

NAVSHIPS 92459

Non-Registered

INSTRUCTION BOOK
for
RADIO
MODULATOR
MD-209/UC

SCHUTTIG AND COMPANY, INC.
COLLEGE PARK, MARYLAND

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

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Code 993-100
9 March 1955

From: Chief, Bureau of Ships
To: All Activities Concerned with the
Installation, Operation and Main-
tenance of the Subject Equipment

Subj: Instruction Book for Radio Modula-
tor MD-209/UC, NAVSHIPS 92459

1. This is the instruction book for the subject equipment and is in effect upon receipt.
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W. D. Leggett, Jr.
Chief of Bureau

RECORD OF CORRECTIONS MADE

CHANGE NO.	DATE	SIGNATURE OF OFFICER MAKING CORRECTION
T-1	1-29-59	<i>Hazel Summers</i>

TEMPORARY CORRECTION T-1 TO INSTRUCTION BOOK FOR RADIO MODULATOR MD-209/UC
NAVSHIPS 92459

This Temporary Correction is in effect immediately. It provides additional Stock Numbers, corrections to Stock Numbers, additional reference numbers and Support Phrases.

On Pages 6-1 through 6-10 make the following pen and ink corrections and then insert this Temporary Correction under the front cover of the Instruction Book as a permanent record.

REF. DESIG.	ADD OR CORRECT STOCK NUMBER TO:	REF. DESIG.	ADD REFERENCE IN DESCRIPTION COLUMN
C37	/ For Replacement Use N16-C-45780-5861	/ DS1	GE #47
E42	/ N16-S-34576-6513	/ E1	Electrical Industries Inc., #1B-60W-PP
R11	/ N16-R-49876-438	/ E3	Millen #36002
R17	/ N16-R-50200-438	/ D4	Hoffman Radio Co., HK-13
R37	/ N16-R-50399-131	/ E10	Navy Dwg RE10F479F
R41	/ For Replacement Use N16-R-87849-4391	/ E11	Elcon type TT-16
R51	/ N16-R-87519-4580	/ F1	Bussman BAG-2
T3	/ N17-T-75903-2201	/ L7	Ohmite type Z-50
W5	— Delete SNSN - Add "Low Failure Item - if required requisition from ESO referencing NAVSHIPS 900,180A"	/ TB1	H.B. Jones 3-141Y
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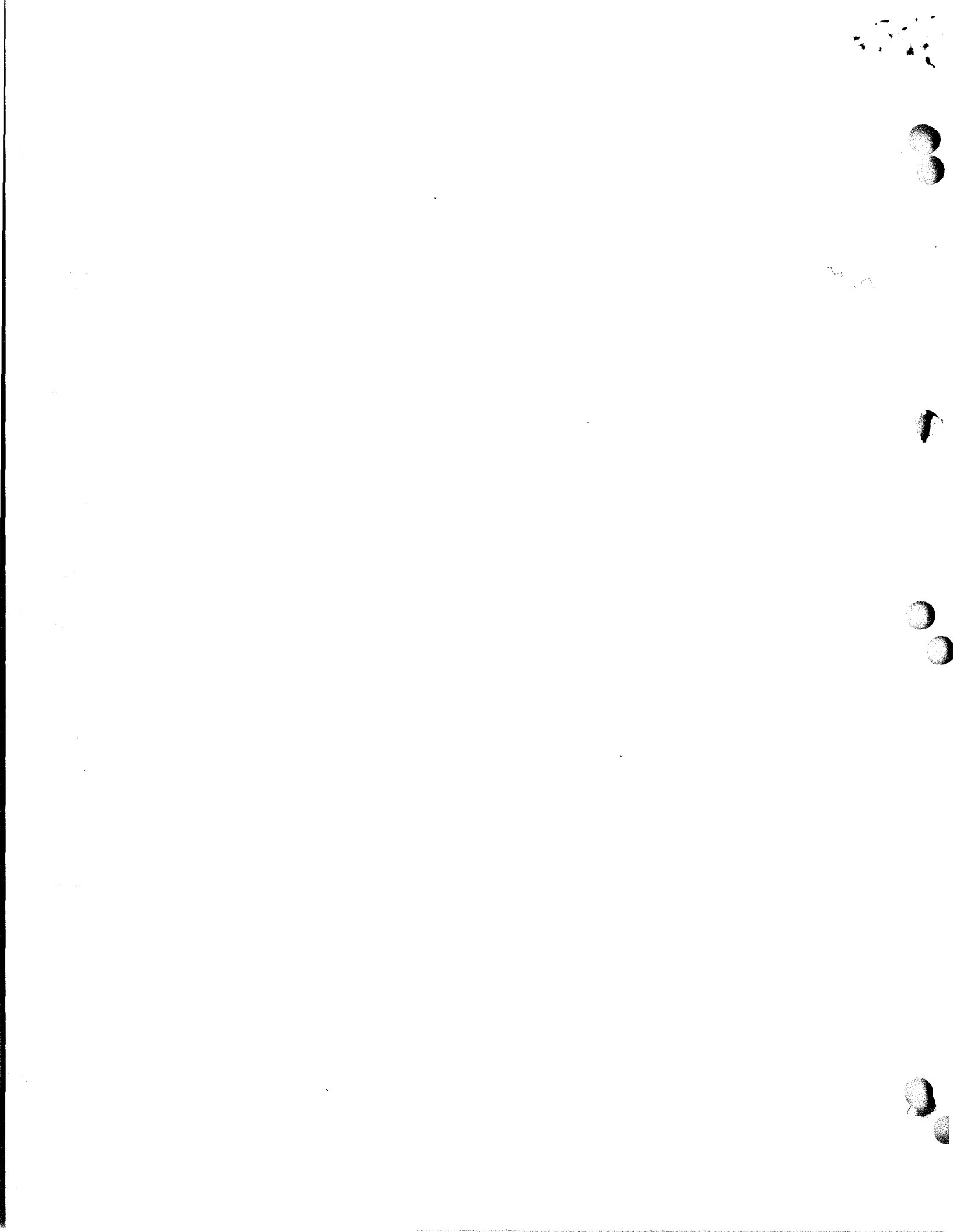


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SAFETY NOTICE

The attention of officers and operating personnel is directed to Chapter 67 of Bureau of Ships Manual or superseding instructions on the subject of Radio-Safety precautions to be observed.

1. While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed.

KEEP AWAY FROM LIVE CIRCUITS:

2. Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside equipment with high voltage supply on. To avoid casualties ALWAYS remove power and discharge and ground circuits prior to touching them.

DON'T SERVICE OR ADJUST ALONE:

3. Under no circumstances should any person reach within the equipment for the purpose of servicing or adjusting without the immediate presence or assistance of another person capable of rendering aid.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION BY THE PRONE PRESSURE METHOD SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE BUREAU OF MEDICINE AND SURGERY.

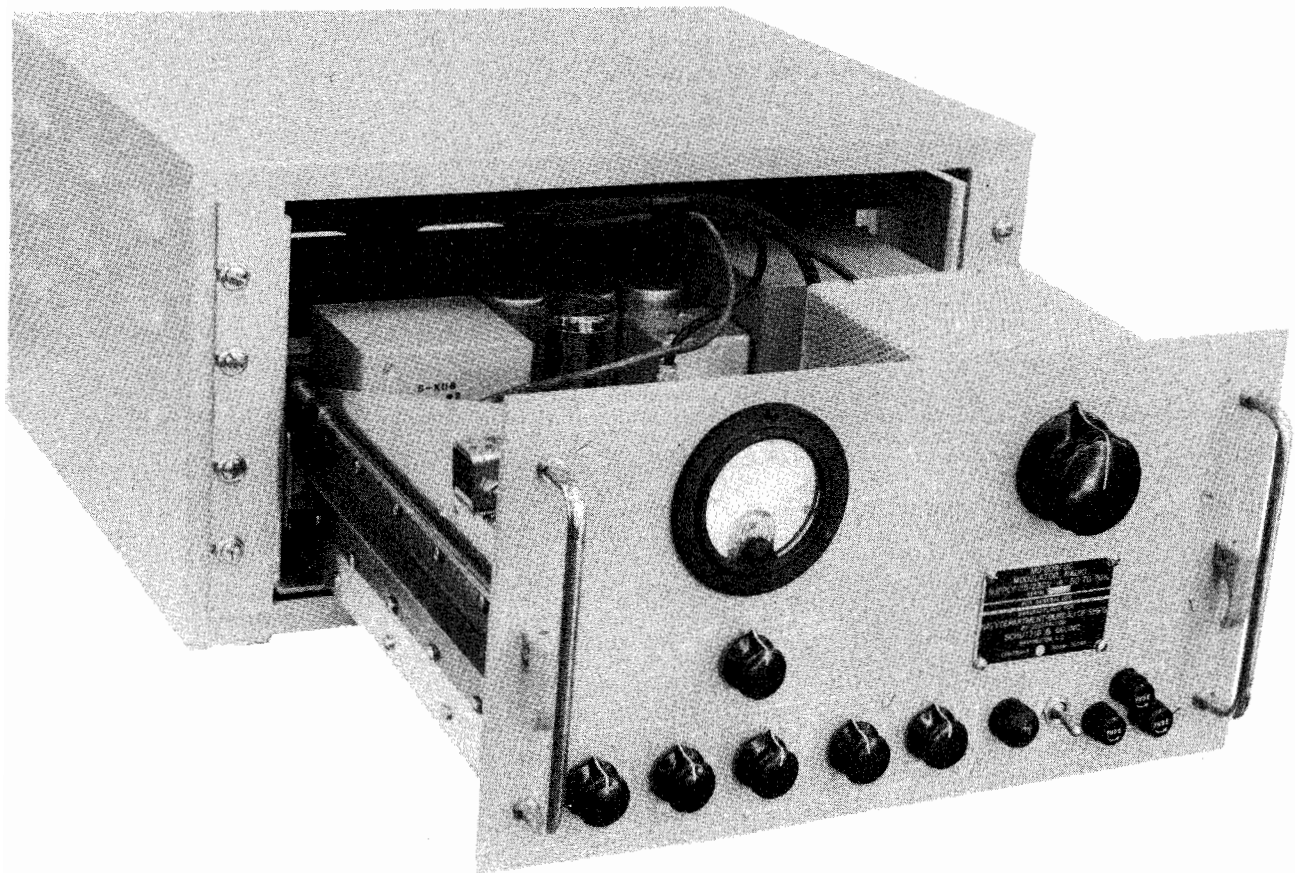


Figure 1-1. Radio Modulator, MD-209/UC, Extended on Slides

SECTION 1

GENERAL DESCRIPTION

1. INTRODUCTION

This publication describes the installation, operation, maintenance, and theory of operation of the MODULATOR, RADIO, MD-209/UC. It provides detailed information about the maintenance parts, and includes illustrations and diagrams to enable the user to obtain maximum effective use of this equipment.

2. DESCRIPTION

a. **Purpose.** Radio Modulator, MD-209/UC is a device for electronically shifting the phase of a radio frequency signal at an audio frequency rate. Its use permits audio frequency transmission by an A-1 emission type transmitter. Audio frequency modulation signals used for this purpose must be in the frequency range 250 to 6,000 cps.

b. **Basic Principles of Operation.** The modulator is designed to phase modulate an RF signal in the range 2 to 5 mc. It is intended to be used with transmitters whose output frequency is in the range 4 to 20 mc. Because phase deviation is multiplied when frequency is multiplied, a control (MODULATION RANGE) is provided to reduce phase shift in proportion to the frequency multiplication used. The RF input is terminated in a 51-ohm resistive load. An RF input level between 1 to 20 volts is required. The nominal maximum modulation capability is $\pm 1/2$ radian of RF phase shift at all modulating frequencies within the above limits. Audio modulating signals should be between -20 dbm and +10 dbm to satisfactorily modulate the RF signal. The audio input circuit

matches a line of 600 ohms nominal impedance.

All power necessary to operate the unit is obtained from the built-in power supply. This supply can be adjusted to operate from either a 115-volt or 230-volt, 60 cycle ac power source. The power input is filtered to prevent RF voltage from appearing on the line.

3. REFERENCE DATA

a. Nomenclature:	Modulator, Radio, MD-209/UC.
b. Contract:	NObsr-52566, dated 18 June 1951.
c. Manufacturer:	Schuttig and Company, Inc., College Park, Maryland.
d. Inspected by:	Inspector of Naval Material, Baltimore, Maryland.
e. Number of Shipping Boxes:	1
f. Frequency Range:	2 to 5 mc.
g. Modulating Capability:	$\pm 1/2$ radian phase shift.
h. Audio Input:	500 to 600 ohms impedance; -20 to +10 dbm level.
i. RF Input:	1 to 20 volts RMS, 2 to 5 mc.
j. RF Output:	20 volts RMS, 2 to 5 mc.
k. Power Requirements:	115 or 230 volts, single phase, alternating current, 50 to 70 cycles.

Table 1-2. Tube Complement

Reference Symbol	Type	Function	Total Quantity
V1	5725	RF Modulator	2
V2	5725	RF Modulator	
V3	6AU6WA	RF Amplifier	1
V4	5749	RF Amplifier	1
V5	6AK6WA	RF Amplifier	1
V6	5933WA	RF Power Amplifier	1
V7	12AT7WA	Audio Amplifier	1
V8	5814A	Meter Rectifier and Amplifier	1
V9	OA2WA	Voltage Regulator	1
V10	5R4WGB	Rectifier, B+	1

TABLE 1-1. EQUIPMENT SUPPLIED

Quantity per Equipment	Name of Unit	Navy Type Desig.	Over-all Dimensions			Shipping Volume	Weight	
			Height	Width	Depth		Net	Shipping
1	Modulator, Radio	MD-209/UC	10-19/32	20-1/2	17-29/32			
1	Spare Parts Box with Spares		6	12	6		26	
2	Instruction Books		11	8-1/2	3/16		1/2	

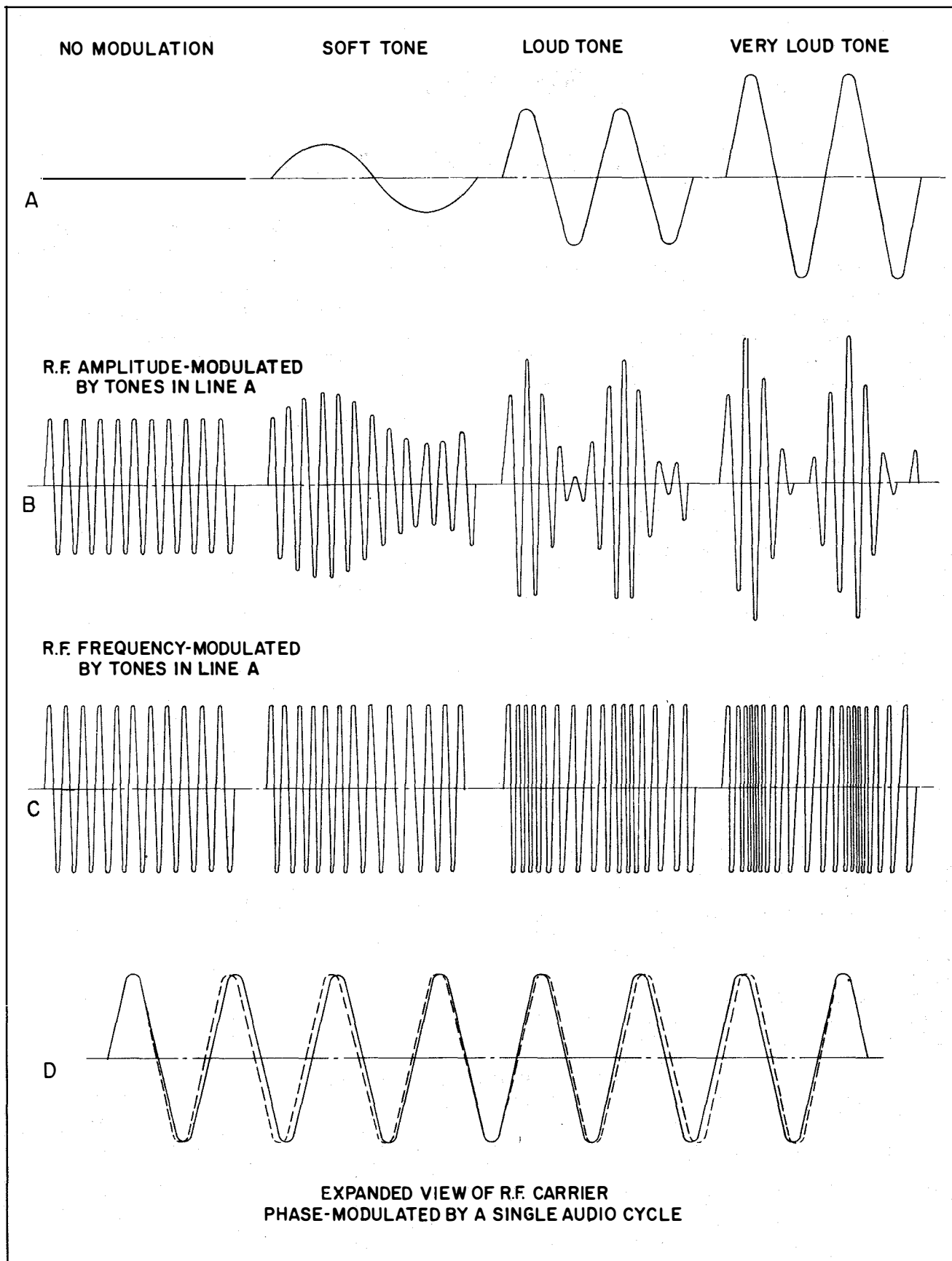


Figure 2-1. Comparison of Common Radio Modulation Methods

SECTION 2

THEORY OF OPERATION

1. GENERAL PRINCIPLES

a. Types of Modulation. Information may be conveyed by modifying any of the three characteristics of a radio carrier: amplitude, frequency, or phase. The MD-209/UC Radio Modulator is designed to impart information to a radio carrier by shifting its phase according to audio frequency modulating signals. Figure 2-1 compares the three most commonly used methods of audio modulation: amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM). The line at the top (audio voltage) indicates the information to be transmitted by the carrier. It varies from no signal to tones of increasing intensity.

(1) Amplitude Modulation. The AM transmission carries the information by varying the amplitude of the RF carrier to match the audio voltage level changes. As shown in the fourth AM trace, excessive modulating voltage levels will cause discontinuities in the RF carrier, with resulting distortion of the audio information. In addition, excessive amplitude modulation causes "splatter" or interference on a much wider band of frequencies than occupied by the carrier alone.

(2) Frequency Modulation. FM is the result of varying the frequency of the carrier in proportion to the audio modulating signal. The frequency change of deviation is always proportional to the instantaneous amplitude of the modulating signal. In FM, the transmitted power level always remains constant. Because of this, FM systems will permit the transmission of a much greater dynamic range of modulating signals than will an AM system. The only limitation on dynamic range ("100% modulation") in FM is that imposed by the bandwidth that the receiver will accept.

(3) Phase Modulation. PM results when the phase of the carrier is shifted ahead of and behind the phase of the unmodulated carrier in accordance with the modulating frequency. The amount of phase shift is a function of the amplitude of the modulating signal. The rate at which the shift of phase occurs is a function of the frequency of the modulating signal. The

frequency spectrum of a phase modulated radio frequency carrier is similar to that of a frequency modulated carrier. However, unlike FM, wherein the frequency change is proportional only to the amplitude of the modulating signal, the instantaneous frequency change in a phase-modulated carrier is proportional to both the frequency of the modulating signal and its amplitude. Thus, for a given amplitude of modulating signal, high audio frequencies produce greater instantaneous carrier frequency shift than low audio frequencies, and when detected in a normal discriminator circuit, phase modulated signals over-emphasize the higher audio frequencies.

A phase-modulated carrier, therefore, has a greater portion of its energy in sidebands farther removed from the carrier than those of an FM carrier.

If the relative strengths of the various audio modulating frequencies are suitably changed by means of a compensating network, it is possible to cause the PM sideband energy distribution to be identical to that from an FM transmitter and thus actually convert a phase-modulated signal to true FM. When this transmission is detected at the receiver discriminator, it will be "flat" or identical with the audio frequencies as they were prior to compensation.

b. Methods of Frequency and Phase Modulation. Unlike AM, which requires an elaborate and bulky modulator to furnish the large amount of audio power required, FM and PM require essentially no audio power.

(1) The simplest methods of achieving FM or PM is a reactance modulator, a vacuum tube connected across a tank circuit in such a way that it simulates a capacitance or an inductance, depending on the signal fed to it. It thus changes the resonant frequency of the tank circuit by an amount proportional to the signal applied to the reactance tube. When used with a very stable oscillator or amplifier tank circuit, the reactance modulator produces more phase shift than frequency deviation. This is accompanied by amplitude modulation and distortion of a degree generally dependent on the

Q of the tank circuit and the sensitivity of the modulator. When a reactance modulator is used with a self-excited oscillator, it is also difficult to maintain frequency stability. For these reasons, other methods are often used.

(2) Another method of phase modulation utilizes the fact that when two signals of fixed phase displacement (between them), but with varying amplitudes, are combined, a signal results having a phase shift proportional to the relative strengths of the two input signals. If the two signals are combined in a common load, the resulting voltage developed across the load is equal in phase and amplitude to the sum of the two component signals.

In this equipment, a constant amplitude is obtained by using push-pull modulation. As the voltage from one modulator tube rises, the voltage from the other lowers so that the total signal voltage remains constant, and only the resultant phase angle varies.

2. BASIC CIRCUIT DESCRIPTION

The MD-209/UC Radio Modulator phase modulates an RF signal by a method similar to that described in paragraph 1b(2) above.

a. Audio Section. An audio signal introduced at the audio input is amplified by audio amplifiers V7A and V7B. A variable attenuator is placed between V7A and V7B to reduce the audio output applied to the modulator tubes. V7B is used as a phase-splitter in order to obtain push-pull audio voltage to apply to the two modulator tubes.

b. Modulator Section. V1 and V2 are the modulator tubes for the equipment. The RF input signal is divided into two portions by a phase-shift network. The two outputs from the phase-shift network maintain a constant phase difference of approximately 90 degrees. Each of these signals is applied to the first grid of one of the two modulator tubes. Push-pull audio from the audio phase-divider tube (V7B) is applied to the third grid (suppressor) of each of the modulator tubes. The output of each modulator tube consists of RF voltage amplitude modulated by the audio voltage. The RF input of each modulator tube is 90 degrees out of phase with the other. Because these tubes share a common load resistor, their phase and amplitude components add in the manner described above to produce a signal of essentially constant amplitude and varying phase.

c. Amplifier Section. The modulator output is amplified by a three-stage broad-band amplifier to raise the signal to a useful level. V3, V4, and V5 are the broad-band amplifier tubes. The output of each of these tubes includes a filter circuit for making the amplifier response uniform over a wide frequency range. The broad-band amplifier has uniform response from low audio frequencies to about 5.5 megacycles and, for this reason, requires no tuning. The output of V5 is applied to the grid of V6, the power amplifier. This amplifier supplies the power required to develop 20 volts of RF signal across a 50-ohm load. The output circuit of the power amplifier must be tuned to each operating frequency used.

d. Metering Section. Provisions are included for metering the following circuits: Audio

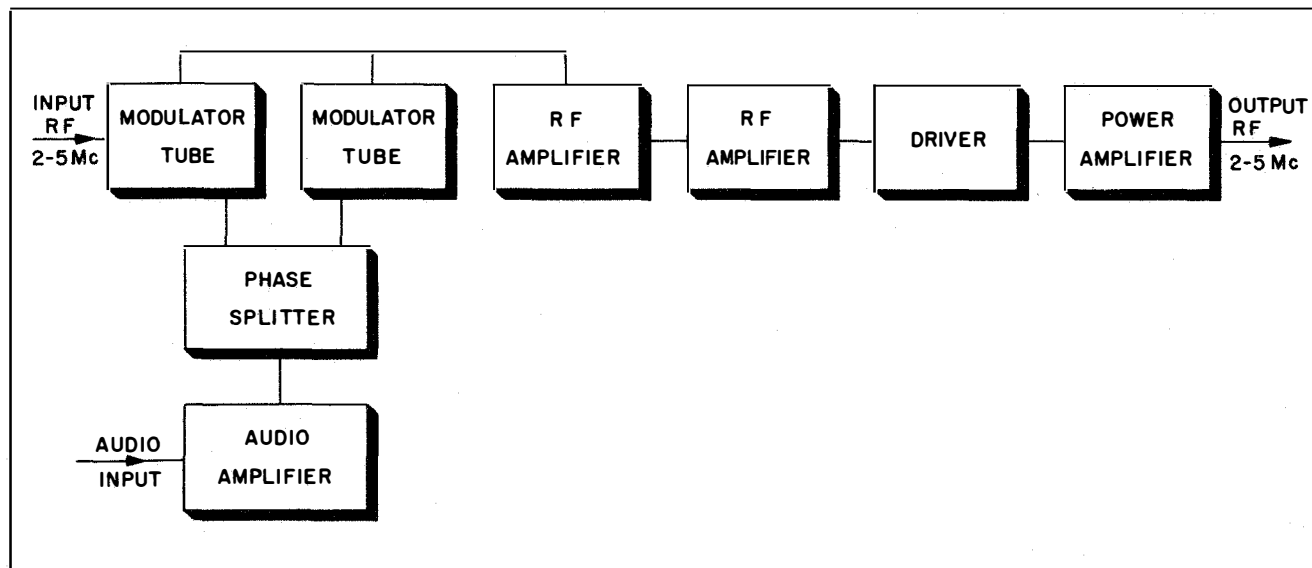


Figure 2-2. Functional Block Diagram

Input, RF Output, and the Grid Voltage of each modulator tube. The meter is used to adjust the RF and Audio Input levels to the proper values, balance the modulator phase-shift network and to tune the power amplifier stage. No absolute values are shown on the meter face, only arbitrary reference marks which are calibrated by factory adjustments. These calibrating controls should not be tampered with or changed except under the conditions described in Section 5.

3. DETAILED CIRCUIT DESCRIPTION

a. RF Input. RF input signals are introduced through J1, mounted in the rear of the modulator cabinet. Because this equipment is mounted on slides for easy inspection and accessibility, a short length of RG-58/U coaxial cable connects J1 to P1, a plug connector plugging into J2, on the modulator chassis. R1, the terminating resistor for the 50-ohm input, consists of six 300-ohm, 2-watt resistors connected in parallel. This permits dissipating 12 watts of power in an essentially resistive load, shielded to prevent stray radiation. C1 is an isolating capacitor to prevent dc voltage from an external source from being dissipated across R1. R2 is the RF gain control which varies the signal applied to the modulator tubes.

b. Modulator Section. Figure 2-3 shows a functional diagram of the modulator circuit. V1 and V2 are the modulator tubes which cause the RF input to be phase modulated in accordance with the audio input signals. RF voltage from the input is applied to the center of a phase-shift network consisting of C4, R5, R6, and C5. This network consists of two branches, each branch acting as a signal voltage divider. Each branch consists of a capacitor and a resistor in series. Grid voltage for each modulator tube is taken from the junction of one of the two branches.

When an alternating current is passed through an ideal capacitor, the voltage lags the current by 90 degrees. Since all actual capacitors have dielectric losses, the actual circuit may be represented by an ideal capacitor connected in series with a resistor. This effective resistance absorbs some power and causes the phase shift to be somewhat less than 90 degrees. When the resistance is increased until it equals the series reactance of the capacitor at a given frequency, the phase shift is 45 degrees. In this unit, a variable resistance is placed in series with each of the phase-shift capacitors in order to add enough resistance to obtain a 45 degree phase shift in each leg of the phase-shift

network. Because the RF signal is applied to the first grid of V1 through a series capacitance, the phase angle of the voltage lags the phase of the RF input voltage by 45 degrees. The voltage applied to the grid of V2 is caused to lead the RF input voltage by 45 degrees by shunting the phase-shift capacitance across the grid to ground, thus reversing the sign or direction of the phase shift seen by the grid. The phase difference, therefore, between the first grids of these tubes is 90 degrees. Since the reactance of the capacitors vary with oper-

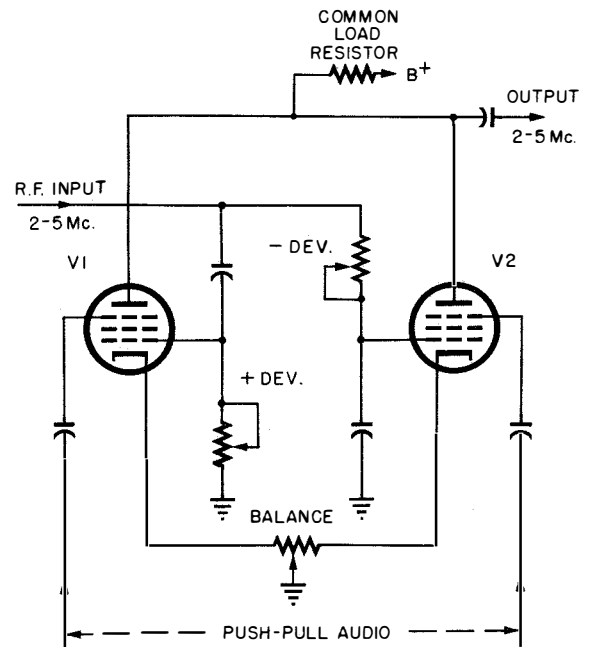


Figure 2-3. Modulator, Functional Diagram

ating frequency, the potentiometers must be carefully readjusted for each new operating frequency. This is easily done by using the metering circuit to be fully described later.

Push-pull audio voltage from the audio phase-splitter is introduced to the third grids (suppressor) of V1 and V2 by means of coupling capacitors C5 and C7, respectively. R8 and R9, respectively, complete the dc path to ground in order to bias to these grids. In addition they load the coupling capacitors to secure the proper audio frequency response. Each modulator tube mixes the audio and RF signals to yield a modulated RF signal having RF components 90 degrees out of phase and audio components 180 degrees out of phase with those from the other tube. In order to compensate for tube variations, a balancing potentiometer links the cathodes of V1 and V2. This permits compensating the differences of amplification between the two tubes so that the audio modulation produced in each tube will

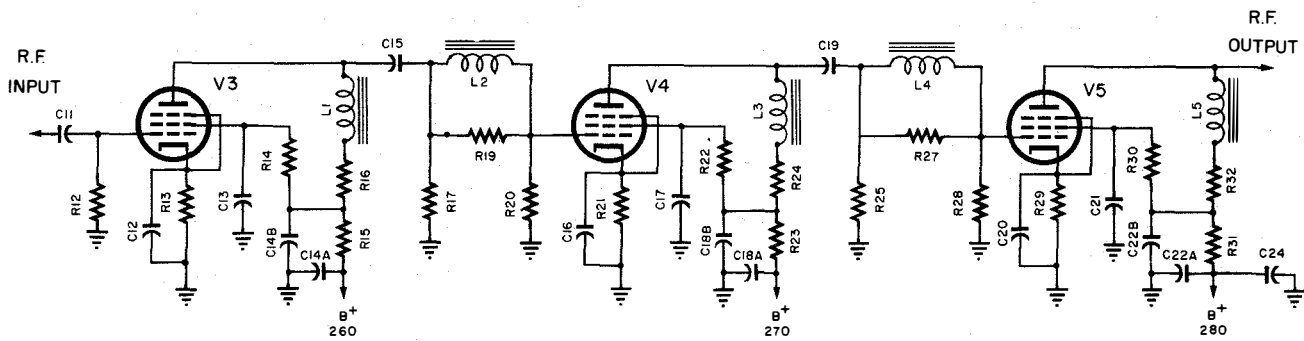


Figure 2-4. Broad-Band Amplifier, Simplified Schematic Diagram

equal that from the other. R4 and R7 complete the cathode balancing circuit. C3 and C6, respectively, are the screen bypass capacitors for V1 and V2. R10 is the common screen resistor for both tubes. B+ is supplied to the two tubes through R11, the common load resistor, across which phase modulated signals are developed. It is in this resistor that the addition of phase and amplitude components of the two RF signals are added to produce the required phase shift and remove amplitude modulation. C10 is the B+ bypass capacitor.

The action of the modulator may be visualized by regarding each modulator tube as a sort of control valve regulating the amount of phase-shifted signal released to the next stage. Since the audio modulation is push-pull, one tube output increases as the other diminishes, thus causing the phase of the resultant signal to vary. Every audio cycle, therefore, produces a cycle of RF phase shift.

Amplitude variations tend to cancel out because the transconductances of the two modulator tubes have been balanced, thus maintaining a uniform average output between the two tubes. Amplitude variations may occur if the modulator tubes are operated outside of the linear portion of their characteristic curve.

c. Broad-Band Amplifier. Figure 2-4 shows a partial schematic of the broad-band amplifier. Phase-modulated signals developed across the modulator load resistor are coupled to the grid of V3 by means of coupling capacitors C9 and C11. V3, V4, and V5 comprise a broad-band amplifier to provide RF voltage to the power output tube. V3 is a type 6AU6WA pentode used in a conventional broad-band amplifier circuit. R12 is the grid biasing resistor and R13 is the cathode resistor, bypassed by C12. C13 and C14 are bypass capacitors for the B+ supply to the screen and plate of V3. R15,

R16, and R18 are B+ isolating resistors, and help prevent RF radiation. L1 and L2 are "peaking" coils to broaden the response of the amplifier. C15 couples the output of V3 to the input of V4 and prevents B+ voltage from appearing on the grid of V4. R19 helps flatten the response curve of the circuit by reducing the Q of L2. V4 is a remote cut-off pentode used in an amplifier circuit identical to the preceding stage. A type 5749 tube is used to prevent excessive tube self-biasing at high input signal levels. All other components are identical in function to the equivalent components of V3. V3 and V4 are primarily voltage amplifiers required to provide voltage gain. V5, a type 6AK6WA tube, is a power amplifier used to obtain sufficient drive for the final amplifier. Additional power is required because the final stage is operated as a Class "C" amplifier and draws considerable grid current. Components associated with V5 have functions identical with those described for the components of the V3 and V4 stages.

d. Power Amplifier. The output amplifier for the Modulator consists of V6, a type 5933WA beam-power tetrode, having characteristics similar to an RMA type 807. Unlike the three amplifier stages preceding it, the power amplifier must be tuned to the specific operating frequency. The plate tank circuit consists of variable capacitor C27 (OUTPUT TUNING) and the primary winding of T2, the RF output transformer. L7, is an RF isolating choke, R37 and R38 are voltage dropping resistors for the screen of this tube. R39 is a voltage limiting resistor to protect the power amplifier from damage when there is insufficient grid excitation. C29 and C30 are bypass capacitors used with these resistors. R35 is the screen resistor for V6, and C25 is its bypass capacitor. The secondary winding of T2 develops the RF output voltage of the Modulator, and is designed to match a 50-ohm

load. The RF output connector on the equipment chassis is J3. A short length of coaxial cable (W4) conveys this power output to a jack (J4) at the rear of the cabinet.

e. **Audio Section.** Figure 2-5 shows a partial schematic diagram of the audio section. Audio frequency signals are introduced at terminals 1 and 3 of the terminal board (TB1) in the rear of the cabinet. A short piece of shielded 600-ohm cable (W5) terminates in P3, a plug connector which plugs into J5, the audio input receptacle on the equipment chassis. J5 connects to the primary winding of T4, an isolating transformer which permits using a balanced or unbalanced audio input signal. The output of T4 feeds a low-pass filter, Z1. This filter attenuates all frequencies above 6,000 cycles to prevent high frequency interference from other sources. This filter is unbalanced and consists of L11, L12, L13, and C45 through C48. The output filter connects to the primary winding of T1, the audio input transformer. The output winding of T1 is connected across R41 (MODULATION GAIN), the audio gain control. V7A is a type 12AT7WA dual triode. The first section of V7A is a conventional audio amplifier. R42 is the plate resistor and R43 the cathode resistor for the tube section. The output of V7A is coupled by C31 to V7B via an attenuator circuit (MODULATION RATIO), consisting of R44, R45, R46, R47, and R48. The attenuator is used to reduce the audio gain in proportion to the frequency multiplication which the RF output of the Modulator will undergo before transmission. The second section of V7 (pins 6, 7, and 8) is used as a phase-splitter. Because the plate and cathode resistors R49 and R50, respectively, are of equal value, the audio output appearing across each of them is 180 degrees out of phase, and equal in amplitude, to the other. This voltage is applied to the suppressor grids of the modulator tubes as explained in Paragraph 3b.

f. **Metering Section.** Facilities are provided for metering the RF input, the audio input, the RF output, and the RF voltage on the first grids of the modulator tubes. Figure 2-6 shows a schematic diagram of the metering circuits. Selector switch S2 connects the meter, M1, to the circuit to be metered.

(1) RF voltage from the input appears at terminal 1 of S2A. When the selector switch is in position 1, the meter is connected in series with a type 1N38A crystal diode (CR2) and a meter calibrating potentiometer, R41. Capacitor C32 prevents dc voltage from the rectifier from appearing in any of the metered circuits. R51 is used to calibrate the meter. It should not be changed or readjusted except under the conditions specified in Section 5, Paragraph 4a. In use, the RF input level to the modulator section is determined by placing the meter selector switch in position 1 and adjusting the RF gain control until the meter hand is opposite the RF mark on the meter face. This is the correct operating input level for the modulator.

(2) Audio voltage is metered by applying a portion of the grid voltage of V7B to the grid of the meter audio amplifier, V8A, a type 5814 twin-triode. R52, the plate load resistor for this tube section, is a factory adjusted potentiometer used to calibrate the audio metering circuit. This adjustment should not be changed or tampered with except under the conditions specified in paragraph 4b of Section 5. The second section of V8 (pins 6, 7, and 8) is used as a meter rectifier. R54 is the diode load resistor and completes the dc circuit. The diode output is metered through the selector switch, S2B. Correct audio level is obtained by adjusting R41 (MODULATION GAIN) until the meter hand is at the correct reference mark (MOD) on the meter.

(3) Positions 2 and 3 of the selector switch

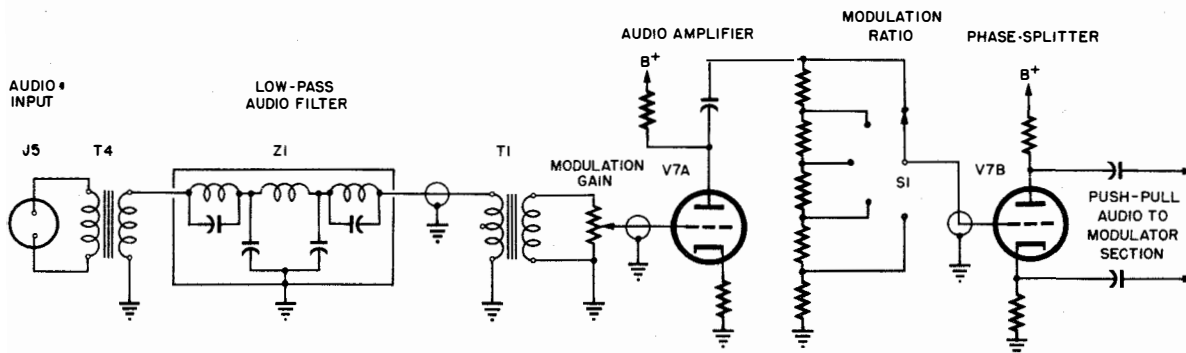


Figure 2-5. Audio Section, Partial Schematic

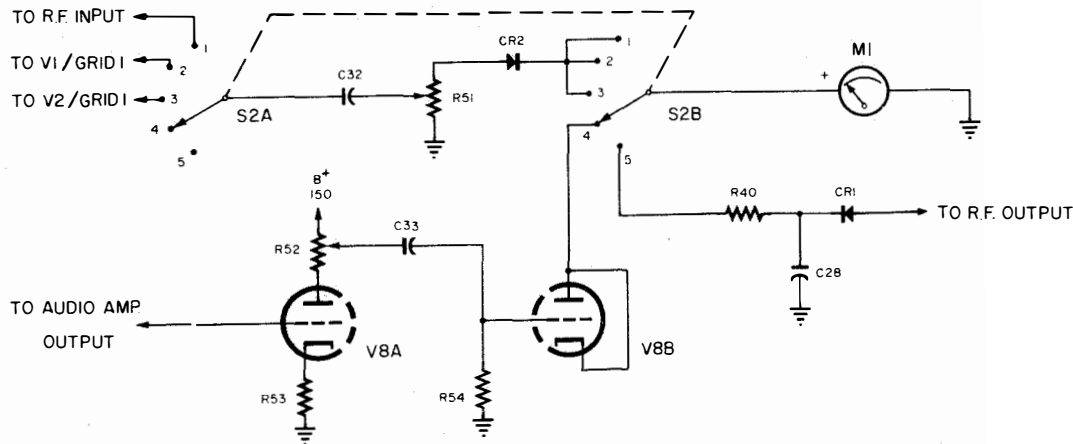


Figure 2-6. Metering Circuits, Partial Schematic

permit metering the RF voltage appearing on the first grid on each of the two modulator tubes. Position 2 is connected to the first grid of V1. Position 3 indicates the RF voltage at the grid of V2. It is very important to adjust the phase-shift network of the modulator so that these grid voltages are exactly equal, in order that distortion may be avoided. Since in both switch positions, the meter is adjusted to a common point using the same crystal diode, diode and meter errors become unimportant because metering is comparative rather than numerical.

(4) RF output is metered as an aid to tuning. A type 1N38A crystal rectifier is connected to the secondary winding of T2. Its rectified output voltage is filtered by C28 and R40 and connected to the meter through switch position 5. None of the reference marks on the meter are used in tuning the final amplifier tank circuit. This function is used by placing the selector switch in position 5 and adjusting the output tuning control (C27) until peak voltage is indicated on the meter.

g. **Power Supply.** The power supply provides all internal ac and dc operating voltages required by the unit. Power enters the unit at terminals 3 and 4 of terminal board TB2 mounted at the rear of the cabinet. A short power cord (W7) terminates in P4, a plug connector, mating with J6, mounted on the chassis. Each side of the power input line is fused. A two-ampere fuse is required in each fuse holder for operation.

A low-pass radio interference filter (Z1) is placed in the power line between the fuses and the primary winding of the power transformer. The primary winding of the power transformer T3 is tapped for 115-volt and 230-volt opera-

tion. The unit may be adjusted to operate on either voltage by connecting the power input lead to the correct terminal of the power transformer. For 230-volt operation, the power lead should be removed from terminal 2 and connected to terminal 3. The low-pass filter attenuates all radio frequencies from 10 kc to 200 mc, 30 db or more. There are four secondary windings for power transformer T2, a high-voltage winding supplying 390 volts on either side of the ground center tap. These windings are connected to the plates of V10, a type 5R4WGB full-wave rectifier. Filament voltage for this tube is supplied by a 5-volt, 3-ampere secondary winding of the transformer. Filament volts for all other tubes in the equipment are supplied by a 6.3-volt, 4.5-ampere winding and a 6.3-volt, 1.5-ampere winding. The latter winding is used only to supply filament volts for V6, the RF output tube. The rectified full-wave output of V10 is filtered by a conventional pi-section filter consisting of capacitors C32, C35, and L10. L10, the filter choke, is shunted by C33 and C34 which tune the choke to the ripple frequency (120 cps). This increases the series reactance of the filter to transients, rectifier noise and the 120 cps ripple frequency. B+ voltage for the power amplifier is tapped off at the junction of L10 and R56. R56 is a voltage dropping and filtering resistor. C31 connected between the junction of R55 and R56 and ground produces further filtering of the B+ supply. B+ voltage is supplied at this point for the broad band amplifier. R55 limits the flow of current through V9, a type OA2WA voltage-regulator tube. This circuit provides regulated voltage used in the audio meter amplifier, the audio amplifier and phase-splitter and the two modulator tubes. The use of regulated voltage in these sections provides increased stability of operation under varying line voltages.

SECTION 3

INSTALLATION

1. UNPACKING AND CHECKING

Carefully remove the modulator from its carton and inspect the unit for any apparent damage. Carefully remove dust and cushioning materials from the unit. Check the equipment furnished against the accompanying packing slips. Remove the tubes from the equipment and check them for internal short circuits which may have occurred in shipment. Replace all good tubes in the sockets from which they came! Discard any tubes found to be defective and replace all tube shields.

Before being shipped from the factory, the equipment has been carefully adjusted and tested. If no damage has been received during shipment the equipment should be ready for operation. If any tubes have been damaged during shipment it may be necessary to recalibrate or readjust the equipment in accordance with the procedures outlined in Section 4.

2. INSTALLATION

The Radio Modulator MD-209/UC is furnished in its own shock-mounted cabinet. See Figure 3-1 for all mounting dimensions required. The unit may be mounted on a table, desk, or other flat surface to which it may be bolted. Figure 3-1 provides information necessary to mount the unit in this fashion. It may be desired to mount the unit in an existing rack. To do this it is necessary to unplug the cables connecting the unit to the terminal strips in the rear of the cabinet. Remove the screws holding the mounting wings to the cabinet. The entire equipment chassis and slide assembly may then be mounted in an existing rack. Two methods of making external connections to the unit are possible:

a. Remove the terminal strip bracket from the rear of the cabinet and fasten it in the rear of the rack. Mount it in a position similar to that used in the equipment cabinet. The cables from the terminal strips may then be reconnected to the mounted unit and external connections made through the terminal strips.

b. Connectors identical to those used on the short cables from the terminal strip may be attached to the cables from the associated equipment. It is then necessary only to plug these cables into their appropriate receptacles on the modulator chassis.

Figure 3-2 shows an external view of the terminal strips. External connections to the unit should be made in the following manner when the terminal strips are used:

Remove the cover plate from the rear of the cabinet. Connect the source of power to terminals 3 and 4 of TB2 at the rear of the cabinet or rack. The audio input signal source should be connected to terminals 1 and 3 of TB1, also at the rear of the cabinet. A balanced or unbalanced audio input line may be used. Terminal 2 may be connected to the ground side of the line if an unbalanced input is used. Input and output cables should be prepared using suitable coaxial cable connected to the plug connectors (UG-21B/U) furnished. RF input is supplied to the equipment at J1 at the rear of the unit. RF output is taken from J4, also at the rear of the cabinet.

NOTE

The unit is shipped wired for 115-volt ac operation. If operation on 230-volts ac is desired, remove the Modulator from its cabinet and disconnect the wire from terminal 2 of T3 and reconnect it to terminal 3.

3. INITIAL ADJUSTMENTS

Before energizing the equipment, make sure that all tubes are in their correct sockets and that all tube shields are on.

Perform the following adjustments to the equipment:

Step 1. Place the RF INPUT control in a completely counterclockwise position.

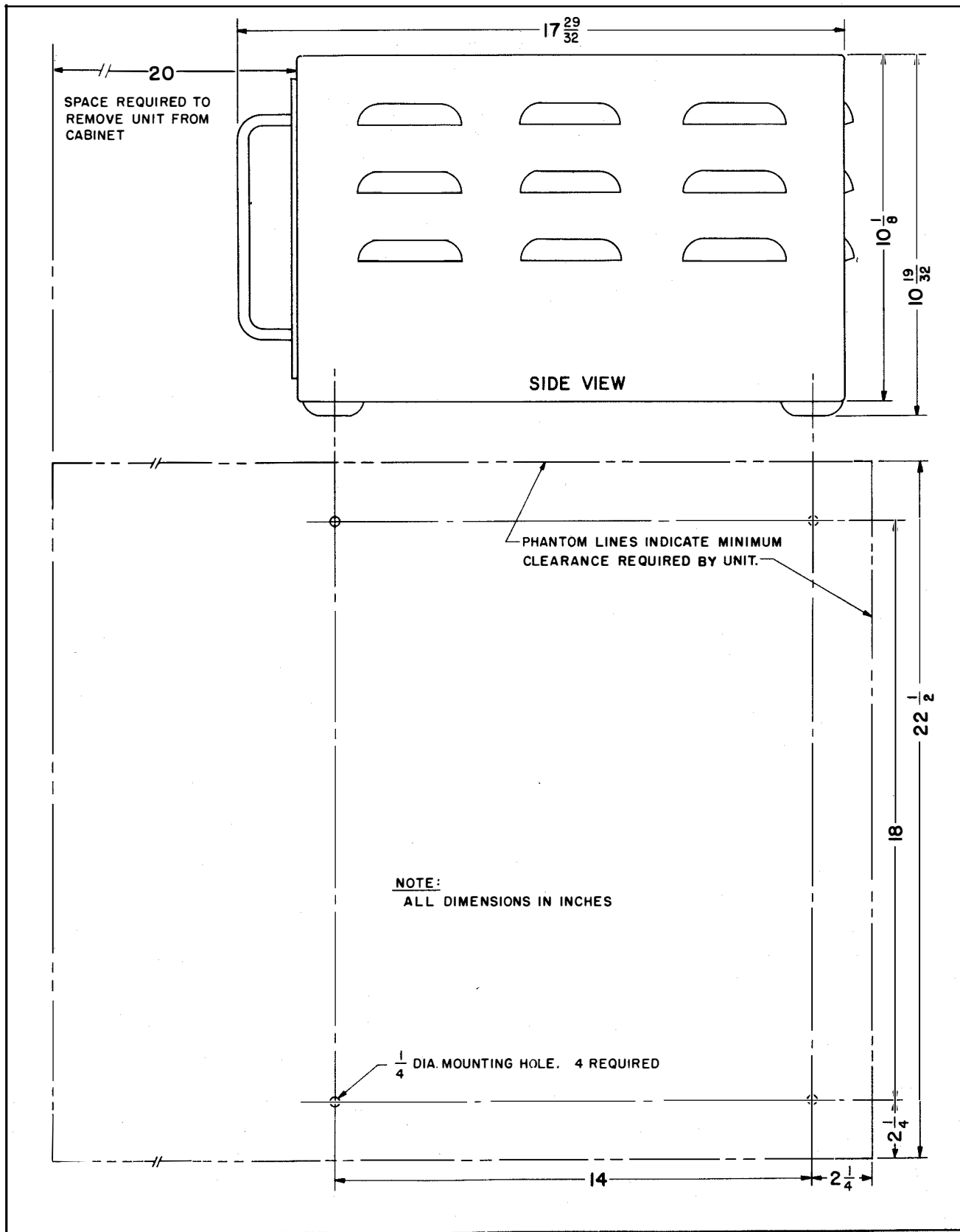


Figure 3-1. Outline and Mounting Dimensions

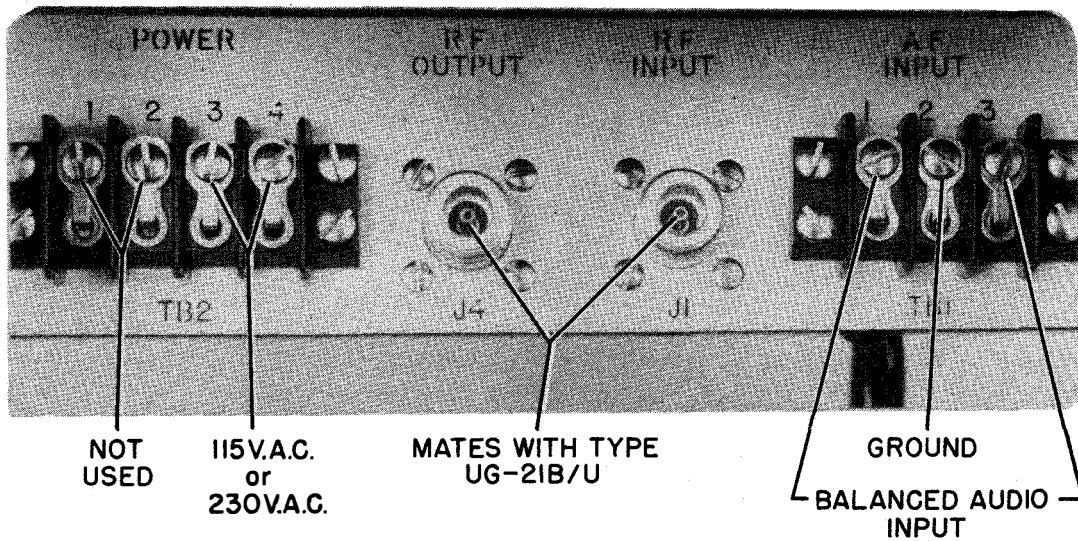


Figure 3-2. External Terminal Identification

- Step 2. Place the MODULATOR GAIN control in a completely counterclockwise position.
- Step 3. Place the +DEV and -DEV controls to the position that indicates the approximate RF frequency to be used.
- Step 4. Place the OUTPUT TUNING control to the position indicating the approximate

RF frequency to be used.

- Step 5. Place the MODULATION RATIO control to the position indicating the RF multiplying factor to be used following the output of the phase modulator.
- Step 6. Turn the power switch ON. The indicator light should glow, indicating the unit is on.

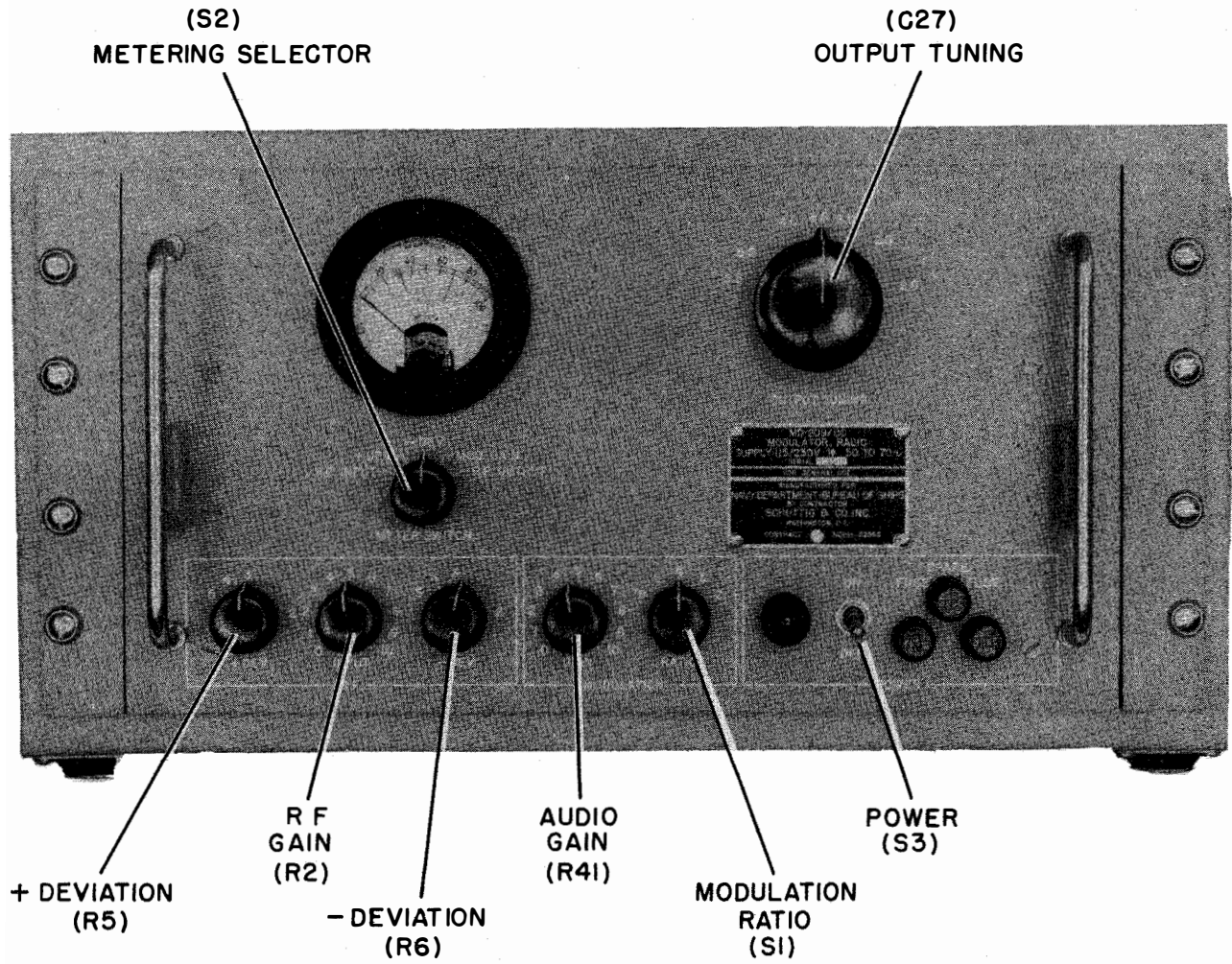


Figure 4-1. Operating Controls

SECTION 4

OPERATION

1. GENERAL

The MD-209/UC Radio Modulator is a device permitting a type A-1 emission transmitter to be phase modulated by audio tones. The transmitter must have provisions for connecting the modulator between the master oscillator and its following stages.

Because most radio transmitters employ frequency multiplication subsequent to the master oscillator, provisions have been included in the phase modulator for reducing the phase deviation in proportion to the frequency multiplication employed in the transmitter. A selector switch (MODULATION RATIO) permits selecting multiplication factors of 2, 3, 4, 6, and 8.

2. OPERATING ADJUSTMENTS

Because safeguards have been built into the circuitry used in this equipment, no special precautions need be taken against damaging the equipment as long as the operating instructions are followed. To place the equipment in operation, adjust the transmitter to the desired operating frequency and connect it to the equipment as described in Section 3. Figure 4-1 shows the operating controls of the unit.

Perform the following operations:

- Step 1. Place RF INPUT control and MODULATOR GAIN control in a completely counterclockwise position.
- Step 2. Place the +DEV, -DEV, and OUTPUT TUNING controls to the positions indicating the approximate RF frequency to be used.
- Step 3. Place the MODULATION RATIO control to the position indicating the RF multiplying factor to be used in equipment following the output of the phase modulator.
- Step 4. Turn the power switch ON. The indi-

cator light should glow, indicating the unit is on.

- Step 5. Place METER SWITCH control in RF INPUT position and adjust RF INPUT control clockwise until meter pointer is at the red line marked RF.
- Step 6. Place the METER SWITCH control in +DEV position and adjust the +DEV control in either direction until the meter pointer is at the red line marked DEV.
- Step 7. Place the METER SWITCH control in -DEV position. Adjust the -DEV control in either direction until the meter pointer is at the red line marked DEV (same line used in Step 6). Repeat steps 5, 6, and 7 for fine adjustment.
- Step 8. Place the meter switch in MOD GAIN position.
- Step 9. Adjust MODULATION GAIN control clockwise until the meter pointer comes up to red line marked MOD.
- Step 10. Place the METER SWITCH control in RF output position.
- Step 11. Adjust the OUTPUT TUNING control in either direction until maximum meter indication is achieved.

NOTE

Do not leave the METER SWITCH control in +DEV or -DEV position while Phase Modulator is in operation. The METER SWITCH control may be left in any other position, but it is suggested that this control be left in MOD GAIN position to provide constant indication of modulation index.

FAILURE REPORTS

A Failure Report must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, form DD-787, which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS. Full instructions are to be found on each card.

Use great care in filling the card out to make certain it carries adequate information. For example under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T-805, in the case of a transformer, or R-207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure and attach an extra piece of paper if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards and envelopes on board. They may be obtained from the nearest District Printing and Publication Office.

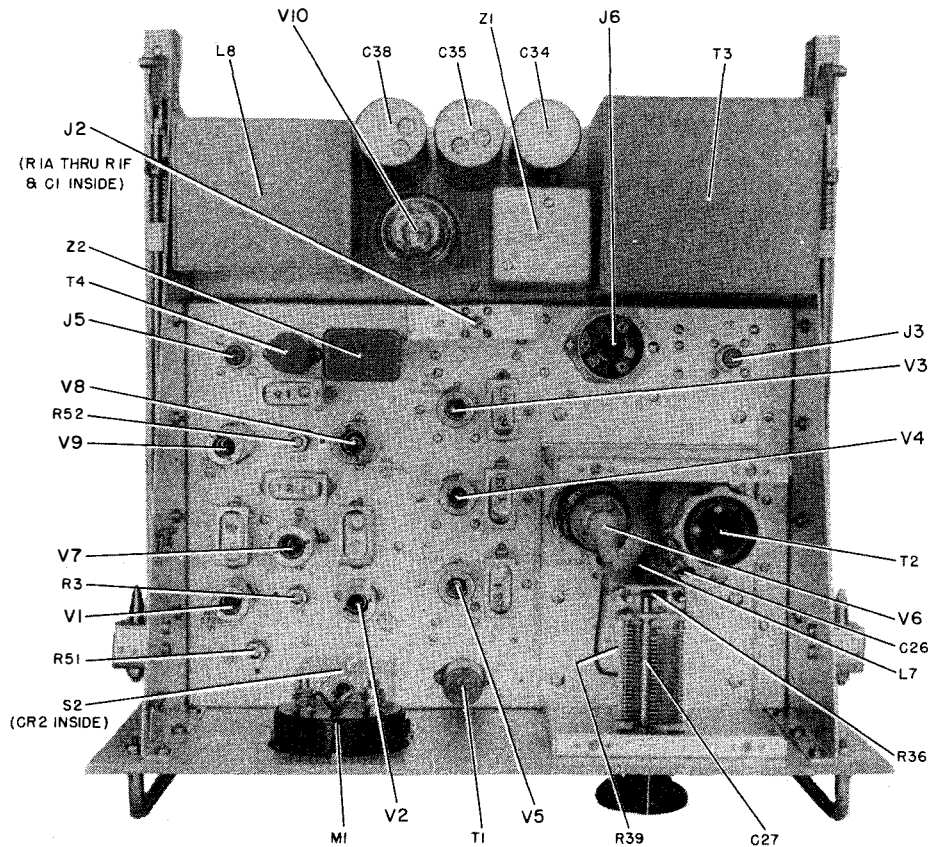


Figure 5-1. Location of Electron Tubes

SECTION 5

MAINTENANCE

1. PERIODIC INSPECTION

This equipment has been designed to provide long, trouble-free service as long as proper preventive maintenance procedures are followed. It is recommended that this equipment be periodically inspected as outlined below and any signs of deterioration or defective performance promptly be corrected.

a. Weekly Inspection. At least once a week the equipment should be examined internally and externally for signs of improper functioning or damage. Look for charred resistors or leakage from transformers and filter capacitors. Look for signs of corrosion or rust and the loosening of hardware.

b. Monthly Inspection. Once a month, at the time the weekly inspection is made, all tubes should be checked on a good tube checker. To avoid unnecessarily changing the circuit constants, each modulator tube should be tested and replaced before removing the other from its socket. Figure 5-1 shows the location of all electron tubes. Before replacing the tubes in the equipment, clean the pins of each tube with very fine emery cloth, being careful not to bend the pins. A good, noncorrosive contact cleaner may be applied to each pin before replacing the tubes.

NOTE

Avoid replacing older tubes unless they definitely test BAD. New tubes change their characteristics rapidly, and are more likely to fail than older tubes. Most tube failures occur in the first 50 or 100 hours, or then usually after thousands of hours.

2. CORRECTIVE MAINTENANCE

Before attempting to troubleshoot this equipment, the technician should thoroughly familiarize himself with the theory of operation, referring to the material in Section 2, as well as

the data and illustrations in this section. Particular attention should be paid to learning a logical system for localizing the sources of trouble.

3. TROUBLESHOOTING

It is important in diagnosing troubles and locating their source that the maintenance man be thoroughly familiar with the character of normal operation. A systematic approach to troubleshooting will result in great savings in time and work. Start with the most basic and fundamental causes of trouble and eliminate them before looking for something more complex. Thus, check the fuse and the power supply first, then check the tubes in the affected section.

a. Theory of Localization. Quick and efficient troubleshooting is possible only when a systematic approach is employed in searching for the source of equipment failure.

The most effective method of discovering the cause of trouble is by progressively localizing it. Determine the approximate nature of the trouble, deciding whether it is basic--such as a power supply failure, or more subtle--such as weak tubes. Determine the section in which the defect is located, using the block diagram, Figure 2-2, as required. After identifying the defective section, locate the specific stage or tube that includes the error. By measuring pin voltages and comparing with those shown in Figure 5-3, the defective components may be identified and replaced or repaired.

b. Recommended Troubleshooting Procedure.

(1) Test all tubes on a good transconductance type tube tester. Replace those tubes indicating short circuits or which do not meet current transconductance requirements. **REPLACE THE GOOD TUBES IN THE SOCKETS FROM WHICH THEY CAME!**

(2) Locate the defective section of the equipment. Check backward through the set starting with the output, injecting signals appropriate to

the section being checked. Measure all B+ voltages starting with the power supply and compare with those shown on the schematic diagram or tube socket voltage and resistance chart.

(3) Having located the section or stage which has failed, locate the components responsible. Measure voltages at each pin of the tube sockets in this section. Refer to the tube socket pin voltage chart, Figure 5-3, for correct voltages. With the unit turned OFF, measure the resistance to ground at the affected tube socket pins involved.

(4) After locating and replacing the defective parts, measure the voltages in the circuit to see that they are in accordance with those shown on the schematic diagram. This is important to prevent a possible repetition of the breakdown.

If the voltages are not correct, trace the cause of the error by measuring the circuit voltages back to their source. Replace any defective components.

4. CALIBRATIONS

R3, R51, and R52 are calibrating controls and should not be adjusted except when the unit is undergoing maintenance or calibration. R3 balances the two modulator tubes, R51 is the RF calibration control, and R52 is the audio calibration control.

a. RF Calibration. R51 is a meter calibrating potentiometer for RF input and plus and minus deviation. This potentiometer is used to compensate for losses due to component variation, placement of leads, tube changes, etc. It must not be tampered with or readjusted unless components of the RF input or metering circuit are replaced. If this occurs, the potentiometer should be adjusted as follows:

- Step 1. Place the meter selector switch (S2) in position 1.
- Step 2. Connect an RF voltmeter between the arm of R2 (center terminal) and ground.
- Step 3. Inject an RF signal (1-20 volts, 2-5 mc) at the RF input.
- Step 4. Adjust RF until exactly 1 volt is indicated on the RF voltmeter.
- Step 5. Adjust R51 until the meter indicator

comes exactly to the red line marked "RF"

- Step 6. Lock the shaft of R51 to prevent accidental changing of the adjustment.

b. Audio Calibration. In this equipment, the amount of phase shift is determined by the audio level. Greater audio level increases the phase shift. It is necessary, therefore, to calibrate the audio meter indication in terms of the maximum phase shift desired. This adjustment should be made whenever V8 is replaced. To do this, perform the following operations:

- Step 1. Make sure that R51 has been adjusted as directed above.
- Step 2. Connect a suitable source of RF energy (2-5 mc, 1-20 volts) to the input. This may be the transmitter master oscillator or some other source. Perform operating adjustments of Paragraph 2 of Section 4 through Step 8.
- Step 3. Tune a suitable AM receiver to the third harmonic of the Modulator frequency.
- Step 4. Apply an audio modulating tone (3,000-6,000 cps, -20 to +10 dbm) to the audio input of the Modulator. Make some provision for measuring this audio input voltage.
- Step 5. Increase (or decrease) the audio input level until the third harmonic of the carrier frequency is observed to just disappear. Note the exact audio voltage.
- Step 6. Reduce the audio voltage to exactly 5/8 the value noted in Step 5.
- Step 7. Adjust R52 until the meter hand is exactly at the red line marked "MOD".
- Step 8. Lock or secure R52 against further adjustment.

c. Balance. A balancing network is provided between the two modulator tubes in order to compensate for variations in tubes, components, etc. Since the modulator circuits have many variables, an over-all balance is obtained by adjusting for best performance. This adjustment must be checked whenever V1 or V2 is replaced. When the two tubes are perfectly balanced, amplitude modulation is at a minimum. This fact is used as a convenient method of checking the over-all balance of these tubes.

To make this adjustment, perform the following steps:

- Step 1. Complete all operating adjustments required to place the unit in operation.
- Step 2. Prepare a suitable AM detector for the audio modulation on the RF carrier. This may be a series diode and a very sensitive ac voltmeter; it may be a series diode, an audio amplifier and a less sensitive ac voltmeter; or it may be an AM communications receiver capable of receiving signals at the operating frequency. Connect the AM demodulator selected between ground and the junction of C9 and C11. Figure 5-2 shows the location of this test point. It is important that the signal be taken from this point because the following amplifier stages serve as limiters and tend to remove any remaining amplitude modulation.

- Step 3. Adjust the ac voltmeter to give a suitable reading when the audio modulating signal is at its normal operating level.

NOTE: The arm of R3 must remain in the center 90 degrees of its range during this adjustment. While low audio levels may be observed near either end of the potentiometer range, these are obtained by cutting off the action of one tube and thus strongly reducing the modulation. If balance is not obtained near the center of the control range, try replacing V1 or V2 until a fairly balanced pair of tubes is obtained.

- Step 4. Adjust R3 until minimum audio voltage is indicated on the ac voltmeter. If a receiver is used, adjust R3 for minimum audible signal. An ac voltmeter across the receiver output will provide greater accuracy in making this adjustment.

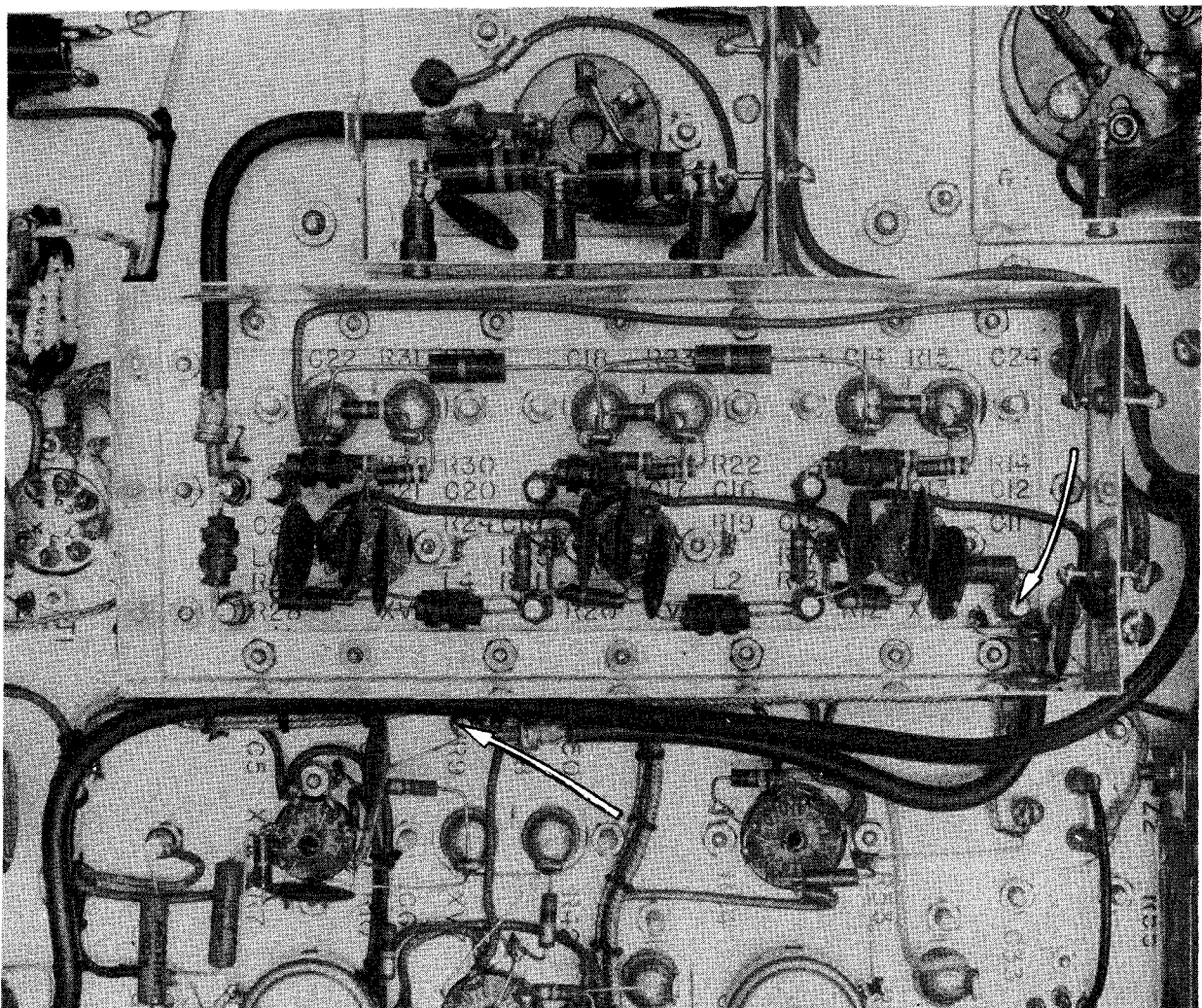


Figure 5-2. Modulator Balance Test Point

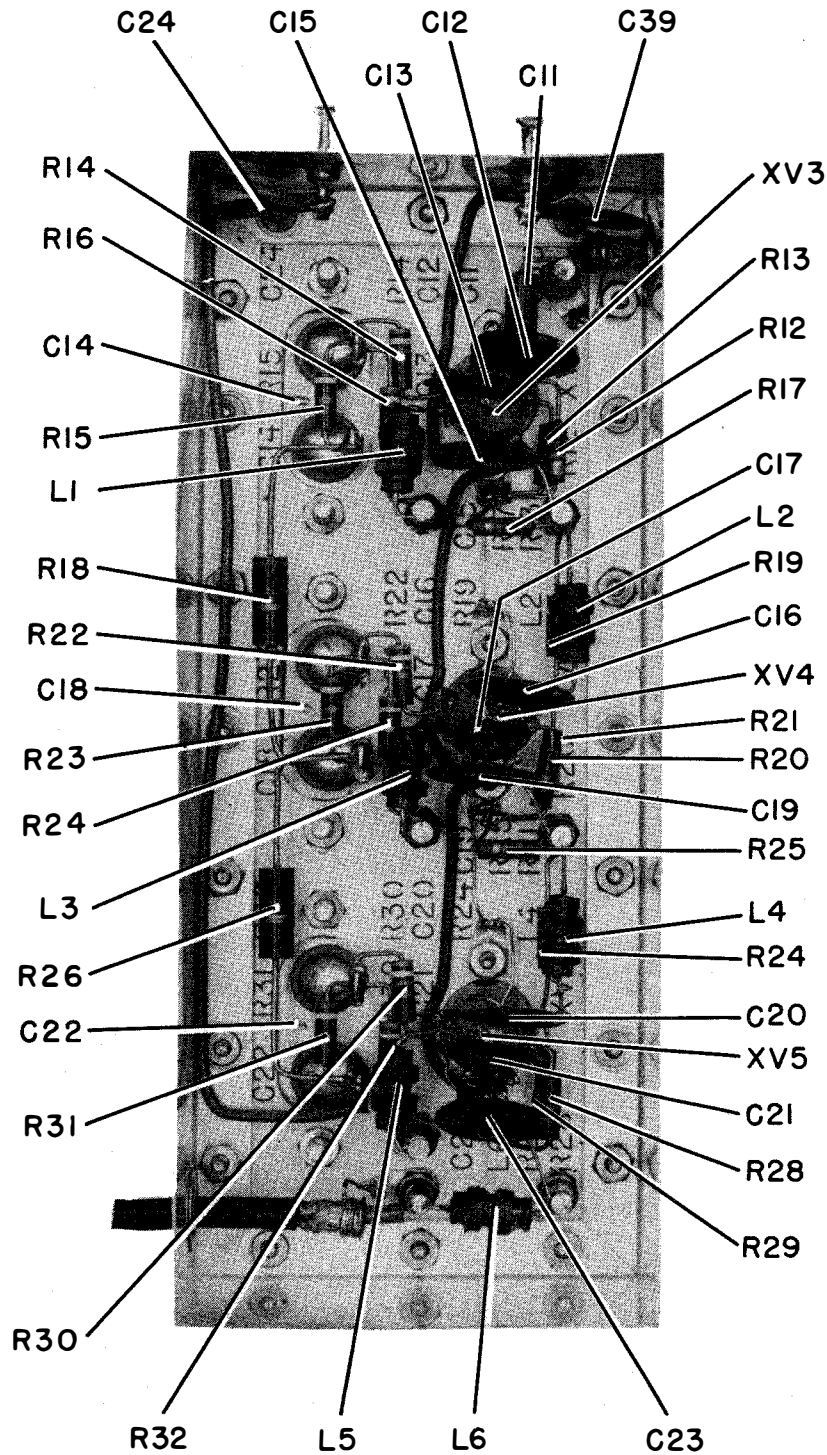


Figure 5-3. Broad-Band Amplifier, Location of Components

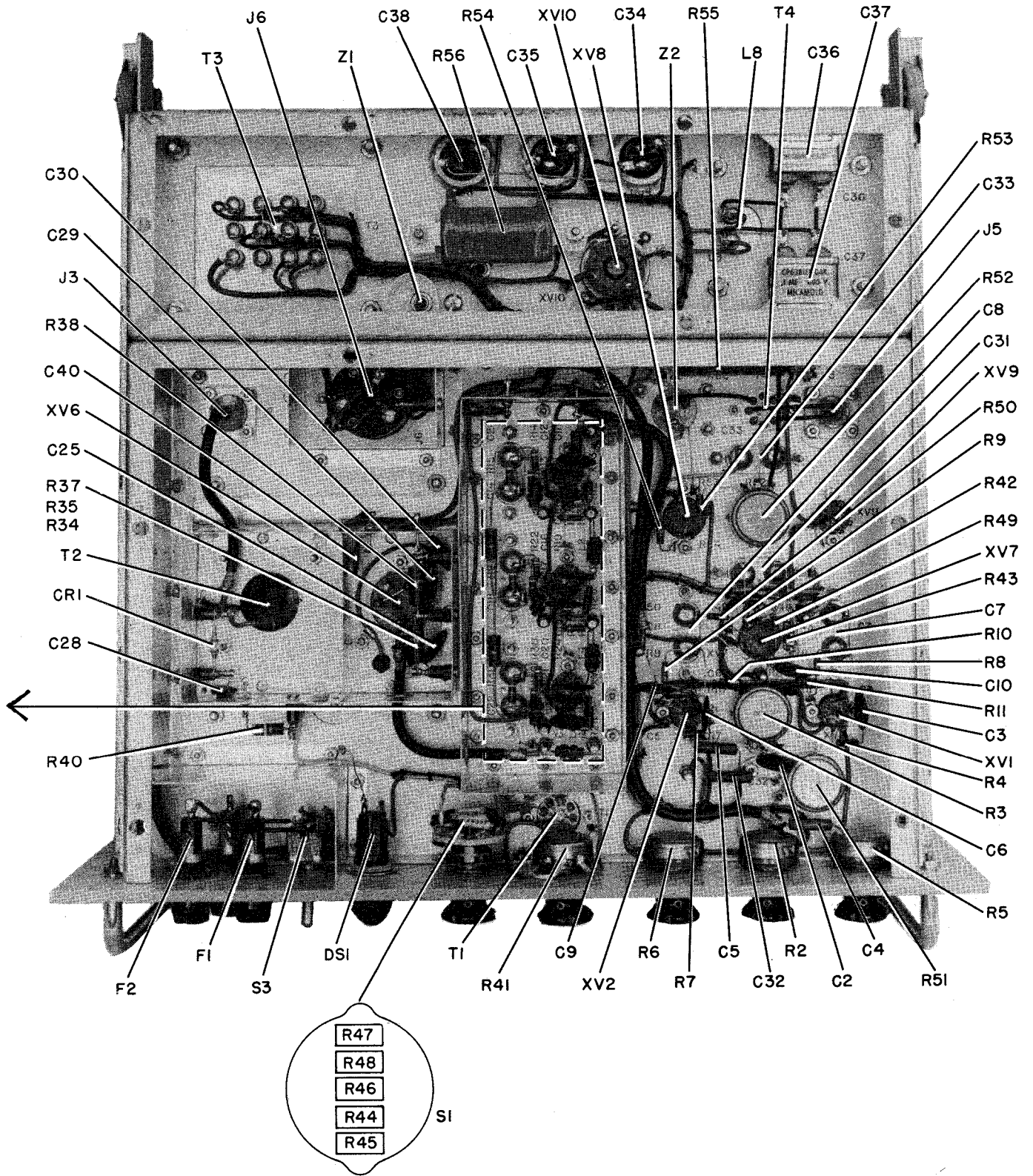
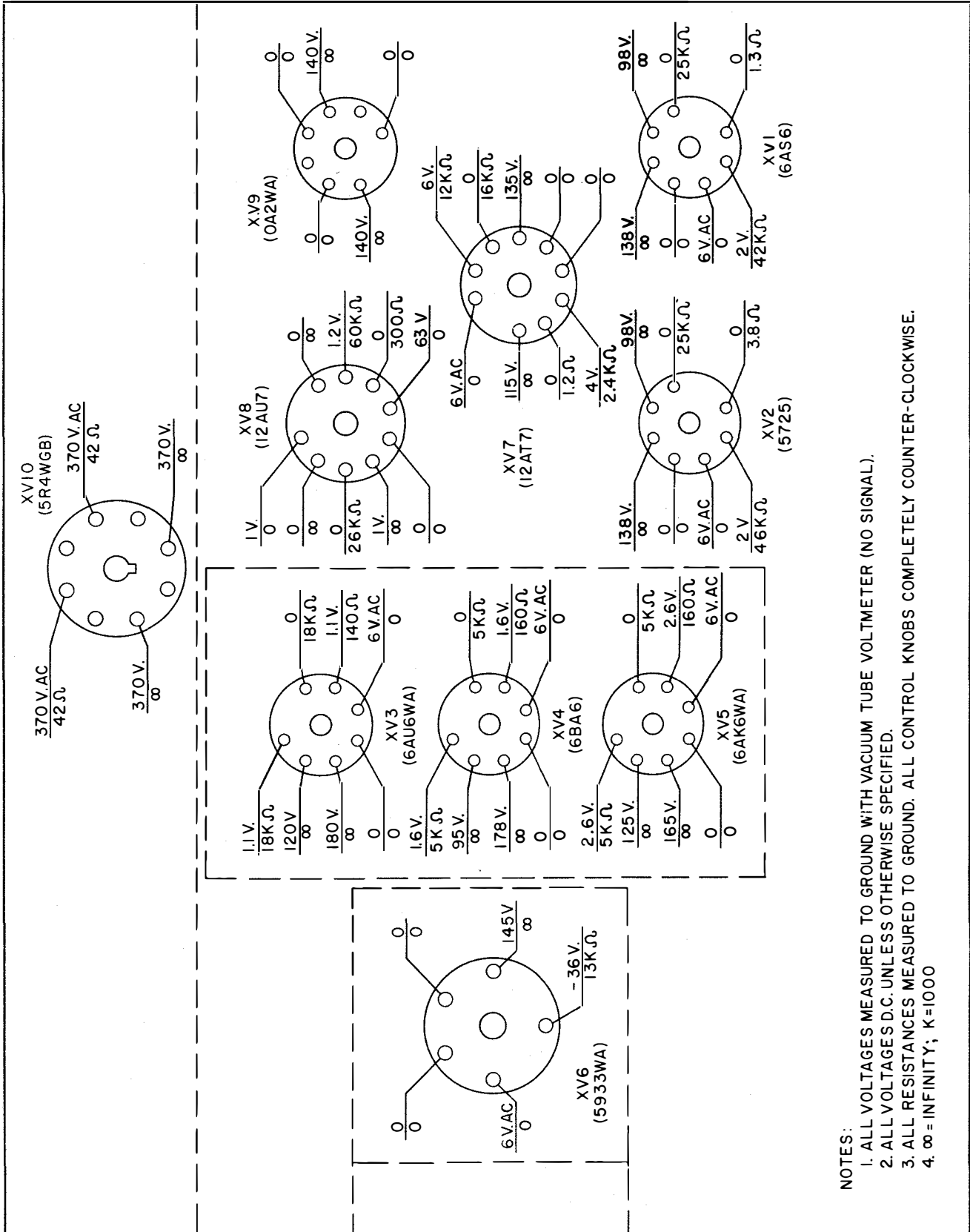


Figure 5-4. Phase Modulator, Location of Components

ESOLIBRARY



NOTES:
 1. ALL VOLTAGES MEASURED TO GROUND WITH VACUUM TUBE VOLTMETER (NO SIGNAL).
 2. ALL VOLTAGES D.C. UNLESS OTHERWISE SPECIFIED.
 3. ALL RESISTANCES MEASURED TO GROUND. ALL CONTROL KNOBS COMPLETELY COUNTER-CLOCKWISE.
 4. ∞ = INFINITY; K=1000

Figure 5-5. Tube Socket Pin Voltage and Resistance Diagram

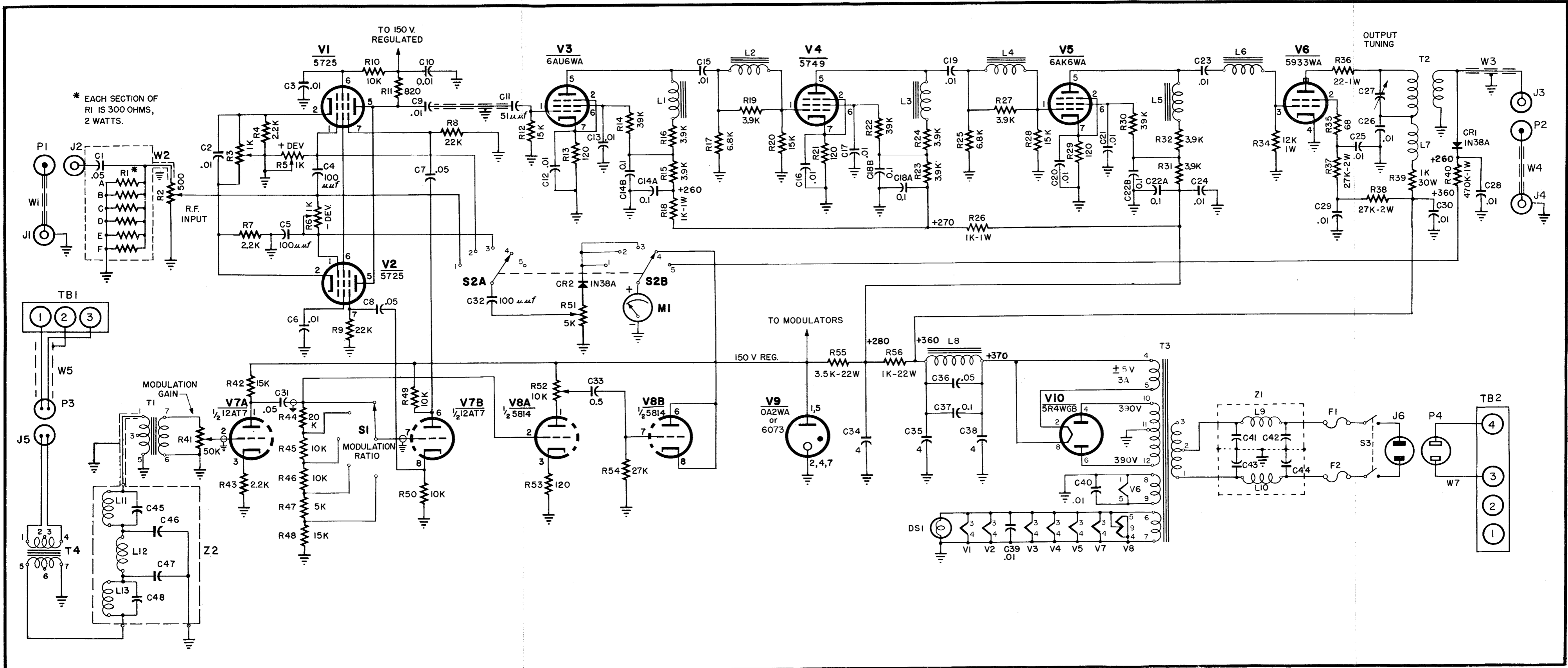


Figure 5-6. Schematic Diagram

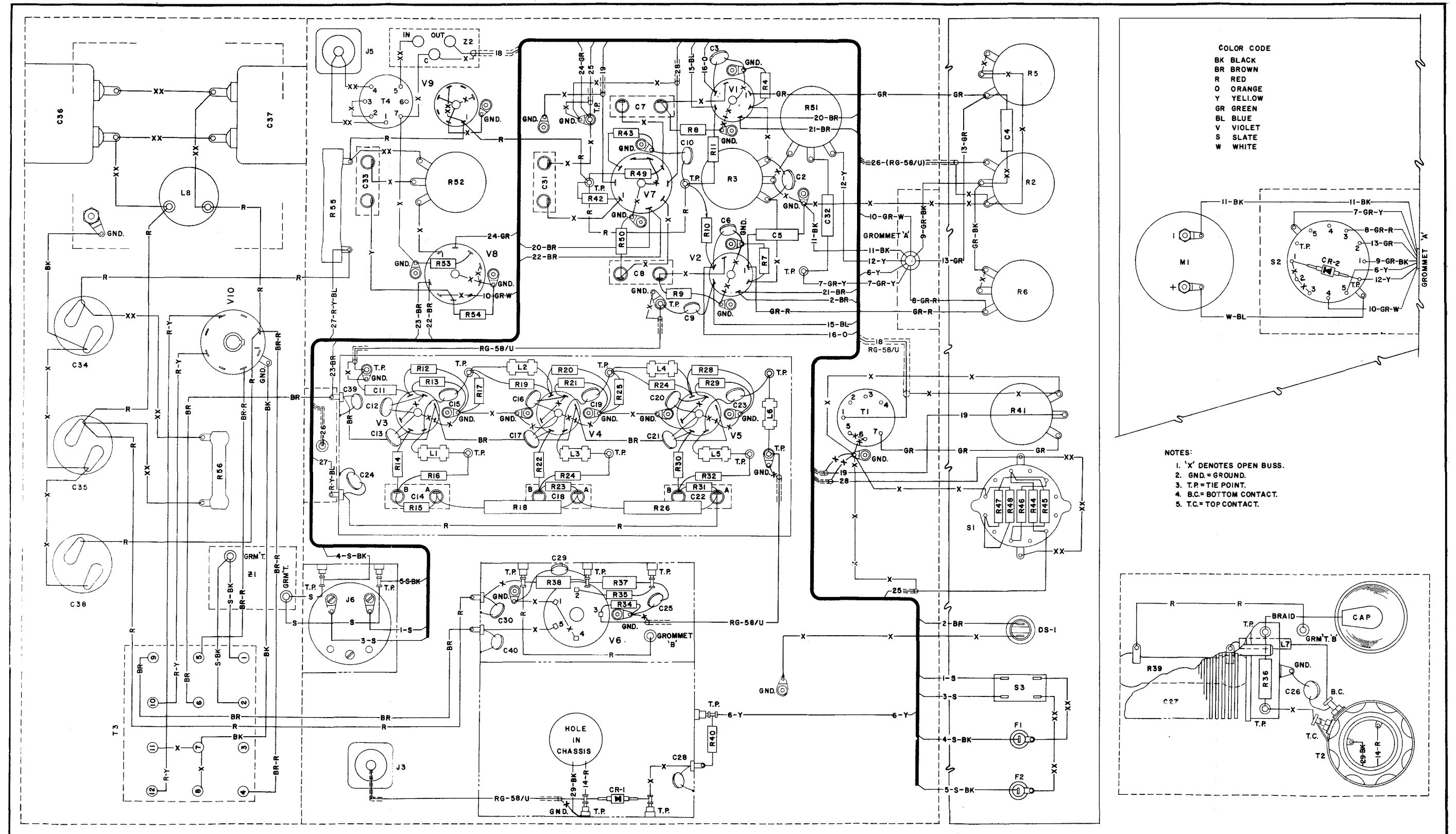


TABLE 6-1. REPLACEABLE PARTS

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
C1	---- N16-C019143-6783 ----	CAPACITOR, FIXED, CERAMIC DIELECTRIC: single section; 600 w. v. d. c. ; 0.05 μ f, +20%, -10%; dim. 1-9/32 wide, 27/32 high, 3/32 thick, Mfd. by Centralab, Milwaukee, Wisc. , Cat. No. DF-503	RF Input
C2	---- N16-C-99999-746 ----	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 10,000 μ μ f, 500 w. v. d. c. ; CK63Y103Z	Modulator cathode balancing
C3		Same as C2	Screen bypass, V1
C4	---- N16-C-17077-1294 ----	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 100 μ μ f, \pm 5%; 500 w. v. d. c. ; CC26UJ101J	RF phase-shifter
C5		Same as C4	RF phase-shifter
C6		Same as C2	Screen bypass, V2
C7	---- For replacement use SNSN N16-C-44257-1102 ----	CAPACITOR, FIXED, PAPER DIELECTRIC: .05 μ f, \pm 10%; 600 w. v. d. c. ; CP61B1EF503K Includes Bracket CP06SA1	Audio output coupling, V7B
C8		Same as C7	Audio output coupling, V7B
C9		Same as C2	Output coupling, V1, V2
C10		Same as C2	B+ bypass, V1, V2
C11	---- N16-C-16597-1249 ----	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 51 μ μ f, \pm 5%; 500 w. v. d. c. ; CC21UJ510J	Output coupling, V1, V2
C12		Same as C2	Cathode bypass, V3
C13		Same as C2	Screen bypass, V3
C14	---- For replacement use SNSN N16-C-53204-4069 ----	CAPACITOR, FIXED, PAPER DIELECTRIC: 0.1 μ f each section, +20%, -10%; 600 w. v. d. c. ; CP61B6EF104V. Includes Bracket CP06SA3; (Standard Navy No. N16-M-60958-3571)	B+ bypass, V3
C15		Same as C2	Output coupling, V3
C16		Same as C2	Cathode bypass, V4
C17		Same as C2	Screen bypass, V4
C18		Same as C14	B+ bypass, V4
C19		Same as C2	Output coupling, V4
C20		Same as C2	Cathode bypass, V5
C21		Same as C2	Screen bypass, V5
C22		Same as C14	B+ bypass, V5
C23		Same as C2	Output coupling, V5
C24		Same as C2	B+ feed through, broad-band amp.

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
C25		Same as C2	Screen bypass, V6
C26		Same as C2	Plate tank bypass, V6
C27	---- N16-C-61711-7721 ----	CAPACITOR, VARIABLE, AIR DIELECTRIC: plate-meshing type; single section; 13.5 μf to 320 μf ; 1,000 v ac peak voltage; no trimmers; shaft adjustment, 180° clockwise rotation of plates; Mfd. by Hammarlund, New York, New York; Cat. No. MC-325-M	Plate tuning, V6
C28		Same as C2	RF output metering voltage filter
C29		Same as C2	Screen bypass, V6
C30		Same as C2	B+ bypass, V6
C31		Same as C7	Audio coupling, V7A
C32		Same as C4	DC blocking, S2
C33	---- For replacement use SNSN N16-C-47297-1111 ----	CAPACITOR, FIXED, PAPER DIELECTRIC: 0.5 μf , $\pm 10\%$; 600 w. v. d. c. ; CP61B1EF504K. Includes Bracket CP06SA4 (Bracket Standard Navy No. N16-M-60958-3591)	Audio coupling, V8
C34	---- N16-C-49958-7507 ----	CAPACITOR, FIXED, PAPER DIELECTRIC: 4 μf , $\pm 10\%$; 600 w. v. d. c. ; CP41B1EF405K	B+ filter
C35		Same as C34	B+ filter
C36	---- N16-C-44257-1095 ----	CAPACITOR, FIXED, PAPER DIELECTRIC: .05 μf , $\pm 10\%$; 600 w. v. d. c. ; CP63B1EF503K	Resonating capacitor, L8
C37	<i>For replacement use</i> N16-C-45777-1077 <i>N16-C-45780-5861</i>	CAPACITOR, FIXED, PAPER DIELECTRIC: 0.1 μf , $\pm 10\%$; 600 w. v. d. c. ; CP63B1EF104K	Resonating capacitor, L8
C38		Same as C34	B+ filter
C39		Same as C2	Filament voltage filter
C40		Same as C2	Filament voltage filter
CR1	---- N16-T-51738-10 ----	CRYSTAL RECTIFIER: germanium diode glass enclosed, Type 1N38A	RF output metering rectifier
CR2		Same as CR1	RF input metering rectifier
DS1	---- G17-L-6297 ----	LAMP, INCANDESCENT <i>GE #47</i>	Front panel indicator
E1	---- N17-I-59411-2404 ----	INSULATOR, FEEDTHRU <i>Electrical Industries, Inc., 15-60W-PP</i>	Broad-band amplifier enclosure

Ch T-1

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
E2		Same as E1	
E3	----- N17-C-800646-201 -----	CLIP, ELECTRICAL: for V6 <i>Miller # 36002</i>	
E4	----- N16-K-700302-611 -----	KNOB <i>Huffman Radio Co. - EK13</i>	
E5 thru E9		Same as E4	
E10	----- N16-K-700408-519 -----	KNOB <i>Navy Divy RE10F479F</i>	
E11	----- N17-T-28255-3250 -----	TERMINAL, STUD <i>Elcon type TT-16</i>	
E12 thru E29		Same as E11	
E30	----- N17-A-27451-1003 -----	ADAPTER, CONNECTOR: coaxial; for RG-58/U; UG-175/U	RF output connector, J3
E31		Same as E30	Audio input, J5
E32	----- N17-S-250051-153 -----	SHIELD, ELECTRICAL CONNECTOR: for RG-58/U; UG-177/U	
E33		Same as E32	
E34		Same as E32	
E35		Same as E32	
E36	----- N16-S-34520-3862 -----	SHIELD, ELECTRON TUBE: TS102U01	
E37		Same as E36	
E38	----- N16-S-34557-8351 -----	SHIELD, ELECTRON TUBE: TS102U02	
E39		Same as E38	
E40		Same as E38	
E41	----- N16-R503580-0484 -----	RETAINER, ELECTRON TUBE: for V6; Mfd. by Augat Bros., Inc., Cat. No. 1007-1	
E42	----- N16-S-34576- 8514 ⁶⁵¹³ -----	SHIELD, ELECTRON TUBE: TS103U02	
E43		Same as E42	
E44	----- N16-S-34607-6039 -----	SHIELD, ELECTRON TUBE: TS102U03	

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
E45	---- N16-R503580-0479 ----	RETAINER, ELECTRON TUBE: for V10; Mfd. by Augat Bros., Inc., Attleboro, Mass., Cat. No. 124F1-21D	
F1	---- N17-F-16300-90 ----	FUSE: 2 ampere <i>Bussman BAG-2</i>	Front panel
F2		Same as F1	Front panel
F3		Same as F1	Front panel spare
J1	---- N17-C-73108-5905 ----	CONNECTOR, RECEPTACLE, ELECTRICAL: UG-58/U	RF input, terminal board
J2	---- N17-C-73108-1267 ----	CONNECTOR, RECEPTACLE, ELECTRICAL: UG-290/U	RF input, chassis
J3	---- N17-C-73108-5875 ----	CONNECTOR, RECEPTACLE, ELECTRICAL: Signal Corps Type SO-239, Navy Type NT-49194	RF output, chassis
J4		Same as J1	RF output, terminal board
J5	---- N17-C-73127-5741 ----	CONNECTOR, RECEPTACLE, ELECTRICAL: UG-103/U	Audio input, chassis
J6	---- N17-C-73471-5400 ----	CONNECTOR, RECEPTACLE, ELECTRICAL: 3 identical mating ends; bakelite; straight; partially enclosing shell; polarized; twist-lock; 2 mounting holes, 0.156 in. dia.; Mfd. by Harvey Hubbell, Inc., Bridgeport, Conn., Cat. No. 7556	Power receptacle, chassis
L1	---- N16-C073204-1707 ----	COIL, RADIO FREQUENCY: One 2-pie universal windings; 58 turns #34 AWG; single silk enamel; 0.14 mh, ±5%; Mfd. by Edwin I. Guthman, Chicago, Ill., Cat. No. 34-5022	Plate, V3
L2		Same as L1	Grid, V4
L3		Same as L1	Plate, V4
L4		Same as L1	Grid, V5
L5		Same as L1	Plate, V5
L6		Same as L1	Grid, V6
L7	---- N16-C-73043-1051 ----	COIL, RADIO FREQUENCY <i>Chait type 2-50</i>	B+ supply, V6
L8	---- N16-R029190-1985 ----	REACTOR, FIXED INDUCTANCE: 1 coil; 8 hys.; 0.200 amp. dc, 85 ohms dc; 1.2 kv insulation test; MIL-T-27 type TF1AO4; Mfd. by Tresco, Phila., Penn., Cat. No. 200136	Power supply, B+ filter
M1	---- N17-M-18968-6671 ----	AMMETER: 0-100 microamperes; 3-1/2 in. round case; MR35W100DCUA (MIL Type)	Front panel

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
P1	---- N17-C-71408-5333 ----	CONNECTOR, PLUG, ELECTRICAL: UG-88/U	RF input cable
P2	---- N17-C-71412-8709 ----	CONNECTOR, PLUG, ELECTRICAL: PL-259	RF output cable
P3	---- N17-C-71435-7292 ----	CONNECTOR, PLUG, ELECTRICAL: UG-102/U	Audio input cable
P4	---- N17-C-71168-1296 ----	CONNECTOR, PLUG, ELECTRICAL: 3 contacts; 3 identical mating ends; bakelite; straight; dim. 1.5 in. high, 1.5 in. dia.; twist-lock; 0.562 in. dia. max. cable accommodated with cable clamp; Mfd. by Harvey Hubbell, Inc., Bridgeport, Conn., Cat. No. 7555	Power input cable
R1A	---- N16-R-49696-996 ----	RESISTOR, FIXED, COMPOSITION: 300 ohms, ±5%; 2 watts; RC42GF301J	RF input load
R1B		Same as R1A	RF input load
R1C		Same as R1A	RF input load
R1D		Same as R1A	RF input load
R1E		Same as R1A	RF input load
R1F		Same as R1A	RF input load
R2	---- N16-R-87189-4320 ----	RESISTOR, VARIABLE, COMPOSITION: poten- tiometer; 500 ohms, ±10%; 2 watts; linear taper; 3/8-32 x 3/8 bushing; plain round shaft 1/4 dia. x 7/8. Allen Bradley No. JU5011 with P3056 shaft and bushing	RF gain control
R3	---- N16-R-87349-4560 ----	RESISTOR, VARIABLE, COMPOSITION: single section, 1,000 ohms, ±10%; 2 watts; linear taper; phenolic body, enclosed metal case; single metal slotted shaft 1/4 in. dia., 5/8 in. long; Mfd. by Allen Bradley, Milwaukee, Wisc., Cat. No. JLU1021	Modulator balance
R4	---- N16-R-50011-438 ----	RESISTOR, FIXED, COMPOSITION: 2,200 ohms, ±5%; 1/2 watt; RC20GF222J	Cathode, V1
R5	---- N16-R-87349-4425 ----	RESISTOR, VARIABLE, COMPOSITION: poten- tiometer; 1,000 ohms, ±10%; 2 watt; linear taper; 3/8-32 x 3/8 bushing; plain round shaft 1/4 dia. x 7/8 long; Mfd. by Allen Bradley No. JU1021 with P3056 shaft and bushing	+ Dev., Grid V1
R6		Same as R5	- Dev., Grid V2
R7		Same as R4	Cathode, V2
R8	---- N16-R-50371-433 ----	RESISTOR, FIXED, COMPOSITION: 22,000 ohms, ±5%; 1/2 watt; RC20GF223J	Suppressor, V1
R9		Same as R8	Suppressor, V2
R10	---- N16-R-50281-438 ----	RESISTOR, FIXED, COMPOSITION: 10,000 ohms, ±5%; 1/2 watt; RC20GF103J	Screen, V1, V2

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TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
R11	---- 438 N16-R-49876-438 ----	RESISTOR, FIXED, COMPOSITION: 820 ohms, ±5%; 1/2 watt; RC20GF821J	Plate, V1, V2
R12	---- N16-R-50335-438 ----	RESISTOR, FIXED, COMPOSITION: 15,000 ohms, ±5%; 1/2 watt; RC20GF153J	Grid, V3
R13	---- N16-R-49597-438 ----	RESISTOR, FIXED, COMPOSITION: 120 ohms, ±5%; 1/2 watt; RC20GF121J	Cathode, V3
R14	---- N16-R-50443-438 ----	RESISTOR, FIXED, COMPOSITION: 39,000 ohms, ±5%; 1/2 watt; RC20GF393J	Screen, V3
R15	---- N16-R-50092-438 ----	RESISTOR, FIXED, COMPOSITION: 3,900 ohms, ±5%; 1/2 watt; RC20GF392J	B+, V3
R16		Same as R15	B+, V3
R17	---- 438 N16-R-50200-438 ----	RESISTOR, FIXED, COMPOSITION: 6,800 ohms, ±5%; 1/2 watt; RC20GF682J	Grid, V4
R18	---- N16-R-49921-715 ----	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, ±5%; 1 watt; RC32GF102J	B+, V3
R19		Same as R15	Grid, V4
R20		Same as R12	Grid, V4
R21		Same as R13	Cathode, V4
R22		Same as R14	Screen, V4
R23		Same as R15	B+, V4
R24		Same as R15	Plate resistor, V4
R25		Same as R17	Grid, V5
R26		Same as R18	B+, V4
R27		Same as R15	Grid, V5
R28		Same as R12	Grid, V5
R29		Same as R13	Cathode, V5
R30		Same as R14	Screen, V5
R31		Same as R15	B+, V5
R32		Same as R15	Plate resistor, V5
R33		Deleted	
R34	---- N16-R-50308-716 ----	RESISTOR, FIXED, COMPOSITION: 12,000 ohms, ±5%; 1 watt; RC32GF123J	Grid, V6
R35	---- N16-R-49498-438 ----	RESISTOR, FIXED, COMPOSITION: 68 ohms, ±5%; 1/2 watt; RC20GF680J	Screen, V6

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
R36	----- N16-R-49318-698 -----	RESISTOR, FIXED, COMPOSITION: 22 ohms, ±5%; 1 watt; RC32GF220J	Plate, V6
R37	----- N16-R- 50881 ⁵⁰³⁹⁹ -131 -----	RESISTOR, FIXED, COMPOSITION: 27,000 ohms, ±5%; 2 watts; RC42GF273J	Screen, V6
R38		Same as R37	B+ isolating, V6
R39	----- N16-R-66030-9926 -----	RESISTOR, FIXED, WIRE-WOUND: 1,000 ohms, ±5%; 30 watts; RW34G102	B+, V6
R40	----- N16-R-50821-713 -----	RESISTOR, FIXED, COMPOSITION: 470,000 ohms, ±5%; 1 watt; RC32GF474J	RF output metering, filter
R41	<i>For replacement use</i> N16-R-87849- 4419 ⁴³⁹¹ -----	RESISTOR, VARIABLE, COMPOSITION: single section, 50,000 ohms, ±10%; 2 watts; Std. C taper, Ref. dwg. Group 3; phenolic body, enclosed metal case; round metal shaft, 1/4 in. dia., 7/8 in. lg.; Mfd. by Allen Bradley Co., Milwaukee, Wisc., Cat. No. JA5031	Modulation gain
R42		Same as R12	Plate, V7A
R43		Same as R4	Cathode, V7A
R44	----- For replacement use SNSN N16-R-73112-5351 -----	RESISTOR, FIXED, FILM: high stability; 20,000 ohms, ±1%; 1/2 watt; RN-15-X-2002-F	Modulation range attenuation, S1
R45	----- N16-R-73092-6518 -----	RESISTOR, FIXED, FILM: high stability; 10,000 ohms, ±1%; 1/2 watt; RN-15-X-1002-F	Modulation range attenuation, S1
R46		Same as R45	Modulation range attenuation, S1
R47	----- For replacement use SNSN N16-R-73044-2811 -----	RESISTOR, FIXED, FILM: high stability; 4,990 ohms, ±1%; 1/2 watt; RN-15-X-4991-F	Modulation range attenuation, S1
R48	----- For replacement use SNSN N16-R-73105-1451 -----	RESISTOR, FIXED, FILM: high stability; 15,000 ohms, ±1%; 1/2 watt; RN-15-X-1502-F	Modulation range attenuation, S1
R49		Same as R10	Plate, V7B
R50		Same as R10	Cathode, V7B
R51	----- N16-R-87519-4580 -----	RESISTOR, VARIABLE, COMPOSITION: single section, 5,000 ohms, ±10%; 2 watts; Std. A taper, Ref. dwg. Group 3; phenolic, enclosed metal case; slotted metal shaft, 1/4 in. dia., 5/8 in. long; Mfd. by Allen Bradley, Milwaukee, Wisc., Cat. No. JLU5021	Metering section

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
R52	---- N16-R-87749-4560 ----	RESISTOR, VARIABLE, COMPOSITION: single section, 25,000 ohms, ±10%; 2 watt; Std. A taper, Ref. dwg. Group 3; phenolic, enclosed metal case; slotted metal shaft, 1/4 in. dia., 5/8 in. long; Mfd. by Allen Bradley, Milwaukee, Wisc., Cat. No. JLU2531	Plate, V8A
R53	---- N16-R-49768-438 ----	RESISTOR, FIXED, COMPOSITION: 470 ohms, ±5%; 1/2 watt; RC20GF471J	Cathode, V8A
R54	---- N16-R-50398-131 ----	RESISTOR, FIXED, COMPOSITION: 27,000 ohms, ±5%; 1/2 watt; RC20GF273J	Grid, V8B
R55	---- N16-R-66187-3601 ----	RESISTOR, FIXED, WIRE-WOUND: 3,500 ohms, ±5%; 22 watts; RW21G352	Current limiter, V9
R56	---- N16-R-66030-6719 ----	RESISTOR, FIXED, WIRE-WOUND: 1,000 ohms, ±5%; 22 watts; RW21G102	Voltage dropping resistor, power supply
S1	---- N17-S060994-3911 ----	SWITCH, ROTARY: single section; 6 positions; nonpile-up type contacts, 2 moving, 12 fixed contacts; 850 v dc max., 0.88 amps dc; non-shorting; dim. 9/16 in. long, 1-5/16 in. wide, 1-1/2 in. high; round shaft, 2-1/4 in. lg., 1/4 in. dia.; Mfd. by Centralab, Milwaukee, Wisc., Cat. No. PA2003	Modulation range, front panel
S2		Same as S1	Meter selector, front panel
S3	---- N17-S-73082-9028 ----	SWITCH, TOGGLE: D. P. S. T.; power on-off Bat handle; ST22K	Power switch, front panel
T1	---- N17-T-61514-7738 ----	TRANSFORMER, AUDIO FREQUENCY: input type; primary winding impedance 500 ohms, tapped at 50 ohms, 200 ohms, 500 ohms; secondary winding impedance 50,000 ohms; dc current not rated; +5 dbm max. audio operating level; primary to secondary turns ratio 1 to 10; frequency response ±2 db over range 50 cycles to 10 kc; MIL-T-27 type TF1A10YY; Mfd. by United Transformer Co., Cat. No. H-1.	Audio input
T2	---- N17-T-077067-3206 ----	TRANSFORMER, RADIO FREQUENCY: 2 to 5 mc frequency range; 2 winding; primary winding 30 turns, No. 20 B&S gauge, untapped; secondary winding 7-1/2 turns, No. 16 B&S gauge untapped; over-all dim. 5-1/4 in. length, 2-3/8 in. width, 2-3/8 in. depth; Mfd. by Schuttig and Co., Inc., College Park, Md., Dwg. No. C2914	RF output, V6
T3	---- N17-T- 99900-3 75203-2201	TRANSFORMER, POWER, STEP-DOWN AND STEP-UP: hermetically sealed; primary winding 230 volts tapped at 115 volts, 50-70 cps, single phase; secondary windings 5 volts ac, 3 amps; 6.3 volts ac, 4.5 amps; 6.3 volts ac, 1 amp; output winding 770 volts ac, center tapped; 200 ma dc; air cooled; impregnated; MIL-T-27 type TF1A03YY; Mfd. by Tresco, Phila., Penn., Cat. No. 100208	Power transformer

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TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
T4	----- N17-T-62159-2071 -----	TRANSFORMER, AUDIO FREQUENCY: line type; two primary windings; 600 ohms impedance; 150 ohms impedance; single secondary winding, 600 ohms center tapped; hermetically sealed steel case; over-all dim. 1-26/64 in. lg., 61/64 in. wide, 1-13/32 in. high; 8 dbm max. audio operating level; frequency data, ±2 db over frequency range 50-10,000 cps, not tuned; 7 solder lug type terminals located axially at one end; 2 mtg. holes .14 in. dia. on 1-1/8 in centers; MIL-T-27 type TF1A16YY; Mfd. by United Transformer Co., Cat. No. H-8	Audio input impedance matching transformer
TB1	----- N17-B-77586-2582 -----	TERMINAL BOARD: barrier type, 3 contact <i>H. B. Jones 3-141Y</i>	In cabinet
TB2	----- N17-B-77637-3414 -----	TERMINAL BOARD: barrier type, 4 contact; Mfd. by Jones Division of Cinch Mfg. Co., Chicago, Ill., Cat. No. 4-141-Y	In cabinet
V1	----- N16-T-75725 -----	ELECTRON TUBE: Type 5725	Modulator
V2	-----	Same as V1	Modulator
V3	----- N16-T-56203-53 -----	ELECTRON TUBE: Type 6AU6WA	Broad-band amplifier
V4	----- N16-T-75749 -----	ELECTRON TUBE: Type 5749	Broad-band amplifier
V5	----- N16-T-56192-85 -----	ELECTRON TUBE: Type 6AK6WA	Broad-band amplifier
V6	----- N16-T-75933-85 -----	ELECTRON TUBE: Type 5933WA	RF output
V7	----- N16-T-58240-14 -----	ELECTRON TUBE: Type 12AT7WA	Audio amplifier
V8	----- N16-T-75814-5 -----	ELECTRON TUBE: Type 5814A	Meter amplifier
V9	----- N16-T-52001-3 -----	ELECTRON TUBE: Type OA2WA	Voltage regulator
V10	----- N16-T-55446-5 -----	ELECTRON TUBE: Type 5R4WGB	Power rectifier
W1	----- For replacement use SNSN N15-C-12200-580 -----	CABLE, RADIO FREQUENCY: RG-58/U	RF input cable
W2		Same as W1	Terminating load output cable

TABLE 6-1. REPLACEABLE PARTS--Cont'd

Ref. Desig.	STOCK NUMBERS Signal Corps Standard Navy Air Force	NAME AND DESCRIPTION	LOCATING FUNCTION
W3		Same as W1	RF output cable, chassis
W4		Same as W1	RF output cable, cabinet
W5	---- N16-C-1128 * ----	CABLE, SPECIAL PURPOSE, ELECTRICAL: No. 22 AWG, 2 conductor, tinned copper braid shield; Mfd. by Belden, Chicago, Ill., No. 8739	Audio input, cabinet
W6		Same as W5	Audio input, chassis
W7	---- N15-C-31025-9025 ----	CABLE, POWER, ELECTRIC: 2 conductor, power cord, No. 18 AWG stranded, Type SJ; rubber jacket, rubber cover	Power input, cabinet
XDS1	---- N17-L-76854-4324	LIGHT, INDICATOR: indicates Power "ON" Dialco No, 81410-111	
XF1	---- N17-F-74267-5075 ----	FUSEHOLDER <i>Bussan HKP</i>	Front panel
XF2	----	Same as XF1	Front panel
XF3		Same as XF1	Front panel spare
XV1	---- N16-S-62603-6702 ----	SOCKET, ELECTRON TUBE: TS102P01	
XV2		Same as XV1	
XV3		Same as XV1	
XV4		Same as XV1	
XV5		Same as XV1	
XV6	---- N16-S-61717-4641 ----	SOCKET, ELECTRON TUBE: 5 contact, mica filled bakelite <i>Amphenol MIP5-</i>	
XV7	---- N16-S-64063-6713 ----	SOCKET, ELECTRON TUBE: 9 pin min. ; TS103P01	
XV8		Same as XV7	
XV9		Same as XV1	
XV10	---- N16-S-63515-4151 ----	SOCKET, ELECTRON TUBE: 8 pin octal; TS101P01	
Z1	---- N17-S059067-7003 ----	FILTER, LOW PASS: 10 kc cut-off frequency; 4 solder lug terminals; metal case, hermetically sealed; two .187 in. dia. mtg. holes on 2-3/8 in. centers; Mfd. by Hopkins Engineering Co., Altedena, Calif., Cat. No. 118 <i>Shuttig Dwg # A4824</i>	Power input
Z2	---- N16-F044106-7080 ----	FILTER, LOW PASS: 8 kc cut-off frequency; 500/600 ohms input impedance, 500/600 ohms output impedance; 3 solder lug type terminals; over-all dim. 1-11/16 in. lg., 1-3/16 in. wide, 2-1/2 in. high; magnetic shield case, hermeti- cally sealed; 4 6-32 mtg. studs on 3/4 in. x 1-1/4 in. mtg. centers; Mfd. by United Trans- former Co., Cat. No. LML-8000	Audio input filter

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* Low failure item - if required
regulation from ESO referring
Navships 980,180A.