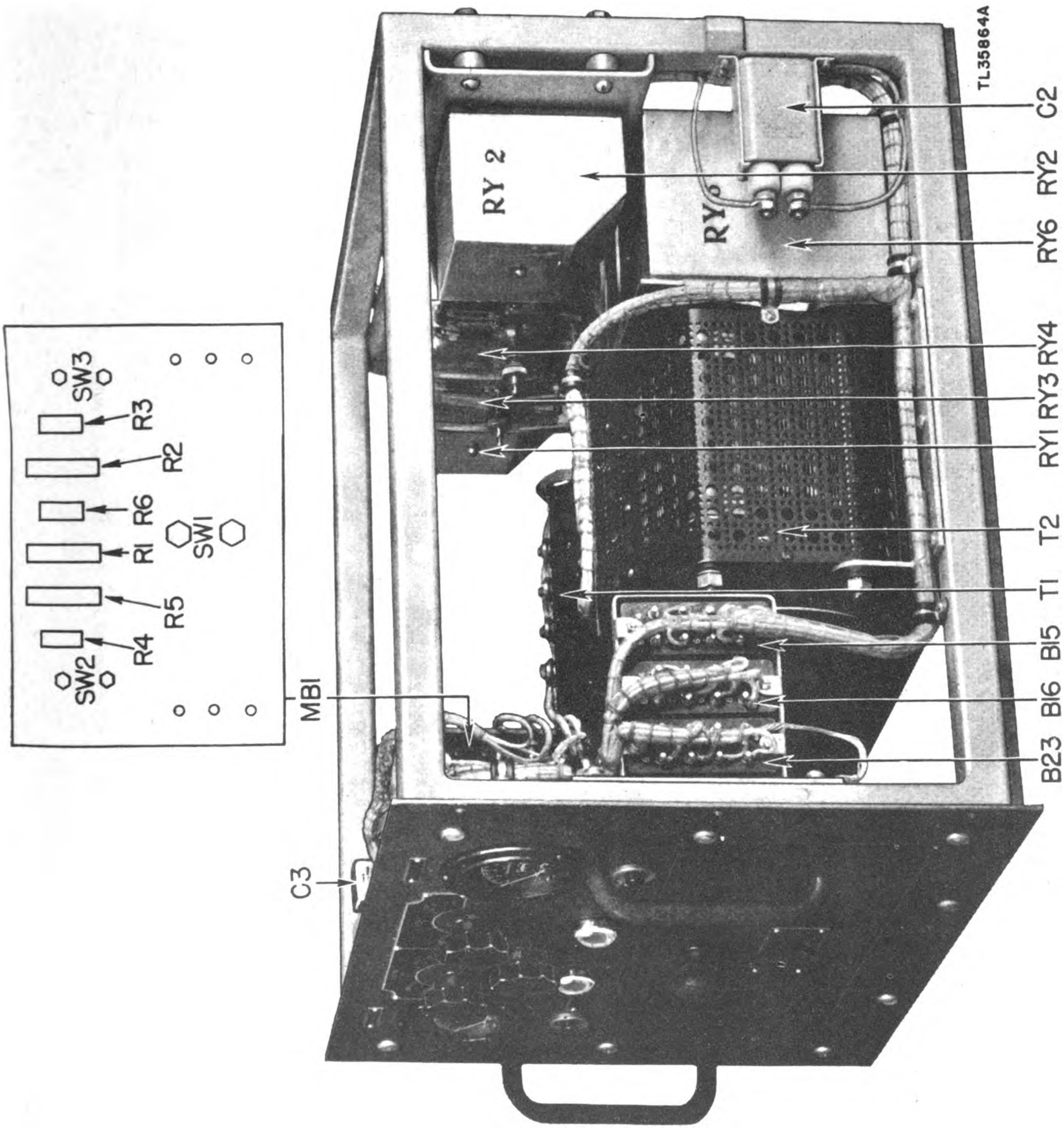


Figure 426. Control Box C-61/MPN-1, front oblique view.

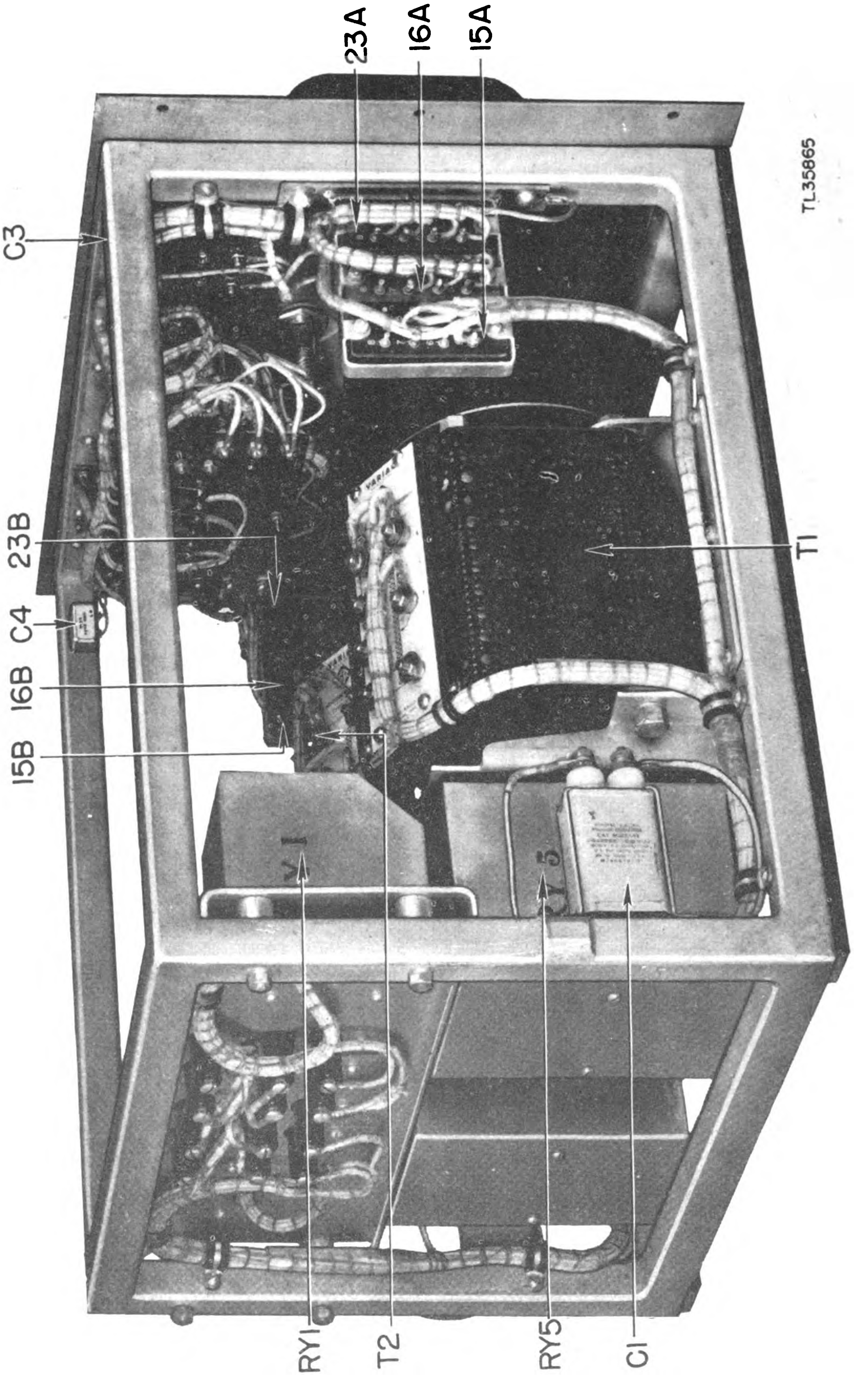


Figure 427. Control Box C-61/MPN-1, rear oblique view.

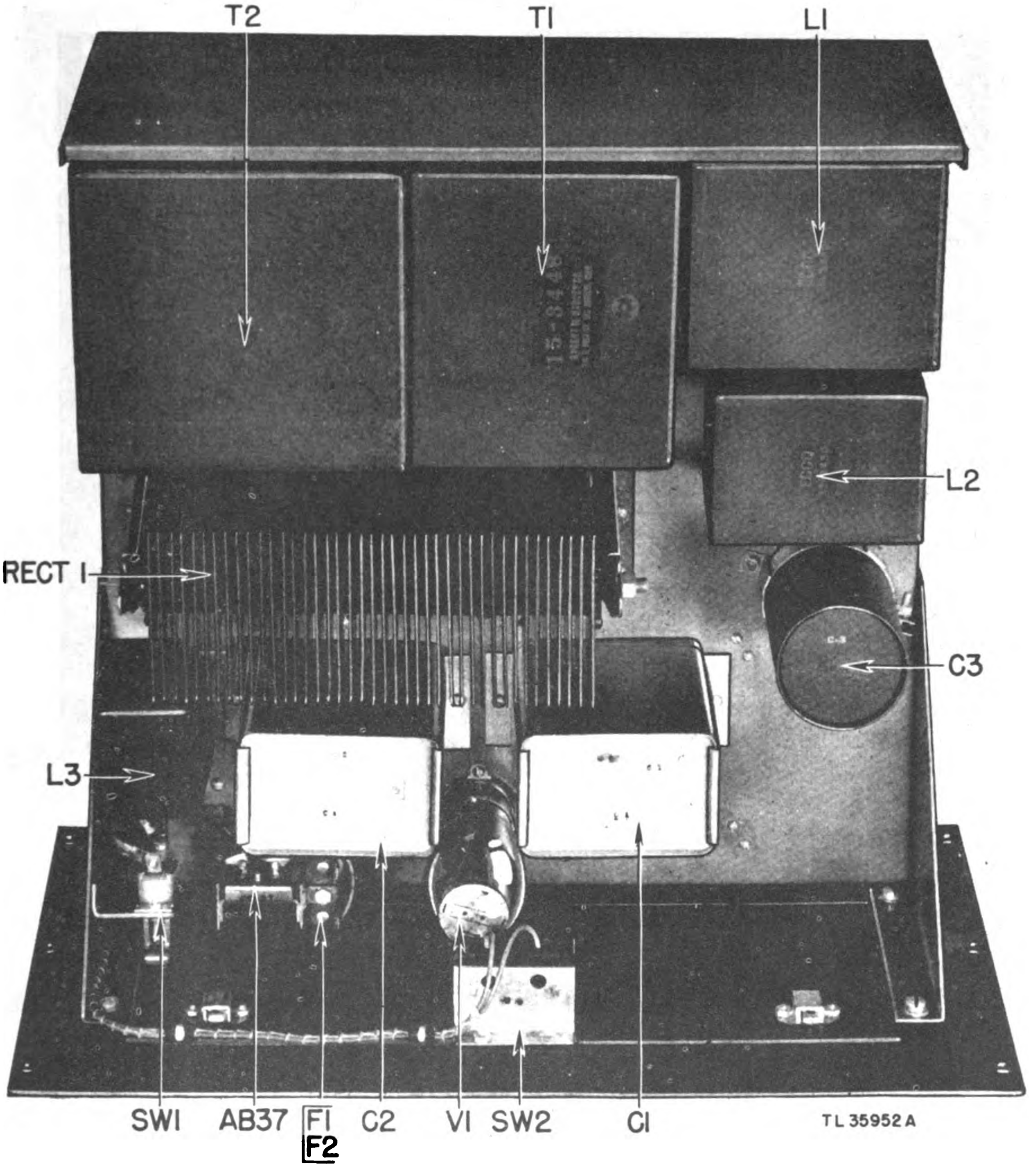


Figure 428. Rectifier Power Unit PP-28/MPN-1, top view.

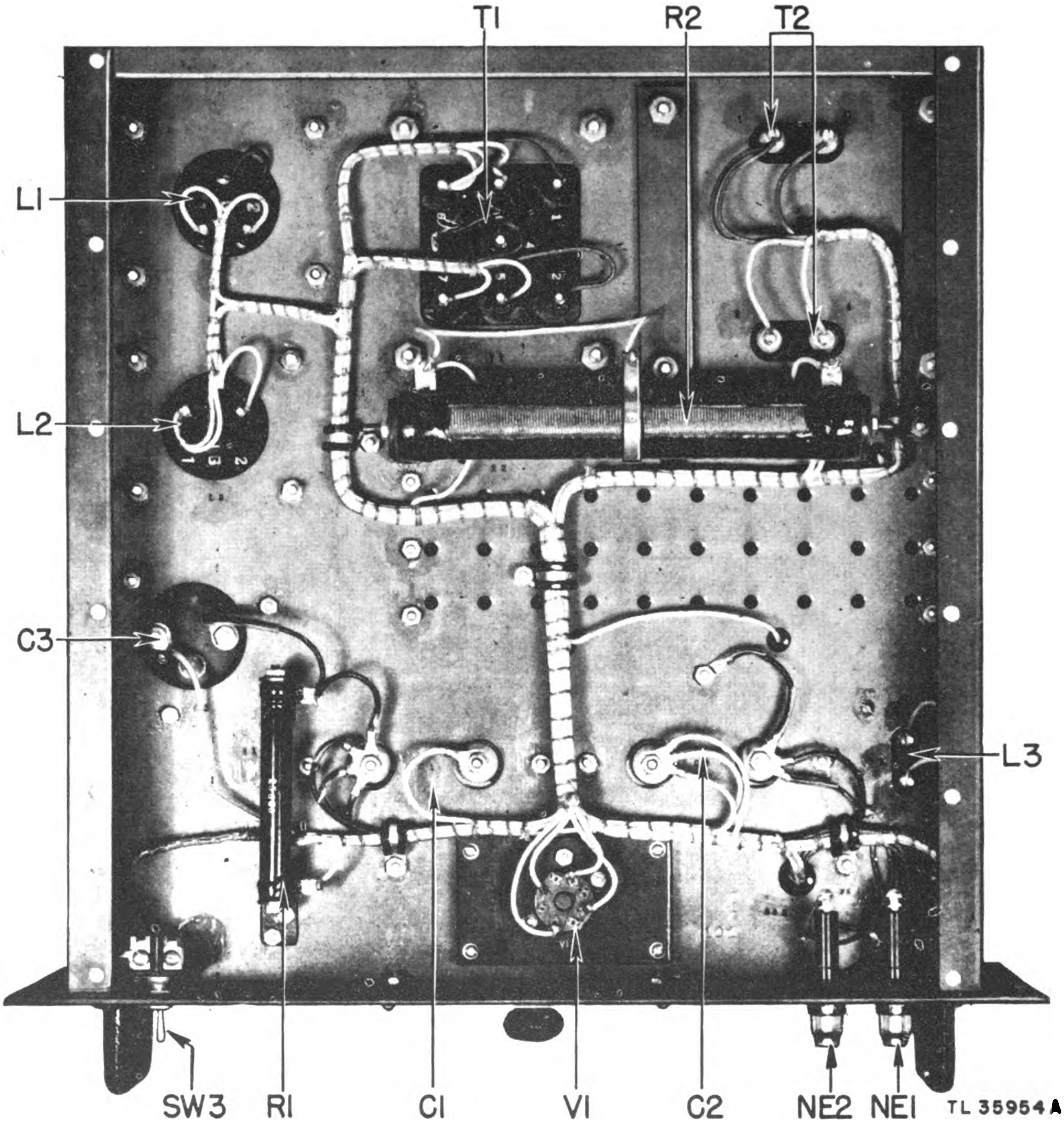


Figure 429. Rectifier Power Unit PP-28/MPN-1, bottom view.

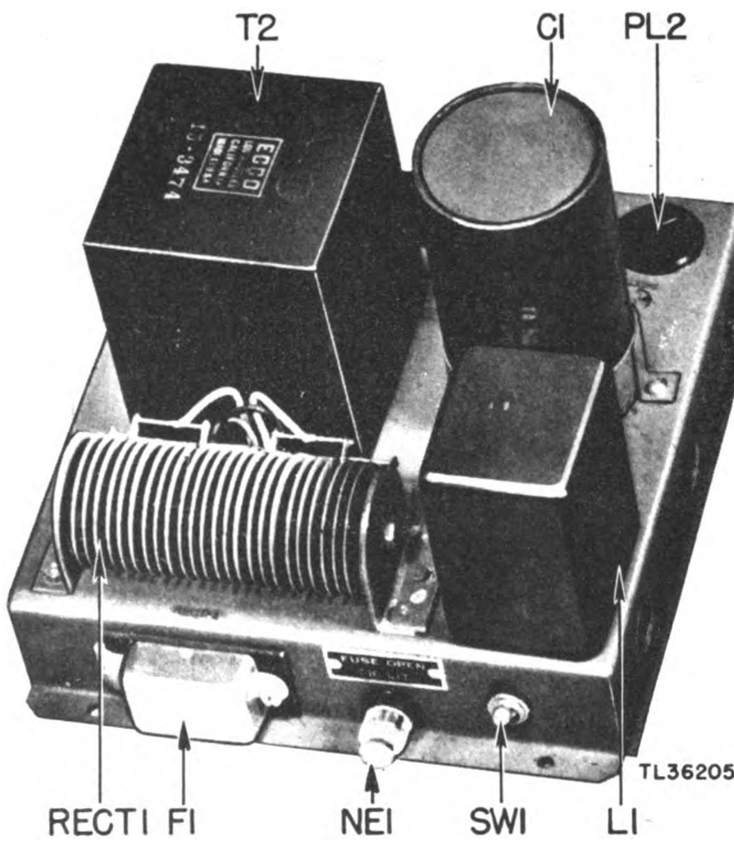


Figure 430. Rectifier Power Unit PP-100/MPN-1, top view.

(2) BRAKE MECHANISM (fig. 224).

(a) Press the armature (11) down until it rests on the core pin (10).

(b) Turn the adjustment nuts (12) until there is approximately 1/32-inch clearance between the cotter pin (13) and the armature.

b. 4-kv Time Delay Relays. The procedure used in adjusting the time delay relays in the 4-kv power supplies is similar to the one described above. The timing indicator however is not marked and the correct adjustment has to be estimated. There is no brake mechanism.

c. Overcurrent Relays. The two Westinghouse type MN overcurrent relays in Control Box C-61 have been properly adjusted at the factory and should not be disturbed unless absolutely necessary. These relays should operate at from .06 to .07 amperes. If a new adjustment is necessary it should be made as follows:

(1) Adjust the bearing screws (1) so that the overcurrent armature (2) is approximately centered on the frame, and the latch arm (3) has sufficient clearance on both sides of the notch through which it passes. End play in the bearings should be perceptible, but should not be more than a few thousandths of an inch.

(2) With the overcurrent armature closed, make sure that the L-shaped bracket (4) supporting the latch arm is so located that there is a gap of approximately 1/64 inch between the ends of the reset armature (5) and the frame casting.

(3) Check the adjustment of the bushing which passes through the top of the glass cover. With the push rod (6) held in and the overcurrent armature closed, there should be a gap of about 0.005 inch between the reset armature and the reset coil core. The armature stop screw (7) is adjusted by first turning it in until the armature just touches the bronze pin in the center of the core and then backing it out exactly three turns. Tighten the locknut (8) securely.

(4) Check the adjustment of latch plate (9). With the armature held closed, there should be a gap of 0.005 to 0.010 inch between the overcurrent armature and the core pin.

(5) With the overcurrent armature horizontal and by applying slight tension to spring (10), further extend the spring by one or two turns of the screw (11) into which the spring is hooked.

(6) Adjust the stationary contact stud (12) to obtain a contact gap of 5/64 to 3/32 inch when the overcurrent armature is closed. With the contacts closed, turn screw (13) in until the bracket spring (14) just touches the back of the contact, then turn it one-half turn further.

(7) If discrepancies are found to exist between the scale markings and the actual operating values, these may be corrected by further variation of the tension applied to the armature restraining spring.

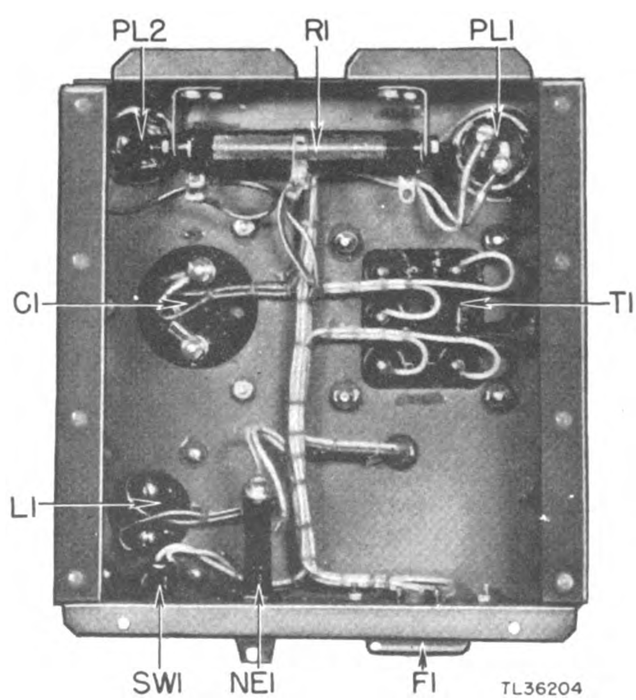


Figure 431. Rectifier Power Unit: PP-100/MPN-1, bottom view.

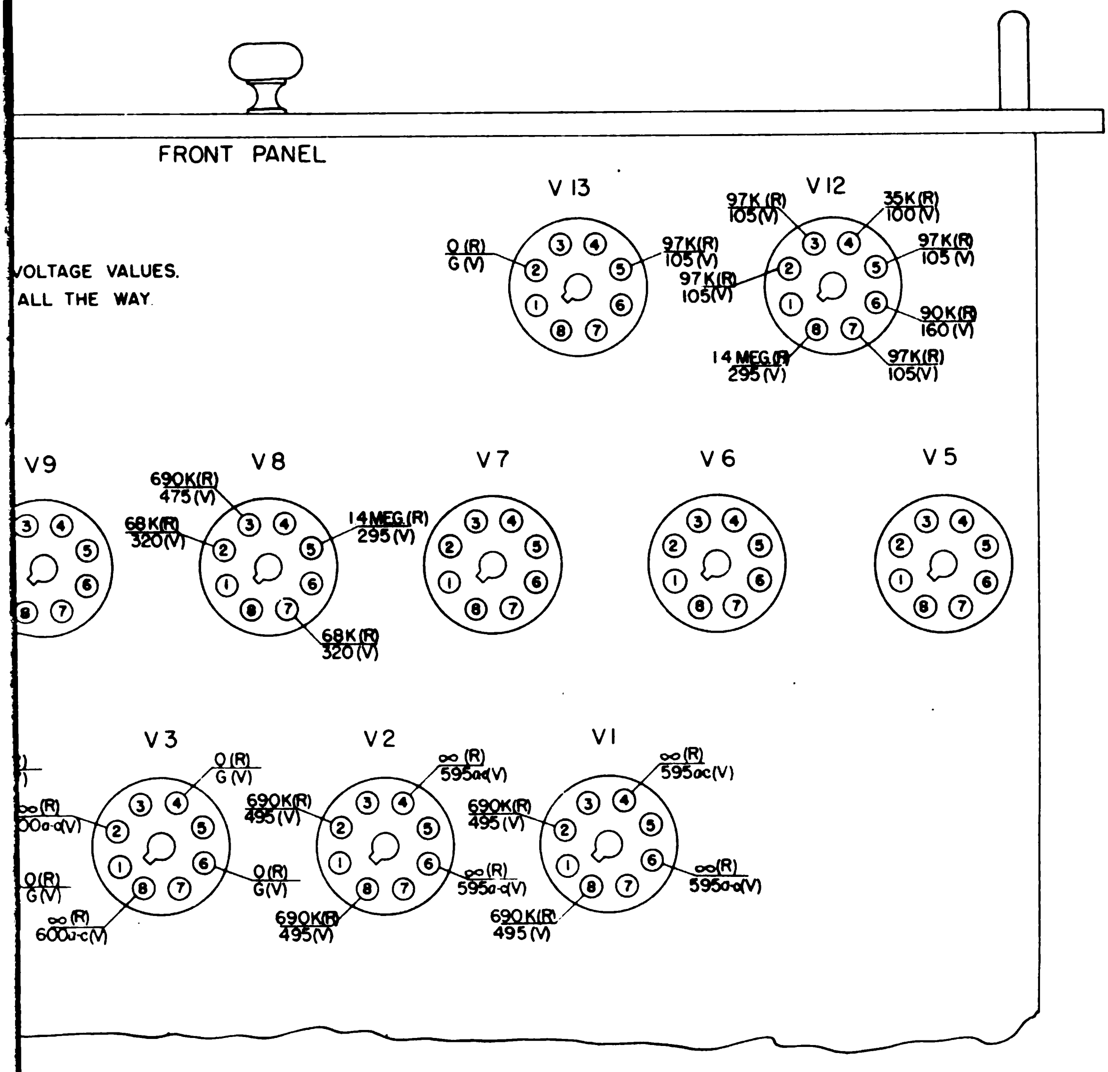


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Figure 432. Rectifier Power Unit PP-22/MPN-1, voltage and resistance chart.

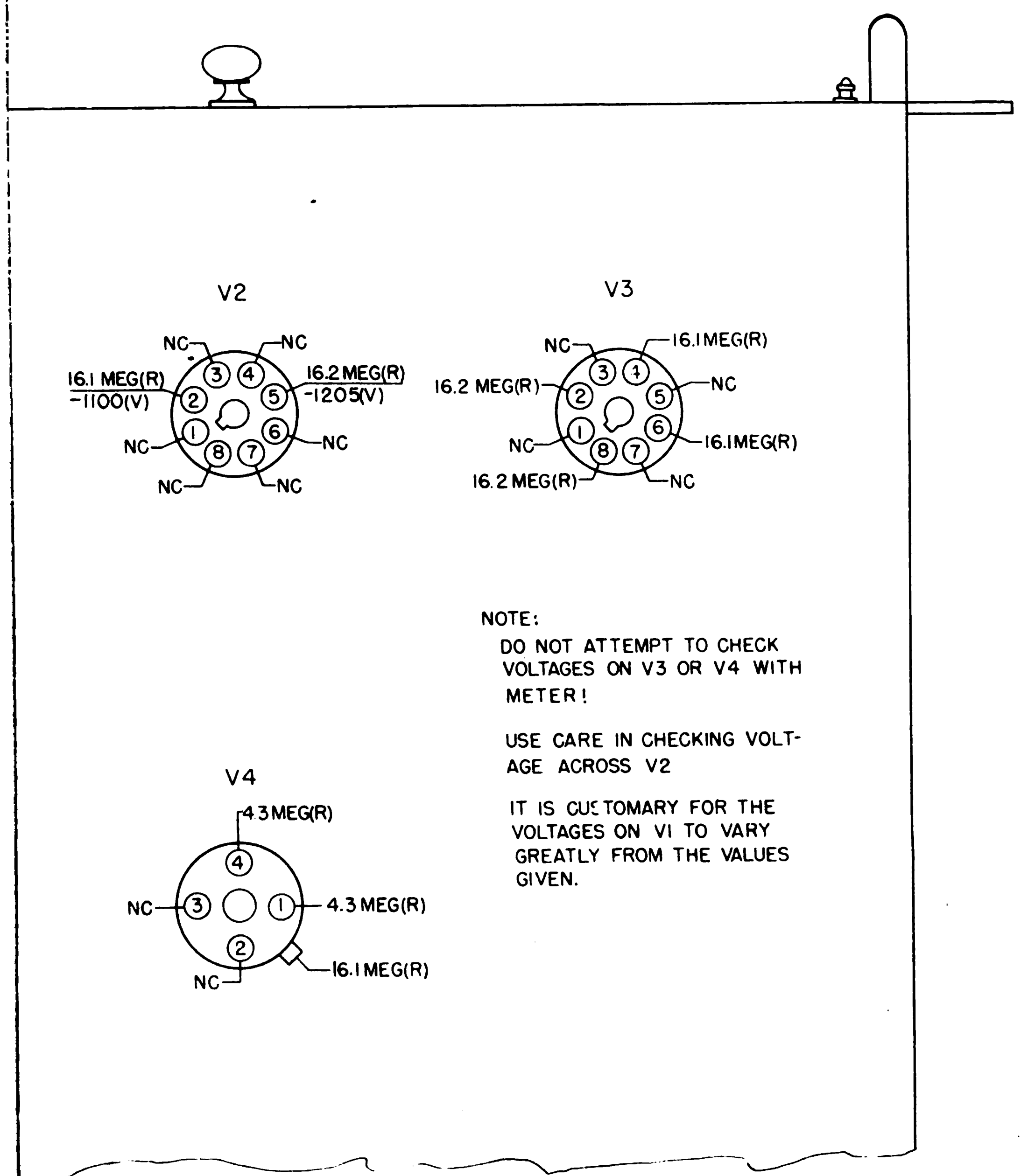

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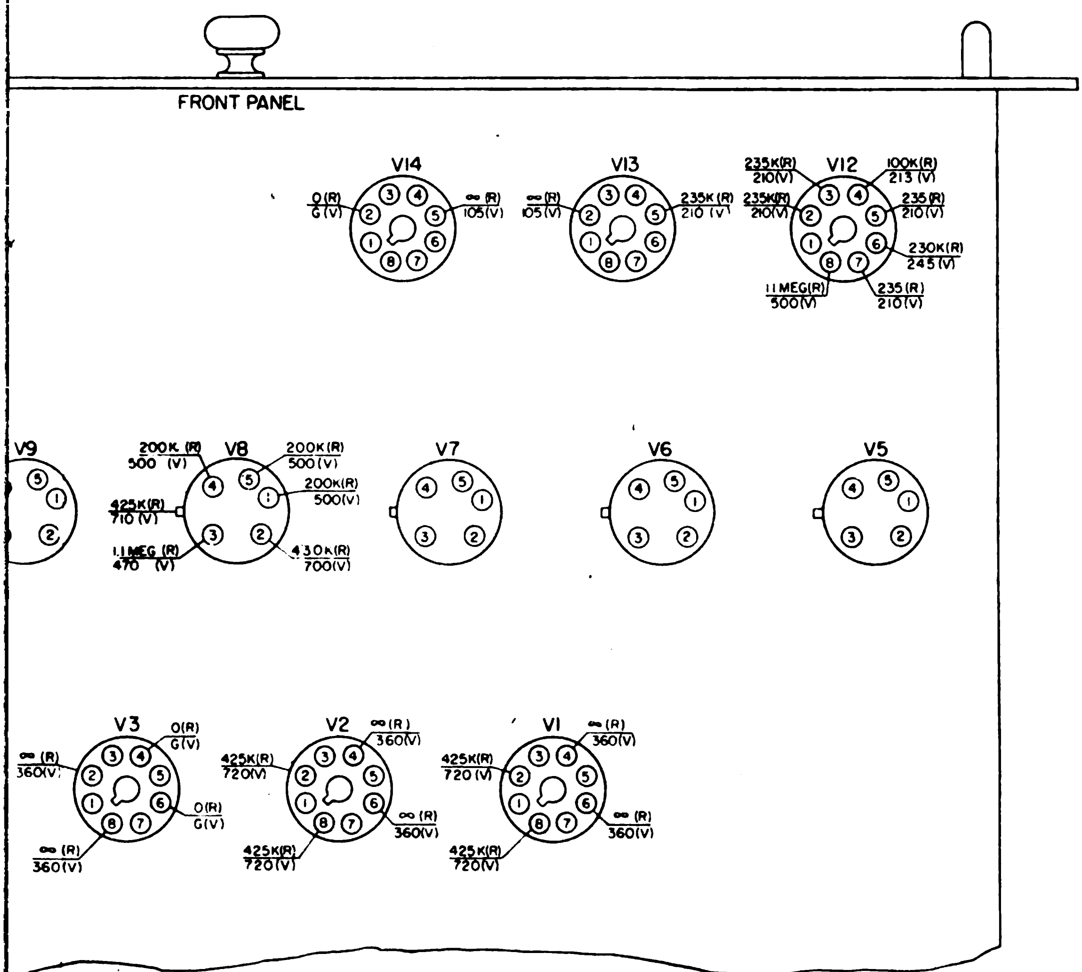
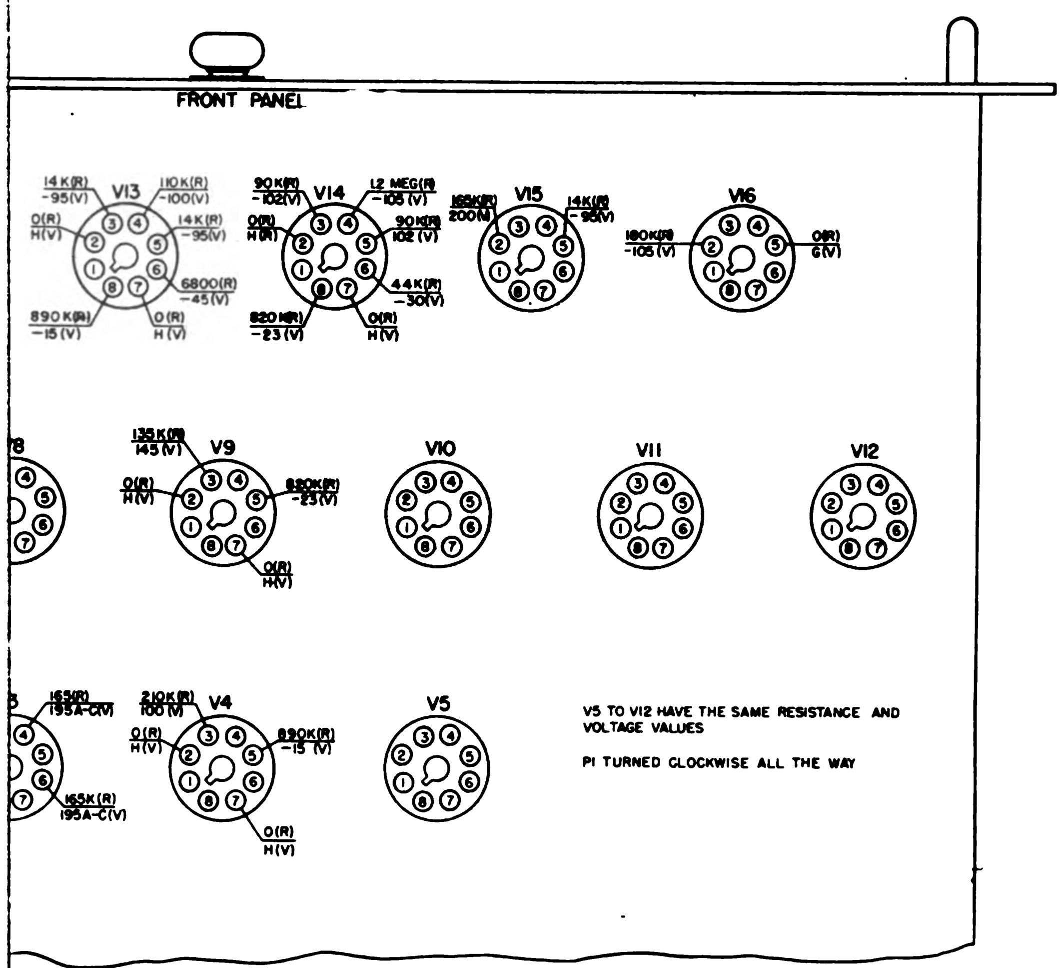
Figure 433. Rectifier Power Unit PP-23/MPN-1, voltage and resistance chart.



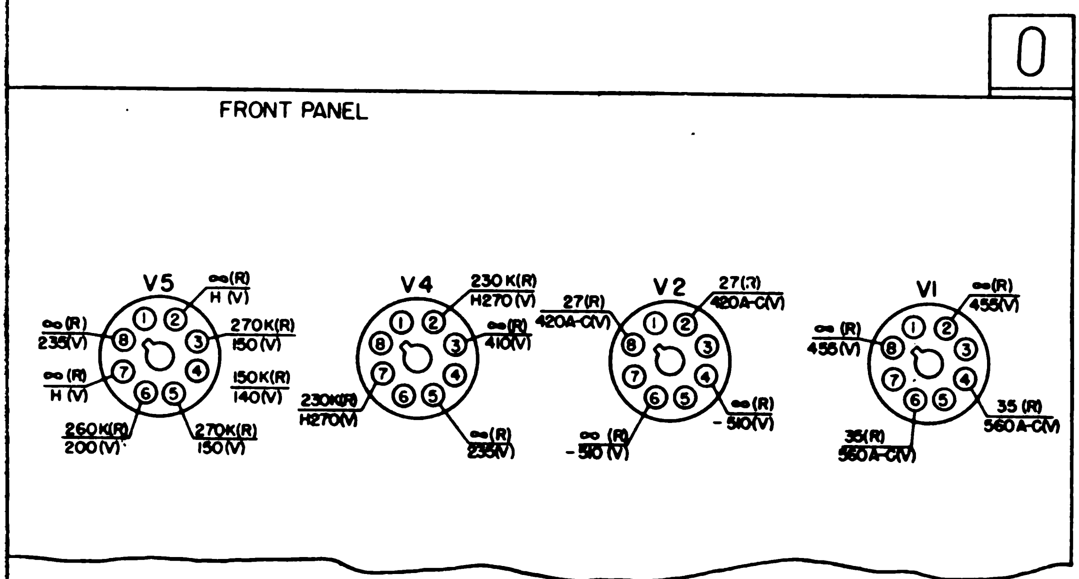
TL 36014A

Figure 434. Rectifier Power Unit PP-24/MPN-1, voltage and resistance chart.



TL 36011A

Figure 435. Rectifier Power Unit PP-25/MPN-1, voltage and resistance chart.



TL 36007A

Figure 436. Rectifier Power Unit PP-27/MPN-1, voltage and resistance chart.

SECTION III

COMMUNICATIONS SYSTEM

> WARNING: *Voltages sufficient to cause death on contact are exposed at many points in the communication racks. Do not place hands or arms within these units with the high voltage on. Do not make any connection into this equipment which brings high voltage out to an exposed point. Always ground high-voltage capacitors before touching them or their associated parts.*

247. REFERENCE DATA.

a. Communications System.

(1) Figure 402. Communications Rack MT-121/MPN-1, (rack A), cabling diagram.

(2) Figure 403. Communications Rack MT-120/MPN-1, (rack B), cabling diagram.

(3) Figure 404. Indicator Rack MT-118/MPN-1, cabling diagram.

b. Approach Indicator ID-38/MPN-1.

(1) Figure 172. Front view.
(2) Figure 437. Interior view.
(3) Figure 438. Top view.
(4) Figure 439. Bottom view.
(5) Figure 174. Schematic diagram.
(6) Figure 440. Voltage and resistance chart.

c. Search Central SN-6/MPN-1.

(1) Figure 68. Front view.
(2) Figure 86. Schematic diagram.

d. Observer's Control Box C-139/MPN-1.

(1) Figure 441. Front view.
(2) Figure 442. Rear view.
(4) Figure 246. Schematic diagram.

e. Intercommunication Panel SB-2/MPN-1.

(1) Figure 70. Front view.
(2) Figure 443. Top view.
(3) Figure 444. Bottom view.
(4) Figure 238. Schematic diagram.

f. Telephone Box TA-6/MPN-1.

(1) Figure 445. Interior view.
(2) Figure 232. Schematic diagram.

g. Headphone Matching Assembly CU-46/MPN-1.

(1) Figure 446. Top view.
(2) Figure 447. Bottom view.
(3) Figure 239. Schematic diagram.

h. Tower Receiver Control Box C-140/MPN-1.

(1) Figure 242. Front view.
(2) Figure 448. Rear view.
(3) Figure 245. Schematic diagram.

i. Tower Receiver BC-1206-C.

(1) Figure 449. Top view.
(2) Figure 450. Bottom view.
(3) Figure 244. Schematic diagram.
(4) Figure 451. Resistance chart.

j. General.

(1) Figure 406. Connector adaptation for SCR-274 transmitter, schematic diagram.
(2) Figure 198. Power distribution control circuit.
(3) Figure 253. Capacitor color code.
(4) Figure 254. Resistor color code.
(5) Figure 255. Tube base chart.

248. PROCEDURE.

a. Trouble-shooting Charts. There are eight trouble-shooting charts for use in the communications system as follows:

(1) Paragraph 249 is a general trouble-shooting chart for the complete communications and intercommunications systems.

(2) Paragraph 250 is a detailed trouble-shooting chart for the communications circuits located in the approach indicator.

(3) Paragraph 251 deals with trouble shooting the communications circuits located in the two search centrals.

(4) Paragraph 252 is a trouble-shooting chart for the observer's control box.

(5) Paragraph 253 covers the trouble shooting for the communications circuits in the intercommunications panel.

(6) Paragraph 254 covers those faults likely to occur in telephone matching unit.

(7) Paragraph 255 is a trouble-shooting chart for the headphone matching unit.

(8) Paragraph 256 is a detailed trouble-shooting chart on Tower Receiver BC-1206-C.

b. Use of Charts. The first chart (par. 249), covers faults that are likely to occur in the communications system as a whole. However, it does not, in every case, completely isolate the trouble to a particular circuit element. For example, if the procedure given in the first trouble-shooting chart definitely isolates the fault to the approach indicator, a reference will be made to the detailed chart on the approach indicator (par. 250). The latter chart will isolate the fault to a defective circuit element. The other charts included are used in exactly the same manner; starting first with the general chart. It is not always necessary to refer to a second chart before finding the trouble. The cross-chart reference is used only when a complete procedure in the general trouble-shooting chart for the system, would become unnecessarily involved if all the details were included. In cases where there is no doubt as to which component is faulty, refer directly to the chart covering the component involved.

c. Alignment Instructions. Alignment procedures and methods of checking and adjusting the communications equipment are given in paragraph 257. Information peculiar to the use of the standard Signal Corps communications equipment in Radio Set AN/MPN-1 will be found in this paragraph.

d. Use of a Test Receiver or Transmitter. Because Radio Set AN/MPN-1 will be used at airfields, it is very likely that there will be radio equipment available at the field of the same type as used in Radio Set AN/MPN-1. Some of this equipment can be used to good advantage as a "test radio set" for monitoring and transmitting to the radio communications equipment within the trailer.

249. TROUBLE-SHOOTING CHART FOR COMMUNICATIONS SYSTEM.

A. SYMPTOM:

1. No radio reception by pilot from any of the three operators' positions.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switch in wrong position.	1. Check that circuit breaker SW13 on power distribution panel is in correct operating position.
2. Line voltage supply.	2. Check to see if rectifier filaments in power units are lighted. If not lighted, check power input circuit (fig. 198).

B. SYMPTOM:

1. No radio reception by the pilot from one of the three operating positions only.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switches in wrong position.	1. Check that the following switches are in correct operating position: *a.* ON-OFF switches on power supplies Rectifier Unit RA-62 or Rectifier Power Supply PP-28, and on the microphone in use. *b.* Correct channel selected on transmitter control box for SCR-274-N or SCR-522-A. *c.* Switch in REM position on Radio Control Box BC-602-A. *d.* Radio Control Box BC-451-A in VOICE position. *e.* Key knob on top of Radio Control Box BC-451-A turned fully counterclockwise. *f.* The TRANS-REC-INTERCOM key in TRANS position.

PROBABLE LOCATION OF FAULT	PROCEDURE
2. Transmitter output.	2a. Check for unmodulated signal with a test receiver or test equipment supplied. If signal is received, the transmitter, power supply, and antenna system are OK and pilot's receiver system is at fault. b. If no signal is received, check the antennas, SCR-274-N antenna relay, and antenna current meter. c. If still no signal is received, check the power supply for the transmitter in use (Rectifier Unit RA-62 or Rectifier Power Supply PP-28). d. Replace the transmitter.
3. Microphone supply.	3. Check the microphone, microphone switch, and microphone current. To check the microphone current, switch MIC. SUPPLY switch from A to B position on the approach indicator panel. If no microphone current in the A or B position, see paragraph 250.
4. Low microphone supply.	4. Check microphone supply output, measuring microphone voltage from ground to ring of microphone plug. To measure the microphone voltage, take off mica insulator cover of jack plug and measure between the first lead and ground. With microphone in circuit, the reading should be between 4 and 10 volts. If low, refer to paragraph 250.
5. Approach indicator or search central communications circuit.	5a. Refer to paragraph 250 is there is no reception from the approach indicator position. b. Refer to paragraph 251 if there is no reception at one of the two search centrals positions.

C. SYMPTOM:

1. Operators cannot receive the airplane.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switch in wrong position.	1. Check that circuit breaker SW13 on power distribution panel is in correct operating position.
2. Line voltage supply.	2. Check to see if rectifier filaments in power units are lighted. If not lighted, check power input circuit (fig. 198).

D. SYMPTOM:

1. One operator cannot receive the airplane.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switches in wrong position.	1. Check that the following switches are in correct operating position: a. ON-OFF switches of power supplies. b. Control switches of receiver. c. TRANS-REC-INTERCOM key on observer's control box. If key is in transmit position, the controller and tracker positions are cut off. d. TRANS-REC-INTERCOM key of position used in REC position. e. Channel selector switch in correct position.

2. Communications circuit defective in one of three positions.	2a. Refer to paragraph 250 for defects in approach indicator position.
	b. Refer to paragraph 251 for defects in search central positions.
3. Antenna system.	3a. Check the antenna system thoroughly.
	b. Check the SCR-274-N antenna relay. It may be stuck.
4. Headphones and headphone matching unit.	4a. Check the operation of the headphones by exchanging with another position.
	b. Check the headphone matching unit for Radio Receiver BC-342-N for mismatch due to open transformer or connection.
5. Defective receiver.	5. Replace defective receiver.
6. Defective radio equipment in airplane.	6. If no signal is received with the receiver tuned to the channel on which reception is desired, try reception on another channel.

E. SYMPTOM:

1. No sidetone on HF or VHF channel (operator cannot hear his voice in headphones).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Microphone headset.	1a. Check to see if microphone ON-OFF switch is in ON position or held in unlock position.
	b. Exchange with another microphone headset.
2. Channel selector switch.	2. Check operation of channel selector switch at location used.
3. TRANS-REC-INTERCOM switch.	3. Check operation on the TRANS-REC-INTERCOM switch for position used.
4. Approach indicator.	4. Check the three potentiometers in the approach indicator for controlling the SCR-274-N sidetone feedback circuits in the three positions.
5. Power supply.	5. Check power supply switches as for symptom D.
6. Transmitter.	6. If the fault is not cleared after the above, replace the SCR-522 or SCR-274-N transmitter being used.

F. SYMPTOM:

1. Pilot or operator hears tone or CW instead of VOICE.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Radio Control Box BC-451-A.	1. Check control box. Control may be set on TONE or CW. Set on VOICE.

G. SYMPTOMS:

1. Intermittent or faulty transmission.
2. Poor modulation.
3. Pilot reports poor reception.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Observer's control box.	1a. Check position of tower receiver switch on observer's control box. Intermittent operation may be caused by switch being in transmit position.

	b. If tower receiver switch is in correct receive position and fault remains, remove receptacle #5 from the approach indicator. If this clears the trouble, look for a defective switch in the observer's control box (par. 252).
2. TRANS-REC-INTERCOM key.	2. Check the TRANS-REC-INTERCOM key being used. If it does not stay in position, take the switch out of case and adjust the contacts.
3. SCR-522-A (if trouble in VHF system).	3*a.* If audio modulation on the SCR-522-A is not loud enough, turn up modulation gain on the SCR-522-A transmitter. *b.* See alignment procedure for SCR-522-A.
4. SCR-274-N (if trouble in HF system).	4*a.* Faulty modulation on SCR-274-N. See instruction manual on Radio Set SCR-274-N. *b.* Check alignment of SCR-274-N.
5. Antennas.	5. Check antennas for high resistance joints or loose connections. Be sure joints are tight.
6. Search centrals.	6. Check setting of P11 gain control in the search central. Reset for proper gain. See trouble shooting of search centrals (par. 251) if fault is not cleared.
7. Primary power supply.	7. Check for low or unregulated voltage.

H. SYMPTOM:

1. Receiving station reports a heterodyne whistle on carrier.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Two channels on same frequency.	1. If a test station reports your signal has a heterodyne whistle on the carrier, look for two transmitters at the same frequency on the air at the same time.

I. SYMPTOMS:

1. Intermittent or faulty reception.
2. Distorted or weak signals in headphones.
3. Interference or excessive noise level.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Operators' jacks and plugs.	1. Check the jacks or plugs for signs of high resistance grounds.
2. Headphones.	2. Try another set of headphones.
3. Headphone matching assembly.	3. Check for defective transformer or loose connection which may result in distorted or weak signals due to mismatching.
4. Interference.	4. If interference is excessive on the SCR-274-N HF channels, connect up the remote antenna box, first disconnecting the antenna connections to Radio Receiver BC-342-N.
5. Radio Receiver BC-342-N or SCR-522 receiver.	5. Check for alignment of receiver in use. See instruction books on the receiver for details.

J. SYMPTOM:

1. Faulty intercommunications system in all operators' position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switch in wrong position.	1. Check position MIC SUPPLY switch on the approach indicator. No intercom is possible in the B position.
2. Approach indicator.	2. Refer to paragraph 250.

K. SYMPTOM:

1. Faulty intercommunications in one or more operators' position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switch in wrong position.	1*a*. Check ON-OFF switch on microphone. *b*. Check position of TRANS-REC-INTERCOM switch in operating position. Should be in INTERCOM position.
2. Observer's control box.	2. Check position of TRANS-REC-INTERCOM key in the observer's control box. If in the TRANS position, the controller and tracker positions will have no intercommunications.
3. Microphone power supply.	3. Refer to paragraph 250.
4. Capacitor input of approach indicator.	4. Defective input capacitor in the approach indicator intercommunications circuit.
5. Selector switch on intercommunication panel.	5. Check the position of the selector switch on the intercommunication panel. Only one of the search operators may be in communication at a time with IFF or cable position.
6. Intercommunications switch.	6. Check INTERCOM at faulty position.
7. Microphone transformer.	7. Check microphone transformer at faulty position.
8. Junction Box J-29.	8. Check the connection of the cable to the cab telephone set (Telephone Box TA-6/MPN-1).
9. Microphone or headsets.	9. Check the operation of the microphones, or headsets, exchanging with another set. See addendum IV.

L. SYMPTOM:

1. No aural signal (pilot receives no aural signal. No sidetone in headphones).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Approach indicator.	1*a*. Check operation of aural signal switch on panel. *b*. Check cable connections. *c*. Check setting of aural signal potentiometer. *d*. Check tone transformer inside approach indicator. *e*. Refer to paragraph 250.
2. Observer's control box.	2. Check position of TRANS-REC-INTERCOM switch. If this switch is in the TRANS position the controller is cut off, including the aural signal.
3. Aural signal unit.	3. Check the aural signal unit. See trouble shooting on aural signal unit (par. 226).
4. Microphones and headphones.	4. Check microphones and headphone sets operation. See addendum IV.
5. Transmitter or associated circuits.	5. If aural signal is absent on only one channel, the transmitter or modulator is defective in that channel.

M. SYMPTOM:

1. No reception or faulty reception on tower receiver.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No input.	1. Make checks to be sure that tower is broadcasting on the frequency of the tower receiver.
2. Tower receiver.	2*a*. Plug phones into jack in front of tower receiver. *b*. With power supply turned on, tune in station. *c*. If tower receiver is inoperative, cause of trouble may be found in tower receiver antenna or Rectifier Power Unit PP-100. *d*. If fault is in tower receiver see paragraph 256.
3. Tower receiver control box and observer's control box.	3. If tower receiver operates satisfactorily, but reception is poor in remote positions, check switches and potentiometers on the tower receiver control box and the tower receiver switch on the observer's control box:

N. SYMPTOM:

1. Faulty or no operation at observer's control box.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Approach indicator.	1. Check for proper operation at the approach indicator. See trouble shooting on approach indicator (par. 250).
2. Observer's control box.	2. If the TRANS-REC-INTERCOM positions are satisfactory in the approach indicator but faulty at the observer's control box, cause of trouble lies in the switches, potentiometer, or microphone transformer in the observer's control box (par. 252).
3. Microphone power supply.	3. Check for microphone supply (par. 250).

250. TROUBLE-SHOOTING CHART FOR APPROACH INDICATOR.

A. SYMPTOM:

1. Transmitter does not go on.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. TRANS-REC-INT COM switch.	1. Check switch SW2 for dirty or misaligned contacts.
2. Channel selector switch.	2*a*. Check switch SW1 for dirty or misaligned contacts. *b*. Check wiring to receptacle No. 2.

B. SYMPTOM:

1. No microphone supply.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Fuse.	1. Check fuse F1 and F2. A blown fuse is indicated by neon lights NE1 and NE2 being lit.
2. Rectifier.	2*a*. Transformer T9 or T10 defective.
	b. Defective rectifier, RECT 1 or RECT 2. The normal output is approximately 15 volts.
	c. Open chokes L1 or L2.
	d. Check capacitors C6, C8, or C9 for short.
	e. Defective switch SW4.
	f. Open resistor R2.
	g. Primary of transformer T1 open.

C. SYMPTOM:

1. No intercommunication.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. MIC SUPPLY switch.	1*a*. Defective switch SW4.
	b. MIC SUPPLY switch must be in position A.
2. Rectifier.	2*a*. Test tube V1.
	b. Check microphone supply rectifier as in symptom B above.
	c. Shorted C10 or C11.
	d. Inductance L3 open.
3. Amplifier.	3*a*. Check tubes V2 and V3.
	b. Test transformers T3 and T5 for open circuits.
	c. Check potentiometers P6 and P8.
	d. Check for correct resistance value of resistors R8 and R10.
	e. Check capacitors C2 and C4 for a shorted condition.
	f. Test secondary of transformer T1 for open circuit.
	g. Check potentiometer P1 for open circuit.
	h. Check tube socket resistance and voltage readings (fig. 440).

D. SYMPTOM:

1. Crosstalk interference.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. P1 in approach indicator.	1*a*. Turn fully clockwise.
	b. If not corrected, refer to figure 174 and check value of input voltage and resistance of P1.

E. SYMPTOM:

1. No modulation signal to transmitters.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Microphone circuit.	1*a*. Check spring tension of microphone jacks.
	b. Check microphone supply as in symptom B above.
	c. Check resistors R3, R4, R5, R6, and R7 for open circuit.

F. SYMPTOMS:

1. No signal received from pilot.
2. Normal output at receivers.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Relay RY1 circuit.	1*a*. Check contacts of relay RY1 for dirt or misalignment.
	b. Potentiometer P2 defective or turned off.
	c. Loose terminal strip AB11.
	d. Receptacle 3 not screwed on tight.
	e. Defective aural signal switch.

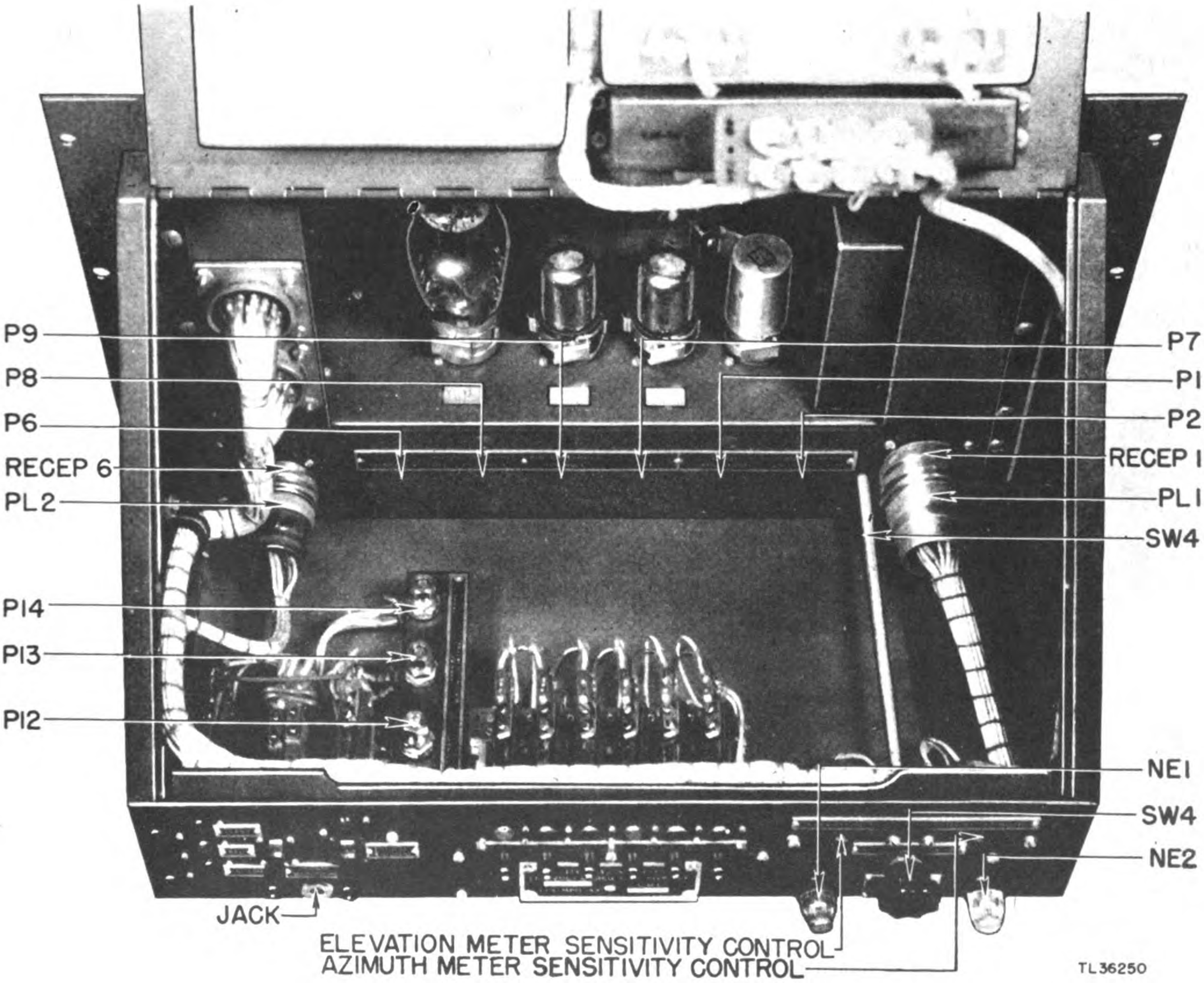


Figure 437. Approach Indicator ID-38/MPN-1, interior view.

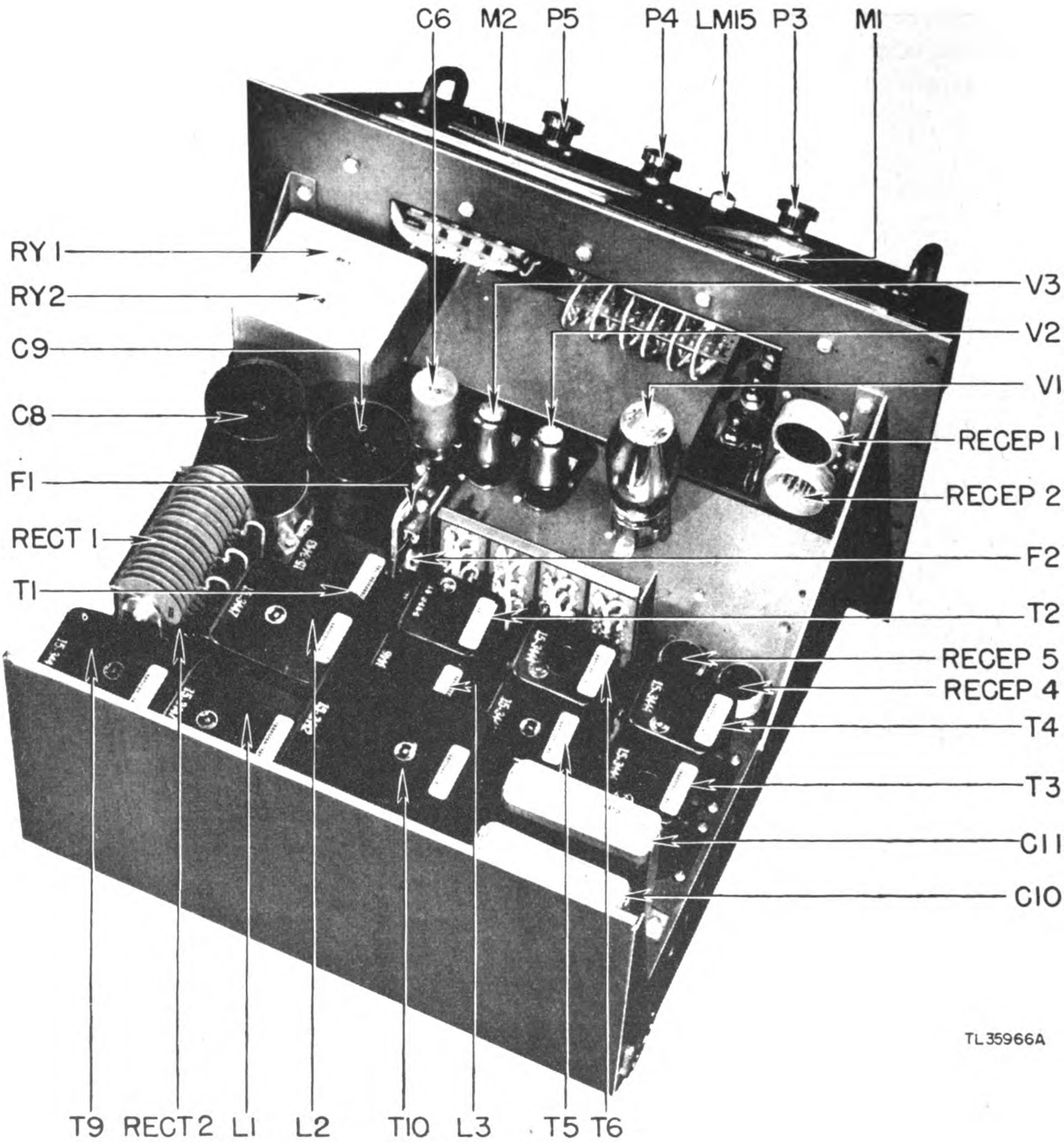


Figure 438. Approach Indicator ID-38/MPN-1, top view.

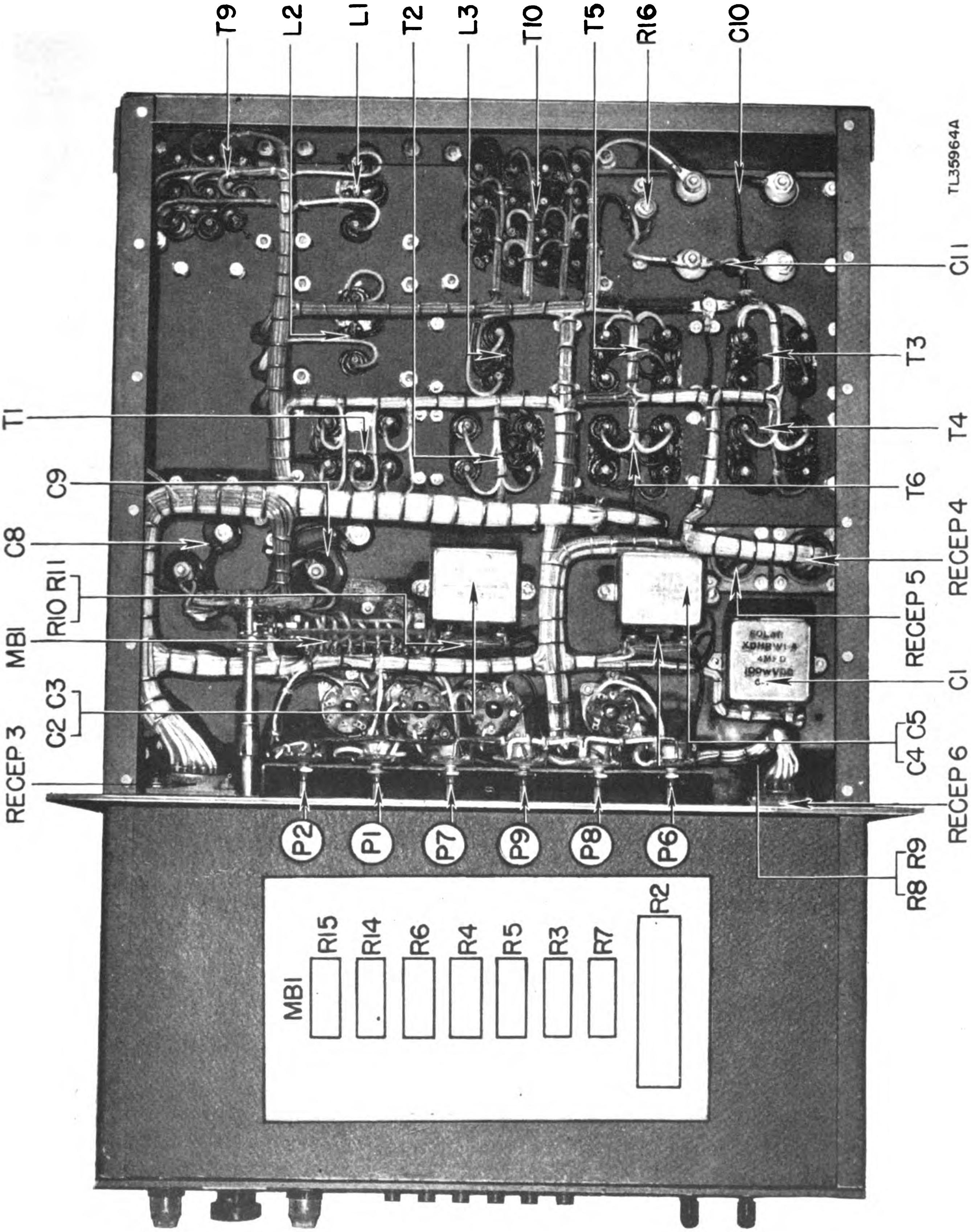


Figure 439. Approach Indicator ID-38/MPN-1, bottom view.

G. SYMPTOM:

1. No aural signal heard in headphones.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Switches SW1 and SW2.	1. Check contacts and spring tension on switches SW1 and SW2.

251. TROUBLE-SHOOTING CHART FOR SEARCH CENTRAL.

A. SYMPTOM:

1. Transmitter cannot be modulated from search central position.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Microphone circuit.	1*a*. Check microphone jack for dirty or misaligned contacts.
	b. Check microphone voltage. Voltage between chassis and top leaf of microphone jack should be 4 to 10 volts with the microphone plug inserted in the jack. See addendum IV.
	c. Check capacitor C54 for shorted condition.
	d. Check resistor R81 for correct value.
	e. Check transformer T5 for open primary winding.
2. Switch SW3.	2*a*. Check TRANS-REC-INT COM switch for dirty or misaligned contacts.
	b. Check receptacle PL1 to see that it is screwed on tight and has no broken or shorted wiring.
	c. Check resistors R82, R83, R84, R85, R86, and P11 for correct resistance value.

B. SYMPTOM:

1. Output of receivers not heard in headphones.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Headphone circuit.	1*a*. Check jack for proper spring tension and for dirty or misaligned contacts.
	b. Check receptacle PL1 for loose connections, especially the wiring from contact M.
	c. Check contacts of switch SW3 when switch is in the receive position.
	d. See addendum IV.

C. SYMPTOM:

1. Crosstalk interference.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. P11 in search central.	1*a*. Turn fully clockwise.
	b. If not corrected, refer to figure 86 and check value of input voltage and resistance of P11.

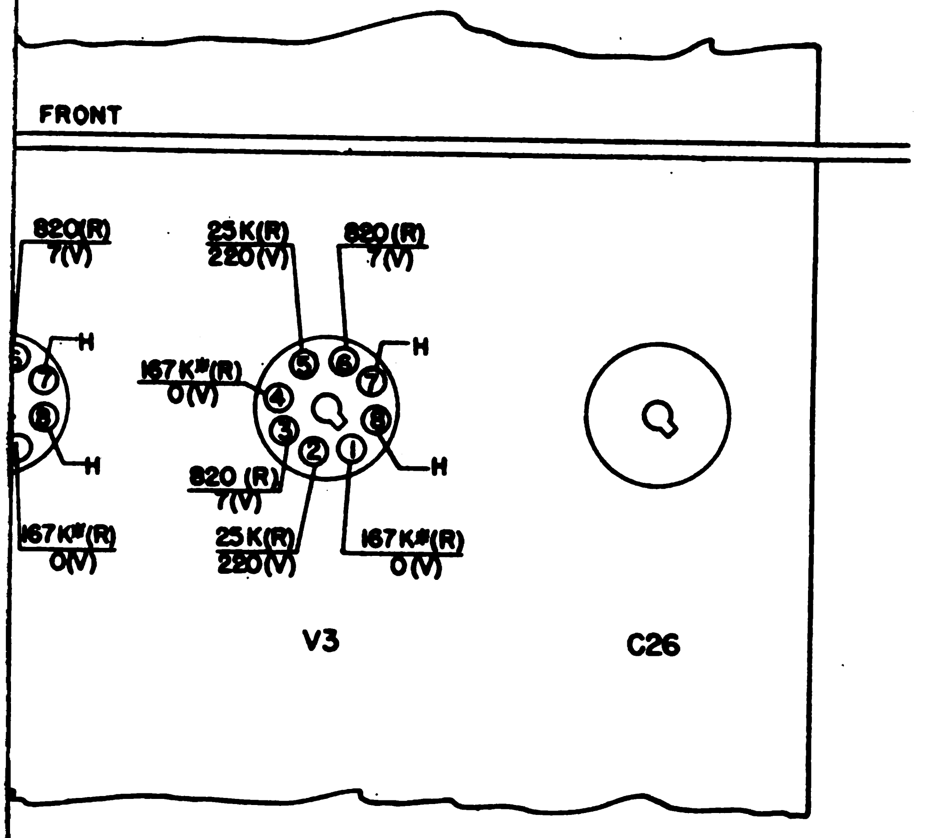


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Figure 440. Approach Indicator ID-38/MPN-1, voltage and resistance chart.

252. TROUBLE-SHOOTING CHART FOR OBSERVER'S CONTROL BOX.

A. SYMPTOM:

1. No reception from tower receiver.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Tower receiver gain control.	1. Check resistors R3 and P2 for proper resistance value.
2. TOWER REC. switch.	2*a*. Check switch SW2 for dirty or misaligned contacts.
	b. Check for loose or broken connections to switch SW3 and to receptacle 1.

B. SYMPTOMS:

1. No modulation to transmitter.
2. No intercommunication.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Microphone voltage.	1*a*. Test for microphone voltage at contact M of receptacle 1. If between 6 and 10 volts are obtained, check item below.
	b. Check jack JK1 for dirty or misaligned contacts.
	c. Test capacitor for a shorted condition.
	d. Test resistors R1 and P1 for correct resistance values.
	e. Test windings of transformer T1.
2. Switches.	2*a*. Check back contact of switch SW1 for dirty contacts. This contact must be closed when switch is in center position.
	b. Check contacts of switch SW2 for dirt or misalignment.
	c. Check all wiring for loose or broken connections.

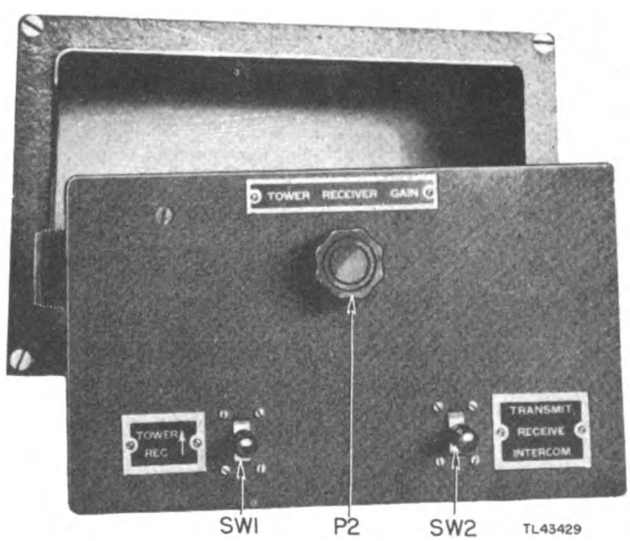

Figure 441. Observer's Control Box C-139/MPN-1, front view.

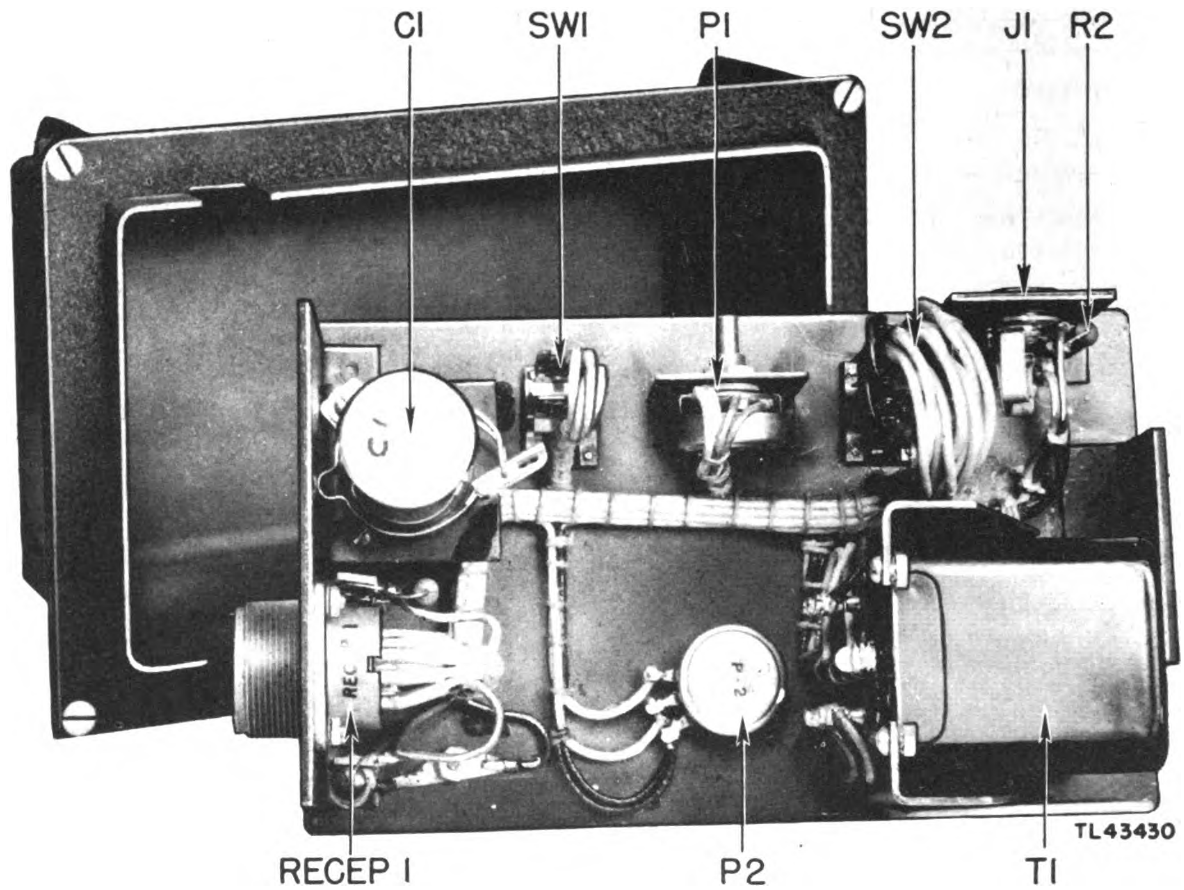

Figure 442. Observer's Control Box C-139/MPN-1, rear view.

253. TROUBLE-SHOOTING CHART FOR INTERCOMMUNICATION PANEL.

A. SYMPTOM:

1. Transmitter does not start when channel selector switch is pressed.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Channel control switch.	1*a*. Inspect channel control switch for dirty or misaligned contacts. *b*. Check all plugs and terminal strips for tightness.

B. SYMPTOM:

1. Indicator lamp does not light. Transmission normal.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Lamp circuit.	1*a*. Check for burned-out bulb. *b*. Check lamp socket for loose or broken connections. *c*. Check switch contacts that control lamp circuit. NOTE: If none of the lamps will light, check socket and terminal strips for loose connections.

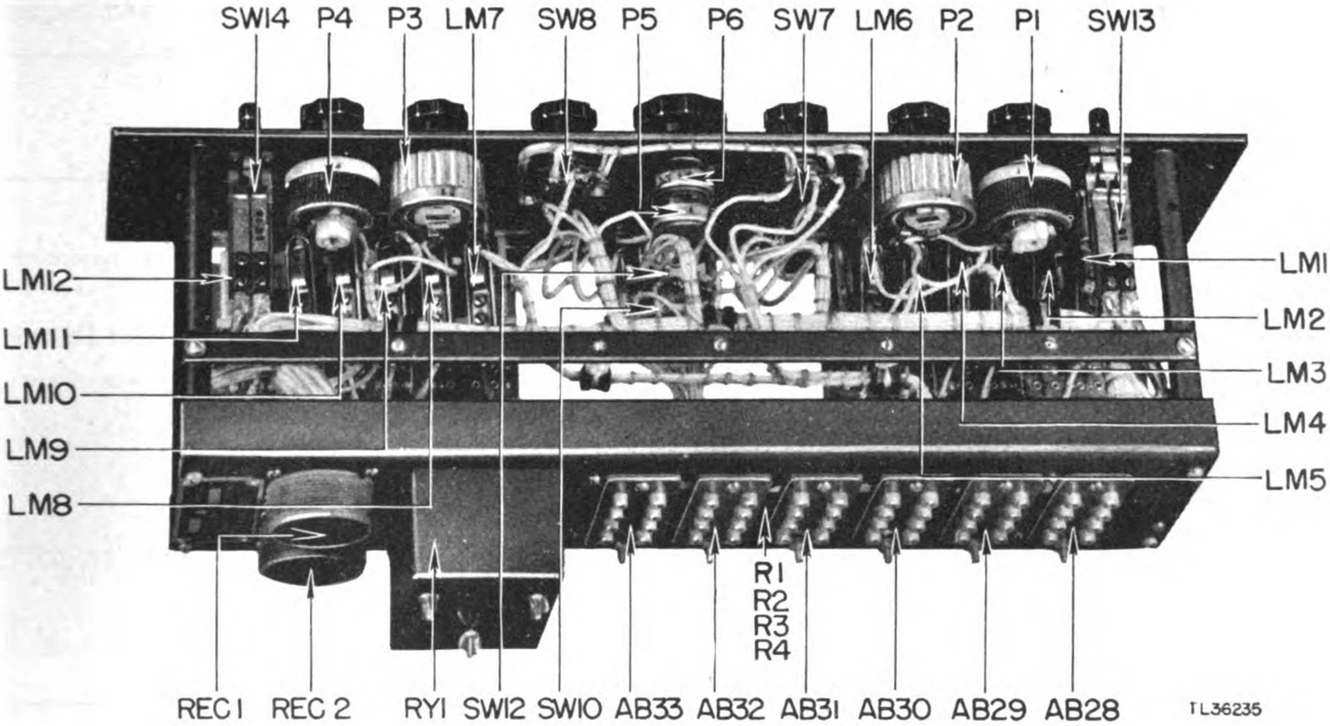

Figure 443. Intercommunications Panel SB-2/MPN-1, top view.

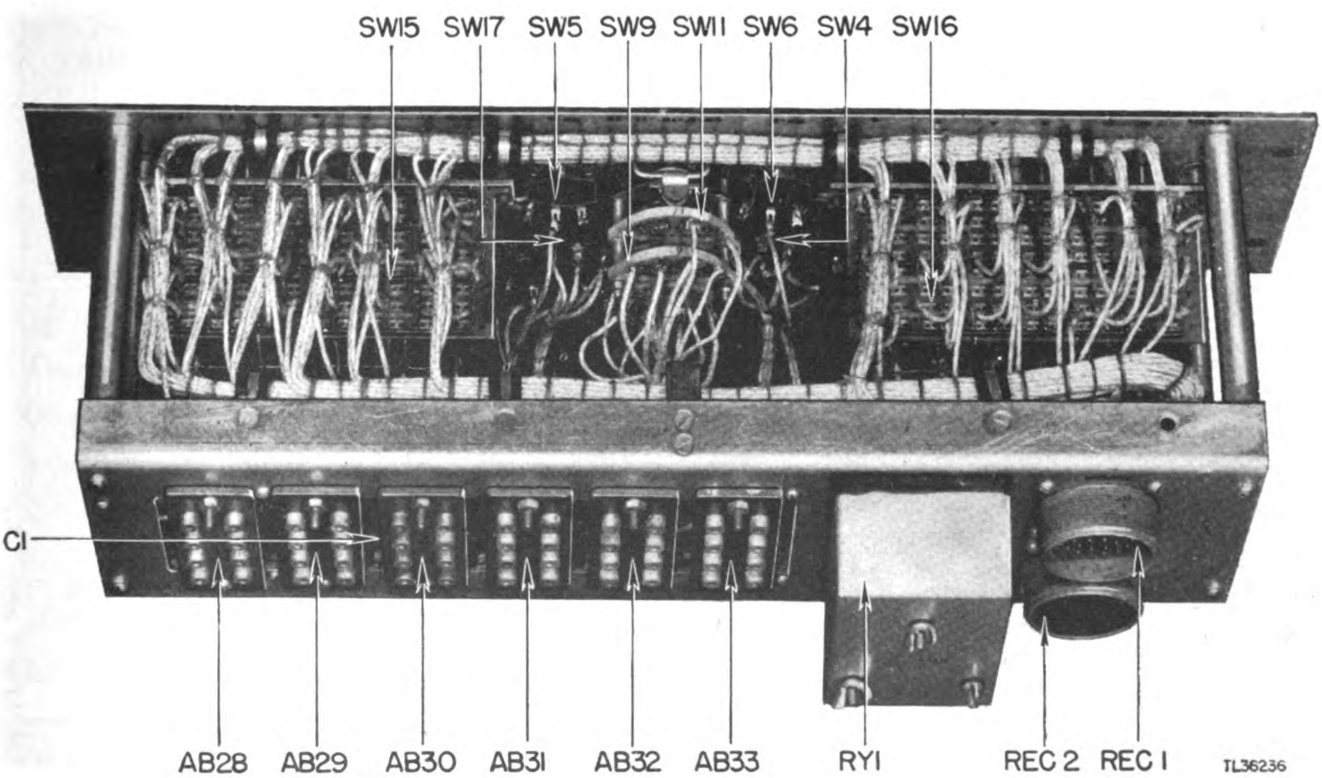

Figure 444. Intercommunications Panel SB-2/MPN-1, bottom view.

254. TROUBLE-SHOOTING CHART FOR TELEPHONE BOX.

A. SYMPTOM:

1. No speech output.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Microphone power.	1*a*. Measure the d-c voltage between chassis and pin C on receptacle 1. The voltage should be 6 to 10 volts.
	b. Measure the voltage between chassis and the top leaf of JK1. It should be 4 to 6 volts.
2. Microphone circuit.	2*a*. Check the jack for dirty and misaligned contacts.
	b. Test capacitor C1 for a shorted condition.
	c. Test resistance value of resistor R1.
	d. Check transformer T1 for open or shorted windings.
	e. Check all wiring for loose or broken connections.

255. TROUBLE-SHOOTING CHART FOR HEADPHONE MATCHING ASSEMBLY.

A. SYMPTOM:

1. Weak or no output.

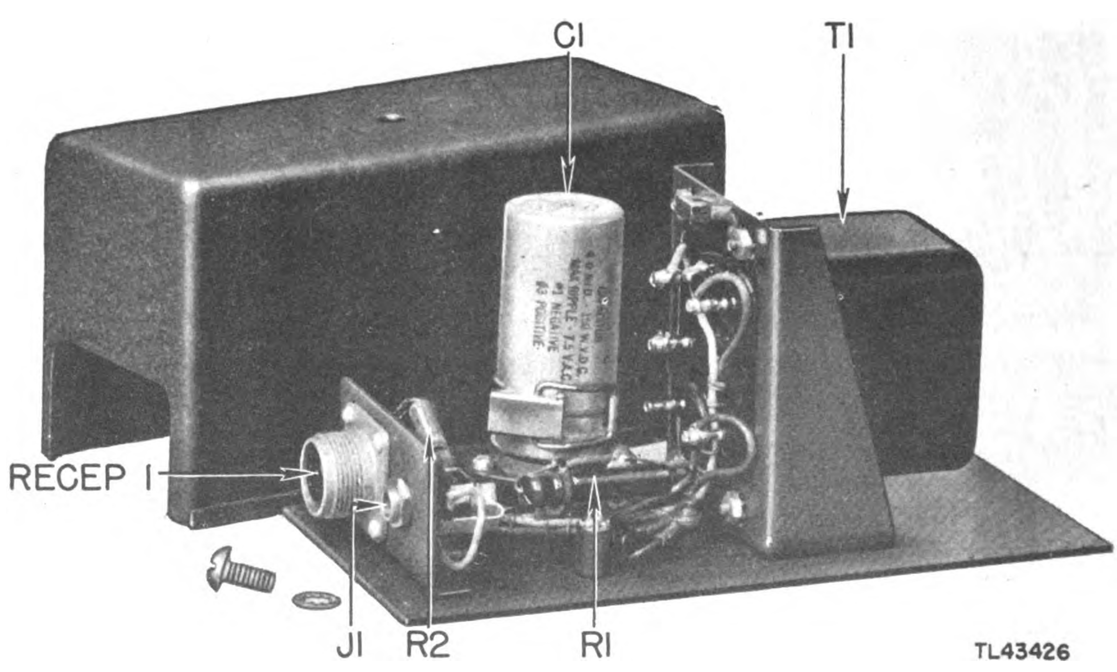

Figure 445. Telephone Box TA-6/MPN-1, interior view.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Transformers.	1*a*. Check transformer primary and secondary winding for an open circuit.
	b. Check tightness of terminal strip connections.
	c. Check receptacle to see that it is screwed on tight and that there are no broken or shorted connections.
	d. Check all wiring for broken or loose connections, especially the ground leads.

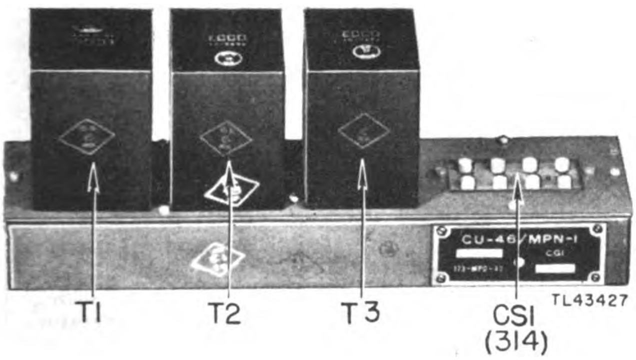

Figure 446. Headphone Matching Assembly CU-46/MPN-1, top view.

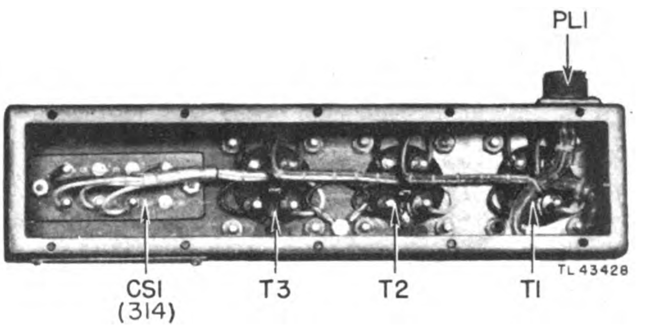

Figure 447. Headphone Matching Assembly CU-46/MPN-1, bottom view.

256. TROUBLE-SHOOTING CHART FOR TOWER RECEIVER.

A. SYMPTOMS:

1. No audio output from tower receiver.
2. Power supply voltage normal (28 volts dc).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Antenna or ground connection.	1. Check antenna and ground connections.
2. ON-OFF switch.	2. Check continuity of switch SW1 in ON position.
3. Defective tube.	3. Check all tubes. Replace any found defective.
4. Defective circuit element.	4. Check tube socket resistance readings (fig. 451). Determine cause of any abnormal reading.
5. I-f alignment or local oscillator badly out of line.	5. Refer to paragraph 257, subparagraph *i*, for alignment procedure.
6. Gain control potentiometer.	6. Check potentiometer VR1. Replace if defective.

B. SYMPTOM:

1. Weak or distorted output.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Antenna or ground connection.	1. Check antenna and ground connection.
2. Low power input.	2*a*. Check that the receiver has 28 volts dc supplied. *b*. If not, check Rectifier Power Unit PP-100.
3. Defective tubes.	3. Check tubes. Replace any with poor emission or high resistance shorts.
4. Receiver alignment.	4. Check i-f and local oscillator alignment. Refer to paragraph 257, subparagraph *i*, for procedure.
5. Defective coupling or bypass capacitor.	5. Check capacitors C5, C6, C8, and C9.
6. Defective circuit element.	6. Check tube socket resistance readings (fig. 451). Determine cause of any abnormal readings.

ALIGNMENT PROCEDURE CHART

Adjustment	Connecting point for signal generator	Alignment frequency	Dummy antenna in series with signal generator
1st and 2nd i-f transformers.	Mixer grid (pin 6 of tube 14J7).	135 kc	50 μuf
Set receiver dial to 400 kc. Adjust antenna rf. and oscillator trimmers for maximum output.	Antenna socket J1.	400 kc	50 μuf
Set receiver dial to 210 kc. Adjust oscillator padder C3 for maximum output.	Antenna socket J1.	210 kc	50 μuf

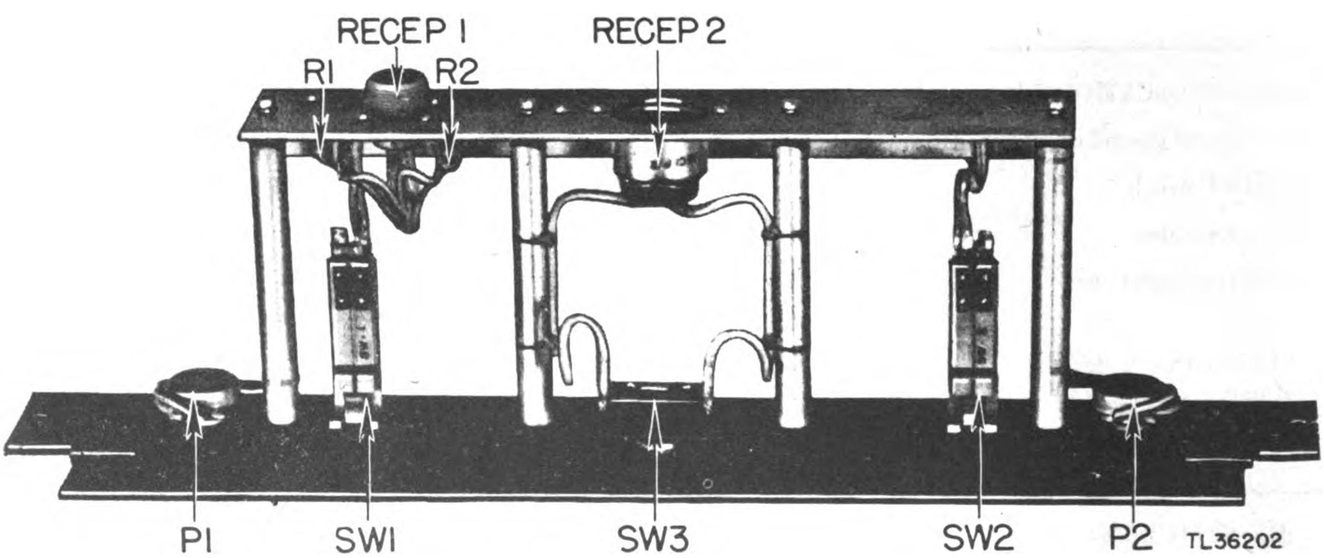

Figure 448. Tower Receiver Control Box C-140/MPN-1, rear view.

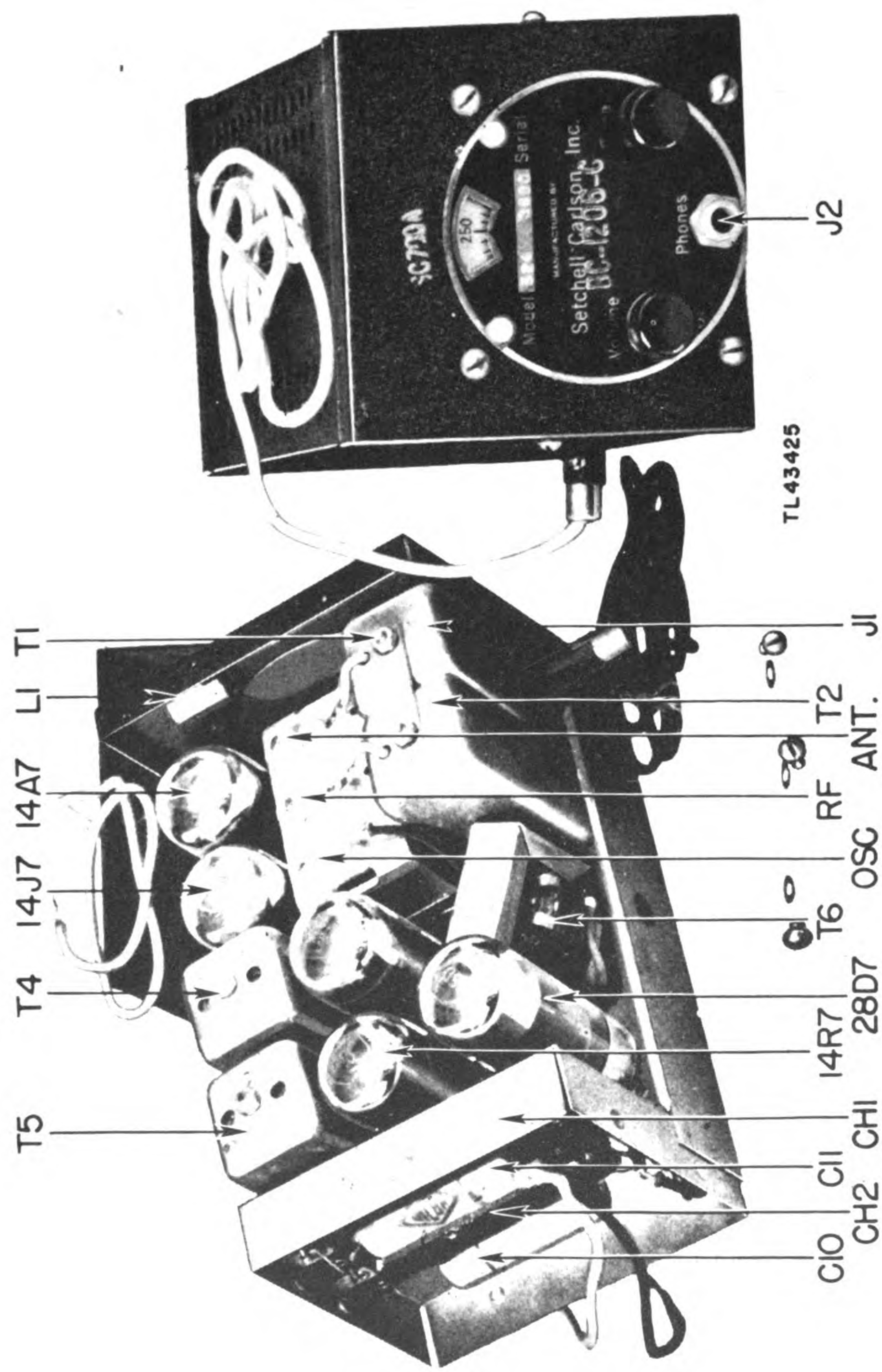

Figure 449. Tower Receiver BC-1206-C, top view.

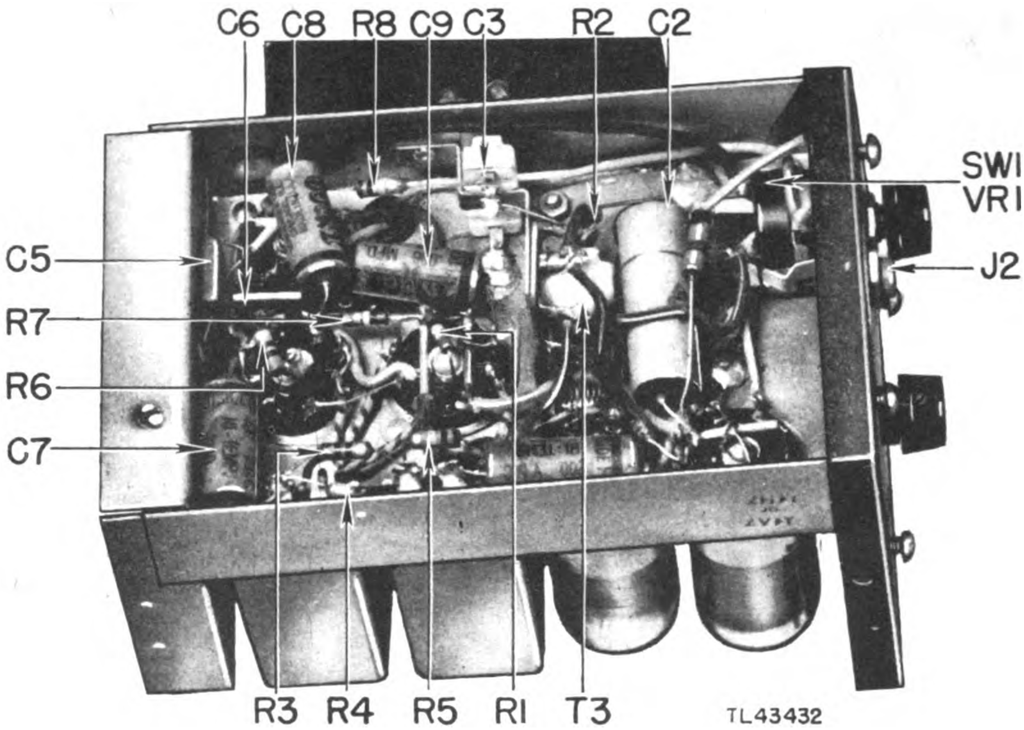

Figure 450. Tower Receiver BC-1206-C, bottom view.

257. ALIGNMENT OF COMMUNICATIONS AND INTERCOMMUNICATIONS.

a. Power. (1) Set power switch on all three RA-62 power supplies to 125-volt tap.

(2) Turn circuit breaker SW13, on power distribution panel, to ON position.

(3) In the A rack turn on all SCR-522-A power supplies. Be sure that the ON-OFF switch on Rectifier Unit RA-62 is on the ON position. Turn on all SCR-274-N power supplies. Be sure the cheater switch and the ON-OFF switch are in the ON position if the door is open.

b. To Tune Radio Set SCR-274-N. (1) Throw SW50 on Control Box BC-451-A to CW position.

(2) Screw down black knob on top of Control Box BC-451-A. This knob is to key the transmitter for CW use. Screwing down the knob keeps the transmitter on continuously.

(3) Turn the frequency control knob on the SCR-274-N transmitter being tuned, until dial reading corresponds to the crystal frequency as indicated by the printing on top of the crystal case.

(4) Open snapslide H52, and adjust C60, the master oscillator capacitor, until the resonance indicator tube V53 shows the widest shadow as seen in this mirror on the bottom side of lid above tube V53. This assures that tuning will be within 0.05 percent of correct frequency, across the entire tuning dial range. This is done to calibrate the dial with the crystal.

(5) Unlock controls, ANT. COUPLING, ANT. INDUCTANCE and ANT. FREQUENCY (also marked LOCK on knob) and lock again when adjustments are completed. Adjust antenna inductance for maximum current reading on antenna current indicator (part of BC-442-A). Adjust antenna coupling for maximum antenna current. By rocking back and forth between these two controls, maximum output is obtained.

(6) Repeat procedure (3), (4), and (5) for the two remaining transmitter groups.

(7) Release the turned-down knob on top of BC-451-A and turn microphone switch SW50 to the VOICE position.

c. To Tune SCR-522-A Transmitters. Standard procedure for tune-up of these transmitters and receivers is covered in Instruction Book for Operation and Maintenance, Army Air Forces T.O. No. 08-10-105, paragraph 9A and 9B. The only deviation used is in tuning the receivers. This tuning is done with audio and relay controls at full clockwise rotation; the radar interference can be substituted for a signal generator. By actual measurement, this gives the same sensitivity as with a signal

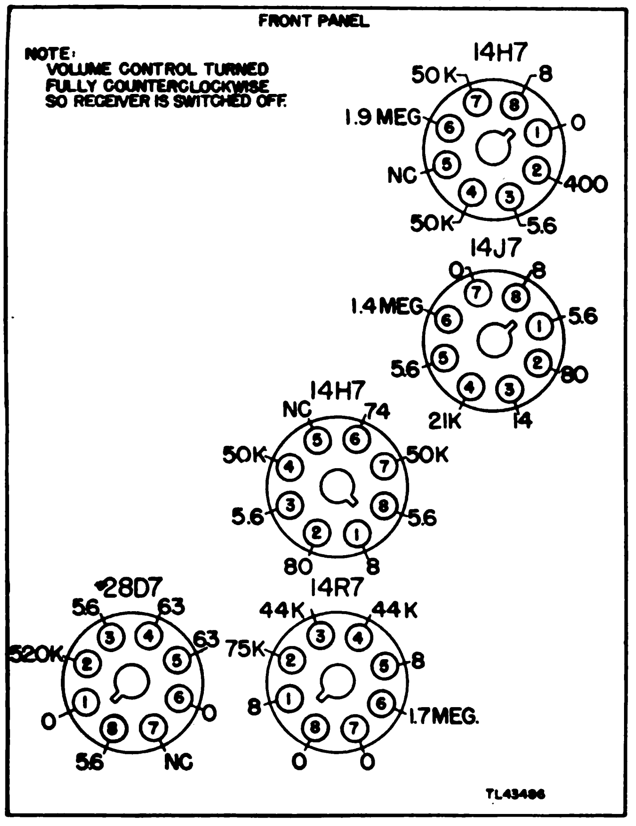

Figure 451. Tower Receiver BC-1206-C, resistance chart.

generator and is recommended. SCR-522-A is crystal controlled. To change frequency, change crystals.

d. To Check Receiver BC-342-N. (1) Turn OFF-ON switch to AVC position, and allow the receiver to warm up for at least 15 minutes.

(2) Check receivers sensitivity on all bands. First unlock the thumbnut on lower left-hand corner.

(3) Tune the receiver to approximately the frequency of its companion (SCR-274) transmitter. Listen to this receiver from PPI No. 1 position. Push the corresponding button on the intercommunications panel for the No. 2 PPI position. Press transmitter key on the BC-451-A. Tune receiver now to exact frequency of transmitter. This eliminates possibility of missing initial contact with the airplane, as the calibration of these receivers is by no means accurate.

(4) Repeat above procedure for the other two receivers.

e. To Set Up Intercommunication System. (1) Set microphone power supply switch in A position.

(2) Turn P11 in both search centrals and the microphone gain potentiometer in the approach indicator to maximum clockwise position.

(3) Plug the combination headset and microphone into the PPI No. 1 position, push intercommunication key and adjust gain potentiometer for No. 1 PPI position in approach indicator to a comfortable side-tone level.

(4) Repeat for the No. 2 PPI and for the controller's position.

f. Crosstalk. Check all channels, HF and VHF for crosstalk. Use two operators for this check.

g. Operation of Push Buttons and Keys. Check the operation of each button on the intercommunication system and in the controller's position on the approach indicator. Be sure the buttons control the proper transmitter and receiver.

(2) Push the transmit key and give test count, observing antenna current meter for modulation. Check on all HF channels.

(3) Repeat subparagraph (2) for all VHF channels, using a field intensity meter to observe modulation.

h. Setting Controls for Channels. Set up communications for operation as follows:

(1) HF communication No. 1 set for channel No. 1 (3375KC).

(2) HF communication No. 2 set for channel No. 2 (4250KC).

(3) HF communication No. 3 set for channel No. 3 (6905KC).

(4) VHF communication No. 1 set for channel A (149580KC).

(5) VHF communication No. 2 set for channel B (151740KC).

(6) VHF communication No. 3 set for channel C (154980KC).

i. Alignment of Tower Receiver BC-1206-C. The i-f stages and local oscillator of the tower receiver should be adjusted in the manner indicated in the chart (p. 632). The signal generator used for alignment must provide a modulated output signal with a band coverage of at least 135 to 400 kc. The i-f transformers, trimmers, and oscillator padder are adjusted for maximum output as measured with an a-c voltmeter from the audio output connection jack J2.

SECTION IV

AIR CONDITIONER MX-31/MP

258. REFERENCE DATA.

a. Figure 452. Motor input wiring of air conditioner.
b. Figure 453. Air Conditioner MX-31/MP, front view.
c. Figure 454. Air Conditioner MX-31/MP, side view.
d. Figure 455. Halide leak detector.
e. Figure 456. Halide leak detector, disassembled.
f. Figure 457. Compressor oil pump.
g. Figure 458. Compressor piston assembly.
h. Figure 459. Compressor body assembly.
i. Figure 460. Compressor discharge valve assembly.

259. PROCEDURE. The symptoms given in the trouble-shooting chart for the air conditioner (par. 260), as well as the corrective procedures are complete in themselves and do not require further explanation. Terms peculiar to the refrigeration industry have been used throughout this section. They are defined in paragraph 268. In addition to the trouble-shooting chart, considerable information on servicing and repairing the air conditioner will be found in paragraphs 261 through 267. Some of the operations and service instructions given are rather difficult to do in the field because of a lack of proper equipment. Hence, the rather technical service procedure following the trouble-shooting chart is, in the main, for the assistance of depot personnel.

260. TROUBLE-SHOOTING CHART FOR AIR CONDITIONER.

A. SYMPTOM:
1. High head pressure.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Receiver.	1*a*. Purge air or other noncondensable gas from receiver. *b*. Draw off excess gas into service drum.
2. Condenser.	2. Clean condenser of lint, caked dirt, or other obstruction.
3. Condenser fan.	3. Change fan-blade pitch. Increasing the pitch increases the air volume; decreasing the pitch decreases the air volume.

B. SYMPTOM:
1. Low head pressure.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Expansion valve.	1. Change valve adjustment if liquid refrigerant is flooding evaporator.
2. Thermal bulb.	2. Examine fastenings.
3. Discharge valve.	3. Test with gauges; if leaky, replace.

C. SYMPTOM:
1. High suction pressure.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Expansion valve.	1*a*. Regulate expansion valve to avoid overfeeding.
	b. Check thermal bulb attachment.
2. Suction valves.	2. Check for leaks. Remove head, examine valve disks and rings; replace if worn.

D. SYMPTOM:

1. Low suction pressure.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Liquid line and expansion valves or suction screens.	1. Pump down, remove, examine for restrictions, and clean screen.
2. Over-all system defect.	2*a*. Check for gas shortage at test cock.
	b. Check for excess oil. Remove if necessary.
3. Expansion valves.	3. Open valve. If this does not correct trouble, adjust valve to give more flow.

E. SYMPTOM:

1. Compressor noisy.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Compressor.	1*a*. Bolt down rigidly to foundation.
	b. Check oil level; check for oil at refrigerant test cock; check symptoms on oil chart. Too much oil in circulation may cause hydraulic knock.
	c. Determine location of worn parts such as piston, piston pins, etc. Repair, or replace compressor.
2. Expansion valve.	2*a*. Close valve if open too wide.
	b. Check to see if thermal bulb is correctly placed.
	c. Loop suction line so refrigerant will not flood back on off cycle. Flooding back of refrigerant causes slugging.

F. SYMPTOM:

1. Oil leaves crankcase.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Expansion valves.	1*a*. Readjust expansion valves; check thermal bulbs for proper mounting.
	b. Valves may be wire drawn on needle and seat from passage of vaporous refrigerant through valve due to low refrigerant charge. Back seat, or replace if necessary.
2. Piston.	2. Replace leaking piston rings or worn cylinder.

G. SYMPTOM:

1. Oil does not return to crankcase.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Oil check valve.	1. If valve is stuck, remove burrs on hinge pole.
2. Expansion valve.	2. Adjust valve to flood coil.

H. SYMPTOMS:

1. Motor fuse blows.
2. Overload relay trips.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Motor.	1*a*. Check fuse and overload heater element sizes against full load motor current. Install larger sizes if necessary within safe limit of motor. Use larger element if necessary, but not large enough to lower motor protection.
	b. Arcing or burned switch contacts may need replacement. Check carefully. Replace contacts or entire switch if necessary.
	c. Check voltages with voltmeter. If more than 10 percent low, correct.
2. Discharge valve.	2. Test discharge valve. Replace if leaky, to avoid heavy load on motor when starting up due to heavy pressure over piston.

I. SYMPTOM:

1. Motor hot.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Motor.	1*a*. Check voltage with meter; if more than 10 percent low, correct.
	b. Oil bearings to reduce friction.

J. SYMPTOM:

1. Compressor will not start.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Motor.	1*a*. Throw in switch.
	b. Clean contacts.

K. SYMPTOM:

1. Head gasket leaks.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Head gasket.	1a. Examine gaskets, replace if necessary.
	b. Tighten head bolts.
	c. Replace washers.
2. Crankcase.	2. Check flooding of refrigerant to crankcase. Examine for conditions on refrigerant and oil diagnosis chart.

L. SYMPTOM:

1. Cylinder and crankcase sweating.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Over-all system defect.	1. Examine for conditions on refrigerant and oil chart.

M. SYMPTOM:

1. Connecting-rod knock.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Connecting-rod bearings.	1. Replace bearings. Remove bearing cap and insert new liners. Do not file bearing caps.

N. SYMPTOM:

1. Motor does not start.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Motor condensers.	1. Check condenser located in box at top of motor. Replace if necessary.
2. Overload relays.	2. Reset relays.

O. SYMPTOM:

1. Direction of rotation of motor incorrect.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Wire connections in box at end of motor near condenser coil.	1. Rewire as shown in figure 452. The wiring at the top of the figure will cause the motor to rotate counterclockwise (looking at the motor from the pulley end). The wiring at the bottom will result in clockwise rotation.

261. GENERAL SERVICE OPERATIONS.

a. Replacing Belts. The following procedure should be carefully followed when removing and replacing belts:

(1) Remove the condenser fan guard.

(2) Loosen the compressor base bolts and slide the compressor slightly toward the motor.

(3) Remove the four cap screws which fasten the supply air fan to the motor pulley.

(4) Loosen the Allen setscrews in the motor pulley and slide it on the shaft toward the motor.

(5) Remove the belts by passing them first over the motor pulley, then over the condenser fan blades.

REFRIGERANT AND OIL DIAGNOSIS CHART

If	Expansion Valves	Suction Surges	Suction Line at Compressor	Crankcase	Cylinders	Comp. Disch. Line	Liquid Line	Test at Pet Cock	Compressor
Too much oil is in circulation in system	Appear to have lack of capacity	Hard to control	Warmer than line from expansion valve to coil but cooler than with correct oil circulation	At same or lower temp. than suction line, low back pressure	Warm to cool	Hot	May be cooler than outlet water temp.	Oily residue when refrigerant evaporates	Noisy
Correct amount of oil in circulation	Normal for load	Sharply defined	Warmer than line from expansion valve to coil	Warmer than suction line normal back pressure	Warm	Very hot	Outlet temperature	Slight or no stain when refrigerant evaporates	Normal
Too much liquid refrigerant circulating in system	Open to far	Hard to control	Cold	Cold	Cold	Warm or even cool	Cool	Oil residue when refrigerant evaporates	Slugs on start or stop
Too little refrigerant in system	Appear to have lack of capacity	No Surging	Approaching Room Temperature	Warm. Low back pressure	Warm	Hot	Warmer than outlet water temp.	Vapor, oil or both	Normal

(6) Install the new belts by passing them first over the condenser fan blades, then over the motor pulley. Always replace both belts, never just one. Use a matched set of belts.

(7) Slide the motor pulley to its former position and tighten the Allen setscrews.

(8) Connect the supply air fan to the motor pulley by means of the four cap screws.

(9) Adjust the belts for proper tension by sliding the compressor. If the condenser fan venturiplate strikes the fan when the compressor is moved, loosen the screws holding the venturiplate, slide the plate laterally until

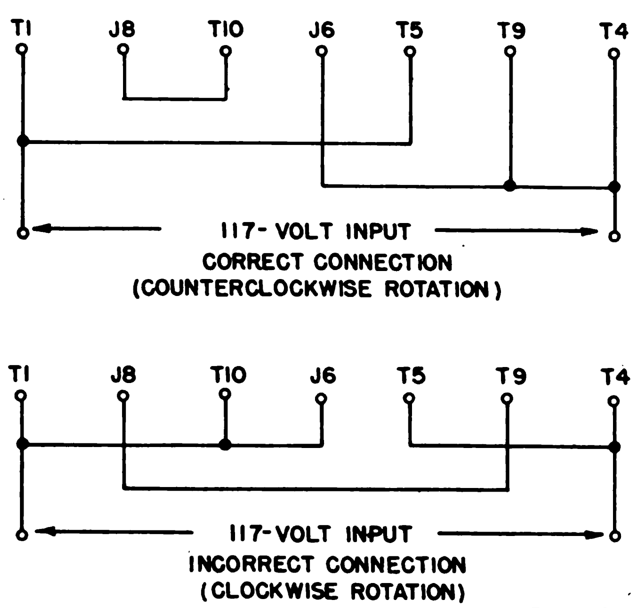

Figure 452. Motor input wiring of air conditioner.

it is clear, and then tighten the screws. Proper tension can be tested by depressing the top belt with a finger midway between the pulleys. For properly adjusted belts the depression will be about ½ inch.

charge in the system. The other connection or connections are then quickly made. If more than a few minutes must elapse during preparation after breaking connections, the free ends of the system should be plugged.

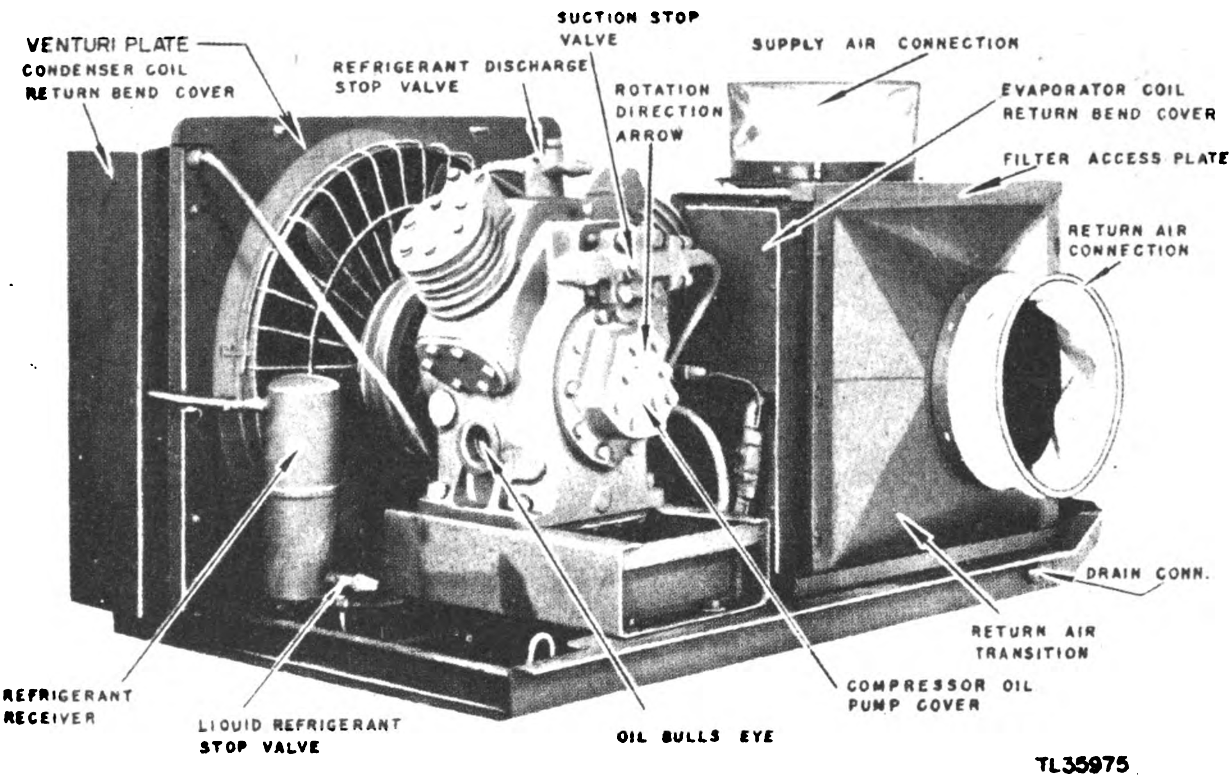

Figure 453. Air Conditioner MX-31/MP, front view.

*b. **Shut-down Precautions.*** It should be thoroughly understood that the greatest precautions must be taken to exclude air and moisture from a refrigeration system: that it should not be opened to the atmosphere without first removing the refrigerant, Freon-12, from that part of the system to be serviced. Whenever it is necessary to open the system in order to make repairs or replacements, the final evacuation should be to a pressure slightly above atmospheric pressure; that is, one to two pounds on the pressure gauge. (See pumping down instructions, paragraph 268). If the final evacuation reaches a pressure lower than 0 pounds on the gauge, sufficient refrigerant should be bled into the evacuated part of the system to raise the pressure to between one and two pounds. Connections are then broken and the replacement or the new part installed. One connection on the new part should first be made so that the air or other foreign gases in the part can be swept out through the free end by purging with refrigerant gas bled from the Refrigerant or oil charging lines, although of small size and short length, should be purged with refrigerant gas immediately before actual charging starts. An examination of any system will show that repairs cannot be made in the high side between the discharge stop valve and the liquid line shut-off valve without either losing the refrigerant charge or transferring it to an empty refrigerant cylinder. Since the receiver is provided with a stop valve at its inlet, the high side piping can be worked on by confining the charge of refrigerant in the receiver.

*c. **Adding Refrigerant.*** (1) Open the suction shut-off valve all the way, i.e., to its backseat. This shuts off the opening to the gauge plug, allowing removal of the gauge or plug.

(2) Insert a ¼-inch pipe to the ¼-inch flare fitting and attach it loosely to the end of a charging line or copper tubing which has previously been connected to the weighed refrigerant drum.

(3) Open the valve on the drum for a few seconds to allow gas to escape and sweep air from the charging line through the loose flare nut at the compressor stop valve. Then tighten the flare nut.

(4) With the machine running, screw in the stem of the compressor suction stop valve about two turns. Then use the refrigerant drum valve to control the flow of refrigerant, being careful to avoid any sudden rise of pressure as noted on the gauge.

(5) Periodically test for a showing of liquid refrigerant at the receiver test cock and charge an additional small amount after refrigerant first appears at the cock. Close the drum valve, backseat the suction stop valve, and disconnect the drum.

(6) Always charge with the drum valve up so as to avoid drawing out any foreign matter which may be in the drum.

NOTE: As refrigerant is taken from it, the pressure in the drum will finally drop to the level of the machine suction pressure. All the refrigerant can be removed by closing the suction stop valve completely, thereby pumping down the crankcase pressure to below atmospheric pressure and drawing a vacuum on the drum.

d. Removing Refrigerant. The refrigerant may be pumped into a service drum by disconnecting the liquid line from the liquid stop valve and plugging, after first pumping down the system. Connection to an empty refrigerant drum is made directly to the liquid line valve. Seldom, if ever, will it be possible to recover all of the refrigerant. Weigh the empty drum before filling and check occasionally to see that the net weight of Freon-12 is not exceeded. Standard cylinders hold 4, 10, 25, and 145 pounds of Freon-12, respectively.

CAUTION: In all service operations involving the transfer of refrigerant from one container to another, the flow will be from the higher to the lower pressure region. When all the liquid has been recovered, the refrigerant gas flowing into the service drum will have to be condensed by standing the drum in a barrel of ice water. Standard "Freon-12" cylinders must not be filled beyond their rated capacity, since there is danger of a rupture because of increased pressure due to a rise in temperature.

e. Testing Discharge Valve. Install a head pressure gauge and a suction gauge. Pump down the compressor crankcase to two pounds pressure. Stop the compressor, close the suction and the discharge valves quickly, and observe if the crankcase pressure rises and the lead pressure falls. If a valve is leaking, these pressures will change rapidly. The head pressure drop should not exceed about three pounds in 1 minute.

f. Cleaning Liquid Line Strainers or Expansion Valve Screens. Close the liquid line valve at the receiver, pump down the system to two pounds pressure and stop the compressor. Remove the refrigerant line and plug the tubing ends to exclude air. Remove the screens and clean them. Reinstall the screens, purge all lines, open the valves and start the compressor.

g. Test for Sufficient Gas. Liquid receivers are fitted with a liquid level test cock, and tests for sufficient refrigerant should be made at this point. With the unit running under normal load, open the liquid level test cock. If only vapor issues from the outlet, the system is insufficiently charged. A hot liquid line is also an indication of insufficient charge. The liquid line should be slightly warmer than the temperature of the surrounding air. Testing in this fashion requires experience and is not recommended over the more positive test cock method.

h. Test for Excessive Oil in Circulation. This test is made at the liquid level test cock. With a clean piece of white paper held against the opening of the petcock, turn the valve stem and allow a small quantity of refrigerant to spray on the paper. If a proper amount of oil is in circulation, the oily residue left on evaporation of the refrigerant should not produce a stain of greater intensity than that required to make the paper appear water-marked. The conditions listed in the oil diagnosis chart should also be investigated when testing.

i. Removal of Noncondensable Gases from System. Air and noncondensable gases collect in the receiver above the refrigerant. These can only be removed by purging. After the low side has been opened for servicing the compressor or the expansion valve, or the system has been opened for any reason, it is advisable to allow a small amount of gas to escape in order to carry away any air and consequent moisture which has entered the low side during the servicing operation. Purging is also necessary when the head pressure goes beyond the point shown as the normal pressure on the Freon characteristics chart (par. 267). To purge the system, close the discharge shut-off valve on the compressor to keep gas from leaving

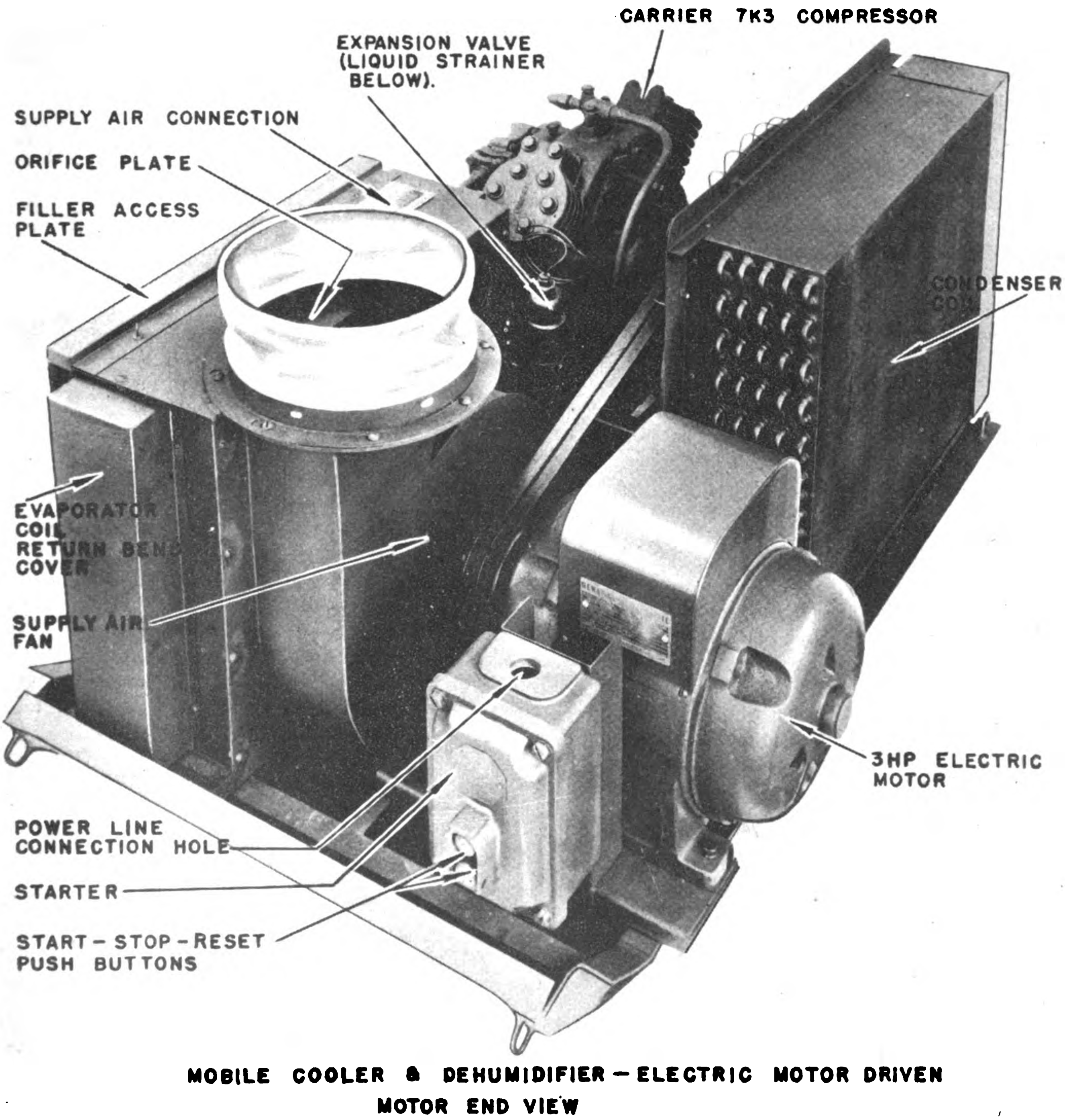

Figure 454. Air Conditioner MX-31/MP, side view.

the compressor body. With an end wrench, loosen the plug in the discharge shut-off valve sufficiently to allow a small amount of gas and air to escape for a period of about 5 and not more than 10 seconds. If the head pressure remains high, repeat the operation.

262. HALIDE LEAK DETECTOR.

a. Testing for Leaks. The most positive method for finding leaks is with the halide leak detector included in the tool kit. Testing with oil or soapsuds at joints will locate only the larger leaks and is therefore ineffective in determining the tightness of the system. In checking for leaks, place the end of the exploring tube at the joint or point of test and observe the color of the lamp flame. Small leaks give a greenish tint to the flame, while large leaks color the flame a vivid blue. Pressure is produced in the fuel tank by the heat generated when the alcohol is burned in the small cup under the burner. The alcohol vapor under pressure burns with a blue-tinted flame when mixed with air in the burner. The air used in the burner is drawn through the sampling tube. Therefore, any traces of Freon-12 mixed with the air drawn in through the tube are immediately evident. The gas decomposes when coming in contact with the heated copper flame-ring in the burner and colors the flame. The base cap of the torch (M) is also used as the filler cap (fig. 456). Unscrew this cap and fill the small tank (L) located under it with the special anhydrous alcohol provided. (Alcohols that contain solids will cause clogging, filling the fuel passages and thus impairing the operations of the torch.) Do not attempt to fill the torch too rapidly, as time must be allowed for the wick within the tank to soak up the fuel. If this fact is not taken into consideration, only a partial charge of alcohol will be obtained in the tank, thus cutting down the operating time for that particular refill. If possible, use a small-necked bottle for carrying extra fuel so that a funnel will be unnecessary. Under ordinary operating conditions, the torch will burn for about 45 to 60 minutes on a full charge. This operating time, of course, depends entirely upon the size of the flame, which is adjusted by the use of the small handwheel control valve on the side of the torch. To generate the torch, the small cup located directly under the burner should be half filled with alcohol and lighted. Allow this alcohol to burn away completely before attempting to make tests. When lighting the burner, be sure to open the valve a little. If the torch does not light at once, partially choke off the air supply through the sampling tube. This increases the richness of the mixture. When checking for very small leaks, throttle the flame, as the percentage of the sample drawn in through the sampling tube increases in proportion to the amount of fuel being consumed with the reduction of the flame size. At no time should the valve be opened to the extent that the flame flares out of the top of the chimney. Be sure that the base cap is screwed on tightly and also that the packing nut on the handwheel control valve is tight before generating the torch. A loss of pressure at these points will materially affect the operation of the torch.

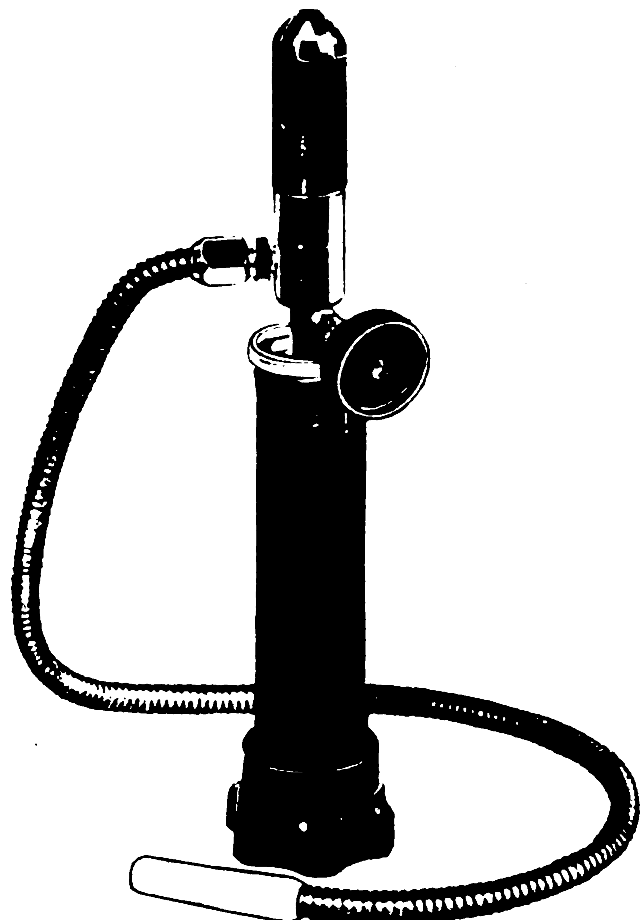

Figure 455. Halide leak detector.

b. Disassembling the Torch. (1) Remove the base cap (M) of the torch.

(2) Loosen the screw (P) in the side and at the bottom of the composition case (O), and remove the case from the torch.

(3) Place one end of the fuel tank (L) and the hexagonal section of the generator valve assembly (H) in a vise. Unscrew the tank with a wrench placed on the bottom or filler end. Tighten the vise only enough to prevent the hexagonal end from turning. Do not draw up too tightly.

(4) Remove the wick with the perforated metal shield on the upper end of it (K). This is most easily accomplished

by using two scratch awls, or other pointed tools, opposite each other; allowing the points to engage in the holes of the perforated brass shield; then, with a prying action, pull out the wick assembly. Above this wick is a coarse screen (J) and a fine mesh screen (I). After these screens are removed, the fuel supply hole in the generator valve assembly will be visible. This hole leads up through

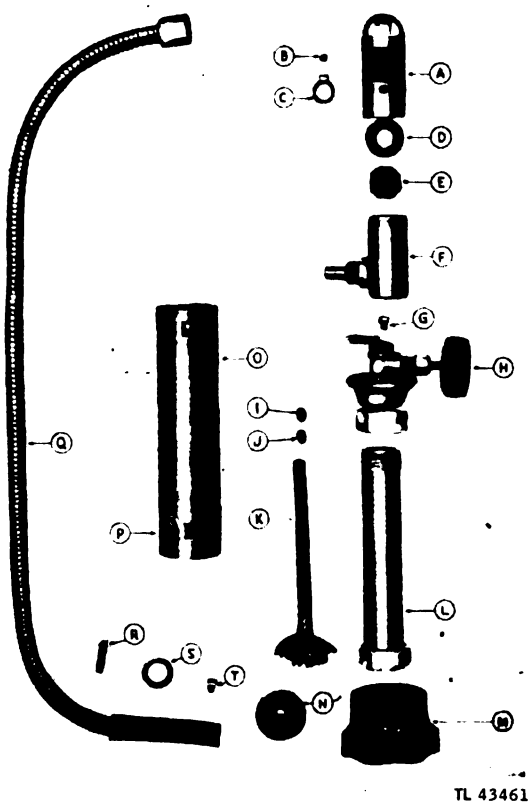

Figure 456. Halide leak detector, disassembled.

the valve to the small jet or fuel outlet (G). To remove this jet, use a standard 1/4-inch suction valve key.

(5) After the jet is removed and the control valve is opened several turns, there should be no restriction to the flow of fuel or air through this passage. To clean the passage, back the valve needle off the seat several turns or remove the needle altogether. Use a small drill, not over No. 52 in size, or a small wire to clear away obstructions. If the torch, however, fails to allow fuel to pass through the fuel jet after generating, remove the jet and replace it with the extra one (T) carried in the base cap of the torch under the small brass disk (N). If no time is lost in effecting this change over, the torch may be lighted without another generating operation. Under the brass disk in the base cap there is also an extra washer (S) for the base cap and a jet cleaning wire (R). A clean jet should always be kept in the reserve location under the brass disk.

CAUTION: Do not try to clean the jet while it is assembled in the torch. This will merely push foreign substances back from the orifice and allow them to return to the jet when the valve is opened. A complete disassembly of the torch should not be required if the proper alcohol is used. At no time should a rubber stopper be used on the alcohol container.

263. COMPRESSOR LUBRICATION. This discussion on compressor lubrication is offered as a guide in maintaining the proper oil level in the compressor. The compressor oil levels for the type 7K3 unit here used are as follows:

Factory oil change	4 pts.
Oil level, lowest speed	1/3 bull's-eye
Oil level, highest speed	1/3 bull's-eye
Minimum oil level, machine standing 15 minutes	1/2 bull's-eye

These are average values; if it is observed that the oil level is slightly lower than listed, it does not necessarily follow that there is insufficient lubrication if a good visual splash can be observed through the bull's-eye. It is only when splash is poor that trouble results. Should oil be added to a unit which already has an excess of oil in the system (determined by the test at the refrigerant test cock on the receiver), paradoxically it will tend to lower the oil level in the crankcase rather than raise it. This is due to the fact that when oil returns to the crankcase it always contains some refrigerant, which causes foaming upon entering the warm crankcase; therefore, the more oil the more foaming, and hence the increased loss. There is one important condition which must be maintained and that is, the temperature of the crankcase. This must be somewhat warm. While the crankcase may be chilled for a short period after a machine is started up from a long shutdown, it should warm up in 1/2 hour and should eventually run at a temperature of around 105° F., which is slightly warm to the touch. Under some conditions it may run hotter than this but should not run colder. A crankcase which is running colder than normal is an indication of one or both of two conditions: expansion valves adjusted with too little superheat, or excessive oil in the system. If the crankcase is running cool, the oil level will always be lower than it would be if the crankcase were at normal temperature. The reason for this is that the refrigerant which is evaporating from the oil in the crankcase is cooling it and causing the oil to foam, thus carrying it out into the system. At the same time the refrigerant is maintaining a pressure on the crankcase in excess of the suction pressure, preventing the return of oil at the proper rate, as described above. To correct a low oil level condition, check the expansion valve setting for the correct superheat. A final check of the expansion valve setting should be made to make sure the compressor cylinder walls are warm to the touch, with no perceptible chilling particularly at the point directly above the bottom flange where they attach to the crankcase. If there is only a small amount of superheat, or if the crankcase is running cold with a normal superheat, it may be advisable to increase the superheat temporarily in order to facilitate the return of oil to the crankcase. The next step is to remove the excess oil from circulation. It can be said at this point that any oil which cannot be retained in the crankcase is excess oil and should be removed from the system. The best way to remove the excess oil is to loosen the oil drain plug in the compressor crankcase and allow the lubricant to bleed out slowly while the compressor is running. The rate of removal should be about one quart per hour. As the oil is drained from the crankcase, it will be replaced by oil dropping out of circulation from the system. As the amount of excess oil is gradually reduced, there will be a noticeable rise in the crankcase level despite the fact that the oil is being removed from the crankcase. The process should be continued until there is no more than a slight trace of excess oil in the system. To check this, place a finger or a piece of clean white paper near the opening in the liquid test cock on the receiver. Open the test cock to allow a small amount of refrigerant to spray on the finger or the paper. Unless the amount of oil in the system is excessive, only a slight trace should be detected when the refrigerant evaporates. When this procedure is followed slowly enough to allow ample time for the oil to return to the crankcase, the oil should rise to a normal level in the crankcase at about the time that all excess oil has been removed. If it has not done so, it may still be assumed that the oil level is high enough to maintain satisfactory operation of the compressor. No advantage will be gained by allowing excess oil to circulate in the system, and the removal of oil should by all means be carried out until this excess is eliminated. There is, however, one point which might be mentioned in connection with this compressor. The machine will, after a shutdown of any duration, lose considerable oil, sometimes to the point where splash almost ceases. It may be anywhere from 20 minutes to 1 hour before the oil will begin to return, depending on how much refrigerant has been absorbed in the crankcase during the shut-down period. It should not be alarming, as it happens on every normal installation.

a. Adding Oil. The most direct way of adding oil to a compressor is to pump down by slowly closing the suction stop valve, until the crankcase pressure remains at two pounds. Unscrew the oil filler plug found near the top of the crankcase and pour in oil from a sealed container. Use heavy medium dehydrated oil. By reference to the compressor oil levels given at the beginning of this paragraph, an idea will be obtained as to how much oil should remain in the crankcase for good lubrication; and although some oil may be in circulation, it will normally be only a fraction of the quantity in the crankcase.

b. Removing Oil. To remove oil from the crankcase of a compressor, reduce the pressure in the crankcase to two pounds by gradually closing the suction shut-off valve. Stop the compressor. Open the oil test plug or loosen (do not take out) the drain plug in the compressor body and allow the required amount of oil to drain out.

NOTE: Since the crankcase is under slight pressure, do not fully remove the drain plug from the compressor, but allow the oil to seep out around the threads of the loosened plug. Retighten the drain plug, open the suction shut-off valve, and restart the compressor.

c. Oil Pump. The forced-feed system of lubrication is used. The pump on the end of the compressor shaft opposite the flywheel is precision machined and is seldom repaired in the field. The pump is an integral assembly

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Figure 457. Compressor oil pump.

of the compressor and is mounted on the end cover plate. Its shaft fits into a slot in the end of the crankshaft. The oil pressure should register a minimum of 20 pounds over the suction pressure. In other words, a gauge attached to the pump will register the sum of the suction pressure and the oil pressure. For example, if the suction pressure is 40 pounds, the oil pressure gauge should read at least 60 pounds, and not over 70 pounds. Readings should be taken after a few minutes running time.

264. COMPRESSOR SERVICING.

a. Removing Discharge Valve. (1) Pump down the crankcase by gradually closing the suction shut-off valve until a crankcase pressure of two pounds has been reached.

(2) Stop the compressor.

(3) Close the discharge shut-off valves.

(4) Remove the plug from the gauge tap of the discharge shut-off valve and relieve the pressure in the head of the compressor.

(5) Remove the compressor head bolts, lift off the head, and remove the discharge valve.

(6) Replace the valve and compressor heads, using new gaskets.

(7) Open the suction shut-off valves slightly to purge the head of the compressor.

(8) Replace the gauge tap plug.

(9) Open the discharge shut-off valve.

(10) Open the suction shut-off valve and start the compressor.

b. Removing Compressor Body. (1) Close the suction shut-off valve gradually until a crankcase pressure of two pounds has been reached.

(2) Stop the compressor and close the discharge shut-off valve.

(3) Remove all bolts from the suction and discharge shut-off valves.

(4) Withdraw the compressor.

(5) Replace the compressor body with a new one and attach the suction valve.

(6) Attach the discharge valve or head fitting loosely; purge the compressor by opening the suction valve slightly; then fasten the discharge valve or head fitting.

(7) Open the discharge and suction shut-off valves.

(8) Start the compressor.

c. Testing Shaft Seals for Leaks. Shaft seals sometimes show indications of leaking immediately after installation. There are several causes that would indicate a leak even though the seal holds perfectly. At the time the seal cover plate and the old seal assembly are removed, oil-containing refrigerant may have leaked around the housing or on the shaft. This will be sufficient to give a strong indication of leaks. During operation, the seal assembly is covered with oil which lubricates the bearing surface of the seal and also prevents leakage of refrigerant. If the seal is assembled dry, that is, without first dipping the nose in oil, it is possible that a slight leakage may occur until the compressor has made a few revolutions and has filled the seal housing with oil. Always dip the seal nose in clean refrigerator oil before assembling the parts in the compressor.

d. Repairing Seal Leak. While it is possible to repair a scored or scratched shaft seal by lapping with jeweler's rouge and oil on a lapping plate, the replaceable seal used here is so designed that the seal bellows, or shoulder, may be replaced quickly. It is considered a surer method of repairing, to replace the seal assembly or separate seal parts when required rather than to attempt to relap them. Relapping is more easily accomplished in a shop properly equipped for such work.

(1) Before attempting to replace a seal, study the exploded views (figs. 458-460) of the compressor. Note the order in which the seal parts are assembled to the compressor body.

(2) Reduce the crankcase pressure to two pounds by gradually closing the suction shut-off valve. Stop the compressor and close both stop valves. Remove the flywheel and seal cover plate. Remove the seal parts. Wipe out the seal recess with a clean lint-free cloth. Next insert the neoprene gasket in the recess in the seal shoulder, and, holding the shoulder face down, dip it in a clean volatile oil solvent. Allow the solvent to dry off and then dip the shoulder in clean compressor oil.

(3) Slide the shoulder on the shaft, being as careful as possible not to touch the bright surface.

(4) Next, follow the same procedure with the nose or bearing surface of the seal bellows assembly, having first seated the back of the seal assembly into the recess in the cover plate.

(5) Place the lead gasket over the seal and slide the whole assembly over the shaft and against the shoulder previously installed.

(6) Insert all cover plate bolts and pull the cover up to a seat against the lead gasket.

e. Cleaning Suction Strainers. (1) Reduce the crankcase pressure to two pounds by gradually closing the suction shut-off valve.

(2) Stop the compressor.

(3) Close the discharge shut-off valve.

(4) Remove the strainer and plate by removing the bolts holding it to the strainer body.

(5) Remove the strainer and clean the screen, using a small brush carbon tetrachloride or a similar solvent.

(6) Dry the strainer screen thoroughly and replace it in the strainer body.

(7) Purge the strainer cavity by opening the suction shut-off valve slightly and replace the strainer end plate.
(8) Open the discharge and suction shut-off valves and start the compressor.

265. GENERAL PRECAUTIONS.

a. Importance of Dehydration. Too much emphasis cannot be placed on the importance of perfect dehydration of any installation. Failure to remove the last traces of moisture or to prevent the admission of moisture during servicing operations inevitably leads to trouble. Slight excess of water in a Freon system will result in the formation of an acid condition that may lead to:

(1) Severe corrosion of steel parts.

(2) Intercrystalline corrosion of the bellows used in seals and expansion valves.

(3) Copper plating of the shaft and bearing.

(4) Slugging or gumming of the oil.

(5) Plugging of strainers because of corrosion and break down of particles.

(6) Freezing and plugging of the expansion valves; and numerous other troubles.

b. Use of Alcohol. The introduction of alcohol or other similar commercial preparations for the purpose of overcoming freezing trouble at expansion valves due to moisture in the system, is to be severely criticized. The cure leads to trouble worse than the cause.

c. Dirt in Compressor. This is a difficult problem owing to the use of steel coils and piping. Particles of mill scale will pass through the fine mesh screens used in suction scale traps and strainers, and these must often be augmented by felt strainers until the system has been thoroughly run in and this loose material has been accumulated at the liquid strainer where it may be removed.

266. SERVICING THERMAL EXPANSION VALVE.

The thermal expansion valve is controlled by pressure differential between the vapor pressure in the evaporator and the vapor pressure in the thermal bulb. Since the thermal bulb is in thermal bond with the suction line, the vapor pressure in the bulb is a function of the suction line temperature. Since the valve operates on a pressure differential, it cannot be set to produce a fixed evaporator pressure. Under the action of the thermal valve, the evaporator pressure will vary in the direction of load increase or decrease. To make the valve operative, since it works through pressure differential, it is necessary that the pressure in the thermal bulb be somewhat higher than the pressure in the evaporator, which means that the suction line where the bulb is clamped must be at a higher temperature than that within the evaporator. Hence, the vapor in the suction line at this point must be in a somewhat superheated state. This superheat should be at the minimum which will allow the valve to regulate. The amount of superheating will, in general, vary between 5 and 10 degrees. Excessive superheat indicates lack of sufficient refrigerant flow through the expansion valve, reducing the capacity of the evaporator. The sensitivity and response of the thermal expansion valve is largely dependent upon the proper installation of the thermal bulb. The thermal bulb should always be firmly clamped to the suction line. A telephone or radio ground clamp makes an excellent means for attaching the bulb to the suction line and assures a thorough contact. A thermal expansion valve of sufficient capacity will maintain all the evaporator surface effectively in contact with a boiling refrigerant, regardless of the change in load on the evaporator. Under normal conditions, the thermal bulb will cause the expansion valve to close during the shut-down period. There are, however, certain conditions that will affect this and may permit overflooding of the evaporator. For this reason, suction lines are trapped. In this unit, the evaporator and thermal bulb are under the same conditions of temperature and pressure. Hence, the valve will remain closed during shut-down periods.

a. Thermal Expansion Valve Adjustment. Grasp the suction line at least 18 inches beyond the location of the thermal bulb; gradually adjust the valve with the other hand. When the valve is properly adjusted, a slight surge in temperature, appearing with a regular cycle, will be noted. The rise in temperature is slower than the drop in temperature. Actual overflow of liquid is evidenced by a sharp and very quick drop in temperature; also by the usual evidence of sweating of the compressor crankcase and oil slugging at the start of the running period. This must not be allowed. See the oil diagnosis chart.

267. CHARACTERISTICS OF FREON-12.

a. Odor. Faintly sweet, resembling carbon tetrachloride cleaning fluid. There is no odor in concentrations of less than 20 percent by volume of air.

b. Color. Colorless.

c. Physical Properties. Gaseous at atmospheric pressure and at room temperature. It liquefies at a pressure of about 75 pounds per-square-inch. It is nontoxic, nonirritating, nonexplosive, and noninflammable. It will not corrode iron, steel, copper, brass, or any other common metal or alloy. It decomposes, however, in the presence of fire to form an irritant gas; therefore, care should be taken not to release a large quantity of concentrated refrigerant where a torch is being used for repair or soldering operations.

FREON CHARACTERISTICS CHART

Temperature in degrees F.	Gauge pressure lb sq in	Volume vapor cu ft lb
–20	0.58	2.47
–14	2.85	2.17
–10	4.50	2.00
– 4	7.21	1.77
0	9.17	1.63
5	11.81	1.48
10	14.65	1.35
14	17.10	1.25
20	21.05	1.12
24	23.88	1.04
30	28.46	.93
34	31.72	.87
40	36.98	.79
44	40.70	.74
50	46.69	.67
54	50.93	.63
60	57.71	.57
64	62.50	.54
70	70.12	.49
74	75.50	.46
80	84.06	.42
84	90.1	.40
90	99.6	.36
94	106.3	.34
100	116.9	.31
110	136.0	.27
120	157.1	.24
130	180.2	.20

268. REFRIGERATION TERMS.

a. Pumping Down. Whenever a refrigeration system is to be opened to the atmosphere for service operations or repairs, it is necessary to remove the refrigerant from the part of the system to be opened. The refrigerant is confined to the receiver by closing the liquid line stop valve and (with a gauge attached to the suction stop valve) operating the machine. Thus all the gas is drawn back to the compressor and condensed in the condenser, but is prevented from going further by the liquid stop valve. Final evacuation of the "system" should be to a pressure of one to two pounds, so that when it is opened temporarily the slight gas pressure will permit a small amount of refrigerant to escape and prevent the entrance of air at the opened port. When performing this operation, first pull the gauge pressure down to about 5 inches of pressure and stop the machine. The gauge pressure will build up quite rapidly. When it reaches the 0 pound level, start the machine again, and pump down again to about 5 inches. The build-up will be slower and finally, if the operation is timed correctly, will rise to slightly over 0 and stay there several minutes. If by chance the pressure will not rise to 0 or slightly above, sufficient gas can be admitted to the system by quickly opening and closing the liquid stop valve, building the pressure up to the desired point. If the low pressure safety control is set above the 0 pound level, it will be necessary to hold the pressure control contacts closed by hand in order to permit operation of the machine. In order to confine refrigerant to the condenser, close the compressor discharge shut-off valve.

b. Backseating a Valve. The compressor discharge and suction stop valves are usually provided with a double seating valve and a gauge tapping. Turning the valve stem all the way to the right (forward) closes the outlet of the valve, and in this position the gauge connection is open to the pressure in the compressor. Turning the valve stem all the way to left (out) backseats the valve, and closes off the gauge connection. Therefore, when attaching a gauge or charging line to the gauge opening, the valve must be back-seated to prevent escape of refrigerant from the gauge tapping.

c. Charging. Charging is the addition of refrigerant to a system from an external drum.

d. Purging. Purging is the release of air or noncondensable gases from a system through a cock placed near the top of the receiver. It also denotes the sweeping of air out of a newly installed part or connection by releasing refrigerant gas into the part and allowing it to escape from the open end, thus pushing the air ahead of it.

e. Gas. Gas, as referred to, is a refrigerant in either the liquid or gaseous state.

f. Slugging. Slugging refers either to the liquid refrigerant returning to the compressor and thereby causing the valves to be noisy, or to the oil that is pumped out of the compressor crankcase or returned to the compressor in a solid mass which causes knocks in the compressor.

g. Low Side. The low side is that part of a system lying between the expansion valve and the suction valve in the compressor. It includes the evaporating or cooling surface, the suction line, and the compressor crankcase. It also indicates the portion of the equipment under suction pressures. The term is sometimes used to designate the evaporator coils.

*h. **High Side.*** The high side is the remainder of the system, i.e., that part of it which is under high pressure. It sometimes means the condensing unit.

*i. **Low Pressure Control.*** The low pressure control is an electrical contact device operated from the suction line pressure which acts to prevent compressor operation when the suction pressure falls below a predetermined point. It is used either as an operating control or a safety control.

*j. **High Pressure Control.*** The high pressure control is an electrical contact device operated by head

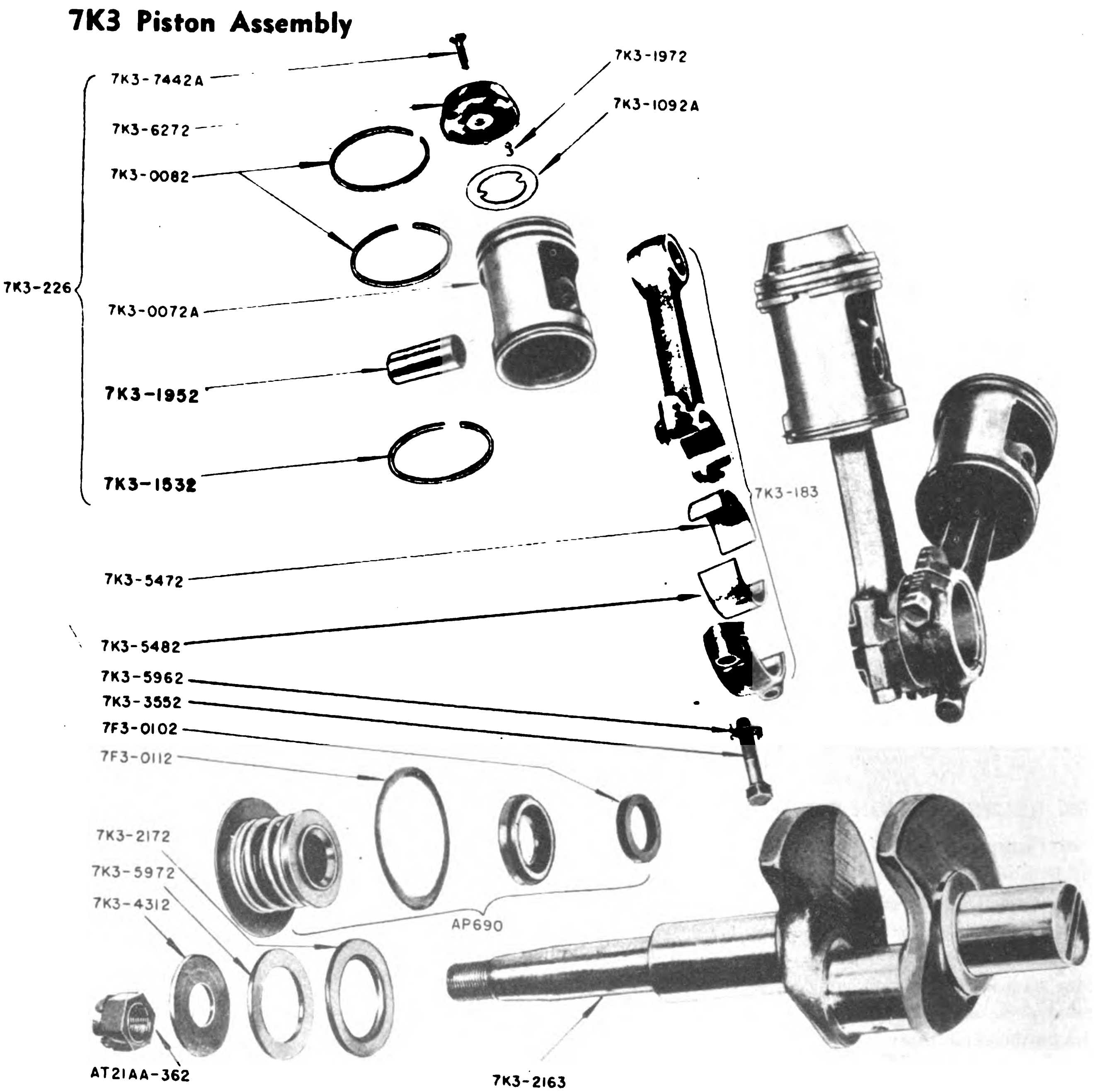

Figure 458. Compressor piston assembly.

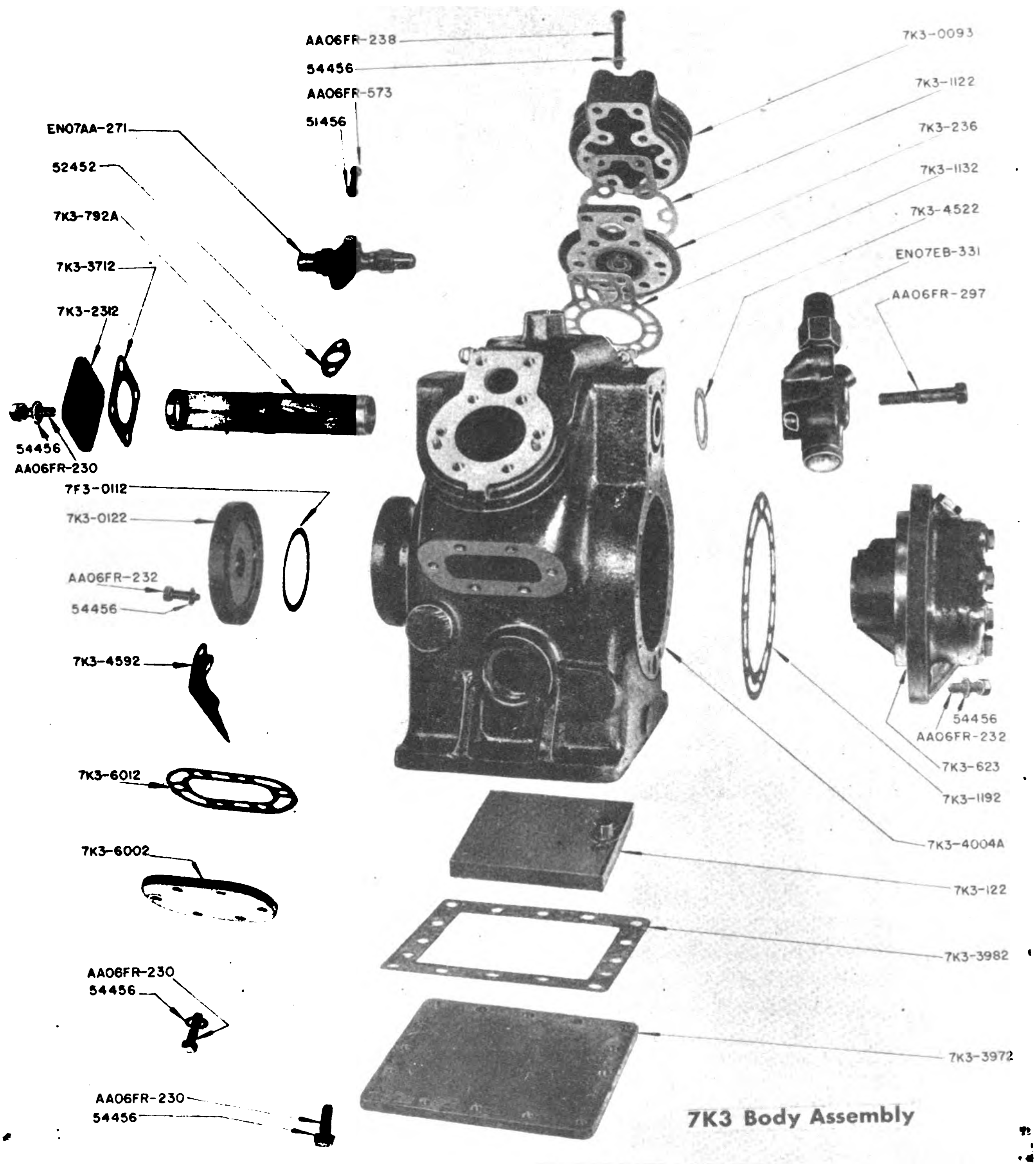

Figure 459. Compressor body assembly.

pressure and acting as a safety control to prevent damage to the compressor in case of dangerously high head pressure.

k. ***Frosting Back.*** Frosting back is the appearance of frost on the suction line, extending as far back as the compressor.

l. ***Saturation.*** Saturation is the condition of the gaseous refrigerant in the presence of boiling liquid at a given pressure. In tables of refrigerant properties, corresponding temperatures and pressures are given at the saturation point.

n. ***Wire-drawn Valves.*** Wire drawing is an erosive effect generally caused by leakage of vapor or gas through an opening, such as in a valve not in secure contact with the seat. This erosion can be largely eliminated by securely closing valve on the seat each time it is operated.

m. ***Superheat.*** Superheat is additional heat beyond that required to produce saturation at any specific pressure. It is usually spoken of in terms of degrees Fahrenheit above saturation temperature. For example, from the table of Freon properties it is seen that the temperature corresponding to 81.06 pounds gauge pressure is 80° F. Should a temperature measurement of refrigerant at 81 pounds pressure show 90° F., the gas would be said to have 10 degrees of superheat.

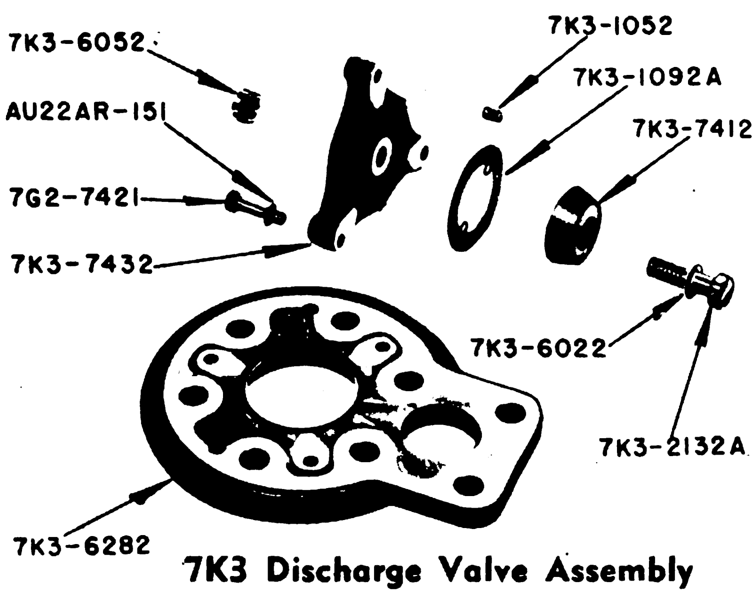

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Figure 460. Compressor discharge valve assembly.

SECTION V

HYDRAULIC LEVELING SYSTEM

WARNING: ***Never lift the rear of the trailer sufficiently with the hydraulic jacks to take all of the weight off the back tires. The jacks are not braced laterally and the entire trailer can slide sideways. This will force the jacks against the trailer body causing bending or breaking of the jacks.***

269. REFERENCE DATA.

a. Figure 247. Hydraulic leveling system, block diagram.

b. Figure 461. Hydraulic jack in place.

c. Figure 462. Hydraulic pump motor.

d. Figure 463. Hydraulic system control box.

270. SPECIAL INFORMATION. When it is necessary to add oil to the hydraulic system, it is important that the oil added be of the same grade and brand as that originally used in the system. Different kinds of oil should not be mixed as they may have a different base and consequently cause corrosion or gumming of the hydraulic system. The hydraulic system of Radio Set AN/MPN-1 has been filled at the factory with General Petroleum No. 230 White Oil. Should it be necessary to add another brand of oil, it is recommended that the entire hydraulic system be drained, flushed, and completely refilled with the new oil. The characteristics of the oil used must be such as to maintain a viscosity of SAE-10 at ambient temperatures from –50 degrees to +140 degrees.

271. TROUBLE-SHOOTING CHART FOR HYDRAULIC LEVELING SYSTEM.

A. SYMPTOM:

1. Leaks as indicated by change in spirit level reading (a slight amount of oil on the pipes and parts is not only permissible but desirable).

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Pipe connections between pump and manifold and from manifold to leveling jacks.	1*a*. If any leaks appear at the joints, tighten those affected with a pipe wrench. These are tapered ½-inch thread pipe connections, and should be firmly seated. *b*. If further tightening is impossible, or tightening proves ineffective, place the main hydraulic drive control in the neutral position to back off the pressure within the lines. *c*. Loosen the pipe connection with a pipe wrench; apply Normal No. 30, or equal, sealing compound and retighten the joint as far as it will go.
2. Flexible wire-wound hose connections to the hydraulic jacks (fig. 461).	2. If a hose is damaged, replace as follows: *a*. Back off the pressure in the system by keeping the main valve in neutral position. *b*. Remove the sleeve union at both ends of the hose from the pipe connection. *c*. Remove the union from the hose, and install on the replacement hose. *d*. Connect the new hose, making certain that the unions are tightly connected to the hose and to the piping. Apply sealing compound, Normal No. 30, or equal, as previously indicated in 1*c*. above.
3. Hydraulic jack control valves.	3*a*. Examine the Crane No. 232 H type hydraulic jack control valves (fig. 463) for leakage at the seat. *b*. In case any slight leakage of oil is noted, tighten the cap over the valve gland with a hexagonal wrench.
4. Insufficient oil in system.	4*a*. Occasionally it will be necessary, after replacing a hose or repairing a leak, to refill the system with oil (par. 270). Open the petcock at the side of the sump. Open the pipe cap at top of the master valve. Pour the oil in carefully to prevent excess air from entering the system. *b*. Bleed out all air in the system by working the jacks up and down. Otherwise, jacks will lose pressure by air leaking out gradually. WARNING: Keep all dust and dirt out of the oil or it may seep into valve stem and cause leakage.
5. Jack cylinder.	5. If above checks do not clear the fault, a jack cylinder may have become defective, causing a leak. Replace with new jack, follow-

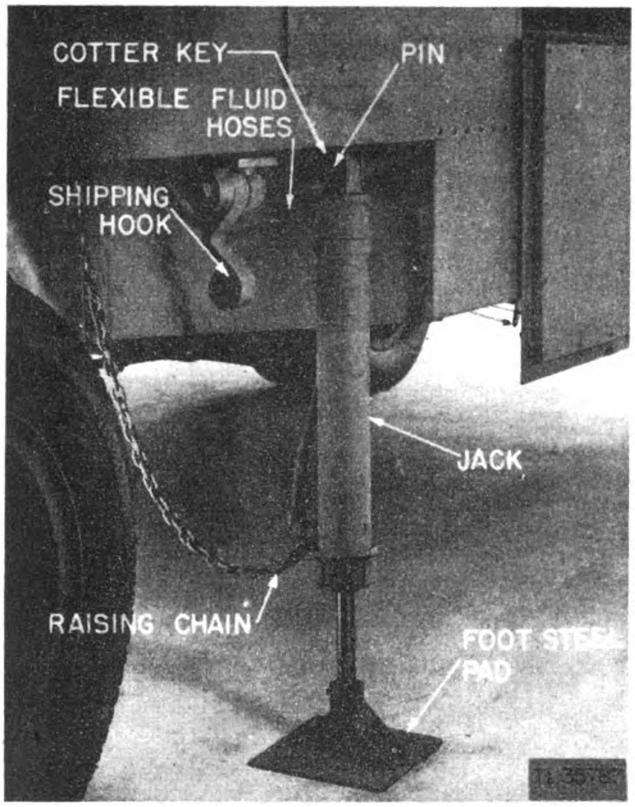

Figure 461. Hydraulic jack in place.

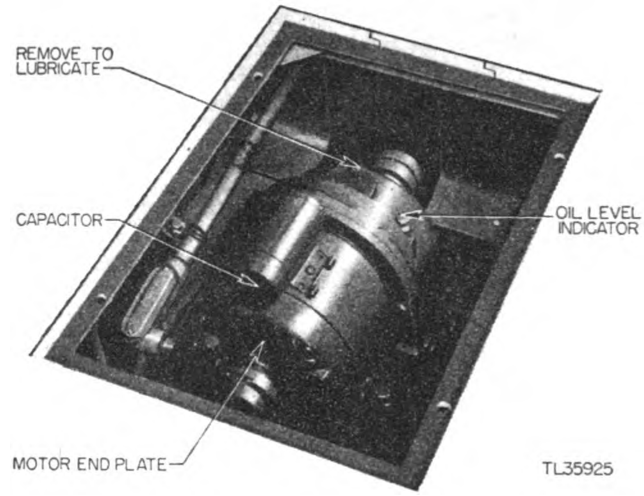

Figure 462. Hydraulic pump motor.

ing procedure given in item 2. Be sure that the connections of jack to pipes are correct. Top of cylinder is connected to the high pressure line. Jacks should be perpendicular at start of action or jack may break. The fifth wheel must be in neutral position when operating jack on pin or the fifth wheel will be damaged.

B. SYMPTOM:

1. Irregular action of leveling.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Air bubbles in system.	1. Run jacks up and down. Put pressure on them to gradually force air out. This operation takes some time.
2. Shortage of fluid.	2. See symptom A, item 4.
3. Pressure regulator.	3*a*. Take off cap cover of pressure regulator screw. Loosen locknut. Screw slotted screw in to increase pressure and out to decrease pressure. *b*. Sticking of pressure regulator may be caused by broken spring or foreign material under seat of regulator ball. Clean or replace the regulator.
4. Leaking oil line.	4. See symptom A.
5. Faulty pump.	5. This will be a rare case because of the positive action of the pump. But foreign matter in the oil may cause faulty action in the pump. Flush out the oil and replace with new oil.

C. SYMPTOM:

1. Overheating of motor.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. Friction in gear head or motor (fig. 463).	1*a*. Hand test of heat will indicate any existing friction. *b*. Lubricate if necessary. *c*. Disconnect coupling between pump motor and pump. If motor now runs without overheating, the pump system is at fault.
2. Defective pump.	2. This would be a rare case because of the positive action of pump. Fault may be caused by foreign matter in oil, or excessive wear.
3. Defective motor.	3*a*. Windings of motor may be shorted. *b*. Frozen bearing or defective parts will cause motor to stick. Replace part as needed or replace motor.

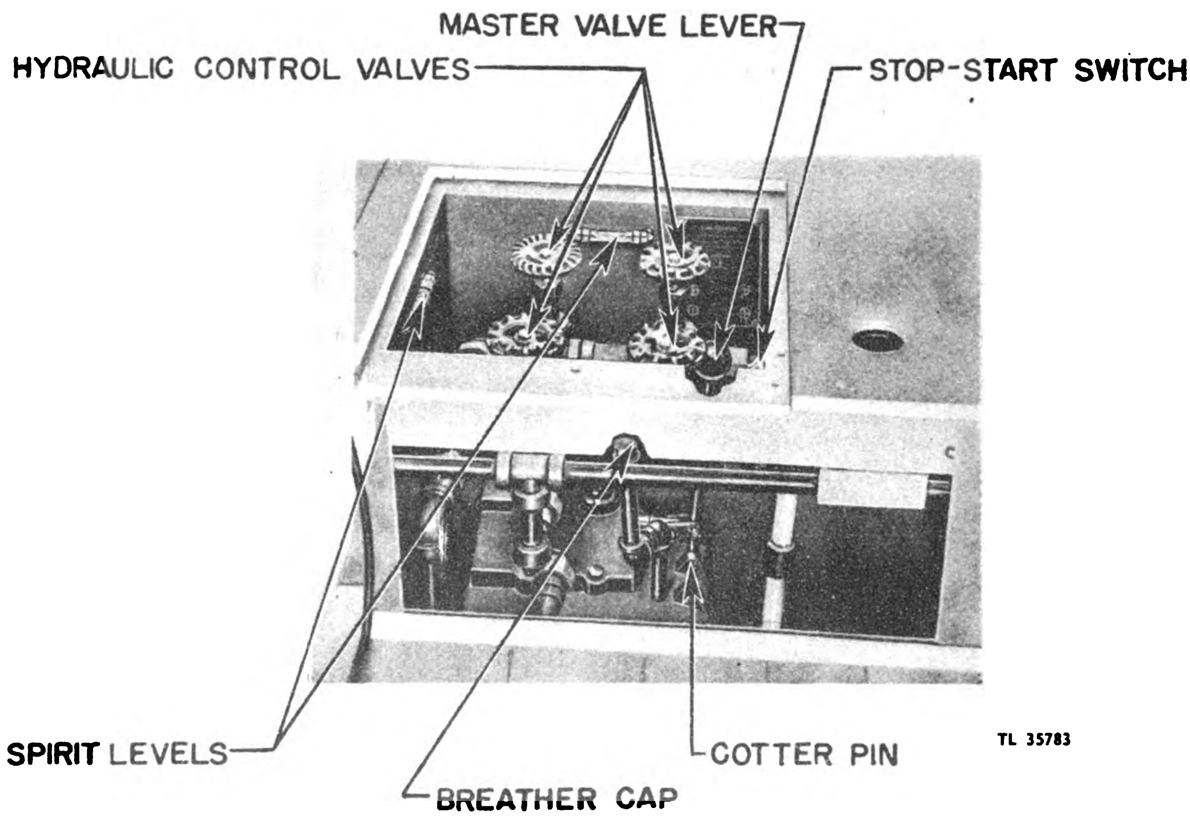

Figure 463. Hydraulic system control box.

D. SYMPTOM:

1. No operation of system.

PROBABLE LOCATION OF FAULT	PROCEDURE
1. No power supply.	1*a*. Check position of circuit breaker SW15 in power distribution panel. *b*. Check operation of start-stop button located on the wall near the hydraulic well.

	c. Check connections at terminal box on pump motor.
2. Defective pump motor.	2a. Check capacitor, motor will not start if capacitor is open.
	b. Replace with another pump motor.
3. Coupling of pump and motor.	3. Check coupling for connection. Replace if defective.
4. Defective jack.	4. Jack cylinder may be inoperative. Replace with another jack. See symptom A, item 5.
5. Defective pump.	5. See symptom C, item 2.

CONTRACTS:
W3435-SC-109
W28-004-SC-91

JULY 1, 1944

MAINTENANCE PARTS LIST FOR RADIO SET AN/MPN-1

PREFACE

This Maintenance Parts List for Radio Set AN/MPN-1 represents a table of allowance for first through fourth echelons of maintenance. No breakdown of specific parts for specific echelons are provided. One stock of parts only is supplied, and this may either be stored in the air base shop,. or split up between the shop and the set as particular circumstances dictate.

An asterisk in the column entitled "Depot Stocks" indicates that the particular item is available in depot and can be requisitioned through channels.

All requisitions for maintenance parts should include Signal Corps stock numbers and item descriptions. **The equipment item number should be included in the item description as a double check against the mis-typing of the stock number.**

Revisions to this list will be published from time to time in Sig-7 of the Army Service Force catalog. All items listed are in classified sections as outlined in the index. Capacitors, resistors and potentiometers are listed in a sequence according to their value. Other sections are listed alphabetically under each classification.

NOTICE: Should any Gilfillan Brothers, Inc., manufactured part, other than those listed herein, be required, it is imperative that a full description of the item, together with nomenclature of the component and the unit's serial number be included when ordering.

CONFIDENTIAL

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FOR
RADIO SET AN/MPN-1

CONFIDENTIAL

MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

NOTE: Order maintenance parts by stock number, name and description. Only maintenance parts can be requisitioned.

Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
		AN/MPN-1/1-1	1F4W1-83	CABLE: coaxial; flexible; surge impedance 50 ohm; Western Electric RG38U, W. E. Dwg No D163296; single conductor; #17 AWG solid copper wire; synthetic rubber; copper braided shield; outer covering dble cotton braid; outer dia .292".	Ft	2		*
		AN/MPN-1/1-2	1F4W1-84	CABLE: coaxial; flexible; surge impedance 70 ohm; Simplex KS8086; single conductor; #22 AWG solid tinned copper; rubber compound; copper braided shield; outer covering waxed cotton braid; .292" OD.	Ft	29	15	*
		AN/MPN-1/1-3	1B3000/00	CABLE: power; insulated; round .670" OD; Rockbestos type E; #00 AWG stranded, single conductor.	Ft	400	25	*
		AN/MPN-1/1-4	1B3016-10	CABLE: high tension; shielded; varnished cambric round, .375" OD; Packard 844; #16 AWG, stranded.	Ft	100	25	*
		AN/MPN-1/1-5	1A822.5	WIRE: bare; copper; #22 AWG solid, soft; tinned; Roeblings; wt 1.945 lbs per 1,000 ft.	Ft	42	10	*
		AN/MPN-1/1-6	1A820.3	WIRE: bare; copper; #20 AWG solid, soft, tinned; Roeblings; wt 3 lbs per 1,000 ft.	Ft	242	25	*
		AN/MPN-1/1-7	1A818.11	WIRE: bare; copper; #18 AWG solid, soft, tinned; Roeblings; wt 4.917 lbs per 1,000 ft.	Ft	66	10	*
		AN/MPN-1/1-8	1A816.11	WIRE: bare; copper; #16 AWG solid, soft, tinned; Roeblings; wt 7.818 lbs per 1,000 ft.	Ft	6		*
		AN/MPN-1/1-9	1A814.10	WIRE: bare; copper; #14 AWG solid, soft, tinned; Roeblings; wt 12.43 lbs per 1,000 ft.	Ft	4		*
		AN/MPN-1/1-10	1B1122.3	WIRE: insulated; copper; single #22 AWG conductor; stranded; Rockbestos type ACA; .070" OD; color white.	Ft	100	25	*

*Indicates stock available.

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		AN/MPN-1/1-11	1B1122.5	WIRE: insulated; tinned copper; single #22 AWG conductor; stranded; Lenz S12CL; .085" OD; color coded black.	Ft	276	25	*
		AN/MPN-1/1-12	1B820.86	WIRE: insulated; tinned copper; single #20 AWG conductor; 10 strands #30; Lenz S12CL; 10,000 v; .085" OD; color coded black.	Ft	8		*
		AN/MPN-1/1-13	1B1120.35	WIRE: insulated; tinned copper; single #20 AWG conductor; stranded; Lenz S12CL; 1,250 v; .085" OD; color coded black.	Ft	3752	50	*
		AN/MPN-1/1-14	1B818.65	WIRE: insulated; tinned copper; single #18 AWG conductor; stranded; Lenz S12CL; 105" OD; color coded black.	Ft	1090	25	*
		AN/MPN-1/1-15	1B818.90	WIRE: insulated; tinned copper; single #18 AWG conductor; solid; Boston Insulation Co, Navy No 62040; flexible woven wire shield with outer covering of cotton braid; .365" OD; color coded white.	Ft	250	25	*
		AN/MPN-1/1-16	1B818.91	WIRE: insulated; tinned copper; single #18 AWG conductor; stranded; Belden 8898; insulation 3/32" rubber wall; 7/32" OD; color coded red.	Ft	100	25	*
		AN/MPN-1/1-17	1B816.76	WIRE: insulated; copper; single #16 AWG conductor; stranded; Rockbestos ACA; .134" OD; color coded white.	Ft	1020	50	*
		AN/MPN-1/1-18	1B1116.6	WIRE: insulated; tinned copper; single #16 AWG conductor; stranded; Lenz S12CL; .100" OD; 1,250 v; color coded black.	Ft	1787	50	*
		AN/MPN-1/1-19	1B816.77	WIRE: insulated; tinned copper; single #16 AWG conductor; stranded; Lenz S12CL; .121" OD; 5,000 v; color coded black.	Ft	20	10	*
		AN/MPN-1/1-20	1B514	WIRE: insulated; tinned copper; single #14 AWG conductor; stranded; Rockbestos type ACA; .130" OD; color coded white.	Ft	760	50	*

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
		AN/MPN-1/1-21	1B510	WIRE: insulated; copper; single #10 AWG conductor; stranded; Rockbestos type ACA; 180" OD; color coded white.	Ft	175	25	*
		AN/MPN-1/1-22	1B518	WIRE: insulated; copper; single #18 AWG conductor; stranded; Rockbestos type ACA; .155" OD; color coded white.	Ft	935	50	*
		AN/MPN-1/1-23	1B812.41	WIRE: insulated; copper; single conductor; stranded #12 AWG; Okonite type 12; black rubber insulation; 1/2" OD; 15,000 v insulation test.	Ft	78	25	*
		AN/MPN-1/1-24	1B806.14	WIRE: insulated; copper; single conductor; stranded #6 AWG; .0141" dia; Rockbestos type ACA; .282" OD; color coded white; 1,000 v.	Ft	8		*
		AN/MPN-1/1-25	1B804.6	WIRE: insulated; copper; single conductor; stranded #4 AWG; .0177" dia; Rockbestos type ACA; .336" OD; color coded white; 1,000 v.	Ft	8.5		*

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
25 26	C1, 11 C10	AN/MPN-1/2-1	3D279	CAPACITOR: fixed; mica; 10 mmfd ± 20%; 300 vdcw; Micamold type "Q".	ea	6	2	*
20 24	C9 C23	AN/MPN-1/2-2	3D9010-57	CAPACITOR: fixed; tube-dielectric; 10 mmfd ± 10%; 500 vdcw; Muter type N-700A.	ea	6	2	*
18	C16	AN/MPN-1/2-3	3K2020012	CAPACITOR: fixed; mica; 20 mmfd ± 5%; 500 vdcw; Aerovox Corp type CM-20A200J.	ea	4	2	*
19	C10	AN/MPN-1/2-4	3DK9022-5	CAPACITOR: fixed; silvered mica; 22 mmfd ± 10%; 1000 vdcw; Solar Mfg Corp type MOSW-142210.	ea	2	1	*
16	C20	AN/MPN-1/2-5	3D9025-55	CAPACITOR: fixed; mica; 25 mmfd ± 5%; 500 vdcw; Solar type MT-1306.	ea	2	1	*
24	C35	AN/MPN-1/2-6	3D9025-56	CAPACITOR: fixed; mica; 25 mmfd ± 10%; 500 vdcw; Micamold type "Q".	ea	4	2	*
24 19	C53 C53	AN/MPN-1/2-7	3K2033014	CAPACITOR: fixed; mica-dielectric; 33 mmfd ± 20%; 500 vdcw; Aerovox type CM20A330M.	ea	6	2	*
19	C27, 30, 52	AN/MPN-1/2-8	3K2047012	CAPACITOR: fixed; mica; 47 mmfd ± 5%; 500 vdcw; Micamold type CM20A470J.	ea	6	2	*
19	C25	AN/MPN-1/2-9	3K2047011	CAPACITOR: fixed; mica-dielectric; 47 mmfd ± 10%; 500 vdcw; Aerovox type CM20A470K.	ea	2	1	*
18	C3, 17	AN/MPN-1/2-10	3K2051012	CAPACITOR: fixed; mica; 50 mmfd ± 10%; 500 vdcw: Solar type MOW-1410.	ea	8	3	*
20	C1, 5, 15, 28	AN/MPN-1/2-11	3D9050-108	CAPACITOR: fixed; tube-dielectric; 50 mmfd ± 10%; 500 vdcw; Muter type N-700A.	ea	8	3	*
20	C4	AN/MPN-1/2-12	3D9075-16	CAPACITOR: fixed; tube-dielectric; 75 mmfd ± 10%; 500 vdcw; Muter N-700B.	ea	2	1	*
32	C4, 5	AN/MPN-1/2-13	3K2010112	CAPACITOR: fixed; mica; 100 mmfd ± 5%; 500 vdcw; Aerovox Corp type CM20D101J.	ea	8	3	*
18	C2	AN/MPN-1/2-14	3D9100-63	CAPACITOR: fixed; mica; 100 mmfd ± 5%; 500 vdcw; Cornell-Dubilier type 5W5T1.	ea	4	2	*

*Indicates stock available.

MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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18	C4	AN/MPN-1/2-15	3K2010111	CAPACITOR: fixed; mica; 100 mmfd ± 5%; 500 vdcw; Solar type MOW-1416.	ea	4	2	*
19	C17, 18, 29, 32	AN/MPN-1/2-16	3K2010114	CAPACITOR: fixed; mica; 100 mmfd ± 10%; 500 vdcw; Aerovox 1468S.	ea	8	3	*
20 24 25 26	C6 C4, 8, 12, 16, 20, 39, 40 C7 C6	AN/MPN-1/2-17	3D9100-141	CAPACITOR: fixed; tube-dielectric; 100 mmfd ± 10%; 500 vdcw; Muter type N-700.	ea	34	6	*
18	C9	AN/MPN-1/2-18	3K2010112	CAPACITOR: fixed; mica; 100 mmfd ± 20%; 500 vdcw; Micamold type CM20A101M.	ea	4	2	*
18	C24	AN/MPN-1/2-19	3D9140-3	CAPACITOR: fixed; tube-dielectric; 100 mmfd ± 20%; 500 vdcw; Muter type N-700B.	ea	4	2	*
24	C38	AN/MPN-1/2-20	3D9100-142	CAPACITOR: fixed; tube-dielectric; 140 mmfd ± 10%; 500 vdcw; Muter type N-700C.	ea	4	2	*
16	C28, 32, 36, 40	AN/MPN-1/2-21	3K2015133	CAPACITOR: fixed; mica; 150 mmfd ± 2%; 500 vdcw; Aerovox CM20C151G.	ea	8	3	*
20	C20	AN/MPN-1/2-22	3D9150-32	CAPACITOR: fixed; tube-dielectric; 150 mmfd ± 10%; 500 vdcw; Muter type N-700C.	ea	2	1	*
16	C16, 21	AN/MPN-1/2-23	3K2015111	CAPACITOR: fixed; tube-dielectric; 150 mmfd ± 10%; 500 vdcw; Aerovox type CM20A151K.	ea	4	2	*
23	C21, 22	AN/MPN-1/2-24	3DA1.500-20	CAPACITOR: fixed; mica; 150 mmfd ± 10%; 600 vdcw: Cornell-Dubilier type 4LST-12015.	ea	4	2	*
23	C1, 2, 3, 4	AN/MPN-1/2-25	3DA1-500.19	CAPACITOR: fixed; mica; 150 mmfd ± 10%; 1200 vdcw; Sangamo type H-5215.	ea	8	3	*
19	C8	AN/MPN-1/2-26	3K2020122	CAPACITOR: fixed; mica; 200 mmfd ± 5%; 1000 vdcw; Solar type MOBW-1325.	ea	2	1	*
32	C8	AN/MPN-1/2-27	3K2024142	CAPACITOR: fixed; mica; 240 mmfd ± 5%; 500 vdcw; Aerovox type CM20D241J.	ea	4	2	*

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32	C7	AN/MPN-1/2-28	3K5524142	CAPACITOR: fixed; mica; 240 mmfd ± 5%; 2500 vdcw; Micamold type CM55D241J.	ea	4	2	*
19	C24	AN/MPN-1/2-29	3D9250-31.1	CAPACITOR: fixed; mica; 250 mmfd ± 10%; 500 vdcw; Solar type MWW-1219-10.	ea	2	1	*
16	C52	AN/MPN-1/2-30	3K2027112	CAPACITOR: fixed; mica; 270 mmfd ± 5%; 500 vdcw: Aerovox type CM20A271J.	ea	2	1	*
16	C29, 33, 37, 41	AN/MPN-1/2-31	3K2030133	CAPACITOR: fixed; mica; 300 mmfd ± 2%; 500 vdcw; Aerovox type CM20C301G.	ea	8	3	*
16 19	C15 C13	AN/MPN-1/2-32	3K2030112	CAPACITOR: fixed; mica; 300 mmfd ± 5%; 500 vdcw; Aerovox type CM20A301J.	ea	4	2	*
16	C14, 19	AN/MPN-1/2-33	3D9300-23	CAPACITOR: fixed; mica; 300 mmfd ± 5%; 500 vdcw; Solar type MT-1320.	ea	4	2	*
19	C2	AN/MPN-1/2-34	3D9310	CAPACITOR: fixed; mica; 310 mmfd ± 2%; 500 vdcw; Solar type MWBW.	ea	2	1	*
16	C1	AN/MPN-1/2-35	3K2033143	CAPACITOR: fixed; mica; 330 mmfd ± 2%; 500 vdcw; Aerovox type CM20D331G.	ea	2	1	*
16	C23	AN/MPN-1/2-36	3K2036112	CAPACITOR: fixed; mica; 360 mmfd ± 5%; 500 vdcw: Aerovox type CM20A361J.	ea	2	1	*
19	C28, 31	AN/MPN-1/2-37	3K2047112	CAPACITOR: fixed; mica; 470 mmfd ± 5%; 500 vdcw; Aerovox type 1468-S.	ea	4	2	*
19	C9	AN/MPN-1/2-38	3D9470-6	CAPACITOR: fixed; mica; 470 mmfd ± 5%; 1000 vdcw; Solar type MWBW1-347-5.	ea	2	1	*
20	C21, 30	AN/MPN-1/2-39	3D9500-119	CAPACITOR: fixed; tube-dielectric; 500 mmfd ± 10%; 500 vdcw; Muter type N700D.	ea	4	2	*
23	C19, 20	AN/MPN-1/2-40	3D9500-79	CAPACITOR: fixed; mica; 500 mmfd ± 10%; 2500 vdcw; Cornell-Dubilier type 4-23050.	ea	4	2	*
16 19	C22 C26	AN/MPN-1/2-41	3K2051112	CAPACITOR: fixed; mica; 510 mmfd ± 5%; 500 vdcw: Aerovox type CM20A511J.	ea	4	2	*
18	C5, 18, 19, 20	AN/MPN-1/2-42	3K2051112	CAPACITOR: fixed; mica; 510 mmfd ± 5%; 500 vdcw; Solar type CM20A511J.	ea	16	4	*

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32	C6	AN/MPN-1/2-43	3K5551142	CAPACITOR: fixed; mica-dielectric; 510 mmfd ± 5%; 2500 vdcw; Micamold type CM55D511J.	ea	4	2	*
16	C30, 34, 38, 42	AN/MPN-1/2-44	3K2562143	CAPACITOR: fixed; mica-dielectric; 620 mmfd; ± 2%; 500 vdcw: Solar type CM25D621G.	ea	8	3	*
16	C8	AN/MPN-1/2-45	3K2575112	CAPACITOR: fixed; mica-dielectric; 750 mmfd ± 5%; 500 vdcw; Solar type CM25A751J.	ea	2	1	*
24	C1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 14, 15, 17, 18, 19, 21, 22, 25, 26, 30, 31, 32, 33, 37, 51	AN/MPN-1/2-47	3DKA1-108	CAPACITOR: fixed; tube-dielectric; 1000 mmfd ± 20%; 300 vdcw; Muter type K-1200 "B".	ea	140	35	*
25	C3, 4, 5, 6, 8, 9, 10, 14, 15, 16							
26	C2, 3, 4, 5, 7, 8, 9, 13, 14, 15							
19	C21	AN/MPN-1/2-48	3K3010224	CAPACITOR: fixed; mica; 1000 mmfd ± 20%; 500 vdcw; Solar type ZWBW1227-614.	ea	2	1	*
18	C6, 12	AN/MPN-1/2-49	3K3010212	CAPACITOR: fixed; mica-dielectric; 1000 mmfd ± 5%; 500 vdcw; Solar type CM30A102J.	ea	8	3	*
20	C43	AN/MPN-1/2-50	3DA1-100	CAPACITOR: fixed; paper; 1000 mmfd ± 20%; 600 vdcw; Solar Corp type MPW5101.	ea	2	1	*
6 8	C2, 5 C2, 5	AN/MPN-1/2-51	3K4510221	CAPACITOR: fixed; mica; 1000 mmfd ± 10%; 2500 vdcw; Cornell-Dubilier type 4S-52010.	ea	8	3	*

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27	C3	AN/MPN-1/2-52	3DA1-138	CAPACITOR: fixed; mica; 1000 mmfd ± 10%; 12,500 vdcw; Sangamo type "E".	ea	2	1	*
24	C52	AN/MPN-1/2-53	3DA1.500-1	CAPACITOR: fixed; mica; 1500 mmfd ± 10%; 500 vdcw; Sangamo type C1215.	ea	4	2	*
20	C13, 14, 16, 17	AN/MPN-1/2-54	3DA2-50	CAPACITOR: fixed; mica; 2000 mmfd ± 10%; 500 vdcw: Aerovox type 1467LS.	ea	8	3	*
32	C15	AN/MPN-1/2-55	3DA2-116.3	CAPACITOR: fixed; paper; 2000 mmfd ± 20%; 1000 vdcw; Solar type MPW5103.	ea	4	2	*
19	C37, 38, 39, 40, 41, 42, 43, 44, 51	AN/MPN-1/2-56	3DA3-56.1	CAPACITOR: fixed; paper-dielectric; 3000 mmfd ± 20%; 600 vdcw; Micamold type CN41B302.	ea	18	4	*
4	C19	AN/MPN-1/2-57	3DC3-34.2	CAPACITOR: fixed; paper-dielectric; 3000 mmfd ± 20%; 800 vdcw; Cornell-Dubilier type CN35A302.	ea	2	1	*
19 20	C54 C22, 31	AN/MPN-1/2-58	3DA3-34.2	CAPACITOR: fixed; paper-dielectric; 3000 mmfd ± 20%; 800 vdcw; Micamold type CN35A302.	ea	6	2	*
16 19	C10, 12, 13, 17, 18 C54	AN/MPN-1/2-59	3DA3-31.1	CAPACITOR: fixed; mica; 3000 mmfd ± 20%; 800 vdcw; Solar type MWW-823-5.	ea	12	3	*
19	C11	AN/MPN-1/2-60	3DA3-65	CAPACITOR: fixed; mica; 3000 mmfd ± 10%; 1000 vdcw; Solar type MWBW-123-10.	ea	2	1	*
32	C10	AN/MPN-1/2-61	3DA4-68	CAPACITOR: fixed; paper-dielectric; 4000 mmfd ± 20%; 1000 vdcw; Solar type MPW-5107.	ea	4	2	*
20	C44	AN/MPN-1/2-62	3DA5-73.2	CAPACITOR: fixed; paper; 5000 mmfd ± 20%; 600 vdcw; Solar type MPW-5129.	ea	2	1	*
18	C10	AN/MPN-1/2-63	3DA6-32	CAPACITOR: fixed; mica-dielectric; 6000 mmfd ± 20%; 500 vdcw; Micamold type CM40A602M.	ea	4	2	*
18 19	C21 C5, 15, 20, 23, 35	AN/MPN-1/2-64	3DA6-67	CAPACITOR: fixed; paper-dielectric; 6000 mmfd ± 20%; 600 vdcw; Micamold type CN35A602.	ea	14	4	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
16	C3, 24, 25, 26	AN/MPN-1/2-65	3DA6-68	CAPACITOR: fixed; paper-dielectric; 6000 mmfd ± 20%; 600 vdcw; Solar type CN41B602.	ea	8	3	*
24	C50	AN/MPN-1/2-66	3K4068231	CAPACITOR: fixed; mica-dielectric; 6800 mmfd ± 10%; 500 vdcw; Micamold type CM40C682K.	ea	4	2	*
24 25 26	C24, 29 C2, 12, 13 C1, 11, 12	AN/MPN-1/2-67	3DA10-138	CAPACITOR: fixed; tube-dielectric; 10,000 mmfd ± 20%; 300 vdcw; Muter type K-1200E.	ea	20	5	*
18 19 20 24	C11, 13, 27, 29, 31 C3, 6, 7 34, 45, 46, 47 C2, 3, 23, 37, 40 C41, 42, 43, 44, 45, 49, 57	AN/MPN-1/2-68	3DA10-218	CAPACITOR: fixed; paper-dielectric; 10,000 mmfd ± 20%; 400 vdcw; Micamold type CN35A103.	ea	72	10	*
9	C1	AN/MPN-1/2-69	3DA10-197.1	CAPACITOR: fixed; paper; Dykanol "D"; 10,000 mmfd ± 20%; 600 vdcw; Cornell-Dubilier type MD6S1.	ea	1	1	*
9 14 16	 C6, 7 C4, 5, 6 7, 43, 44, 45, 46	AN/MPN-1/2-70	3DA10-56.2	CAPACITOR: fixed; paper-dielectric; 10,000 mmfd ± 20%; 600 vdcw; Solar type MPW-5135.	ea	26	6	*
6 8	C1, 3, 4 6 C1, 3, 4 6	AN/MPN-1/2-71	3K5510321	CAPACITOR: fixed; mica; 10,000 mmfd ± 10%; 1200 vdcw; Cornell-Dubilier type 4S-21010.	ea	16	4	*
20	C12	AN/MPN-1/2-72	3DA10-15	CAPACITOR: fixed; mica; 10,000 mmfd ± 10%; 2500 vdcw; Solar type XMW2.5-11-10.	ea	2	1	*
23	C9, 10, 11, 12	AN/MPN-1/2-73	3DA20-101	CAPACITOR: fixed; paper-dielectric; 20,000 mmfd ± 10%; 400 vdcw; Solar type MPW-5143.	ea	8	3	*

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16 20 32	C47, 48, 49, 50 C45 C11	AN/MPN-1/2-74	3DA20-92	CAPACITOR: fixed; paper-dielectric; 20,000 mmfd ± 20%; 600 vdcw: Solar type MPW-5137.	ea	14	4	*
32	C9	AN/MPN-1/2-75	3DA20-100	CAPACITOR: fixed; paper-dielectric; 20,000 mmfd ± 20%; 1000 vdcw; Solar type MPW-5116.	ea	4	2	*
16	C2	AN/MPN-1/2-76	3DA50-39.2	CAPACITOR: fixed; paper-dielectric; 50,000 mmfd ± 20%; 600 vdcw; Cornell-Dubilier type DYTR-6005	ea	2	1	*
20	C33, 36	AN/MPN-1/2-77	3DA50-39.1	CAPACITOR: fixed; paper-dielectric; 50,000 mmfd ± 20%; 600 vdcw; Cornell-Dubilier type DYR-6005.	ea	4	2	*
4 19	C16, 17 C1	AN/MPN-1/2-78	3D50-114.1	CAPACITOR: fixed; paper-dielectric; 50,000 mmfd ± 20%; 600 vdcw; Solar type MPW-5139.	ea	10	3	*
18	C33	AN/MPN-1/2-79	3DA50-41.1	CAPACITOR: fixed; paper-dielectric; 50,000 mmfd ± 20%; 1000 vdcw: Cornell-Dubilier type DYR-10005.	ea	4	2	*
23	C17, 18	AN/MPN-1/2-80	3DA60-8	CAPACITOR: fixed; 60,000 mmfd ± 10%; 15,000 vdcw; G.E. type 26F585G2.	ea	4	2	*
32	C12	AN/MPN-1/2-81	3DA100-252	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 20%; 600 vdcw; Aerovox type 630.	ea	4	2	*
10	C4	AN/MPN-1/2-82	3DA100-90.1	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 10%; 600 vdcw; Cornell Dubilier type DYR-6010.	ea	2	1	*
4 12 13 18 19 20 24	C11,12, 20 C3,4 C4,7,8 C7,15, 22,23 C16,33 C8,11, 18,24, 25,46, 55 C48,55, 59	AN/MPN-1/2-83	3DA100-90.3	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 20%; 600 vdcw; CD type DYR-6010.	ea	62	6	*
23	C8	AN/MPN-1/2-84	3DA100-266	CAPACITOR: fixed; 100,000 mmfd ± 10%; 600 vdcw; Girard-Hopkins type OBI.	ea	2	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
24	C27,28	AN/MPN-1/2-85	3DA100-90.3	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 20%; 600 vdcw; CD type DYR-6111.	ea	4	2	*
10	C3	AN/MPN-1/2-85A	3DB16100E	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 10%; 600 vdcw; CD type DYR-6100.	ea	2	1	*
20 24	C54 C61	AN/MPN-1/2-86	3DA100-104.1	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 20%; 1000 vdcw; CD type DYR-10010.	ea	6	2	*
11	C3,4	AN/MPN-1/2-87	3DA100-251.1	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 20%; 4000 vdcw; Sprague type 8480.	ea	4	2	*
11	C1,2	AN/MPN-1/2-88	3DA100-251	CAPACITOR: fixed; paper-dielectric; 100,000 mmfd ± 20%; 6200 vdcw; Sprague type 8479.	ea	4	2	*
19 20 24 22	C14,36 C7,26,41, 42,47,53 C47 C3,4	AN/MPN-1/2-89	3DA250-21.1	CAPACITOR: fixed; paper-dielectric; 250,000 mmfd ± 20%; 600 vdcw; CD type DYR-6025.	ea	22	5	*
16	C27,31, 35,39	AN/MPN-1/2-90	3DA250-34.2	CAPACITOR: fixed; paper-dielectric; 250,000 mmfd ± 20%; 600 vdcw; CD type DYTR-6025.	ea	8	3	*
23	C7	AN/MPN-1/2-91	3DA250-23.1	CAPACITOR: fixed; paper-dielectric; 250,000 mmfd ± 10%; 1000 vdcw; CD type DYR-10025.	ea	2	1	*
23	C13,14	AN/MPN-1/2-92	3DA250-35	CAPACITOR: fixed; paper-dielectric; 250,000 mmfd ± 10%; 2000 vdcw; CD type TJU-200025.	ea	4	2	*
19 24	C22 C46,56	AN/MPN-1/2-93	3DA500-97.3-1	CAPACITOR: fixed; paper-dielectric; 500,000 mmfd ± 20%; 600 vdcw; CD type DYR-6050.	ea	10	3	*
20	C50,52	AN/MPN-1/2-94	3DA500-201	CAPACITOR: fixed; paper-dielectric; 500,000 mmfd ± 20%; 2500 vdcw; Aerovox type 2509.	ea	4	2	*
3 4 11 13 18 19	C2,3,4,5 C18 C5,6,7 C5,6 C1,8,14, 26,30 C19,48,49,50	AN/MPN-1/2-96	3DB1.6100E	CAPACITOR: fixed; paper-dielectric; 1 mfd ± 20%; 600 vdcw; CD type DYR-6100.	ea	44	6	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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14 16	C5 C11	AN/MPN-1/2-97	3DB2.6020-10	CAPACITOR: fixed; paper-dielectric; 2 mfd ± 20%; 600 vdcw; CD type TJU-6020.	ea	4	2	*
22 23	C1,2 C15,16	AN/MPN-1/2-98	3DB2.93-1	CAPACITOR: fixed; paper-dielectric; 2 mfd ± 10%; 600 vdcw; G.E. type 9CE5A93.	ea	6	2	*
12	C2	AN/MPN-1/2-99	3DB2.10020-2	CAPACITOR: fixed; paper-dielectric; 2 mfd ± 20%; 1000 vdcw; CD type TJU-10020.	ea	2	1	*
27	C1,2	AN/MPN-1/2-100	3DB2.145	CAPACITOR: fixed; paper-dielectric; 2 mfd ± 10%; 7500 vdcw; G.E. type 14F145.	ea	4	2	*
3 16	C1 C51	AN/MPN-1/2-101	3DB4-121	CAPACITOR: fixed; paper-dielectric; 4 mfd ± 20%; 100 vdcw; Solar type XDH-1-4.	ea	3	1	*
10	C2	AN/MPN-1/2-102	3DKB4-70	CAPACITOR: fixed; paper-dielectric; 4 mfd ± 10%; 600 vdcw; CD type TJU-6040.	ea	2	1	*
13 18 20 24	C3 C28 C19,34, 48 C58	AN/MPN-1/2-103	3DB4-39.2	CAPACITOR: fixed; paper-dielectric; 4 mfd ± 20%; 600 vdcw; CD type TJU-6040.	ea	16	4	*
14 18	C3,4 C32	AN/MPN-1/2-104	3DB4-70.2	CAPACITOR: fixed; paper-dielectric; 4 mfd ± 20%; 1000 vdcw; CD type TJU-10040.	ea	8	3	*
3 4 20	C10,11 C7,13,14 C35,39	AN/MPN-1/2-105	3DB8-59.2	CAPACITOR: fixed; paper-dielectric; 8 mfd ± 20%; 600 vdcw; CD type TJU-6080.	ea	12	4	*
13 14 24	C1,2 C1,2 C54	AN/MPN-1/2-106	3DB8-42.6	CAPACITOR: fixed; paper-dielectric; 8 mfd ± 20%; 1000 vdcw; CD type TJU-10080.	ea	12	4	*
10 71	C1 C1,2	AN/MPN-1/2-107	3DB8-42.2	CAPACITOR: fixed; paper-dielectric; 8 mfd ± 10%; 1500 vdcw; CD type TJL-15080.	ea	8	3	*
12	C1	AN/MPN-1/2-108	3DB8-51.1	CAPACITOR: fixed; paper-dielectric; 8 mfd ± 20%; 1500 vdcw; CD type TJU-15080.	ea	2	1	*
20	C10	AN/MPN-1/2-109	3DB10-81	CAPACITOR: fixed; paper-dielectric; 10 mfd ± 20%; 450 vdcw; Solar type DO-410.	ea	2	1	*

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20	C49,51	AN/MPN-1/2-110	3DKB10-47.1	CAPACITOR: fixed; paper-dielectric; 10 mfd ± 20%; 600 vdcw; CD type TJU-6100.	ea	4	2	*
23	C5,6	AN/MPN-1/2-111	3DB10-38	CAPACITOR: fixed; paper-dielectric; 10 mfd ± 10%; 1500 vdcw; G.E. type 9CE5A92.	ea	4	2	*
3 4 16 20 76 80	C6 C1,2,3,4, 5,6,8,9, 10,15 C54 C32,38 C1 C1	AN/MPN-1/2-112	3DB40-34	CAPACITOR: fixed; paper-dielectric; 40 mfd ± 20%; 150 vdcw; Solar type DO-140; dry electrolytic in metal container with standard octal socket.	ea	29	6	*
3 71 77	C8,9 C3 C1	AN/MPN-1/2-113	3DB2000-10	CAPACITOR: fixed; paper-dielectric; 2000 mfd ± 10%; 50 vdcw; CD type FA5020; dry electrolytic in metal container with molded in bakelite soldered lug terminals.	ea	6	2	*
24	C34,36	AN/MPN-1/2-114	3DR9013V-3	CAPACITOR: variable; ceramic-dielectric; 3-13 mmfd; 1300 vdc test; Erie type TS2A; trimmer, screw adjustment.	ea	8	3	*
20	C27,29	AN/MPN-1/2-115	3D9020V-8	CAPACITOR: variable; ceramic-dielectric; 5 to 20 mmfd; 500 vdc test; Erie type TS2A; trimmer, screw adjustment.	ea	4	2	*
19	C12	AN/MPN-1/2-116	3D9075V-20	CAPACITOR: variable; air padder; 8 to 75 mmfd; 800 vdc test; National type USR-75; screwdriver adjustment.	ea	2	1	*
32	C2,3	AN/MPN-1/2-117	3D9100V-46	CAPACITOR: variable; air padder; 5.5 to 110 mmfd; 800 vdc test; Teleradio type AP-9; screwdriver adjustment.	ea	8	3	*
16	C9,53	AN/MPN-1/2-118	3D940V-15	CAPACITOR: variable; air padder; 6.5 to 140 mmfd; 800 vdc test; Teleradio type AP-9; screwdriver adjustment.	ea	2	1	*

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18	L1,2	AN/MPN-1/3-1	3C323-64A	COIL: choke; filter; Gilfillan Bros per spec 15-2480; .75 h at .5 ma dc; resistance 30 ohms; 1600 vdc insulation test.	ea	8	1	*
3	L1,2	AN/MPN-1/3-2	3C323-64E	COIL: choke; filter; Gilfillan Bros per spec 15-3447; 5 h at 180 ma dc; resistance 70 ohms; 1100 vdc insulation test.	ea	2	1	*
71	L2	AN/MPN-1/3-3	3C326-65C	COIL: choke; filter; Gilfillan Bros per spec 15-3450; 5 h at 200 ma dc; resistance 60 ohms; 1824 turns of #25 PE wire; 2300 vdc insulation test.	ea	3	1	*
71	L1	AN/MPN-1/3-4	3C323-64P	COIL: choke; filter; Gilfillan Bros per spec 15-3449; 10 h at .200 amp dc; resistance 40 ohms; 2150 turns #23 PE wire; 2300 vdc insulation test.	ea	3	1	*
3	L3	AN/MPN-1/3-5	3C323-64R	COIL: choke; filter; Gilfillan Bros per spec 15-3446; 10 h at 75 ma dc; resistance 160 ohms; 1600 vdc insulation test.	ea	1	1	*
10 12	L1 L1	AN/MPN-1/3-6	3C323-64F	COIL: choke; filter; Gilfillan Bros per spec 15-3420; 10 h at 450 ma dc; resistance 70 ohms; 2400 vdc insulation test.	ea	4	1	*
13	L1	AN/MPN-1/3-7	3C323-64B	COIL: choke; filter; Gilfillan Bros per spec 15-3411; 10 h at 500 ma dc; resistance 40 ohms; 1920 turns of #23 AWG PE; 1975 vdc insulation test.	ea	2	1	*
13 14	L2 L2	AN/MPN-1/3-8	3C323-64L	COIL: choke; filter; Gilfillan Bros per spec 15-2479; 10 h at 65 ma dc; resistance 460 ohms; 1600 vdc insulation test.	ea	4	1	*
20	L3,4	AN/MPN-1/3-9	3C323-64M	COIL: choke; filter; Gilfillan Bros per spec 15-2476; 12 h at 150 ma dc; resistance 230 ohms; 1600 vdc insulation test.	ea	4	1	*
14 24	L1 L28	AN/MPN-1/3-10	3C323-64N	COIL: choke; filter; Gilfillan Bros per spec 15-2474; 13 h; 250 ma; resistance 121 ohms; 1600 vdc insulation test.	ea	6	1	*

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4	L1,2	AN/MPN-1/3-11	3C323-64D	COIL: choke; filter; Gilfillan Bros per spec 15-3431; 20 h at .050 amp dc resistance 400 ohms; 3552 turns of #33 PE;3100 vdc insulation test.	ea	4	1	*
24	L29	AN/MPN-1/3-12	3C323-64G	COIL: choke; filter; Gilfillan Bros per spec 15-2473; 22 h; 35 ma dc; resistance 525 ohms; 1600 vdc insulation test.	ea	4	1	*
24	L27	AN/MPN-1/3-13	3C323-64C	COIL: choke; filter; Gilfillan Bros per spec 15-2475; 500 h at 0.5 ma dc; resistance 6150 ohms; 1600 vdc insulation test.	ea	4	1	*
17	L2	AN/MPN-1/3-14	2C1565-35/C1	COIL: deflection assembly; Gilfillan Bros dwg no. B00-3339-1.	ea	2	1	*
6 8	L4 L4	AN/MPN-1/3-15	2C1565-36/C4	COIL: deflection assembly; Gilfillan Bros dwg No. B00-3339-10.	ea	2	1	*
6 8	L2 L2	AN/MPN-1/3-16	2C1565-36/C3	COIL: deflection assembly; Gilfillan Bros dwg no. B00-3339-2.	ea	2	1	*
6 8 17	L3	AN/MPN-1/3-17	2C1565-36/C2	COIL: focusing assembly; Gilfillan Bros dwg no. C00-6201; 42,000 turns #36 AWG enameled wire; on linen base phenolic tube; taped and coated with cellulose acetate with black lacquer coloring; resistance 18,000 ohms.	ea	4		*
32	L2	AN/MPN-1/3-18	3Z1891-2	COIL: RF choke; Ohmite P-300; .3 microhenries inductance; .003 ohms dc resistance; wound on 50 ohm ± 20%, 10 watt, vitreous enameled resistor; 8 turns of #12 AWG wire on resistor.	ea	4	1	*
19	L1,2	AN/MPN-1/3-19	3C326-300	COIL: RF choke; National Co Inc type #300; 1 mh inductance; 10 ohm dc resistance; current carrying capacity 300 ma.	ea	4	1	*
24	L26	AN/MPN-1/3-20	3C323-22G	COIL: RF choke; Teleradio dwg no. CH-844-18; 1 uh inductance; 15 ohm dc resistance; current carrying capacity 125 ma; winding impregnated with lacquer.	ea	4	1	*
32	L3,4	AN/MPN-1/3-21	3C326-100	COIL: RF choke; National R-100; 2.5 mh; dc resistance 50 ohms.	ea	8	1	*

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19	L3	AN/MPN-1/3-22	3C323-22F	COIL: RF choke; Teleradio CH-844-12; 3 mh, current capacity 75 ma, resistance 10 ohms.	ea	2	1	*
18	L3,4	AN/MPN-1/3-23	3C323-22M	COIL: RF choke; Teleradio CH-113-55; 4.5 mh.	ea	8	1	*
18	L5,6	AN/MPN-1/3-24	3C323-22G	COIL: RF choke; Teleradio CH-126-18; 5 mh; current capacity 200 ma; 4 sections pi wound.	ea	8	1	*
23	L6	AN/MPN-1/3-25	3C323-22P	COIL: RF choke; Teleradio dwg no. CH-113-61; .5 mh, 3 ohms dc resistance; 250 ma.	ea	2	1	*
19	L4,5,6	AN/MPN-1/3-26	3C323-22H	COIL: RF choke; Teleradio dwg no. CH-126-10; 5.5 mh inductance; 45 ohm dc resistance; current carrying capacity 125 ma.	ea	6	1	*
24 25 26	L2,5,8, 11,14,17, 19,20,21, 24 L3,6 L4,7	AN/MPN-1/3-27	3C323-64H	COIL: RF choke; Gilfillan Bros dwg no. A00-4417; 25 turns #30 E AWG copper wire; wound on IRC resistor BT-1/2, 1 meg resistance, 1/2 watt.	ea	48	2	*
32	L5	AN/MPN-1/3-28	3C323-22E	COIL: RF choke; Teleradio CH-126-25 alt. 9 10 mh; 4 sections pi wound.	ea	4	1	*
71 78	L3 L1	AN/MPN-1/3-29	3C323-64J	COIL: RF choke; Mallory type T-4659; 10 millihenry .2 ohms dc resistance current carrying capacity 125 ma.	ea	4	1	*
23	L2,3,4, 5	AN/MPN-1/3-30	3C323-22L	COIL: RF choke; Teleradio dwg no. CH-113-4; 10 mh inductance; 61 ohm dc resistance; current carrying capacity 125 ma.	ea	8	1	*
24 25 26	L3,6,9, 12,15 L4 L5	AN/MPN-1/3-31	3C323-65A	COIL: RF choke; F. W. Sickles Co type #12736, Gilfillan Bros dwg no. A00-4418; 17.4 microhenry + 5%; dc resistance 1.16 ohm; 50 turns #34 DSE wire; coil form is an IRC resistor BT-1/2, 820 ohm, 1/2 watt.	ea	24	2	*

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24	L25	AN/MPN-1/3-32	3C307-16	COIL: RF choke; F. W. Sickles Co type #12736; Gilfillan Bros dwg no. A00-4418-1; 17.4 microhenry ± 5%; dc resistance 1.16 ohm; 50 turns #34 DSE wire; coil form is an IRC resistor, BT-1/2, 18,000 ohm, 1/2 watt.	ea	4	1	*
24	L18	AN/MPN-1/3-33	3C323-64Q	COIL: RF choke; Gilfillan Bros dwg no. A00-4421A; 20 microhenry ± 5%; dc resistance 2.6 ohms; center universal winding on form; 52 turns #38 S.S.E.; form 7/16" lg x 7/32" dia; dia of coil 1/2".	ea	4	1	*
16	L3	AN/MPN-1/3-34	3C323-22N	COIL: RF choke; Teleradio dwg no. CH-126-22; 30 mh; 170 ohm dc resistance; current carrying capacity 75 ma.	ea	2	1	*
32	L1	AN/MPN-1/3-35	3C323-64K	COIL: RF choke; Gilfillan Bros dwg no. C00-4998; 50 microhenry; single layer wound; 56 turns #18 enameled wire tapped at 9-1/2 turns; bakelite form 1-1/2" OD x 1-3/8" ID x 3-1/4" lg.	ea	4	1	*
20	L1,2	AN/MPN-1/3-36	3C323-22K	COIL: RF choke; Teleradio CH-844-8; 150 uh; current capacity 75 ma, resistance 6 ohms.	ea	4	1	*
23	L1	AN/MPN-1/3-37	2C2537-11/C1	COIL: RF choke; Gilfillan Bros dwg no. B00-8685; 4 section continuous winding, 5 stud connections; 9 turns per section; coil form 3/8" dia x 2" lg.	ea	2	1	*
24 25	L1 L1,2	AN/MPN-1/3-38	2C4180-38/C1	COIL: RF tuning; Gilfillan Bros dwg no. B00-4934-1; air core; brass slug tuned; unshielded; single layer winding 12 turns #28 enamel wire on ceramic coil form Galvin type GC-1.	ea	8	1	*
24 25 26	L4,7,10, 13,16 L5 L6,8	AN/MPN-1/3-39	2C4180-38/C2	COIL: RF tuning; Gilfillan Bros dwg no. B00-4934-3; air core; brass slug tuned; unshielded; single layer winding 13 turns #28 enamel wire on ceramic coil form Galvin type GC-1.	ea	26	2	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
26	L1	AN/MPN-1/3-40	2C3736-2/C1	COIL: RF tuning; Gilfillan Bros dwg no. B00-4934-7; air core; brass slug tuned; unshielded; single layer winding 8 turns #28 enameled wire on ceramic coil form Galvin type GC-1.	ea	2	1	*
25	L7	AN/MPN-1/3-41	3C1084Z7	COIL: RF tuning; Gilfillan Bros dwg no. B00-4934-4; air core; brass slug tuned; unshielded; single layer winding 14 turns #28 enameled wire on ceramic coil form Galvin type GC-1.	ea	2	1	*

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
77 80	Recpt 1 Recpt 1	AN/MPN-1/4-1	2Z8799-231	CONNECTOR: female; straight; Amphenol AN-3102-14S-2S; four #20 contacts.	ea	2	1	*
81	PL1	AN/MPN-1/4-2	2ZK7409-20	CONNECTOR: female; straight; Amphenol AN-3102-14S-5S; five #20 contacts.	ea	1	1	*
		AN/MPN-1/4-3	2Z7409	CONNECTOR: female; straight; Amphenol AN-3102-16S-1S; seven #20 contacts.	ea		1	*
25	PL5	AN/MPN-1/4-4	2Z8673.33	CONNECTOR: female; straight Amphenol AN-3102-16S-5S; three #16 contacts.	ea	2	1	*
21		AN/MPN-1/4-5	2Z8680	CONNECTOR: female; straight; Amphenol AN-3102-18-1S; ten #20 contacts.	ea	4	1	*
2		AN/MPN-1/4-6	2Z8674.21	CONNECTOR: female; straight; Amphenol AN-3102-18-4S; four #16 contacts.	ea	1	1	*
11 15	SK2,3, 5,6	AN/MPN-1/4-7	2Z8671.31	CONNECTOR: female; straight; Amphenol AN-3102-18-16S; one #12 contact.	ea	6	1	*
3 76	Recpt 1	AN/MPN-1/4-8	2Z8684-5	CONNECTOR: female; straight; Amphenol AN-3102-20-1S; fourteen #20 contacts.	ea	2	1	*
3 9	Recpt 2	AN/MPN-1/4-9	2Z3083	CONNECTOR: female; straight; Amphenol AN-3102-28-12S; twenty-six #16 contacts.	ea	3	1	*
78	PL2	AN/MPN-1/4-10	6Z7784.1	CONNECTOR: female; straight; Amphenol 60-F; contacts; polarized.	ea	1	1	*
23 32 81	PL1,2 PL2,3,4, 5	AN/MPN-1/4-11	2Z7111.61	CONNECTOR: female; straight; Amphenol 83-1R; socket contact.	ea	16	2	*
20	PL4	AN/MPN-1/4-12	2Z3063	CONNECTOR: female; chassis or box type receptacle; straight; Amphenol 83-22R; 2 contacts.	ea	2	1	*
73		AN/MPN-1/4-13	2Z8673.18	CONNECTOR: female; straight; Amphenol PCG-3F; three contacts.	ea	4	1	*
3		AN/MPN-1/4-14	2Z3078	CONNECTOR: female; straight; Cannon AN-3102-20-29S; seventeen #20 contacts.	ea	1	1	*

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21		AN/MPN-1/4-15	2Z8671.13	CONNECTOR: male; straight; Amphenol AN-3102-8S-1P; one #20 prong.	ea	8	1	*
21		AN/MPN-1/4-16	2Z7117.11	CONNECTOR: male; straight; Amphenol AN-3102-16S-1P; seven #20 prongs.	ea		1	*
21 73	 PL1	AN/MPN-1/4-17	2Z8799-130.1	CONNECTOR: male; straight; Amphenol AN-3102-18-1P; ten #20 prongs.	ea	6	1	*
6 8 15	 SK1 SK1,4	AN/MPN-1/4-18	2Z8799-204	CONNECTOR: male; straight; Amphenol AN-3102-18-16P; one #12 prong.	ea	4	1	*
3		AN/MPN-1/4-19	2Z8799-162	CONNECTOR: male; straight; Amphenol AN-3102-20-1P; 14 - #20 prongs.	ea	1	1	*
3 9	 Recpt 1	AN/MPN-1/4-20	2Z7136.2	CONNECTOR: male; straight; Amphenol AN-3102-28-12P; twenty-six #16 prongs.	ea	2	1	*
16	PL1	AN/MPN-1/4-21	2Z3037	CONNECTOR: male; straight; Cannon AN-3102-20-29P; peak voltage 200; seventeen #20 prongs.	ea	2	1	*
25 26	PL1 PL1	AN/MPN-1/4-22	2Z3024	CONNECTOR: male; straight; Jones P-2404-SB; four blade type prongs.	ea	4	1	*
20	PL1,2,3	AN/MPN-1/4-23	2Z8799-239	JACK: assembly; S.O. 239; coaxial connector; Selectar type JPT-5.	ea	6	1	*
4 24		AN/MPN-1/4-24	2Z5682-2	JACK: banana; single circuit; E. F. Johnson type 74.	ea	12	2	*
25 26	JK1 JK1	AN/MPN-1/4-25	2Z5581-2	JACK: headphone; Mallory type A2; single circuit; normally closed.	ea	4	1	*
23 25 27	JK1,2,3, 4 JK1,2 JK1,2	AN/MPN-1/4-26	2Z5581-20	JACK: headphone; shorting jack; Mallory Yaxley type B-111-745; Gilfillan Bros dwg no. A10-7858A.	ea	14	2	*
3 16 76 80	 PL2 J1 J1	AN/MPN-1/4-27	2Z5533A	JACK: midget headphone; National Fab Prod Co type JK33A; 2 circuit; normally open with one normally closed contact on inner contactor.	ea	5	1	*
6 8 16 18 19 24		AN/MPN-1/4-28	2Z5581-12	JACK: tip; Amphenol 78-1P; single prong; molded bakelite body; black; breakdown voltage 10,000 volts dc from contact to panel.	ea	84	10	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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25 26	PL2 PL2	AN/MPN-1/4-29	2Z8671.56	PLUG: female; straight; Amphenol AN-3106-8S-1S; one #20 contact.	ea	4	1	*
3		AN/MPN-1/4-30	2ZK8684-7	PLUG: female; straight; Amphenol AN-3106-20-1S; fourteen #20 contact.	ea	1	1	*
2		AN/MPN-1/4-31	2Z3078-1	PLUG: female; straight; Amphenol AN-3106-20-29S; seventeen #20 contacts.	ea	2	1	*
2		AN/MPN-1/4-32	2Z3082-2	PLUG: female; straight; Amphenol AN-3106-28-12S; twenty-six #16 contacts.	ea	2	1	*
24	PL1	AN/MPN-1/4-33	2Z8671.33	PLUG: female; angle 90°; Amphenol AN-3108-8S-1S; one #20 contact.	ea	4	1	*
24	PL2	AN/MPN-1/4-34	2Z7226-Q187	PLUG: female; angle 90°; Amphenol AN-3108-18-1S; ten #20 contacts.	ea	4	1	*
6 8 26		AN/MPN-1/4-35	2Z8678.27	PLUG: female; straight; Amphenol PF8-7; 8 contacts.	ea	4	1	*
25 26	SK1,2 SK1,2	AN/MPN-1/4-36	2Z8674.91	PLUG: female; rectangular; Jones S-2404-FHE; 4 contacts for blade type prongs.	ea	4	1	*
78		AN/MPN-1/4-37	2Z7113.46	PLUG: male; straight; Amphenol 60-M4.	ea	1	1	*
20 77 78	PL5 PL1 Recpt 2	AN/MPN-1/4-38	2Z7138.1	PLUG: male; straight Amphenol 61-M10.	ea	4	1	*
80		AN/MPN-1/4-39	2ZK7114.21	PLUG: male; straight; Amphenol AN-3106-14S-2P; four #20 prongs.	ea	1	1	*
25	PL4	AN/MPN-1/4-40	2Z7113.44	PLUG: male; straight; Amphenol AN-3106-16S-5P; three #16 prongs.	ea	2	1	*
25 26	PL1 PL1	AN/MPN-1/4-41	2Z7120.1	PLUG: male; straight; Amphenol AN-3106-18-1P; ten #20 prongs.	ea	4	1	*
76		AN/MPN-1/4-42	2Z7124.6	PLUG: male; straight; Amphenol AN-3106-20-1P; fourteen #20 prongs.	ea	1	1	*
2		AN/MPN-1/4-43	2Z3037-1	PLUG: male; straight; Amphenol AN-3106-20-29P; seventeen #20 contacts.	ea	1	1	*
2		AN/MPN-1/4-44	2Z3045	PLUG: male; straight; Amphenol AN-3106-28-12P; twenty-six #16 contacts.	ea	2	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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3		AN/MPN-1/4-45	2Z7126.5	PLUG: male; angle 90°; Amphenol AN-3108-28-12P; twenty-six #16 prongs.	ea	1	1	*
6 8		AN/MPN-1/4-46	2Z7111.116	PLUG: male; straight; ICA 886-B; insulated needle point with banana plug receptacle.	ea	4	1	*
4 24 25		AN/MPN-1/4-47	2Z7249.3	PLUG: male; straight; Johnson 75; banana.	ea	16	2	*

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11	F1,2	AN/MPN-1/5-1	3Z1946	FUSE: cartridge; 1/2 amp, 250 v; Littelfuse type 3AG.	ea	4	20	*
78	F1	AN/MPN-1/5-2	3Z9126	FUSE: cartridge; 1 amp, 250 v; Littelfuse type 3AG.	ea	1	5	*
13	F2	AN/MPN-1/5-3	3Z1927	FUSE: cartridge; 2 amp, 250 v; Littelfuse type 3AG.	ea	2	10	*
3 4 13 16 20 71	F1,2 F1 F1 F1 F1 F1,2	AN/MPN-1/5-4	3Z2603.17	FUSE: cartridge; 3 amp, 250 v; Littelfuse type 3AG.	ea	16	30	*
24	F1	AN/MPN-1/5-5	3Z2605.2	FUSE: cartridge; 5 amp, 250 v; Littelfuse type 3AG.	ea	4	10	*
12	F1	AN/MPN-1/5-6	3Z2608.1	FUSE: cartridge; 8 amp, 250 v; Littelfuse type 3AG.	ea	2	10	*

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23		AN/MPN-1/6-1	3G1630-9	INSULATOR: bushing; adalet; Angus-Campbell PEML-01; buff; overall length 9/16"; inside dia 1/4"; outside dia 3/8" with flange, 5/8" OD; threaded for 3/8" standard nut; supplied with nut.	ea	4	2	*
23		AN/MPN-1/6-2	3G1630-10	INSULATOR: bushing; adalet Angus-Campbell PEML-1; buff; overall length 5/8"; inside dia 5/16"; outside dia 1/2" with flange, 3/4" OD; threaded for 1/2" standard nut; supplied with nut.	ea	6	2	*
22 23		AN/MPN-1/6-3	3G1630-9.1	INSULATOR: bushing; adalet; Angus-Campbell PEML-1-1/2; buff; overall length 9/16"; inside dia 7/16"; outside dia 5/8" with flange, 7/8" OD; threaded for 5/8" standard nut; supplied with nut.	ea	12	3	*
23		AN/MPN-1/6-4	3G112-64.1	INSULATOR: feed through; glazed porcelain; E. F. Johnson #44; white; overall length 1-3/4"; inside dia 5/16"; outside dia 11/16", two sections, male and female; thru type stud 6-32 x 1-3/4" with 2 nuts and washer on each end.	ea	6	2	*
23		AN/MPN-1/6-5	3G1050-33	INSULATOR: feed through; glazed porcelain; E. F. Johnson #45; white; overall length 3-1/2"; inside dia 9/16"; outside dia 1-1/4"; two sections, male and female; thru type stud 10-32 x 3-1/2" with 2 nuts and 1 washer on each end.	ea	4	2	*
62		AN/MPN-1/6-6	3G1830-67056	INSULATOR: lead-in; pyrex; Corning Glass Works 67056; clear; overall length 1-11/16"; inside dia base 1-5/16"; outside dia base 2-1/2"; hole in top 29/64" dia.	ea	2	2	*
23 27		AN/MPN-1/6-7	3G1350-100	INSULATOR: stand-off; glazed porcelain; Crowley;Gilfillan Bros dwg no. C17-5387; white; overall lg 2"; dia 1-3/4"; core size 1"; threaded on each end for 1/4-20 screw; 1 hole in each end for locking insulator to mount to prevent turning on studs; 5 flanges for reducing leakage.	ea	52	5	*

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23		AN/MPN-1/6-8	3G1250-16.32	INSULATOR: stand-off; glazed porcelain; General Ceramic 1019-00; white; overall length 1"; inside dia threaded for 10-32 screw; outside dia 3/4".	ea	24	3	*
27		AN/MPN-1/6-9	3G1880-24	INSULATOR: stand-off; glazed porcelain; General Ceramic 1019-00; white; overall length 1-1/2"; inside dia threaded for 10-32 screw; outside dia 3/4".	ea	8	2	*
11		AN/MPN-1/6-10	3G1250-32.19	INSULATOR: stand-off; glazed porcelain; General Ceramic 1148-06; white; overall length 2"; inside dia threaded for 1/4"-20 screw; outside dia 1".	ea	4	2	*
6 8		AN/MPN-1/6-11	3G1050-22.2	INSULATOR: stand-off; glazed porcelain; E. F. Johnson #65B; white; overall length 1-7/8"; inside dia 9/16"; outside dia 1-1/4"; mtg/c brass base 1-3/4" lg x 1-3/8" wide with 2 mtg holes 3/16" dia, 1-1/2" on centers; 1 stud terminal 10-32.	ea	2	2	*
16		AN/MPN-1/6-12	3G1000-5.2	INSULATOR: stand-off; glazed porcelain; E. F. Johnson #500; white; overall length 5/8"; base dia 5/8"; top 7/16"; threaded for 6-32 screw on each end; includes two 6-32 x 1/4" screws, and 1 cork washer.	ea	2	2	*

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7	LM1,2	AN/MPN-1/7-1	2Z5878-9	LAMP: incandescent; 6.3 v, 5 W, 5 cp; .8 amp; G. E. 1855; round, long; dia 1/2"; clear; 1-1/3" lg; miniature bayonet; tungsten.	ea	2	3	*
10		AN/MPN-1/7-2	6Z6806.8	LAMP: incandescent; 6-8 v, 21 cp; Tungsol 1129; pear shape; dia of base 5/8"; clear; overall lg 1-7/8"; medium bipin; single contact; tungsten.	ea	20	10	*
1		AN/MPN-1/7-3	6Z6820-15	LAMP: incandescent; 120 v; 50 W; G. E. WL101; pear shape; base 1" dia; inside frost; overall lg 3-3/4"; medium screw.	ea	10	5	*
3	LM15	AN/MPN-1/7-4	2Z5934-1	LAMP: indicator; 6-8 v, 1 cp; Tungsol 51; round; 3/8" dia base; clear; overall lg 7/8"; miniature bipin, single contact; tungsten.	ea	1	3	*
6 8 50 73	LM1,2 LM1,2,3,4 LM1	AN/MPN-1/7-5	2Z5929.3	LAMP: indicator; 6-8 v; 6 cp; Tungsol 82; round; base 5/8" dia; clear; overall lg 1-1/4"; medium bipin; dbl contact; tungsten.	ea	16	10	*
3 5 6 8 16 20	LM11,12,13,14 LM1 LM1	AN/MPN-1/7-6	2Z5927	LAMP: indicator; 6-8 v, 250 ma; G. E. Mazda TS44; round long; base 3/8" dia; clear; overall lg 1-1/8"; miniature bipin; tungsten.	ea	20	10	*
		AN/MPN-1/7-7	2Z5878-6	LAMP: indicator; 18 v, 250 ma; Sylvania S-1455A; G-5; dia base 3/8" clear; overall lg 1-1/8"; miniature bayonet; tungsten.				
		AN/MPN-1/7-8	2Z5952	LAMP: indicator; G. E. 47; base dia 3/8"; clear; overall lg 1-1/8"; single contact; miniature bipin; tungsten.	ea	4	5	*
25 26	NE1 NE1	AN/MPN-1/7-9	2Z5890-10	LAMP: neon glow; 105 v, 1/10 W; G.E. type G-6; round; base 5/8" dia; clear; overall lg 1-1/4"; medium bipin, single contact.	ea	4	5	*

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19	NE1,2	AN/MPN-1/7-10	2Z5889-3	LAMP: neon; 105-125 v, 1/4 W; G.E. type NE-48; T4-1/2; 5/8" dia; clear; overall lg 1-1/2"; medium bipin, double contact.	ea	4	5	*
3 4 11 12 16 24 71 78 13	NE1,2 NE1 NE1,2 NE1 NE1 NE1,2 NE1,2 NE1 NE1,2	AN/MPN-1/7-11	2Z588	LAMP: neon; Littelfuse 5122; round long; dia 1/4"; clear; overall lg 1-5/8"; miniature bayonet.	ea	31	10	*
22	LM1,2	AN/MPN-1/7-12	2Z5903	LAMP: pilot light; 120 v, 6 W; G.E. Mazda S6; pear shape; base 1/2" dia; clear; overall lg 1-3/4"; medium screw; tungsten.	ea	2	5	*
3 9	LM1 thru LM10 LM1 thru LM12	AN/MPN-1/7-13	4C5492F	LAMP: telephone switchboard; 12 v, 120 ma; Western Electric 2-F; long tube; dia 1/4"; clear; overall lg 1-5/8"; carbon.	ea	22	10	*

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22	M1,2	AN/MPN-1/8-1	3F851-36	MILLIAMMETER: 0-1 ma dc; Triplett type 321-A; panel mtg, flush; round metal case.	ea	2		*
3	M1,2	AN/MPN-1/8-2	3F855-19	MILLIAMMETER: Center reading; 5-0-5, range 500 u amp; Weston type 271; surface mtg; metal fan shaped case.	ea	2		*
57		AN/MPN-1/8-3	3F3358-3	TIME METER: 115 v ac, 60 cyc; G. E. type 8KT8Y26; flush type panel mtg; bakelite case.	ea	1		*
57		AN/MPN-1/8-4	3F8150-84	VOLTMETER: 0-150 v ac; Triplett type 331-A; accuracy 2%; 110 ohms per volt; magnetic vane type movement; round flush mtg molded case.	ea	1		*

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15	RY1,2	AN/MPN-1/9-1	2Z7586-46	RELAY: antenna contactor; SPDT: Bendix type 3962; solenoid type; 100 vdc; 1 contact normally closed; 1 open; contacts enclosed in evacuated glass envelope; contacts rated at 20,000 VRF; 8 amp; actuated by external electro-magnet; enclosed in bakelite housing.	ea	2	1	*
50		AN/MPN-1/9-2	2Z7587-67	RELAY: contactor; 1 contact; SPST; G.E. type CR1057-U1D19; solenoid, 1 contact normally closed; 115 v, 50/60 cyc; contacts rated at 1/4 hp, 115 v, coil #22D4G-50.	ea	2	1	*
15	RY3,4	AN/MPN-1/9-3	2Z7587-69	RELAY: contactor; 2 contacts; 1 PST; Leach type 1351; double break; normally open; contacts.	ea	2	1	*
4	RY1,2,4	AN/MPN-1/9-4	2Z7587-66	RELAY: contactor; 2 contacts; SPDT; Allied type PC-1; solenoid type, 2 contacts, 1 normally open, 1 normally closed; contacts rated at 110 v ac, 5 amp; coil rated at 115 v, coil resistance 2500 ohms.	ea	6		*
23	RY1	AN/MPN-1/9-5	2Z7587-68	RELAY: contactor; double contact; 1 PDT; Leach type 1118; one contact normally closed; 1 open; rated at 115 v ac, 2 amps; coil rated at 6 va, 115 v ac.	ea	2	1	*
50		AN/MPN-/9-6	2Z7590-76	RELAY: contactor; 4 contacts; 2 PST; A-B type B-110; 2 contacts normally shorted; 2 normally open; double break; contacts rated at 600 v ac, 10 amp; coil rated at 110 v ac, 60 cyc. 23 va.	ea	1	1	*
22	RY1,2	AN/MPN-1/9-7	2Z7590-75	RELAY: contactor; 4 contacts; DPST; AB type B-200-F2; contacts normally open; double break; contacts rated at 600 v ac, 10 amp; coil rated at 110 v ac, 60 cyc, 23 va.	ea	2	1	*
4	RY3	AN/MPN-1/9-8	2Z7683	RELAY: contactor; 4 contacts; 2 PDT; Leach type 1037; two contacts normally closed, two normally open; adjustable upper screw contacts; rated at 115 v ac, 4 amp; coil rated at 2.8 ma; 115 v ac; winding resistance 5000 ohms.	ea	2	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

NOTE: Order maintenance parts by stock number, name and description. Only maintenance parts can be requisitioned.

Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
6 8 9	RY1 RY1 RY1	AN/MPN-1/9-9	2Z7587-59	RELAY: contactor; 4 contacts; 2 PDT; Leach type 1357; two contacts normally closed; two normally open; contacts rated at 115 v ac, 6 amp; coil rating 6 va at 115 v ac.	ea	3	1	*
4	RY5	AN/MPN-1/9-10	2Z7591-7	RELAY: contactor; 6 contacts; 3 PDT; Advance type 979B; 3 contacts normally closed; 3 normally open; contacts rated at 110 v ac, 10 amp, coil rated at 6 w 110 v ac; coil resistance 280 ohms.	ea	2	1	*
3 6 8	RY1,2 RY2,3 RY2,3	AN/MPN-1/9-11	2Z7593-50	RELAY: contactor; 8 contacts; 4 PDT; Leach type 2128G; 4 contacts normally closed; 4 open; contacts rated at 115 v ac, 6 amp; coil rated at 6 va, 115 v ac.	ea	6	1	*
22	RY3,4	AN/MPN-1/9-12	2Z7587-53	RELAY: overload; Navy type cay 29192; 1 contact SPST; WEMCO type MN1201991; solenoid type; 2 coils; 1 contact normally closed; overload coil operates between .04 and .16 amp dc; reset coil 115 v, 60 cyc; glass case with bakelite base.	ea	2	1	*
11	RY1	AN/MPN-1/9-13	2Z7587-70	RELAY: time delay; single contact; SPDT; R.W. Cramer type TD4-120S; micro-switch operated by induction motor driven gear train.	ea	2	1	*
22	RY5,6	AN/MPN-1/9-14	2Z7687-12	RELAY: time delay; 2 contacts; 2 PST; WL type 362-642; 2 contacts normally open; contacts rated at 115 v ac, 4 amp; coil rated at 115 v ac; driven by type B-3; 110 v, 60 cyc synchronous motor; differential gear mechanism for control of time delay; gear train rachet operated solenoid plunger through coil #3316.	ea	2	1	*
4	RY1,2,4	AN/MPN-1/9-15	2Z7585-59	RELAY: transfer; 2 contacts; SPDT: Allied type AS-3D42; solenoid type; 1 contact normally closed; 1 open; contacts rated at 110 v ac, 5 amp; coil rated at 59 v dc, 17 ma; coil resistance 3485 ohms.	ea	6	1	*

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
25 26	SW5 SW5	AN/MPN-1/9-16	3Z9558-18	SWITCH: momentary; roller leaf actuator; Microswitch type B-R-L2; single pole, double throw; 10 amp, 125 v.	ea	2	1	*
7		AN/MPN-1/9-17	3Z9824-250	SWITCH: momentary interlock; A.H. & H. type 3391; SPST; single section; 1 amp, 125 v ac.	ea	2	1	*
11	SW3	AN/MPN-1/9-18	3Z9824-31.20	SWITCH: momentary interlock; A.H. & H. type 3592-C; SPST; circuit normally closed; open when pushed in; current 3 A; 250 v ac.	ea	2	1	*
1 11 12 23 24 25 26 27 71	 SW1 SW1 SW1 SW5 SW1,2 SW1,2 SW1 SW2	AN/MPN-1/9-19	3Z9811.2	SWITCH: momentary interlock; G.E. type ML7460330-G4; single pole; single throw.	ea	23	4	*
22	SW4,5	AN/MPN-1/9-20	3Z9824-39.6	SWITCH: push button; Square D type 986; single pole; single throw; double break, normally open.	ea	2	1	*
3 9	SW1 SW15,16	AN/MPN-1/9-21	3Z9824-261.4	SWITCH: push button; Oak type 26414; type #130; 6 gang, each gang consisting of two double pole double throw sections and one double pole single throw section; 3 amp, 125 v, shorting type contacts.	ea	5	1	*
9 19	SW5,6, 7,8 SW1	AN/MPN-1/9-22	3Z9825-58.49	SWITCH: rotary; Centralab type 1460; 1 pole 2 position; 1 amp at 6 v.	ea	6	1	*
20	SW6	AN/MPN-1/9-23	3Z9825-55.6	SWITCH: rotary; Mallory type 3215J; 4 position; one circuit.	ea	2	1	*
20	SW4,5	AN/MPN-1/9-24	3Z9693-4	SWITCH: rotary; Mallory type 3223J; 3 position, 2 circuit, 3 contact per circuit; nonshorting contacts.	ea	4	1	*
16	SW2	AN/MPN-1/9-25	3Z825-58.50	SWITCH: rotary; Centralab type 1466; 2 poles 3 positions; shorting type contacts.	ea	2	1	*
20	SW2	AN/MPN-1/9-26	3Z8314.1	SWITCH: rotary; Mallory type 3226J; 5 positions; 2 circuit, 6 contacts per circuit; nonshorting contacts.	ea	2	1	*

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16	SW1	AN/MPN-1/9-27	3Z9826-17	SWITCH: rotary; G.B. dwg #B22-6260B; 4 sections each with 2 pole, 4 positions; shorting type contacts; phenolic sections.	ea	2	1	*
20	SW3	AN/MPN-1/9-28	3Z9825-58.48	SWITCH: rotary; Centralab type 1413; 2 pole, 11 positions, 2 sections; non-shorting contacts; steatite sections.	ea	4	1	*
32	SW1	AN/MPN-1/9-29	3Z9825-58.23	SWITCH: rotary; Centralab type 2507; 3 pole, 2 positions, 1 section; non-shorting contacts; steatite.	ea	4	1	*
22	SW2,3	AN/MPN-1/9-30	3Z9825-58.52	SWITCH: rotary; Centralab type 2521; 3 pole, 6 positions, 3 sections; non-shorting contacts; steatite sections.	ea	2	1	*
3	SW4	AN/MPN-1/9-31	3Z9825-58.51	SWITCH: rotary; Centralab type 1409; 4 pole, 2 position, 1 section; non-shorting contacts; steatite sections.	ea	1	1	*
9 20	SW9 SW1	AN/MPN-1/9-32	3Z9825-58.32	SWITCH: rotary; Centralab type 2515; 4 pole, 5 positions, 2 section; non-shorting contacts; steatite sections.	ea	3	1	*
22	SW1	AN/MPN-1/9-33	3Z9826-17.1	SWITCH: rotary; G.B. dwg #B22-6381A; 5 sections; 15 poles 2 positions; non-shorting type contacts; isolantite sections.	ea	1	1	*
16	SW3	AN/MPN-1/9-34	4C5003.520	SWITCH: telephone switchboard type key, nonlocking; Kellogg type 1000-ES3520; 5 poles per section; 3 position double restoring; position A two break three make; position B two break three make.	ea	2	1	*
3	SW2	AN/MPN-1/9-35	4C5003.519	SWITCH: telephone switchboard key; Kellogg type 1000-ES3519; three position double restoring; position A three make three break; position B two make one break; phenolic insulation.	ea	1	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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76	SW2	AN/MPN-1/9-36	4C5010.82	SWITCH: telephone switchboard key; Kellogg type 1000; with contact arrangement as follows; position A break before make, 2 make, 1 break; 3 positions non-locking each way; position B 1 break, 2 make.	ea	1	1	*
76	SW1	AN/MPN-1/9-37	4C5010.39	SWITCH: telephone switchboard key; Kellogg type 1000; with contact arrangement as follows; 2 position nonlocking, 2 sets break before make.	ea	1	1	*
3	SW3	AN/MPN-1/9-38	4C5014	SWITCH: telephone switchboard type key; Kellogg type 1042; 3 positions, double pole single throw; 2 single pole single throw.	ea	1	1	*
9 77	SW13,14 SW1,2	AN/MPN-1/9-39	4C5001	SWITCH: telephone switchboard type key; Kellogg type 1001; with 3 single locking positions; 4 section; 2 with single pole single throw; 2 grounding sections.	ea	4	1	*
15	SW1	AN/MPN-1/9-40	4C5104.79AW	SWITCH: telephone switchboard type key; WE type 479-AW; 3 positions; 4 sections.	ea	1	1	*
11 12 23 24 25 26 27 71	SW2 SW2 SW2 SW4 SW3,4 SW3,4 SW2 SW1	AN/MPN-1/9-41	3Z9849	SWITCH: toggle; Cutler Hammer type 8201; single pole; nonshorting contacts; 5 amp, 125 v.	ea	19	4	*
77	SW3	AN/MPN-1/9-42	3Z9858-8.85	SWITCH: toggle; A.H. & H. type 80607-AB; single pole single throw.	ea	1	1	*
5 7 20 24	 SW1 SW7 SW6	AN/MPN-1/9-43	3Z9862-2.7	SWITCH: toggle; G.E. type 1GA1A1; two position; single pole single throw; 3 amp, 250 v.	ea	12	2	*
71	SW3	AN/MPN-1/9-44	3Z9849.9	SWITCH: toggle; Cutler Hammer type 8244; double pole; 10 ampk 250 v, 15 amp, 125 v.	ea	3	1	*
24	SW1	AN/MPN-1/9-45	3Z9847-4.13	SWITCH: toggle; G.E. type 1GA4A1; 2 position, double pole double throw; 3 amp, 125 v.	ea	4	1	*

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24 78	SW2,3 SW1	AN/MPN-1/9-46	3Z9847-4.12	SWITCH: toggle; G.E. type 1GA3A1; 2 positions; 2 sections; 1 single pole single throw; second single pole double throw; current 3 amp, 125 v.	ea	9	2	*
19	SW4,17	AN/MPN-1/9-47	3Z9849.10-4	SWITCH: toggle; Cutler Hammer type 8373; double pole double throw; 3 amp, 250 v.	ea	2	1	*
1		AN/MPN-1/9-48	3Z9861-5	SWITCH: tumbler, standard brown handle; Pass & Seymour type 3970; single pole, quadruple break; 2 positions; current 20 amp, 125 v.	ea	1	1	*
1		AN/MPN-1/9-49	3Z9849.102	SWITCH: tumbler; double pole, 20 amps, 125 v ac; Cutler Hammer type 8701.	ea	2	1	*

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9	P1,4	AN/MPN-1/10-1	3Z7006-3	POTENTIOMETER: single section; 6 ohms ± 20%; 25 W; Ohmite type H-0143; wire wound; linear taper.	ea	2	1	*
9	P2,3	AN/MPN-1/10-2	3Z7025-5	POTENTIOMETER: single section; 25 ohms ± 20%; 25 W; IRC type PR-25; wire wound; linear taper.	ea	2	1	*
16	P8,9	AN/MPN-1/10-3	2Z7277.39	POTENTIOMETER: single section; 100 ohms ± 10%; 2 W; IRC type "W"; wire wound; linear taper.	ea	4	2	*
3	P2	AN/MPN-1/10-4	2Z7278-11	POTENTIOMETER: single section; 500 ohms ± 10%; 2 W; IRC type "W"; wire wound; linear taper.	ea	1	1	*
24	P1	AN/MPN-1/10-5	2ZK7283.9	POTENTIOMETER: single section; 500 ohms ± 20%; 4 W; Mallory type M500P; wire wound; linear taper.	ea	4	2	*
18	P3,4	AN/MPN-1/10-6	3Z7250-2	POTENTIOMETER: single section; 500 ohms ± 10%; 25 W; IRC type PR-25; wire wound; linear taper.	ea	8	3	*
4	P8	AN/MPN-1/10-7	3Z7315-1	POTENTIOMETER: single section; 1500 ohms ± 10%; 25 W; IRC type PR-25; wire wound; linear taper.	ea	2	1	*
4 6 8 24	P2,3 P1,4 P1,4 P8	AN/MPN-1/10-8	2Z7268.43	POTENTIOMETER: single section; 2000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	12	4	*
5	P5	AN/MPN-1/10-8A	2Z7279-59	POTENTIOMETER: single section; 2000 ohms ± 10%; 6 W; General Radio or Muter type 314A; modified per Gilfillan Bros dwg no. B00-4308-D.	ea	1	1	*
7	P1	AN/MPN-1/10-8B	2Z7279-58	POTENTIOMETER: single section; 2000 ohms ± 10%; 6 W; General Radio or Muter type 314A; modified per Gilfillan Bros dwg no. B00-4307-D.	ea	1	1	*
19	P10	AN/MPN-1/10-9	2Z7269.98	POTENTIOMETER: single section; 3000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*

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19	P2,5,7	AN/MPN-1/10-10	2Z7280-16	POTENTIOMETER: single section; 5000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	4	2	*
12	P1	AN/MPN-1/10-11	2Z7269.99	POTENTIOMETER: single section; 5000 ohms ; 4 W; Mallory type M5MP; wire wound; linear taper.	ea	2	1	*
4 19	P1,4,6,7 P8,9	AN/MPN-1/10-12	2Z7269.97	POTENTIOMETER: single section; 10,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	12	4	*
3	P12,13,14	AN/MPN-1/10-13	2Z7269.97	POTENTIOMETER: single section; 10,000 ohms ± 20%; 2 W; A-B type "J"; carbon; linear taper.	ea	3	1	*
7	P3	AN/MPN-1/10-14	2Z7284-50	POTENTIOMETER: dual section; 10,000 ohms; 2 W; A-B type "JJ"; carbon; linear taper.	ea	1	1	*
10	P2	AN/MPN-1/10-15	2Z7280-15	POTENTIOMETER: single section; 10,000 ohms; 4 W; Mallory type M10MP; wire wound; linear taper.	ea	2	1	*
3	P11	AN/MPN-1/10-16	2Z7270.103	POTENTIOMETER: single section; 15,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	1	1	*
3	P10	AN/MPN-1/10-17	2Z7270.104	POTENTIOMETER: single section; 20,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	1	1	*
16	P2	AN/MPN-1/10-18	2Z7270.109	POTENTIOMETER: single section; 20,000 ohms; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
18 19	P2,8 P3	AN/MPN-1/10-19	2Z7270.105	POTENTIOMETER: single section; 25,000 ohms ± 10%; 2W; A-B type "J"; carbon; linear taper.	ea	10	3	*
8	P2,3,5,6	AN/MPN-1/10-20	2Z7281.44	POTENTIOMETER: single section; 25,000 ohms ± 10%; 3 W; Clarostat type P-58; wire wound; linear taper.	ea	4	2	*
10	P1	AN/MPN-1/10-22	2Z7281.45	POTENTIOMETER: single section; 25,000 ohms ± 10%; 4 W; Mallory type M25MP; wire wound; linear taper.	ea	2	1	*
19	P4,6	AN/MPN-1/10-23	2Z7270.101	POTENTIOMETER: single section; 30,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	4	2	*

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4 18 19 24	P5 P9,10 P1 P9	AN/MPN-1/10-24	2Z7270.102	POTENTIOMETER: single section; 50,000 ohms ±10%; 2 W; A-B type "J"; carbon; linear taper.	ea	16	4	*
12 13 14 16	P2 P1 P1 P1	AN/MPN-1/10-25	2Z7270.102	POTENTIOMETER: single section; 50,000 ohms ± 20%; 2 W; A-B type "J"; carbon; linear taper.	ea	8	3	*
16	P1	AN/MPN-1/10-26	2Z7270.59	POTENTIOMETER: single section; 50,000 ohms; 2 W; A-B type "J"; carbon; linear taper.	ea	1	1	*
18	P1,7	AN/MPN-1/10-26A	2Z720.112	POTENTIOMETER: single section; 50,000 ohms ± 20%; 2 W; Stackpole type MG; carbon;linear taper.	ea	8	3	*
11	P1,2	AN/MPN-1/10-27	2Z7281.28	POTENTIOMETER: single section; 50,000 ohms ± 20%; 3 W; Clarostat type P-58; wire wound; linear taper.	ea	4	2	*
19	P14,15	AN/MPN-1/10-28	2Z7281.28	POTENTIOMETER: single section; 50,000 ohms ± 20%; 4 W; Clarostat type P-58; wire wound; linear taper.	ea	4	2	*
3 18 19 24 76	P1 P6,12,13 P11,12, 13 P3,4,5,7 P1	AN/MPN-1/10-29	2Z7271-98	POTENTIOMETER: single section; 100,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	36	6	*
16	P11	AN/MPN-1/10-30	2Z7271-98	POTENTIOMETER: single section; 100,000 ohms ± 20%; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
20	P8	AN/MPN-1/10-31	2Z7271-97	POTENTIOMETER: single section; 100,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
16	P4	AN/MPN-1/10-32	2Z7271.99	POTENTIOMETER: single section; 100,000 ohms; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
9	P5,6	AN/MPN-1/10-33	2Z7272-100	POTENTIOMETER: dual section; 250,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*

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18	P5,11	AN/MPN-1/10-34	2Z7272-100	POTENTIOMETER: single section; 250,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	8	3	*
20	P2	AN/MPN-1/10-35	2Z7272-99	POTENTIOMETER: single section; 250,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
3 24	P6,7,8,9 P2	AN/MPN-1/10-36	2Z7272-103	POTENTIOMETER: single section; 500,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	8	3	*
20	P4,7	AN/MPN-1/10-37	2Z7272-101	POTENTIOMETER: single section; 500,000 ohms ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	4	2	*
16	P5,6,7,10	AN/MPN-1/10-38	2Z7272-103	POTENTIOMETER: single section; 500,000 ohms ± 20%; 2 W; A-B type "J"; carbon; linear taper.	ea	8	3	*
16	P3	AN/MPN-1/10-39	2Z7272-102	POTENTIOMETER: single section; 500,000 ohms; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
20	P5,6	AN/MPN-1/10-40	2Z7273-41.1	POTENTIOMETER: single section; 1 meg ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	4	2	*
20	P3	AN/MPN-1/10-41	2Z7274.21	POTENTIOMETER: single section; 2 meg ± 10%; 2 W; A-B type "J"; carbon; linear taper.	ea	2	1	*
46		AN/MPN-1/10-42	2Z7281.50	POTENTIOMETER: sine; special; Sickles as per MIT dwg #B3347-E.	ea	1	1	*

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71	R2	AN/MPN-1/11-1	3Z5995-33	RESISTOR: fixed; wire wound; 5 ohms ± 5%; 160 W; Ohmite type 1156.	ea	3	1	*
3	R5	AN/MPN-1/11-2	3Z5996-18	RESISTOR: fixed; carbon; 6 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	1	1	*
23	R33,34, 35,36	AN/MPN-1/11-3	3Z6001-28.1	RESISTOR: fixed; wire wound; 10 ohms ± 10%; 10 W; Sprague type CSF631166F.	ea	8	3	*
78	R1	AN/MPN-1/11-4	3Z6001-65	RESISTOR: adjustable; wire wound; 10 ohms ± 20%; 50 W; Ohmite type 0561.	ea	1	1	*
23	R1,2	AN/MPN-1/11-5	3Z6002-39	RESISTOR: fixed; carbon; 20 ohms ± 10%; 4 W; IRC type MPT.	ea	4	2	*
23	R25 thru 32	AN/MPN-1/11-6	3Z6002-22.1	RESISTOR: fixed; wire wound; 20 ohms ± 10%; 10 W; Sprague type CSF631167F.	ea	16	4	*
11	R7	AN/MPN-1/11-7	3Z6003C3-11	RESISTOR: fixed; wire wound; 33 ohms ± 10%; 5 W; Sprague type 5-K.	ea	2	1	*
24 25 26	R2,6,10, 14,32 R1,2,3,7 R1,2,3,7	AN/MPN-1/11-8	3RC20BE470K	RESISTOR: fixed; carbon; 47 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	36	6	*
18 20 32	R13,19, 37,43,58, 60 R38 R5,6	AN/MPN-1/11-9	3RC20BE470M	RESISTOR: fixed; carbon; 47 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	34	6	*
16	R76,77	AN/MPN-1/11-10	3RC41BE470M	RESISTOR: fixed; carbon; 47 ohms ± 20%; 2 W; IRC type BT-2.	ea	4	2	*
16	R75	AN/MPN-1/11-11	3Z4850-11	RESISTOR: fixed; wire wound; 50 ohms ± 5%; 10 W; WL type 1-3/4" Z.	ea	2	1	*
23	R3,4	AN/MPN-1/11-12	3Z6005-47.1	RESISTOR: fixed; wire wound; 50 ohms ± 10%; 10 W; Sprague type CSF631168F.	ea	4	2	*
10 12 13	R2,4,6, 8,10,14 R3,4,7,8, 11,12,15, 16,19,20, 23,24,27, 28 R20,22, 24,26,28, 30,32	AN/MPN-1/11-13	3RC30BE680M	RESISTOR: fixed; carbon; 68 ohms ± 20%; 1 W; AB type GB-1.	ea	56	6	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
13	R6	AN/MPN-1/11-14	3RC31BE680M	RESISTOR: fixed; carbon; 68 ohms ± 20%; 1 W; IRC type BT-1.	ea	2	1	*
24	R1,18	AN/MPN-1/11-15	3ZK6007E5-4	RESISTOR: fixed; carbon; 75 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	8	3	*
23	R48,47	AN/MPN-1/11-16	3RC20BE750K	RESISTOR: fixed; carbon; 75 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	4	2	*
3 16	R3,4 R82,83	AN/MPN-1/11-17	3RC20BE101J	RESISTOR: fixed; carbon; 100 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	6	2	*
24	R40,73, 75	AN/MPN-1/11-18	3RC20BE101K	RESISTOR: fixed; carbon; 100 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	12	4	*
19 20 24	R83 R39 R26	AN/MPN-1/11-19	3RC20BE101M	RESISTOR: fixed; carbon; 100 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	8	3	*
22	R3,4,6	AN/MPN-1/11-20	3RC30BE101J	RESISTOR: fixed; carbon; 100 ohms ± 5%; 1 W; AB type GB-1.	ea	4	2	*
76	R2	AN/MPN-1/11-21	3RC31BE101K	RESISTOR: fixed; carbon; 100 ohms ± 10%; 1 W; IRC type BT-1.	ea	1	1	*
24	R65	AN/MPN-1/11-22	3RC30BE101M	RESISTOR: fixed; carbon; 100 ohms ± 20%; 1 W; AB type GB-1.	ea	4	2	*
3 16	R1 R80	AN/MPN-1/11-23	3Z6010-23	RESISTOR: fixed; wire wound; 100 ohms ± 10%; 2 W; IRC type BW-2.	ea	3	1	*
24	R34	AN/MPN-1/11-24	3RC30BE181K	RESISTOR: fixed; carbon; 180 ohms ± 10%; 1 W; AB type GB-1.	ea	4	2	*
19	R31,41	AN/MPN-1/11-25	3RC20BE201M	RESISTOR: fixed; carbon; 200 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	4	2	*
3 16 76 80	R2 R81 R1 R1	AN/MPN-1/11-26	3Z6020-58	RESISTOR: fixed; wire wound; 200 ohms ± 10%; 2 W; IRC type BW-2.	ea	5	2	*
24 25 26	R5,9,13, 17,20,22 R6,9,11 R6,9,11	AN/MPN-1/11-27	3RC20BE221K	RESISTOR: fixed; carbon; 220 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	36	6	*
16 20 24	R42 R29 R28	AN/MPN-1/11-28	3RC20BE221M	RESISTOR: fixed; carbon; 220 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	8	3	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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3 16	R6,7 R85,86	AN/MPN-1/11-29	3RC20BE251J	RESISTOR: fixed; carbon; 250 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	6	2	*
20	R54	AN/MPN-1/11-30	3RC20BE271K	RESISTOR: fixed; carbon; 270 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
20	R47	AN/MPN-1/11-31	3RC41BE301J	RESISTOR: fixed; carbon; 300 ohms ± 5%; 2 W; IRC type BT-2.	ea	2	1	*
19	R87	AN/MPN-1/11-32	3Z6030-39	RESISTOR: fixed; carbon; 300 ohms ± 10%; 2 W; IRC type BT-2.	ea	2	1	*
16	R71,72, 73,74	AN/MPN-1/11-33	3Z6030-51	RESISTOR: fixed; wire wound; 300 ohms ± 10%; " W; IRC type BW-2.	ea	8	3	*
5	R1,2	AN/MPN-1/11-34	3Z6030-46	RESISTOR: adjustable; wire wound; 300 ohms ± 5%; 10 W; IRC type ABA.	ea	4	2	*
18 19	R15,16, 17,18, 39,40, 41,42 R92	AN/MPN-1/11-35	3RC20BE471M	RESISTOR: fixed; carbon; 470 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	34	6	*
10 12	R1,3,5, 7,9,11,13 R2,5,10, 13,18,22, 25	AN/MPN-1/11-36	3RC30BE471M	RESISTOR: fixed; carbon; 470 ohms ± 20%; 1 W; AB type GB-1.	ea	34	6	*
23	R6,7	AN/MPN-1/11-37	3ZK6060-50	RESISTOR: fixed; carbon; 600 ohms ± 20%; 2 W; IRC type BT-2.	ea	4	2	*
19	R25	AN/MPN-1/11-38	3Z6082-3	RESISTOR: fixed; carbon; 820 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
3 24 25 26	R8,9,10, 11 R4,8,12, 16,21 R5 R5	AN/MPN-1/11-39	3Z6082-1	RESISTOR: fixed; carbon; 820 ohms ± 10%; 1/2 W; IRC type BT-1/2.	ea	28	6	*
4 19 20 24	R19 R37,42 R37 R66,74, 76	AN/MPN-1/11-40	3Z6100-75	RESISTOR: fixed; carbon; 1000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	20	5	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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13 18	R8,21,23,25,27,29,31,33 R1	AN/MPN-1/11-41	3Z6100-121	RESISTOR: fixed; carbon; 1000 ohms ± 20%; 1 W; AB type GB-1.	ea	20	5	*
76 77	R3 R1,2	AN/MPN-1/11-42	3Z6100-17	RESISTOR: fixed; carbon; 1000 ohms ± 10%; 1 W; IRC type BT-1.	ea	3	1	*
23	R41,42	AN/MPN-1/11-43	3RC41BE102K	RESISTOR: fixed; carbon; 1000 ohms ± 10%; 2 W; IRC type BT-2.	ea	4	2	*
14	R2	AN/MPN-1/11-44	3Z6100-16.1	RESISTOR: fixed; wire wound; 1000 ohms ± 10%; 50 W; IRC type EP.	ea	2	1	*
20	R56	AN/MPN-1/11-45	3Z6150-27	RESISTOR: fixed; carbon; 1500 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
20	R2	AN/MPN-1/11-46	3Z6150-25	RESISTOR: fixed; carbon; 1500 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	2	1	*
25 26	R10 R10	AN/MPN-1/11-47	3Z6150-75	RESISTOR: fixed; carbon; 1500 ohms ± 10%; 1 W; AB type GB-1.	ea	4	2	*
18	R54	AN/MPN-1/11-48	3Z6100-39	RESISTOR: fixed; carbon; 1500 ohms ± 10%; 2 W; IRC type BT-2.	ea	4	2	*
24	R45,46	AN/MPN-1/11-49	3Z6200-28	RESISTOR: fixed; carbon; 2000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	8	3	*
80	R2	AN/MPN-1/11-50	3Z6200-9	RESISTOR: fixed; carbon; 2000 ohms ± 10%; 1 W; IRC type BT-1.	ea	1	1	*
18	R20	AN/MPN-1/11-51	3Z6200-126	RESISTOR: adjustable; wire wound; 2000 ohms ± 10%; 25 W; IRC type DHA.	ea	4	2	*
24	R6	AN/MPN-1/11-52	3Z6200-124	RESISTOR: adjustable; wire wound; 2000 ohms; 25 W; Ohmite type 0377.	ea	4	2	*
19	R5,36,43,90,93	AN/MPN-1/11-53	3Z6220-20	RESISTOR: fixed; carbon; 2200 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	10	3	*
12 13 20	R1,6,9,14,17,21,26 R18 R43	AN/MPN-1/11-54	3Z6220-17	RESISTOR: fixed; carbon; 2200 ohms ± 20%; 1 W; AB type GB-1.	ea	18	4	*
26	R13	AN/MPN-1/11-55	3Z6220-31	RESISTOR: fixed; wire wound; 2200 ohms ± 10%; 5 W; Sprague type NI.	ea	2	1	*
20	R46	AN/MPN-1/11-56	3Z6250-81	RESISTOR: fixed; wire wound; 2500 ohms ± 5%; 25 W; Sprague type NI.	ea	2	1	*

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18	R21	AN/MPN-1/11-57	3Z6250-82	RESISTOR: fixed; wire wound; 2500 ohms ± 10%; 25 W; IRC type DH.	ea	4	2	*
19	R24	AN/MPN-1/11-58	3Z6300-134	RESISTOR: fixed; wire wound; 3000 ohms ± 10%; 10 W; IRC type AB.	ea	2	1	*
19 20	R32 R5	AN/MPN-1/11-59	3Z6330-3	RESISTOR: fixed; carbon; 3300 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	4	2	*
10	R15	AN/MPN-1/11-60	3RC30BE332K	RESISTOR: fixed; carbon; 3300 ohms ± 10%; 1 W; AB type GB-1.	ea	2	1	*
24	R29	AN/MPN-1/11-61	3Z6300-55	RESISTOR: fixed; carbon; 3300 ohms ± 20%; 1 W; AB type GB-1.	ea	4	2	*
20	R19	AN/MPN-1/11-62	3Z6360-6	RESISTOR: fixed; carbon; 3600 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
19	R38	AN/MPN-1/11-63	3Z6390-3	RESISTOR: fixed; carbon; 3900 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
22	R2,5	AN/MPN-1/11-64	3Z6400-67	RESISTOR: fixed; carbon; 4000 ohms ± 5%; 1 W; IRC type BT-1.	ea	2	1	*
20	R60	AN/MPN-1/11-65	3Z6430-2	RESISTOR: fixed; carbon; 4300 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
4 9 24	R11 R1,2 R24,62	AN/MPN-1/11-66	3Z6470-8	RESISTOR: fixed; carbon; 4700 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	12	4	*
16 18 19	R6,11 R23,70 R12,30	AN/MPN-1/11-67	3Z6470-14	RESISTOR: fixed; carbon; 4700 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	16	4	*
12 16 19	R37 R4 R4	AN/MPN-1/11-68	3Z6470-15	RESISTOR: fixed; carbon; 4700 ohms ± 20%; 1 W; AB type GB-1.	ea	6	2	*
14 20 24	R4 R44 R56,58, 71	AN/MPN-1/11-69	3RC41BE472M	RESISTOR: fixed; carbon; 4700 ohms ± 20%; 2 W; IRC type BT-2.	ea	16	4	*
11	R6	AN/MPN-1/11-70	3Z6470-29	RESISTOR: fixed; wire wound; 4700 ohms ± 10%; 5 W; Sprague type 5-K.	ea	2	1	*
24	R72	AN/MPN-1/11-71	3Z6500-179	RESISTOR: fixed; wire wound; 5000 ohms ± 10%; 5 W; Sprague type 5-K.	ea	4	2	*

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4	R1,2,3,4	AN/MPN-1/11-72	3Z6500-141.1	RESISTOR: fixed; wire wound; 5000 ohms ± 20%; 8 W; IRC type DG.	ea	8	3	*
4	R13	AN/MPN-1/11-73	3ZK6500-122	RESISTOR: adjustable; wire wound; 5000 ohms; 25 W; IRC type DHA.	ea	2	1	*
20	R18	AN/MPN-1/11-74	3Z6501-11	RESISTOR: fixed; carbon; 5100 ohms ± 5%; 2 W; IRC type BT-2.	ea	2	1	*
19	R96,98, 105,107	AN/MPN-1/11-75	3RC20BE562K	RESISTOR: fixed; carbon; 5600 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	8	3	*
24	R70	AN/MPN-1/11-76	3Z6562-3	RESISTOR: fixed; carbon; 6200 ohms ± 5%; 2 W; IRC type BT-2.	ea	4	2	*
13	R17	AN/MPN-1/11-77	3Z6568-7	RESISTOR: fixed; carbon; 6800 ohms ± 10%; 2 W; IRC type BT-2.	ea	2	1	*
14	R3	AN/MPN-1/11-78	3Z6568-18	RESISTOR: fixed; carbon; 6800 ohms ± 20%; 2 W; IRC type BT-2.	ea	2	1	*
19	R82	AN/MPN-1/11-79	3Z6575-62	RESISTOR: fixed; wire wound; 7500 ohms ± 10%; 10 W; Utah type CC.	ea	2	1	*
14	R1	AN/MPN-1/11-80	3Z6575-60	RESISTOR: fixed; wire wound; 7500 ohms ± 10%; 20 W; IRC type DG.	ea	2	1	*
19	R21	AN/MPN-1/11-81	3Z6582-1	RESISTOR: fixed; carbon; 8200 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
19	R22	AN/MPN-1/11-82	3Z6610-57	RESISTOR: fixed; carbon; 10,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
16 18 19 20	R5,7,19 R50,62, 64 R8,11,40, 95,104 R48	AN/MPN-1/11-83	3Z6610-73	RESISTOR: fixed; carbon; 10,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	30	6	*
22	R1	AN/MPN-1/11-84	3ZK6610-92	RESISTOR: fixed; carbon; 10,000 ohms ± 5%; 1 W; IRC type BT-1.	ea	1	1	*
11	R10	AN/MPN-1/11-85	3Z6610-93	RESISTOR: fixed; carbon; 10,000 ohms ± 20%; 1 W; AB type GB-1.	ea	2	1	*

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16	R16,21, 22	AN/MPN-1/11-86	3Z6610-88	RESISTOR: fixed; carbon; 10,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	6	2	*
18 27	R14,38 R27,28	AN/MPN-1/11-87	3RC41BE103M	RESISTOR: fixed; carbon; 10,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	12	4	*
10 24	R16 R54	AN/MPN-1/11-88	3ZK6610-91	RESISTOR: fixed; wire wound; 10,000 ohms ± 10%; 5 W; Sprague type 5-K.	ea	6	2	*
19	R23	AN/MPN-1/11-89	3Z6610-145	RESISTOR: fixed; wire wound; 10,000 ohms ± 20%; 5 W; Sprague type 5-K.	ea	2	1	*
16	R17	AN/MPN-1/11-90	3Z5510-4	RESISTOR: fixed; wire wound; 10,000 ohms ± 5%; 20 WL type 2" T.	ea	2	1	*
27	R26	AN/MPN-1/11-91	3Z6610-190	RESISTOR: fixed; wire wound; 10,000 ohms ± 20%; 24 W; IRC type ER.	ea	2	1	*
23	R39,40, 43,44, 45,46	AN/MPN-1/11-92	3Z6610-106.1	RESISTOR: fixed; wire wound; 10,000 ohms ± 10%; 50 W; Sprague type CSF631̅54F.	ea	12	4	*
18	R9	AN/MPN-1/11-93	3RC20BE153K	RESISTOR: fixed; carbon; 15,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	4	2	*
13	R10	AN/MPN-1/11-94	3Z6615-43	RESISTOR: fixed; carbon; 15,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	2	1	*
19	R64	AN/MPN-1/11-95	3Z6615-101.1	RESISTOR: fixed; wire wound; 15,000 ohms ± 10%; 5 W; Sprague type 5-K.	ea	2	1	*
23	R8	AN/MPN-1/11-96	3Z6615-56.1	RESISTOR: fixed; wire wound; 15,000 ohms ± 10%; 8 W; IRC type DG.	ea	2	1	*
27	R1 thru R20	AN/MPN-1/11-97	3Z6615-56.2	RESISTOR: fixed; wire wound; 15,000 ohms ± 20%; 8 W; IRC type DG.	ea	40	6	*
32	R7	AN/MPN-1/11-98	3Z5550.15	RESISTOR: fixed; wire wound; 15,000 ohms ± 5%; 10 W; WL type 1-3/4" Z.	ea	4	2	*
24	R50	AN/MPN-1/11-99	3RC41BE163J	RESISTOR: fixed; carbon; 16,000 ohms ± 5%; 2 W; IRC type BT-2.	ea	4	2	*
24	R36	AN/MPN-1/11-100	3Z6618-32	RESISTOR: fixed; carbon; 18,000 ohms ± 20%; 1/2 W; IRC type BT-1/2.	ea	4	2	
3 20	R14 R13,36	AN/MPN-1/11-101	3RC20BE203J	RESISTOR: fixed; carbon; 20,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	5	2	*

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16	R12	AN/MPN-1/11-102	3RC20BE203K	RESISTOR: fixed; carbon; 20,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
23	R9,10, 11,13, 17,12	AN/MPN-1/11-103	3RC41BE203K	RESISTOR: fixed; carbon; 20,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	12	4	*
19	R15,18, 20	AN/MPN-1/11-104	3Z6620-86.1	RESISTOR: fixed; wire wound; 20,000 ohms ± 10%; 5 W; Sprague type 5-K.	ea	6	2	*
18	R11,32	AN/MPN-1/11-105	3Z6620-128	RESISTOR: fixed; wire wound; 20,000 ohms ± 10%; 8 W; IRC type CD.	ea	8	3	*
18	R2,44, 51	AN/MPN-1/11-106	3Z6620-106	RESISTOR: fixed; wire wound; 20,000 ohms ± 5%; 10 W; Sprague type 10-K.	ea	12	4	*
16 19 32	R25,37 R111 R3	AN/MPN-1/11-107	3Z5600.7	RESISTOR: fixed; wire wound; 20,000 ohms ± 10%; 10 W; WL type 1-3/4" Z.	ea	12	4	*
9 24 25 26	R3,4 R63 R12 R12	AN/MPN-1/11-108	3Z6622-10	RESISTOR: fixed; carbon; 22,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	10	3	*
6 8 16 17 18 19 20	R3,6 R3,6 R47,52, 57,62 R3 R6,8,27, 47,49 R13 R4,11, 53,63	AN/MPN-1/11-109	3Z6622-13	RESISTOR: fixed; carbon; 22,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	40	6	*
19	R39	AN/MPN-1/11-110	3RC30BE223K	RESISTOR: fixed; carbon; 22,000 ohms ± 10%; 1 W; AB type GB-1.	ea	2	1	*
19	R81	AN/MPN-1/11-111	3Z6622-12	RESISTOR: fixed; carbon; 22,000 ohms ± 20%; 1 W; AB type GB-1.	ea	2	1	*
16	R34,87	AN/MPN-1/11-112	3Z6622-6	RESISTOR: fixed; carbon; 22,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	4	2	*
18 20	R22,31, 59,61,75 R3,22	AN/MPN-1/11-113	3Z6622-32	RESISTOR: fixed; carbon; 22,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	24	6	*
12	R38	AN/MPN-1/11-114	3Z6622-23	RESISTOR: fixed; wire wound; 22,000 ohms ± 5%; 5 W; Sprague type 5-K.	ea	2	1	*

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19	R29,33	AN/MPN-1/11-115	3Z6624-3	RESISTOR: fixed; carbon; 24,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	4	2	*
11	R5	AN/MPN-1/11-116	3Z6624-9	RESISTOR: fixed; wire wound; 24,000 ohms ± 5%; 10 W; Sprague type 10-K.	ea	2	1	*
20	R10	AN/MPN-1/11-117	3ZK6625-56	RESISTOR: fixed; carbon; 25,000 ohms ± 5%; 2 W; IRC type BT-2.	ea	2	1	*
23	R5	AN/MPN-1/11-118	3Z6625-75	RESISTOR: fixed; carbon; 25,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	2	1	*
23	R37,38	AN/MPN-1/11-119	3Z6625-82	RESISTOR: fixed; wire wound; 25,000 ohms ± 20%; 5 W; Sprague type 5-K.	ea	4	2	*
18	R66,67, 71	AN/MPN-1/11-120	3Z6250-68	RESISTOR: fixed; wire wound; 25,000 ohms ± 5%; 10 W; Sprague type 10-K.	ea	12	4	*
3	R16	AN/MPN-1/11-121	3Z6625-117	RESISTOR: fixed; wire wound; 25,000 ohms ± 20%; 10 W; Sprague type 10-K.	ea	1	1	*
16	R46	AN/MPN-1/11-122	3Z6625-63	RESISTOR: adjustable; wire wound; 25,000 ohms ± 10%; 25 W; Ohmite type 0389.	ea	2	1	*
71	R1	AN/MPN-1/11-123	3Z6625-34.1	RESISTOR: fixed; wire wound; 25,000 ohms ± 20%; 50 W; Ohmite type 0418.	ea	3	1	*
3	R15	AN/MPN-1/11-124	3RC20BE273J	RESISTOR: fixed; carbon; 27,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	1	1	*
16 24	R32 R61	AN/MPN-1/11-125	3Z6627-7	RESISTOR: fixed; carbon; 27,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	6	2	*
19	R89,91	AN/MPN-1/11-126	3Z6627-14	RESISTOR: fixed; carbon; 27,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	4	2	*
4	R12	AN/MPN-1/11-127	3Z5607	RESISTOR: fixed; wire wound; 27,000 ohms ± 5%; 10 W; WL type 1-3/4" Z.	ea	2	1	*
20	R7,70	AN/MPN-1/11-128	3Z6628-1	RESISTOR: fixed; carbon; 28,000 ohms ± 5%; 2 W; IRC type BT-2.	ea	4	2	*
20	R68,69	AN/MPN-1/11-129	3Z6628-2	RESISTOR: fixed; carbon; 28,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	4	2	*
16 19	R38 R67,76	AN/MPN-1/11-130	3Z6630-13	RESISTOR: fixed; carbon; 30,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	6	2	*
24	R51	AN/MPN-1/11-131	3Z6630-7	RESISTOR: fixed; carbon; 30,000 ohms ± 5%; 2 W; IRC type BT-2.	ea	4	2	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

NOTE: Order maintenance parts by stock number, name and description. Only maintenance parts can be requisitioned.

Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
19 20	R86 R20	AN/MPN-1/11-132	3Z6633-14	RESISTOR: fixed; carbon; 33,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	4	2	*
11	R9	AN/MPN-1/11-133	3Z6633-8	RESISTOR: fixed; carbon; 33,000 ohms ± 20%; 1 W; AB type GB-1.	ea	2	1	*
10 19	R17 R26	AN/MPN-1/11-134	3RC41BE333M	RESISTOR: fixed; carbon; 33,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	4	2	*
23	R21,22, 23,24	AN/MPN-1/11-135	3Z6636-6	RESISTOR: fixed; carbon; 36,000 ohms ± 10%; 1/2 W; IRC type BT-1/2.	ea	8	3	*
16	R40	AN/MPN-1/11-136	3Z6639-9	RESISTOR: fixed; carbon; 39,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
19	R103	AN/MPN-1/11-137	3Z6636-3	RESISTOR: fixed; carbon; 39,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
23	R14,15, 16,18, 19,20	AN/MPN-1/11-138	3Z6639-5	RESISTOR: fixed; carbon; 39,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	12	4	*
16 19	R15,41 R102	AN/MPN-1/11-139	3Z6639-3	RESISTOR: fixed; carbon; 47,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	6	2	*
16 18 19 20 24 73	R29 R34,36 R71,72, 116 R28 R37,38, 39 R3	AN/MPN-1/11-140	3Z6647-26	RESISTOR: fixed; carbon; 47,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	32	6	*
13	R1,2	AN/MPN-1/11-141	3Z6647-18	RESISTOR: fixed; carbon; 47,000 ohms ± 20%; 1 W; AB type GB-1.	ea	4	2	*
4 19	R15,16, 22 R65,77	AN/MPN-1/11-142	3Z6647-20	RESISTOR: fixed; carbon; 47,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	10	3	*
19 20	R49,50, 59,60, 80 R9,21,26	AN/MPN-1/11-143	3ZK6647-22-1	RESISTOR: fixed; carbon; 47,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	16	4	*
18	R28,74	AN/MPN-1/11-143A	3Z6647-36	RESISTOR: fixed; wire wound; 47,000 ohms ± 5%; 10 W; Sprague type 10-K.	ea	8	3	*
4	R9	AN/MPN-1/11-144	3Z5627.6	RESISTOR: fixed; wire wound; 47,000 ohms ± 5%; 10 W; WL type 1-3/4" Z.	ea	2	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

NOTE: Order maintenance parts by stock number, name and description. Only maintenance parts can be requisitioned.

Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
19	R10,27	AN/MPN-1/11-145	3Z6647-34	RESISTOR: fixed; wire wound; 47,000 ohms ± 20%; 10 W; Sprague type 10-K.	ea	4	2	*
19 32	R112,113 R4	AN/MPN-1/11-146	3Z5630.6	RESISTOR: fixed; wire wound; 50,000 ohms ± 5%; 10 W; WL type 1-3/4" Z.	ea	8	3	*
24	R60,64	AN/MPN-1/11-147	3Z6650-129	RESISTOR: fixed; wire wound; 50,000 ohms ± 5%; 10 W; Sprague type 10-K.	ea	8	3	*
20	R14	AN/MPN-1/11-148	3Z6651	RESISTOR: fixed; carbon; 51,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
16 19	R10,33 R2,78	AN/MPN-1/11-149	3Z6656-3	RESISTOR: fixed; carbon; 56,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	8	3	*
20	R23	AN/MPN-1/11-150	3Z6662-13	RESISTOR: fixed; carbon; 62,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	2	1	*
19 20	R34 R24	AN/MPN-1/11-151	3Z6668-3	RESISTOR: fixed; carbon; 68,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	4	2	*
18	R4,48	AN/MPN-1/11-152	3Z6668-9	RESISTOR: fixed; carbon; 68,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	8	3	*
12 16	R34 R78,79	AN/MPN-1/11-153	3ZK6668-14	RESISTOR: fixed; carbon; 68,000 ohms ± 10%; 1 W; AB type GB-1.	ea	6	2	*
11 20	R8 R42	AN/MPN-1/11-154	3Z6668-15	RESISTOR: fixed; carbon; 68,000 ohms ± 20%; 1 W; AB type GB-1.	ea	4	2	*
6 8 17	R2,5 R2,5 R1	AN/MPN-1/11-155	3RC41BE683M	RESISTOR: fixed; carbon; 68,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	10	4	*
19 20	R115 R27	AN/MPN-1/11-156	3Z6675-84	RESISTOR: fixed; carbon; 75,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	4	2	*
4 18	R21 R52,53, 55,56	AN/MPN-1/11-157	3Z6675-10	RESISTOR: fixed; carbon; 75,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	18	4	*
14 16 19 24	R5 R2 R6,85 R77	AN/MPN-1/11-158	3Z6682-4	RESISTOR: fixed; carbon; 82,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	12	4	*
10	R22	AN/MPN-1/11-159	3ZF4052	RESISTOR: fixed; carbon; 82,000 ohms ± 10%; 1 W; AB type GB-1.	ea	2	1	*
19	R44,57	AN/MPN-1/11-160	3Z6682-5	RESISTOR: fixed; carbon; 82,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	4	2	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
16	R26	AN/MPN-1/11-161	3Z6700-7	RESISTOR: fixed; carbon; 100,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
24	R44,47	AN/MPN-1/11-162	3Z6700-54	RESISTOR: fixed; carbon; 100,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	8	3	*
6 8 14 16 18 19	R1,4 R1,4 R6 R8,18 R30,68, 78 R9,14,68, 69,73,74, 84,88,94, 101	AN/MPN-1/11-163	3Z6700-117	RESISTOR: fixed; carbon; 100,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	70	10	*
12	R30,31, 32	AN/MPN-1/11-164	3ZF4041	RESISTOR: fixed; carbon; 100,000 ohms ± 10%; 1 W; AB type GB-1.	ea	6	2	*
13 18 19	R13,14, 15,16,19 R7,25 R46,47, 55,56,79	AN/MPN-1/11-165	3Z6700-74	RESISTOR: fixed; carbon; 100,000 ohms ± 20%; 1 W; AB type GB-1.	ea	28	6	*
11 12 24	R1 R39 R42	AN/MPN-1/11-166	3Z6700-32	RESISTOR: fixed; carbon; 100,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	8	3	*
20	R31,57	AN/MPN-1/11-167	3Z6700-42	RESISTOR: fixed; carbon; 100,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	4	2	*
4	R10	AN/MPN-1/11-168	3Z5680-3	RESISTOR: fixed; wire wound; 100,000 ohms ± 5%; 25 W; WL type 2-1/2" T.	ea	2	1	*
12	R29	AN/MPN-1/11-169	3ZF4043	RESISTOR: fixed; carbon; 120,000 ohms ± 10%; 1 W; AB type GB-1.	ea	2	1	*
18	R5,46	AN/MPN-1/11-170	3Z6715-34	RESISTOR: fixed; carbon; 150,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	8	3	*
10	R18,20, 21,23	AN/MPN-1/11-171	3ZF4044	RESISTOR: fixed; carbon; 150,000 ohms ± 10%; 1 W; AB type GB-1.	ea	8	3	*
18	R24,72	AN/MPN-1/11-172	3Z6715-36	RESISTOR: fixed; carbon; 150,000 ohms ± 20%; 1 W; AB type GB-1.	ea	8	3	*
13 24	R3,4 R41	AN/MPN-1/11-173	3RC41BE154M	RESISTOR: fixed; carbon; 150,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	8	3	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
16 20	R27 R34	AN/MPN-1/11-174	3RC20BE203J	RESISTOR: fixed; carbon; 200,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	4	2	*
11	R2	AN/MPN-1/11-175	3Z6672O-21	RESISTOR: fixed; carbon; 200,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	2	1	*
16 19	R23,28, 35 R28	AN/MPN-1/11-176	3Z6722-11	RESISTOR: fixed; carbon; 220,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	8	3	*
16 18 19 20 24	R1,9 R63,65, 69,77 R1,7,17, 48,58,70 R1,51,52 R55,59, 69,78,79	AN/MPN-1/11-177	3Z6722-13	RESISTOR: fixed; carbon; 220,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	58	6	*
20	R59,64	AN/MPN-1/11-178	3ZK6722-14	RESISTOR: fixed; carbon; 220,000 ohms ± 20%; 1 W; AB type GB-1.	ea	4	2	*
13 19	R5 R97,99, 106,108	AN/MPN-1/11-179	3Z6722-23	RESISTOR: fixed; carbon; 220,000 ohms ± 10%; 2 W; IRC type BT-2.	ea	10	3	*
16 20	R51,56, 61,66 R67	AN/MPN-1/11-180	3Z6724-2	RESISTOR: fixed; carbon; 240,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	10	3	*
16	R36	AN/MPN-1/11-181	3Z6727-9	RESISTOR: fixed; carbon; 270,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
16 20	R39 R15	AN/MPN-1/11-182	3ZK6730-14	RESISTOR: fixed; carbon; 300,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	4	2	*
16 18 19	R24 R3,45 R110	AN/MPN-1/11-183	3Z6733-2	RESISTOR: fixed; carbon; 330,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	12	4	*
16	R13	AN/MPN-1/11-184	3Z6733-8	RESISTOR: fixed; carbon; 330,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	2	1	*
13	R11	AN/MPN-1/11-185	3RC30BE334M	RESISTOR: fixed; carbon; 330,000 ohms ± 20%; 1 W; AB type GB-1.	ea	2	1	*
20	R65	AN/MPN-1/11-186	3RC41BE334M	RESISTOR: fixed; carbon; 330,000 ohms ± 20%; 2 W; IRC type BT-2.	ea	2	1	*

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16 19 24	R30 R52,62 R67,68	AN/MPN-1/11-187	3Z6739-5	RESISTOR: fixed; carbon; 390,000 ohms ± 10%; 1/2 w; AB type EB-1/2.	ea	14	4	*
14 17 18 19 20 24 32	R7 R2 R10,12, 29,35 R16,51, 61,66, 75,114 R12,62 R30 R1	AN/MPN-1/11-188	3Z6747-15	RESISTOR: fixed; carbon; 470,000 ohms ± 20%; 1/2 w; AB type EB-1/2.	ea	44	6	*
24	R53	AN/MPN-1/11-189	3RC30BE474M	RESISTOR: fixed; carbon; 470,000 ohms ± 20%; 1 W; AB type GB-1.	ea	4	2	*
16	R50,55, 60,65	AN/MPN-1/11-190	3Z6751-2	RESISTOR: fixed; carbon; 510,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	8	4	*
20	R61	AN/MPN-1/11-191	3Z6768-5	RESISTOR: fixed; carbon; 680,000 ohms ± 20%; 1/2 W; AB type EB-1/2.	ea	2	1	*
10 12 13	R19 R33 R7,12	AN/MPN-1/11-192	3RC30BE684M	RESISTOR: fixed; carbon; 680,000 ohms ± 20%; 1 W; AB type GB-1.	ea	8	3	*
20	R8	AN/MPN-1/11-193	3ZK6775-13	RESISTOR: fixed; carbon; 750,000 ohms ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
16	R48	AN/MPN-1/11-194	3Z6782-5	RESISTOR: fixed; carbon; 820,000 ohms ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
16 19 20	R3,49, 53,54,58, 59,63,64 R3 R16,49, 50	AN/MPN-1/11-195	3Z6801-2	RESISTOR: fixed; carbon; 1 meg ± 5%; 1/2 W; AB type EB-1/2.	ea	24	6	*
4 16 18 19 24	R5,6,7,8, 14,17,18 R14,20, 44,67,68, 69,70 R26,33, 57,73 R45,53, 54,63 R25,52	AN/MPN-1/11-196	3Z6801-43	RESISTOR: fixed; carbon; 1 meg ± 20%; 1/2 W; AB type EB-1/2.	ea	60	6	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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24 25 26	R3,7,11, 15,19,23, 27,31,33, 35 R4,8 R4,8	AN/MPN-1/11-197	3Z6801-16	RESISTOR: fixed; carbon; 1 meg ± 20%; 1/2 W; IRC type BT-1/2.	ea	48	6	*
13	R9	AN/MPN-1/11-198	3ZK6801-75	RESISTOR: fixed; carbon; 1 meg ± 20%; 1 w; AB type GB-1.	ea	2	1	*
4	R20	AN/MPN-1/11-199	3ZK6801A5-14	RESISTOR: fixed; carbon; 1.5 meg ± 5%; 1/2 W; AB type EB-1/2.	ea	2	1	*
20 25	R17,32, 33,35 R3	AN/MPN-1/11-200	3Z6802-10	RESISTOR: fixed; carbon; 2 meg ± 5%; 1/2 W; AB type EB-1/2.	ea	10	3	*
26	R1	AN/MPN-1/11-201	3RC20BE205K	RESISTOR: fixed; carbon; 2 meg ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
24	R48,49	AN/MPN-1/11-202	3Z6802A2-10	RESISTOR: fixed; carbon; 2.2 meg ± 20%; 1/2 W; AB type EB-1/2.	ea	8	3	*
26	R2	AN/MPN-1/11-203	3Z6803-6	RESISTOR: fixed; carbon; 3 meg ± 10%; 1/2 W; AB type EB-1/2.	ea	2	1	*
27	R21,29	AN/MPN-1/11-205	3Z6803-17	RESISTOR: fixed; wire wound; 3 meg ± 10%; 22 W; Sprague Megomax type 2.	ea	6	2	*
24 73 19	R57 R2,5 R35	AN/MPN-1/11-206	3Z6803A3-8	RESISTOR: fixed; carbon; 3.3 meg ± 20%; 1/2 W; AB type EB-1/2.	ea	10	3	*
25	R1,2	AN/MPN-1/11-207	3Z6804-11	RESISTOR: fixed; carbon; 4 meg ± 10%; 1/2 W; AB type EB-1/2.	ea	4	2	*
11	R3	AN/MPN-1/11-208	3Z6804-12	RESISTOR: fixed; wire wound; 4 meg ± 10%; 4 W; Sprague Megomax type 1.	ea	2	1	*
19	R19	AN/MPN-1/11-209	3ZK6804A7-10	RESISTOR: fixed; carbon; 4.7 meg ± 20%; 1/2 W; AB type EB-1/2.	ea	2	1	*
11	R4	AN/MPN-1/11-210	3Z6812-1	RESISTOR: fixed; wire wound; 12 meg ± 10%; 4 W; Sprague Megomax type 1.	ea	2	1	*
27	R22,23	AN/MPN-1/11-211	3Z6820-6	RESISTOR: fixed; wire wound; 20 meg ± 10%; 15 W; Sprague Megomax type 2.	ea	4	2	*
20	R40	AN/MPN-1/11-212	3Z6822	RESISTOR: fixed; carbon; 22 meg ± 20%; 1/2 W; AB type EB-1/2.	ea	2	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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3 9		AN/MPN-1/12-1	4C9715-609	SOCKET: Lamp; Cook Part No. 609.	ea	22	4	*
3		AN/MPN-1/12-2	2Z5883-106.1	SOCKET: Lamp; miniature bayonet base; Dialco Part No. 707	ea	6	2	*
20		AN/MPN-1/12-3	2Z5991-3	SOCKET: Lamp; miniature bayonet; Drake Part No. 40; red frosted jewel.	ea	2	2	*
3		AN/MPN-1/12-4	2Z5887-110	SOCKET: Lamp; miniature bayonet, plain jewel; Gothard Part No. 404PL.	ea	1	1	*
6 8		AN/MPN-1/12-5	2Z5883-111	SOCKET: Lamp; miniature bayonet; Gothard Part No. 610.	ea	4	2	*
3 4 11 12 13 16 24 71 78		AN/MPN-1/12-6	2Z5984.2	SOCKET: Lamp, panel mounting; Littelfuse Part No. 1414; 90-250 volt; bakelite body; transparent molded cap.	ea	31	4	*
19		AN/MPN-1/12-	2Z8672.65	SOCKET: Lamp surface; G. E. Part No. 303; cadmium shell; bakelite base.	ea	4	2	*
73		AN/MPN-1/12-8	2Z5883-109	SOCKET: Lamp; Cole-Hersee Part No. 2014; double contacts.	ea	2	2	*
3		AN/MPN-1/12-9	2Z5883-41	SOCKET: Lamp; Dialco type 705; dwg no. B00-12046a; miniature bayonet.	ea	1	1	*
20		AN/MPN-1/12-10	2Z8674.15	SOCKET: Tube; 4 contact; Amphenol Part No. 77A-4T; bakelite shell; nickel-plated shell mtg plate.	ea	2	2	*
11		AN/MPN-1/12-11	2Z8659-5	SOCKET: Tube; 4 contact; Amphenol Part No. MIP4TM; bakelite body.	ea	2	2	*
11 12 13 18		AN/MPN-1/12-12	2Z8665.3	SOCKET: Tube; 5 contact; Amphenol Part No. MIP5TM; bakelite body.	ea	48	5	*
20		AN/MPN-1/12-13	2Z8677.18	SOCKET: Tube; 7 large contact; Amphenol Part No. MIP7LTM; bakelite body.	ea	2	2	*

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3 4 10 11 12 13 14 16 18 19 20 24 25 26 32 71 73 76 80		AN/MPN-1/12-14	2Z8795.12	SOCKET: Tube; 8 contact; Amphenol Part No. MIP8TN; bakelite body.	ea	435	10	*
32		AN/MPN-1/12-15	2Z8763-4	SOCKET: Tube; 5 contact; Amphenol Part No. RSS5; steatite body.	ea	4	2	*
23		AN/MPN-1/12-16	2Z8711-4	SOCKET: Tube; National Part No. XM-10; 4 clip, bayonet type shell.	ea	4	2	*
23		AN/MPN-1/12-17	2Z8663-1	SOCKET: Tube; E. F. Johnson Part No. 247; wafer; 7 prong; 6 flatnose prongs; 1 V shape prong.	ea	2	2	*
23 27		AN/MPN-1/12-18	2Z8674.16	SOCKET: Tube; Ucinite Part No. UCSC-115-034; 4 prong; porcelain base.	ea	12	3	*

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16 19 20	T1 T1 T1	AN/MPN-1/13-1	2Z9614-62	TRANSFORMER: AF; oscillator; Chi Trans type 5227-D.	ea	6	1	*
16 19 23	T2 T2 T1	AN/MPN-1/13-2	2Z9614-57	TRANSFORMER: AF; pulse; G.E. type 68G711; G.E. dwg #K-5898738AX; two winding; 6.70 ohms primary; .230 ohms secondary; turns ratio 4:1.	ea	6	1	*
23	T2	AN/MPN-1/13-3	2Z9614-60	TRANSFORMER: AF; pulse; G.E. type 80G16; G.E. dwg #K-5898738CH; 3 windings; turns ratio 1:1:.5.	ea	2	1	*
16 19	T3 T3,4	AN/MPN-1/13-4	2Z9614-61	TRANSFORMER: AF; pulse; WEMCO dwg #132-AW; 3 windings; 1:1:1.	ea	6	1	*
3 16 76 80	T1 T5 T1 T1	AN/MPN-1/13-5	2Z9614-56	TRANSFORMER: AF; G.B. dwg #15-3443; primary 200 ohms; secondary 50,000 ohms tapped at 500 ohms; frequency response 200 to 4000 cps; turns ratio 1:15.8; overall.	ea	5	1	*
3	T2	AN/MPN-1/13-6	2Z9637.24	TRANSFORMER: AF; output; G.B. dwg 15-3454; primary 500 ohms; secondary 500 ohms; frequency response ± 1 db from 200 to 4000 cyc; 1:1.	ea	1	1	*
81	T1,2,3	AN/MPN-1/13-7	2Z9632.177	TRANSFORMER: AF; output; G.B. dwg #15-3456; primary 4000 ohms; secondary 300 ohms; frequency response ± 1 db; 200-4000 cyc; turns ratio 3.64:1.	ea	3	1	*
3	T3,4, 5,6	AN/MPN-1/13-8	2Z9632.178	TRANSFORMER: AF; output; G.B. dwg #15-3444; primary 7500 ohms; secondary 500 ohms; frequency response 200 to 4000 cps; turns ratio 3.88:1.	ea	4	1	*
23 27	T1	AN/MPN-1/13-9	2Z9611.23	TRANSFORMER: filament; Raytheon dwg #UX6899; primary 115 v ac, 60 cyc; secondary #1, 5 v, 5.5 amp; secondary #2, 5 v, 5.5 amp, each insulated for 29,000 v test.	ea	4	1	*
25 26	T1,2 T1,2	AN/MPN-1/13-10	2Z9611.194	TRANSFORMER: filament; Raytheon Dwg #UX-7022A; primary 115 v ac, 60 cyc; secondary #1, 6.3 v, 1.5 amp; air insulated for 19,000 v test.	ea	4	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
18	T1	AN/MPN-1/13-11	2Z9611.186	TRANSFORMER: filament; G.B. dwg #15-3380; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 2 amp, center tap; secondary #2, 6.3 v, 2 amp, center tap.	ea	4	1	*
18	T3	AN/MPN-1/13-12	2Z9611.192	TRANSFORMER: filament; G.B. dwg #15-3381; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 5 amp, center tap; secondary #2, 6.3 v, 1 amp, center tap.	ea	4	1	*
73	T1	AN/MPN-1/13-13	2Z9611.184	TRANSFORMER: filament; G.B. dwg #15-3462; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 1 amp, center tap; secondary #2, 5 v, 2 amp.	ea	2	1	*
10 12	T2 T2	AN/MPN-1/13-14	2Z9611.179	TRANSFORMER: filament; G.B. dwg #15-3417; primary 117 v ac, 60 cyc; secondary #1, 5 v, 3 amp, center tap; secondary #2, 5 v, 3 amp, center tap; secondary #3, 5 v, 6 amp, center tap.	ea	4	1	*
13	T2	AN/MPN-1/13-15	2Z9611.189	TRANSFORMER: filament; G.B. dwg #15-3413; primary 117 v ac, 60 cyc; secondary #1, 5 v, 6 amp, center tap; secondary #2, 5 v, 3 amp, center tap.	ea	2	1	*
18	T2	AN/MPN-1/13-16	2Z9611.190	TRANSFORMER: filament; G.B. dwg #15-3401; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 1.2 amp, center tap; secondary #2, 6.3 v, 3.2 amp, center tap.	ea	4	1	*
13	T1	AN/MPN-1/13-17	2Z9611.188	TRANSFORMER: filament; G.B. dwg #15-3414; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 9.6 amp.	ea	2	1	*
10 12	T1 T1	AN/MPN-1/13-18	2Z9611.178	TRANSFORMER: filament; G.B. dwg #15-3418; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 1 amp, center tap; secondary #2, 6.3 v, 7 amp, center tap.	ea	4	1	*
16 19 24	T4 T5 T3	AN/MPN-1/13-19	2Z9611.193	TRANSFORMER: filament; G.B. dwg #15-3425; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 9 amp, center tap; secondary #2, 6.3 v, 2.2 amp, center tap.	ea	8	1	*

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8 11	T1 T1	AN/MPN-1/13-20	2Z9612.182	TRANSFORMER: filament; G.B. dwg #15-3427; primary 117 v, 60 cyc; secondary #1, 6.3 v, 1.2 amp, center tap.	ea	4	1	*
32	T1	AN/MPN-1/13-21	2Z9611.181	TRANSFORMER: filament; G.B. dwg #15-3430; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, .6 amp; secondary #2, 6.3 v, 1.5 amp.	ea	4	1	*
5 7	T1 T1	AN/MPN-1/13-22	2Z9611.183	TRANSFORMER: filament; G.B. dwg #15-3432; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 1 amp; secondary #2, 6.3 v, 1 amp; secondary #3, 6.3 v, 1 amp.	ea	2	1	*
18	T4	AN/MPN-1/13-23	2Z9611.180	TRANSFORMER: filament; G.B. dwg #15-3461; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 1 amp, center tap; secondary #2, 6.3 v, 1 amp, center tap.	ea	4	1	*
14 24	T2 T2	AN/MPN-1/13-24	2Z9611.185	TRANSFORMER: filament; G.B. dwg #15-3463; primary 117 v ac, 60 cyc; secondary #1, 6.3 v, 1 amp, center tap; secondary #2, 5 v, 3 amp, center tap; secondary #3, 5 v, 3 amp, center tap.	ea	6	1	*
23	T4	AN/MPN-1/13-25	2Z9611.187	TRANSFORMER: filament; G.B. dwg #15-3453; primary 117 v ac, 60 cyc; secondary #1, 27 v, 8.8 amp; secondary #2, 6.3 v, 2.5 amp.	ea	2	1	*
20	T2	AN/MPN-1/13-26	2Z9611.191	TRANSFORMER: filament; G.B. dwg #15-3384; primary 117 v ac, 60 cyc; secondary #1, 440-0-440 v, 150 ma; secondary #2, 6.3 v, 6.25 amp; secondary #3, 5 v, 3 amp.	ea	2	1	*
3	T9	AN/MPN-1/13-27	2Z9613.192	TRANSFORMER: filament and plate; G.B. dwg #15-3441; primary 117 v ac, 60 cyc; secondary #1, 50 v tapped at 46 v, 200 ma; secondary #2, 10 v, 2 amp, center tap.	ea	1	1	*
11	T3	AN/MPN-1/13-28	2Z9613.187	TRANSFORMER: filament and plate; G.B. dwg #15-3422; primary 117 v ac, 60 cyc; secondary #1, 405-0-405 v, 20 ma; secondary #2, 5 v, 3 amp, center tap.	ea	2	1	*

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14 24	T1 T1	AN/MPN-1/13-29	2Z9613.196	TRANSFORMER: filament and plate; G.B. dwg no. 15-3426-B; primary 117 v ac, 60 cyc; secondary #1, 500-400-0-500 v, 250 ma; secondary #2, 6.3 v, 1.5 amp.	ea	6	1	*
4	T2	AN/MPN-1/13-30	2Z9613.191	TRANSFORMER: filament and plate; G.B. dwg no. 15-3429; primary 117 v ac, 60 cyc; current rating 8 amp; secondary #1, 540-0-540, 55 ma; secondary #2 5 v, 3 amp, secondary #3 6.3 v, 1.8 amp; secondary #4, 6.3 v, 1.2 amp; secondary #5, 6.3 v, 1.2 amp.	ea	2	1	*
3	T10	AN/MPN-1/13-31	2Z9613.193	TRANSFORMER: filament and plate; G.B. dwg no. 15-3442; primary 117 v ac, 60 cyc; secondary #1, 525 v, 75 ma, center tap; secondary #2, 5 v, 2 amp; secondary #3, 6.3 v, 1.8 amp; secondary #4 10 v, 2 amp, center tap; secondary #5, 50 v, tapped at 46 v, 200 ma.	ea	1	1	*
23	T3	AN/MPN-1/13-32	2Z9613.189	TRANSFORMER: filament and plate; G.B. dwg no. 15-3452; primary 117 v ac, 60 cyc; secondary #1, 1100 v, tapped at 550 v on taps 3,4,5; taps 3 and 4 rated at 95 ma, taps 4 and 5 rated at 70 ma; secondary #2, 2.5 v, 5 amp; secondary #3, 2.5 v, 5 amp.	ea	2	1	*
20	T3	AN/MPN-1/13-33	2Z9613.188	TRANSFORMER: filament and plate; G.B. dwg no. 15-3377; primary 117 v ac, 60 cyc; secondary #1, 1250 v, 2 ma; secondary #2, 2.5 v, 1.75 amp; secondary #3, 2.5 v, 2.1 amp.	ea	2	1	*
71	T1	AN/MPN-1/13-34	2Z9613.190	TRANSFORMER: filament and plate;G.B. dwg no. 15-3448; primary 117 v ac, 60 cyc; secondary #1, 1500 v, 200 ma, center tap; secondary #2, 5 v, 3 amp.	ea	3	1	*
11	T2	AN/MPN-1/13-35	2Z9613.194	TRANSFORMER: filament and plate; G.B. dwg no. 15-3467; primary 117 v ac, 60 cyc; secondary #1, 4100 v, 1 ma; secondary #2, 2.5 v, 1.75 amp.	ea	2	1	*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
24	L22,23	AN/MPN-1/13-36	2Z9641.112	TRANSFORMER: IF discriminator; Harvey dwg no. C-5382-A; double tuned; two 3-13 mmfd trimmer condensers; one 20 mmfd ceramicon connected between primary and center tap on secondary; unshielded; wound on bakelite rod 1-13/16" x 3/8" dia; pri 9 turns #26 AWG; sec two 9 turns sections #26 AWG in series.	ea	4	1	*
26	L2,3	AN/MPN-1/13-37	2C3736-7/C2	TRANSFORMER: IF; input; G.B. dwg no. B00-4935D; air core; brass slug tuned; unshielded; primary 3 turns #28 AWG enamel wire wound over secondary with single layer polystrene tape between windings; secondary 15 turns #28 AWG enamel wire; coil form Galvin type GC-1; coil coated with varnish and baked.	ea	4	1	*
27	T2	AN/MPN-1/13-38	2Z9612.87	TRANSFORMER: plate; G.B. dwg no. 15-3455; primary 113 v ac, 60 cyc; secondary #1, 6180 v, 200 ma.	ea	2	1	*
4	T1	AN/MPN-1/13-39	2Z9612.84	TRANSFORMER: plate; G.B. dwg no. 15-3428; current rate 8 amp; primary voltage 117 v ac, 60 cyc; secondary #1, 300 v, 80 ma; secondary #2, 300 v, 40 ma; secondary #3, 65 v, 175 ma; secondary #4, 45 v, 40 ma; secondary #5, 300 v, 45 ma.	ea	2	1	*
12	T3	AN/MPN-1/13-40	2Z9612.85	TRANSFORMER: plate; G.B. dwg no. 15-3416; primary 117 v ac, 60 cyc; secondary #1, 980 v, 450 ma.	ea	2	1	*
10	T3	AN/MPN-1/13-41	2Z9612.88	TRANSFORMER: plate; G.B. dwg no. 15-3415; primary 117 v ac, 60 cyc; secondary #1, 690 v, 450 ma.	ea	2	1	*
13	T3	AN/MPN-1/13-42	2Z9612.86	TRANSFORMER: plate; G.B. dwg no. 15-3410; primary 117 v ac, 60 cyc; secondary #1, 400-0-400 v, 40 ma; secondary #2, 380-0-380 v, 500 ma.	ea	2	1	*
78	T1	AN/MPN-1/13-43	2Z9613.195	TRANSFORMER: power; G.B. dwg no. 15-3474; primary 117 v ac, 50/60 cyc; secondary #1, 29 v, 1.2 amp, center tap.	ea	1	1	*

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71	T2	AN/MPN-1/13-44	2Z9613.20	TRANSFORMER: power; Mallory type T4660; primary 117 v ac, 50/60 cyc; secondary #1, 62 v, 5 amp.	ea	3	1	*
56		AN/MPN-1/13-45	3H5620-25	TRANSFORMER: power; Jeffries dwg no. X521F15; primary 230 v ac to 115 v ac; 3 wire, 50/60 cyc; rating 20 KVA.	ea	1	1	*
22	T1,2	AN/MPN-1/13-46	2Z9957-16	TRANSFORMER: variac; General Radio type 100-Q; primary 215 v ac, 60 cyc; maximum output 2 KVA; output voltage 0-135 v current 18 amp.	ea	2		*

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25	V2	AN/MPN-1/14-1	2V1B24	Vacuum Tube 1B24	ea	2	12	*
25	V1	AN/MPN-1/14-2	2J2J32	Vacuum Tube 2J32	ea	2	12	*
26	V1	AN/MPN-1/14-3	2J2J36	Vacuum Tube 2J36	ea	2	12	*
11 20	V4 V15	AN/MPN-1/14-4	2J2X2	Vacuum Tube 2X2	ea	4	8	*
20	V11	AN/MPN-1/14-5	2J3AP1	Vacuum Tube 3AP1	ea	2	6	*
3 4 10 11 12 13 14 20 24 71	V1 V7 V1, 2, 3, 4 V3 V1, 2, 3, 4 V1,2,3 V1, 2 V14 V17, 20 V1	AN/MPN-1/14-6	2J5R4GY	Vacuum Tube 5R4GY	ea	44	84	*
19 20 24 25 26	V6, 22 V9 V1 thru V9, V11 V1, 2 V1, 2	AN/MPN-1/14-7	2J6AC7	Vacuum Tube 6AC7	ea	50	96	*
10 13 14 24	V5 thru V11 V4 thru V12 V4 V18, 24, 25	AN/MPN-1/14-8	2J6B4G	Vacuum Tube 6B4G	ea	46	66	*
24	V10	AN/MPN-1/14-9	2J6H6	Vacuum Tube 6H6	ea	4	6	*
10 12 13 14 18 19 20 24	V12 V12 V13, 14 V5 V2, 6 V10, 12, 18, 19 V7, 13 V19, 26	AN/MPN-1/14-10	2J6SJ7GT	Vacuum Tube 6SJ7-GT	ea	46	66	*

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3	V2, 3	AN/MPN-1/14-11	2J6SN7GT	Vacuum Tube 6SN7-GT	ea	126	183	*
4	V9, 10							
16	V1, V3 thru V12							
17	V1							
18	V1,3,7, 8,11,13, 16,21, 24							
19	V1,3,4, 5,7,8,9, 11,13, 14,15, 16,17, 20,21							
20	V1,2,3, 5,6,8							
24	V15, 16							
32	V1, 3							
50	V1							
16	V2,13, 14,15,16	AN/MPN-1/14-12	2J6V6GT	Vacuum Tube 6V6-GT	ea	52	100	*
18	V12,15, 18,20, 23,25							
19	V2, 23, 24							
20	V4, 10							
24	V8, 14							
6	CRT 1,2	AN/MPN-1/14-13	2J7BP7	Vacuum Tube 7BP7	ea	6	17	*
8	CRT 1,2							
17	CRT 1							
27	V1, 2	AN/MPN-1/14-14	2J705A	Vacuum Tube 705A	ea	4	12	*
25	V3	AN/MPN-1/14-15	2J707B	Vacuum Tube 707B	ea	2	6	*
23	V4, 5, 6, 7	AN/MPN-1/14-16	2V715A/B	Vacuum Tube 715A/B	ea	8	23	*
25	V2	AN/MPN-1/14-17	2V721A	Vacuum Tube 721A	ea	2	12	*
26	V3	AN/MPN-1/14-18	2V723A	Vacuum Tube 723A	ea	2	4	*
25	V3	AN/MPN-1/14-19	2V724A	Vacuum Tube 724A	ea	2	12	*

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11 12 18 32	V1 V5 thru V11 V4,5,9, 10, 17, 22 V2	AN/MPN-1/14-20	2J807	Vacuum Tube 807	ea	44	127	*
23	V1	AN/MPN-1/14-21	2J3E29	Vacuum Tube 3E29	ea	2	6	*
4 20 24	V8 V12 V13	AN/MPN-1/14-22	2J884	Vacuum Tube 884	ea	8	15	*
50	V2, 3	AN/MPN-1/14-23	2J927	Vacuum Tube 927	ea	4	6	*
23	V2, 3	AN/MPN-1/14-24	2J1616	Vacuum Tube 1616	ea	4	12	*
4 24	V1, 2, 3, 4 V12	AN/MPN-1/14-25	2J2050	Vacuum Tube 2050	ea	12	17	*
4 10 11 12 13 24	V5 V13 V2 V13,14 V15,16 V21,23	AN/MPN-1/14-26	2J0C3/VR105	Vacuum Tube VR-105	ea	22	32	*
4 14 24	V6 V3, 6 V22	AN/MPN-1/14-27	2J0D3/VR150	Vacuum Tube VR-150	ea	10	14	*

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1		AN/MPN-1/15-1	2Z9408.55	TERMINAL BOARD: 8 spring clip terminals; screw tightened; 4 circuit; bakelite; Burke 1004.	ea	2	1	*
		AN/MPN-1/15-2	2Z9416.28	TERMINAL BOARD: 16 screw lug terminals; 8 circuit; individual bakelite strip sleeve; Curtis FT-8	ea	96	5	*
27		AN/MPN-1/15-3	2Z9420.14	TERMINAL BOARD: 20 screw lug terminals; 10 circuits; individual bakelite strip sleeve; Curtis FT-10.	ea	6	2	*
		AN/MPN-1/15-4	2Z9408-57	TERMINAL BOARD: male 8 solder lugs screw combination terminals; phenolic; G.B. dwg no. B00-4467-B.	ea	98	5	*
		AN/MPN-1/15-5	2Z9408.58	TERMINAL BOARD: female 8 solder and 8 screw terminals; phenolic; G.B. dwg no. B00-4468-B.	ea	98	5	*
25 26		AN/MPN-1/15-6	2Z9402.44	TERMINAL BOARD: 4 screw lug terminals; 2 circuit; molded bakelite shell; H. B. Jones 2-141.	ea	5	2	*
11 76		AN/MPN-1/15-7	2ZK9401.10	TERMINAL BOARD: tie points; 2 solder eyelet type terminals and center mtg eyelet; bakelite strip; Miller 1520.	ea	4	1	*
25 26		AN/MPN-1/15-8	2Z9401.23	TERMINAL BOARD: tie points; 1 solder eyelet type terminals and outside mtg eyelet; bakelite strip; National Fab 1101.	ea	20	4	*
25 26		AN/MPN-1/15-9	2Z9402.71	TERMINAL BOARD: tie points; 2 solder eyelet type terminal and center mtg eyelet; bakelite strip; National Fab 1120.	ea	10	3	*
25		AN/MPN-1/15-10	2Z9402.117	TERMINAL BOARD: tie points; 2 solder eyelet type terminal and outside mtg eyelet; bakelite strip; National Fab 1133.	ea	2	1	*
80		AN/MPN-1/15-11	2Z9402.116	TERMINAL BOARD: tie points; 2 solder eyelet type terminals and center mtg eyelet; bakelite strip; National Fab 1520.	ea	1	1	*

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6		AN/MPN-1/15-12	2Z9406.65	TERMINAL BOARD: 6 screw terminals; 3 circuits; 3 individual bakelite units; assembled with mtg clamps; Square D 9080-3-S.	ea	2	1	*
1		AN/MPN-1/15-13	2Z9408.56	TERMINAL BOARD: 8 screw terminals; 4 circuits; 4 individual bakelite units; assembled with mtg clamps; Square D 9080-4-S.	ea	2	1	*
6		AN/MPN-1/15-14	2Z9410.43	TERMINAL BOARD: 10 screw terminals; 5 circuits; 5 individual bakelite units; assembled with mtg clamps; Square D 9080-5-S.	ea	2	1	*
1		AN/MPN-1/15-15	2Z9412.61	TERMINAL BOARD: 12 screw terminals; 6 inserts; 6 individual bakelite units; assembled with mtg clamps; Square D 9080-6-S.	ea	1	1	*
24		AN/MPN-1/15-16	2Z9401.42	TERMINAL BOARD: tie point; 1 solder lug terminal; bakelite strip; National Fab 1112.	ea	4	1	*

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62		AN/MPN-1/16-1	2Z307-18	ADAPTER: Amphenol AN-3055-14-4.	ea	3		*
62		AN/MPN-1/16-2	6Z149-3	ADAPTER: Amphenol AN-3055-22-8.	ea	6	1	*
62		AN/MPN-1/16-3	6Z149-2	ADAPTER: Amphenol AN-3055-28-10.	ea	6	1	*
		AN/MPN-1/16-4	8A802-2	ALCOHOL: methyl; Carrier Corp.	qt			*
		AN/MPN-1/16-5	3H304-20	BEARING: ball, Fafnir type 203TT; double felt seal; single row of 8 balls 9/32" dia each; bore .6693", OD 1.5748", width .718".	ea	2		*
50		AN/MPN-1/16-6	3H304-5	BEARING: ball, Fafnir type 201TT-3; double felt seal; single row of 7 balls 1/4" dia each; bore .5118", OD 1.2598", width .656".	ea	2		*
50		AN/MPN-1/16-7	4G5033.3/B11	BEARING: ball, Fafnir type 200TT; double felt seal; single row of 7 balls 7/32" dia each, bore .3937", OD 1.1811", width .656".	ea	2		*
50		AN/MPN-1/16-8	3H304-11	BEARING: ball, Fafnir type S3DD; double shield; single row of balls, bore 3/8", OD 7/8", width 9/32".	ea	6		*
30 36		AN/MPN-1/16-9	3H304-23	BEARING: ball, Fafnir type K3A2; double seal; metal shield, single row of 10 balls 1/8" dia each; bore .190", OD .625", inner ring width .297", outer ring width .234".	ea	2		*
17 30 36		AN/MPN-1/16-10	3H304-21	BEARING: ball, Fafnir type K3L; double seal; metal shield, single row of 10 balls 1/8" dia each; bore .190", OD .625", inner ring width .245", outer ring .203".	ea	61		*
20 36		AN/MPN-1/16-11	3H304-22	BEARING: ball, Fafnir type K4A; double metal seal; aircraft type; single row of balls; bore .250", OD .750", inner ring .281" wide, outer ring .219" wide, 13 balls 1/8" dia each.	ea	22		*
		AN/MPN-1/16-12	6J928A/90	BEARING: ball, Fafnir type KF6A; 16 balls 1/8" dia each, bore .3750", OD .8750", width outer ring .500", width inner ring .562", OD inner ring .489".	ea			*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

NOTE: Order maintenance parts by stock number, name and description. Only maintenance parts can be requisitioned.

Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
29		AN/MPN-1/16-13	3H304-24	BEARING: pillow block; Fafnir type LAK; single bearing, mechani-seal; bore 3/4"; overall height 2-1/2", overall lg 5-1/4"; mtd with 3/8" bolts; mtg/c 3-7/8".	ea	2		*
26		AN/MPN-1/16-14	3H2715/B1	BEARING: ball, New Departure type R2; extra light series, single row of 7 balls, 1/16" dia each, bore .1250", OD .3750", width .1562".	ea	2		*
30 36		AN/MPN-1/16-15	3H305-23	BEARING: ball, New Departure type 77R3; extra light series, double shield, single row of 7 balls 3/32" dia each, bore .1875", OD .500", width .1969".	ea	48		*
5 7		AN/MPN-1/16-16	3H305-24	BEARING: ball, New Departure type 77R10; extra light series; double shield; single row 10 balls 3/16" dia each, bore 5/8"; OD 1.3750", width .3438".	ea	4		*
35		AN/MPN-1/16-17	3H1904/B11	BEARING: ball, New Departure type 88504; double seal, single row of 8 balls 5/16" dia each, bore .7874", OD 1.8504", width .6988", seal width .611".	ea	1		*
43		AN/MPN-1/16-19	3H310-8	BEARING: ball, S.K.F. type 7018; extra light series; comb, radial and thrust, single row of balls; bore 3.543", OD 5.5118", width .9449".	ea	1		*
43		AN/MPN-1/16-20	3H310-7	BEARING: ball, S.K.F. type 7020; extra light series; comb, radial and thrust; single row of balls; bore 3.937", OD 5.9055", width .9449".	ea	1		*
1		AN/MPN-1/16-21	6Z1038-5	BOX: flush device; Appleton #180.	ea	2		*
1		AN/MPN-1/16-22	6Z1038-1	BOX: flush device; Appleton #2018.	ea	2		*
3 16 20		AN/MPN-1/16-23	2Z1403-3	BUSHING & NUT: cadmium plated, Hexagon top bushing, studded and threaded, with Hexagon lock nut, Mallory type UB-241	ea	11		*

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84		AN/MPN-1/16-24	2ZK3352.18	CAP & CHAIN: Amphenol 9760-18; use on AN-3100 and AN-3102, size 18 connectors.	ea	1		*
3		AN/MPN-1/16-25	4C2502HC	CAP: lamp; red glass jewel; WE type 2P.	ea	2	1	*
3 9		AN/MPN-1/16-26	4C5492R	CAP: lamp; blue glass jewel; WE type 2R.	ea	13	3	*
3 9		AN/MPN-1/16-27	4C2502S	CAP: lamp; green glass jewel; WE type 2S.	ea	7	2	*
18 32		AN/MPN-1/16-28	2ZK1619-2	CAP: tube; Millen 36002; porcelain cap type "M" with solder type connector strip; ID of porcelain cap 7/16", for clip size 3/8".	ea	10	2	*
23		AN/MPN-1/16-29	2Z9400	CAP: tube; National SPG; plastic cap type MC with shaped solder type connector strip; ID of plastic cap 9/16" for clip size 1/2" dia.	ea	8	2	*
11 12 20		AN/MPN-1/16-30	2ZK1613-2	CAP: tube; National SPP-3; porcelain cap type "C" with shaped solder type connector strip; ID of porcelain cap 13/32" for clip size 13/32".	ea	20	3	*
23 26		AN/MPN-1/16-31	2Z1605-19	CAP: tube; National SPP-9; porcelain cap type with shaped solder type connector strip; ID of porcelain cap 19/32" for clip size 9/16" dia.	ea	6	2	*
25		AN/MPN-1/16-32	2Z2724-1	CAP: tube; Cinch type 6004; clip, tube, nickel plated copper.	ea	10	3	*
3 18 19 22 23 24 25 26 27 28 71		AN/MPN-1/16-33	6Z6918-7.1	CATCH: roll point; American Cabinet Hdwe type E3655; made of 3 parts; shell, spring and two piece catch plate.	ea	46	5	*
74		AN/MPN-1/16-34	3H3000-55/C10	CHAIN: roller-chain; Boston Gear Works type #35; 36" lg; chain, power transmission, standard, 3/8" single pitch, 3/16" wide.	ea	1	1	*

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74		AN/MPN-1/16-35	3H3380-38/C15	CHAIN: roller-chain; Boston Gear Works type #35; 48" lg; chain, power transmission; standard 3/8" single pitch, 3/16" wide.	ea	1	1	*
24 26 28		AN/MPN-1/16-36	2Z2644.15	CLAMP: cable; Amphenol type AN-3057-3; fits max OD cable 5/16"; overall dim 5/8" dia x 1" d; 1/2"-28 thd; 5-40 x 7/16" screws.	ea	8	1	*
17		AN/MPN-1/16-37	2Z2636-12	CLAMP: cable; Amphenol type AN-3057-6; fits cable 1/2" OD max; overall dim 15/16" dia x 1-5/64" d; 3/4"-20 thd; 5-40 x 5/8" screws.	ea	2	1	*
3 71 78		AN/MPN-1/16-38	2Z2643.26	CLAMP: mounting; for FA-5020 capacitor; CD type 22072; 3/4" wd, 2-1/2" OD x 2-15/32" ID.	ea	6	2	*
4 10 11 20 24 32		AN/MPN-1/16-39	2Z2636-26	CLAMP: tube; Birtcher type 926C.	ea	54	5	*
3 10 12 13 20 32 73 80		AN/MPN-1/16-40	2Z5042-4	CLAMP: tube; Birtcher type 926B.	ea	32	5	*
2 3 10 11 12 13 14 20		AN/MPN-1/16-41	2Z2636-28	CLAMP: tube; Birtcher type 926A.	ea	54	5	*
23		AN/MPN-1/16-42	2Z2726.3	CLIP: Fahnestock type #10; nickel plated spring type battery clip standard, .125 dia mtg hole, centered max size wire #14.	ea	4	1	*
23 26 27		AN/MPN-1/16-43	2Z2726	CLIP: Fahnestock type #41; cadmium plated ferrule type clip, .09375" mtg hole dia; 5/16" square top, 7/8" d.	ea	12	2	*

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16		AN/MPN-1/16-44	2Z1961	CLOCK: Army type; black gun metal case; A-11 #505-01 eight day.	ea	2		*
25		AN/MPN-1/16-45	6Z3163-10	CONNECTOR: conduit coupling straight; Amphenol AN-3058-3; conduit size 3/16"; overall dim hex shaped flange 51/64" x 11/16"; 1-1/8" overall d; 1/2"-28 thd.	ea	2	1	*
25 26		AN/MPN-1/16-46	6Z3163-8	CONNECTOR: conduit box connector; straight; Amphenol AN-3064-6; conduit size 3/8"; overall dim hex shaped flange 15/16" dia; 3/4" d; 3/4"-20 thd.	ea	4	1	*
24		AN/MPN-1/16-47	6Z3163-1	CONNECTOR: conduit box connector; straight; Amphenol AN-3064-10; conduit size 5/8"; hex shaped flange 1-1/4"; 3/8" d; 1"-20 thd.	ea	4	1	*
50		AN/MPN-1/16-48	2Z7590-76/1	CONTACT POINT: for AB relay type B-110.	set	1	1	*
22		AN/MPN-1/16-49	2Z7590-75/1	CONTACT POINT: for AB relay type B-200-F2.	set	2	1	*
4		AN/MPN-1/16-50	2Z7591-7/1	CONTACT POINT: for Advance relay type 979-B.	set	2	1	*
23		AN/MPN-1/16-51	2Z7587-68/1	CONTACT POINT: for Leach relay type 1118.	set	2	1	*
15		AN/MPN-1/16-52	2Z7587-69/1	CONTACT POINT: for Leach relay type 1351.	set	2	1	*
6 8 9		AN/MPN-1/16-53	2Z7587-59/1	CONTACT POINT: for Leach relay type 1357.	set	6	2	*
4		AN/MPN-1/16-54	2Z7683/1	CONTACT POINT: for Leach relay type 1037.	set	2	1	*
3 6 8		AN/MPN-1/16-55	2Z7593-50/1	CONTACT POINT: for Leach relay type 2128.	set	8	3	*
22		AN/MPN-1/16-56	2Z7687-12/1	CONTACT POINT: for WL relay type 362-642.	set	2	1	*
22		AN/MPN-1/16-57	2Z7587-53/1	CONTACT POINT: for WEMCO relay type MN120991.	set	2	1	*
26		AN/MPN-1/16-58	2Z3269-30	COUPLING: loop; Gilfillan Bros dwg no. B00-9954; magnetic coupling assembly.	ea	1		*

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20		AN/MPN-1/16-59	2Z3269-29	COUPLING, SHAFT: National type TX8.	ea	10	2	*
20		AN/MPN-1/16-60	2Z3279-6	COUPLING, SHAFT: Birnbash type #531.	ea	2	1	*
6 8		AN/MPN-1/16-61	2Z3352.48	COVER, RUBBER: R.C.A. type M426872-1.	ea	4	1	*
26		AN/MPN-1/16-62	2Z7520-1	CRYSTAL UNIT: Sylvania IN-21A.	ea	2	50	*
25		AN/MPN-1/16-63	2Z7520-7	CRYSTAL UNIT: Sylvania IN-23.	ea	2	50	*
37 43		AN/MPN-1/16-64	2Z5016.2	DOOR PULLS: Stanley 482-J #3; plain brass, black painted.	ea	14	2	*
25 26		AN/MPN-1/16-65	6ZK3821-5	FERRULE: Amphenol 3050-6.	ea	3	1	*
25		AN/MPN-1/16-66	6Z3821-26	FERRULE: Amphenol 3051-6; for connector size 16 and 16S, fitting size 8.	ea	1	1	*
24 25 26		AN/MPN-1/16-67	6Z3821-20	FERRULE: Amphenol AN-3052-6; for connector size 18, fitting size 10.	ea	12	2	*
25 26		AN/MPN-1/16-68	2Z3020-18	FITTING: Mendelsohn CIU-49284 (Type N cable); coupling connector for concentric cable.	ea	4		*
26		AN/MPN-1/16-69	2Z3020-17	FITTING: Mendelsohn right angle, CIU-49267; coaxial line connector.	ea	6		*
23		AN/MPN-1/16-70	3Z1028	FUSE CLIP: Chase-Shawmut 2103; clip, fuse, ferrule type, 30 amp, 250 v.	ea	64	5	*
23 27		AN/MPN-1/16-71	3Z1101-1	FUSE CLIP: Chase-Shawmut 2106; ferrule type, 60 amps, 600 v.	ea	40	5	*
4 24		AN/MPN-1/16-72	3Z1011	FUSE CLIP: Littelfuse 1011.	ea	12	2	*
3 16 20 71		AN/MPN-1/16-73	3Z1013.6	FUSE CLIP: Littelfuse 1216.	ea	16	2	*
25		AN/MPN-1/16-74	3Z1013.11	FUSE CLIP: Littelfuse 1437.	ea	2	1	*
3 16 20 71		AN/MPN-1/16-75	3Z3282-11.3	FUSE LUG: Littelfuse 66-2.	ea	16	2	*

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78		AN/MPN-1/16-76	2Z3282-11.2	FUSE MOUNT: Littelfuse 1237.	ea	1	1	*
26		AN/MPN-1/16-77	2Z4867.70	GASKET: neoprene; Dayton Rubber Co X-1452; round; 15/16" internal, 1-1/16" external, 1/8" th.	ea	2	1	*
26		AN/MPN-1/16-78	2Z4867.71	GASKET: neoprene; Vellumoid Co 2577-E; 1-1/2" OD x 1-1/4" ID x 1/8".	ea	2	1	*
50		AN/MPN-1/16-79	2Z4871-62	GEAR: bevel; as per Gilfillan Bros dwg no. A36-12123; 16 teeth; pitch dia 1", hole 3/8", hub dia 13/16".	ea	1		*
50		AN/MPN-1/16-80	2Z4871-63	GEAR: bevel; as per Gilfillan Bros dwg no. A32-12122 ; 32 teeth; pitch dia 2", hole 1/2", hub dia 1-1/8".	ea	1		*
30 36		AN/MPN-1/16-81	2Z4871-70	GEAR: bevel; as per Gilfillan Bros dwg no. A32-12125; 64 teeth; pitch dia 4"; hole .625", hub dia 1-3/4".	ea	2		*
30 36		AN/MPN-1/16-82	2Z4871-71	GEAR: bevel; as per Gilfillan Bros dwg no. A32-12124; 16 teeth; pitch dia 1", hole 1/2", hub dia 13/16".	ea	2		*
50		AN/MPN-1/16-83	2Z4871-72	GEAR: sprocket; as per Gilfillan Bros dwg no. A36-11584; 72 teeth; pitch dia 8.60", hole 5/8", hub dia 2".	ea	1		*
46		AN/MPN-1/16-84	2Z4871-67	GEAR: spur; as per Gilfillan Bros dwg no. B36-7947; 120 teeth; pitch dia 12", hole 3.125".	ea	1		*
46		AN/MPN 1/16-85	2Z4871-65	GEAR: spur; as per Gilfillan Bros dwg no. A36-8867; 36 teeth; pitch dia 3-6/10", hole 3/4", hub dia 2-1/8".	ea	1		*
46		AN/MPN-1/16-86	2A264-38/G1	GEAR: spur; as per Gilfillan Bros dwg no. A36-7946; 144 teeth; pitch dia 6", hole 3.750", hub dia 4.500".	ea	1		*
46		AN/MPN-1/16-87	2A264-38/G2	GEAR: spur; as per Gilfillan Bros dwg no. B00-8865A; 144 teeth; pitch dia 6", hole .562", hub dia 1-5/8".	ea	1		*
11 12 23 24 25 26 27 71		AN/MPN-1/16-88	3Z3339	GUARD: Cutler-Hammer type 49-1229-2; red bakelite body, metal base, base 2-1/8" x 19/32", overall height 1-1/16", mtg centers 1-13/16".	ea	20	1	*

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20		AN/MPN-1/16-89	2Z5040-360	HOOD: Amphenol 83-1H	ea	2		*
20		AN/MPN-1/16-90	3F4325-64/H1	HOOD: Selectar CSX 49193	ea	6	1	*
3 9		AN/MPN-1/16-91	2Z5851-56	JEWEL: glass; Cook Mfg Co; for #609 socket; color blue.	ea	42	3	*
25 26		AN/MPN-1/16-92	2Z5891-54	JEWEL: Dialco 910-JHS	ea	4	1	*
25		AN/MPN-1/16-93	2Z5891-57	JEWEL: glass; Oak Mfg Co; for #609 socket; color green	ea	2	1	*
25		AN/MPN-1/16-94	2Z5891-55	JEWEL: glass; Oak Mfg Co; for #609 socket; color red	ea	4	1	*
23 27		AN/MPN-1/16-95	2Z5630-7	JUMPER, BONDING: Thomas-Betts CQ-5Q; tinned copper cable 7 x #35 AWG (245) strands; lug mtg center 5"; one lug fits #10 screw; opposite lug fits #12 screw; overall length 5-1/4".	ea	5		*
23		AN/MPN-1/16-96	2Z5630-8	JUMPER, BONDING: Thomas-Betts CQ-6Q; tinned copper cable 7 x #35 AWG (245) strands; lug mtg center 6"; mtg lug holes fit #10 screws.	ea	4		*
23		AN/MPN-1/16-97	2Z5630-10	JUMPER, BONDING: Thomas-Betts CS-9S; tinned copper cable; 7 x #35 AWG (245) strands; lug mtg center 9"; mtg lug holes for 1/4" screws; overall lg 9-1/4"	ea	6		*
22		AN/MPN-1/16-98	2Z5630-9	JUMPER, BONDING: Thomas-Betts CQ-10Q; tinned copper cable; 7 x #35 AWG (245) strands; lug mtg/c 10"; mtg lug holes for #10 screw; overall lg 10-1/2".	ea	1		*
		AN/MPN-1/16-99	6L80037	KIT (AZIMUTH ANTENNA HARDWARE): Gilfillan Bros dwg no. A61-11991.	ea		1	*
		AN/MPN-1/16-100	6L80038	KIT (ELEVATION ANTENNA HARDWARE): Gilfillan Bros dwg no. A61-11992.	ea		1	*
		AN/MPN-1/16-101	6Z6570	KIT (GROMMET): Gilfillan Bros dwg no. A61-11989.	ea		1	*
		AN/MPN-1/16-101A	6L80035	KIT (HARDWARE): Gilfillan Bros dwg no. A61-11988.	ea		1	*
		AN/MPN-1/16-101B	6L80036	KIT (SEARCH ANTENNA HARDWARE): Gilfillan Bros dwg no. A61-11990	ea		1	*

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3 5 6 7 8 9 16 20 76 77		AN/MPN-1/16-102	2Z5748.25	KNOB: Crowe Name Plate Mfg Co dwg no. A6528A; round with lucite pointer black bakelite; 1/4" shaft hole.	ea	67	3	*
7		AN/MPN-1/16-103	2Z5748.27	KNOB: Crowe Name Plate Mfg Co dwg no. A6523; round; black bakelite; 1/4" shaft hole.	ea	1	1	*
5 9 22		AN/MPN-1/16-104	2Z5748.26	KNOB: Crowe Name Plate Mfg Co dwg no. A6529A; round with lucite pointer, black bakelite; 1/4" shaft hole.	ea	5	1	*
18 19 23 24 25 26 27 71		AN/MPN-1/16-105	2Z5822-83	KNOB-DRAWER: Frost Mfg Co dwg no. LN73; round with flared shank, tapped for 8-32 screw.	ea	19	2	*
26		AN/MPN-1/16-106	2C3736-7/M1	MAGNET & KEEPER: Cinaudagraph Corp type 15A135; serial #08561 Gauss 1390.	ea	2	1	*
25		AN/MPN-1/16-107	2C3736-6/M1	MAGNET & KEEPER: Cinaudagraph Corp type 13A250; cat 15-2500; serial C-876 CFS .2501 Gauss.	ea	2	1	*
6 8		AN/MPN-1/16-108	2C1536-36/M1	MIRROR: Thompson Glass Co D-40-6956; plate; 85% reflection.	ea	2	3	*
25 26		AN/MPN-1/16-109	6Z7249-5	NUT, COUPLING: Amphenol AN-3054-6; for use with AN Connector size 14,14S.	ea	6		*
25		AN/MPN-1/16-110	6Z77249-16	NUT, COUPLING: Amphenol AN-3054-8; for use with AN Connector size 16,16S.	ea	2		*
24 25 26		AN/MPN-1/16-111	6ZK7249-10	NUT, COUPLING: Amphenol AN-3054-10; for use with AN Connector size 18.	ea	12		*
25		AN/MPN-1/16-112	2Z6855-1	NUT, LOCK: Amphenol AN-3066-3; hex shaped; 1/2"-28 thd.	ea	2		*

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25 26		AN/MPN-1/16-113	6Z2382-3	NUT, LOCK: Amphenol AN-3066-6; hex shaped; 3/4"-20 thd.	ea	4		*
24		AN/MPN-1/16-114	6Z2382-1	NUT, LOCK: Amphenol AN-3066-10; hex shaped; 1"-20 thd.	ea	4		*
10 11 12 16 19 24		AN/MPN-1/16-115	2C4180-38/N1	NUT, LOCK: potentiometer shaft; James Millen 10061 for 1/4" shaft.	ea	48	2	*
6 8 19 73		AN/MPN-1/16-116	2Z5531.21	PHONE TIP: Insuline Co of America 360.	ea	10		*
17		AN/MPN-1/16-117	2Z7334	PULLEY: Lockheed 2-229030; plastic round 1" OD 3/8" th with bakelite bushing 7/32" dia hole.	ea	3	1	*
7		AN/MPN-1/16-118	6Z7681	PULLEY: Westinghouse 2-229140W; Fafnir bearing ingot; round fibre pulley 2" dia metallic center with bushing dia hole .15625".	ea	4	1	*
1		AN/MPN-1/16-119	6J1101-2/P15	PUMP: Hydraulic Equipment N B15-125 Series 15; stamped MS "HYDRECO" M502.	ea	1		*
4	Rect 1	AN/MPN-1/16-120	3H4859-14	RECTIFIER: selenium; IT&R type 1B1A1; one stack; output .075 amp; 12.5 volts; 6 cells.	ea	2	1	*
4	Rect 3	AN/MPN-1/16-121	3H4859-20	RECTIFIER: selenium; IT&R type 1B8A1; one stack; output .075 amp; 100 volts; 53 cells.	ea	2	1	*
4	Rect 2	AN/MPN-1/16-122	3H4859-21	RECTIFIER: selenium; IT&R type 2B8C1; one stack; output .150 amp; 100 volts; 53 cells.	ea	2	1	*
71	Rect 1	AN/MPN-1/16-123	3H4845-10	RECTIFIER: special; Mallory type 1S80C9.	ea	3	1	*
15	Rect 1	AN/MPN-1/16-124	3H4851-1	RECTIFIER: selenium; Selenium Corp DE-001309-P.	ea	1	1	*
3	Rect 1,2	AN/MPN-1/16-125	3H4851-2	RECTIFIER: selenium; Selenium Corp DE-303-S.	ea	2	1	*

*Indicates stock available.

MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

NOTE: Order maintenance parts by stock number, name and description. Only maintenance parts can be requisitioned.

Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
26		AN/MPN-1/16-126	2Z7392-3	R.F. PLUMBING: assembly in "S" transmitter as per Gilfillan Bros dwg no. C.G.I. 6751.	ea	1		*
26		AN/MPN-1/16-127	2Z7392-1	R.F. PLUMBING: cross and converter assembly in "S" transmitter as per Gilfillan Bros dwg no. C.G.I. 6696.	ea	2		*
26		AN/MPN-1/16-128	2Z7392-16	R.F. PLUMBING: magnetron coupler in "S" transmitter as per Gilfillan Bros dwg no. C.G.I. 10439.	ea	2		*
26		AN/MPN-1/16-129	2Z7392-9	R.F. PLUMBING: T.R. box assembly S wave -G band in "S" transmitter as per Gilfillan Bros dwg no. C.G.I. 10220.	ea	2		*
26		AN/MPN-1/16-130	2Z7392-8	R.F. PLUMBING: fountain pen crystal mixer in "S" transmitter as per Gilfillan Bros dwg no. C.G.I. 10219.	ea	2		*
65		AN/MPN-1/16-131	2Z7392-2	R.F. PLUMBING: "S" transmission line as per Gilfillan Bros dwg no. C.G.I. 5917.	ea	1		*
25		AN/MPN-1/16-132	2Z7392-6	R.F. PLUMBING: "X" transmitter plumbing as per Gilfillan Bros dwg no. C.G.I. 7710.	ea	1		*
25		AN/MPN-1/16-133	2Z7392-4	R.F. PLUMBING: "X" transmitter plumbing as per Gilfillan Bros dwg no. C.G.I. 7173.	ea	1		*
25		AN/MPN-1/16-134	2Z7392	R.F. PLUMBING: "X" transmitter plumbing as per Gilfillan Bros dwg no. C.G.I. 7168.	ea	2		*
25		AN/MPN-1/16-135	2Z7392-16	R.F. PLUMBING: Anti T R Box assembly as per Gilfillan Bros dwg no. C.G.I. 10987.	ea	2		*
25		AN/MPN-1/16-136	2Z7392-17	R.F. PLUMBING: crystal mixer as per Gilfillan Bros dwg no. C.G.I. 20183.	ea	1		*
25		AN/MPN-1/16-137	2Z7392-5	R.F. PLUMBING: "X" transmitter plumbing as per Gilfillan Bros dwg no. C.G.I. 7177.	ea	1		*
63		AN/MPN-1/16-138	2Z7392-7	R.F. PLUMBING: "X" transmission line plumbing as per Gilfillan Bros dwg no. "B" - C.G.I. 9983.	ea	1		*

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
66		AN/MPN-1/16-139	2Z7392-12	R.F. PLUMBING: "X" transmission line plumbing main section sub assem #1 as per Gilfillan Bros dwg no. "C" C.G.I. 10522.	ea	1		*
66		AN/MPN-1/16-140	2Z7392-13	R.F. PLUMBING: "X" transmission line plumbing main section sub assem #2 as per Gilfillan Bros dwg no. "A" - C.G.I. 10523.	ea	1		*
66		AN/MPN-1/16-141	2Z7392-14	R.F. PLUMBING: "X" transmission line plumbing elevation line plumbing elevation sub assem #1 as per Gilfillan Bros dwg no. "F" - C.G.I. 10540.	ea	1		*
66		AN/MPN-1/16-142	2Z7392-15	R.F. PLUMBING: "X" transmission line plumbing elevation section sub assem #2 as per Gilfillan Bros dwg no. "C" - C.G.I. 10541.	ea	1		*
66		AN/MPN-1/16-143	2Z7392-18	R.F. PLUMBING: "X" transmission line plumbing azimuth section sub assem #1 as per Gilfillan Bros dwg no. "E" - C.G.I. 10441.	ea	1		*
66		AN/MPN-1/16-144	2Z7392-11	R.F. PLUMBING: "X" transmission line plumbing azimuth section sub assem #2 as per Gilfillan Bros dwg no. "D" - C.G.I. 10442.	ea	1		*
50		AN/MPN-1/16-145	3Z7990-8/1	SHAFT: telescoping shaft assem COO-10015E; (Gilfillan Bros). Drive shaft between switching unit and scanner gear boxes.	ea	2	1	*
62		AN/MPN-1/16-146	2Z8276-6	SHELL: dummy receptacle; Amphenol 97-151-18; straight; for connector size 18.	ea	1		*
6 8 17		AN/MPN-1/16-147	2Z8276-7	SHELL: dummy receptacle; Amphenol 97-190-6; 90° angle; fitting size 6; 5/8"-24 thd.	ea	2		*
6 8 17		AN/MPN-1/16-148	2Z8276-8	SHELL: dummy receptacle; Amphenol 97-190-12; 90° angle; fitting size 12; 1-3/16"-18 thd.	ea	4		*

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6 8		AN/MPN-1/16-149	2Z8601	SNAP: R.C.A. K-870326; galv sheet metal tube, flanged, grooved at end opposite flange, split in 4 sections, flange bent inward, tube 3/8" lg x 5/32" OD x 1/32" ID, 1/32" pin hole entire length of snap.	ea	2		*
3		AN/MPN-1/16-150	2Z8807-73	SPACER: Cinch 48748; galv sheet metal, tube flanged; flange 9/16" OD x 1/16" th, 3/16" ID, tube 3/16" lg x 9/32" OD x 5/32" ID.	ea	3		*
		AN/MPN-1/16-151	5B4406	STAKES-GROUND: Gilfillan Bros dwg no. COO-3870B; Signal Corps Specs RL-D-5659-B; galvanized iron; overall dim 36" lg x 1-3/8" dia.	ea		2	*
1		AN/MPN-1/16-152	6Z8894-1	VALVE: globe; Crane Co type 232H; brass; overall dimensions 6-1/2" x 2-27/32".	ea	4		*
1		AN/MPN-1/16-153	3H6681	VALVE UNIT AND SUMP TANK ASSEMBLY: cast iron; Hydraulic Equipment Co type Hydreco, model BTV30-D.	ea	1		*
16		AN/MPN-1/16-154	6L50523-9	WASHER, FIBRE: E. F. Johnson Co for #500 insulator; round; 21/32" OD x 5/32" ID x 1/64" th.	ea	2		*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
25 26	BL1 BL1	AN/MPN-1/17-1	3H3000-60	MOTOR: Blower; induction; A. G. Redmond Co type "L"; model 3546; 28 watts; 115 v; 50/60 cyc frequency; single phases; current rating; .38 amp; 1525 rpm; closed frame; 3-1/2" lg; 3-1/4" dia; shaft dia 1/4"; shaft lg 4"; drum type fan blade; dim of blower 5-3/4" x 2-1/4"; round air outlet 2-1/8" dia.	ea	4	2	*
50		AN/MPN-1/17-2	3H3000A25-4	MOTOR: Induction; G. E. type KC; model 5KC48AB313X; 1/4 hp; 115 v; 50/60 cyc frequency; single phase; current rating 5.2 to 4.7 amp; 960-1140 speed; closed frame; 10-3/4" lg; 6-1/4" wd; 8-3/4" ht; shaft dia 9/16", slotted for key; shaft lg 14"; adjustable; 6-1/2" x 4" base; 4 mtg slots; 1-1/4" x 5/16" size of mtg slots; 3" x 5" on centers.	ea	2		*
1		AN/MPN-1/17-3	3H3000A50-8	MOTOR: Gearhead; G. E. type KC Frame 65; model 5KC65AB504; 1/2 hp; 115 v; 60 cyc frequency; single phase; 1725 rpm; closed frame; fixed base; speed of gear shaft 450 rpm.	ea			*
43		AN/MPN-1/17-4	3H3000A25-3	MOTOR: Gearhead; RA style 124222; Master Electric Co type 5820; 1/4 hp; 115/230 v; 50/60 cyc frequency; single phase; current rating 115-4.4 amps, 230-2.2 amps, 1725/1440 speed; closed frame; 13" lg, 7" wd, 7-1/4" ht, shaft dia 3/4"; shaft length from end bell 2-1/2"; slotted for 3/16" key; fixed base; 6 mtg holes, 3/8" size; mtg/c 6-1/8" x 3-1/8" x 6"; shaft speed 100/84; 4 wire leads color coded red, green, black, and yellow for 115/230 volt connector.	ea			*
25 26		AN/MPN-1/17-5	3H3000-59	MOTOR: RF switch motor in transmitters; Speedway Electric Part No. 952-W; 4 watts; 117 v; 50/60 cyc frequency; single phases; 11 rpm; shaft dia 3/16" x 7/8".	ea	2		*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
		AN/MPN-1/18-3	2C1565-38	Approach Indicator ID-38/MPN-1.	ea	1		*
		AN/MPN-1/18-4	2C7895-8	Aural Signal Unit O-8/MPN-1	ea	2		*
		AN/MPN-1/18-5	2Z3790-32	Azimuth Director MX-32/MPN-1 MX-32/MPN-1.	ea	1		*
		AN/MPN-1/18-6	2C1565-36	Azimuth Indicator ID-36/MPN-1.	ea	1		*
		AN/MPN-1/18-7	2Z4052-33	Elevation Director MX-33/MPN-1.	ea	1		*
		AN/MPN-1/18-8	2C1565-37	Elevation Indicator ID-37/MPN-1.	ea	1		*
		AN/MPN-1/18-9	2Z5420-2	Intercommunications Panel SB-2/MPN-1.	ea	1		*
		AN/MPN-1/18-10	3H4698-22	Rectifier Power Unit PP-22/MPN-1.	ea	2		*
		AN/MPN-1/18-11	3H4698-23	Rectifier Power Unit PP-23/MPN-1.	ea	2		*
		AN/MPN-1/18-12	3H4698-24	Rectifier Power Unit PP-24/MPN-1.	ea	2		*
		AN/MPN-1/18-13	3H4698-25	Rectifier Power Unit PP-25/MPN-1.	ea	2		*
		AN/MPN-1/18-14	3H4698-27	Rectifier Power Unit PP-27/MPN-1.	ea	2		*
		AN/MPN-1/18-15	2Z7670-3	Relay Assembly RE-3/MPN-1.	ea	1		*
		AN/MPN-1/18-16	2C7708-6	Search Central SN-6/MPN-1.	ea	2		*
		AN/MPN-1/18-17	2C1565-35	Search Indicator ID-35/MPN-1.	ea	2		*
		AN/MPN-1/18-18	2C449-15	Sweep Amplifier AM-15/MPN-1.	ea	4		*
		AN/MPN-1/18-19	2C7870-5	Synchronizer SN-5/MPN-1.	ea	2		*
		AN/MPN-1/18-20	3F4325-64	Synchroscope TS-64/MPN-1.	ea	2		*
		AN/MPN-1/18-22	2C666-61	Control Box C-61/MPN-1.	ea	1		*
		AN/MPN-1/18-23	2C2537-11	Modulator MD-11/MPN-1.	ea	2		*
		AN/MPN-1/18-24	2C4180-38	Radar Receiver R-38/MPN-1.	ea	4		*
		AN/MPN-1/18-25	2C3736-2	Radio Frequency Unit RF-6/MPN-1.	ea	1		*
		AN/MPN-1/18-26	2C3736-7	Radio Frequency Unit RF-7/MPN-1.	ea	1		*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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Major Component	Ref. Symbol	Equipment Item Number	Signal Corps Stock Number	Name of Part and Description	Unit of Meas.	Quan. per Equip.	1st Ech. through 4th Ech. Stocks	Depot Stocks
		AN/MPN-1/18-27	3H4698-26	Rectifier Power Unit PP-26/MPN-1	ea	2		*
		AN/MPN-1/18-29	2A264-40	Azimuth Antenna Assembly AS-40/MPN-1 consisting of the following sub-assemblies:	ea	1		*
			2A206-41 **	1-Azimuth-Antenna Array AS-41/MPN-1				
			2A3166-20	2-Azimuth Reflector AT-20/MPN-1				
			2C472-14	2-Angle Coupling Unit CU-14/MPN-1				*
			3D6000-15	2-Angle Capacitor Unit CU-15/MPN-1				*
			1F430-12	2-Cord CG-12/MPN-1				*
				1-Hardware Kit for Assembly				*
		AN/MPN-1/18-35	2A264-42	Elevation Antenna Assembly AS-42/MPN-1, consisting of the following sub-assemblies.	ea	1		*
			2A206-43 **	1-Elevation Antenna Array AS-43/MPN-1				*
			2A3166-21	1-Elevation Reflector AT-21/MPN-1				*
			2C472-14	2-Angle Coupling Unit CU-14/MPN-1				
			3D6000-15	2-Angle Capacitor Unit CU-15/MPN-1				
			1F430-12	2-Cord CG-12/MPN-1				
				1-Hardware Kit for Assembly				
		AN/MPN-1/18-41	2Z330-48	Elevation Antenna Follower Assembly MX-48/MPN-1	ea			*
		AN/MPN-1/18-42	2Z330-47	Azimuth Antenna Follower Assembly MX-47/MPN-1	ea			*

*Indicates stock available. **With Angle Cap Unit CU-15/MPN-1

MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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		AN/MPN-1/18-43	2A264-38	Search Antenna Assembly AS-38/MPN-1, consisting of the following sub-assemblies:	ea	1		*
			2A3166-19	1-Search Reflector AT-19/MPN-1				
			2A206-39	1-Search Antenna Array AS-39/MPN-1				
			2A2565-122	1-Search Antenna Mount MT-122/MPN-1				
				1-Hardware Kit for Assembly				
		AN/MPN-1/18-49	3H40-31	Air Conditioner MX-31/MP	ea			*
		AN/MPN-1/18-50	3Z7990-8	Switching Unit SA-8/MPN-1	ea	1		*
		AN/MPN-1/18-56	3H7100-3	Voltage Regulator Unit CN-3/MPN-1	ea	1		*
		AN/MPN-1/18-57	3H4112-1	Power Distribution Panel SB-1/MPN-1	ea	1		*
		AN/MPN-1/18-58	6J470-34	Hydraulic Leveling System MX-34/MPN-1	ea	1		*
		AN/MPN-1/18-59	2Z7562-233	Reflector Target MX-233/UP	ea	1		*
		AN/MPN-1/18-60		Interconnecting Cable, consisting of the following:	ea	2		*
			3E6000-46	2-Cord CX-46/MPN-1				
			3E6000-48	2-Cord CX-48/MPN-1				
		AN/MPN-1/18-62	2A203-22	Antenna AT-22/MPN-1	ea	3		*
		AN/MPN-1/18-66	2Z140-29	Transmission Line CG-29/MPN-1	ea	1		
		AN/MPN-1/18-67	2Z10006-30	Transmission Line CG-30/MPN-1	ea	1		
		AN/MPN-1/18-68	2Z1006-31	Transmission Line CG-31/MPN-1	ea	1		
		AN/MPN-1/18-71	3H4698-28	Rectifier Power Unit PP-28/MPN-1	ea	3		*
		AN/MPN-1/18-73	2C641-40	Commutator Unit SA-40/MPN-1	ea	2		*
		AN/MPN-1/18-74	3H3380-38	Drive Motor Unit PU-38/MPN-1	ea	1		*
		AN/MPN-1/18-75	2Z6880-204	Observer's Desk MX-204/MPN-1	ea	1		*
		AN/MPN-1/18-76	2C666-139	Observer's Control Box C-139/MPN-1	ea	1		*
		AN/MPN-1/18-77	2C667-140	Tower Receiver Control Panel C-140/MPN-1	ea	1		*

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MAINTENANCE PARTS LIST RADIO SET AN/MPN-1

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		AN/MPN-1/18-78	3H4698-100	Rectifier Power Supply PP-100/MPN-1	ea	1		*
		AN/MPN-1/18-79	2A383-43	Antenna Bracket Assembly AB-43/MPN-1	ea	1		*
		AN/MPN-1/18-80	4B8000-6	Telephone Box TA6/MPN-1	ea	1		*
		AN/MPN-1/18-81	2Z5003-46	Headphone Matching Assembly CU-46/MPN-1	ea	1		*
		AN/MPN-1/18-82	3H405-35	Air Blower Unit MX-35/MPN-1	ea	2		*
		AN/MPN-1/18-83	2Z5600-29	Junction Box J-29/MPN-1	ea	1		*
		AN/MPN-1/18-84	2Z5600-30	Junction Box J-30/MPN-1	ea	1		*
		AN/MPN-1/18-85	2Z5600-31	Junction Box J-31/MPN-1	ea	1		*
		AN/MPN-1/18-86	2A380-117	Mounting Bracket MT-117/MPN-1	ea	3		*
		AN/MPN-1/18-87	1F430-11	Cord CG-11/MPN-1	ea	1		*
		AN/MPN-1/18-89	3E6000-45	Cord CX-45/MPN-1	ea	1		*
		AN/MPN-1/18-91	3E6000-47	Cord CX-47/MPN-1	ea	1		*

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		MX-31/MP/16-1	6Z3856-47	AIR FILTER: Carrier Corp. type MC1-1382.	ea			*
		MX-31/MP/16-2	3H40-31/B11	BEARING: connecting rod, lower; Carrier Corp. type 7K3-5482.	ea			*
		MX-31/MP/16-3	3H40-31/B10	BEARING: connecting rod, upper; Carrier Corp. type 7K3-5472.	ea			*
		MX-31/MP/16-4	3H40-31/B15	BELT: Carrier Corp. type KR20BA063.	ea		2	*
		MX-31/MP/16-5	3H40-31/G30	BULLS EYE GLAND: Carrier Corp. type CQ3-2.	ea			*
		MX-31/MP/16-6	3H40-31/G31	BULLS EYE GLASS: Carrier Corp. type CQ3-1.	ea			*
		MX-31/MP/16-7	3H40-31/W1	BULLS EYE WASHER: Carrier Corp. type CQ3-4.	ea			*
		MX-31/MP/16-8	3H40-31/C15	CLAMP: duct; Carrier Corp. type MC1-1232.	ea			*
		MX-31/MP/16-9	3H5315/C15	COIL: for motor starter, heater; Carrier Corp. type A.B. #1 N41.	ea		1	*
		MX-31/MP/16-10	3H40-31/C20	COMPRESSOR: with stop valve; Carrier Corp. type 7K3-494.	ea			*
		MX-31/MP/16-11	3H40-31/R20	CONNECTING ROD ASSEMBLY: Carrier Corp. type 7K3-183.	ea			*
		MX-31/MP/16-12	3H40-31/C30	CRANKSHAFT: Carrier Corp. type 7K3-2163.	ea			*
		MX-31/MP/16-13	3H40-31/V1	DISC: suction valve; Carrier Corp. type 7K3-1092 A.	ea		2	*
		MX-31/MP/16-14	3H40-31/D15	DUCT: each 10' long; Carrier Corp. type MC1-313.	ea			*
		MX-31/MP/16-15	3H40-31/C40	DUCT COLLAR ASSEMBLY: on trailer; Carrier Corp. Type MC1-212.	ea			*
		MX-31/MP/16-16	3H40-31/C41	DUCT COLLAR ASSEMBLY: on unit; Carrier Corp. type MC1-202.	ea			*
		MX-31/MP/16-17	3H40-31/F10	FLYWHEEL: compressor; Carrier Corp. type 41BITH-1063.	ea			*
		MX-31/MP/16-18	6G564	FREON: Carrier Corp. type #12.	lb.			*

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		MX-31/MP/16-19	3H40-31/G1	GASKET: bottom plate; Carrier Corp. type 7K3-3982.	ea		1	*
		MX-31/MP/16-20	2Z4867.72	GASKET: cap screw; Carrier Corp. type 54456.	ea			*
		MX-31/MP/16-21	3H40-31/G6	GASKET: discharge shut-off valve; Carrier Corp. type 52452.	ea		1	*
		MX-31/MP/16-22	3H40-31/G2	GASKET: discharge valve plate, lower; Carrier Corp. type 7K3-1132.	ea		2	*
		MX-31/MP/16-23	3H40-31/G3	GASKET: discharge valve plate, upper; Carrier Corp. type 7K3-1122.	ea		2	*
		MX-31/MP/16-24	3H40-31/G5	GASKET: oil pump to crankcase; Carrier Corp. type 7K3-1192.	ea			*
		MX-31/MP/16-25	3H40-31/G4	GASKET: seal cover plate; Carrier Corp. type 7F3-0112.	ea		2	*
		MX-31/MP/16-26	3H40-31/G7	GASKET: suction shut-off valve; Carrier Corp. type 7K3-4522.	ea		1	*
		MX-31/MP/16-27	6Z4251-10	GAUGE: high pressure; Carrier Corp. type WR222.	ea			*
		MX-31/MP/16-28	6Z4251-9	GAUGE: low pressure; Carrier Corp. type WR223.	ea			*
		MX-31/MP/16-29	3H3000-58	MOTOR: Carrier Corp. type MC1-1271.	ea			*
		MX-31/MP/16-30	3H3000-58/S16	MOTOR SHAFT EXTENSION: Carrier Corp. type MC1-162.	ea			*
		MX-31/MP/16-31	6G1351	OIL: heavy medium refrigeration; Carrier Corp. type DTE.	gal.			*
		MX-31/MP/16-32	3H40-31/S15	OIL FILTER SCREEN ASSEMBLY: Carrier Corp. type 7K3-122.	ea			*
		MX-31/MP/16-33	3H40-31/P25	OIL PUMP ASSEMBLY: Carrier Corp. type 7K3-623.	ea			*
		MX-31/MP/16-34	3H40-31/P15	ORIFICE PLATE: fan discharge; Carrier Corp. type MC1-1482.	ea			*
		MX-31/MP/16-35	3H40-31/P45	PISTON-ASSEMBLY: Carrier Corp. type 7K3-226.	ea			*
		MX-31/MP/16-36	3H40-31/P10	PISTON PIN: Carrier Corp. type 7K3-1952.	ea			*

*Indicates stock available.

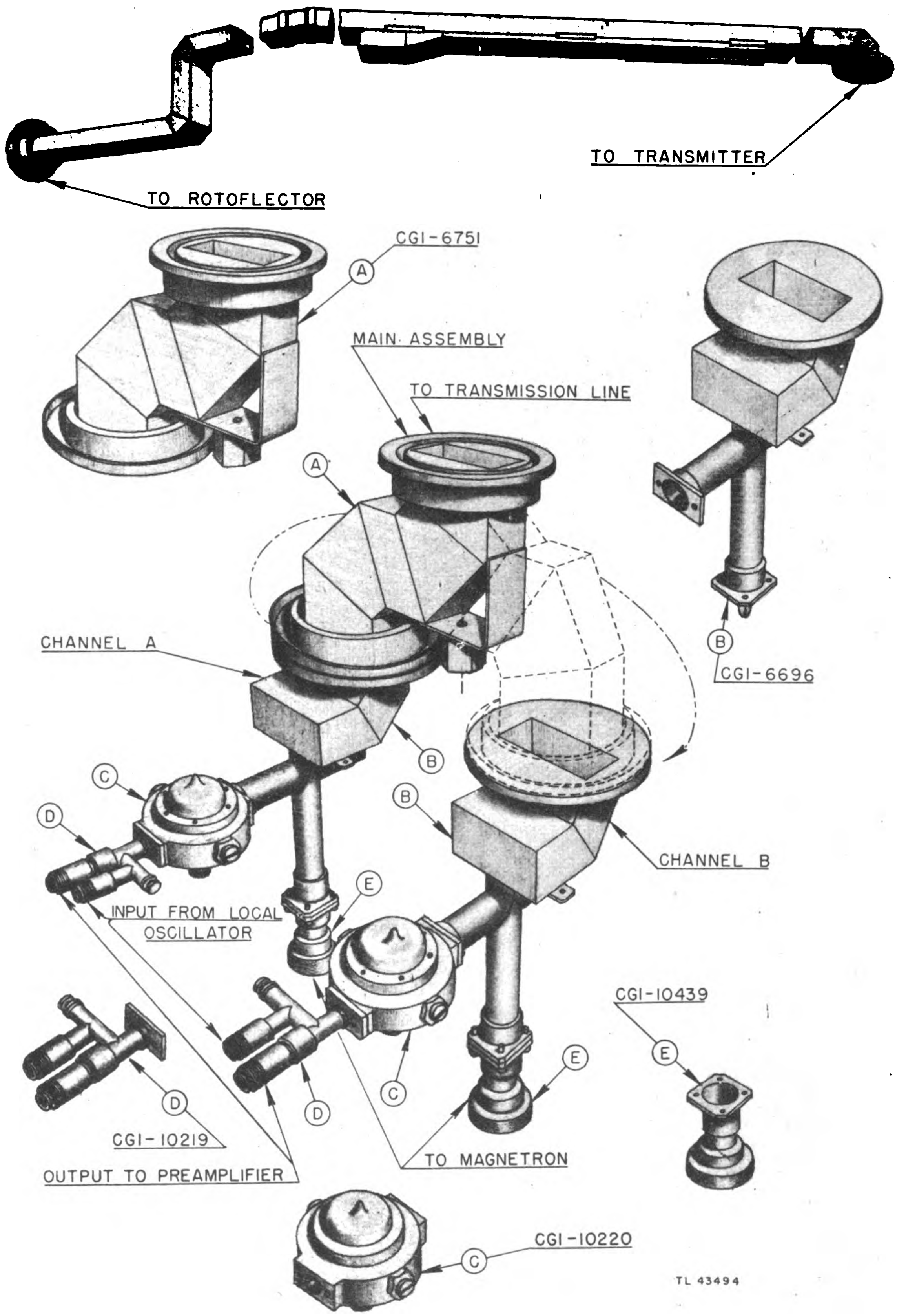

Figure 464. S-band r-f plumbing.

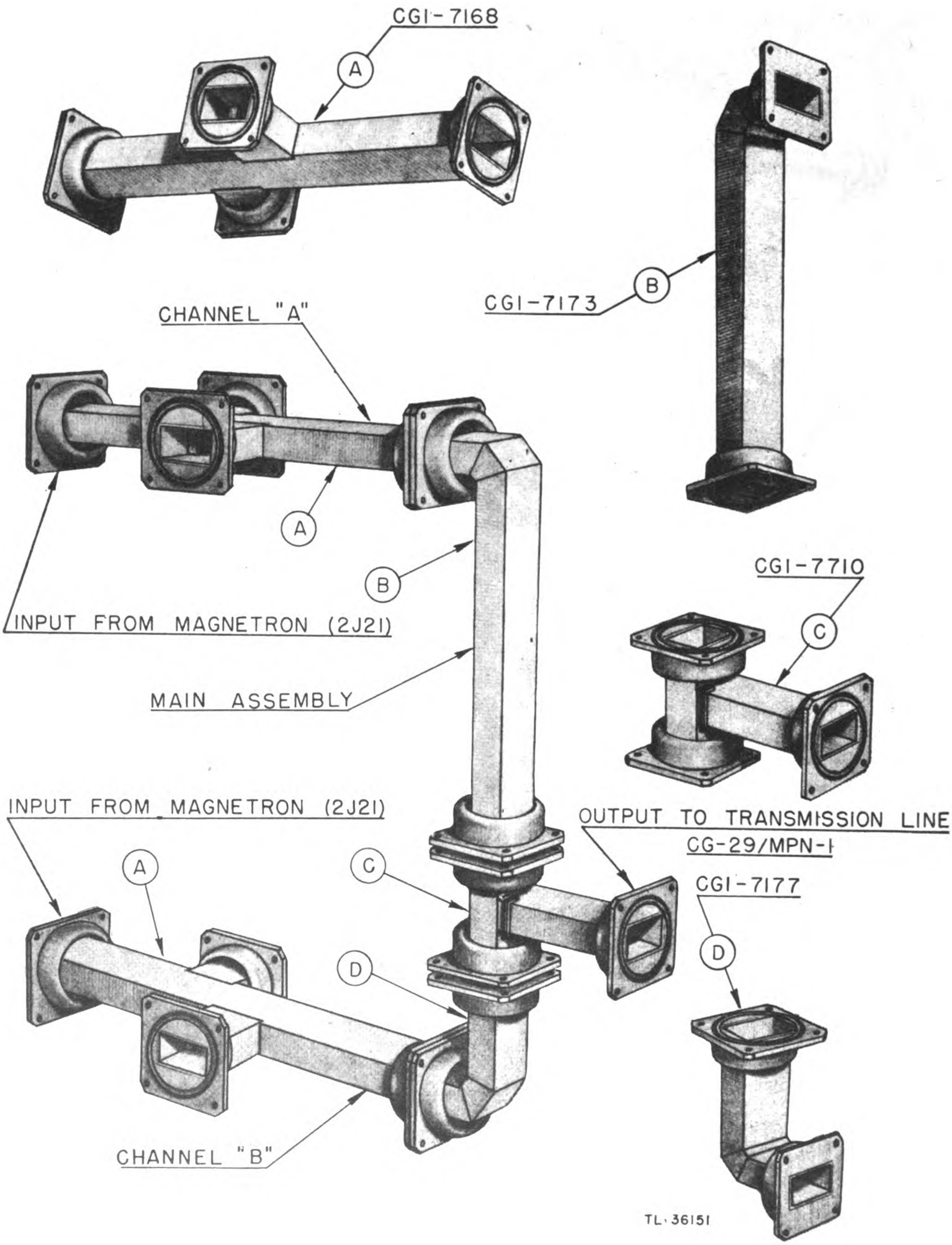

Figure 465A. X-band r-f plumbing.

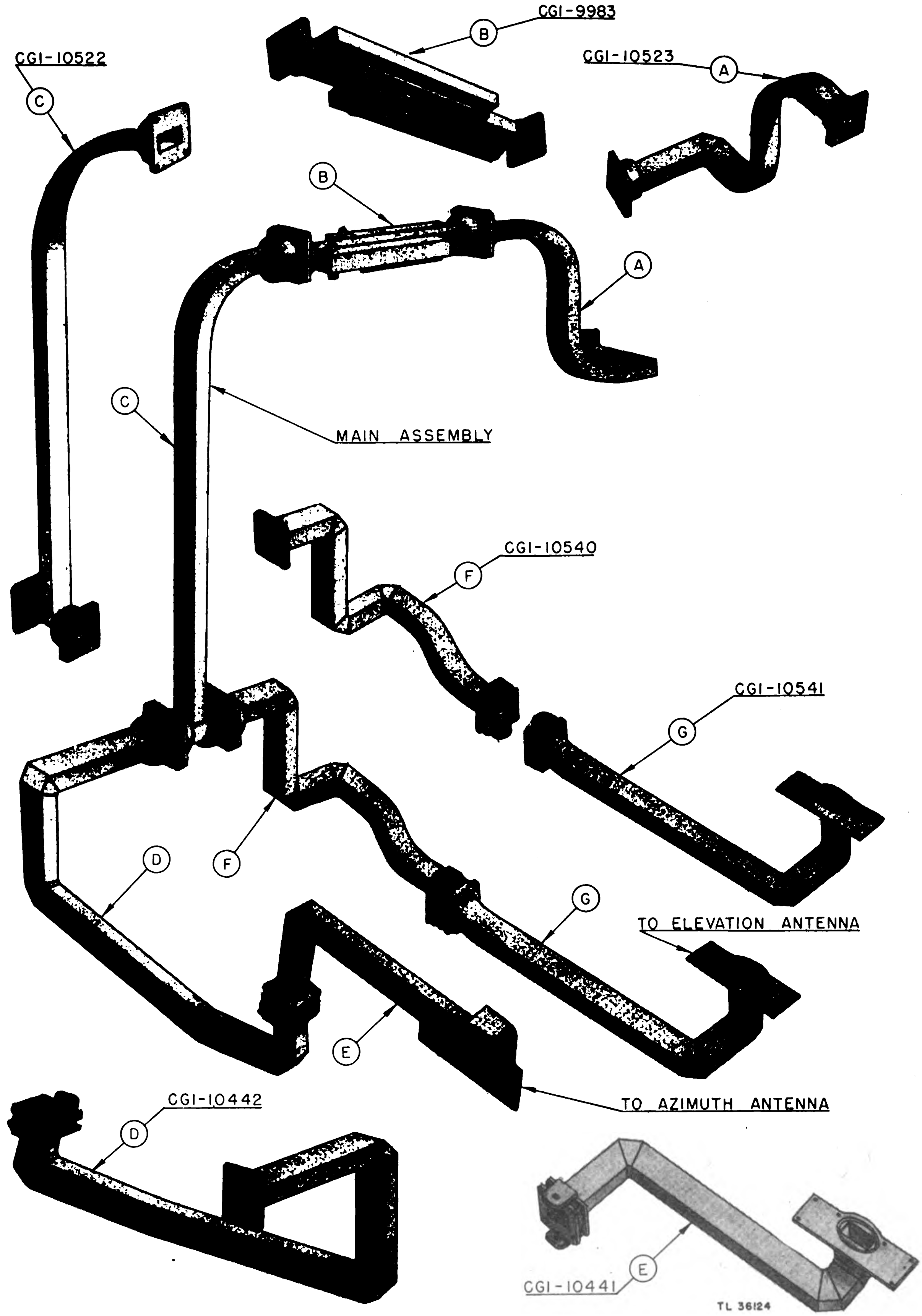

Figure 465B. X-band r-f plumbing.

ADDENDA

ADDENDUM I.

STC CIRCUIT

1. USE IN SEARCH SYSTEM. Radio Set AN/MPN-1 did not use the sensitivity time control circuit (STC) in Radar Receiver R-38/MPN-1 for the search system on the first units manufactured. However, all radar receivers furnished were identical and both the search and precision receivers include STC equipment. The positive trigger pulse from the synchronizer was wired to terminal 4 of connector strip 12 on the precision radar receivers only, which left the STC circuit inoperative in the search system. Switch SW2 STC should be left OFF on search receivers not having the trigger pulse which actuates the STC circuit. Later units include wiring which brings the synchronizer trigger pulse to the search receiver connector strips as well as to the precision receivers. The STC circuit was found useful in reducing near-by ground clutter on the search system, especially in emergency cases when airplanes were landed with the search system alone. The procedure for adjusting the STC circuit for use in both the search and precision systems will be found in paragraph 182.

ADDENDUM II

LOOSENING CONES AND COUPLING ON SWITCHING UNIT

1. INSTRUCTIONS.

a. In order to adjust the r-f blades or the blanker blades, it is necessary to loosen the locking cones in the end of the supporting spools. To adjust one scanner in correct phase to the other scanner, it is necessary to loosen the slip ring on the adjustable coupling. To enable this to be done easily, quickly and without injury to the unit, four spare Allen socket headscrews have been provided ($\frac{10}{32}$ x $\frac{5}{8}$ long). These screws will be found in four spare holes near the nameplate.

b. To loosen either cone, first unlock the two check nuts which bind the cone, then remove two of the spare screws and insert in the tapped holes provided in the cone. Tighten evenly on both screws until cone releases.

c. To loosen the slip ring on the adjustable coupling, first cut and remove the lockwire from the coupling screws, then remove the screws themselves. No connection now exists between the shafts. Misalignment of the original locking holes is necessary for the following procedure, therefore, rotate either shaft until the two clearance holes that have been provided in the inner flange of the slip-ring half of the coupling are lined up with either pair of the four tapped holes provided in the opposite half of coupling. One of these two positions will produce this misalignment. Next take the four spare screws, use two to lock both halves of coupling together, and use the other two in the original locking holes **but from the reverse direction.** Be sure these two screws are diametrically opposite each other. Tighten evenly until enough pressure is exerted to loosen the slip ring.

d. After loosening either the cones or coupling, do not make any adjustments until the spare screws have been removed and put back in the spare holes near the nameplate. The proper adjustments can now be made and secured by the original method.

ADDENDUM III

NOTICE AGAINST CONTINUED OPERATION OF ALTERNATE CHANNEL PREHEAT

WARNING

During preparation of this manual, it was not known that with one channel in operation, continued use of the alternate channel preheat could cause serious damage to the components of Radio Set AN/MPN-1. Therefore, regardless of the instruction to the contrary in this manual, *do not leave the alternate channel preheat ON for a length of time exceeding 2½ hours.* Because of the slow rate of cooling, it is preferable that preheat be not left ON longer than this time during any 8-hour period.

(1) If it is suspected that the channel being used will go out of operation, preheat for the alternate channel should be turned ON. Generally there will be indications of such failure prior to its happening. Be alert for indications of trouble so there will be ample time to preheat the alternate channel before failure occurs.

(2) As a precautionary measure, during that time whenever a large group of aircraft is being directed for landings by Radio Set AN/MPN-1, the alternate channel preheat should be ON.

NOTICE AGAINST LEAVING SELECTOR SWITCHES IN ANY OF THE FOUR POSITIONS FOR READING 715 A/B GRID CURRENTS

WARNING

The selector switches in the control box are never to be left on any one of the four positions (I GRID S1, I GRID S2, I GRID X1, and I GRID X2) reading the 715 A/B grid currents. The operator should read any one or all of the grid currents and return the selector switch to any of the other positions except the four for reading 715 A/B grid currents.

ADDENDUM IV

ADDITIONAL COMMUNICATIONS SCHEMATIC DIAGRAMS

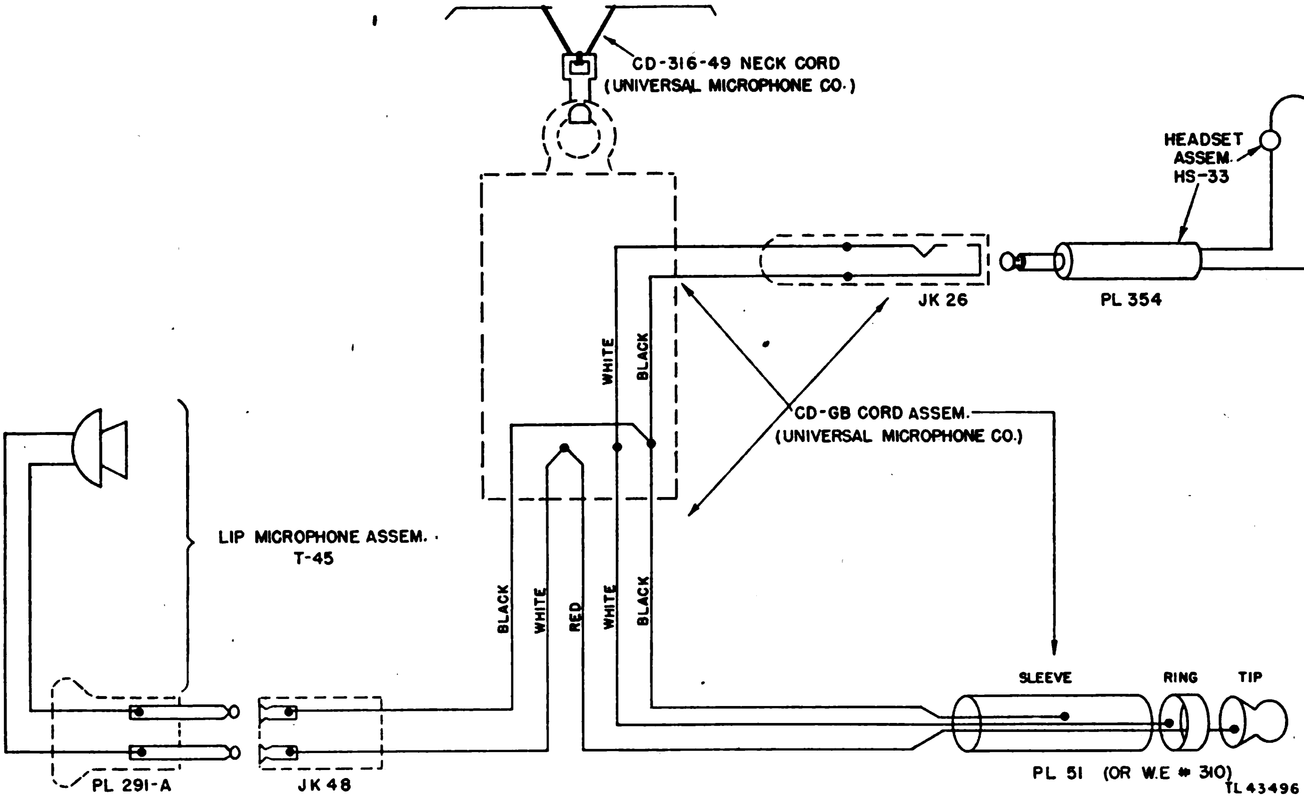

Figure 466. Microphone and headset assembly, schematic diagram.

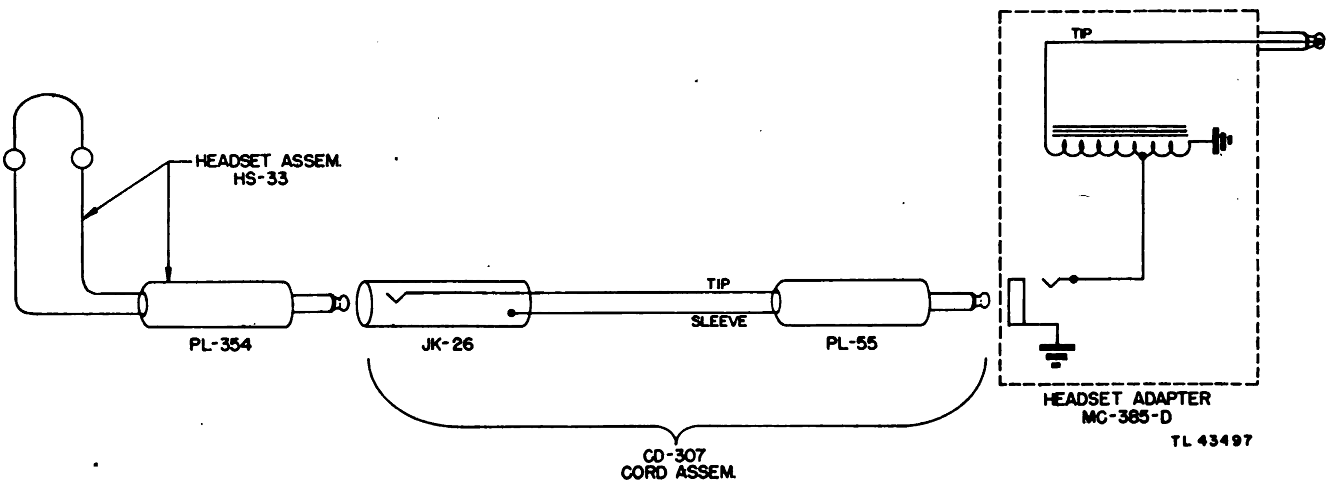

Figure 467. Tracker's headset assembly, schematic diagram.

ADDENDUM V

CHANGE TO IMPROVE LEADING EDGE OF INTENSIFYING PULSE TO FIRST ANODE OF CRT IN SEARCH INDICATOR

To improve the leading edge of the positive-going intensifying pulse from the gating multivibrator V5(b) in the search central to the first anode of the CRT in the search indicator, the output from this stage has been eliminated. An output (No. 6, fig. 347) is now taken from the plate of V5(a) between R21 and R22. This wave is inverted by the previously unused second triode of V1 (6SN7GT) in the search indicator, and the output from the plate (pin 5) of this tube is fed to the first anode of the CRT (V2). The second triode of V1 has been made an inverter by adding C3, R4, and R5 to the search indicator in this stage (fig. 72). Waveform No. 8 in figure 347 does not occur at terminal 24-8 now. Waveform No. 6 (fig. 347) will be found there.