OPERATING AND SERVICING MANUAL

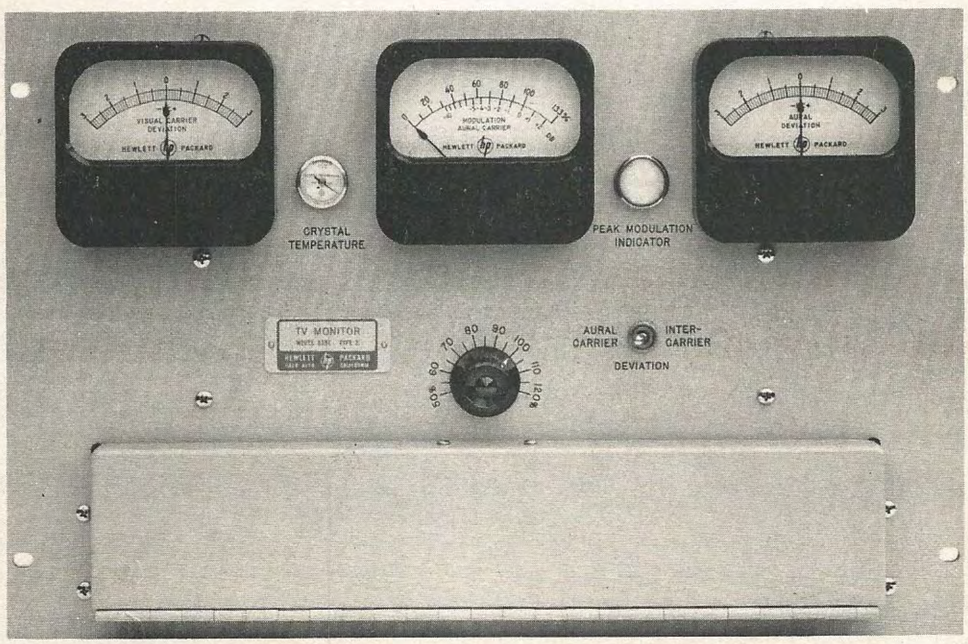
3600

hp

test. equip rqd

MODEL 335E
TV MONITOR
TYPE 2

FCC APPROVAL NO. 3-110



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SPECIFICATIONS

AURAL DEVIATION METER

Range:	± 3 kc from assigned center frequency.
Accuracy:	± 500 cps for 30 days, channels 2-13. ± 500 cps for 10 days, channels 14-83.

AURAL MODULATION METER

Range:	0 to 133% (25-kc swing equals 100%). Also calibrated in db from -10 to +2 (0 db equals 100% modulation).
Accuracy:	Indicates modulation percentage within ± 5% for modulation frequencies between 50 and 15,000 cps.
Polarity:	Responds to positive or negative peaks as selected by front panel switch.

PEAK MODULATION INDICATOR

Range:	Flashes when any preset modulation level is reached between 50% and 120%.
Polarity:	Responds to positive or negative peaks as selected by front panel switch.

AUDIO OUTPUT

High Impedance:	10 volts into 100,000 ohms, unbalanced, at 100% modulation at low frequencies. Distortion less than .25% at 100% modulation. Noise at least 65 db below output level corresponding to 100% modulation at low frequencies.
Low Impedance:	1 milliwatt (0 VU) into 600 ohms, balanced, at 100% modulation at low frequencies.
Frequency Response:	Flat within ± .5 db from 50 to 15,000 cycles, with standard 75-microsecond de-emphasis.

VISUAL DEVIATION METER

Range:	± 3 kc from assigned frequency.
Accuracy:	± 500 cps for 30 days, channels 2-13. ± 500 cps for 10 days, channels 14-83.

SPECIFICATIONS (CONT'D.)

INTER-CARRIER SPACING	
Range:	± 3 kc from 4.5 mc.
Accuracy:	± 500 cps for 6 months.
GENERAL	
RF Power Required:	Less than 1 watt from each transmitter. Separate type-N connectors provided for aural and visual inputs.
Frequency Range:	Any television broadcast channel as specified from 2 to 83, including offset channels.
Power Required:	115 volts ± 10%, 60 cycles, 280 watts.
Ambient Operating Temperature:	Unit must be mounted where ambient temperature will not exceed 45°C (113°F).
Space Required:	Unit mounts in a standard 19-inch rack and requires 12-1/4 inches of vertical space and is approximately 15-inches deep.
Weight:	Approximately 68 lbs. Shipping approximately 107 lbs.
Accessories Furnished:	2 125-UG21B/U Type-N Connectors for rf inputs.
Accessories Available:	External Aural Deviation Meter Assembly, 335E-95F. External Aural Modulation Meter Assembly, 335E-95G. External Visual Carrier Deviation Meter Assembly, 335E-95H.

CAUTION

CIRCUIT DAMAGE MAY RESULT FROM EXCESSIVE RF INPUT TO THIS INSTRUMENT. FOLLOW THE INSTRUCTIONS IN PARAGRAPH 2-1 TO ADJUST RF INPUT LEVEL.

CONTENTS

SECTION I
DESCRIPTION AND INSTALLATION

1-1 DESCRIPTION

The ⓗⓟ Model 335E Television Monitor is a complete transmitter frequency and aural modulation percentage monitor for any commercial TV channel from 2 through 83. Type approval number 3-110 has been issued by the Federal Communications Commission for all ⓗⓟ Model 335E Type 2 TV Monitors.

Continuous indication of any deviation from assigned frequency is indicated by panel meters. In addition, any deviation from the standard 4.5 mc intercarrier separation may be read directly.

A meter is provided to monitor aural transmitter modulation; a peak modulation indicator lamp flashes a warning when instantaneous aural modulation exceeds any preset value between 50% and 120%. An audio output is also provided for monitoring and measurement purposes. This output is equipped with the standard 75-microsecond de-emphasis circuit.

The Model 335E can also be used for performing other tests required for proper operation of a television station such as the measurement of incidental AM of the FM aural carrier, frequency response and distortion checks on the aural transmitter, residual noise on the aural carrier, and carrier shift with modulation.

The 335E utilizes pivoted-drawer mounting within the rack so that it can be pulled out and tilted up for convenient inspection. The cabinet for the 335E contains the drawer mechanism which mounts on the rack frame. The instrument chassis is easily removed from the drawer mounting if desired.

In addition to this manual, the following items are included with your instrument:

1) Two type-N connectors (UG-21B/U).

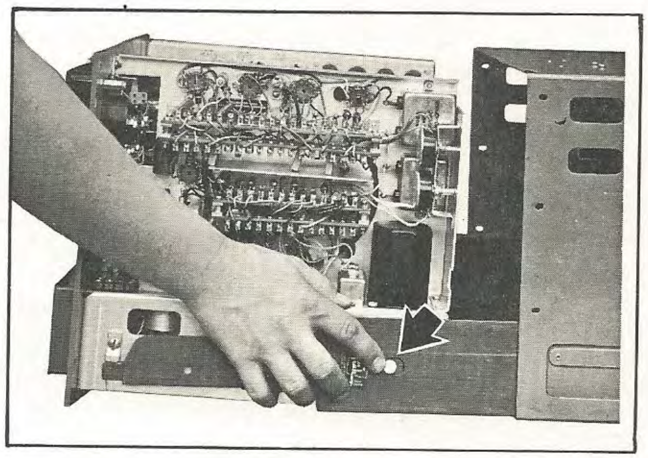
2) One set of rack-mounting hardware.

1-2 INSTALLATION

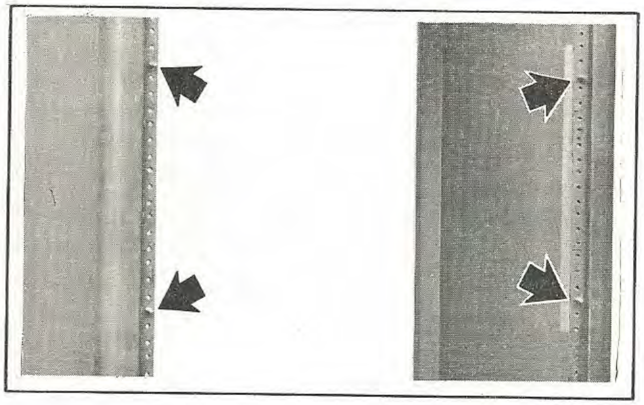
The instrument is supplied with all necessary hardware for mounting in a standard 19-inch rack that has been drilled and tapped for 12-24 mounting screws. The vertical height required is approximately 12-1/4 inches. The rack should be fastened to the floor for stability. For easy access to the unit when it is out of the rack, it is suggested that the instrument be mounted so the bottom of the panel is approximately 50 inches off the floor.

The unit should be installed in a well-ventilated location where the ambient temperature does not exceed 45°C (113°F). It is also important to allow sufficient clearance behind the unit for free passage of air out of the dust cover.

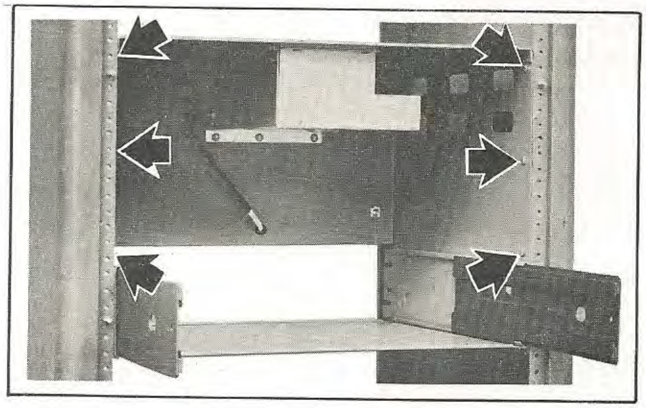
To mount the 335E in a relay rack proceed as follows:



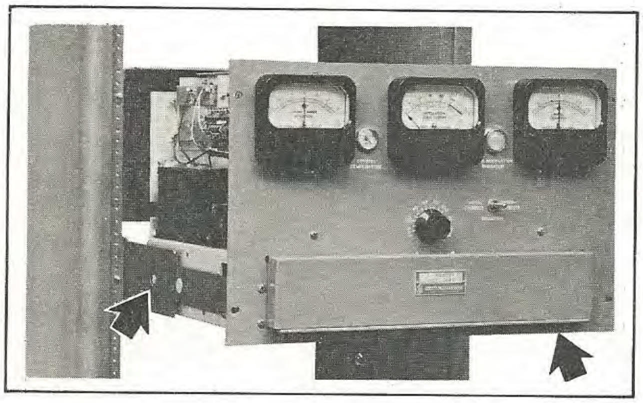
(1) Disconnect fan power cord at rear of the instrument. Slide instrument from cabinet after pushing catches on chassis rails.



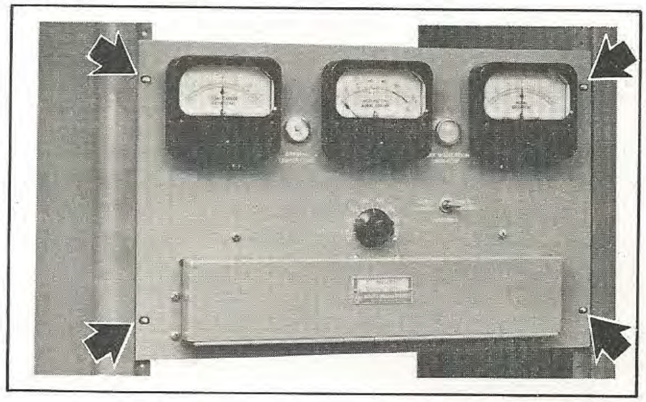
(2) Mount two angle-brackets in rack using four 12-24 screws supplied. Make sure brackets are parallel and far enough apart to clear cabinet.



(3) Fasten cabinet to angle brackets with six 8-32 screws and lockwashers provided. Adjust angle brackets for snug fit.



(4) Extend chassis slides from dust cover until they lock in position. Engage instrument in chassis slides. Depress catches to lock it in place.



(5) Connect fan cord at rear of instrument. Slide 335E into rack. The 12-24 screws should come through holes in panel. Attach four cap nuts provided.

1-3 INPUT CONNECTORS

All connections are made at the back of the 335E along the lower edge (see Figure 1-1). Allow enough slack in all wires and cables so that the 335E will slide from the rack without disconnecting cables.

A. POWER LINE

The three-conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset, round pin added to a standard two-blade connector which grounds the 335E chassis when used with the appropriate receptacle. To use this connector in a standard two-contact receptacle, an adapter should be used to connect the NEMA connector to the two-contact system. When the adapter is used the ground connection becomes a short lead which should be connected to a secure ground.

The instrument should be connected to a 115-volt power source that is never de-energized. This is to allow the crystal oven heater circuit to operate continuously for maximum oscillator stability. The POWER switch on the panel controls all the power applied to the instrument except the crystal oven heater circuits.

B. RF INPUTS

Connect the VISUAL and AURAL RF INPUT conectors, located on the rear of the instrument with the appropriate monitoring outputs provided on the transmitter. Table 1-1 lists types of cable and connectors which can be used at the monitor. Assembly instructions for coaxial connectors are given in Figure 1-2 and 1-3.

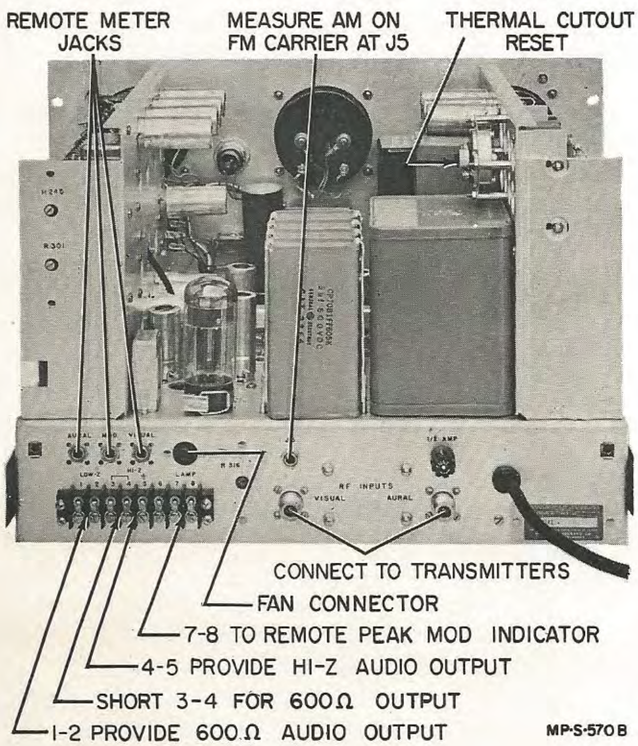


Figure 1-1. Rear View Showing Connectors

The amount of rf power required from the transmitters for proper operation of the 335E Monitor is very small, and should be maintained within reasonably close limits. The input voltage to the monitor should fall in the range of 0.05 volt to 1.5 volts. The value increases with frequency of operation. Adjustment of transmitter coupling is described in paragraph 2-1.

TABLE 1-1. INPUT CABLE AND CONNECTOR

Cable	Connectors
RG-8/U RG-9/U RG-9A/U RG-10/U	UG-21B/U (furnished) or UG-21D/U
RG-55/U RG/58/U	UG-536/U

Since the voltage required is small, care must be taken to insure that excessive rf power is not coupled into the monitor which can result in severe damage to the input circuits. The diodes CR7 and CR8 will burn out if overloaded. If the monitor seems to require excessive rf input for proper monitoring level, check these diodes.

1-4 OUTPUT CONNECTORS

All connections are made at the rear of the 335E chassis. Allow enough slack in all wires and cables to permit the instrument to be slid from the rack without disconnecting cables.

A. AUDIO OUTPUT

Two audio output voltages are available on the terminal strip at the rear of the instrument: A balanced low-impedance output for monitoring purposes, and an unbalanced high-impedance output for noise and distortion measurement purposes. Both of these outputs contain the standard 75-microsecond de-emphasis circuit. Only one of these output circuits should be used at a time. The unbalanced output should be used for distortion measurements to eliminate the small amount of distortion introduced by the output transformer in the balanced output.

A balanced low-impedance output (600 ohms) is available at terminals 1 and 2 at the back of the instrument (see Figure 1-1). The output level of this circuit is approximately 1 milliwatt (0 VU) into a 600-ohm circuit, with 100% modulation at low frequencies. A connection must be made between terminals 3 and 4 as indicated on the schematic diagram, before the low-impedance output will operate. Double-conductor shielded cable should be used for this circuit.

An unbalanced high-impedance audio output is available between terminals 4 and 5 at the rear of the instrument. When the unbalanced output is in use there should be no connection between terminals 3 and 4. The output level of this circuit is approximately 10 volts into a 100,000-ohm load with 100% modulation at low frequencies. Shielded cable should be used for this circuit.

B. REMOTE INDICATORS

External meters may be used with the instrument to duplicate all three panel meters at some remote location. Meters for remote indication may be ordered from the Hewlett-Packard Company. Refer to Section V, Table of Replaceable Parts, for procurement instructions and stock numbers.

Meters should be mounted in a non-magnetic (e.g. aluminum) panel for maximum accuracy. The meters may be illuminated from an external 6.3-volt power source.

1) Aural Deviation: The remote aural deviation meter is connected to J6 with double conductor shielded cable and a three-circuit phone plug. The positive meter terminal should be connnected to the tip of the plug and the remote meter multiplier to the ring. The plug sleeve should be connected to the cable shield at the instrument.

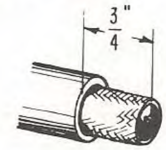
2) Modulation Aural Carrier: The remote modulation meter is connected to J7 with single conductor shielded cable and a standard two conductor phone plug. The positive meter terminal should be connected to the shield (ground).

3) Visual Carrier Deviation: The remote visual carrier deviation meter is connected to J4 with single conductor shielded cable and a standard two conductor phone plug. The positive meter terminal should be connected to the shield (ground).

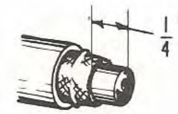
4) Peak Modulation Indicator: A remote peak modulation indicator may be connected to terminals 7 and 8 at the rear of the instrument. This indicator should be a 3 or 6 watt, type S6, 120 volt, incandescent lamp, mounted in a suitable socket.

ASSEMBLY OF UG-21B/U CONNECTOR AND RG-9/U CABLE

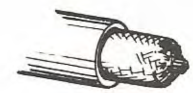
Cut the RG-9/U cable to the desired length. Remove 3/4 inch of the outer protective covering from the end of the cable. Do not injure the shield braid when cutting the outer covering.

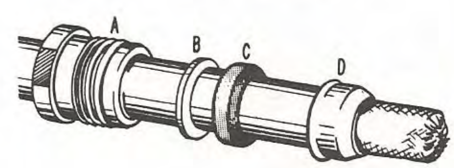


Slide the shield braid back and remove 1/4 inch of the dielectric material. Do not nick the center conductor when cutting the dielectric.



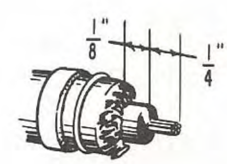
Slide shield braid back over the end of the center conductor and taper to allow connector parts to slide over cable.



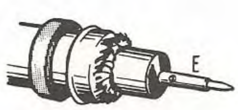


Assemble the parts of the connector on the cable as shown. Slide end fitting D down until it fits tightly over the outer plastic covering of the RG-9/U.

Unbraid and fan the shield braid over the tapered end fitting. Trim the shield braid around the edge of the end fitting as indicated. Cut the dielectric 1/8 inch from the shield braid. Do not nick the center conductor when cutting the dielectric. Cut off the center conductor 1/4 inch from the dielectric.



Slide tip E over the center conductor and solder in place. Do not apply excessive heat when soldering the tip in place as it will melt the dielectric. If the dielectric is slightly bulged after soldering the tip in place, it will be necessary to trim it to conform to the large diameter of the tip so that it will fit properly into the outer shell.



Place outer shell F over the cable end. Tip E should slide into shell F until it is flush with the end of the shell. Now tighten the assembly by turning nut A while holding the outer shell.

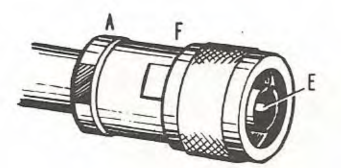
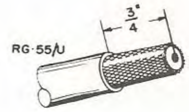


Figure 1-2

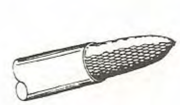
ASSEMBLY OF UG-536/U CONNECTOR AND RG-55/U CABLE

Cut RG-55/U cable to the desired length. Remove 3/4 inch of the outer protective covering from the end of the cable. Do not injure the shield braid when cutting the outer covering.

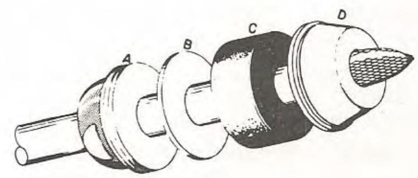


Slide back the shield braid and remove 1/4 inch of the dielectric material. Do not nick the center conductor when cutting the dielectric.

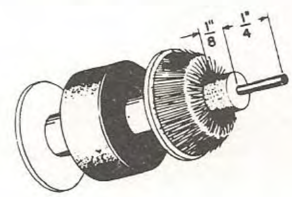
Slide shield braid back over the end of the center conductor and taper to allow connector parts to slide over cable.



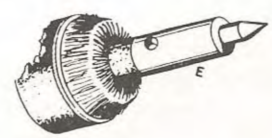
Assemble the parts of the connector on the cable. Slide end fitting D down until it fits tightly over the outer plastic covering of the RG-55/U cable.



Unbraid and fan the shield braid over the tapered end fitting. Cut the dielectric 1/8 inch from the shield braid. Do not nick the center conductor when cutting the dielectric. Cut off the center conductor 1/4 inch from the dielectric. Tin the exposed inner conductor. Do not apply excessive heat to the center conductor as this will melt the dielectric.



Slide tip E over the center conductor and solder in place. Do not apply excessive heat when soldering the tip in place as it will melt the dielectric. If the dielectric is slightly bulged after soldering the tip in place, it will be necessary to trim it to conform to the large diameter of the tip so that it will fit properly into the outer shell.



Place the outer shell F over the cable end. Tip E should slide into shell F until it is flush with the end of the shell. Now tighten the assembly by turning nut A while holding the outer shell.

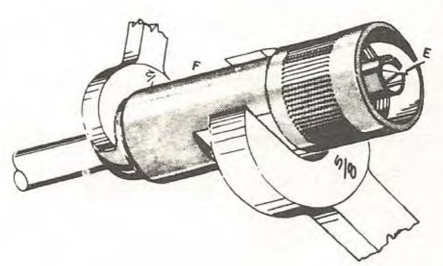


Figure 1-3

SECTION II
OPERATING INSTRUCTIONS

2-1 INITIAL OPERATION AND TRANSMITTER COUPLING ADJUSTMENT

Proceed as follows after the monitor is installed and rf cables to the transmitters are connected:

1) Connect the 335E to the 115-volt, 60-cycle power line. Observe CRYSTAL TEMPERATURE thermometer during warm-up; it should not exceed 70°C (green area of scale).

2) Adjust monitor rf coupling at transmitters as follows:

a. Adjust monitoring output from each transmitter to minimum.

b. Energize transmitters.

c. Set function selector switch to CARRIER LEVEL position.

d. Adjust coupling at visual transmitter for a reading of +1 to +3 kc on the VISUAL CARRIER DEVIATION meter with transmitter operating at normal power with black level and sync pulse modulation only.

e. Adjust coupling at aural transmitter for a reading of +1 to +3 kc on the AURAL DEVIATION meter with transmitter operating at normal power.

3) Proceed with calibration procedure given in paragraph 2-2.

2-2 PERIODIC CALIBRATION

Use the following calibration procedure after initial transmitter coupling adjustment and at weekly intervals thereafter to assure accurate monitor operation.

1) Turn on monitor and allow to warm up for 30 minutes.

2) Calibrate aural circuits. Refer to Figure 2-1, number 15.

3) Calibrate visual circuits. Refer to Figure 2-1, number 9.

4) Calibrate intercarrier circuits. Proceed as follows:

a. Set function selector to CALIBRATE.

b. Connect 3500-cycle audio oscillator to J1. Both deviation meters should now indicate zero if steps 2 and 3 have been completed properly.

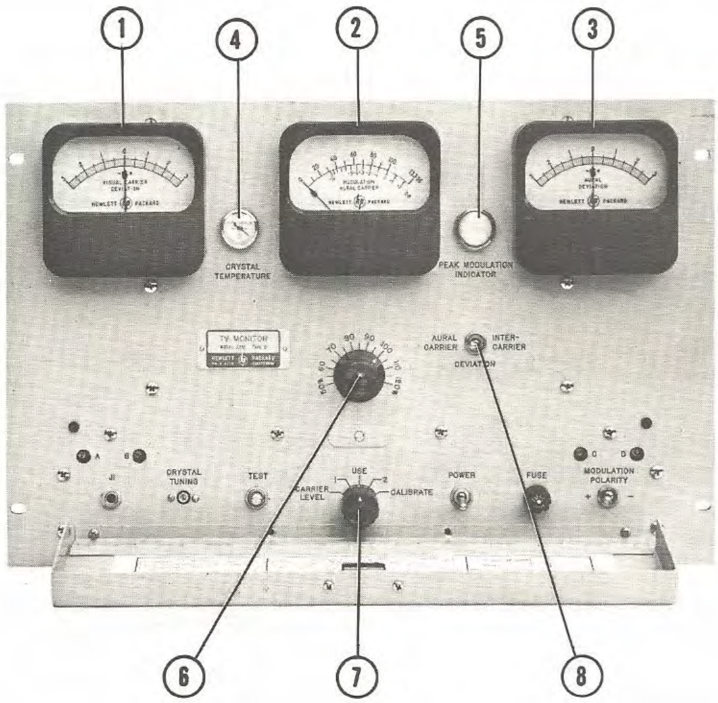
c. Set the DEVIATION switch to INTERCARRIER. Any shift in audio oscillator frequency should now produuce equal and opposite indications on the two deviation meters. For example: if the oscillator frequency is shifted to 6500 cycles the VISUAL CARRIER DEVIATION meter indication should shift to +3 KC and the AURAL DEVIATION meter (now indicating intercarrier deviation) should indicate -3 KC. If it does not, adjust R294 (inside the instrument near V15) until the AURAL DEVIATION meter indication is equal and of opposite polarity to the VISUAL CARRIER DEVIATION meter indication.

5) Check "1" position of function selector switch as follows:

a. Set the function selector to "1".

b. The VISUAL CARRIER DEVIATION meter monitors grid current in the visual mixer (V3) and should indicate between +1 kc and +3 kc.

FRONT PANEL CONTROLS AND INDICATORS



1. VISUAL CARRIER DEVIATION meter indicates deviation from assigned visual carrier frequency when function switch is in USE position.

2. MODULATION AURAL CARRIER meter indicates percent modulation of aural carrier. Since meter damping averages complex modulation wave forms, it will not indicate peaks during normal modulation with speech or music.

3. AURAL DEVIATION meter indicates deviation from assigned aural carrier frequency when function switch is in USE position and DEVIATION switch is in AURAL CARRIER position. Indicates deviation from required 4.5-mc carrier separation when DEVIATION switch is in INTER-CARRIER position.

4. CRYSTAL TEMPERATURE thermometer gives temperature inside master oscillator crystal oven. Pointer should lie inside green area (approximately 65°C).

5. PEAK MODULATION INDICATOR flashes if instantaneous modulation peaks exceed value selected on 50%-120% control.

6. 50%-120% control selects modulation percentage at which the PEAK MODULATION INDICATOR flashes.

7. FUNCTION switch is normally set to USE position. See Table 2-1 for other settings.

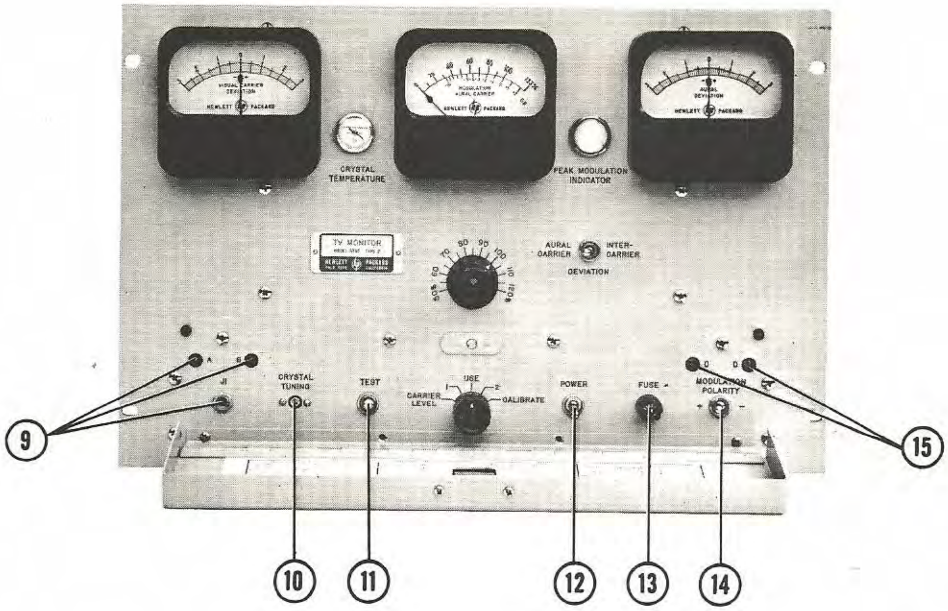
8. DEVIATION switch:

   AURAL CARRIER position permits AURAL DEVIATION meter to indicate aural frequency deviation.

   INTER-CARRIER position permits AURAL DEVIATION meter to indicate deviation of carriers from normal 4.5 mc separation.

Figure 2-1

FRONT PANEL CONTROLS AND INDICATORS (CONT'D)



9. Calibration of visual circuits:
   a) Set function switch to USE.
   b) Connect accurate 3500-cps (±10 cps) oscillator with at least one volt output to J1.
   c) Adjust "A" to center VISUAL CARRIER DEVIATION meter (o kc).
   d) Change frequency to 5000 cps.
   e) Adjust "B" for +1.5 kc on meter.

10. CRYSTAL TUNING control adjusts frequency of master oscillator. Adjust so that AURAL CARRIER DEVIATION meter agrees with simultaneous report from monitoring service.

11. TEST button lowers oscillator frequency slightly when pressed. Both deviation meters should deflect to the right when button is pressed. Shift is 0.3 kc on channels 2 thru 4. Shift is 0.5 kc on channels 5 thru 13. Shift is 1.0 kc on channels 14 thru 83.

12. POWER switch controls all power to instrument except for crystal ovens.

13. FUSE protects all circuits except for crystal ovens. Oven fuse is located on rear of chassis. A thermal switch turns power off if internal temperature exceeds 130°F; refer to Section IV, Maintenance, to reset.

14. MODULATION POLARITY switch permits check of modulation symmetry. MODULATION AURAL CARRIER meter should have same reading in either switch position.

15. Calibration of aural circuits:
    a) Set function switch to CALIBRATE.
    b) Set DEVIATION switch to AURAL CARRIER.
    c) Adjust "D" for 100% on MODULATION AURAL CARRIER meter. .
    d) Adjust "C" to center AURAL DEVIATION meter (0 kc).

Figure 2-1 (Cont'd.)

c. The MODULATION AURAL CARRIER meter monitors grid current in the first multiplier (V2), and should indicate at least 10% (arbitrary reading). This meter indication checks the operation of the master oscillator (V1) and the first multiplier (V2).

d. The AURAL DEVIATION meter monitors grid current in the aural mixer (V5) and should indicate between +1 kc and +3 kc.

6) Check "2" position of function selector switch as follows:

a. Set the function selector to "2".

b. The VISUAL CARRIER DEVIATION meter monitors grid current in the 4.3535-mc crystal oscillator (V4) and should indicate between +1 kc and +3 kc.

c. The MODULATION AURAL CARRIER meter is not connected and its reading has no significance.

d. The AURAL DEVIATION meter monitors master oscillator AGC voltage and should indicate about +0.5 kc.

7) Energize transmitter and check tuning as follows:

a. Set function selector switch to USE.

b. Set DEVIATION switch to AURAL CARRIER.

c. Press TEST button. Both deviation meters should deflect 0.3 to 1 kc to the right.

8) Adjust master oscillator frequency after 335E has been connected to power line for at least 24 hours. Refer to paragraph 2-3.

2-3 MASTER OSCILLATOR ADJUSTMENT

The CRYSTAL TUNING control should not be adjusted without consulting an approved monitoring service. No adjustments should be attempted until the unit has been connected to the power line (crystal oven operating) for a continuous period of 24 hours and the complete instrument has been turned on for at least one hour.

The best method of adjusting the CRYSTAL TUNING control requires telephone contact with a monitoring service. Adjust the CRYSTAL TUNING control until the AURAL DEVIATION meter (with DEVIATION switch in AURAL position) corresponds exactly with the report given by the monitoring service. The VISUAL CARRIER DEVIATION meter should now agree very closely with the report of the monitoring service. If it does not, refer to paragraph 4-14, 4.3535-mc Oscillator Adjustment.

Another method of adjusting the master oscillator may be used when direct contact with the monitoring service is impractical. When the monitoring service report is received, check the transmitter log for the day and time the measurement was made. If, for example, the monitoring service report indicates the aural transmitter was 500 cycles high and the log indicates the aural transmitter was 300 cycles high at the same time, the indication is that the Model 335E was in error by 200 cycles. To correct this, adjust the CRYSTAL TUNING control to raise the present AURAL DEVIATION indication by 200 cycles.

2-4 DAILY OPERATING PROCEDURE

1) Operate function selector switch to CALIBRATE. Turn the POWER switch on. Allow at least 30 minutes warm-up before making any adjustments.

2) Check CRYSTAL TEMPERATURE. It should be stable at 65°C ±5° (within the green sector).

3) Check aural circuit calibration. See Figure 2-1. number 15.

4) Set the function selector switch to "2". The VISUAL CARRIER DEVIATION meter should indicate between +1 kc and +3 kc.

5) Set function selector to the "1" position. The CARRIER DEVIATION meters should indicate between + 1 kc and +3 kc.

6) After both transmitters are on the air set the function selector to CARRIER LEVEL. Both DEVIATION meters should indicate between +1 kc and +3 kc with black level and sync pulse modulation only.

7) Set the function selector switch to USE and the DEVIATION switch to AURAL CARRIER for normal operation of the monitor. It is good practice to check aural circuit calibration (Figure 2-1, number 15) before recording AURAL DEVIATION meter readings.

If monitor is operated with function selector switch in USE position without a signal input, it may give false readings. Correct readings will return when proper input is restored.

8) Frequency deviation from standard 4.5-mc carrier separation is shown on the AURAL DEVIATION meter when the DEVIATION switch is operated to INTER-CARRIER.

2-5 AURAL AMPLITUDE MODULATION CHECK

A jack is provided at the back of the monitor to allow measurement of incidental amplitude modulation on the aural carrier. The measurement can be made at J5 with a sensitive ac voltmeter such as an ⓗⓟ Model 400D or the voltmeter section of an ⓗⓟ Model 330B/C/D and a dc electronic voltmeter such as an ⓗⓟ Model 410B.

Proceed as follows:

1) With the function selector in CARRIER LEVEL position, measure the dc voltage across a phone plug inserted into J5. This voltage will be between about 0.1 volt and 3 volts. Record this reading.

2) Replace the dc voltmeter with a sensitive ac voltmeter. Read and record the ac voltage.

3) The percentage of amplitude modulation may then be obtained with the following formula:

$$\%\ \text{ampl.mod.} = \frac{141.4 \times \text{ac voltage}}{\text{dc voltage}}$$

Example: The dc voltage measured 1.78 volts. The ac voltage measured 0.0028 volts.

$$\%\ \text{ampl.mod.} = \frac{141.4 \times 0.0028}{1.78} = 0.22\%$$

In some cases, the input voltage requirement of the monitor may be so low that difficulty will be found in measuring these voltages. In this case it is permissible to readjust the coupling probe that samples the aural transmitter output so that a dc level of up to, but not more than, three volts is obtained. Return transmitter-to-monitor coupling to normal setting when measurement is completed.

TABLE 2-1. METER SWITCHING CHART

FUNCTION SWITCH POSITION	VISUAL CARRIER DEVIATION METER		MODULATION AURAL CARRIER METER		AURAL DEVIATION METER	
	Indicates	Normal Reading	Indicates	Normal Reading	Indicates	Normal Reading
CARRIER LEVEL	Visual transmitter input level	+1 to +3 kc. (No visual modulation; "BLACK" level).	Not connected	----	Aural transmitter input level	+1 to +3 kc.
1	Visual mixer grid current	+1 to +3 kc. (No rf input)	First multiplier grid current	Over 10%	Aural mixer grid current	+1 to +3 kc (No rf input)
USE	Visual carrier deviation	KC deviation	Aural percent modulation	Percent Modulation	Aural carrier or inter-carrier deviation	KC deviation
2	4.3535 mc oscillator	+1 to +3 kc	No significance	----	AGC in master oscillator	About +0.5kc
CALIBRATE	No significance	----	Aural discriminator constant current	100%	Aural IF	0 kc

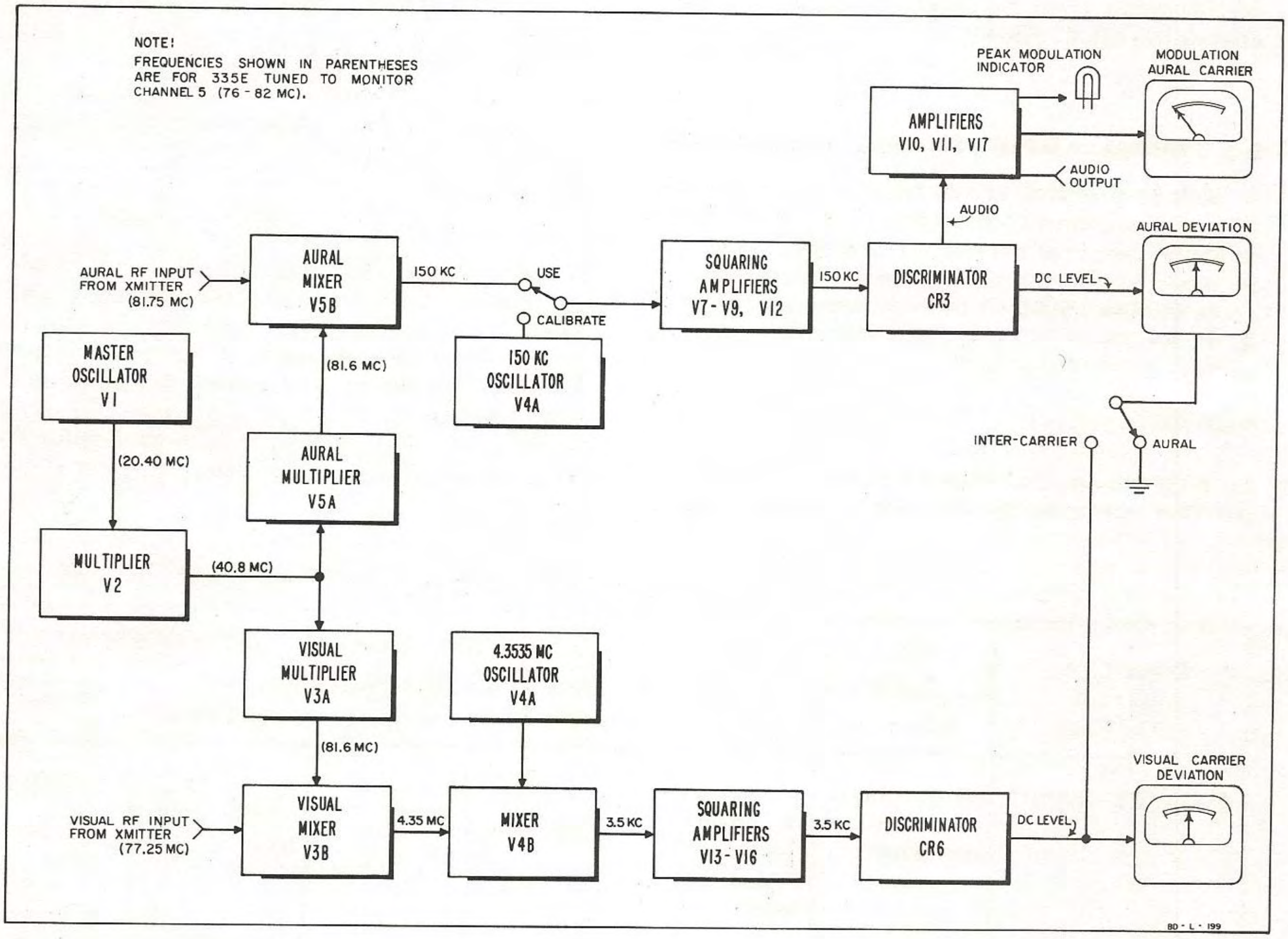


Figure 3-1. Block Diagram

SECTION III
THEORY OF OPERATION

3-1 GENERAL OPERATION

Figure 3-1 shows general circuit operation for all instruments. Master oscillator and multiplier frequencies for channel 5 only are given. Specific M. O. and multiplier frequencies for the channel to which a particular monitor is tuned is shown on a label attached to the instrument.

The output of the master oscillator is multiplied to a frequency 150 kc below the assigned center frequency of the aural transmitter. This frequency is combined with the aural transmitter frequency to produce a 150-kc intermediate frequency. The output of the discriminator is shown on a meter which indicates deviation from assigned frequency. The audio discriminator output is used to operate a meter which indicates modulation percentage.

The multiplied master oscillator frequency also falls 4.35 mc above assigned visual carrier frequency. This frequency is combined with the visual transmitter frequency to produce a 4.35-mc intermediate frequency. The intermediate frequency is mixed with a crystal-controlled 4.3535-mc signal to produce a second intermediate frequency of 3.5 kc. The output of the visual discriminator is used to operate a meter which indicates deviation from assigned carrier frequency.

The remaining paragraphs in this section cover detailed circuit operation; consult the schematic diagrams at the rear of Section IV, Maintenance, for complete circuit diagrams.

3-2 MASTER OSCILLATOR

The master oscillator (VI) is the standard to which both carriers are compared. Crystal frequency is in the 19- to 28-mc range. The exact frequency is shown on a label attached to the instrument. Master oscillator frequency is always chosen so that one of its harmonics falls 150 kc below the assigned aural carrier frequency and 4.35 mc above the assigned visual carrier frequency. The crystal is enclosed in a temperature-controlled oven for maximum stability.

The AURAL DEVIATION meter monitors oscillator AGC voltage when the function selector switch is in the "2" position.

3-3 MULTIPLIERS

The first multiplier (V2) is common to both aural and visual channels. It is usually operated as a doubler; however, on some channels it is used as a tripler. The MODULATION AURAL CARRIER meter indicates grid current in this stage when the function selector switch is in the "1" position.

Both the visual multiplier (half of V3) and the aural multiplier (half of V5) are driven by the first multiplier. In general these circuits operate as doublers although they may be operated as straight amplifiers on channels 2,3, and 4. With the function selector switch in the "1" position, the VISUAL CARRIER DEVIATION meter checks visual multiplier output and the AURAL DEVIATION meter checks aural multiplier output.

The exact multiplier output frequencies for a particular unit are given on a label attached to the instrument.

3-4 AURAL MIXER

The aural mixer (half of V5) combines the aural multiplier output and the AURAL RF INPUT to produce a 150-kc difference frequency if the transmitter is on frequency. If the transmitter is above its assigned frequency, the mixer output will be higher than 150 kc. If the transmitter is below its assigned frequency, the mixer output will be less than 150 kc.

The AURAL DEVIATION meter checks the AURAL RF INPUT when the function selector switch is in the CARRIER LEVEL position.

3-5 AURAL AMPLIFIER, DISCRIMINATOR, AND DEVIATION METER

Squaring amplifiers V6 through V9 supply a push-pull square wave of constant amplitude to the discriminator. Current regulator V12 assures constant output amplitude from V9.

The pulse-counting type discriminator detects audio modulation and supplies a dc current representing average transmitter frequency to the AURAL DEVIATION meter.

Figure 3-2 is a simplified diagram of the discriminator circuit. With the transmitter on frequency, the 150-kc square wave is differentiated, rectified, and combined with the bucking current from R244 to produce a zero reading on the AURAL DEVIATION meter. If the transmitter carrier frequency is high, the average voltage at the discriminator output is more negative and deflects the AURAL DEVIATION meter to the right. If transmitter carrier frequency is low, the average voltage at the discriminator output is less negative and deflects the AURAL DEVIATION meter to the left. The audio variations at the disciminator output are coupled through T1 to the audio amplifier and modulation indicator circuits.

3-6 AUDIO CIRCUITS AND MODULATION INDICATORS

Audio amplifier V10 is a stable, low distortion audio amplifier with negative feedback through transformer T1.

The input to cathode follower V11B contains a standard 75-microsecond de-emphasis network. A high-impedance, low-distortion, unbalanced audio output can be obtained between terminals 4 and 5 of TB201 if the link between terminals 3 and 4 is removed. A balanced 600-ohm output is provided at terminals 1 and 2 of TB201 with the shorting link installed between terminals 3 and 4.

Amplifier and cathode follower V11A provides isolation between the peak modulation indicator circuit and the modulation meter circuit. The metering circuit consists of a half-wave rectifier followed by a network which damps the meter in accordance with FCC requirements.

The metering circuit does not contain a de-emphasis network. The MODULATION AURAL CARRIER meter therefore responds to true transmitter modulation, regardless of modulation frequency. For

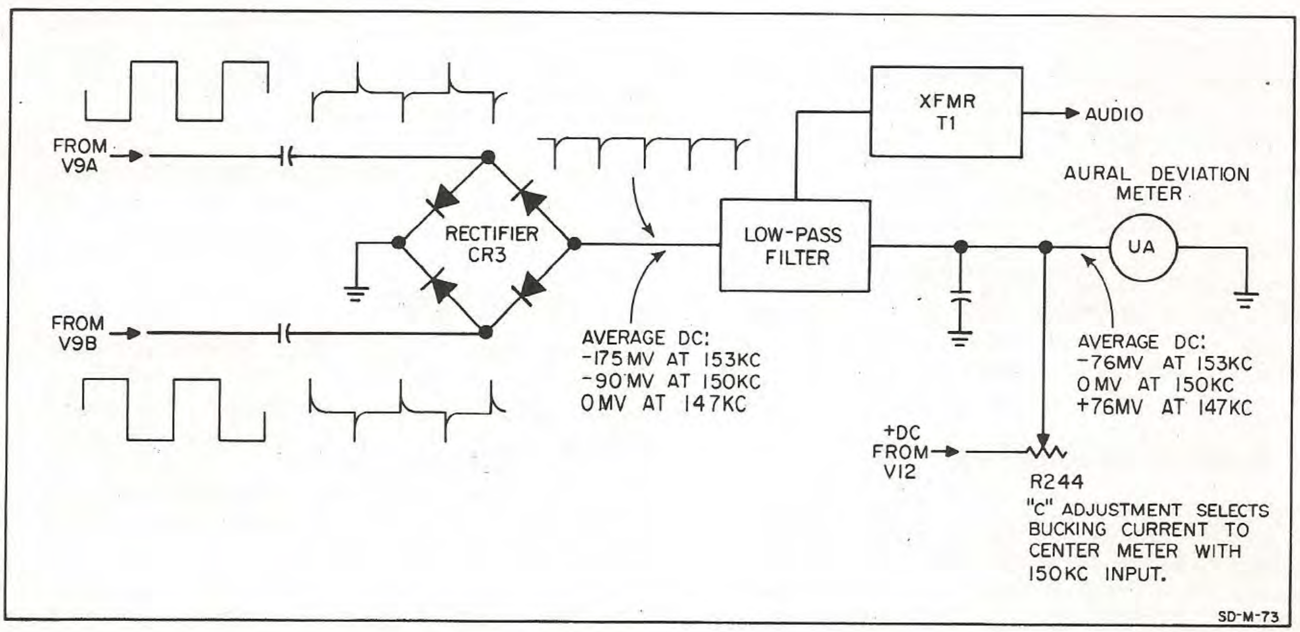


Figure 3-2. Simplified Diagram of the Discriminator Circuit

the same reason, the modulation meter does not follow VU meters in the audio system ahead of the transmitter pre-emphasis network.

Audio peaks are rectified by CR14 and coupled to the grid of thyratron V17. When the input voltage to V17 exceeds the triggering level selected by the 50%-120% control (R312), the thyratron fires, lighting the PEAK MODULATION INDICATOR lamp. Since the triggering circuit operates quickly, modulation peaks of short duration may cause the lamp to flash when the modulation shown on the MODULATION AURAL CARRIER meter is only a fraction of that selected on the 50%-120% control.

3-7 VISUAL MIXER AND 4.3535-MC OSCILLATOR/MIXER

The visual mixer (half of V3) combines the visual multiplier output and the VISUAL RF INPUT to produce a difference frequency of 4.35 mc. The VISUAL CARRIER DEVIATION meter checks VISUAL RF INPUT when the function selector switch is in the CARRIER LEVEL position.

The 4.35-mc output of the visual mixer is combined in the mixer portion of V4 with 4.3535 mc from the oscillator portion of V4 to produce a 3.5-kc difference frequency. The VISUAL CARRIER DEVIATION meter checks the operation of the 4.3535-mc oscillator when the function selector switch is in the "2" position.

3-8 VISUAL AMPLIFIERS, DISCRIMINATORS, AND DEVIATION METER

The 3.5-kc output of the final visual mixer is passed through a filter (Z1-Z2) which eliminates 15, 750-cps horizontal sync pulses. Squaring amplifiers V13 through V15 supply a push-pull square wave of constant amplitude to the discriminator. Current regulator V16 assures constant output amplitude from V15.

The pulse-counting type discriminator supplies a dc current representing transmitter frequency of the VISUAL CARRIER DEVIATION meter. The operation of this discriminator is the same as that of the aural discriminator discussed in paragraph 3-5, except that the nominal input frequency is 3.5 kc.

3-9 POWER SUPPLY

A conventional regulator (V19, V20, V21) supplies +300 volts to all circuits. Any ac component (ripple) on the +300-volt line is minimized by feedback through V22 to control tube V20.

Constant-voltage transformer T3 supplies filament power to frequency-determining circuits and V22 in the power supply.

Crystal oven power (T5) is not controlled by POWER switch S4. The crystal ovens operate continuously whenever the instrument is connected to a power line.

TABLE 4-1. RECOMMENDED TEST EQUIPMENT FOR COMPLETE MAINTENANCE

Description	Example
Electronic Voltmeter	ⓗⓟ Model 410B
Sensitive AC Voltmeter	ⓗⓟ Model 400D or 403A
Oscilloscope	ⓗⓟ Model 150A or 160B
Low-Distortion Audio Oscillator	ⓗⓟ Model 206A
Distortion Analyzer	ⓗⓟ Model 330C
High-Frequency Electronic Counter (optional)	ⓗⓟ Model 524B/C/D with 525A (if M.O. is below 25 mc) or 525B (if M.O. is above 25 mc)

SECTION IV
MAINTENANCE

4-1 INTRODUCTION

Maintenance information of a general nature is discussed in paragraphs 4-1 through 4-6. Calibration and circuit adjustments are covered in paragraphs 4-7 through 4-14. Refer to Figures 4-4 through 4-7 for physical location of components.

All normal maintenance can be done while the instrument is mounted in the rack. Removing the four cap nuts on the panel allows the instrument to slide out of the rack for inspection. The chassis may be tipped up approximately 60^{o} for access to components on the bottom. The fan connector and leads connected to TB201 at the rear of the instrument must be removed before the instrument can be tipped fully. After the chassis is in position the cables may be reconnected.

If the instrument fails to operate with the power switch turned on, check both fuse F1 on the panel and the thermal cutout located inside the instrument. Crystal oven heater circuits are fused only by F2 located on the back of the instrument.

The thermal cutout opens the main power circuit to protect the instrument when the temperature inside the cabinet reaches 130^{o}F. To restore power proceed as follows:

1) Remove cause of overheating (check fan operation and rack temperature).

2) Press the RESET button on the thermal cutout (see Figure 4-4).

4-2 METER LAMP REPLACEMENT

The two lamps that illuminate each meter may be replaced by removing the two screws on the front of the meter and pulling the meter case away from the control panel. The lamps inside of the meter case may then be removed and replaced with new lamps. Replace the meter case on the control panel and install the two mounting screws.

4-3 REMOVING INSTRUMENT FROM RACK

If it becomes necessary to remove the instrument from the rack proceed as follows:

1) Remove the four cap nuts on the panel.

2) Disconnect all wires and cables at the back of the instrument.

3) Slide the instrument out of the rack as far as possible.

4) Grasp the instrument firmly, press the catches in the chassis rails, and withdraw the instrument from the rack.

5) Reverse the above procedure to replace the instrument in the rack.

Restore power to the instrument as soon as possible after removing it from the rack to maintain constant crystal oven temperature to avoid the necessity of retuning the master oscillator.

4-4 TROUBLESHOOTING

In case of complete failure of the monitor, be sure to check the fuse, located on the front panel, and the thermal cutout switch located inside the instrument.

Usually malfunctions occur in either the visual or aural circuits. Use the troubleshooting aids, Figure 4-1 and Table 4-2, to assist in locating troubles in these circuits.

Service time can be saved if 1) the frequencies of the monitor master oscillator, the visual transmitter, and the aural transmitter are accurately known; and 2) all front panel meter indications are evaluated for each position of the function selector switch.

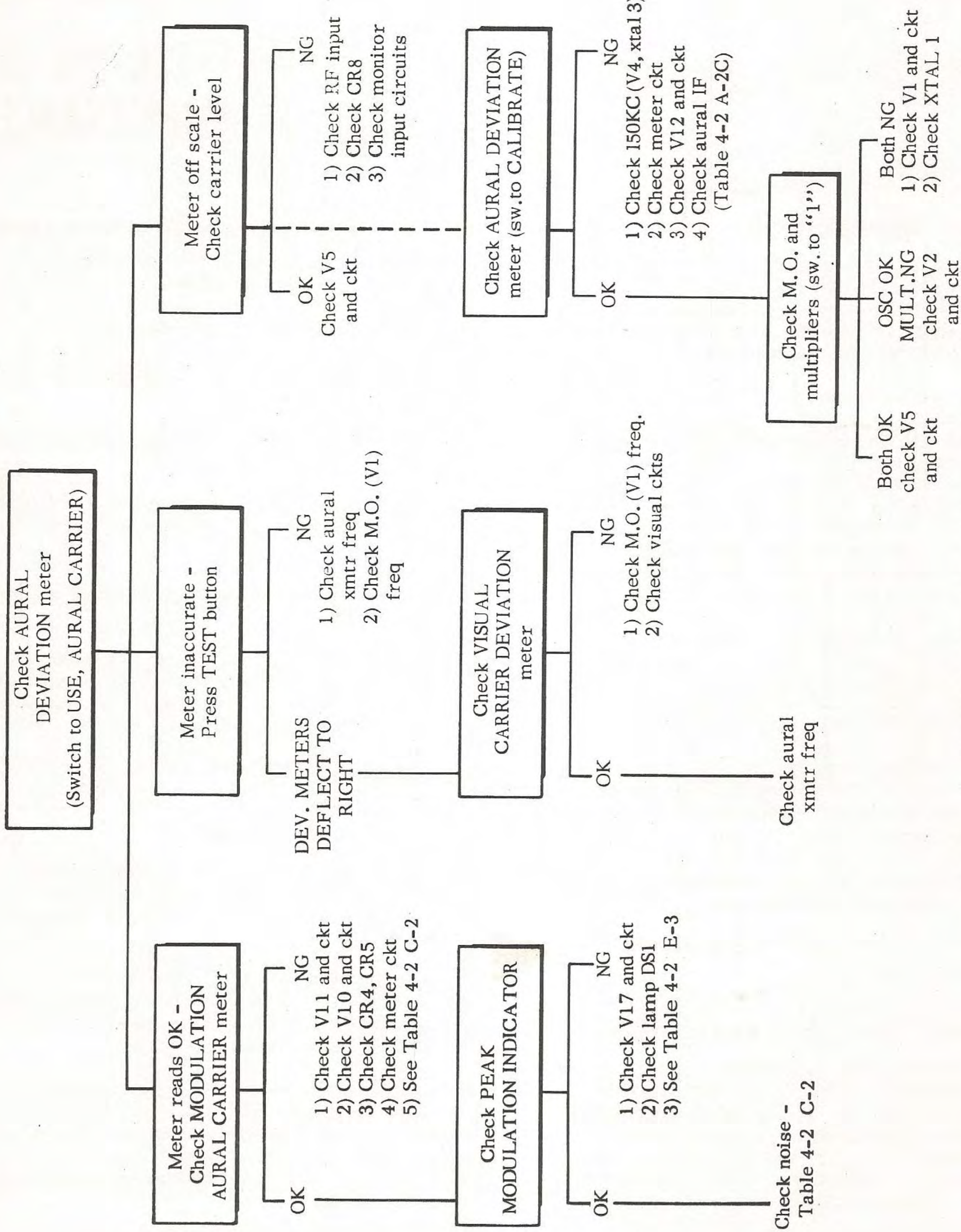


Figure 4-1. Troubleshooting Chart - Aural Circuits

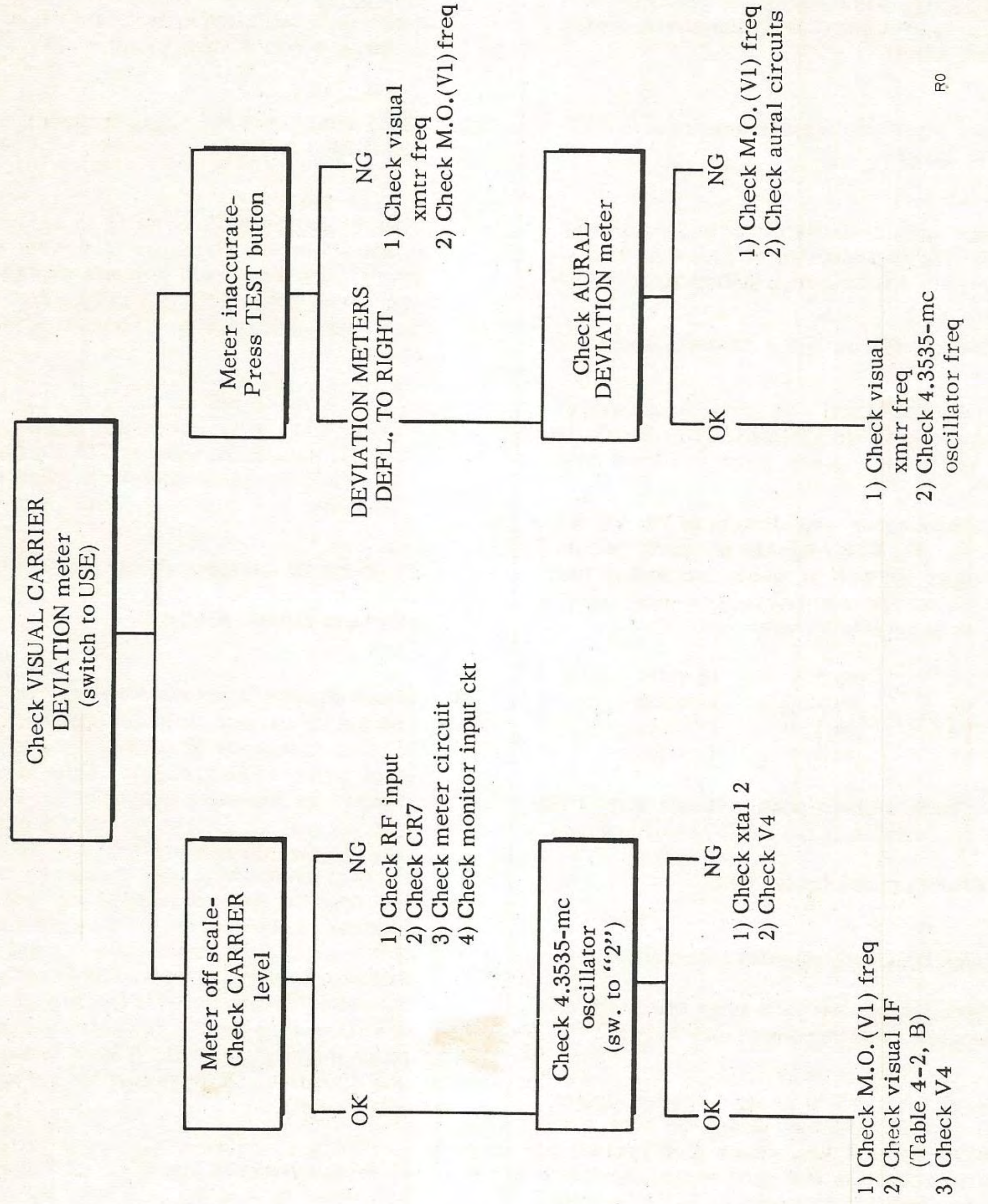


Figure 4-1. Troubleshooting Chart (Cont'd) Visual Circuits

TABLE 4-2. TROUBLESHOOTING

A. Symptoms: Visual deviation meter indicating properly; aural deviation meter erratic or off scale.

1. Check input from aural transmitter in CARRIER LEVEL.

2. Check aural deviation meter in CALIBRATE, DEVIATION switch in AURAL CARRIER--it should indicate zero deviation; if it does not:

   a) Check B+ on aural chassis, should be +300 volts.

   b) Observe signal with oscilloscope at pin 6 (plate), V7 in CALIBRATE. Should be 150 kc sine wave, over five volts rms.

   c) Check tubes and circuits of V4, V6, V7, V8, V9, V12. Waveform should become more square at each succeeding tube plate. Approximate peak-to-peak square wave amplitudes are:

V6	pin 1	16 volts
V7	pin 1, 3	15 volts
V8	pin 1, 9	16 volts
V9	pin 1, 9	42 volts

   These peak-to-peak voltages should be approximately the same in USE position.

   d) Check crystal bridge CR3.

3. Check frequency of aural transmitter.

4. Check frequencies of master oscillator and visual transmitter--both may be off.

5. Check level of 150 kc signal at pin 6 (plate), V7 in USE position; should be over three volts rms. If low, check grid current of aural mixer, as indicated on aural deviation meter with function selector in "1"--should indicate between +1 and +3 kc. If too low, check V2 and V5, tuning of C113 and C135 (adjustments 12 and 13).

* * * * * * *

B. Symptoms: Aural deviation meter indicating properly; modulation meter working; visual deviation meter erratic or off scale.

1. Check input level from visual transmitter in CARRIER LEVEL.

2. Connect audio oscillator to J1 as described in adjustment 8. Check calibration and sensitivity; meter should indicate accurately with input levels of 1 volt to 10 volts rms. If it does not operate correctly at these levels:

   a) Check tubes and circuits of V13, V14, V15, V16. With a one-volt, 3.5-kc input at J1, the square wave at V15 pins 1 and 9 should be approximately 48 volts peak-to-peak.

   b) Check B+ voltage, should be 300 volts.

   c) Check crystal bridge CR6.

3. Check signal at output of V4 mixer with oscilloscope to see if it is approximately correct frequency (2 to 5 kc) and proper level (over 1 volt rms). This may be checked by inserting a phone plug into J1 just far enough so that the tip of the phone plug touches the center contact of the jack, but not far enough to open the circuit. Connect oscilloscope across phone plug. In addition to the desired 3.5 kc signal, much of the modulation on the visual transmitter will also be seen. It will simplify analyzing the observed pattern if this test is performed at a time when the visual transmitter modulation may be removed. If level is too low, see step B-4. If frequency is wrong, see step B-5.

4. If level of output signal of V4 mixer, as measured in step B-3, is low, check grid current of visual mixer, V3, as indicated in "1". Visual deviation meter should indicate +1 and +3 kc with no rf input from the transmitter. If low, check V2 and V3, tuning of C113 and C116 (paragraph 4-13).

TABLE 4-2. TROUBLESHOOTING (CONT'D)

B. Cont'd

If V3 mixer grid current is correct, switch function selector to "2". The visual deviation meter indicates 4.3535-mc oscillator operation; meter should read between +1 and +3 kc. If it does not, check V4.

5. If frequency of output signal of V4 mixer in step 3 is not between 2 kc and 5 kc:

   a) Check frequency of visual transmitter.

   b) Check frequency of master oscillator (paragraph 4-12) and aural transmitter-- both could be off.

   c) Check frequency of 4.3535-mc oscillator (paragraph 4-14).

* * *

C. Symptoms: Aural deviation meter indicating properly; modulation meter erratic, reads high with no modulation; high noise in audio output at rear terminal strip.

1. Check rf input in CARRIER LEVEL position, should indicate between +1 and +3 kc on aural deviation meter.

2. Check noise at audio output, by following procedure described in paragraph 4-8A. Noise should be less than .0056 volts rms. If not, check:

   a) Check B+ voltage, should be +300; check hum on regulated voltage, should be less than .003 volt with no rf input to monitor.

   b) 150-kc signal level at pin 6 (plate) of V7 in CALIBRATE. Should be at least five volts rms.

   c) Check squaring operation of limiter tubes as described in troubleshooting step A-2. Proper limiting operation is essential for noise performance. Check limiting in both CALIBRATE position and USE position with no modulation on aural transmitter.

* * *

D. Symptoms: Audio output voltage normal; modulation meter not functioning.

1. Check V11 tube and circuit.

2. Check diode CR4.

* * *

E. Symptoms: Modulation meter operating normally; peak modulation indicator not operating.

1. Check diode CR14.
2. Check tube V17.
3. Check lamp DS1.
4. Check dc voltage at pin 1 of V17. Should be approximately 10 volts for 10% modulation.

* * *

F. Symptoms: Temperature of master oscillator crystal oven (as indicated on thermometer) too low.

1. Check fuse F2 on rear of chassis.
2. Check tube V18.
3. Check voltage across C303.
4. Check mercury thermostat in crystal oven. See paragraph 4-6.
5. Check thermometer.

* * *

G. Symptoms: Temperature of master oscillator crystal oven too hot.

1. Check REL-1 to see if it is stuck in energized position.

2. Check mercury thermostat in crystal oven. See paragraph 4-6.

* * *

H. Symptoms: Crystal oven temperature normal but instrument dead.

1. Check main power fuse on panel.

2. Check thermal cutout, may need to be reset. Check fan if cutout has tripped.

* * *

4-5 TUBE REPLACEMENT

Whenever a tube is replaced, consult Table 4-3 to determine whether or not the characteristics of the replacement tube will necessitate circuit adjustments. The procedure for performing these adjustments is given in the paragraphs listed under "Required Adjustment".

A tube tester can be used to find tubes which may fail in the near future. Proceed as follows:

1) Check tube using normal filament voltage.

TABLE 4-3. TUBE REPLACEMENT

Tube	Function	Required Adjustment
V1	Master Oscillator	4-12
V2	Multiplier	4-13
V3	Multiplier/Mixer	4-13
V4	Oscillator/Mixer	None
V5	Multiplier/Mixer	4-13
V6 V7 V8	Amplifier Amplifier Amplifier	None
V9	Switching Tube	4-9
V10 V11	Amplifier Cathode Follower	4-8
V12	Current Regulator	4-9
V13 V14	Amplifier Amplifier	None
V15 V16	Switching Tube Current Regulator	4-11
V17	Thyratron	4-10
V18	Oven Control	None
V19 V20 V21 V22	Voltage Regulator Control Amplifier Voltage Reference Amplifier	4-7

2) If the tube checks good, repeat the test using the next lower filament voltage than that normally required by the tube (e.g. 5 volts for 6.3 filaments).

3) If the reading does not change significantly, the tube may be considered good.

4) If the reading shows considerably poorer performance than the first check, a weak tube <u>may</u> be indicated. Repeat the test with a new tube. If its characteristics are also poor at low filament voltage, the test is not valid for that particular tube type. If new-tube characteristics remain about the same at normal and low filament voltage, the original tube is likely to fail and should be replaced.

4-6 OVEN MAINTENANCE

The temperature of the master oscillator crystal oven is regulated by a mercury-column thermostat which closes when the oven reaches operating temperature. This thermostat is connected in the control grid circuit of tube V18. When the thermostat closes, V18 is biased to cut-off, de-energizing the plate relay which disconnects oven heater power. The reverse occurs when the oven temperature drops to the point at which the thermostat opens. Note that tube V18 must be conducting and the relay energized for the oven to heat. Therefore normal failures of the tube and relay will not cause the oven to overheat. As further protection against high temperatures, a bi-metallic thermostat inside the crystal oven is in series with the heater winding. It is normally closed, but opens at about 75° C, ten degrees above normal operating temperature.

After the instrument is connected to the power line for approximately thirty minutes, the crystal oven remains at a constant temperature. The thermometer should indicate 60° C to 70° C (inside green sector). However, if the temperature goes above 70°C (outside green sector), the mercury column has probably separated: Remove crystal oven top and check mercury thermostat. If the crystal oven does not heat, check fuse F2, tube V18, and relay REL-1.

A. OVEN DISASSEMBLY

To disassemble the crystal oven, refer to Figure 4-2 and proceed as follows:

1) Disconnect power cord to remove power from crystal oven.

2) Remove front panel thermometer.

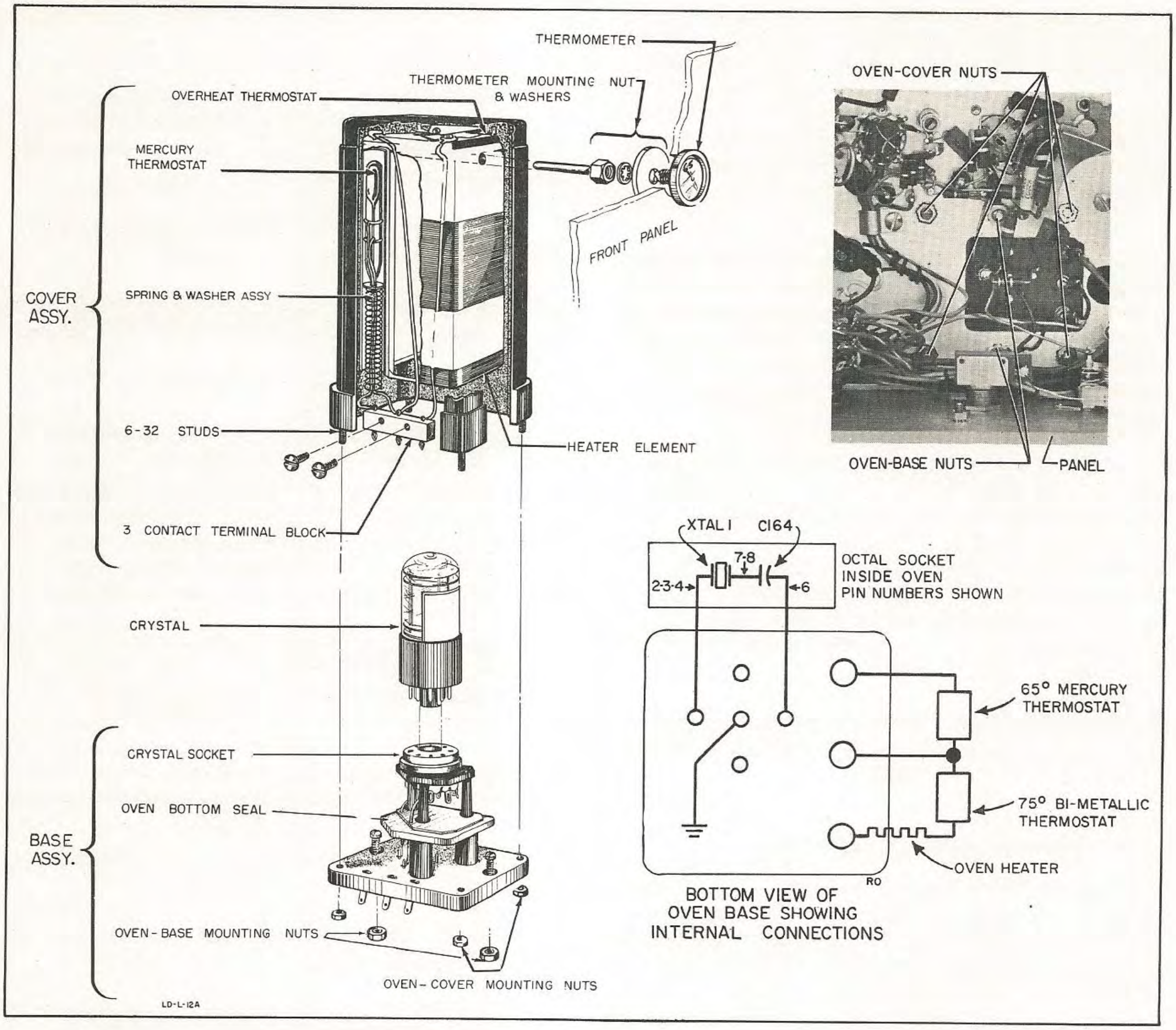


Figure 4-2. Crystal Oven Maintenance

3) Remove four 6-32 nuts which hold corners of oven top. Do not loosen the two base-mounting nuts at the sides of the oven base.

4) Lift off oven top.

B. THERMOSTAT CHECK

To check the mercury thermostat proceed as follows:

1) Remove the two 6-32 screws which hold the three contact terminal block on the oven top.

2) Remove the mercury thermostat by pulling gently and steadily on the lead wires.

3) Remove insulating tape and inspect the thermostat for mercury column separation and minute gas bubbles in the mercury bulb.

4) If either bubbles or separation are present, place the mercury bulb in ice water until the mercury occupies only the bulb compartment. Tap lightly to remove any bubbles or mercury globules left in the column. Then place the bulb in a container of water and heat until mercury completely fills the

column and a small portion of the enlargement at the top of the column. Then remove the thermostat and watch the mercury descend to room temperature. If there is no separation or bubble present, the thermostat may now be put back in service. It may be necessary to repeat the above procedure more than once to unite all the mercury and remove all bubbles.

CAUTION

Immerse only the bulb portion of the thermostat. If the thermostat leads get wet or any moisture collects beneath the plastic insulation covering the contact rings, dry the tube and leads thoroughly before placing back in service. Otherwise leakage between leads may cause the heater relay to remain open.

- - - - -

5) The thermostat should be tested with an ohmmeter as a final check. Connect an ohmmeter to the thermostat leads and heat the mercury bulb. A 100-watt lamp is a handy heat source for this check. The ohmmeter should first show an open circuit and then a short circuit when the mercury column reaches the second contact. The contacts are beneath the rings on the glass tube of the thermostat.

Re-assemble oven. It will be necessary to check the master oscillator frequency after 24 hour warm-up.

4-7 POWER SUPPLY CHECK

Operate the 335E from a variable-voltage transformer equipped with an accurate ac voltmeter. Adjust the line voltage to 115 volts. Adjust R316 on the back of the instrument for +300 volts between the B+ line and ground. This voltage should be constant in any position of the function-selector switch. Slowly vary the supply voltage from 103 volts to 127 volts. The dc voltage should not vary more than 2 volts. If the dc voltage rises at low line voltage, try a new V20. If the voltage drops at low line voltage, try a new V19.

Connect an ac electronic voltmeter such as the ⓗⓟ Model 400D to the regulated 300-volt line using short twisted leads. Measure the ac ripple voltage. The ripple should be less than 0.003 volts over a line voltage range of 103 and 127 volts. If the ripple is high, try a new V22, V20, V19 or V21 in that order. If changing a tube makes no improvement, return original tube to its socket. It may be necessary to try several tubes to find one that meets all requirements. Always check and reset the +300-volt line after changing tubes.

4-8 AUDIO AMPLIFIER CHECK

A. HUM ADJUST

Audio amplifier hum may be minimized using the following procedure. Remember that hum may be accidentally introduced into the equipment through external ground loops.

1) Remove optional link between terminals 3 and 4 of TB201 on the rear of the chassis.

2) Connect high-impedance ac voltmeter, such as an ⓗⓟ Model 400D, to terminals 4 and 5 of TB201.

3) Set function selector switch to CALIBRATE.

4) Adjust R301, located at the rear of the instrument, for minimum meter indication. Hum and noise level should be less than 5.6 millivolts (if not, try new V10 and V11). Note: Function selector switch must be in CALIBRATE position when hum adjustment is made. Operate MODULATION POLARITY switch between + and - during this adjustment.

B. DISTORTION CHECK

Proceed as follows to check audio amplifier distortion:

1) Disconnect spade-lug leads (2) from TB202, located at the lower-right-front side of the chassis.

2) Connect terminal of TB202 with grey lead to ground.

3) Connect 5000-ohm resistor to terminal of TB202 with orange lead.

4) Connect low distortion audio oscillator, such as an ⓗⓟ Model 206A, between other end of resistor and ground. Note: Any distortion originating in this oscillator affects the distortion measured in step 8.

5) Connect distortion analyzer, such as an ⓗⓟ Model 330C, between terminals 4 and 5 of TB201 on the rear of the chassis. Optional link between terminals 3 and 4 of TB201 should be removed.

6) Set function selector switch to USE position.

7) Set audio oscillator voltage for a reading of 100% on MODULATION AURAL CARRIER meter. Normally about one volt output from the oscillator is required for an indication of 100% modulation.

8) Measure distortion according to instructions supplied with distortion analyzer. Distortion should be less than 0.25%. Try replacing V10 and V11 to reduce distortion. Remember to adjust R301 for minimum hum when these tubes are replaced.

4-9 AURAL CALIBRATION

Ordinarily, adjustment of the "C" and "D" controls, described in Figure 2-1 number 15, is all that is required for aural circuit calibration. If the "D" control cannot be adjusted properly, a more extensive calibration procedure is required.

If circuit failure is suspected check power supply, then try replacing tubes V9, V10, V11, and V12.

The following calibration procedure describes how to adjust the aural transmitter to a definite modulation percentage for precise calibration of aural monitoring circuits. An oscilloscope with triggered sweep and an audio oscillator are required.

1) Connect oscilloscope vertical input to terminal 6 on TB201. With no modulation on the aural transmitter, the oscilloscope will display a series of 150-kc pulses, similar to the waveform shown in Figure 4-3A. Adjust the oscilloscope sweep circuits to trigger on the steep negative portion of the waveform.

2) Connect the audio oscillator to the aural transmitter input and set the oscillator to any frequency between 100 and 1000 cps.

3) Gradually apply audio to the transmitter (DO NOT use a step attenuator) until the MODULATION AURAL CARRIER meter indicates approximately 30%. Blurring of the oscilloscope pattern is due to frequency modulation of the 150-kc pulses. Adjust the oscilloscope sweep vernier control until uniform blurring occurs and there are no distinct pulses after the start of the sweep.

4) Increase modulation slowly until the third and fourth pulses just overlap producing a bright pulse as shown in Figure 4-3B. True modulation percentage now is 86%.

5) With the function selector switch in the USE position adjust the "D" control on the panel until the modulation meter indicates 86%. If the "D" control has insufficient range, center the control and adjust the value of R285 by trial until the "D" control can properly adjust the modulation meter.

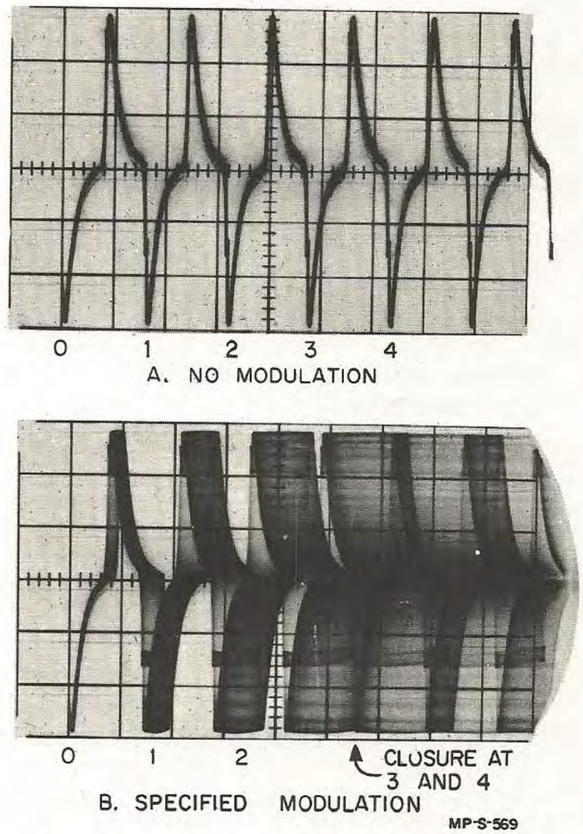


Figure 4-3. Waveforms for Modulation Adjustment

6) Switch to CALIBRATE and set R245 for a MODULATION AURAL CARRIER meter indication of 100%. Calibration is now complete. Steps 7 through 9 may be used to check meter calibration at another modulation frequency.

7) Change audio oscillator to 14 kc.

8) Reduce transmitter modulation and repeat step 3.

9) Slowly increase modulation to produce an overlap between the third and fourth oscilloscope pulses as in step 4. True modulation percentage is now 103%.

4-10 PEAK MODULATION INDICATOR

Proceed as follows to set the flashing point of the PEAK MODULATION INDICATOR lamp:

1) Modulate transmitter with steady audio tone.

2) Loosen the setscrews in the 50% - 100% knob.

3) Slip the knob so that its reading agrees with that of the MODULATION AURAL CARRIER meter.

4-11 VISUAL AND INTERCARRIER CALIBRATION

Complete instructions for calibrating visual circuits ("A" and "B" controls) are given in Figure 2-1, number 9. After aural (paragraph 4-9) and visual circuits are calibrated, adjust the intercarrier deviation control as follows:

1) Connect audio oscillator to J1 on the front panel.

2) Set function selector switch to CALIBRATE, DEVIATION switch to AURAL CARRIER position. With audio oscillator set to 3500 cps, both deviation meters should read zero, indicating proper adjustment of the "A", "B", "C" and "D" controls.

3) Change DEVIATION switch to INTER-CARRIER. Change oscillator output to 4500 cps.

4) Adjust R294, located on the left-hand vertical chassis, for equal but opposite deflection of the deviation meters. The VISUAL CARRIER DEVIATION meter should indicate about +1 kc and the AURAL DEVIATION meter should indicate about -1 kc.

4-12 MASTER OSCILLATOR ADJUSTMENT

Master oscillator frequency adjustment may be made indirectly, using monitoring service reports, as described in paragraph 2-3. Oscillator frequency may also be adjusted directly using an accurate electronic counter, such as an hp Model 524B/C/D with a Model 525A or B. A harmonic of the master oscillator, the output of multiplier V3, may be conveniently sampled at the VISUAL RF INPUT connector at the rear of the instrument.

If the CRYSTAL TUNING control (C102) has insufficient range to adjust master oscillator frequency, set C102 to mid-position and adjust C104 to set the oscillator on frequency.

Inductor L20 seldom requires adjustment. It should be adjusted, with R157 shorted, to give maximum indication on the AURAL DEVIATION meter with the function selector switch set to "2".

4-13 MULTIPLIER/MIXER TUNING

C113: This capacitor resonates with inductor L2 to select the desired harmonic multiplication in V2. It may be necessary to adjust C113 when replacing V2. Adjust C113 for maximum indication on either deviation meter in the "1" position of the function selector switch. If V2 is operating as a doubler, correct tuning will also be indicated by a dip on the MODULATION AURAL CARRIER meter. Since it may be possible to adjust C113 far enough to obtain the wrong harmonic, minimum adjustment should be made. This circuit should be tuned to the frequency indicated for V2 on the label attached to the instrument.

C135: This capacitor resonates with L9 for proper operation of the aural multiplier and mixer (V5). Adjust for maximum indication on the AURAL DEVIATION meter with the function selector switch set to "1". This circuit should be tuned to the frequency indicated for V5 on the label attached to the instrument.

C116: This capacitor resonates with L3 proper operation of the visual multiplier and mixer (V3). Adjust for maximum indication on the VISUAL DEVIATION meter in the "1" position of the function selector switch. This circuit should be tuned to the frequency indicated for V3 on the label attached to the instrument.

L6: This inductance resonates at 4.35 mc with the output capacity of V3 and the input capacity of V4. This control will seldom need to be adjusted. It is adjusted in the USE position of the function selector switch with the visual transmitter rf input connected. Connect an oscilloscope to pin 2 of V14, and adjust L6 for maximum 3.5-kc signal.

C143: This variable capacitor injects a certain amount of the rf input signal on the mixer grid of V3. This provides greater conversion gain for the higher rf input frequencies. In instruments on channel 2 to 13, it will have little effect. It may be necessary to readjust C143 when changing V3. Adjust C143 in the USE position with the visual transmitter input connected. With an oscilloscope connected to pin 2 of V14, adjust C143 for maximum 3.5-kc signal.

4-14 4.3535-MC OSCILLATOR ADJUSTMENT

The frequency of the 4.3535-mc oscillator is easily adjusted indirectly using monitoring service reports. While in contact with the monitoring service, first tune the master oscillator correctly (so that AURAL DEVIATION meter agrees with monitoring report). Then adjust C145 to set the VISUAL CARRIER DEVIATION meter to agree with the monitoring report.

The oscillator may be adjusted directly by connecting an accurate electronic counter to the body of R125 (cathode resistor of V4). Adjust C145 for an indication of 4.3535 mc on the counter.

Inductor L8 in the plate circuit of V4 should only need adjustment if the 4.3535-mc crystal is replaced. With the function selector switch in the "2" position, adjust L8 for maximum indication on the VISUAL CARRIER DEVIATION meter, then turn adjusting screw counterclockwise until meter indication drops to about 80% of maximum. Re-adjust C145 after adjusting L8.

4-15 150-KC OSCILLATOR CHECK

In the CALIBRATE position of the function selector switch half of V4 is used as a 150-kc crystal oscillator to calibrate the AURAL DEVIATION meter circuit. There is no frequency adjustment on this oscillator. The frequency may be checked with an electronic counter or other accurate frequency measuring device at terminal 6 on the back of the instrument, while the function selector switch is in the CALIBRATE position. If this frequency is not between 149,950 and 150,050 cycles, the 150-kc crystal should be replaced.

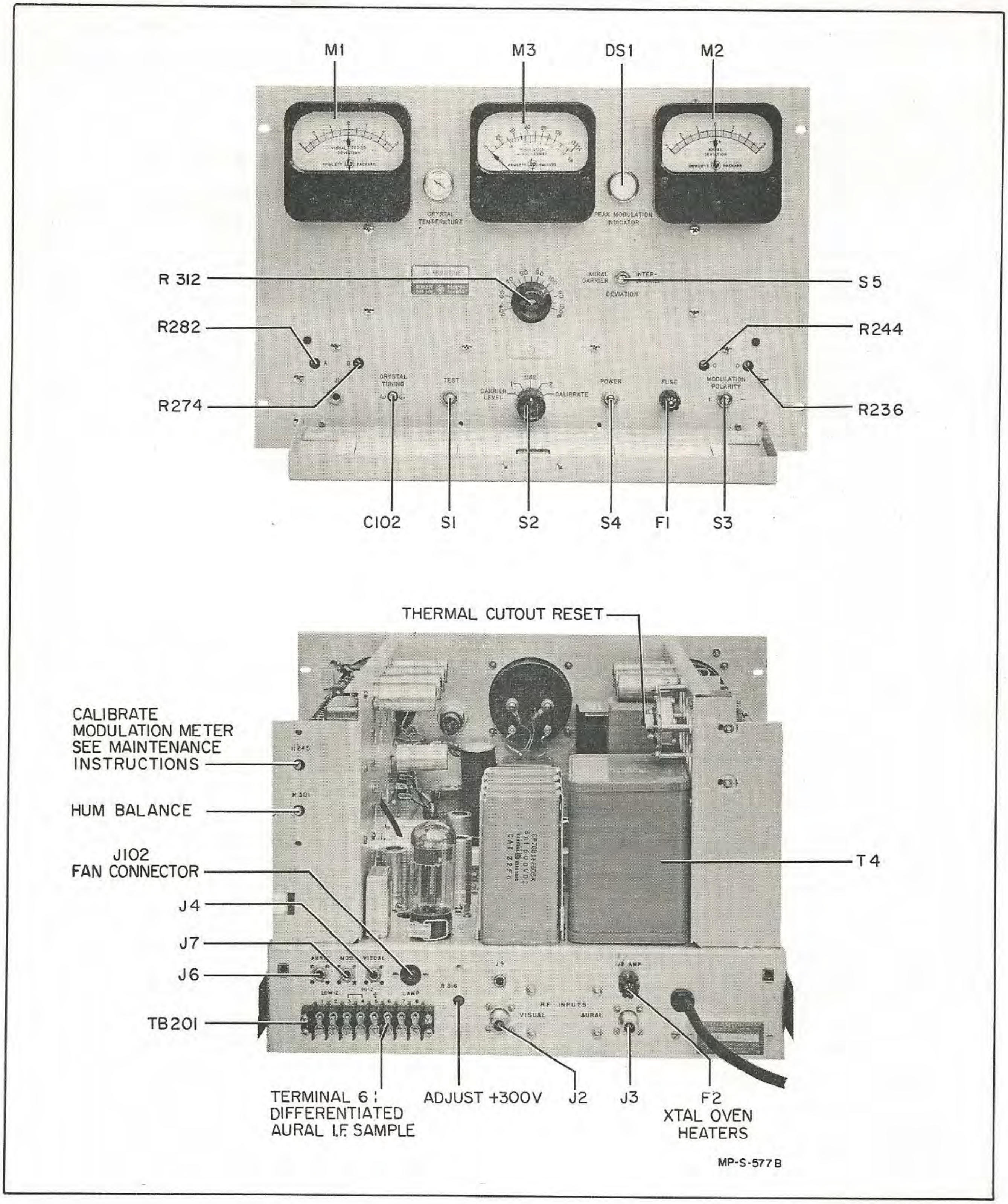


Figure 4-4. Component Location (front and rear)

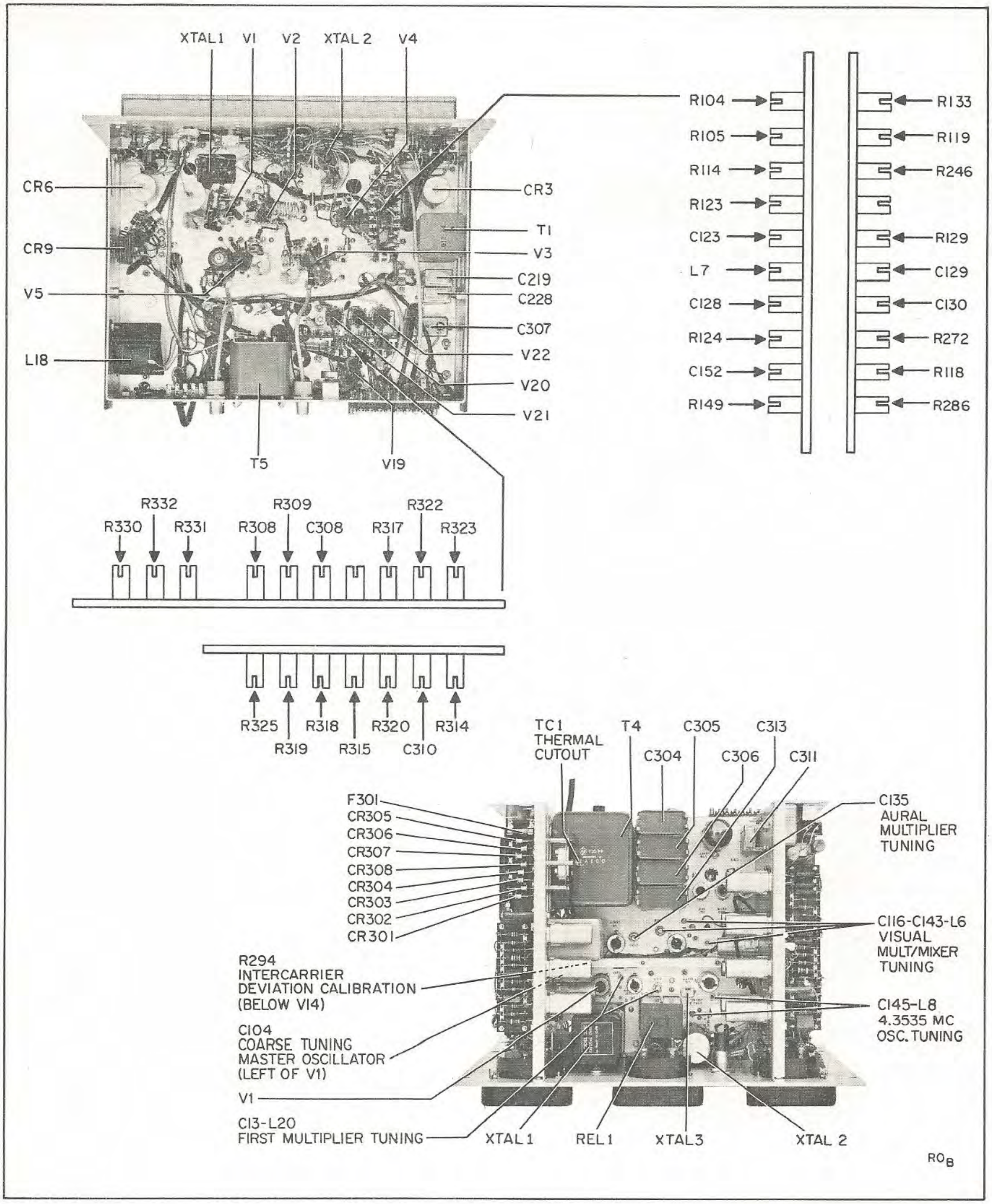


Figure 4-5. Component Location (top and bottom)

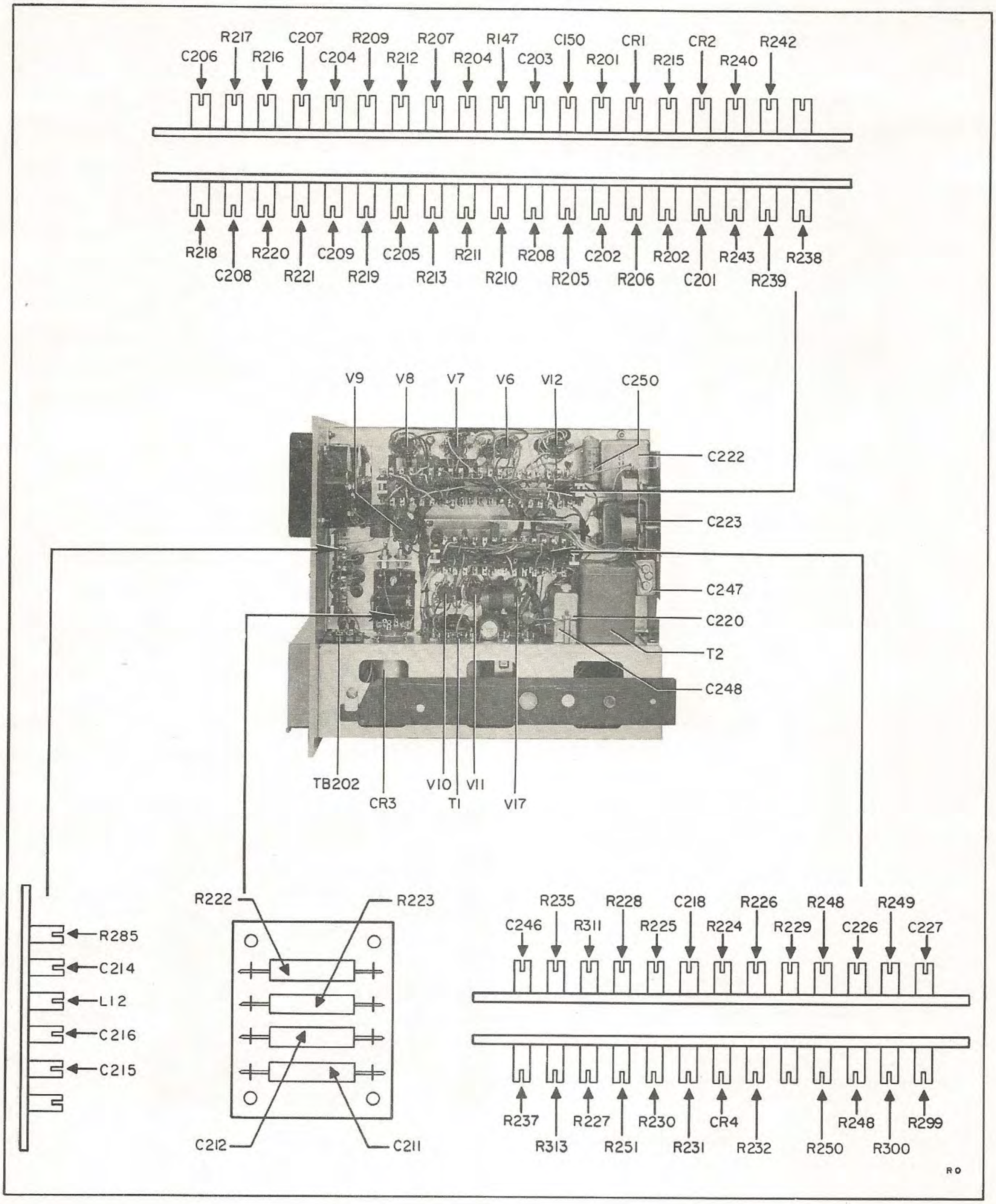


Figure 4-6. Component Location (right side)

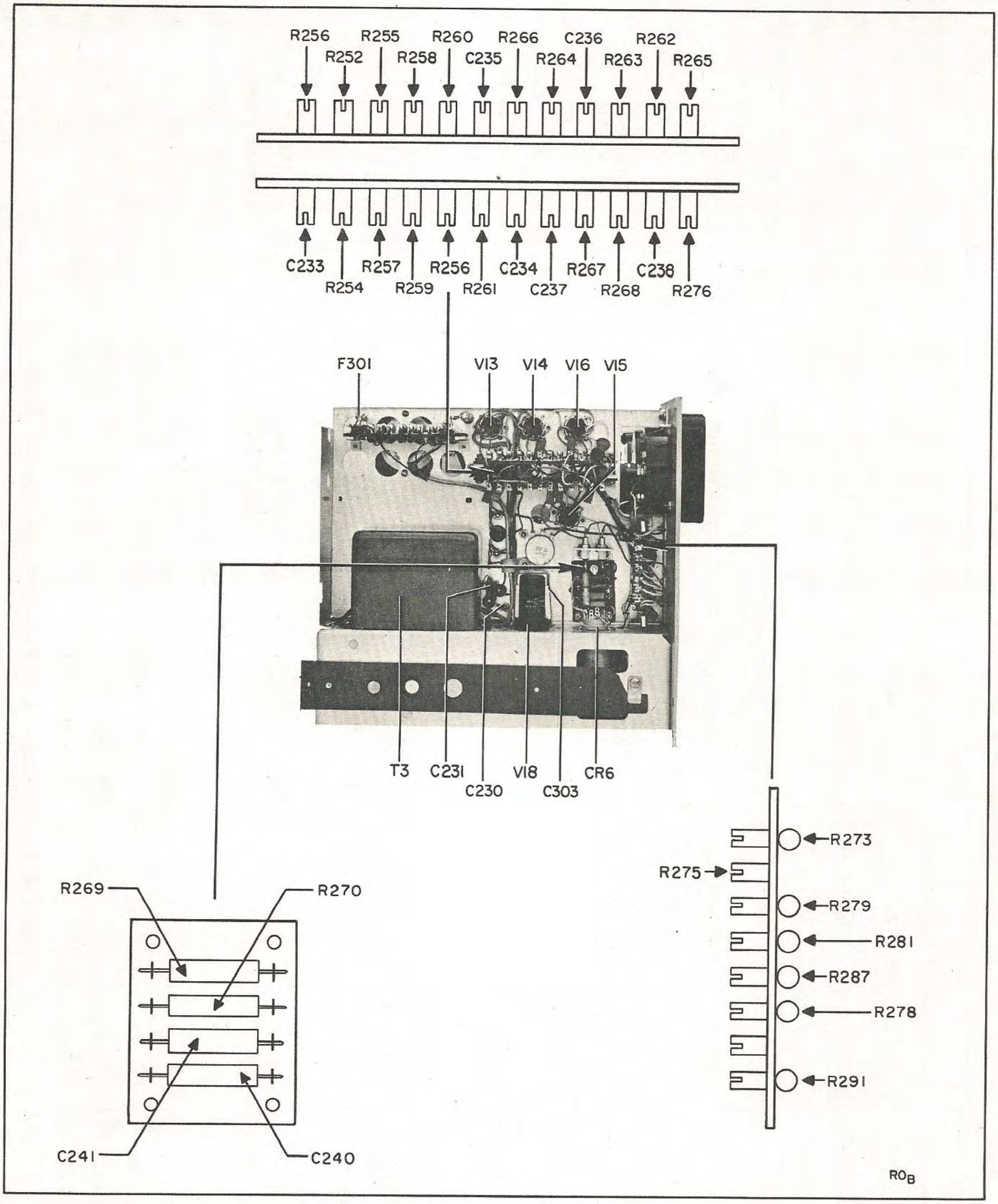


Figure 4-7. Component Location (left side)

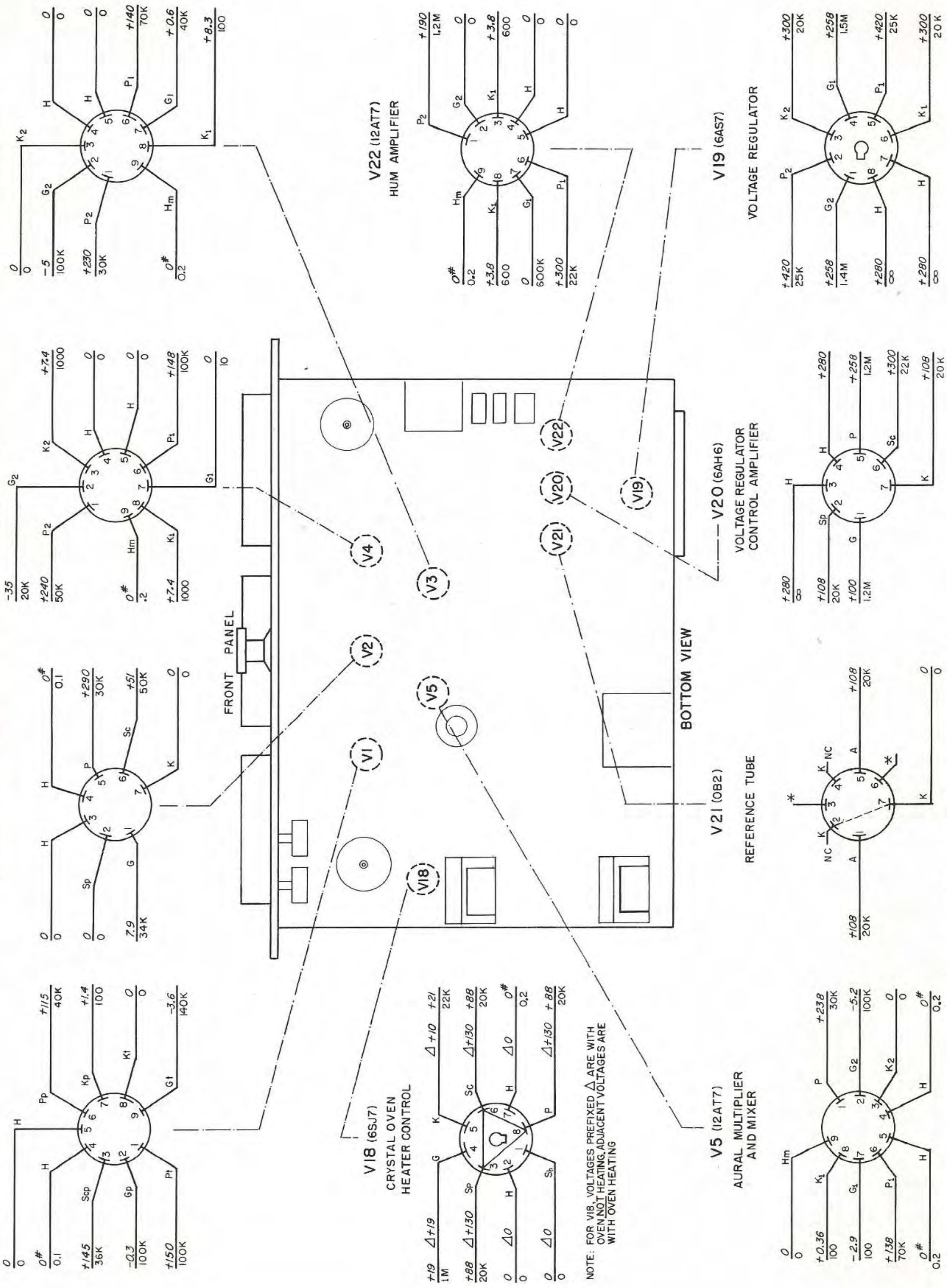
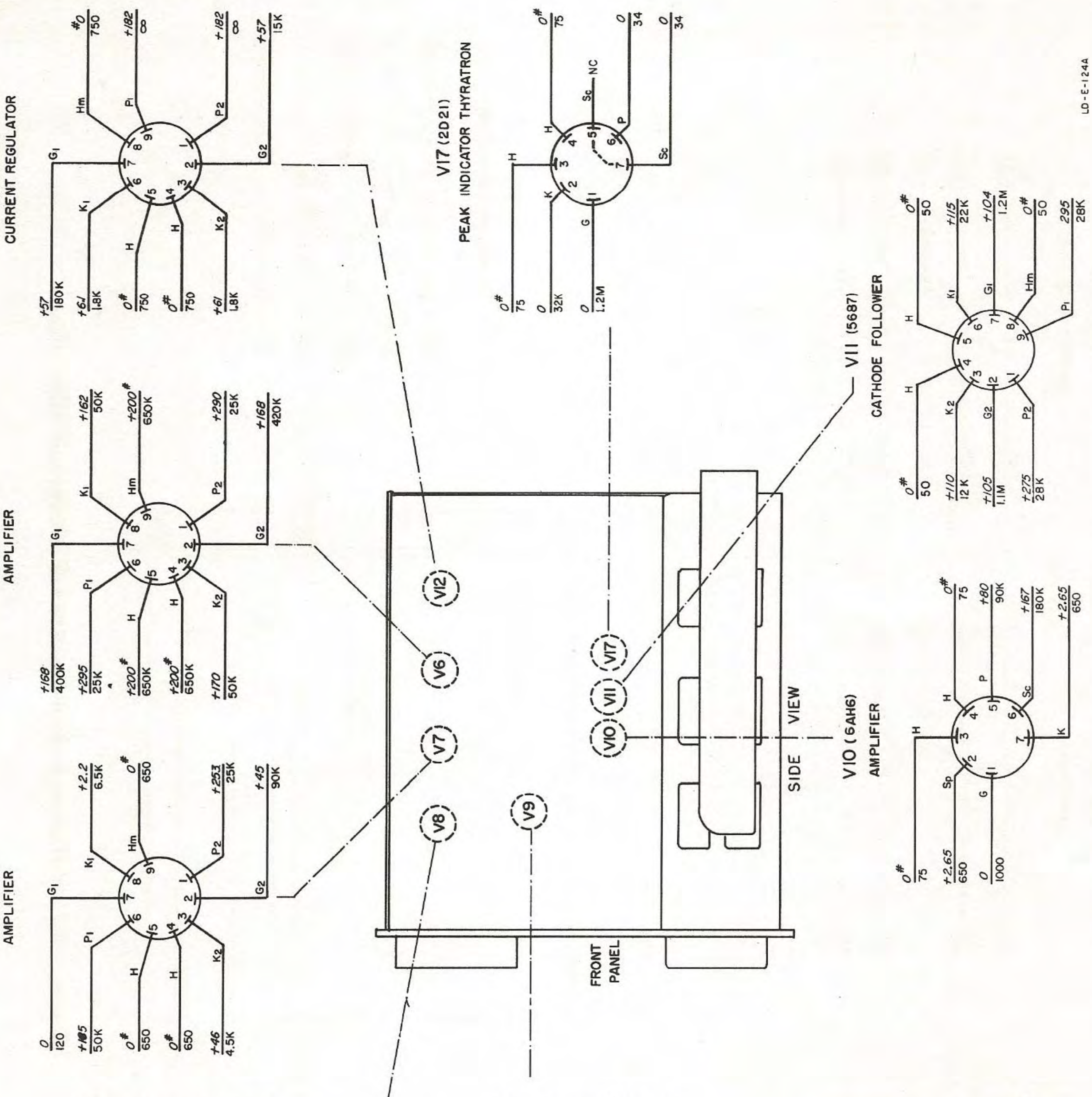


Figure 4-8. Voltage and Resistance Diagram (bottom)



NOTES:

1. FUNCTION SELECTOR SWITCH IN "USE" POSITION.
2. # INDICATES 6.3 VAC IN ADDITION TO ANY DC VOLTAGE SHOWN.
3. SEE POWER SUPPLY SCHEMATIC FOR FILAMENT DETAILS.

Figure 4-9. Voltage and Resistance Diagram (right side)

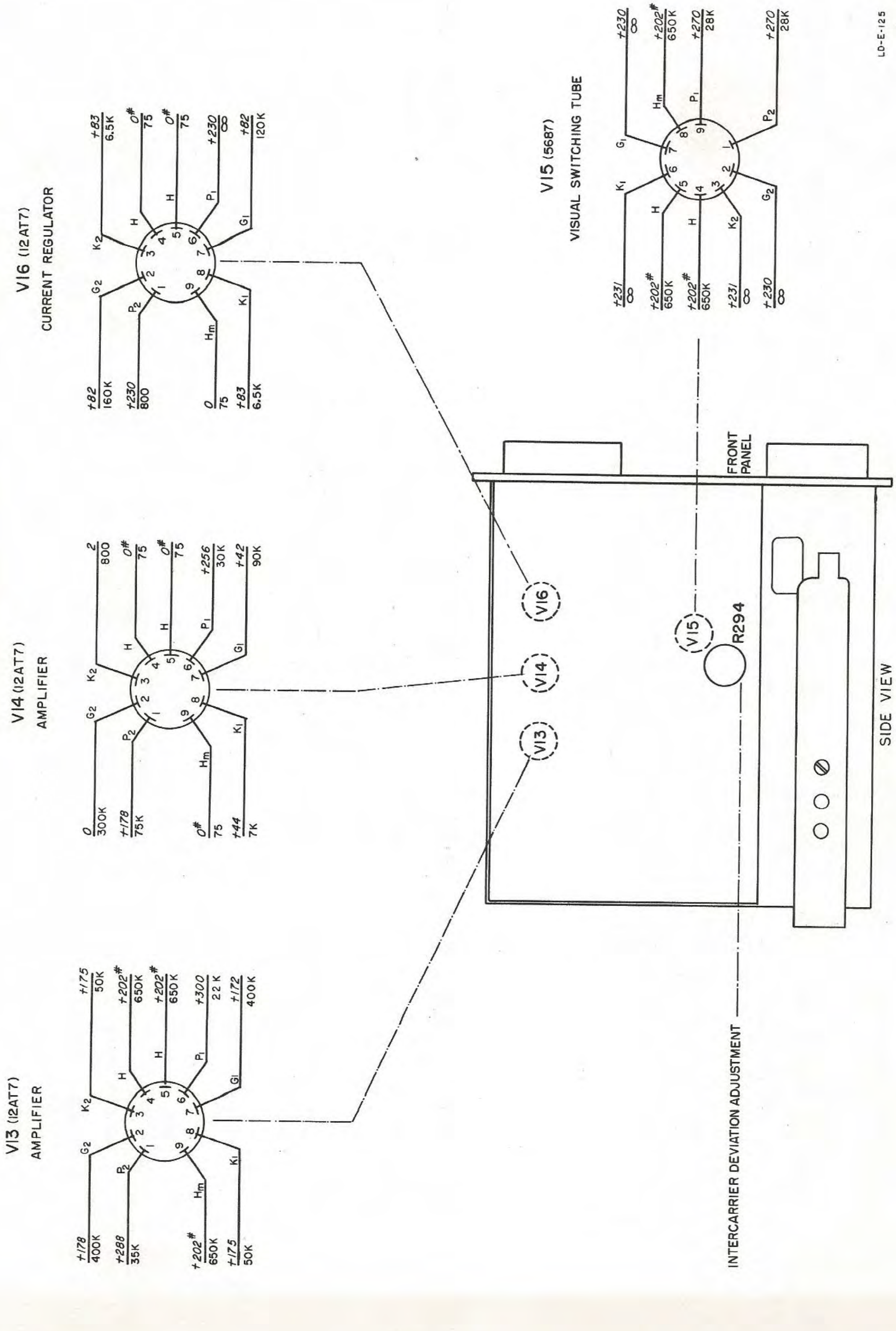


Figure 4-10. Voltage and Resistance Diagram (left side)

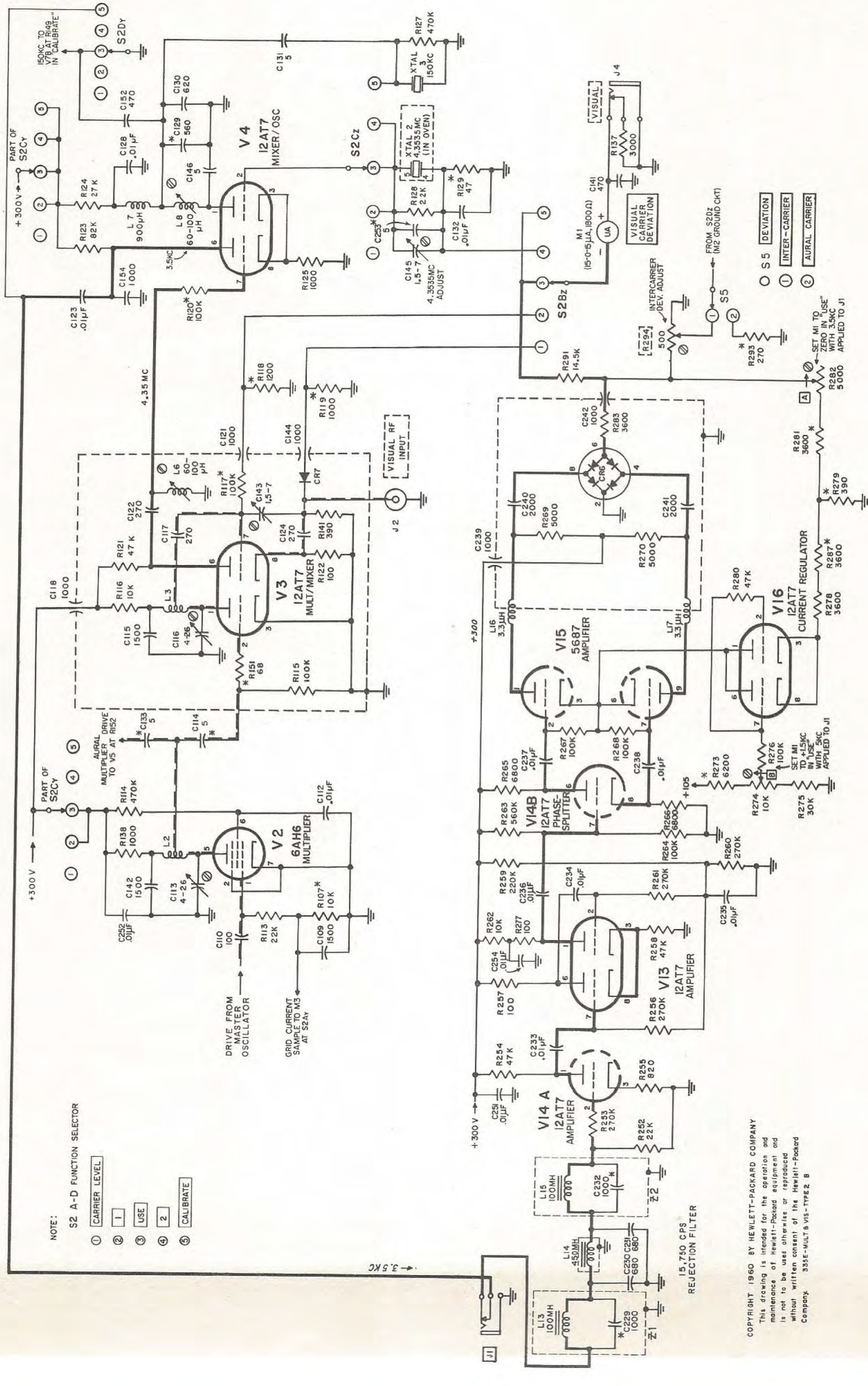


Figure 4-13. Visual Circuits

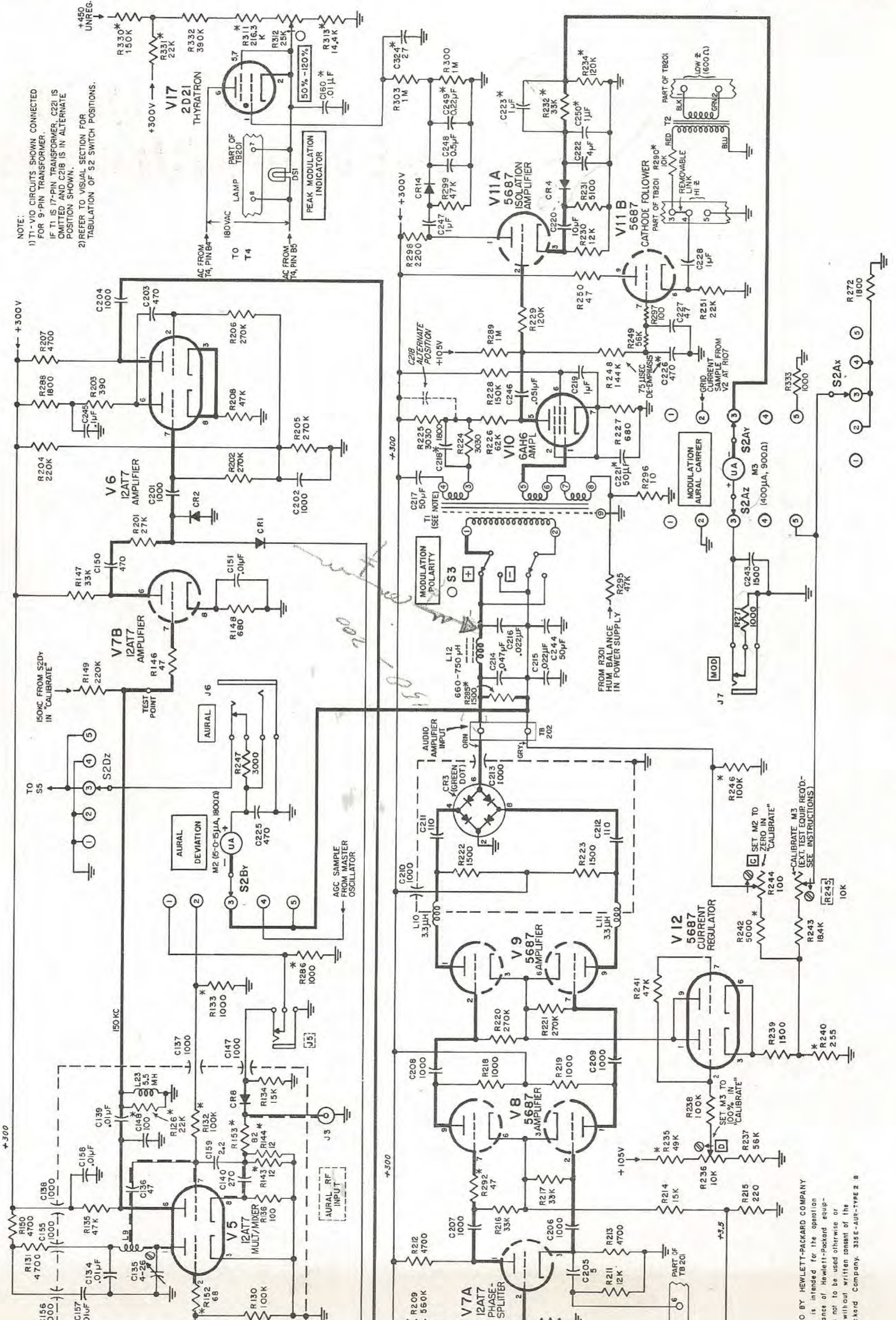


Figure 4-14. Aural Circuits

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Standard components have been used in this instrument, whenever possible. Special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. hp Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed, give complete description, function and location of part.

Corrections to the Table of Replaceable Parts are listed on an Instruction Manual Change sheet at the front of this manual.

RECOMMENDED SPARE PARTS LIST

Column RS in the Table lists the recommended spare parts quantities to maintain one instrument for one year of isolated service. Order complete spare parts kits from the Factory Parts Sales Department. ALWAYS MENTION THE MODEL AND SERIAL NUMBERS OF INSTRUMENTS INVOLVED.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	TQ	RS		
B1	Motor: 1-7/8 in. between mounting stud centers HP*	314-43	1	1		
	Motor: 1-1/2 in. between mounting stud centers (includes exhaust fan) HP*	335E-95J				
C101	Capacitor: variable, ceramic, 1.5-7 $\mu\mu$f, 500 vdcw Optimum value selected at factory L*	13-7	1	1		
C102	Capacitor: variable, air 2.8-11.2 $\mu\mu$f AA*	12-21	1	1		
C103	Not assigned					
C104	Capacitor: variable, air, 3.4-26 $\mu\mu$f AA*	12-9	1	1		
C105	Capacitor: fixed, ceramic, stand-off type, 1500 $\mu\mu$f ±20%, 500 vdcw L*	15-70	6	2		
C106	Capacitor: fixed, ceramic, 33 $\mu\mu$f ±5%, NPO temp. coeff., 600 vdcw L*	15-200	1	1		
C107	Capacitor: fixed, mica, 100 $\mu\mu$f ±10%, 500 vdcw V*	14-73	4	1		
C108, 109	Same as C105					
C110	Same as C107					
C111	Capacitor: fixed, ceramic, 5000 $\mu\mu$f 500 vdcw K*	15-47	5	2		
C112	Capacitor: fixed, ceramic, .01 μf -0% + 100%, 1000 vdcw CC*	15-43	17	4		
C113	Capacitor: variable, air, 3.6-26 $\mu\mu$f AA*	12-10	3	1		
C114	Capacitor: fixed, ceramic, 5 $\mu\mu$f ±0.5%, 500 vdcw Optimum value selected at factory Average value shown	15-29	4	1		
C115	Same as C105					
C116	Same as C113					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		hp STOCK NO.	TQ	RS		
C117	Capacitor: fixed, mica, 270 μμf ±10%, 500 vdcw	V*	14-42	4	1		
C118	Capacitor: fixed, ceramic, feed-thru type, 1000 μμf ±20%, 500 vdcw	L*	15-68	13	3		
C119, 120	Not assigned						
C121	Same as C118						
C122	Same as C117						
C123	Same as C112						
C124	Same as C117						
C125 thru C127	Not assigned						
C128	Capacitor: fixed, mica, .01 μf ±10%, 300 vdcw	V*	14-23	8	2		
C129	Capacitor: fixed, silver mica, 560 μμf ±5%, 500 vdcw Optimum value selected at factory Average value shown	A*	15-11	1	1		
C130	Capacitor: fixed, silver mica, 620 μμf ±5%, 500 vdcw	A*	15-12	1	1		
C131	Same as C114						
C132	Same as C112						
C133	Same as C114						
C134	Same as C112						
C135	Same as C113						
C136	Capacitor: fixed, mica, 47 μμf ±10%, 500 vdcw	V*	14-67	2	1		
C137, 138	Same as C118						
C139	Same as C112						
C140	Same as C117						
C141	Capacitor: fixed, mica, 470 μμf ±10%, 500 vdcw Optimum value selected at factory Average value shown	Z*	14-62	8	2		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		hp STOCK NO.	TQ	RS		
C142	Same as C105						
C143	Capacitor: variable, ceramic, 1.5-7μμf 500 vdcw	L*	13-7	2	1		
C144	Same as C118						
C145	Same as C143						
C146	Same as C114						
C147	Same as C118						
C148	Same as C107. Optimum value adjusted at factory. Average value shown.						
C149	Not assigned						
C150	Same as C141						
C151	Same as C112						
C152	Same as C141						
C153	Not assigned						
C154	Capacitor: fixed, mica, 1000 μμf ±10%, 500 vdcw	V*	14-11	8	2		
C155, 156	Same as C118						
C157, 158	Same as C112						
C159	Capacitor: fixed, titanium dioxide, 2.2 μμf ±10%, 500 vdcw	DD*	15-52	1	1		
C160	Same as C112						
C161	Capacitor: fixed, mica, 330 μμf ±10%, 500 vdcw -20 + 100 ppm/°C Temp coeff.	Z*	14-79	1	1		
C162	Capacitor: fixed, ceramic, 22 μμf ±5%, NPO Temp. coeff. 500 vdcw	K*	15-2	1	1		
C163	Capacitor: fixed, ceramic, 8.2 μμf ±10%, 600 vdcw -1500 + 250 ppm/°C Temp. coeff.	L*	15-199	1	1		
C164	Capacitor: fixed, mica, 62 μμf ±5%, 500 vdcw ±200 ppm/°C Temp. coeff.	A*	15-25	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - **Total quantity used in the instrument.**
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
C165	Capacitor: fixed, ceramic, 110 μμf ±2%, 500 vdcw NPO Temp. coeff. K*	15-22	3	1		
C166	Capacitor: fixed, ceramic, .02 μf -0% + 100%, 600 vdcw G*	15-85	1	1		
C167	Same as C107					
C168	Same as C112					
C169	Capacitor: fixed, ceramic, 3.3 μμf ±.25%, NPO Temp. coeff., 600 vdcw Optimum value selected at factory Average value shown L*	15-179	1	1		
C170 thru C200	Not assigned					
C201, 202	Same as C154					
C203	Same as C141					
C204	Same as C154					
C205	Capacitor: fixed, mica, 5 μμf ±20%, 500 vdcw Z*	14-5	1	1		
C206 thru C209	Same as C154					
C210	Same as C118					
C211,212	Same as C165					
C213	Same as C118					
C214	Capacitor: fixed, paper, .047 μf ±10%, 600 vdcw CC*	16-15	1	1		
C215, 216	Capacitor: fixed, paper, .022 μf ±10%, 600 vdcw CC*	16-12	2	1		
C217	Capacitor: fixed, electrolytic, 50 μf -10% + 200%, 50 vdcw A*	18-50	3	1		
C218	Capacitor: fixed, silver mica, 1800 μμf ±5%, 500 vdcw Optimum value selected at factory Average value shown V*	15-19	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ	RS		
C219	Capacitor: fixed, paper, 1 µf ±10%, 600 vdcw	Z*	17-12	6	2		
C220	Capacitor: fixed, electrolytic, 10 µf, 300 vdcw	Z*	18-16	1	1		
C221	Same as C217 (Not used in Models with 17-pin transformer for T1)						
C222	Capacitor: fixed, paper, 4 µf ±10%, 50 vdcw	P*	17-43	1	1		
C223	Same as C219. Optimum value selected at factory. Average value shown						
C224	Not assigned						
C225, 226	Same as C141						
C227	Same as C136						
C228	Same as C219						
C229	Capacitor: fixed, silver mica, .001 µf ±5%, 500 vdcw Optimum value selected at factory Average value shown (Part of Z1)	A*	15-57	2	1		
C230, 231	Capacitor: fixed, mica, 680 µµf ±10%, 500 vdcw	Z*	14-21	2	1		
C232	Same as C229 (Part of Z2)						
C233 thru C238	Same as C128						
C239	Same as C118						
C240, 241	Capacitor: fixed, silver mica, 2000 µµf ±5%, 500 vdcw	Z*	15-96	2	1		
C242	Same as C118						
C243	Same as C105						
C244	Same as C217						
C245	Capacitor: fixed, paper, .1 µf ±5%, 600 vdcw	CC*	16-54	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗ STOCK NO.	TQ	RS		
C246	Capacitor: fixed, paper, .051 μf ±5%, 600 vdcw CC*	16-53	1	1		
C247	Same as C219					
C248	Capacitor: fixed, paper, 1 section, 0.5 μf ±10%, 400 vdcw CC*	17-56	1	1		
C249	Capacitor: fixed, mylar, .22 μf ±10%, 400 vdcw CC*	16-137	1	1		
C250	Capacitor: fixed, mylar, 1 μf ±5%, 200 vdcw CW*	16-102	1	1		
C251	Same as C112					
C252 thru C300	Not assigned					
C301, 302	Same as C141					
C303	Same as C219					
C304 thru C306	Capacitor: fixed, paper, 6 μf ±10%, 600 vdcw Z*	17-11	4	1		
C307A, B	Capacitor: fixed, paper, two sections, .25 μf/sect. -10% + 20%, 600 vdcw A*	17-14	1	1		
C308, 309	Not assigned					
C310	Same as C128					
C311	Same as C219					
C312	Not assigned					
C313	Same as C304					
C314	Same as C112					
C315	Same as C112					
C316 thru C319	Same as C111					
C320	Same as C118					
C321	Not assigned					
C322	Same as C118					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ℎ𝑝 STOCK NO.	TQ	RS		
C323	Not assigned						
C324	Capacitor: fixed, mica, 27 $\mu\mu$f ± 5%, 500 vdcw	Z*	14-78	1	1		
C325 thru C328	Same as C112						
CR1, 2	Rectifier, crystal	BU*	212-G11A	7	7		
CR3	Crystal diode bridge plug-in unit (Green dot on shield)	HP*	335E-11C	1	1		
CR4	Same as CR1						
CR5	Not assigned						
CR6	Crystal diode bridge plug-in unit	HP*	335E-11	1	1		
CR7, 8	Same as CR1						
CR9	Rectifier, metallic: 100 MA, 160 V	RS*	212-73	1	1		
CR10 thru CR13	Not assigned						
CR14, 15	Same as CR1						
CR301 thru CR308	Rectifier, silicon: 500 MA, 500 PIV		212-149	8	8		
DS1	Lamp, incandescent: 120 V, 6 W	N*	211-5	1	1		
F1	Fuse, cartridge: 3.2 amp, slow-blow	E*	211-45	1	10		
F2	Fuse, cartridge: 250 V, 1/2 amp, slow-blow	E*	211-20	1	10		
F301	Fuse, cartridge: 250 V, 1/2 amp, fast-blow		211-42	1	10		
J1	Jack, telephone: single closed circuit	KK*	124-3	3	1		
J2, 3	Connector, panel, Type N: RF INPUTS	HP*	G-76A	2	1		
J4, 5	Same as J1						
J6	Jack, telephone: 3 conductor with normally closed contact	KK*	124-10	1	1		
J7	Same as J1						
J8 thru J101	Not assigned						
J102	Connector, Jones: female, 2 contact	H*	125-21	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
L1	Coil, R.F.: 1.9 μh (tap selected at factory)	HP*	335E-60G	1	1		
L2	Coil, R.F.: tapped Optimum value selected at factory Average value shown	HP*	335E-60B	1	1		
L3	Coil, R.F.: tapped Optimum value selected at factory Average value shown	HP*	335E-60A	2	1		
L4, 5	Not assigned						
L6	Coil, R.F.: variable, 60-100 μh	MM*	48-19	2	1		
L7	Coil, R.F.: 900 μh	HP*	35F-60D	1	1		
L8	Same as L6						
L9	Same as L3						
L10, 11	Coil, R.F.: 3.3 μh	CG*	48-55	5	2		
L12	Coil, R.F.: 700 μh	HP*	335E-60F	1	1		
L13	Coil, R.F.: 100 mh (part of Z1)	HP*	336C-42	2	1		
L14	Reactor: 450 mh	HP*	911-19	1	1		
L15	Same as L13 (part of Z2)						
L16, 17	Same as L10						
L18	Inductor: 5 henry, 200 ma	HP*	9110-0035	1	1		
L19	Not assigned						
L20	Coil, variable,: 1.5-2.6 μh	HP*	335E-60E	1	1		
L21, 22	Same as L10						
L23	Coil, R.F.: 5.5 mh	MM*	48-3	1	1		
L24	Coil, R.F.: 4.7 μh	HP*	48-40	1	1		
M1	Meter: VISUAL CARRIER DEVIATION	BF*	112-68	1	1		
M2	Meter: AURAL DEVIATION	BF*	112-67	1	1		
M3	Meter: PERCENT MODULATION AURAL CARRIER	BF*	112-45	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
P101	Cable, power: with NEMA connector	HP*	812-56	1	1		
P102	Connector, Jones plug: male, 2 contact	H*	125-22	1	1		
R101	Resistor: fixed, composition, 22 ohms ±10%, 1/2 W	B*	23-22	3	1		
R102, 103	Not assigned						
R104, 105	Resistor: fixed, composition, 3900 ohms ±10%, 2 W	B*	25-3900	2	1		
R106	Not assigned						
R107	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	B*	23-10K	1	1		
R108 thru R112	Not assigned						
R113	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	B*	23-22K	3	1		
R114	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W	B*	24-470K	1	1		
R115	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W	B*	23-100K	7	2		
R116	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	B*	25-10K	1	1		
R117	Same as R115. Optimum value selected at factory. Average value shown.						
R118	Resistor: fixed, composition, 1200 ohms ±10%, 1 W Optimum value selected at factory Average value shown	B*	24-1200	1	1		
R119	Resistor: fixed, composition, 1000 ohms ±10%, 1 W Optimum value selected at factory Average value shown	B*	24-1000	2	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	TQ	RS		
R120	Same as R115					
R121	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W B*	24-47K	9	2		
R122	Resistor: fixed, composition, 100 ohms ±10%, 2 W B*	25-100	4	1		
R123	Resistor: fixed, composition, 82,000 ohms ±10%, 1 W B*	24-82K	1	1		
R124	Resistor: fixed, composition, 27,000 ohms ±10%, 2 W B*	25-27K	2	1		
R125	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W B*	23-1000	2	1		
R126	Same as R113. Optimum value selected at factory. Average value shown					
R127	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W B*	23-470K	1	1		
R128	Same as R113					
R129	Resistor: fixed, composition, 47 ohms ±10%, 1 W Optimum value selected at factory Average value shown	24-47	1	1		
R130	Same as R115					
R131	Resistor: fixed, composition, 4700 ohms ±10%, 1 W B*	24-4700	3	1		
R132	Same as R115 Optimum value selected at factory. Average value shown					
R133	Resistor: fixed, composition, 1000 ohms ±10%, 1 W Optimum value selected at factory Average value shown	24-1000	1	1		
R134	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W B*	23-15K	1	1		
R135	Same as R121					
R136	Same as R122					
R137	Resistor: fixed, composition, 3000 ohms ±5%, 1/2 W B*	23-3000-5	2	1		

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RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗ STOCK NO.	TQ	RS		
R138	Same as R125					
R139, 140	Not assigned					
R141	Resistor: fixed, composition, 390 ohms ±10%, 1/2 W B*	23-390	2	1		
R142	Not assigned					
R143, 144	Resistor: fixed, composition, 12 ohms ±10%, 1/2 W B* Optimum value selected at factory Average value shown	23-12	2	1		
R145	Resistor: fixed, composition, 6800 ohms ±10%, 1/2 W B*	23-6800	2	1		
R146	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W B*	23-47	2	1		
R147	Resistor: fixed, composition, 33, 000 ohms ±10%, 1 W B*	24-33K	3	1		
R148	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W B*	23-680	1	1		
R149	Resistor: fixed, composition, 220, 000 ohms ±10%, 1 W B*	24-220K	4	1		
R150	Same as R131					
R151, 152	Resistor: fixed, composition, 68 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown B*	23-68	2	1		
R153	Resistor: fixed, composition, 82 ohms ±10%, 1 W Optimum value selected at factory Average value shown B*	24-82	1	1		
R154	Same as R101					
R155	Same as R145					
R156	Same as R115					
R157	Resistor: fixed, composition, 47, 000 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown B*	23-47K	2	1		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R158	Resistor: fixed, composition, 68.000 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown B*	23-68K	1	1		
R159	Resistor: fixed, composition, 2.2 megohms ±10%, 1/2 W B*	23-2.2M	1	1		
R160	Resistor: fixed, composition, 39,000 ohms ±10%, 1 W B*	24-39K	1	1		
R161	Same as R121					
R162	Resistor: fixed, composition, 8200 ohms ±10%, 2 W B*	25-8200	1	1		
R163	Resistor: fixed, composition, 2700 ohms ±10%, 1/2 W B*	23-2700	1	1		
R164	Same as R101					
R165	Same as R115					
R166 thru R200	Not assigned					
R201	Resistor: fixed, composition, 27,000 ohms ±10%, 1 W B*	24-27K	1	1		
R202	Resistor: fixed, composition, 270,000 ohms ±10%, 1 W B*	24-270K	8	2		
R203	Same as R141					
R204	Same as R149					
R205, 206	Same as R202					
R207	Same as R131					
R208	Same as R121					
R209	Resistor: fixed, composition, 560,000 ohms ±10%, 1 W B*	24-560K	4	1		
R210	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W B*	24-100K	9	2		
R211	Resistor: fixed, composition, 12,000 ohms ±10%, 1 W B*	24-12K	1	1		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R212, 213	Resistor: fixed, composition, 4700 ohms ±10%, 2 W B*	25-4700	2	1		
R214	Resistor: fixed, wirewound, 15,000 ohms ±10%, 10 W S*	26-25	1	1		
R215	Resistor: fixed, composition, 220 ohms ±10%, 1 W B*	24-220	1	1		
R216, 217	Same as R147					
R218, 219	Resistor: fixed, composition, 1000 ohms ±10%, 2 W B*	25-1000	2	1		
R220, 221	Same as R202					
R222, 223	Resistor: fixed, wirewound, 1500 ohms ±1%, 5 W AC*	26-43	3	1		
R224, 225	Resistor: fixed, deposited carbon, 3030 ohms ±1%, 1 W NN*	31-3030	2	1		
R226	Resistor: fixed, composition, 62,000 ohms ±5%, 2 W B*	25-62K-5	1	1		
R227	Resistor: fixed, composition, 680 ohms ±10%, 1 W B*	24-680	1	1		
R228	Resistor: fixed, composition, 150,000 ohms ±10%, 1 W B*	24-150K	2	1		
R229	Resistor: fixed, composition, 120,000 ohms ±10%, 1 W B*	24-120K	2	1		
R230	Resistor: fixed, composition, 12,000 ohms ±10%, 2 W B*	25-12K	1	1		
R231	Resistor: fixed, composition, 5100 ohms ±5%, 1 W B*	24-5100-5	1	1		
R232	Resistor: fixed, deposited carbon, 33,000 ohms ±1%, 1 W HP* Optimum value selected at factory Average value shown	31-33K	1	1		
R233	Not assigned					
R234	Same as R229					
R235	Resistor: fixed, deposited carbon, 49,000 ohms ±1%, 1 W Optimum value selected at factory Average value shown HP*	31-49K	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
R236	Resistor: variable, wirewound, 10,000 ohms	G*	210-72	3	1		
R237	Resistor: fixed, deposited carbon, 56,000 ohms ±1%, 1 W	NN*	31-56K	1	1		
R238	Same as R210						
R239	Same as R222						
R240	Resistor: fixed, wirewound, 255 ohms ±1%, 5 W Optimum value selected at factory Average value shown	AC*	26-40	1	1		
R241	Same as R121						
R242	Resistor: fixed, wirewound, 5000 ohms ±1%, 5 W Optimum value selected at factory Average value shown	AC*	26-45	3	1		
R243	Resistor: fixed, wirewound, 18,400 ohms ±1%, 10 W	AC*	26-47	1	1		
R244	Resistor: variable, wirewound, 100 ohms ±10%, 2 W	BO*	210-4	1	1		
R245	Same as R236						
R246	Same as R210 Optimum value selected at factory Average value shown						
R247	Same as R137						
R248	Resistor: fixed, deposited carbon, 144,000 ohms ±1%, 1 W	HP*	31-144K	1	1		
R249	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W	B*	24-56K	1	1		
R250	Resistor: fixed, composition, 47 ohms ±10%, 1 W	B*	24-47	2	1		
R251	Resistor: fixed, composition, 22,000 ohms ±10%, 2 W	B*	25-22K	1	1		
R252	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W	B*	24-22K	2	1		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	TQ	RS		
R253	Same as R202						
R254	Same as R121						
R255	Resistor: fixed, composition, 820 ohms ±10%, 1 W	B*	24-820	1	1		
R256	Same as R202						
R257	Resistor: fixed, composition, 100 ohms ±10%, 1 W	B*	24-100	5	2		
R258	Resistor: fixed, composition, 47,000 ohms ±10%, 2 W	B*	25-47K	1	1		
R259	Same as R149						
R260, 261	Same as R202						
R262	Resistor: fixed, composition, 10,000 ohms ±10%, 1 W	B*	24-10K	2	1		
R263	Same as R209						
R264	Same as R210						
R265, 266	Resistor: fixed, composition, 6800 ohms ±10%, 2 W	B*	25-6800	3	1		
R267, 268	Same as R210						
R269, 270	Same as R242						
R271	Resistor: fixed, composition, 1000 ohms ±5%, 1/2 W	B*	23-1000-5	2	1		
R272	Resistor: fixed, composition, 1800 ohms ±10%, 1 W	B*	24-1800	1	1		
R273	Resistor: fixed, wirewound, 6200 ohms ±5%, 2 W Optimum value selected at factory Average value shown	R*	26-32	1	1		
R274	Same as R236						
R275	Resistor: fixed, wirewound, 30,000 ohms ±5%, 10 W	S*	26-12	1	1		
R276	Same as R210						

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	TQ	RS		
R277	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W B*	23-100	3	1		
R278	Resistor: fixed, wirewound, 3600 ohms ±5%, 1 W R*	26-4	4	1		
R279	Resistor: fixed, wirewound, 390 ohms ±1%, 5 W Optimum value selected at factory Average value shown AC*	26-41	1	1		
R280	Same as R121					
R281	Same as R278 Optimum value selected at factory. Average value shown.					
R282	Resistor: variable, composition, 5000 ohms ±10%, 2 W BO*	210-7	1	1		
R283	Same as R278					
R284	Not assigned					
R285	Resistor: fixed, composition, 1500 ohms ±10%, 1 W Optimum value selected at factory Average value shown B*	24-1500	1	1		
R286	Same as R119					
R287	Same as R278 Optimum value selected at factory. Average value shown					
R288	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W B*	23-1800	1	1		
R289	Resistor: fixed, composition, 1 megohm ±10%, 1 W B*	24-1M	4	1		
R290	Same as R262					
R291	Resistor: fixed, wirewound, 14, 500 ohms ±1%, 10 W AC*	26-73	1	1		
R292	Same as R146 Optimum value selected at factory. Average value shown					
R293	Resistor: fixed, composition, 270 ohms ±10%, 1 W Optimum value selected at factory Average value shown	24-270	1	1		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R294	Resistor: variable, wirewound, linear taper, 500 ohms ±10% B*	210-25	1	1		
R295	Same as R157					
R296	Resistor: fixed, composition, 10 ohms ±10%, 1/2 W B*	23-10	1	1		
R297	Same as R257					
R298	Resistor: fixed, composition, 2200 ohms ±10%, 1 W B*	24-2200	2	1		
R299	Same as R121					
R300	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W B*	23-1M	2	1		
R301	Resistor: variable, wirewound, 300 ohms	210-53	1	1		
R302	Not assigned					
R303	Same as R300					
R304	Same as R250					
R305	Same as R298					
R306	Same as R124					
R307	Same as R289					
R308	Same as R149					
R309	Same as R289					
R310	Same as R121					
R311	Resistor: fixed, deposited carbon, 216,300 ohms ±1%, 1 W Optimum value selected at factory Average value shown HP*	31-216.3K	1	1		
R312	Resistor: variable, wirewound, 25,000 ohms ±10%, 3 W BO*	210-10	1	1		
R313	Resistor: fixed, deposited carbon, 14,400 ohms ±1%, 1 W Optimum value selected at factory Average value shown HP*	31-14.4K	1	1		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
R314	Same as R289					
R315	Resistor: fixed, composition, 180, 000 ohms ± 10%, 1 W Optimum value selected at factory Average value shown B*	24-180K	1	1		
R316	Resistor: variable, composition, linear taper, 20,000 ohms ± 20%, 1/3 W BO*	210-213	1	1		
R317	Same as R210 Optimum value selected at factory. Average value shown					
R318, 319	Same as R265					
R320	Same as R210					
R321	Same as R257					
R322	Resistor: fixed, composition, 560 ohms ± 10%, 1 W B*	24-560	1	1		
R323	Same as R209					
R324	Resistor: fixed, wirewound, 3000 ohms ± 10%, 20 W S*	27-45	1	1		
R325	Same as R209					
R326	Resistor: fixed, wirewound, 0.6 ohm ± 10%, 2 W I*	26-39	1	1		
R327	Same as R277					
R328, 329	Same as R257					
R330	Same as R228 Optimum value selected at factory. Average value shown					
R331	Same as R252 Optimum value selected at factory. Average value shown					
R332	Resistor: fixed, composition, 390, 000 ohms ± 10%, 1 W B*	24-390K	1	1		
R333	Same as R271					
R334, 335	Resistor: fixed, wirewound, 110 ohms ± 10%, 10 W	26-130	2	1		
R336 thru R340	Not assigned					
R341, 342	Same as R122					
R343	Same as R277					
R344 thru R351	Resistor: fixed, composition, 510, 000 ohms ± 5%, 1 W	24-510-5	8	3		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	TQ	RS		
REL 1	Relay	Phillips Control Co.	49-17	1	1		
S1	Switch, push button	D*	310-75	1	1		
S2	Switch, rotary: FUNCTION SELECTOR	HP*	310-114	1	1		
S3	Switch, toggle: DPDT	D*	310-54	1	1		
S4	Switch, toggle: SPST, POWER	D*	310-11	1	1		
S5	Switch, toggle: SPDT, DEVIATION	D*	310-12	1	1		
T1	Transformer: Audio Input, 9 pin (If instrument contains 17-pin T1, specify "912-34 with 17 pins")	HP*	912-34	1	1		
T2	Transformer: Audio Output	HP*	912-60	1	1		
T3	Transformer, filament	HP*	910-102	1	1		
T4	Transformer, power	HP*	910-99	1	1		
T5	Transformer, power	HP*	910-103	1	1		
TB201	Terminal strip: 8 terminals	Kulka	36-38	1	1		
TB202	Terminal strip: 2 terminals	Kulka	36-103	1	1		
TC1	Switch, thermal cutout	BA*	310-112	1	1		
V1	Tube, electron: 6U8	ZZ*	212-6U8	1	1		
V2	Tube, electron: 6AH6	ZZ*	212-6AH6	3	3		
V3 thru V7	Tube, electron: 12AT7	ZZ*	212-12AT7	9	9		
V8, 9	Tube, electron: 5687	ZZ*	212-5687	5	5		
V10	Same as V2						
V11, 12	Same as V8						
V13, 14	Same as V3						

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	TQ	RS		
V15	Same as V8					
V16	Same as V3					
V17	Tube, electron: 2D21 ZZ*	212-2D21	1	1		
V18	Tube, electron: 6SJ7 ZZ*	212-6SJ7	1	1		
V19	Tube, electron: 6AS7GA ZZ*	212-6AS7GA	1	1		
V20	Same as V2					
V21	Tube, electron: OB2 ZZ*	212-OB2	1	1		
V22	Same as V3					
XTAL 1	Crystal unit: specify frequency in KC HP*	41-(KC)	1	1		
XTAL 2	Quartz, crystal: 4.3535 MC HP*	G-69A-A2	1	1		
XTAL 3	Quartz, crystal: 150 KC Monitor Prod.	41-31	1	1		
Z1, 2	Filter Assembly: tuned, 15.75 KC, shielded, contains 100 mh and 1000 $\mu\mu$f HP*	336C-42	2	1		
	MISCELLANEOUS					
	Cover: (for REL 1) Phillips Control Co.	49-17A	1	1		
	Connector: UG21B/U, type N, used on RF input cable LL*	125-UG21B/U	2	1		
	Fuseholder T*	140-16	2	1		
	Fan Blade, exhaust for motor with mtg studs 1-7/8 in. between centers BD*	314-44	1	1		
	for motor with mtg studs 1-1/2 in. between centers BD*	314-6	1	1		
	Insulator, standoff: 1 in. long Gen. Ceramics	34-1	1	1		
	Insulator, standoff: 3/4 in. long Gen. Ceramics	34-34	1	1		

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	TQ	RS		
	Knob: CARRIER LEVEL -USE- CALIBRATE HP*	G-74G	1	1		
	Knob: 50% to 120% HP*	G-74K	1	1		
	Lamp, incandescent: 6-8V, .15 amp, frosted, for meter illumination N*	211-26	6	6		
	Meter Assembly, for remote installation, aural carrier deviation HP*	335E-95F				
	Meter Assembly, for remote installation, aural modulation percentage HP*	335E-95G				
	Meter Assembly, for remote installation, visual carrier deviation HP*	335E-95H				
	Oven Top Assembly: complete with thermometer, less crystal (for XTAL 1) HP*	G-69B-1A	1	1		
	Oven: (for XTAL 2) HP*	G-69A-A1	1	1		
	Thermometer: (for XTAL 1) BF*	41-30	1	1		
	Thermostat, mercury (for XTAL 1)	41-5				

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LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY
Laboratory Instruments for Speed and Accuracy
275 PAGE MILL ROAD PALO ALTO. CALIF. U.S.A.
CABLE "HEWPACK"