

OPERATING AND SERVICE MANUAL

MODEL 608D

SERIALS PREFIXED: 247 -
2

VHF SIGNAL GENERATOR

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1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

SPECIFICATIONS

FREQUENCY RANGE: 10 mc to 420 mc in 5 bands.

TUNING CONTROL: Frequency control mechanism provides a main dial calibrated in megacycles and a vernier dial for interpolation purposes. Total scale length: Approximately 45 in.
Calibration: Every other megacycle 130 to 270 mcs; every 5 mcs above 270 mcs.

VERNIER CONTROL: A separate vernier control allows variations of about ± 25 kc (at high frequency setting) for sensitivity checks of extremely selective receivers.

FREQUENCY CALIBRATION ACCURACY: Within $\pm 0.5\%$ over entire frequency range.

RESETTABILITY: Better than $\pm 0.1\%$ after initial instrument warm-up.

CRYSTAL CALIBRATOR: Provides check points every 1 mc up to 270 mc or every 5 mc over the entire frequency range. Accuracy is 0.01% or better at normal room temperature.

FREQUENCY DRIFT: Less than 0.005% over a 10 minute interval after initial instrument warm-up, (15°C to 35°C ambient). When frequency is changed by dial, instrument must re-stabilize one minute for each 10% frequency change. When frequency is changed by bandswitching, 10 minutes are required to re-stabilize.

OUTPUT LEVEL: 0.1 microvolt to 0.5 volt (into a 50-ohm resistive load). Attenuator dial calibrated in volts and dbm. (0 dbm equals 1 milliwatt in 50 ohms.)

OUTPUT VOLTAGE ACCURACY: ± 1 db over entire frequency and attenuation range (into a 50 ohm resistive load).

GENERATOR IMPEDANCE: 50 ohms, maximum swr 1.2.

INTERNAL MODULATION FREQUENCIES: 400 cps $\pm 10\%$ and 1,000 cps $\pm 10\%$.

EXTERNAL AM MODULATION: From 0 to 95% at output levels of 0 dbm and below from modulation frequencies 20 cps to 20 kc. Input requirements: 0.5V rms across 15K ohms.

MODULATION METER ACCURACY: $\pm 10\%$ of full scale 30% to 95% modulation.

ENVELOPE DISTORTION: Less than 5% at 30% sine wave modulation and less than 10% at 50% sine wave modulation.

SPECIFICATIONS (cont'd)

EXTERNAL PULSE MODULATION: Positive 5 volt peak pulse required. 40 mc to 220 mc; combined rise and decay time of rf pulse less than 4 microseconds.

220 mc to 420 mc: Combined rise and decay time of rf pulse less than 1 μ sec.

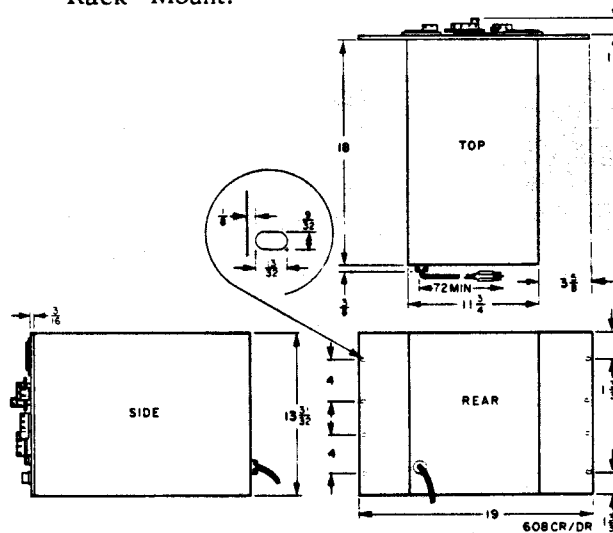
Residual level at least 20 db below 0.5 volt peak pulse output.

INCIDENTAL FREQUENCY MODULATION: Less than 1,000 cycles peak at 50% amplitude modulation for rf output frequencies above 100 mc and less than 0.001% at rf output frequencies below 100 mc.

LEAKAGE: Negligible; permits receiver sensitivity measurements down to at least 0.1 microvolt.

POWER: 115/230 volts $\pm 10\%$, 50/1000 cps. Approximately 220 watts.

DIMENSIONS: Cabinet Mount: 13-1/4 in. wide, 16-3/8 in. high, 21 in. deep.
Rack Mount:



WEIGHT: Cabinet Mount: Net 62 lbs. Shipping 88 lbs.
Rack Mount: Net 62 lbs. Shipping 91 lbs.

ACCESSORIES AVAILABLE: Ⓢ608A-16D Output Cable provides 50 ohms termination and standard binding posts at the end of a 24 in. length of cable. Allows direct connection of the signal generator to high impedance circuits.

Ⓢ608A-95A Fuse Holder provides protection of the attenuator elements when the 608 is used for transceiver tests.

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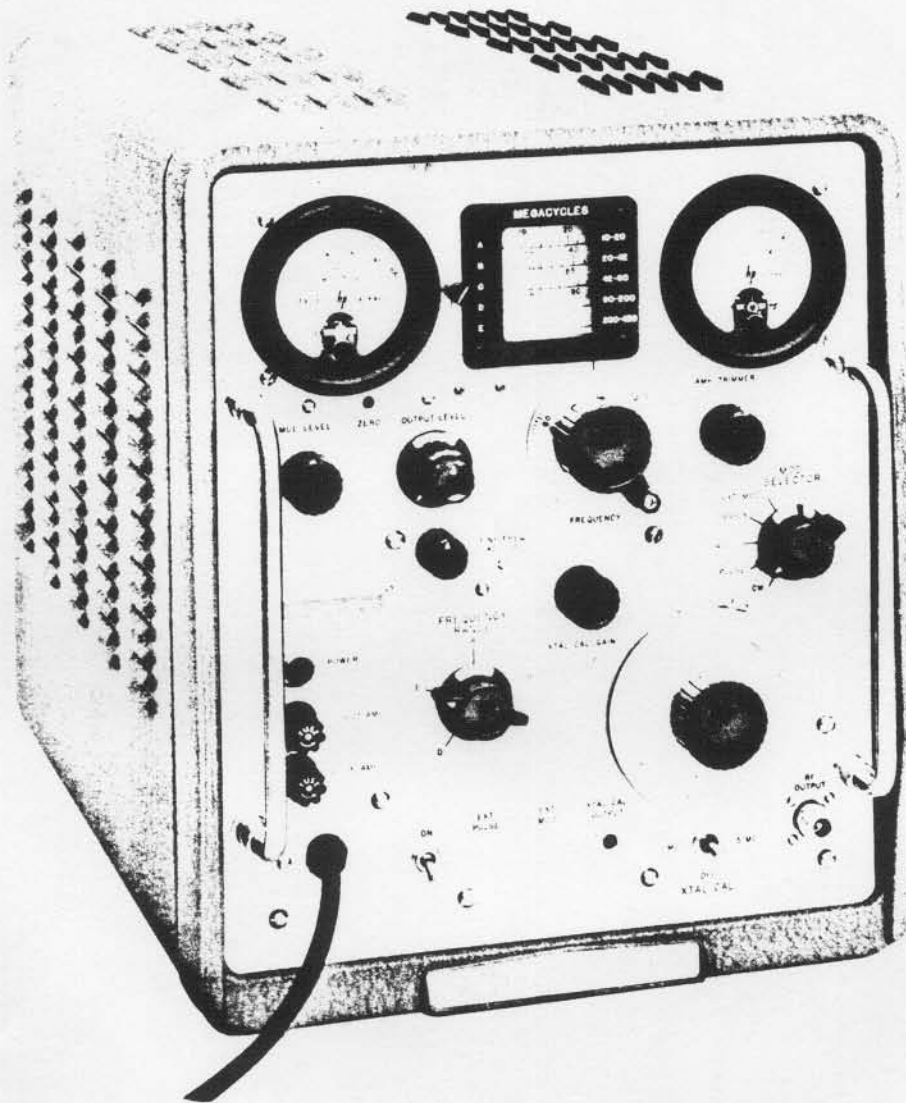


Figure 1-1. Model 608D VHF Signal Generator

SECTION I

GENERAL DESCRIPTION

1-1 INTRODUCTORY

Model 608D VHF Signal Generator furnishes r-f signals from 0.1 microvolt to 0.5 volt over the frequency range from 10 to 420 megacycles. The signals may be amplitude-modulated by internally-generated sine waves or by externally-applied sine waves or pulses.

The level of the output signal is regulated by an attenuator which is adjusted by a calibrated front-panel control. The attenuator is calibrated in both volts and dbm and can be read directly to an accuracy of ± 1 db over the full frequency range when the 608D is terminated in a 50-ohm resistive load.

The 608D includes a crystal-controlled heterodyne calibrator which permits the operator to adjust the calibration of the frequency dial at 1-mc and 5-mc check points over the frequency range of the instrument.

The Model 608D Signal Generator is designed to meet the exacting requirements of precision laboratory work and yet to be equally useful for general applications in the 10- to 420-megacycle frequency range. The equipment can be used for testing, calibrating, and trouble shooting VHF radio equipment and circuits, and for measuring standing-wave ratios, antenna and transmission line characteristics, receiver sensitivity, etc. To obtain utmost accuracy, particular care has been taken in the design of the 608D to hold spurious modulation to a very low value under all operation conditions.

1-2 AUXILIARY EQUIPMENT

Supplied - The special wrench necessary for removing the r-f amplifier tube is supplied. It is mounted on the instrument chassis.

Required - To use the built-in crystal-controlled calibrator, headphones must be provided by the operator.

Available

608A-95A Fuseholder. To protect the output attenuator from damage, for some applications (such as transceiver testing) it is desirable to insert a fuse between the 608D and external equipment. The 608A-95A is a special coaxial fuseholder which houses a type 8AG, 1/16 amp fuse which protects the output attenuator from damage in the event that an external voltage is accidentally applied to the RF OUTPUT connector. The fuseholder has an insertion loss of 0.50 db at 200 mc, 0.56 db at 300 mc, and 0.65 db at 400 mc; its SWR is not greater than 1.35 when connected to a 50-ohm resistive load. Refer to table 5-1, Replaceable Parts, under Miscellaneous, for correct fuse replacement.

608A-16D Terminated Output Cable. This cable assembly provides a 50-ohm termination and standard binding posts at the end of a 40-inch length of cable. The 608A-16D allows direct connection of the 608D to a high-impedance circuit.

1-3 GENERAL ELECTRIC CHARACTERISTICS

The Model 608D generates r-f output signals over the frequency range from 10 to 420 megacycles. Frequency of the output signal is indicated on a direct-reading dial, the calibration of which is accurate to better than $\pm 0.5\%$ when the cursor and FINE FREQ. adjustments are properly aligned. Calibration accuracy may be improved further by use of a built-in crystal-controlled heterodyne calibrator which furnishes 1-mc or 5-mc check points over the entire frequency range of the instrument. At any check point the calibration can be set very close to the calibrator accuracy of 0.01%, bringing overall accuracy to at least $\pm 0.05\%$. Check point signals are obtained when a headphone set (not furnished with the 608D) is plugged into the XTAL CAL. OUTPUT jack. The calibrator can provide up to 0.1 milliwatt to a 600-ohm headphone; output level is adjusted by front panel control, XTAL CAL.GAIN.

The control for the output attenuator is calibrated in both decibels and volts. When the 608D is connected to a 50-ohm resistive load and power into the output attenuator is exactly at the SET LEVEL mark on the

OUTPUT VOLTS meter, the level of power or voltage applied to the RF OUTPUT connector may be read directly on the attenuator dial with an accuracy of ± 1 db. When connected to a 50-ohm resistive load, the VSWR at the RF OUTPUT connector will not be greater than 1.2 (SWR of 1.6 db).

The r-f output signal from the 608D may be amplitude modulated by 1) internally-generated 400- and 1000-cycle sine waves, 2) externally-applied sine waves above 0.5 volt rms over the frequency range from 20 cps to 100 kc or 3) externally-applied pulses above approximately 5 volts. When pulse modulated, the 608D is capable of producing pulses of radio frequency energy as short as 4 microseconds at r-f signal frequencies above 40 megacycles and pulses as short as 1 microsecond above 220 megacycles. The degree of sine-wave modulation is continuously variable from 0 to 95% by a front panel control. All sine-wave modulation of the r-f output signal is continuously monitored and indicated in percentage on a direct-reading modulation meter having an accuracy of $\pm 10\%$ of the meter indication at readings between 30 and 95%.

The envelope of the sine-wave modulated signal contains less than 5% distortion. Incidental amplitude modulation of the CW output signal is less than 0.1%. The total level of harmonics and spurious signals contained in the CW output signal is 40 decibels below the level of the output signal when the output level is greater than 200 microvolts.

R-f leakage is held to a minimum and is such that when the output signal is adjusted for 0.1 microvolt, the conducted signal leakage at any other front panel connector and the radiated leakage two inches from the instrument are each less than 1.0 microvolt.

1-4 GENERAL PHYSICAL CHARACTERISTICS

The 608D is 13-3/4 inches wide by 16-1/4 inches high by 21 inches deep and weighs 63 pounds. The instrument is housed in an aluminum cabinet finished in gray baked enamel. Guard-rail type handles are provided to assist in handling and to protect the front panel controls. Ventilation is provided by louvers in the side and back surfaces of the cabinet. The chassis is removable by loosening the four screws in the rear of the cabinet.

SECTION II

INSTALLATION AND OPERATION

2-1 INSTALLATION

The Model 608D operates from a nominal 115/230 volt, 50 to 1,000 cps single-phase power source. If the equipment is to be operated from a 230-volt source, the power transformer primary winding must be reconnected as indicated on the schematic diagram. The 3-conductor power cable on the 608D is terminated in a polarized 3-prong male connector recommended by the National Electric Manufacturers' Association. The third contact is an offset round pin, added to a standard 2-blade connector, which grounds the instrument chassis when used with the appropriate receptacle. To use this NEMA plug in a standard 2-contact receptacle, it is recommended that a 2-prong to 3-prong adapter be used. The ground connection emerges from the adapter as a short lead which should be connected to a grounded outlet box for the protection of operating personnel.

2-2 MECHANICAL ADJUSTMENT OF METER ZERO

When meter is properly zero-set, pointer rests over the zero calibration mark on the meter scale when instrument is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

- a. Allow the instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.
- b. Turn instrument off and allow 30 seconds for all capacitors to discharge.
- c. Rotate mechanical zero adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.
- d. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer shoots zero, repeat steps c and d.
- e. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counter-clockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step you must repeat steps c through e.

2-3 OPERATING CONTROLS, DIALS, AND TERMINALS

The front panel operating controls, dials, and terminals for the 608D are listed with their functions in Table 2-1 and are shown in Figure 2-1. A simplified block diagram showing which circuits are affected by various front panel controls is shown in Figure 2-2.

TABLE 2-1. CONTROLS AND TERMINALS

Ref. No. Fig. 2-1	Designation	Function
1	DC 0.25 AMP (fuse)	Protects the internal d-c power supply against short circuits in the instrument.
2	AC 3 AMP (fuse)	Protects instrument against short circuits.
	Power switch (hspa instruments)	In the ON position, power from the line is applied to the primary of the power transformer. (Up gives 230-volt operation. Center is OFF, down is 115-volt operation).
3	FINE FREQ. ADJUST	Vernier for FREQUENCY control.
4	POWER (pilot lamp)	Lights when ac power is applied.
5	MOD. SELECTOR (switch)	Sets modulation mode.
6	FREQUENCY RANGE (switch)	Sets up tuned circuits for desired frequency range, and positions range pointer on MEGACYCLES dial.

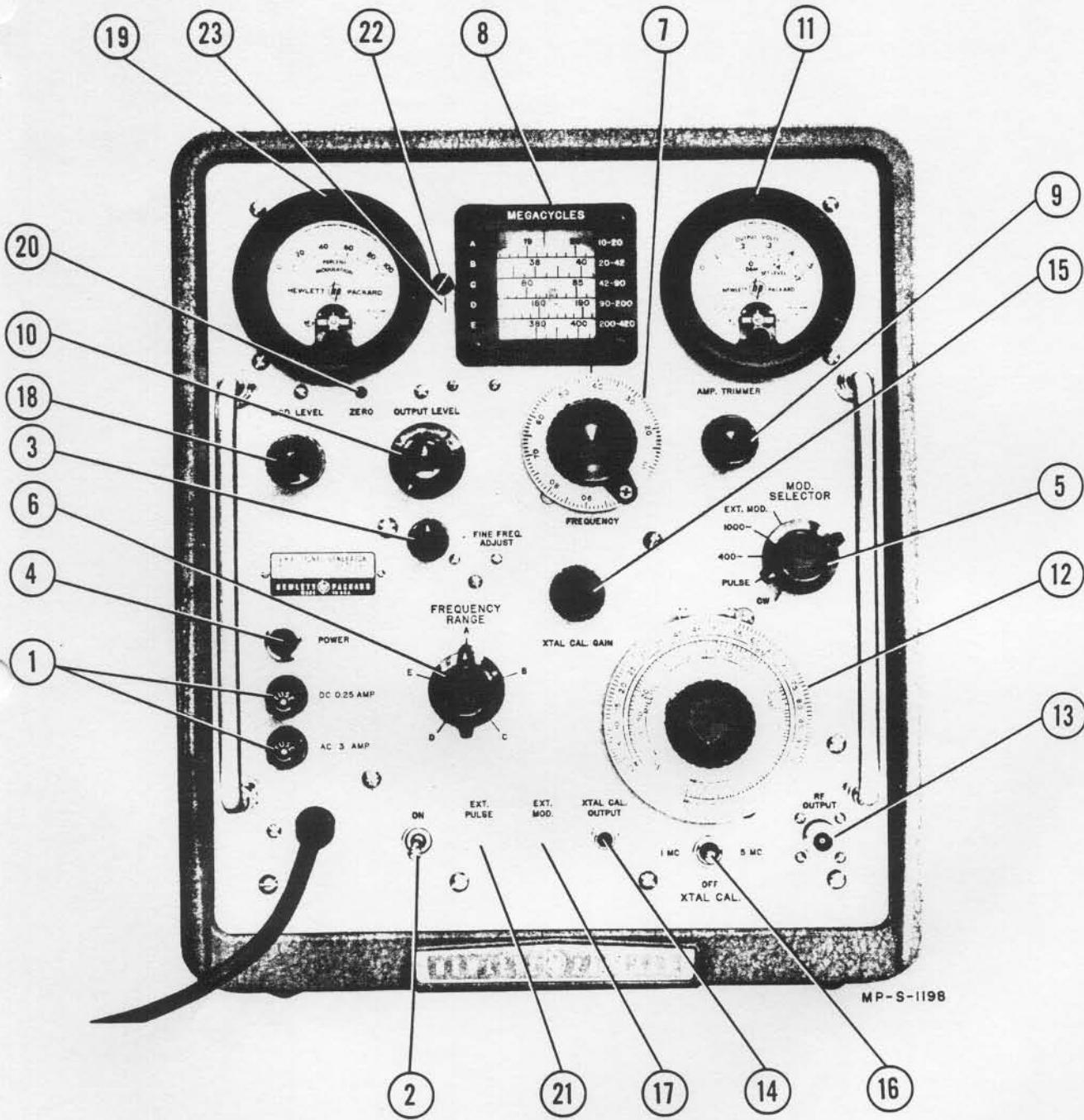


FIGURE 2-1. MODEL 608D SIGNAL GENERATOR FRONT PANEL CONTROLS

TABLE 2-1. CONTROLS AND TERMINALS (CONT'D.)

Ref. No. Figure 2-1	Designation	Function
7	FREQUENCY (control)	Selects output frequency determined by FREQUENCY RANGE switch.
8	MEGACYCLES (dial)	Indicates the frequency of the r-f output signal directly in megacycles.
9	AMP. TRIMMER (control)	Tunes r-f power amplifier for maximum output as indicated on output meter.
10	OUTPUT LEVEL (control)	Adjusts level of r-f power at input to attenuator.
11	OUTPUT VOLTS (meter)	Indicates level of r-f power <u>applied to attenuator.</u>
12	ATTEN (output control)	Adjusts and indicates r-f output level in microvolts, millivolts, and DBM.
13	RF OUTPUT (BNC connector)	Output connector for r-f output signal. (See CAUTION, par. 2-4)
14	XTAL CAL. OUTPUT (jack)	Crystal calibrator output; accommodates earphone plug.
15	XTAL CAL. GAIN (control)	Adjusts loudness of beat-frequency signal obtained from XTAL CAL. OUTPUT jack.
16	XTAL CAL. 1MC-OFF-5MC (switch)	Selector switch for crystal calibrator.
17	EXT. MOD. (connector)	Receives sine wave from external source for modulation of r-f output signal.
18	MOD. LEVEL (control)	Adjusts modulation percentage to desired value (percent of modulation indicated on modulation meter).
19	PERCENT MODULATION (meter)	Indicates percent of modulation on r-f output signal.
20	ZERO (adjustment)	Electrically sets the PERCENT MOD. meter to zero with instrument in operation and no modulation applied.
21	EXT. PULSE (connector)	Receives pulses from external source for modulation of r-f output signal.
22		Cursor adjustment; positions cursor on dial.
23		Panel marker for cursor alignment.

LUBRICATION: The mechanical assemblies of the Model 608D r-f generator require lubrication at regular intervals. See Table 4-1 in the Maintenance Section.

2-4 TURNING ON THE EQUIPMENT

CAUTION

Do not obstruct the ventilating louvers on the sides of the instrument cabinet. Safe operating temperature depends on free air flow through these louvers.

To place the signal generator into operation, proceed as follows:

- Check that the power switch is in the off position.
- With the signal generator plugged into a power source of specified voltage and frequency, place the MOD. SELECTOR in the CW position and the OUTPUT LEVEL control to near maximum (clockwise). Other controls may be set in any position before turning generator on.
- Turn power switch to ON. The POWER pilot lamp should light indicating that power is applied to all circuits of the signal generator.
- Allow equipment to heat for 5 minutes before use. If greatest frequency stability is required, allow equipment to heat for 60 minutes.

CAUTION

Do not connect any source of r-f or d-c power to the RF OUTPUT jack on the Model 608D Signal Generator. To do so will burn out the impedance-matching network in the output attenuator and no output will be obtained. Special care must be taken when working with "transceiver" type equipments, such as VHF aircraft equipment, to insure that the transmitter remains inoperative while the signal generator is connected to the equipment antenna.

NOTE

For protection to the output attenuator on the Model 608D Signal Generator, a special fuseholder (type 608A-95A) is available for connection to the RF OUTPUT connector. When using the signal generator for any application where there is the possibility of voltage being applied to the RF OUTPUT connector, this fuse may be used between the output connector and the test cable connecting the signal generator to the external equipment.

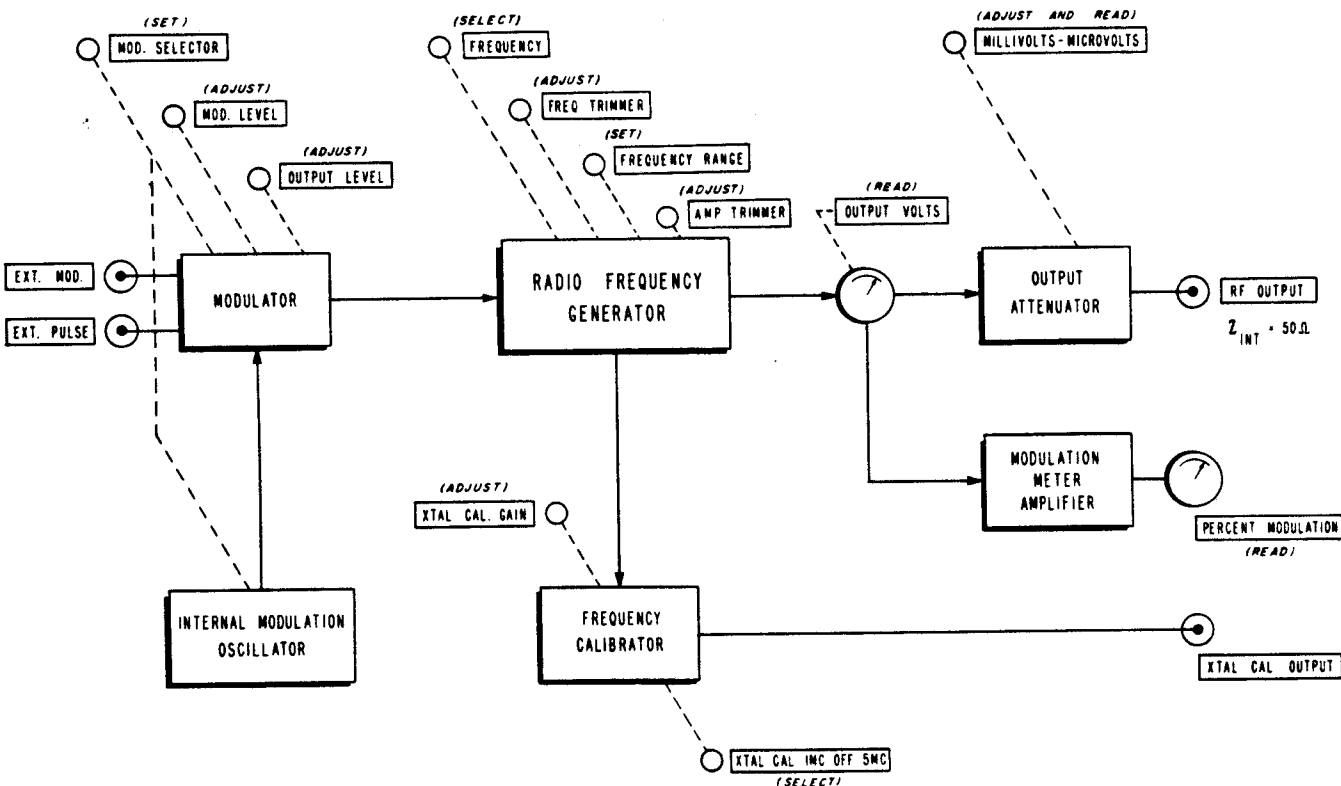


FIGURE 2-2. DIAGRAM SHOWING RELATIONSHIP OF FRONT PANEL CONTROLS TO MAJOR CIRCUITS

2-5 CONTINUOUS-WAVE OPERATION

General

When the 608D is set for CW operation, the PERCENT MODULATION meter may have momentary fluctuations due to switching transients.

Step-by-Step Procedure for CW Operation

- a. Follow the "turning on" procedure (par. 2-4). Check that MOD.SELECTOR is at CW.
- b. Set the 608D for the desired frequency;
Note: For maximum accuracy, see paragraph 2-9 for instructions on using the calibrator.
 - 1) Set the FREQUENCY RANGE switch to the proper range. (Frequency limits for each range are indicated on the housing for the MEGACYCLES dial.)
 - 2) Align the white-line marker on the cursor adjustment with its panel alignment marker.
 - 3) Align the white indicator on the FINE FREQ. ADJUST with its panel alignment marker.
 - 4) Operate the FREQUENCY control to bring the MEGACYCLES dial cursor on the desired frequency.
- c. Connect the external equipment to the RF OUTPUT connector. Note the CAUTION in par. 2-4.
- d. Set the 608D for the desired output level:
 - 1) Set the OUTPUT LEVEL control to obtain some indication on the OUTPUT VOLTS meter.
 - 2) Adjust AMP.TRIMMER for maximum indication on the OUTPUT VOLTS meter.
 - 3) Readjust the OUTPUT LEVEL control to bring the meter indication exactly on the SET LEVEL mark on the OUTPUT VOLTS meter.
 - 4) The attenuator dial is calibrated to read the output level (± 1 db). Set the dial for the desired output level. Whenever the output level is changed, steps 2) and 3) must be repeated.

NOTE

Attenuator dial accuracy and PERCENT MODULATION meter accuracy are within specifications only when the OUTPUT VOLTS meter is indicating exactly on the SET LEVEL mark. Before making any measurements, check that the OUTPUT VOLTS meter is indicating on SET LEVEL.

2-6 INTERNAL SINE-WAVE MODULATION

General

The 608D provides facilities for 400- or 1000-cycle modulation of the r-f signal. The modulating frequencies are accurate to within $\pm 10\%$, and envelope distortion of the modulated carrier is less than 5% for modulation percentages to 30%. The percent modulation is continuously adjustable from 0 to 95% by the MOD. LEVEL control and is read directly from the PERCENT MODULATION meter to within $\pm 10\%$ of the meter reading from 30 to 95%. Incidental frequency modulation resulting from amplitude modulation of the output signal is held extremely low, being less than 1000 cycles for reasonable modulation percentages. For modulation percentages below 50%, the frequency modulation index will not exceed 1.0. Output frequency and power level are set in the same manner as for CW operation except that the MOD. SELECTOR is set to 400 ν or 1000 ν .

Step-by-Step Procedure, Internal Modulation

- a. Follow complete step-by-step procedure for CW operation.
- b. Set the MOD.SELECTOR to 400 ν or 1000 ν as desired.
- c. Set the MOD.LEVEL control for desired degree of modulation as indicated on the PERCENT MODULATION meter.

NOTE

It may be noticed that when the percent modulation is increased to very high levels there will be a resulting increase in the reading of the OUTPUT VOLTS meter. The OUTPUT LEVEL control should be reset to maintain a reading at SET LEVEL on the OUTPUT VOLTS meter.

- d. Subsequent changes may be made in the frequency dial and output attenuator settings while the instrument is being operated with modulation.

2-7 EXTERNAL SINE-WAVE MODULATION

General

Externally-supplied signals in the range from 20 to 20,000 cps and above with an amplitude of approximately 0.5 volt may be used to modulate the r-f signal. The modulating signal is applied through an appropriate cable to the EXT. MOD. connector on

the front panel. The degree of modulation is continuously adjustable by means of the MOD.LEVEL control and is indicated directly on the front panel PERCENT MODULATION meter. The input impedance at the EXT. MOD connector is approximately 20,000 ohms shunted by 50 μf .

Step-by-Step Procedure, External Modulation

- a. Follow complete step-by-step procedure for CW operation.
- b. Set MOD.SELECTOR to EXT. MOD.
- c. Connect modulating source to EXT.MOD. connector.
- d. Set MOD.LEVEL control for desired degree of modulation as read on the PERCENT MODULATION meter.

NOTE

It may be noticed that when the percent modulation is increased to very high levels there will be a resulting increase in the reading of the OUTPUT VOLTS meter. The OUTPUT LEVEL control should be reset to maintain a reading at SET LEVEL on the OUTPUT VOLTS meter.

- e. Subsequent changes may be made in frequency dial and output attenuator settings while the instrument is being operated with modulation.

2-8 PULSE MODULATION

General

Externally-supplied positive pulses above 5 volts in amplitude may be used to pulse-modulate the r-f output signal. The resultant r-f output pulse from the signal generator is of good quality at r-f frequencies above 100 megacycles, is free of transients, and has low residual signal between pulses. On pulse operation the signal generator produces essentially no r-f output signal until an external positive pulse is applied to the EXT.PULSE connector.

When modulation signals are applied to the EXT.PULSE connector, neither the MOD.LEVEL control nor the PERCENT MODULATION meter can be used. However, any pulse above 5 volts amplitude will 100% modulate the r-f output signal, and the peak level of the r-f pulse will be within 1 db of the CW level established by the settings of the OUTPUT LEVEL control and the output attenuator.

Step-by-Step Procedure, Pulse-Modulation

- a. Follow complete step-by-step procedure for CW operation.
- b. Set the MOD.SELECTOR to the PULSE position.
- c. Connect modulating source to EXT.PULSE connector on front panel.

2-9 CRYSTAL-CONTROLLED BEAT-FREQUENCY CALIBRATOR

The frequency (MEGACYCLES) dial in the 608D Signal Generator is calibrated to be accurate within $\pm 0.5\%$. To obtain higher accuracy, a crystal-controlled calibrator has been included to provide the operator with a means for setting the MEGACYCLES dial calibration "on frequency" at any multiple of 1 or 5 megacycles over the entire frequency range of the signal generator.

To utilize the calibrator, a standard 600-ohm headphone (not furnished) is required. The XTAL CAL. OUTPUT jack accommodates a telephone-type two-contact plug.

Basically, the calibrator provides either a 1-mc or a 5-mc signal accurate to $\pm 0.01\%$. By heterodyning this signal with the output frequency, a beat-frequency check point is produced at every integral multiple of 1 or 5 megacycles. Right "on frequency" appears as zero beat.

For best accuracy the MEGACYCLES dial should be set "on frequency" on the calibration line nearest the frequency to be used. The MEGACYCLES dial cursor can be adjusted a small amount each side of center by means of the cursor adjustment to the left of the MEGACYCLES dial (see reference 22 on Figure 2-1).

A volume control, XTAL CAL.GAIN, is provided for adjusting the level of the audio voltage applied to the headphone.

2-10 SIGNAL GENERATOR LOADING CONSIDERATIONS

A resistive load of 50 ohms was used during calibration of the 608D output attenuator dial. Therefore for accurate indication of output power, the external load should be 50 ohms resistive.

The internal impedance of the generator is sufficiently close to 50 ohms that in the worst case a VSWR of only 1.2 (SWR of 1.6 db) exists when the generator is terminated in 50 ohms. This magnitude of VSWR

will have no important effect on the accuracy of attenuator dial calibration. However, if the value of the load is not known and if best accuracy in measurements is desired, it is necessary that the standing wave ratio in the line to the load be minimized.

Table 2-2 shows the calculated power loss when the load on the signal generator causes a voltage standing wave ratio of the magnitude shown. The VSWR values shown are a comparison between a load and a 50-ohm transmission line. The minimum loss figures are based on a mismatch of 1.2 VSWR between the signal generator and transmission line. Mismatches causing the voltage standing wave ratios given in the left-

hand column will result in power losses somewhere between the limits shown in the other two columns. The maximum loss shown is the total loss from the maximum power available from the generator for a given setting of the output attenuator and includes the possible generator VSWR of 1.2. The data does not allow for transmission line to load losses, as in most cases such losses are small enough to be unimportant.

It will be seen that when the load is matched to the transmission line (VSWR = 1.0) the loss from the maximum power available from the signal generator is approximately 0.06 db in the worst case. Although

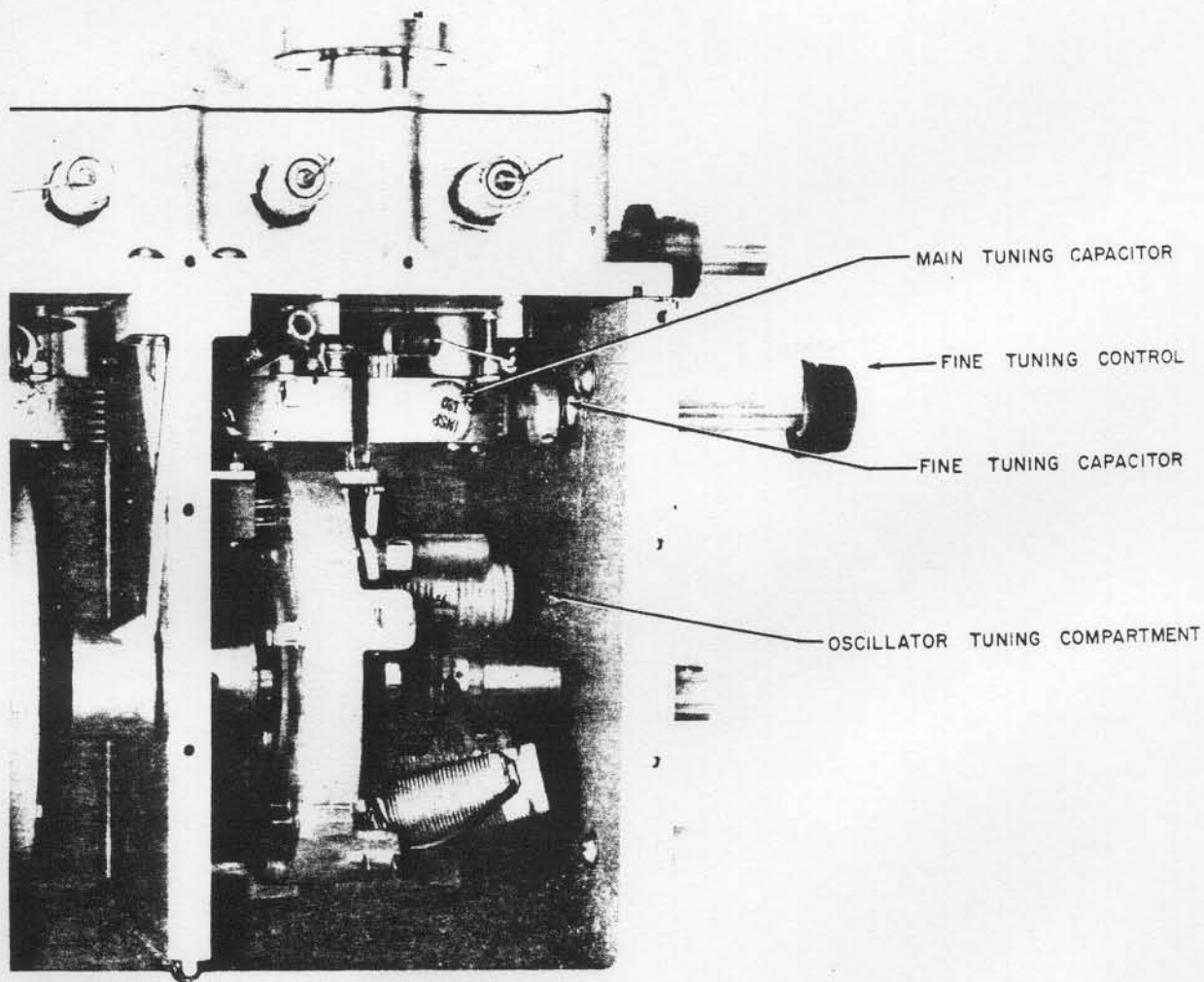


FIGURE 2-3. RF-OSCILLATOR COMPARTMENT SHOWING FINE FREQUENCY TUNING CONTROL

the losses as shown in db are not great numerically, it should be noted that they may represent a considerable difference between the voltage calibration of the output attenuator dial and the actual voltage impressed across the external load.

TABLE 2-2. VSWR AS POWER LOSS

VSWR in 50-ohm Line	Min. Power Loss	Max. Power Loss
1.0	.06 db	.06 db
1.5	.08 db	.37 db
2.0	.3 db	.85 db
2.5	.6 db	1.3 db
3.0	.9 db	1.7 db
4.0	1.5 db	2.4 db
5.0	2.0 db	3.1 db

In most cases when making measurements on receivers designed to work from a 50-ohm line and antenna, the standing wave ratio in the line from the signal generator to the receiver is not significant. The reason for this is that any power reflected from the receiver back towards the generator represents a deficiency in receiver design, and the amount of power lost in such cases is considered as a loss subtractive from the gain of the receiver. A factor, sometimes overlooked, which contributes error in high-frequency measurements is the improper assembly of coaxial connectors. A standing wave ratio of several db can often be attributed to this cause.

2-11 FINE FREQ. ADJUST. CONTROL

Model 608D Signal Generators with serials 104 and above are equipped with a short range incremental tuning device (FINE FREQ.ADJUST) for making extremely small changes in the output signal frequency. The fine frequency tuner is operated from the front panel by a small knob to the left of the main frequency control knob. This control adds a very small capacity to the existing capacity in the oscillator tank, the change occurring over 180° rotation of the knob. When the dot points to the left, the vernier capacity is maximum; when the dot points to the right, the capacity is minimum. The main frequency dial calibration is accurate when the dot on the knob is aligned with the dot on the front panel.

When the signal generator is operated at the high ends of the frequency ranges and when the finest possible control of frequency is required, adjust the main frequency control very close to the desired frequency with the vernier set slightly above minimum capacity, i. e., dot pointing to right; then adjust the vernier control for the exact desired frequency. When operating at the low ends of the frequency ranges the effectiveness of the vernier is decreased and must be used at near maximum capacity.

Figure 2-3 shows the vernier device as it is mounted within the oscillator tuning compartment of the r-f generator assembly. The fine frequency tuner consists of a small metal disk mounted off center at the end of a bakelite control shaft. The shaft is mounted level with the oscillator tuning capacitor which is about 1/2-inch away. As the shaft is turned, the disk moves closer to or farther from the tuning capacitor to increase or decrease the capacity in the tuned circuit.

SECTION III

THEORY OF OPERATION

3-1 GENERAL

The electrical circuits of the Model 608D Signal Generator are divided into the sections shown in the block diagram in Figure 3-1, plus a power supply which is not shown. Briefly, the operation is as follows:

A Colpitts oscillator supplies signals to a buffer amplifier. Output of the buffer amplifier is supplied to a power amplifier. The buffer amplifies oscillator output and isolates the oscillator from the power amplifier. Output of the power amplifier is applied to an attenuator and supplied to output connectors.

A tone modulator, having output frequencies of 400 and 1000 cps, can be used to modulate the output signal. High level cathode modulation is used; i.e., modulation occurs in the last rf amplifier. A 100 percent modulation is thus possible.

An OUTPUT VOLTS meter is supplied rectified rf and gives an indication as to the rf input to the attenuator. This allows the operator to set any reference level and have variable calibrated attenuation in dbm for any output voltage. Percentage modulation can be read directly on a percent modulation meter. The meter indicates the percent modulation of the signal to input of the attenuator, and is thus accurate for any setting of the attenuator.

Exact frequency settings can be made by using the 5 or 1 mc calibrator. The calibrator gives accurate 5 or 1 mc harmonics over the range of the frequency dial. By connecting an earphone to the XTAL CAL. OUTPUT, harmonics can be heard zero-beating with the dial frequency and an exact dial frequency can be set.

00171-2

3-2 RADIO FREQUENCY OSCILLATOR

The Colpitts oscillator generates a sine-wave signal from 10 to 420 megacycles in five frequency bands, each band having approximately a 2:1 frequency range. A type 5675 "pencil" triode tube is used in a Colpitts circuit tuned by a precision split-stator capacitor (plate-meshing type) and five separate r-f transformers, L1 through L5. The tuning capacitor, which is specially constructed for high stability and resettability, consists of two stator sections connecting to the grid and plate of the oscillator tube and a floating rotor which meshes equally between the two stators. The tuning capacitor assembly, mounted inside and near the top of the tuning compartment in the r-f generator housing, is driven by a ball bearing mounted worm drive through the top of the housing.

The tuned coils consist of precision-wound, plated wire on 5/8-inch diameter ceramic forms on the A, B, and C bands and of silver-plated Invar loops on the D and E bands. The five inductors are mounted on a revolving turret actuated by the FREQUENCY RANGE selector.

When the turret is rotated, the desired coil is positioned in the tuned circuit just below the oscillator tube and tuning capacitor, connections being made through large silver contacts mounted directly on the bottoms of the two stators of the tuning capacitor. (Two sets of these contacts are identified in Figure 4-13.) Both ends of the tuning inductor and capacitor are at r-f and d-c potential, with no part of this circuit grounded.

Oscillator tube V6 is operated across the -165 volt and +225 volt supplies with considerable series resistance to limit the maximum plate current that can flow. The plate is series-fed through a

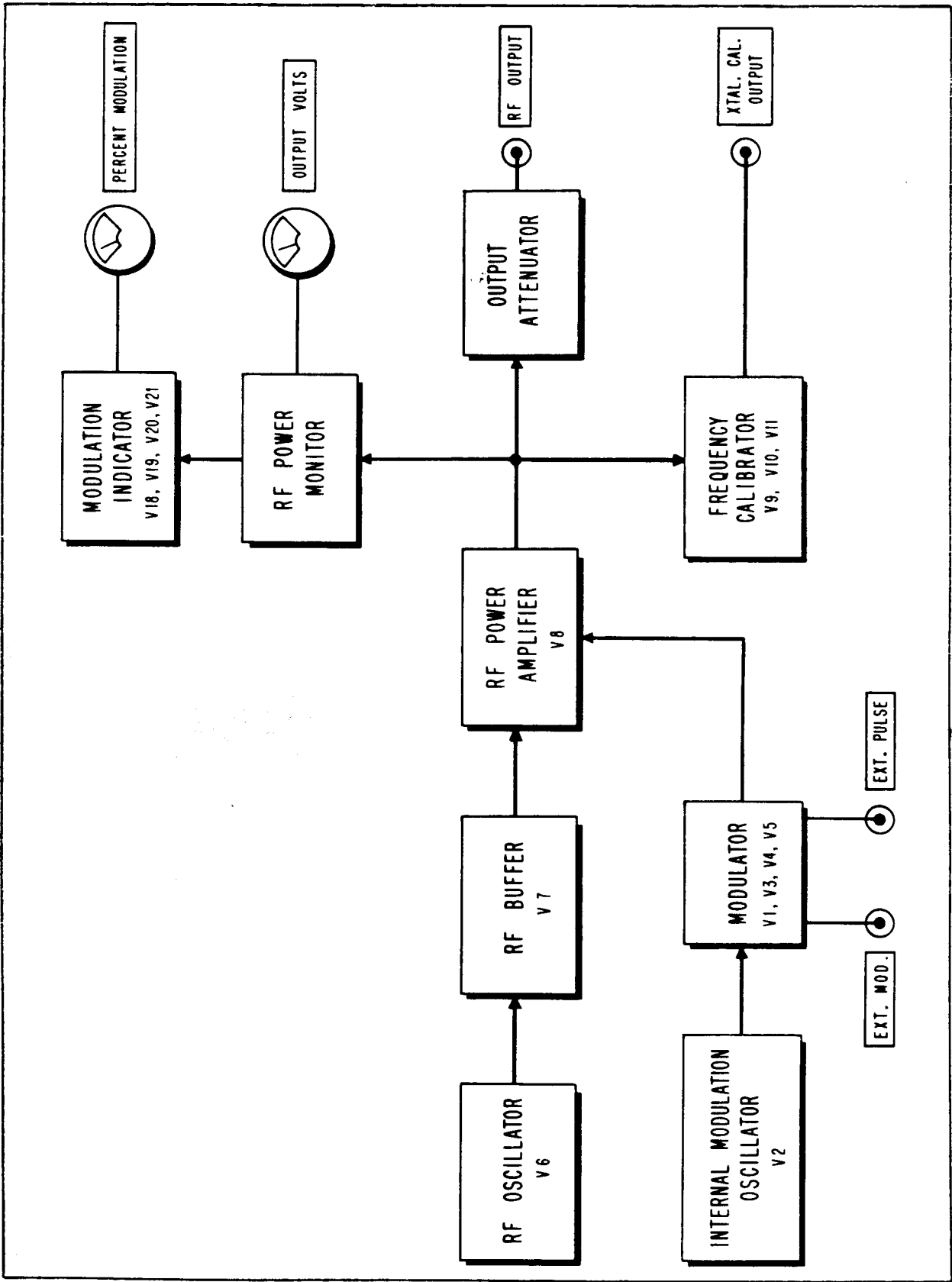


FIGURE 3-1. BLOCK DIAGRAM FOR SIGNAL GENERATOR 608D

3000-ohm resistor, R45, which also serves to isolate the tuned circuit from r-f ground at C15, while the cathode is returned to -165 volts through R42 and R43. Cathode bypass capacitor C25 is actually part of the tube mounting plate and is not visible when the mounting plate is in position. R42 prevents resonance in the cathode lead; R43 in conjunction with R45 limits the maximum plate current that can flow through V6. Bias for the control grid is obtained across grid leak resistor R44, which under usual conditions develops approximately 70 volts of bias. C16 couples the tuning coil to the grid, the r-f drive being determined by the ratio of grid-plate to grid-cathode impedance. These impedances consist partly of interelectrode capacity and largely of lumped constants in the tuned circuit. The grid-plate capacity is shunted by the tuned circuit and a small trimmer capacitor C18, while the grid-cathode capacity is shunted by trimmer capacitor C59. C18 sets the minimum capacity of the tuned circuit and is used to adjust the high-frequency limit of all bands when the oscillator tube is replaced. C59 is an additional adjustment usually set for minimum capacity and requiring no readjustment. This capacitor has minor effect on the grid drive at the high frequency ends of the bands and is usually set for maximum drive. C68, the FINE FREQ.ADJUST control, adds a very small capacity to the existing capacity in the oscillator tank by rotating a small eccentric aluminum disk closer to or farther from the stator of the main tuning capacitor. The inductance of each tuned inductor is variable over a small range by adjusting a single shorting turn on each coil for the A, B, and C bands, and by adjusting the size of the single loops for the D and E bands. These adjustments are used at the factory to set the high-frequency limit of each frequency band.

Stable heater voltage for the oscillator tube is obtained from a regulated dc supply. All power to the oscillator tube is brought through the housing by special filters which have high attenuation to radio frequencies to prevent radiation of the r-f energy outside the instrument.

The r-f generator is enclosed in a housing located on the left side of the chassis. The tuned circuits for the oscillator are located in the lower front compartment, the other circuits in the tube compartment above. An inside view of the r-f generator assembly is shown in Figure 4-13. The oscillator tube is mounted through the top of the tuning compartment so that the grid and plate elements project through the top plate into the tuning compartment, while the heater and cathode elements remain above the top plate. Mounting facilities are contained in the upper compartment, and the tube may be replaced from the upper compartment without entering the tuning compartment.

3-3 RADIO FREQUENCY BUFFER

The loosely-coupled secondary winding on each of the oscillator coils couples r-f energy from the oscillator through a coaxial cable to the buffer stage, located in the tube compartment in the top of the r-f generator housing. The buffer tube, V7, is a type 6BC4 miniature triode connected as an untuned grounded-grid amplifier and serves to isolate the oscillator circuit from the effects of the modulation signal at the cathode of the power amplifier. The use of the buffer reduces incidental frequency modulation to an extremely small value.

Although buffer tube V7 utilizes a large cathode resistor (R116, 7500 ohms), it operates with practically zero bias and relatively high plate current. R116 holds plate current constant for a wide range of tube characteristics and in conjunction with R47, a dropping resistor in the plate supply lead, serves to limit plate current to safe values. Resistors R46, R108, R109, R110, and R112, which are mounted on the coils for each band, damp unwanted resonance in the cathode lead. Resistors R111 and R113 shunting the A and B band coupling coils limit the somewhat greater r-f drive from these coils. The plate of the buffer is coupled to the cathode of the r-f amplifier through a wide-band coupling network consisting of coil L8 with damping resistor R13, series coil L9 with blocking capacitor C29, and shunt peaking coils L10 and L11. Resistors shunting the peaking coils are used as the forms for the windings. The resistor values are selected to damp the resonant peaks of the coils.

3-4 RADIO FREQUENCY POWER AMPLIFIER

Radio frequency power amplifier V8 amplifies the r-f energy, received from the buffer, for application to the r-f output attenuator. The circuit consists of a 5876 "pencil" triode connected as a grounded-grid, cathode-modulated amplifier. The plate circuit of the amplifier is tuned in the same manner as the oscillator, with a similar split-stator capacitor and five untapped coils mounted on a revolving turret. The amplifier tuning capacitor is ganged with the oscillator capacitor by a double-ended worm drive. The amplifier capacitor is provided with a mechanical linkage, controlled from the front panel (AMP. TRIMMER control), to shift the rotor plates from the normal tracking position with respect to the oscillator. This control allows the amplifier tuning to be separately adjusted for maximum output at all frequencies. The coil mounting turret is ganged with that of the oscillator. Tuned coils are wound with copper wire on teflon forms, and the coil in use is so located that the signal is inductively coupled to the output attenuator probe.

The power amplifier tube is operated across the -165V and +225V supplies. The plate is series fed from the 225-volt supply through R57 and bypassed by C33. The cathode is returned through a portion of the wide-band coupling filter and resistors R35 and R36 to the -165V supply. R36 matches the higher impedance of the cathode circuit of V5 to the lower impedance of the cathode circuit of V8, while R35 is the cathode bias-developing resistor. R35 is also the cathode load resistor for control tube V5, and the bias voltage developed across R35 is largely controlled by the current established in V5. The modulating signal is also developed across R35 and with the bias voltage is fed to the cathode of V8. Crystal diode CR7, connected between the cathode return circuit and ground, limits the lowest potential to which the cathode can be driven. This arrangement protects V8 from the effects of any negative switching transients which might be applied to its cathode. The plate tank is tuned by C17B. C32, a small trimmer capacitor across C17B, sets the minimum capacity and is provided for adjusting the tracking of the highest frequency band so that minimum operation of the AMP.TRIMMER control is required. The inductances of the tuned coils can be adjusted over a small range by means of metal sleeves between the cores and coils on the B, C, and D bands and by altering the winding shape and size on the A and E bands. These adjustments are set at the factory to track the low-frequency end of each band with the frequency of the oscillator.

Heater supply voltage for the r-f amplifier, buffer, and oscillator is obtained from the regulated heater-supply. Filter FL9 in the heater circuit reduces incidental frequency modulation by preventing leakage of modulating signals between the heaters of the oscillator and amplifier tubes. The tuned circuits of the r-f amplifier are contained in the rear compartment of the r-f generator housing. The other amplifier circuits are located in the compartment above. The amplifier tube is mounted through the top of the tuning compartment so that the plate element projects through the top plate into the tuning compartment. The heater and cathode elements are in the upper compartment and the tube may be replaced without entering the tuning compartment.

3-5 OUTPUT ATTENUATOR AND R-F POWER MONITOR

To extract power from the r-f power amplifier a piston attenuator is used. The housing for the attenuator projects through the rear of the r-f generator housing and terminates, open-ended, close to the r-f amplifier plate circuit inductor. A single-turn, pickup loop at the end of the attenuator probe couples energy to an impedance-matching network (C37, R59,

C69, and R58) mounted on the face of the probe and through a section of double-shielded coaxial cable to the RF OUTPUT connector. Adjustable capacitor C37 is actually a movable slug in the probe body. It allows minor adjustment of the internal impedance of the generator so that the standing-wave ratio is minimum when the output connector is terminated in a 50-ohm load. Capacitor C69 prevents possible pickup of spurious signals by eliminating a ground loop between the RF OUTPUT connector and attenuator probe ground.

The r-f power applied to the attenuator is sampled and continuously monitored by an antenna (two parallel wires crossing the open end of the attenuator housing) connected to a small detector assembly mounted under the housing inside the r-f amplifier tuning compartment. The level of this power is indicated in both volts and decibels, over a limited range, on the front panel OUTPUT VOLTS meter. A calibration mark on the meter marked SET LEVEL indicates the correct amount of power into the attenuator for direct reading of the output attenuator dial calibrations.

Radio-frequency energy is coupled from the power monitoring antenna to a detector through L17, a small coil used to adjust the frequency response of the detector circuit. Crystal diode CR2 with return resistor R60 rectifies the radio-frequency energy and produces a d-c voltage equal to half the peak-to-peak r-f voltage. C38 and filter FL8 remove the remaining r-f component and couple the d-c voltage to a compensating network, R119, CR3, and R61. FL8 is specially designed to attenuate all radio frequencies above approximately 3 megacycles and to pass all frequencies below that frequency with little or no attenuation. CR3 corrects for nonlinearities in detector CR2 when the r-f signal level is low and detection takes place in the nonlinear region of the CR2. The degree of compensation is set by potentiometer R61 which is adjusted to obtain accurate down-scale readings on the front panel power level meter. M1 is calibrated to indicate the rms value of the r-f output signal. Potentiometer R62 adjusts the calibration of the meter. When R62 is set at the factory, accurate external vhf power measuring equipment is utilized for the calibration procedure (see paragraph 4-15).

3-6 XTAL (BEAT FREQUENCY) CALIBRATOR

The calibrator consists 1) of a 5-mc crystal-controlled oscillator, a 1-mc oscillator, and a detector (located in the r-f amplifier tuning compartment) and 2) of 80-db resistance-coupled amplifier (located on the right side chassis of the instrument).

The 5-mc section of the calibrator is a crystal-controlled electron-coupled oscillator utilizing the pentode half of a type 6U8 tube. Both the plate and screen circuits are tuned to the crystal frequency of approximately 5 megacycles. Limited adjustment of the crystal frequency is provided by trimmer C23 connected across the crystal. The 1-mc section (triode half of the 6U8) is designed for maximum stability, and is so adjusted (paragraph 4-10) that its fifth harmonic locks in with the 5-mc signal from the crystal-controlled oscillator. This arrangement of the calibrator ensures a source of accurate 5-mc and 1-mc signals for calibration purposes.

The output of the calibrator is coupled through blocking capacitor C24 to the cathode of mixing diode CR1. The signal from the r-f power amplifier is inductively coupled to the anode of the mixing diode by running the anode lead of the diode close to the r-f amplifier circuits. Harmonics generated in the crystal are mixed with the r-f signal to produce beat-frequency signals across R50.

Beat frequency signals from the mixing diode are taken through r-f filter FL7 in the r-f generator housing to a conventional three-stage resistance-coupled amplifier consisting of V10 and V11, high- μ twin triodes connected in cascade and located on the rear chassis. Only one half of V10 is used, the remaining half being grounded. Due to the extremely high gain (approximately 80 db) of the amplifier, grounding of the input circuits is extremely critical. The load resistor (R50) for mixer diode CR1 and the cathode and grid return resistor (R51) for V10 are not grounded near the tube socket but are connected to the shield of the input cable which in turn is grounded at the r-f generator housing, as shown on the schematic diagram. Potentiometer R56 in the grid circuit of the last amplifier stage controls the volume of the beat-frequency output signal. The signal from output stage is coupled through 600-ohm line-matching transformer T3 to the front panel XTAL CAL.OUTPUT jack.

3-7 MODULATOR

General

The purpose of the modulator section is threefold: to generate 400- and 1000-cycle sine waves for internal modulation of the generator; to amplify all modulation signals for application to r-f power amplifier V8; to control the level of power from r-f amplifier V8 for all types of operation by varying the bias on power amplifier V8. The modulator consists of a resistance-tuned oscillator, V2, a limiter and a single-stage video amplifier, V1 and V3, and a cathode follower output stage and output level control

tube, V4 and V5. The modulator circuits are located along the upper portion of the right side chassis; the oscillator on the bottom portion.

Modulation Oscillator

A Wien bridge oscillator is used to generate 400 and 1000 cps tones. The circuit consists of a two-stage resistance-coupled amplifier which is caused to oscillate by frequency-selective positive feedback. At the resonant frequency there is no phase shift in the positive feedback, thus voltage of the resonant frequency on the grid of the first tube is reinforced by the output of the second tube and oscillation occurs.

A change in frequency is obtained by inserting different sets of resistors, R3 - R5 or R4 - R6, into the positive feedback network when the MOD. SELECTOR is turned from 1000 cps to 400 cps. Precision resistors having good stability are used in the positive feedback network, a negative feedback circuit is also used to stabilize the oscillator, reduce distortion, and to maintain a constant output level. This circuit consists of a 10-watt lamp, I1, used as a thermal resistance, R8 and R7. The high positive temperature coefficient of the lamp provides automatic amplitude control of the signal. If the amplitude of oscillation increases, current through the lamp increases, thereby increasing the lamp's resistance. Consequently, the negative feedback increases and amplitude of oscillation is maintained constant.

The Wien bridge amplifier consists of two medium- μ triodes, V2A and B, arranged in a conventional resistance-coupled circuit with the output voltage being obtained from the cathode of the second stage. Although heater voltage is applied to the oscillator at all times the 608D is in operation, plate voltage is applied to V2 only when the MOD. SELECTOR switch is in the 400- or 1000-cycle position.

The sine-wave signal from the modulation oscillator (or from an external signal source) is coupled through the MOD.LEVEL control and capacitor C1 to limiter tube V1, a 6BQ7 twin triode.

Limiter

The purpose of V1 is to limit the peak amplitude of modulating pulses, since for pulse modulation the input signal is fed directly to the grid of limiting amplifier V1 without passing through the MOD.LEVEL control. The limiting action of V1 begins at approximately +2 volts peak which is considerably more than that required for 100% modulation of the output signal. Consequently, signals producing less than

100% modulation pass through the limiter unchanged. Limiting effectively squares the top of an incoming positive waveform above approximately 2 volts without affecting its rise and fall or introducing transients. The uninverted signal from amplitude limiter V1 is then amplified approximately 18 db by V3, a resistance-coupled 6CL6 pentode voltage amplifier, and coupled to output cathode follower V4, a triode-connected type 6CL6 pentode.

Output, Sine-Wave Modulation

For sine-wave modulation the signal from the cathode of V4 is coupled through sections E and F of MOD. SELECTOR switch S1 to the grid of output level control tube V5.

In V5, which is the bias supply for the 608D output power amplifier, V8, the modulating signal is superimposed on the bias for V8. Since the cathodes of V5 and r-f power amplifier V8 are connected, any signal placed on the grid of V5 is directly coupled to the cathode of V8.

Output Level Control

The d-c voltage level at the cathodes of V5 and V8 is determined largely by the current flowing in V5. Conduction in V5 is controlled by the voltage divider (R34, two-section variable resistor R37, and R40) in the V5 grid circuit. The setting of R37 is adjusted by means of the OUTPUT LEVEL control on the front panel. Thus the cathode bias for V8, and consequently the level of the r-f output signal, is varied by means of the OUTPUT LEVEL control.

Output Pulse Modulation

At most settings of the MOD.SELECTOR, V4 is returned to the -165V supply through resistor R33. As soon as MOD.SELECTOR is set at PULSE, the cathodes of V4, V5, and V8 are connected, and are returned to the -165V supply through R35. The three tubes are conducting, and the increase in current through R35 produces a sufficiently high bias to cut off output power amplifier V8, reducing the r-f output to zero.

The incoming pulse, positive at input connector EXT. PULSE, is inverted in V3, and the pulse applied to the grid of V4 is negative. V4 cuts off, and potential on the cathode of V8 returns to the pre-pulse (or CW) level. An r-f output pulse having an envelope shaped like the input pulse is then formed.

With the 608D set for pulse modulation, V5 serves only to control the peak level of the r-f output pulse; no pulses are applied to the grid of V5.

3-8 MODULATION-MEASURING CIRCUITS

The modulation-measuring circuits in the 608D indicate any modulation of the r-f output signal between 0 and 100% to an accuracy of $\pm 10\%$ or better. These circuits consist of a stabilized wideband amplifier and a bridge-type metering circuit. The measuring circuit reads the peak value of the rectified modulation signal. The meter is calibrated to indicate the percent modulation of a given amount of r-f carrier power. This amount is designated SET LEVEL on the OUTPUT VOLTS meter. With OUTPUT VOLTS indicating on SET LEVEL, the reading of the PERCENT MODULATION meter will be accurate for all settings of the output attenuator.

A modulation meter amplifier consisting of an r-c amplifier V18 and V19, is stabilized by negative feedback. The amplifier gives approximately 22 db gain up to 2 mc. The feedback line consists of R99 and C55. Output of the modulation amplifier is applied to a balanced bridge detector.

The circuit for the bridge consists of diode rectifier V20 and twin-triode V21, the two triodes constituting two legs of the meter bridge. With no modulation signal applied to the amplifier, the steady-state d-c potential at the plate of amplifier V19 is coupled to the grids of both sections of V21. With equal current flowing in the two sides of the bridge, the bridge is balanced and the meter reads zero. Potentiometer R106 is a front panel zero adjustment of the bridge that provides for variations in tube and component values. A modulation signal from amplifier V19 is rectified by diode V20, and the peak value of the rectified voltage is applied to the triode in one leg of the bridge, unbalancing the bridge and causing the meter to read upscale. The triode in the other leg of the bridge is unaffected by the modulation signal as the signal is filtered out by resistors R100, R101 and by-pass capacitor C58. Potentiometer R104 is adjusted for correct calibration of the meter (see paragraph 4-14).

3-9 POWER SUPPLY

Power for the signal generator is supplied by three regulated dc supplies. A -165 volt supply is the reference for +225 volt and 6.3 volt supplies.

Each regulator is supplied from a full-wave bridge-type silicon rectifier connected across a high-voltage secondary winding on power transformer T1. The power transformer also supplies a-c voltage for all electron tube heaters except the r-f oscillator and power amplifier. The primary winding of T1 is

divided into two parts and may be operated in series for 230-volt lines or in parallel for 115-volt lines. The output of each regulated supply is adjustable, by screwdriver-adjusted potentiometers R80 (+225V) and R71 (-165V) accessible on the rear instrument chassis. The +225V supply uses the -165V supply for reference voltage, and consequently a change in the -165V supply also affects the output from the +225V supply.

Since the -165 and +225 volt supplies are identical in operation, only the -165V supply will be discussed. V14, V15, and V16 constitute the voltage regulator circuit for the -165V supply. V15 is a constant-voltage tube which provides a reference bias for voltage amplifier V14. V16A operates as the regulator tube (or variable resistor) controlled by the voltage at the grid of V14. If the regulated output from the cathode of V16A tends to increase, the voltage at the grid of V14 tends to increase, causing V14 to draw more current. This lowers the plate voltage of V14 and consequently the grid voltage of V16A, resulting in a greater plate resistance for V16A. The greater plate resistance causes a greater voltage drop across V16A, instantaneously compensating for the increased voltage at its cathode and resulting in a substantially constant voltage output. If the regulated output tends

to decrease, the reverse of the above action occurs, also tending to maintain the cathode voltage constant.

Ripple in the output voltage is coupled to the grid of V14 by capacitor C44, while slower variations in the d-c level are fed to the grid of V14 through voltage divider R79, R80, and R81. The bias for V14, and thus the output voltage level from V16A, is determined by the setting of R80.

Operation of the +225-volt supply is similar to the -165-volt power supply, but due to the additional current required (approximately 150 ma), three regulator tubes (V13A and B, V16B) must be used in parallel. The reference voltage for the +225 volt supply is obtained directly from the -165 volt supply.

3-10 HEATER SUPPLY MULTIVIBRATOR

Constant amplitude heater voltage is supplied to V6, V7, and V8 by a regulated supply consisting of CR16 through CR19, Q1, and reference diode CR20. Diode CR20 supplies the base of Q1 with a constant voltage. Since the transistor configuration is an emitter follower, the emitter remains at the same potential (+0.3V), as the base.

SECTION IV MAINTENANCE

4-1 INTRODUCTION

Section IV contains instruction for preventive maintenance, trouble localization, tube replacement procedures, and internal adjustments in the Model 608D VHF Signal Generator. To assist with servicing the signal generator, a trouble-shooting chart which indicates certain possible specific troubles and their symptoms and a signal-tracing block diagram are included. At the end of this section will be found additional locating illustrations, tube socket voltage and resistance diagrams, and the schematic diagram for the complete equipment. The following information can be found in this section:

- 4-2 Cabinet Removal
- 4-3 Periodic Checks and Routine Care
- 4-4 Localizing Trouble
- 4-5 Power-Supply Trouble Shooting and Adjustment
- 4-6 System Analysis Check Chart
- 4-7 Replacement of Electron Tubes
- 4-8 Radio Frequency Oscillator Tube Replacement
- 4-9 Radio Frequency Amplifier and Buffer Tube Replacement
- 4-10 Xtal Frequency Oscillator Tube or Crystal Replacement
- 4-11 Replacement of Power-Supply Tubes
- 4-12 Attenuator Probe Repair and Replacement
- 4-13 Replacement of Lamp I1
- 4-14 Calibration of Percent Modulation Meter
- 4-15 OUTPUT VOLTS meter Calibration and R-F Power Monitor Service
- 4-16 Calibrator Oscillator Repair
- 4-17 Trouble Shooting Chart

4-2 CABINET REMOVAL

To remove the instrument chassis from the cabinet, loosen the four captive screws (Figure 4-1) on the rear of the cabinet and pull the instrument from its cabinet by guard-rail handles. The rear of the instrument chassis is supported on steel rollers and should move freely from the cabinet.

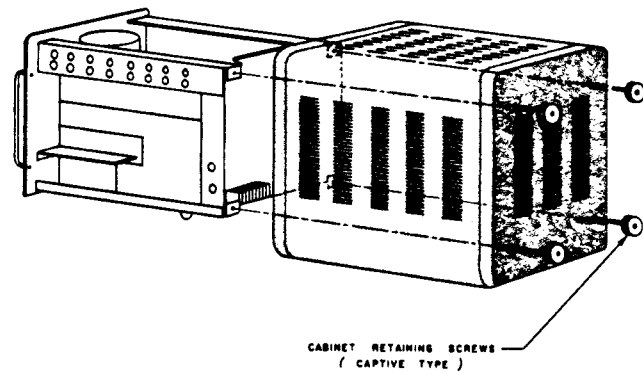


FIGURE 4-1. CABINET REMOVAL

4-3 PERIODIC CHECKS AND ROUTINE CARE

Preventive Maintenance

Reasonable care in transporting, handling, and operating the 608D will help to prolong its useful life and minimize trouble. No special checks are required other than a general alertness for effects from misuse, loose controls, worn cables and connectors, or possible damage that may be evident from the general appearance.

A limited but useful operational check may be performed without the use of external equipment by operating the equipment as instructed in paragraph 2-6, indications of normal operation being read from the two front panel meters.

If the equipment has been subjected to unusual conditions (excessive moisture, dust, heat, vibration, etc.) it is suggested that the instrument be removed from the cabinet and inspected for dirt or moisture accumulation, loosened components, or any possible sign of damage. Forced air under medium pressure is recommended for dusting and drying, although care must be taken not to vary the settings of the internal-adjustment potentiometers and capacitors during the process.

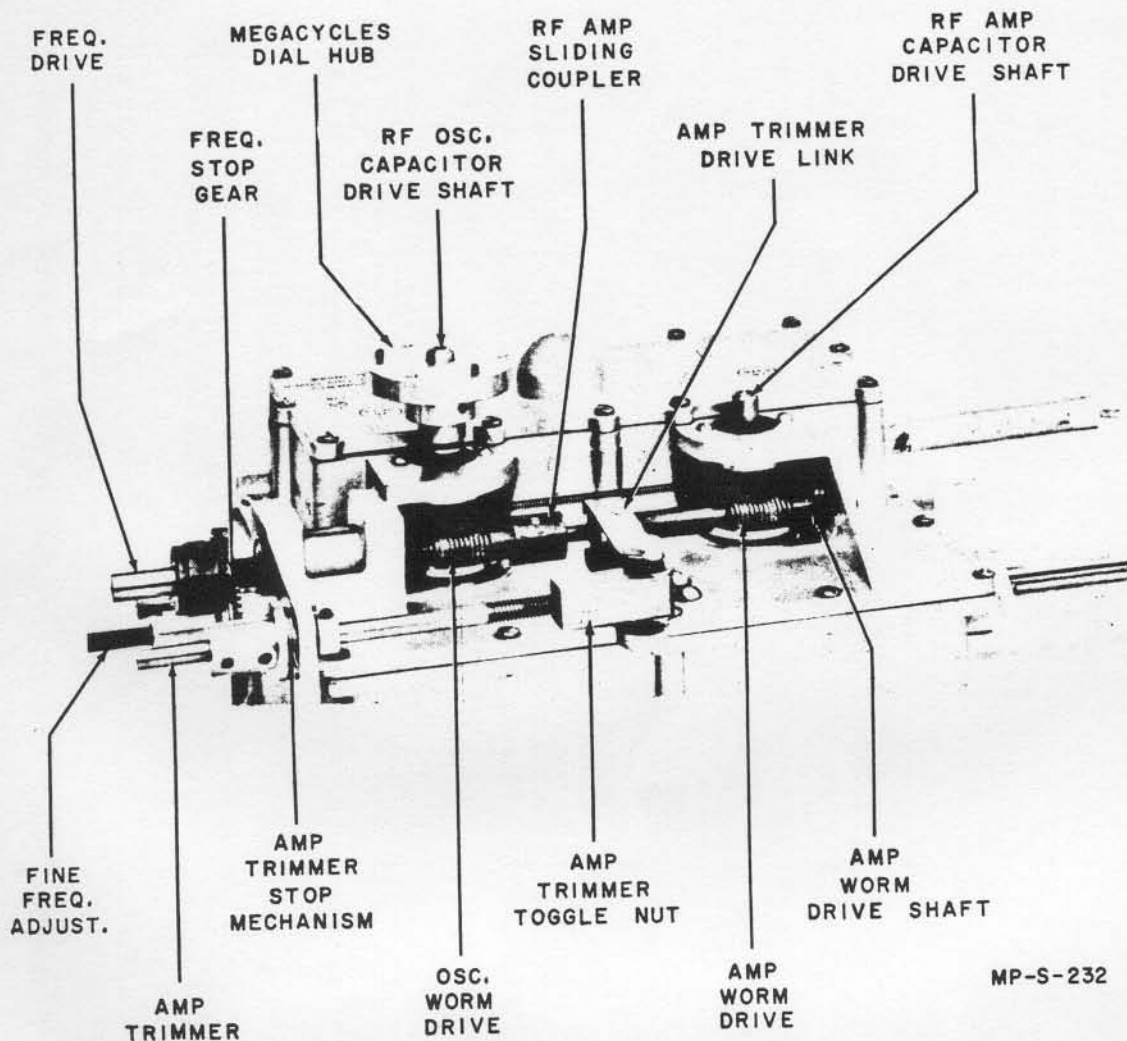


FIGURE 4-2. R-F TUNER DRIVE MECHANISM

When tightening nuts and screws, various degrees of pressure are required depending on the strength of the material and weight which is supported. Avoid overtightening.

Lubrication

The 608D is thoroughly lubricated at the factory. Fully shielded ball bearings are used in many applications and require no subsequent attention. Ball bearings that are not fully shielded require only light machine oil.

After prolonged use of the instrument, lubricated points should be checked for excessive dust accumulation or drying of lubricant. The following chart and Figures 4-2 and 4-7 will assist in the location of the various points of the r-f generator assembly which may need cleaning and/or relubrication.

The two worm gears used in the tuning-capacitor drive should be cleaned and lubricated approximately every sixty days. This maintenance is particularly important when the instrument is operated continuously or for several hours daily. Calibration accuracy and instrument dependability can be maintained only by proper lubrication of the two worm gears in the tuning mechanism.

Other rubbing surfaces and sleeve bearings, including the small pulleys used in the attenuator drive system, should be lubricated quarterly with a light slideway oil such as Shell Tonna G. In all cases, avoid overlubrication.

TABLE 4-1. LUBRICATION CHART

Lubrication Point (See Figures 4-2 and 4-7)	Lubricant
Oscillator and amplifier worm gears	"Moly Lubricant" #1.
AMP.TRIMMER stop mechanism	Light way oil, such as Shell Tonna G and light temp grease, such as General Petroleum BRB#1
AMP.TRIMMER toggle nut	Light way oil, such as Shell Tonna G
AMP.TRIMMER drive link	Light way oil, such as Shell Tonna G
AMP. worm drive shaft	Light way oil, such as Shell Tonna G
RF AMP. sliding coupler	Light way oil, such as Shell Tonna G
Attenuator pulleys	Light way oil, such as Shell Tonna G
* Attenuator drive shaft bearing (front)	Light way oil, such as Shell Tonna G
* Attenuator drive shaft bearing (rear)	Light way oil, such as Shell Tonna G
* Not shown on referenced figures.	

4-4 LOCALIZING TROUBLE

The first step in correcting any trouble which may occur in the signal generator is to isolate the section of the equipment that causes the trouble. The various circuits of the 608D occupy easily defined areas and offer very good circuit accessibility. Figures 4-13 and 4-14 will prove helpful in locating circuits within the r-f generator housing. Isolation of a circuit failure is best accomplished by considering the basic sections shown in the block diagrams in Figures 2-2 and 3-1.

4-5 POWER SUPPLY TROUBLE SHOOTING AND ADJUSTMENT

A systematic trouble-localization procedure is outlined in Table 4-2. The typical values given were obtained with a reliable 5,000 ohm/volt multimeter.

When the correct voltage reading (shown in the second column) is obtained, the particular circuit tested may

be assumed to be operating properly. The condition which results in an incorrect or unstable voltage indication should be corrected as instructed in the service note in the third column. Components are identified in the Figures referenced in the first column.

All voltages are measured between the indicated point and chassis ground. When possible, use a variable voltage line transformer to adjust the line voltage from 105 to 125 volts while measuring the power-supply voltages. Marginal operation is quickly detected in this manner, since the regulated voltages should remain stable during such line voltage changes. The power-supply circuit is shown in block diagram form in Figure 4-3.

4-6 SYSTEM ANALYSIS CHECK CHART

The schematic diagram, Figure 4-19, includes a series of test points. Table 4-3, a system analysis check chart, lists the test points and the measurement data taken at each point.

TABLE 4-2. POWER SUPPLY TROUBLE-SHOOTING CHART

Measure Voltage At:	Normal Indication	Service Note
1. T1 (filament windings) Figure 4-12	6.3 volts ac rms	This voltage should be between 6.2 and 6.3 volts rms when the line voltage is 115 volts. A noticeably higher or lower voltage indicates that the line voltage is significantly more or less than 115 volts.
2. C45 (across terminals) Figure 4-11	-165V dc (regulated)	This is a stable regulated voltage set to -165V by adjustment of R80. If this voltage is significantly high, low, or erratic, check voltage across V15; it should be a steady 90 volts. For excessively high output, check V14; for too low output check V16A and the output of CR12, 13, 14, 15 (100 vdc should be applied to pin 2 of V16A; figure 4-11). Low voltage to the regulator will cause unstable operation of the regulator.
3. V16B (pin 6) Figure 4-11	+225V dc (regulated)	This is a stable regulated voltage set to +225V by adjustment of R71. If this voltage is significantly high, check V12; if too low, check V13 and the output of CR8-CR11 (390 vdc should be applied to pins 2 and 5 of V13). Low voltage to the regulator will cause unstable operation of the regulator.
4. FL1 (red band)	6.3 vdc (regulated)	This voltage is applied only to the three r-f tubes within the r-f generator housing. If this voltage is significantly high, one of the r-f tube filaments may be open.

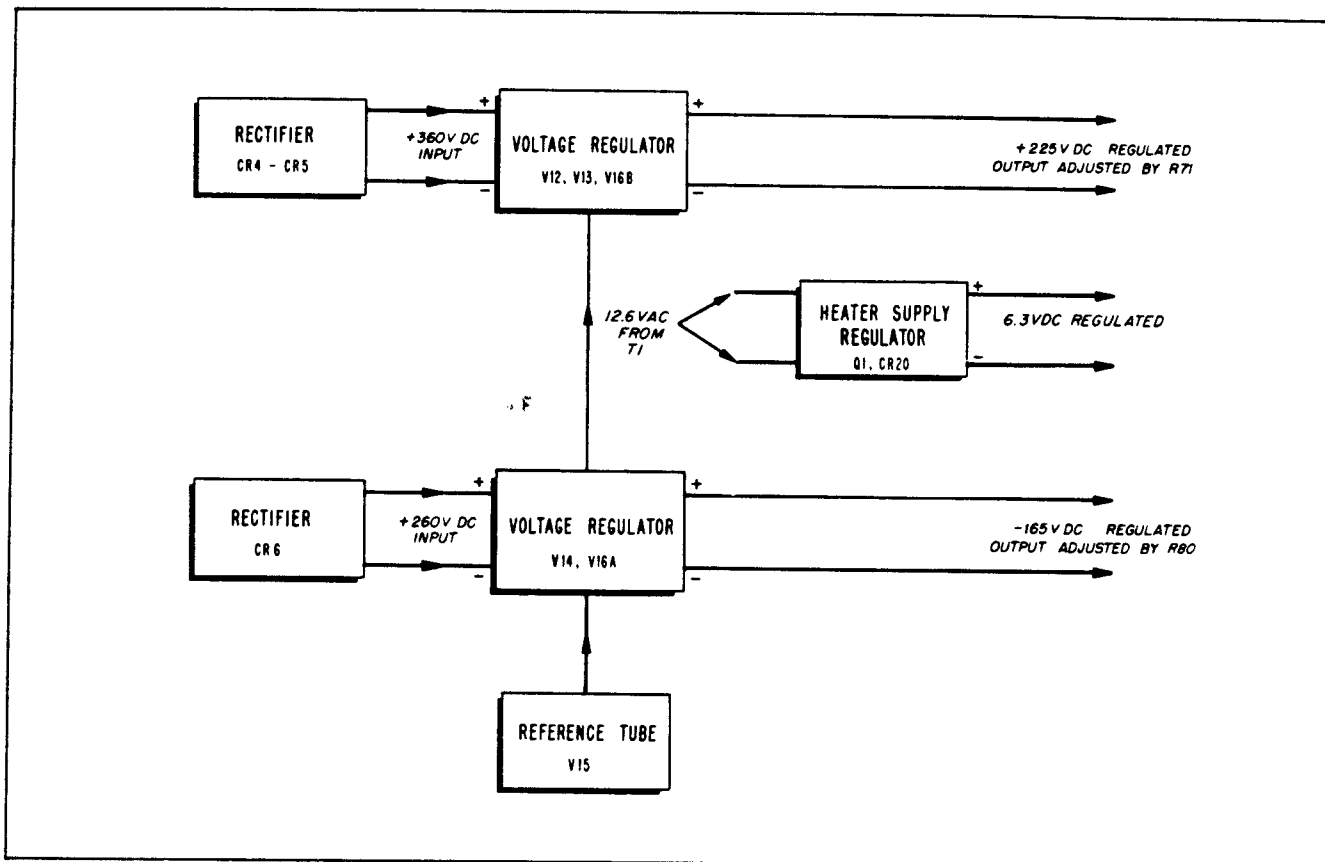


FIGURE 4-3. BLOCK DIAGRAM OF POWER SUPPLY

Measurements made at these test points provide positive means for isolating a source of trouble to a small circuit area, since the measurement data may be analyzed to determine the type of failure. For example, insufficient gain through an amplifier normally indicates a weak tube, distortion may indicate a gassy tube, shorted coupling capacitor, faulty resistor, etc. A faulty resistor can be located by voltage and/or resistance measurements at the tube socket terminals and by comparing the readings with those given in the tube-socket voltage-resistance diagrams at the rear of the manual. A shorted capacitor usually may be located by measuring the resistance across it; low or zero resistance indicates the capacitor is shorted. An open capacitor may be located by substitution.

Unless otherwise noted, the values given in the chart were measured between indicated point and ground with a 20,000 ohm/volt multimeter. When measurements should be made with a high-impedance voltmeter or a meter with greater sensitivity, the requirement is noted.

To start, set the generator for 100-mc CW operation and an output level of 0 dbm, then shift controls as instructed in the chart. Follow steps in order given: some steps assume satisfactory indications were obtained from previous measurements. Initial control settings:

Power Switch	ON
MOD.SELECTOR	CW
FREQUENCY RANGE	D
FREQ.	100
MOD.LEVEL	minimum
AMP.TRIMMER	Set for maximum output
OUTPUT LEVEL	Set for SET LEVEL reading on OUTPUT VOLTS meter
ATTEN	0 dbm
XTAL CAL GAIN	maximum

OUTPUT LEVEL should be adjusted to SET LEVEL unless otherwise specified.

TABLE 4-3. SYSTEM ANALYSIS CHECK CHART

Step & Test Point	Controls		Normal	Possible Cause of Abnormal Indication
1	MOD.SEL.	OUTPUT LEVEL		Excessive ripple: C42 Low voltage: CR12 thru CR15 or excessive current drawn by subsequent circuits.
	CW	for SET LEVEL max cw (max output) max ccw (min output)	260 vdc, 1.4 vac 90 ma dc 95 ma dc	
	PULSE	for SET LEVEL	82 ma dc	
2	CW	for SET LEVEL	-165 vdc 10 millivolts ac	See Table 4-2, step 2.
3	CW	for SET LEVEL max cw	+340 vdc, 2.7 vac 155 ma dc	Excessive ripple: C40 Low voltage: CR8 thru CR11 or excessive current drawn by subsequent circuits.
	400 ν	for SET LEVEL	175 ma dc	
	PULSE	for SET LEVEL	147 ma dc	
4	CW	for SET LEVEL	+225 vdc 10 millivolts ac	See Table 4-2, step 3.
5	Any position		6.3 vdc	See Table 4-2, step 4.
6	MOD.SELECTOR: CW OUTPUT LEVEL: for SET LEVEL MEGACYCLES dial: at low-frequency end FREQUENCY RANGE: A band B band C band D band E band		 -60 vdc -80 vdc -80 vdc -60 vdc -60 vdc	Check -165V Supply, oscillator tube and associated components.
7	MOD.SEL.	OUTPUT LEVEL	+110 vdc	High voltage indicates a weak V7 or open plate circuit
	CW	for SET LEVEL		
8	CW	max ccw (min output)	Voltage across R82 should measure: 0 vdc	Check buffer V7 and level control tube V5 and their associated components; check the OUTPUT LEVEL voltage divider (R34, R37, R38, R40).
		for SET LEVEL max cw (max output)	approx +1.4 vdc approx +7.0 vdc	
	FREQUENCY RANGE: between any two ranges		Should not exceed -4.5 vdc to ground.	Check CR 7.

TABLE 4-3. SYSTEM ANALYSIS CHECK CHART (CONT'D.)

Step & Test Point	Controls	Normal	Possible Cause of Abnormal Indication
9	MOD.SELECTOR: CW OUTPUT LEVEL: max ccw (minimum output) for SET LEVEL max cw (maximum output)	approx +30 vdc approx +3.6 vdc approx -6.4 vdc When disconnected from rf generator CCW approx. +29 CW approx -24	With modulator disconnected from filter FL6, inadequate voltage range indicates poor V5 or defective component in control circuit (see step 11).
10	Set for 400 ν modulation at 10 mc and 100 mc 10% mod. 30% mod. 50% mod. 80% mod.	a-c volts 10 mc 100 mc .48 .3 1.3 .75 2.2 1.2 3.7 1.8	Insufficient signal indicates low amplification farther back in modulator, see steps 14, 15, and 16.
11	MOD.SELECTOR: CW OUTPUT LEVEL: max ccw (minimum output) for SET LEVEL max cw (maximum output)	Use electronic voltmeter +23 vdc - 2 vdc -30 vdc	Rough, insufficient, or excessive voltage: check R34, R37, R38, and R40.
12	Turn off for this measurement.	Nearly infinite resistance.	50 ohms indicates shorted C37, or C69; 25 ohms indicates both C37 and C69 shorted.
13	MOD.SELECTOR: 400 ν - 1000 ν	2 vac rms +6.4 vdc	Adjust R7 to obtain correct voltage; if necessary, change I1.
*14	Set for 400 ν modulation at 10 mc 10% 30% 50% 80%	Use electronic voltmeter .017 vac .048 vac .083 vac .141 vac	Defective R2, MOD.LEVEL control.
* Note: Steps 15, 16, 17, 18, 19 constitute a sequential check of the modulator amplifier and modulation meter amplifier circuits. The voltages shown for step 14 are the approximate voltages required for modulation of the r-f output signal.			

TABLE 4-3. SYSTEM ANALYSIS CHECK CHART (CONT'D.)

Step & Test Point	Controls	Normal	Possible Cause of Abnormal Indication
15	Set for 400 ν modulation at 10 mc 10% 30% 50% 80%	Use electronic volt-meter .068 vac .195 vac .32 vac .56 vac	Low output indicates weak V1. Gain should be approximately equal for these signal levels.
16	Set for 400 ν modulation at 10 mc 10% 30% 50% 80%	.58 vac 1.66 vac 2.8 vac 4.8 vac	Low output indicates weak V3. Gain should be approximately equal for these signal levels.
17	Set for 400 ν modulation at 10 mc 10% 30% 50% 80%	.014 vac .044 vac .174 vac 1.2 vac	Low output indicates weak CR2 (and would be accompanied by inability to reach SET LEVEL on OUTPUT VOLTS meter). See paragraph 4-14.
3	MOD.SELECTOR: CW Adjust OUTPUT LEVEL for OUTPUT VOLTS reading of: .1 volt half scale SET LEVEL full scale	.05 vdc .16 vdc .23 vdc .32 vdc	These voltages vary depending upon forward resistance of CR2 and CR3; if variation is greater than $\pm 10\%$, CR2 and/or CR3 may be bad.
19	Set for 400 ν modulation at 10 mc 10% 30% 50% 80%	.39 vac 1.0 vac 1.55 vac 2.50 vac	Low voltage indicates weak V18 or V19.
20	MOD.SELECTOR : CW MEGACYCLES dial and FREQUENCY RANGE for any 5-mc check point.	4 vdc	Check CR1 and V9; see paragraph 4-10. Note: If voltage is below 1 volt, beat-frequency signals will not be audible.
21	Same as step 20. 600-ohm headphone in XTAL CAL.OUTPUT jack.	4-5 vdc with 600-ohm load across J3.	Low output indicates weak V10 or V11.

9.

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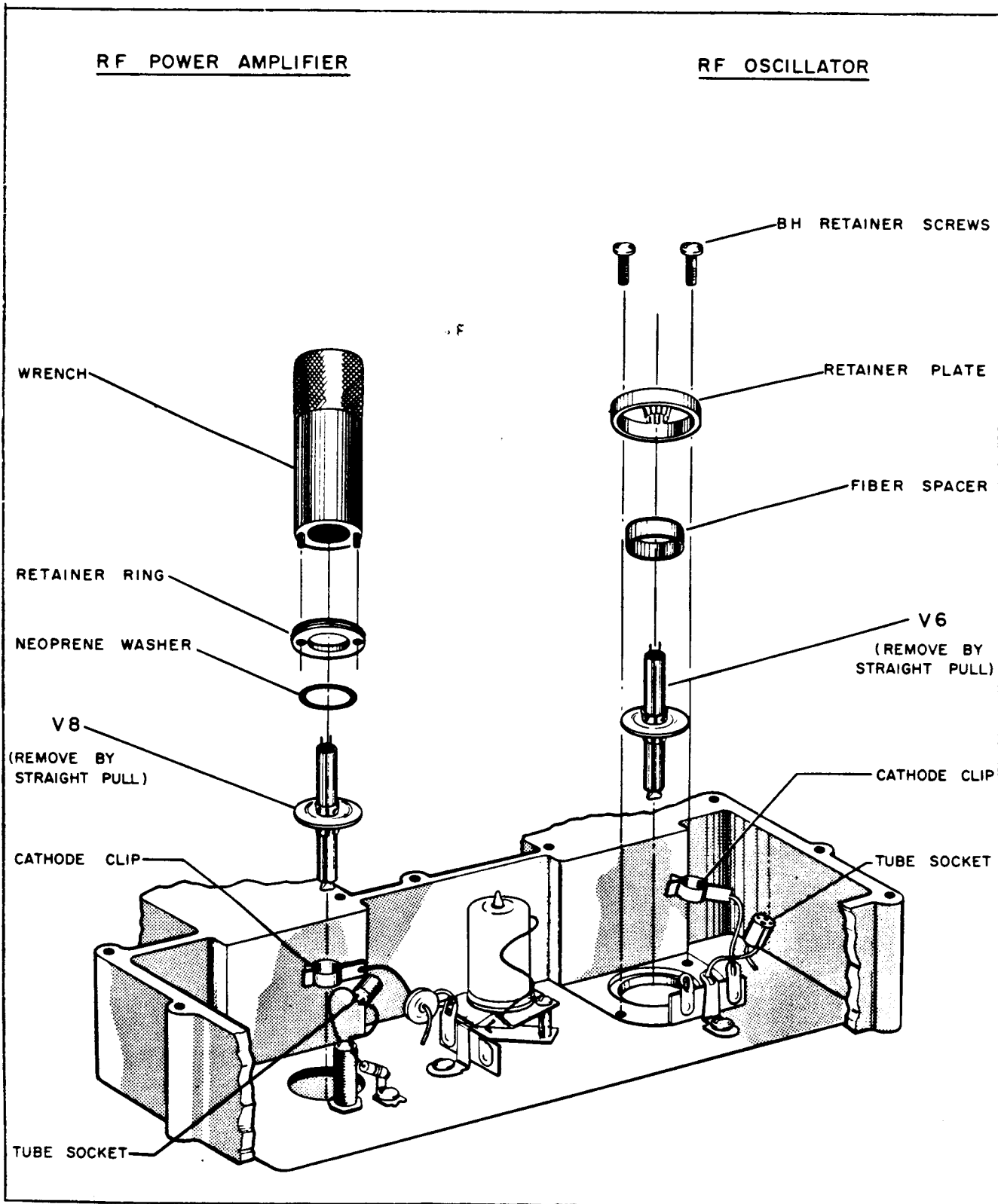


FIGURE 4-5. R-F OSCILLATOR AND AMPLIFIER TUBE REPLACEMENT DIAGRAM

- c. Remove cathode clip from tube.
- d. Remove the two BH screws holding retainer plate, then remove plate and fiber spacer.
- e. Lift tube gently from hole by straight pull.
- f. Replace tube in reverse order of above steps.
- g. Connect a dc voltmeter to the inside lead of FL1. The dc meter should indicate 6.3 vdc. If necessary, change the value of R127 to obtain 6.3 vdc.
- h. Using the CP Model 428B DC Ammeter, measure the current in the green lead to feed-through capacitor C15.
- i. Set the frequency range switch to the E band. The current meter should indicate between 18 and 27 ma. If the meter indication is not within this limit, substitute another 5675 oscillator tube.
- j. Using the internal beat-frequency calibrator, check frequency calibration throughout the range of the signal generator, noting points that are significantly off frequency.

k. To correct calibration at the high-frequency end of all bands simultaneously, adjust trimmer capacitor C18, which is accessible in the tube compartment in the r-f generator housing (see Figure 4-14). This adjustment has only minor effect at the low frequency ends of the ranges.

4-9 RADIO FREQUENCY AMPLIFIER AND BUFFER TUBE REPLACEMENT

Replacement of the r-f amplifier and buffer tubes can affect the amplitude of the r-f generator heater voltage supply and may limit the power output from the signal generator.

To remove r-f amplifier tube V8 and buffer V7, refer to Figure 4-5 and proceed as follows:

- a. Remove frequency dial and top plate from r-f generator housing to gain access to tube compartment.
- b. For buffer V7, replace tube and proceed with step h.
- c. For amplifier V8, remove socket from base of V8 by straight pull.

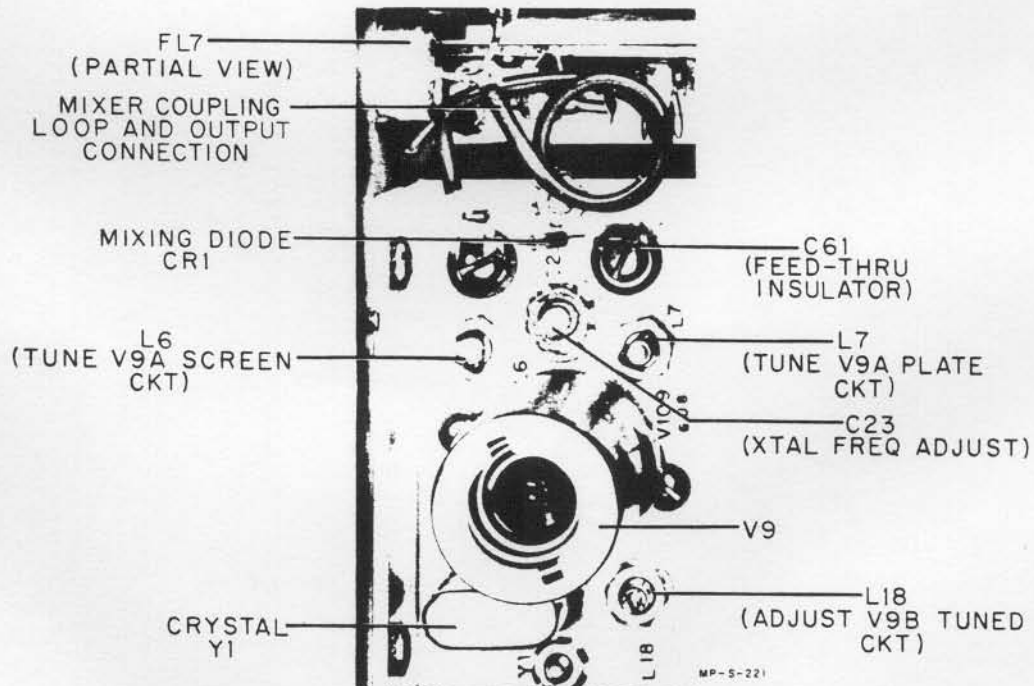


FIGURE 4-6. MODEL 608D CALIBRATOR OSCILLATOR ADJUSTMENT

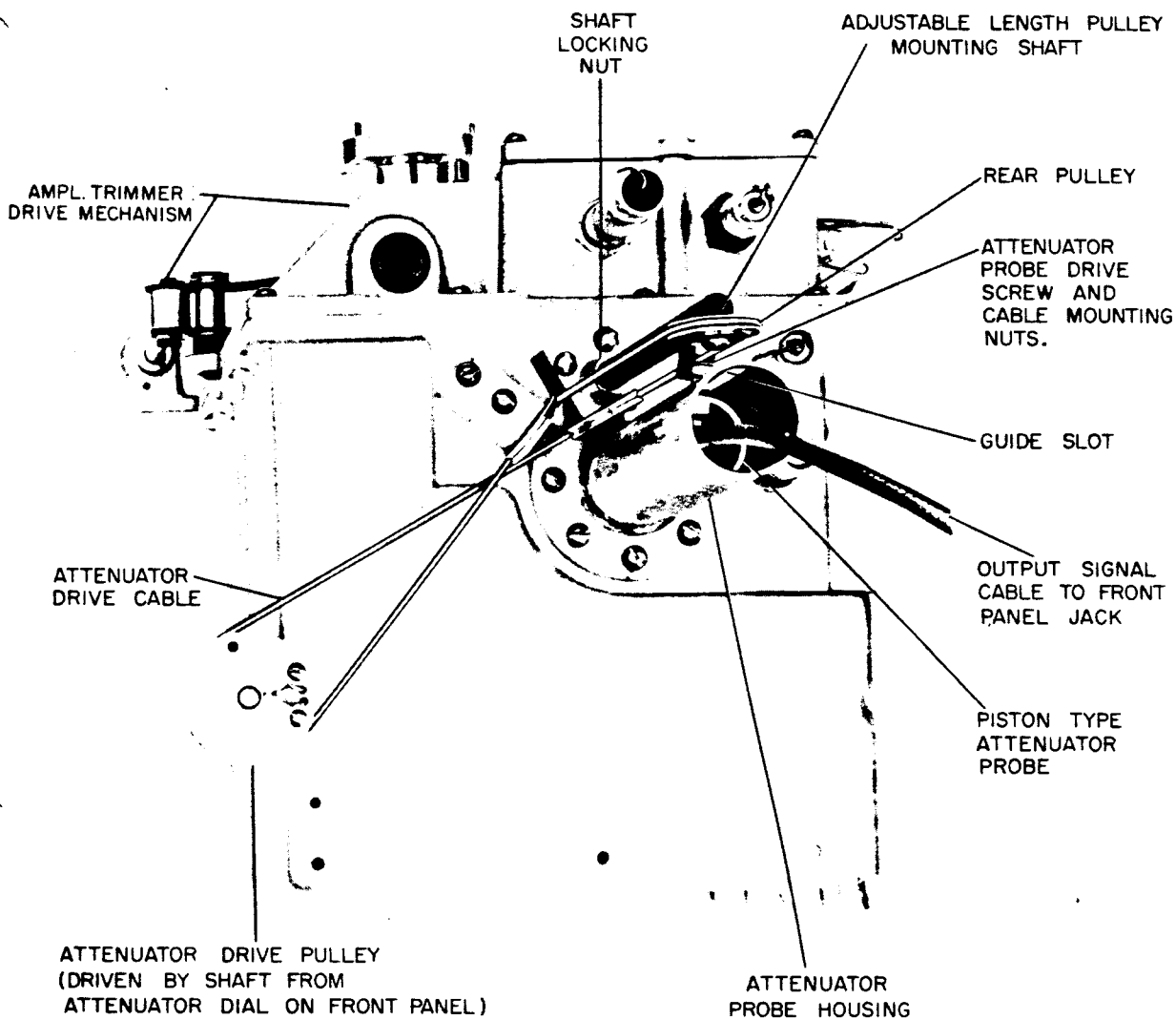


FIGURE 4-7. R-F GENERATOR ASSEMBLY REAR VIEW, SHOWING OUTPUT ATTENUATOR DRIVE SYSTEM

- d. Remove cathode clip from tube.
- e. Using the special wrench (located on instrument chassis, near generator housing) loosen the threaded retainer ring which holds V8 in housing. Remove retainer ring and neoprene washer.
- f. Remove old tube and replace with new type 5876 tube.
- g. Check the power output throughout the full frequency range of the signal generator. With AMP. TRIMMER set for maximum output at each fre-

quency, a full-scale reading should be obtained over the entire frequency range.

4-10 XTAL FREQUENCY OSCILLATOR TUBE OR CRYSTAL REPLACEMENT

To gain access to the calibrator oscillator, remove the side cover on the r-f generator housing. The entire crystal oscillator is mounted on a bracket on the rear wall of the r-f amplifier compartment. Location of oscillator tube V9, crystal Y1, and

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associated adjustments are shown on Figure 4-6. If V9 or Y1 is replaced, the calibrator should be checked and, if necessary, adjusted.

The crystal-controlled frequency calibrator is composed of two circuits: the 5-megacycle crystal-controlled oscillator which utilizes the pentode half of a type 6U8 tube and the 1-megacycle "locked-in" oscillator utilizing the triode section of the 6U8. Each section is adjustable, and both sections should be adjusted at the same time. The frequency of the crystal can only be adjusted over a range of approximately 100 cycles. The frequency of the 1-megacycle oscillator then locks in with the 5-megacycle frequency and is either right on frequency or is very far off, for example, 1.8 megacycles.

To adjust the frequency and output level of the crystal-controlled frequency calibrator, proceed as follows:

- a. Remove the 608D from the cabinet and remove the side plate from the r-f generator housing. Set the XTAL CAL. toggle switch to 5 mc; turn on 608D, and allow to warm up for five minutes.
- b. Measure the 5-megacycle output from the calibrator at r-f filter FL7 located in the wall of the generator housing (Figure 4-10).

Adjust C23 on the calibrator chassis (Figure 4-13) to obtain exactly five megacycles.

- c. Measure the negative d-c voltage at FL7 with a d-c electronic voltmeter.
- d. Adjust L7 to obtain maximum d-c volts at FL7. If the voltage obtained exceeds 3 volts, readjust L6 to again obtain exactly 3 volts dc.
- e. Tune L6 (Figure 4-6) in a clockwise direction to obtain a dip in output in the d-c voltage measured in step c. Two volts should be measured at the bottom of the dip. Then turn L6 counterclockwise to obtain exactly 3 vdc.
- f. Tune the frequency of the 608D exactly on at any 5-mc/s check point.
- g. Set the XTAL CAL. toggle switch to 1 mc. (The d-c output voltage in steps d and e will now be 2 volts).
- h. Adjust L18 to obtain a dip in the d-c voltage measured at FL7. This dip should be approximately 1/2 volt less in amplitude than the reading of approximately 2 volts noted in step g. Set L18 to the exact center of this dip (voltmeter reading of approximately 1.75 volts).

- i. Tune the 608D from one 5-mc/s check point to another, and note the number of 1-mc/s check points obtained. There must be four 1-mc/s check points. If more or less than four zero beat frequencies are obtained, readjust L18 (steph) to another dip to obtain the correct number of check points.

4-11 REPLACEMENT OF POWER SUPPLY TUBES

The output voltage from either or both of the regulated power supplies may be affected slightly by a change in any one of the tubes. The two power supplies are interdependent in that the setting of the +225V supply depends upon a reference point established by the -165V supply. Therefore a tube change in the -165V supply should be followed by a check of the +225V supply. All tubes and components in the power supplies are located on the chassis to the rear of the signal generator. Line voltage should be applied to the instrument through a variable transformer.

To check the output voltage from the power supplies following service or tube replacement, refer to Figure 4-11 for identification of components, and proceed as follows:

- a. With MOD.SELECTOR set to CW and the other controls in any position, turn equipment on.
- b. Check the -165V supply:
 - 1) Connect the positive lead of a voltmeter having a sensitivity of 5000 ohms-per-volt or better to ground.
 - 2) Connect the voltmeter negative lead to the lead connecting both ends of metallic rectifier CR6. Figure 4-11 shows the location of CR6 on the rear chassis. The 5,000 ohms/volt meter connection is made at the CR6 left-hand end as viewed from the rear of the instrument.
 - 3) Voltage should read -165 volts. If necessary, adjust R80 to obtain 165 volts.
 - 4) Vary the line input; voltage should remain at -165V with line voltage changes between 103.5 and 126.5 volts.
- c. Check the +225V supply:
 - 1) Connect the voltmeter negative lead to ground and the positive lead to pin 6 of V13.
 - 2) Voltage reading should be +225 volts. If necessary, adjust R71 to obtain +225 volts.
 - 3) Vary the line input; voltage should remain at +225V ± 4 V with line voltage changes between 103.5 and 126.5 volts.

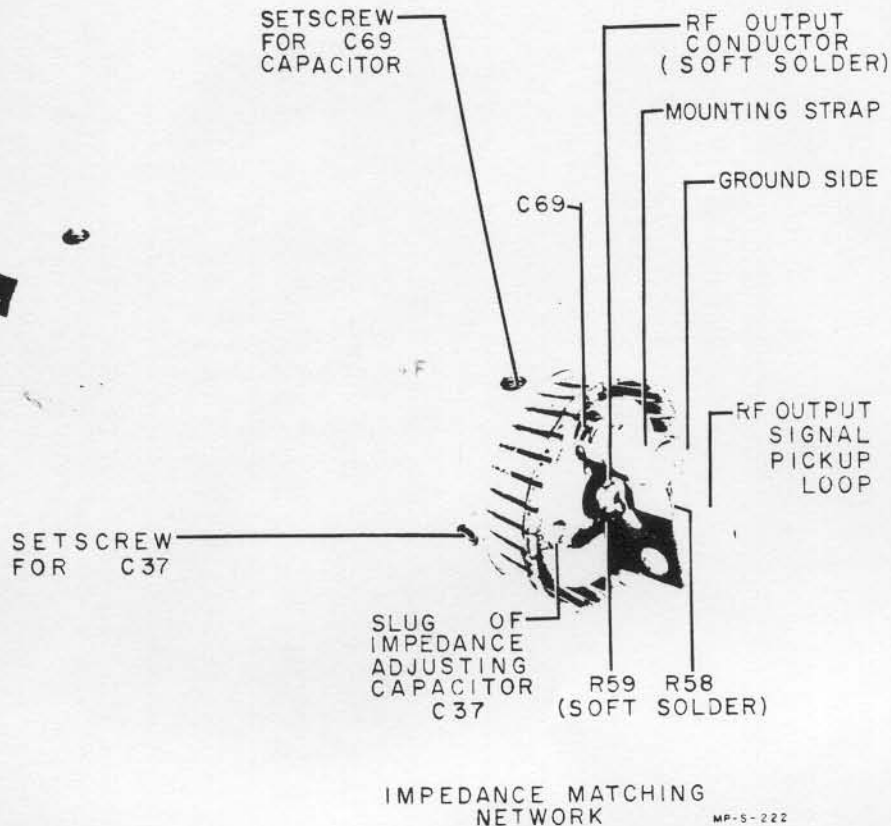


FIGURE 4-8. R-F OUTPUT ATTENUATOR PROBE, SHOWING PICKUP LOOP AND IMPEDANCE MATCHING NETWORK

d. Check the r-f generator heater voltage supply:

1) Connect a dc vacuum tube voltmeter between filter FL1 (red identification band) and ground. The voltmeter should be connected to the terminal of FL1 which is outside the generator housing, the terminal which is shown in Figure 4-10. The voltage at this point is the filament voltage for the r-f oscillator and r-f power amplifier and is furnished by a d-c filament supply.

2) This voltage should be 6.3 volts. If necessary, adjust R128 to obtain 6.3 volts.

4-12 ATTENUATOR PROBE REPAIR AND REPLACEMENT

CAUTION

During removal and replacement of the probe, extreme care must be exercised. The probe consists of a cylindrical metal tube with a series of spring contact fingers around its periphery at one end. These fingers can be accidentally bent

or twisted. It should be noted that one or two of the fingers are bent toward the center of the probe slightly; do not attempt to straighten, since these fingers have been bent to assure clearance between the probe and the end of the guide slot in the attenuator housing.

It is of greatest importance to make certain that the probe is not subjected to shock. If subjected to shock, the electrical components attached to the end of the probe can be broken or their positions altered with a consequent change in the electrical characteristics of the probe.

a. General

As discussed in the CAUTION on Page 4, Sect. II the impedance-matching network in the output attenuator can be damaged if power from an external source is applied to the RF OUTPUT connector.

If electrical components of the output attenuator are damaged, repair or replacement is necessary.

Damage to the impedance-matching network may be confirmed by measuring the VSWR of the attenuator at the RF OUTPUT connector.

NOTE

Attenuator VSWR is determined by positioning of the probe variable capacitor (C37) and the relative position of the two resistors (R58 and R59) on the end of the probe.

Capacitor C37 consists of a metal slug coated with a baked-on plastic insulation (or a plastic tape) and a metal sleeve, mounted inside the probe body. The distance the slug penetrates into the metal sleeve is carefully set at the factory and secured by a setscrew. **DO NOT** loosen this setscrew and move the sleeve unless absolutely necessary. If the position of the sleeve is changed or the sleeve needs replacement, it will be necessary to check the VSWR of the attenuator. Unless equipment such as an impedance bridge or reflectometer setup is available for checking and adjusting VSWR after completing attenuator repair, it is recommended that the entire attenuator probe be replaced as a unit rather than attempting to replace or reposition the C37 sleeve.

If replacement resistors and/or C37 slug are returned to their original positions, VSWR will not be changed appreciably. However, if equipment is available for checking attenuator VSWR, such a check is advisable following replacement of resistors.

To replace the slug part of C37 without affecting attenuator VSWR is difficult. It is recommended that the C37 slug not be replaced unless VSWR can be checked.

b. Removal from Housing

If investigation shows an attenuator to be defective, proceed as follows:

- 1) Turn the attenuator control on the front panel until the probe reaches the end of its travel to the rear of the attenuator housing.
- 2) Remove the nut and washers that hold the drive cable in the probe drive screw (Figure 4-7) in the top of the attenuator probe.

3) Remove probe split drive screw from probe body by removing inner nut and unscrewing.

4) Remove probe by carefully sliding it out of the attenuator housing.

c. Probe Repair

1) Capacitor C69 (Figure 4-8). Capacitor C69 is held in place by a mounting strap and a setscrew. To replace C69, unsolder pickup loop at capacitor end (ground side of loop), loosen setscrew, and slide capacitor out of clamp. Replace by reversing this procedure. The capacitor must be firmly seated in the hole in the end of the probe before tightening the setscrew. The capacitor ground lead can easily be cut in two if the setscrew is tightened excessively.

2) Capacitor C37, Resistor R58, Resistor R59 (Figure 4-8). Before starting replacement procedure, read NOTE in subparagraph a. above.

Carefully measure the distance that the C37 insulated slug protrudes from the end of the probe. This measurement will permit duplication of the slug setting if accidentally changed during attenuator repair. Also note location of the two resistors so that new ones can be mounted as nearly as possible in the same position.

Remove defective resistors R58 and/or R59 without changing the position of the C37 slug.

CAUTION

These resistors are easily damaged by excessive heat. A low temperature soldering iron should be used for unsoldering the old resistors.

After removing both defective resistors, check for a short circuit between the C37 slug and the probe body. If a short circuit exists, it will be necessary to replace the capacitor slug.

Install new resistors. Duplicate original resistor mounting positions and lead lengths as closely as possible. Make connections without excessive bending or pulling on ends of resistors as they are fragile. Use a low temperature solder, and solder connections as quickly as possible.

Measure resistors for any possible change in resistance due to soldering. If original C37 slug is used and original dimensions are maintained within 1/64 inch, VSWR will not be changed appreciably.

If capacitor slug was replaced, carefully adjust penetration depth of slug to dimension determined at start of procedure or, if desired, the VSWR can be checked at several frequencies on E band and the capacitor slug adjusted for optimum VSWR. Adjustment on E band will automatically correct for minimum VSWR on the lower bands. Laboratory test equipment such as an impedance bridge or reflectometer setup will be required for measuring the VSWR. These VSWR checks must be made with attenuator inserted in attenuator housing in instrument, as results obtained will be slightly different with attenuator outside of the housing.

Replace attenuator in housing (subparagraph e).

Make a final performance check (subparagraph f).

d. Probe Replacement

If repair is not possible, both probe and cable must be replaced.

Remove the RF OUTPUT connector from the front panel, and release the cable from the clamp holding the cable to the top of the side gusset. The entire probe assembly may then be removed from the instrument.

Replacement probes are complete with cable and panel connector and require no adjustment of the impedance-matching network upon installation.

e. Replacement in Housing

1) Insert the new or repaired probe in the attenuator housing. Care must be taken in starting the probe into the housing since the diameter at the probe contact fingers is slightly greater than the inner diameter of the housing. The contact fingers should be depressed slightly while starting the probe into its housing. **UNDER NO CIRCUMSTANCES SHOULD THE PROBE BE FORCED.**

2) Replace the split drive screw in the probe, making certain that the screw slot is parallel to the axis of the housing.

3) Set the attenuator drive cable in the screw slot and replace both washers and nut. Do not tighten the nut. The cable must move freely through the slot until the probe penetration has been set.

4) Secure the r-f cable to the clamp on the side gusset. (Cable routing is shown in Figures 4-11 and 4-12.)

5) Connect the instrument to a source of 115-volt a-c power, and turn on the power switch. Unless otherwise specified, the operating controls should be set as follows:

MOD.SELECTOR	CW
MEGACYCLES dial	70 megacycles
FREQUENCY RANGE	C band
AMP.TRIMMER	Adjust for max output
OUTPUT LEVEL	Adjust for SET LEVEL
MOD. LEVEL	Counterclockwise
Attenuator	0 dbm

6) Connect a power meter, such as the Model 430C, through a bolometer mount (Model 476A or equivalent), to the RF OUTPUT connector.

7) Remove r-f generator side plate so that clearance between the attenuator probe and coils of the r-f amplifier tank may be observed.

CAUTION

The following step must be executed as carefully as possible to insure that the pickup loop does not make contact with any of the power amplifier coils. These coils are at B+ potential, and contact between any one of them and the attenuator pickup loop will damage attenuator components.

8) With the attenuator dial set exactly on 0 dbm, manually advance the attenuator probe into the housing until the r-f output signal is exactly 1 milliwatt (0 dbm) as read on the external power meter. If under these conditions the OUTPUT VOLTS meter is not indicating exactly on SET LEVEL, adjust R62 (Figure 4-10) to bring the meter indication exactly on SET LEVEL. If the setting of R62 is changed, check the calibration of the PERCENT MODULATION meter (paragraph 4-14).

8) Tighten down the nut on the split drive screw so that the probe may be actuated by its drive system. Carefully check to see that there is clearance between the various amplifier coils and the pickup loop when the attenuator dial is set to +4 db.

9) Replace r-f generator side plate.

f. Performance Check

Using the external power meter, check the output at 0 db (1.0 milliwatt) at the higher frequencies on the A, B, D, and E bands.

If at all frequencies across the band the OUTPUT VOLTS meter does not indicate exactly on SET LEVEL when the r-f output is 1 milliwatt, ± 1 db, see paragraph 4-15 for instructions on recalibration of the OUTPUT VOLTS meter.

4-13 REPLACEMENT OF LAMP I1

Lamp I1 acts as a positive temperature coefficient resistance, maintaining modulator oscillator output constant. The characteristics of the S6 type lamps used for this purpose ordinarily vary widely from lamp to lamp, causing a corresponding variation in the amplitude of the oscillator output from one 608D to another. To compensate for differences between type S6 lamps, potentiometer R7 is provided for adjustment of the oscillator output voltage level.

After lamp I1 has been replaced, the oscillator output voltage, as measured at pin 3 of V2, should be adjusted to 2 volts rms; if it cannot be adjusted to this value, another lamp must be tried.

4-14 CALIBRATION OF PERCENT MODULATION METER

General

Recalibration of the PERCENT MODULATION meter may be necessary following a repair of the modulation measuring circuits (V18-V21) or after replacement of the meter itself.

Note

Be sure the mechanical meter zero is adjusted properly; refer to paragraph 2-3.

The voltmeter method of calibration outlined below requires:

A peak-reading electronic voltmeter capable of measuring a-c voltages to 500 mc, such as the Model 410B.

A tuned step-up transformer, to obtain adequate output from the 608D for the measurements made on the external voltmeter.

Basically, the voltmeter method of modulation measurement consists of measuring the peak value of the r-f output signal with and without modulation. A doubling of the peak output voltage as indicated on the external voltmeter represents 100% modulation of the output signal, while lesser percentages of modulation are indicated by proportionally smaller voltage increments.

Fabrication of Step-up Transformer

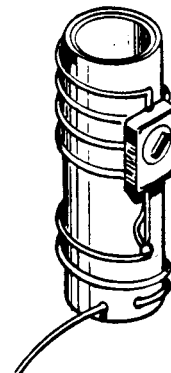
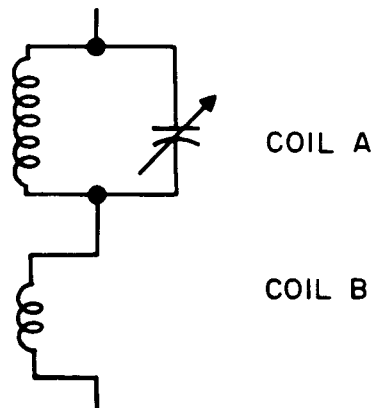
To measure modulation by the voltmeter method, it will be necessary to fabricate a tuned step-up transformer similar to that shown below. Materials at hand may be used as substitutes for those listed.

Coil form:

3/4 inch diameter by approximately 2 inches long; ceramic, polystyrene, or similar material.

Coil A:

5 turns of solid #22 wire spaced 1/8 inch between turns.



Coil B:

2 turns of solid #22 wire spaced 1/8 inch between turns.

Approximately 1/4 inch spacing between coils A and B.

Tuning capacitor:

7 to 45 μ f.

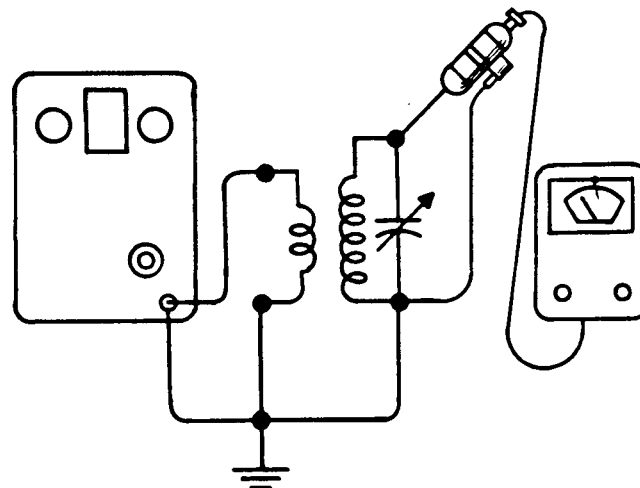
Procedure

The following procedure for calibrating the PERCENT MODULATION meter may be used with either internal or external modulation.

- a. With the controls set as below, turn the power switch on and allow the instrument to warm up.

FREQUENCY RANGE	C band
MEGACYCLES dial	75 to 85 mc
MOD.SELECTOR	1000 ν
AMP.TRIMMER	Adjust for max output
OUTPUT LEVEL	Adjust for SET LEVEL
PERCENT MODULATION	Adjust for 0%
Attenuator	0 dbm

- b. Connect the signal generator to the test apparatus as shown in the diagram below.



- c. Set the 410B voltage range switch to the 10-volt a-c range.
- d. Adjust the capacitor on the step-up transformer to obtain greatest output as read on the vacuum tube voltmeter.
- e. Reading from the 0 to 3V dc scale on the 410B, adjust the output attenuator on the 608D for reading of 1 volt on the 410B.

NOTE

The actual voltage from the tuned circuit will be within the 10-volt range; however, the linear portion of the 3-volt scale can be used as a modulation indicator since the 1-volt calibration mark now represents 0% modulation and the 2-volt calibration will represent 100% modulation, with the intermediate calibration corresponding to the calibrations on the PERCENT MODULATION meter in the signal generator. Accuracy of modulation indication as read from the 410B voltmeter will be within $\pm 5\%$.

- f. Adjust the MOD.LEVEL control for a reading corresponding to 1.8 on the 410B voltmeter 3-volt scale. Application of high percentages of modulation may result in a slight rise (1/2 db) in the OUTPUT VOLTS meter indication. If necessary, readjust the OUTPUT LEVEL control to obtain a reading at SET LEVEL on the OUTPUT VOLTS meter.
- g. Adjust R104 (see Figure 4-12) to provide a reading of 80% on the PERCENT MODULATION meter.
- h. Check the PERCENT MODULATION meter calibration for other modulation percentages, e.g., 1.1 on the voltmeter corresponds to 10% modulation, 1.2 to 20%, etc. The setting of R104 may be refined to obtain best overall calibration accuracy of the PERCENT MODULATION meter.

NOTE

For this procedure the OUTPUT LEVEL control must be set at all times to provide a reading at SET LEVEL on the OUTPUT VOLTS meter.

4-15 OUTPUT VOLTS METER CALIBRATION AND RF POWER MONITOR SERVICE

Recalibration of the OUTPUT VOLTS meter may be necessary following replacement of the attenuator probe, components in the power monitoring circuits, or replacement of the meter itself. If it becomes necessary to replace CR2 or R60 in the power monitor assembly, the frequency response of the meter circuit will also be affected and readjustments will be required.

CAUTION

Do not disturb the positioning of the components in the r-f power monitor assembly (see Figure 4-13) until instructed to do so in the procedure. The position and lead lengths of resistor R60 and L17 and the characteristics of crystal CR2 all affect the frequency response of the meter circuit, mostly on the E band and to a lesser degree on the D band. To restore flat frequency response requires care and skill in repositioning components.

The method of calibration outlined below requires the use of a 50-ohm bolometer mount and power meter, such as the Hewlett-Packard Model 476A Universal Bolometer Mount and Model 430C Microwave Power Meter, to measure the r-f signal power from the generator.

To reset the frequency response on the higher bands, following replacement of components such as CR2 or R60, the OUTPUT VOLTS meter must first be checked for accuracy as described in steps a. through e. below, then adjusted as described in step f. Proceed as follows:

- a. Connect the 608D to a source of 115-volt a-c power. Turn on the power switch, and allow the 608D to warm up with the operating controls in the following positions:

MOD.SELECTOR	CW
MEGACYCLES dial	75 to 80 mc
FREQUENCY RANGE	C band
AMP.TRIMMER	Adjust for max output
OUTPUT LEVEL	Adjust for SET LEVEL
MOD.LEVEL	Extreme counterclockwise
Attenuator	0 dbm

- b. Connect the power meter and bolometer mount to the RF OUTPUT connector on the signal generator.

- c. With the attenuator set for exactly 0 dbm, adjust the **OUTPUT LEVEL** control to obtain exactly 0 dbm on the external power meter.
- d. If necessary, adjust R62 to obtain an exact reading at **SET LEVEL** on the **OUTPUT VOLTS** meter.
- e. Using the external power meter, check the 0 and +7 db calibration points of the **OUTPUT VOLTS** meter (points -4 and +3 decibels from the 0 dbm level).
- 1) Adjust the **OUTPUT LEVEL** control to obtain -4 dbm as read on the external power meter. If necessary, adjust R62 to obtain a reading of 0 dbm on the **OUTPUT VOLTS** meter.
 - 2) Set **OUTPUT LEVEL** control for +3 dbm as read on the external power meter. If necessary, adjust R61 to obtain a reading of +7 dbm on the **OUTPUT VOLTS** meter.
 - 3) Because the R61 and R62 adjustments are interacting, steps 1) and 2) must be repeated to obtain the best overall accuracy of calibration.
- f. Recheck accuracy of calibration at **SET LEVEL** (+4 dbm) and, if necessary, adjust R62 to obtain an exact reading at this point.
- g. Recheck calibration at **SET LEVEL** at frequencies of 100, 250, and 400 megacycles. If the calibration is high or low at the higher frequencies, the **OUTPUT VOLTS** meter reading may be corrected

by adjusting the inductance of L17. Shortening the coil (increasing the inductance) will decrease the meter reading, as shown in Figure 4-9. Lengthening the coil (decreasing the inductance) will increase the meter reading.

CAUTION

Great care should be taken to change only the length of the coil and not to shift the positions of any other components in the power monitor assembly.

If the frequency response is satisfactory at all frequencies up to approximately 300 mc but tends to rise or fall at the higher frequencies, the pigtail connection of resistor R60 which connects to coil L17 may be adjusted very slightly to raise or lower the meter reading at the higher frequencies. Again, great care must be used to adjust the positioning of only one component at a time and to follow each adjustment with a power measurement to see the exact effect of the adjustment. In general, increasing the capacity (increasing the length of the pigtail) between the pigtail and ground may be expected to decrease the meter reading at only the higher frequencies.

Figure 4-9 shows the increase or decrease in the reading of the **OUTPUT VOLTS** meter that is obtained at different frequencies when making each one of the three possible adjustments. Only minor adjustments should be made (very small change in physical position), using the graph for a guide as to the approximate results that may be expected.

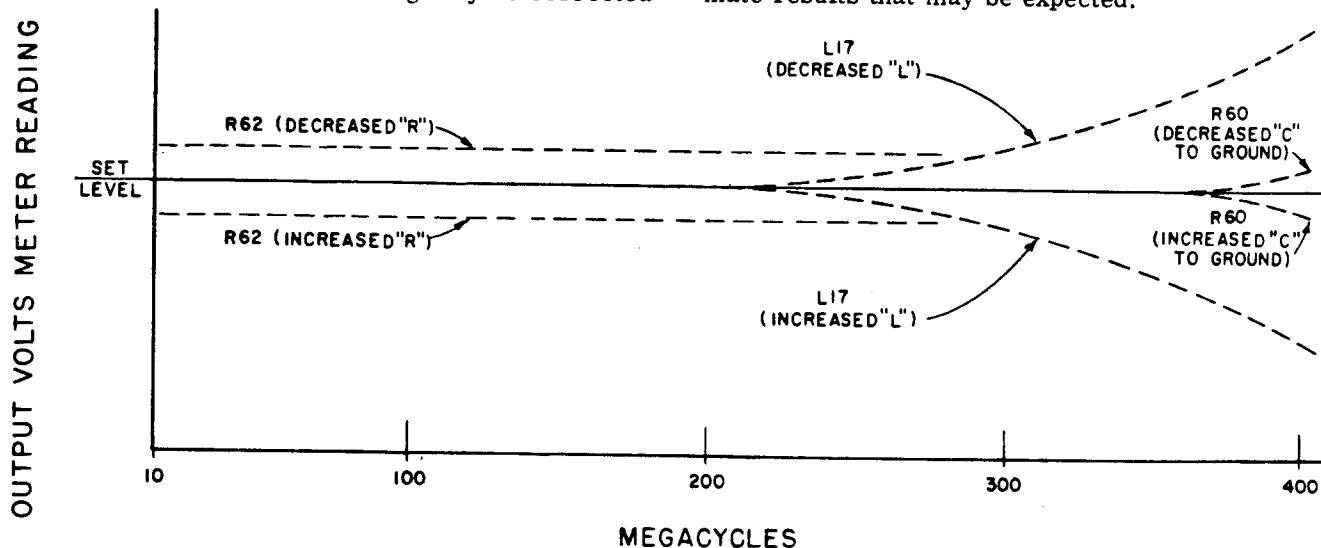


FIGURE 4-9. MODEL 608D POWER MONITOR EFFECT ON OUTPUT LEVEL OF ADJUSTMENTS IN RESISTANCE, INDUCTANCE, AND CAPACITANCE

4-16 CALIBRATOR OSCILLATOR REPAIR

To replace any component in the frequency calibrator oscillator circuit, other than the tube and crystals, the oscillator chassis must be removed from the r-f generator assembly. Proceed as follows:

- a. With signal generator out of its cabinet, remove the side plate from the r-f generator housing.
- b. Unsolder the shielded heater power (yellow) lead from the feed-thru capacitor in the top of the compartment.

- c. Unsolder the shielded plate (red) lead from the tie point in the top of the compartment.
- d. Unsolder the black lead from FL11 (the connection inside the compartment) and the green lead from FL10.
- e. Unsolder the output lead from filter FL7.
- f. Remove the two 6-32 machine screws attaching the oscillator chassis to the generator housing. The oscillator chassis is now free to be removed.

4-17 TROUBLE-SHOOTING CHART**TABLE 4-5 TROUBLE SHOOTING CHART**

SYMPTOM	POSSIBLE TROUBLE	CHECK AND PARAGRAPH REFERENCE
1. A. Low CW RF output (cannot obtain full-scale reading on OUTPUT LEVEL meter).	Low heater voltage from Q1. Weak oscillator V6. Weak buffer V7. Weak amplifier V8.	Check heater voltage. If necessary, set as described in paragraph 4-11d. Check V6 and V7 by measuring r-f signal at cathode of V8 in r-f generator tube compartment. Should be 1.5 to 4.0 volts on band E. Replace tubes to improve.
B. Low or no CW RF output (OUTPUT LEVEL) meter indicates normal output).	Low power supply voltage	Check the +225V and the -165V supplies (paragraph 4-11).
	Open attenuator impedance-matching network.	Measure attenuator resistance: Turn off instrument. Set FREQUENCY RANGE between ranges (to prevent possible damage to coils). Set output attenuator max. cw. Remove side plate from r-f generator (Figure 4-13).
C. Low CW output at low frequency end of the E band.	Weak V6. Weak V8.	Check by replacing V6. Check by replacing V8.
D. Intermittent operation on any one band.	Poor connections at contacts on oscillator or amplifier coil turrets.	Clean contacts. If necessary, bend turret contact for greater pressure.
2. Output signal cannot be reduced by OUTPUT LEVEL control (OUTPUT METER remains upscale).	Weak V5. Defective CR7	Check by replacing V5. Check by replacing CR7.

TABLE 4-5 TROUBLE SHOOTING CHART (CONT'D.)

SYMPTOM	POSSIBLE TROUBLE	CHECK AND PARAGRAPH REFERENCE
<p>3. A. Output level drifts.</p> <p>B. Output level drifts (with changes in line voltage).</p> <p>C. High residual hum on output signal may be read on PERCENT MODULATION meter when no modulation is applied.</p>	<p>Weak V6, V8</p> <p>Power supply does not regulate properly.</p> <p>Same as above.</p>	<p>Check V6 and V8 by replacing.</p> <p>Check stability of regulated +225V and -165V supplies. See paragraph 4-5.</p>
<p>4. Frequency calibration inaccurate at high frequency ends of all bands following replacement of V6.</p>	<p>Replacement tube characteristics different.</p>	<p>Adjust C18 for correct calibration at top of all bands. See paragraph 4-8.</p>
<p>5. Little or no indication from output meter.</p>	<p>Crystal diode CR2 defective. CR3 shorted. No r-f output.</p>	<p>See paragraph 4-15. (See Caution)</p>
<p>6. Change in mod. percent causes change in OUTPUT VOLTS meter reading (about 10% is normal).</p>	<p>Overmodulation can be due to actual r-f signal being less than indicated or due to modulation being greater than the indicated amount.</p>	<p>Check amplitude of r-f output signal with external power meter. Check gain of modulation meter amplifier. Check modulation of r-f carrier by viewing on oscilloscope.</p>
<p>7. Distortion of the modulation envelope, particularly at high modulation levels.</p>	<p>Weak r-f power amplifier V8. Weak r-f oscillator V6. Distorted modulating wave from oscillator V2 or amplifier V3.</p>	<p>Check modulator by checking output sine wave for distortion; measure at modulator side of FL6. Check V8 by substitution. Check r-f drive to power amplifier; should be 4 to 11 volts.</p>
<p>8. Internal modulation not possible.</p>	<p>Loose or defective 10-watt lamp I1 in modulation oscillator V2. Modulation circuit. Defective, V1, V2, V3, V4.</p>	<p>Tighten or replace lamp. Check per Table 4-3. Replace V1, V2, V3, V4 as needed.</p>
<p>9. RF output signal does not go to zero when generator is switched to PULSE operation and no pulses are applied.</p>	<p>Weak cathode follower V4 in modulator.</p>	<p>Replace V4.</p>

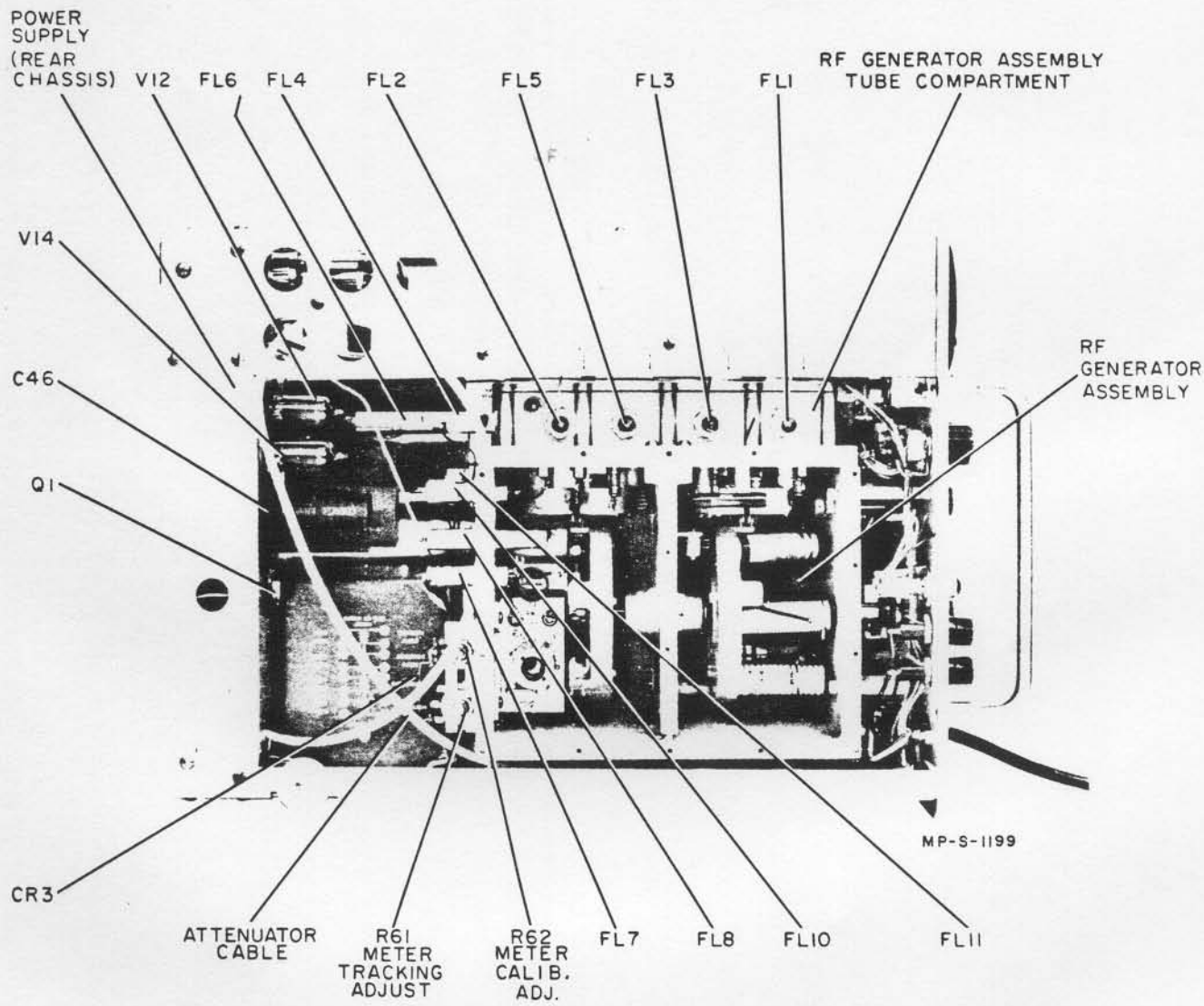


FIGURE 4-10. MODEL 608D LEFT SIDE VIEW CABINET REMOVED

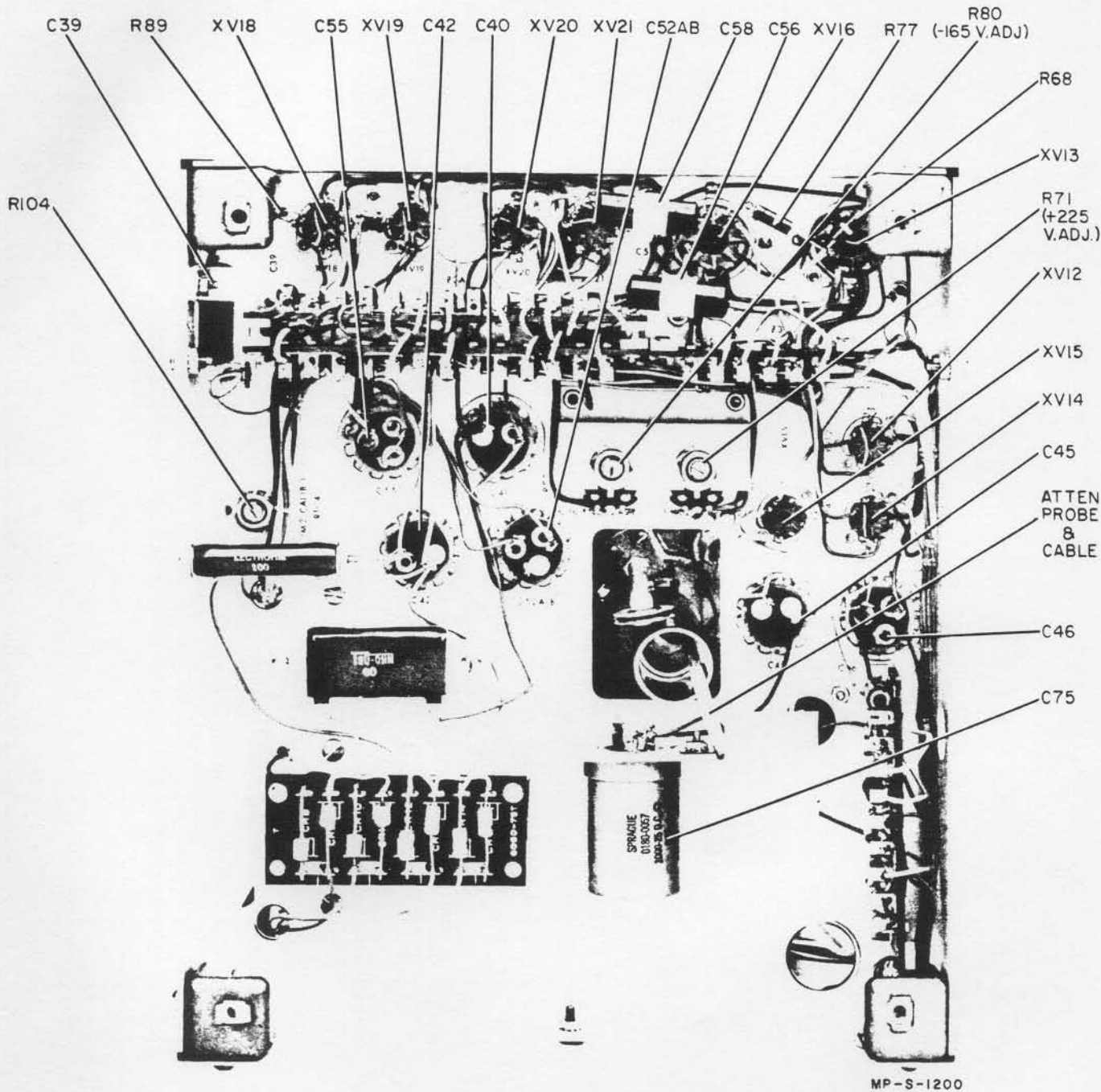


FIGURE 4-11. MODEL 608D REAR VIEW CABINET REMOVED

MODULATOR SECTION

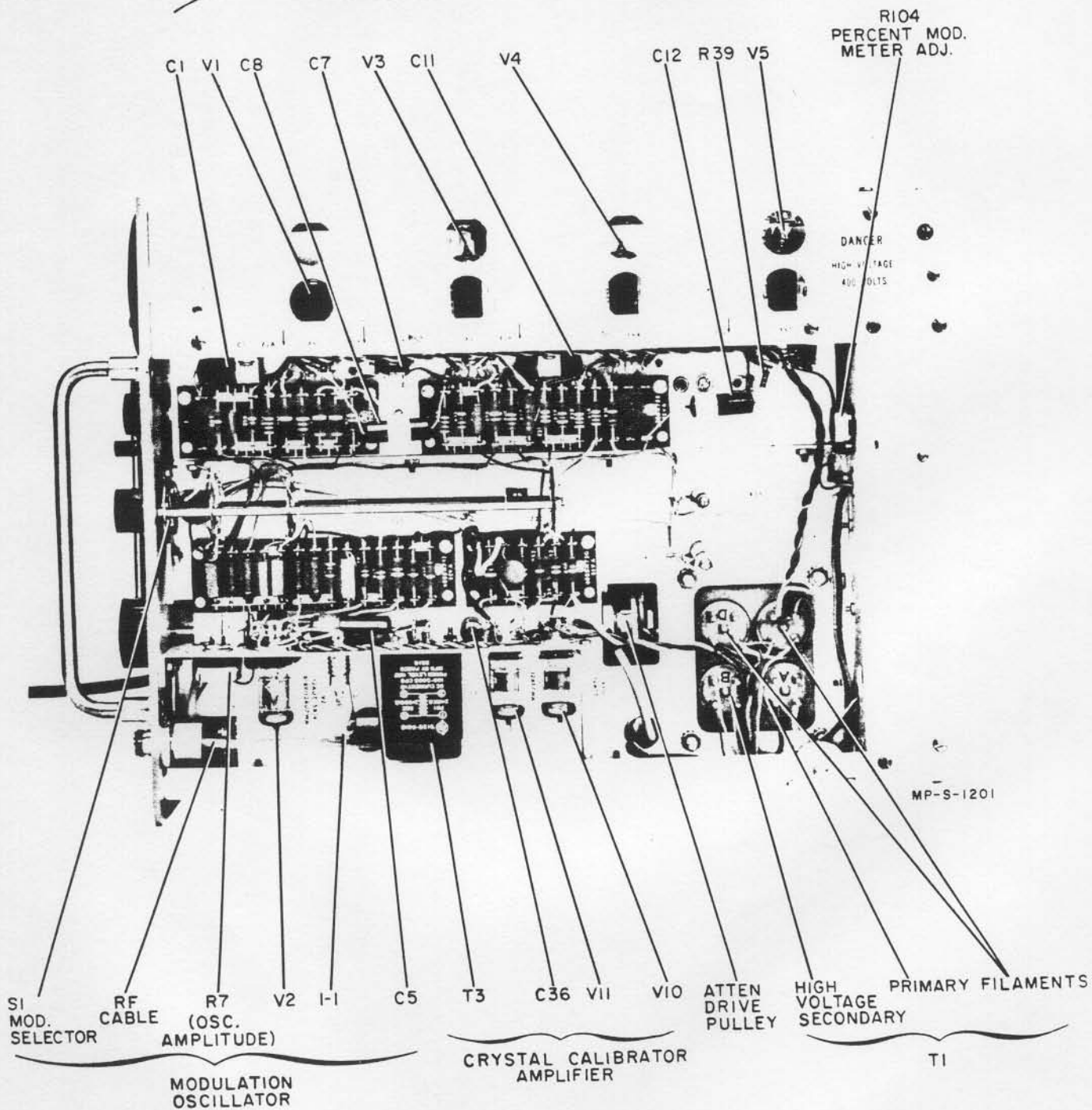


FIGURE 4-12. MODEL 608D RIGHT SIDE VIEW CABINET REMOVED

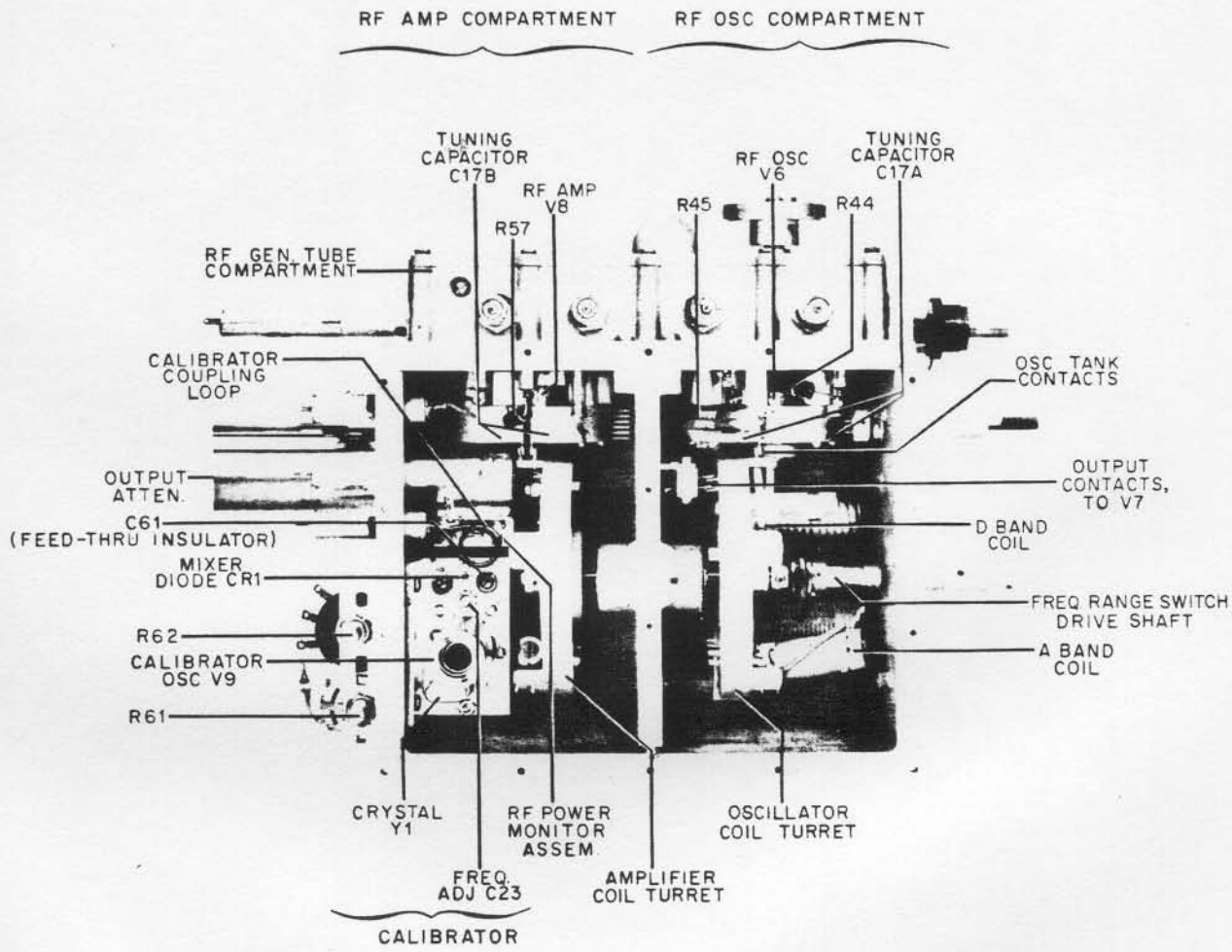


FIGURE 4-13. R-F GENERATOR ASSEMBLY, MODEL 608D SIDE PLATE REMOVED TO SHOW TUNING COMPARTMENTS

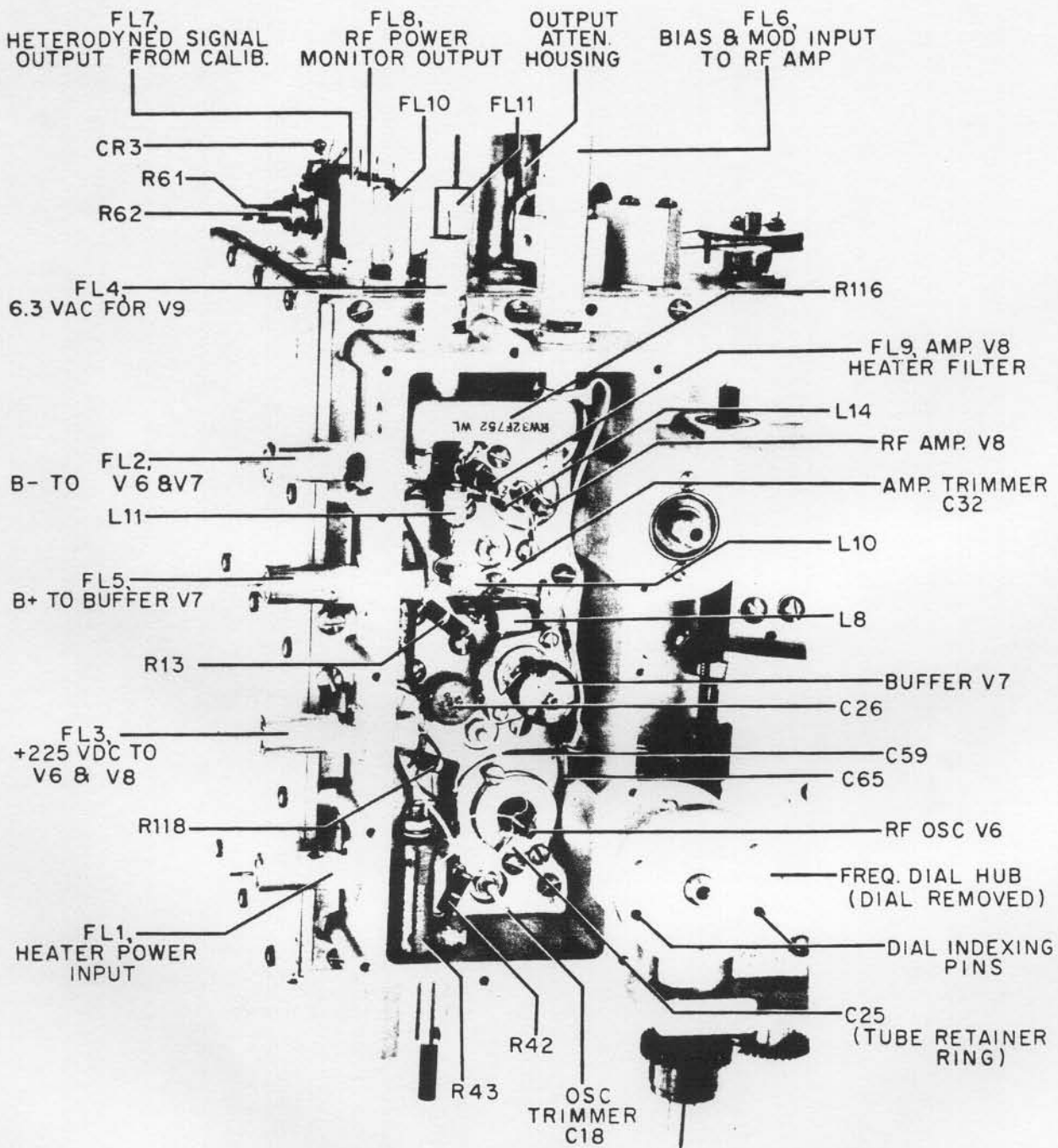


FIGURE 4-14. TUBE COMPARTMENT OF R-F GENERATOR ASSEMBLY, MODEL 608D FREQUENCY DIAL AND COVER PLATE REMOVED

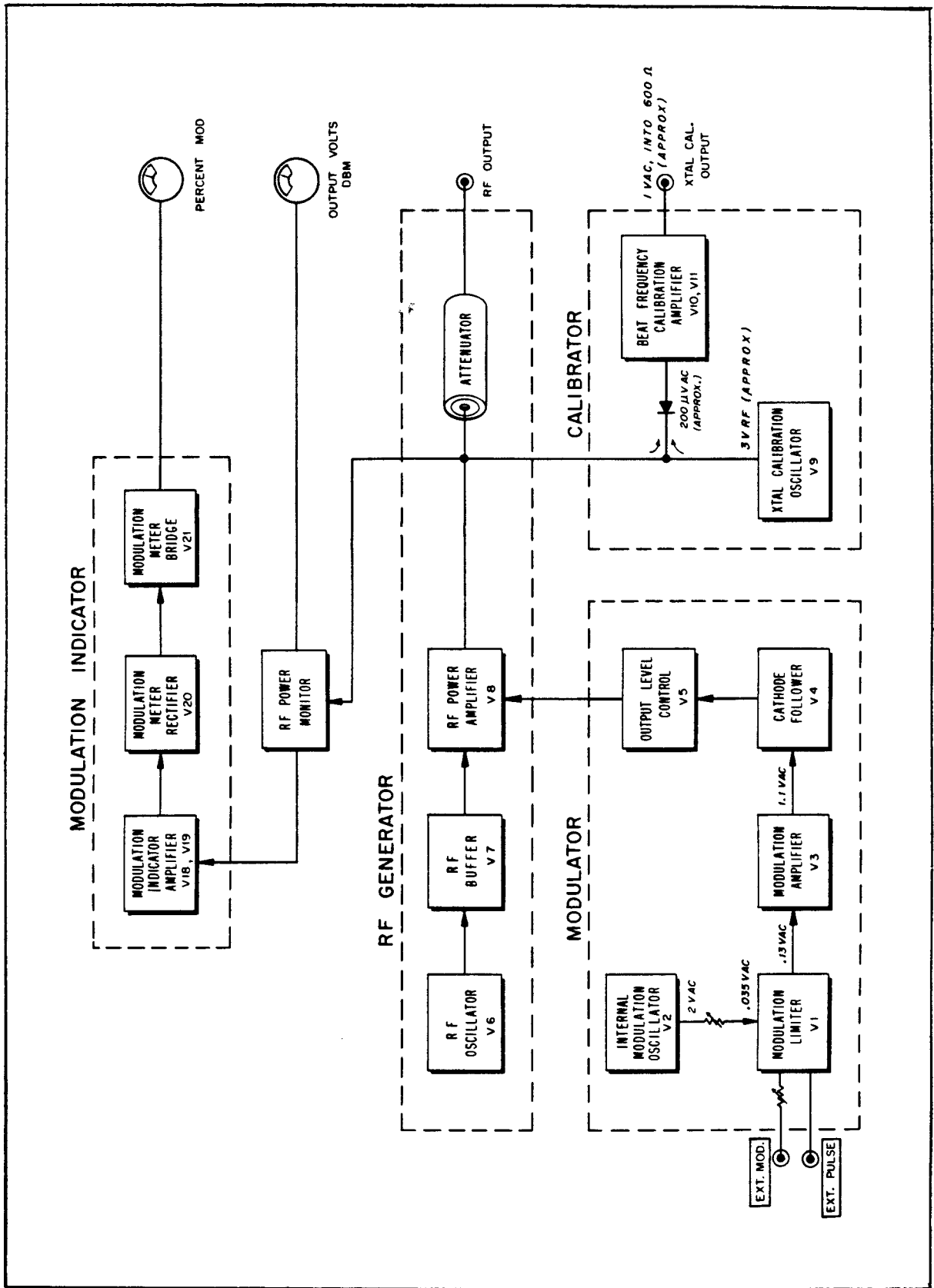


FIGURE 4-15. MODEL 608D SIGNAL TRACING BLOCK DIAGRAM

NOTES PERTAINING TO TUBE SOCKET VOLTAGE-RESISTANCE DIAGRAMS

1. CONDITIONS OF MEASUREMENT

Unless otherwise noted, measurements made with respect to chassis ground using voltmeter having 20,000-ohm-per-volt sensitivity and with front panel controls at the following settings:

FREQUENCY	. F.	100 MC
MOD. SELECTOR		1000 \sim
MOD. LEVEL		30%
OUTPUT LEVEL		Set Level

R71 and R80 in the power supply section were set to provide the normal supply voltages of +225V and -165V, respectively.

2. 20,000-ohm-per-volt meter cannot be used for this measurement since it will load the circuit and provide an erroneous reading. A vacuum-tube voltmeter should be used here.
(Note referenced on Figure 4-16, 4-17.)

3. Reading taken at minimum and maximum setting of OUTPUT LEVEL control.
(Note referenced on Figures 4-16, 4-18.)

4. Voltages measured with respect to -165V bus.
(Note referenced on Figure 4-17.)

5. Resistance to ground with MOD. SELECTOR at:

CW		∞
PULSE		2K
400 \sim , 1000 \sim , EXT. MOD.		28K

(Note referenced on Figure 4-16.)

_____ = EXTERNAL STRAP

----- = INTERNAL CONNECTION

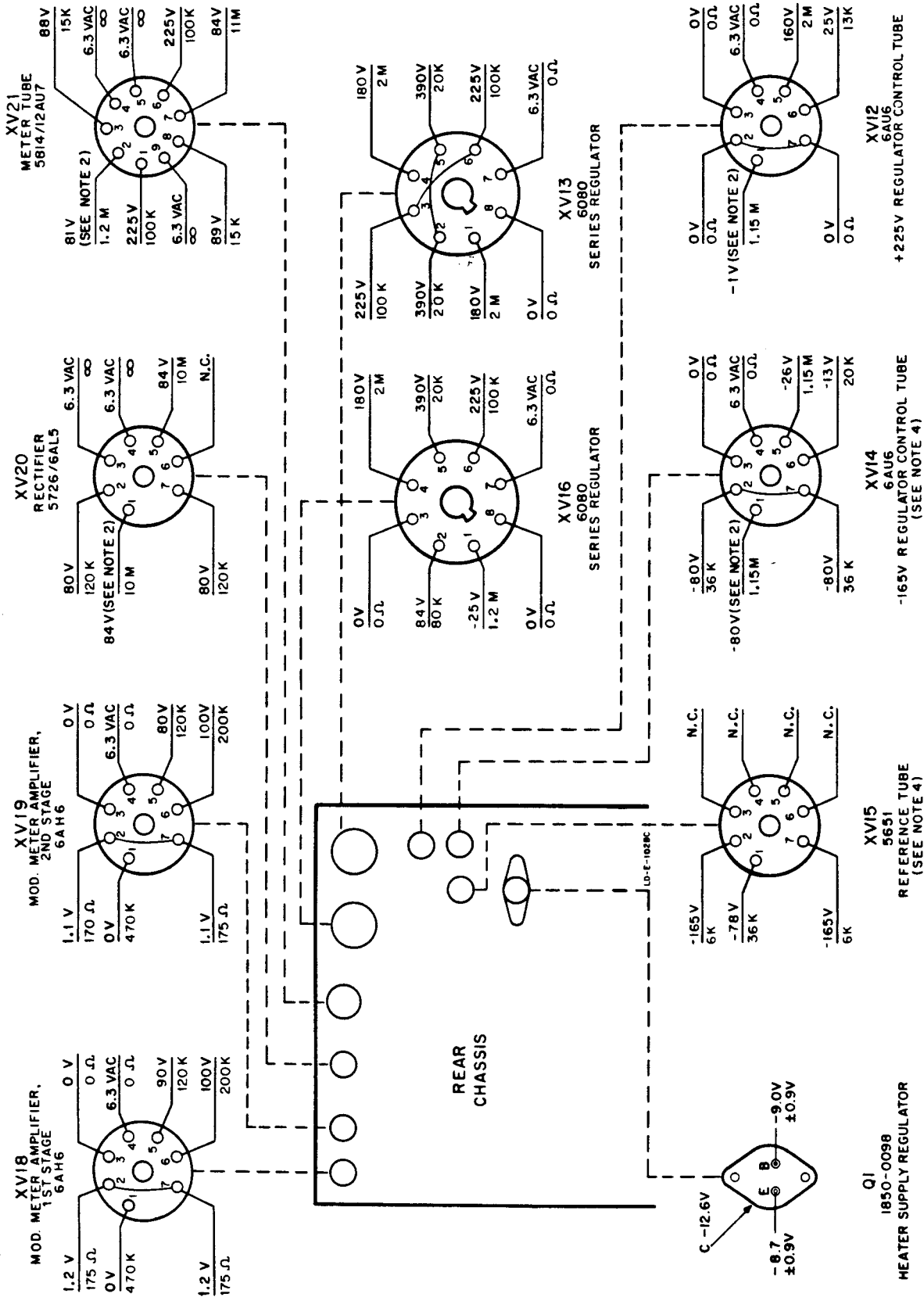


FIGURE 4-17. MODEL 608D TUBE SOCKET VOLTAGE AND RESISTANCE DIAGRAM REAR CHASSIS

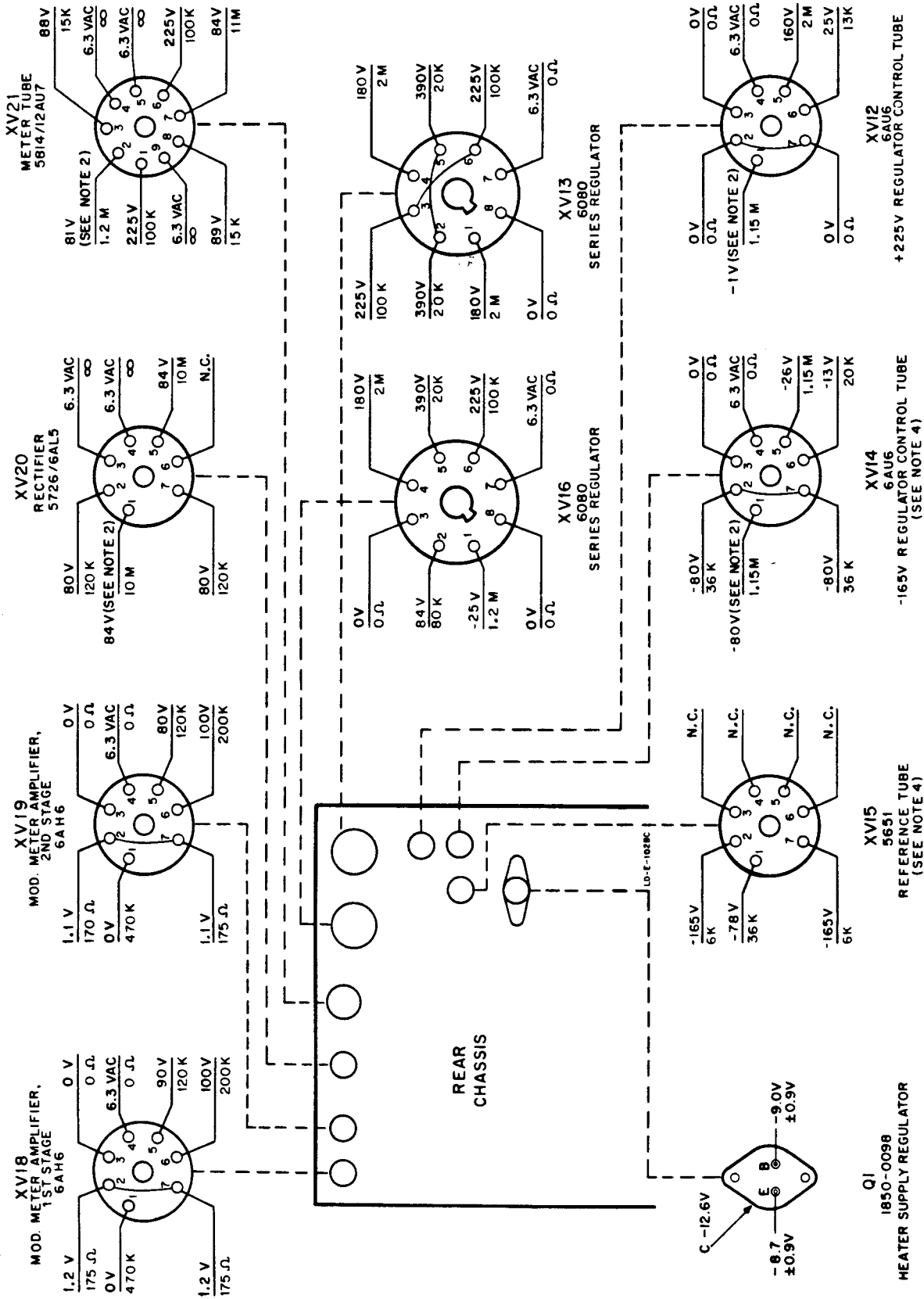


FIGURE 4-17. MODEL 608D TUBE SOCKET VOLTAGE AND RESISTANCE DIAGRAM REAR CHASSIS

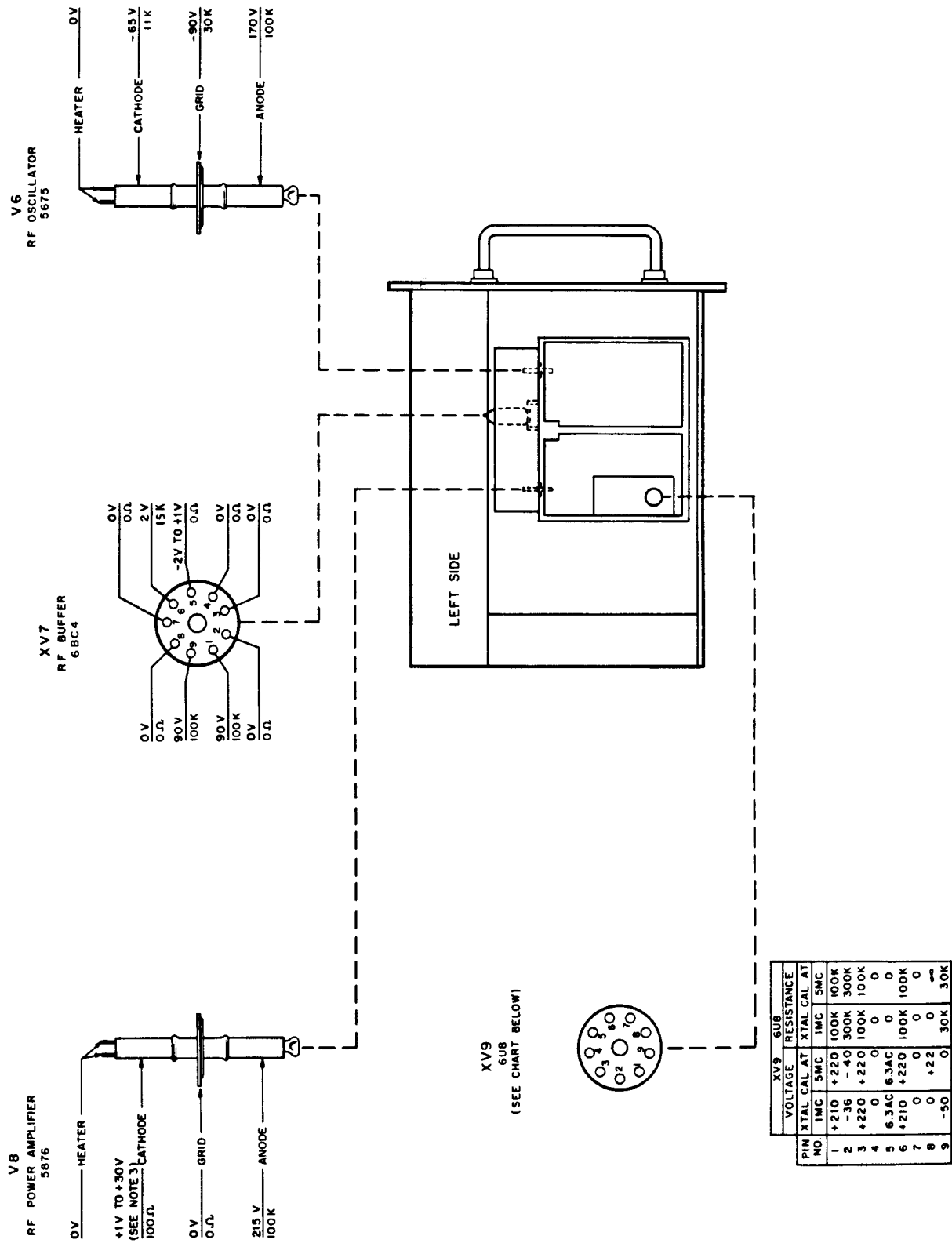
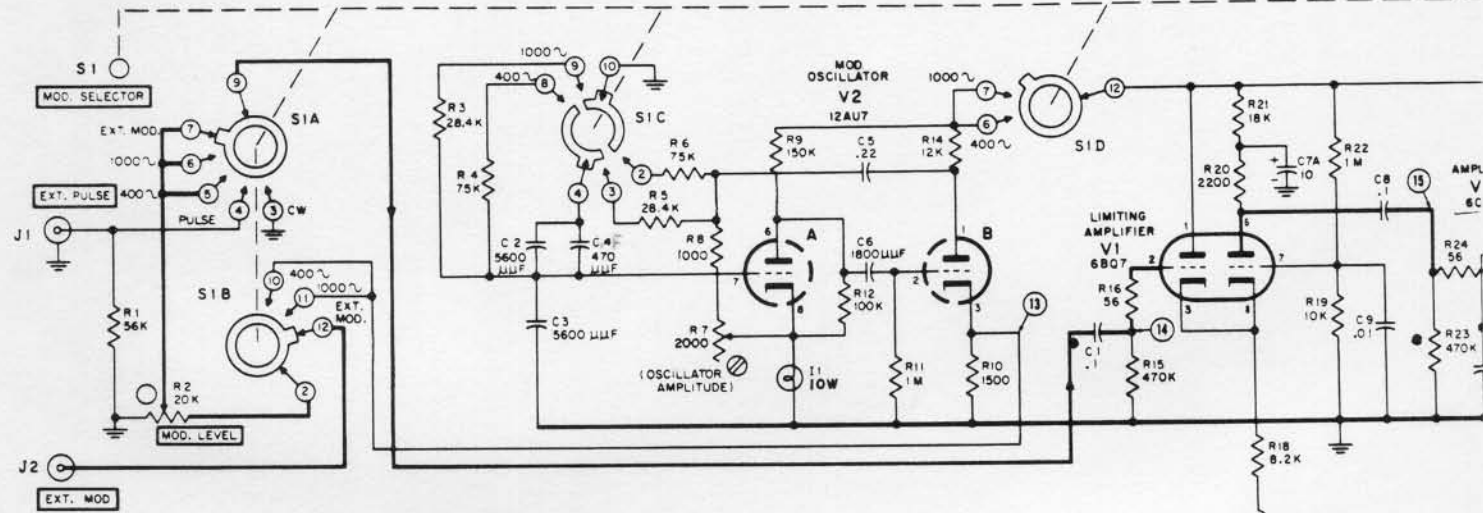
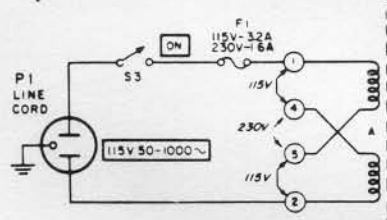


FIGURE 4-18. MODEL 608D TUBE SOCKET VOLTAGE AND RESISTANCE DIAGRAM R-F GENERATOR ASSEMBLY

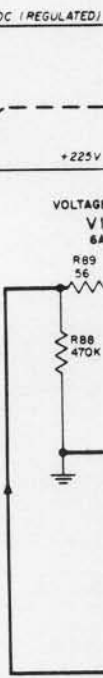
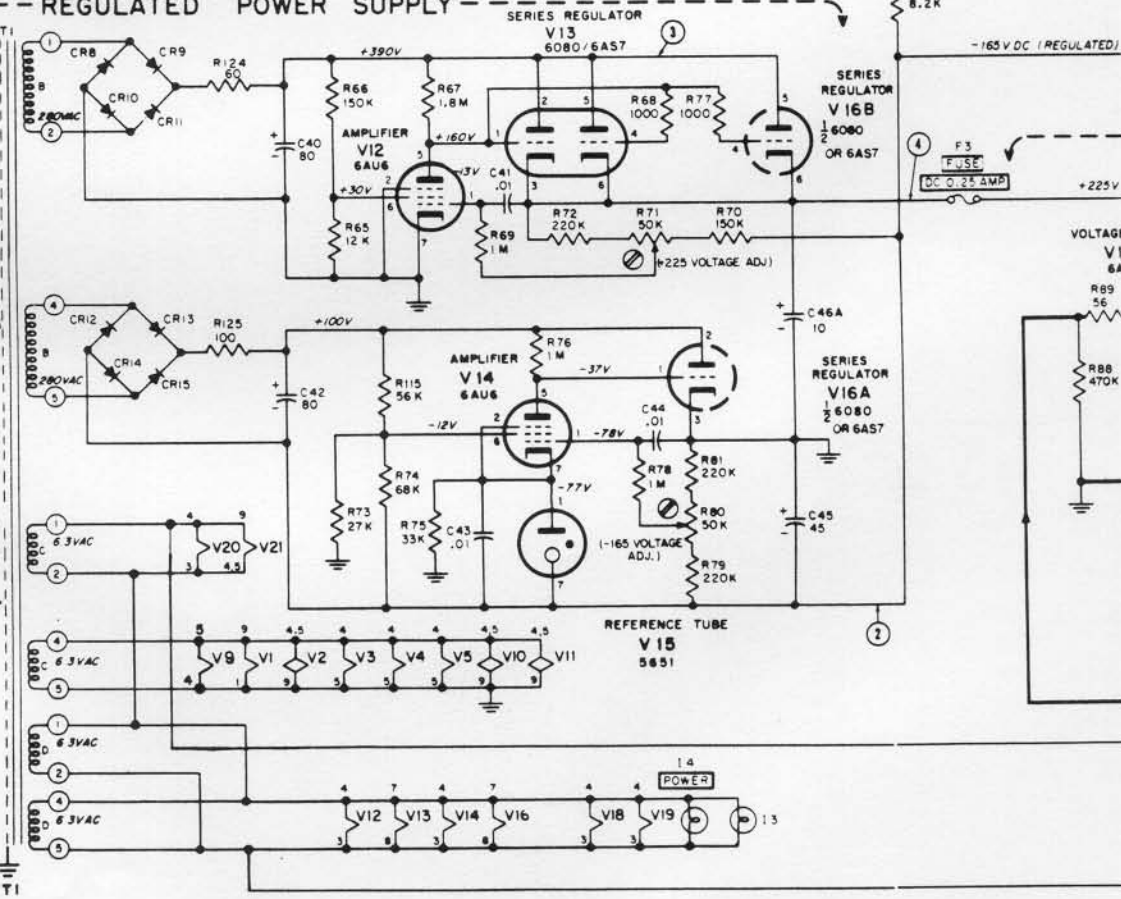
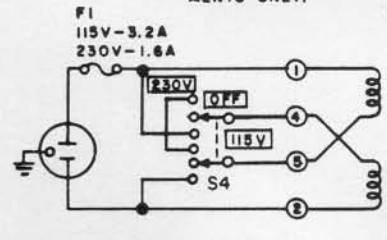
--- MODULATION OSCILLATOR ---



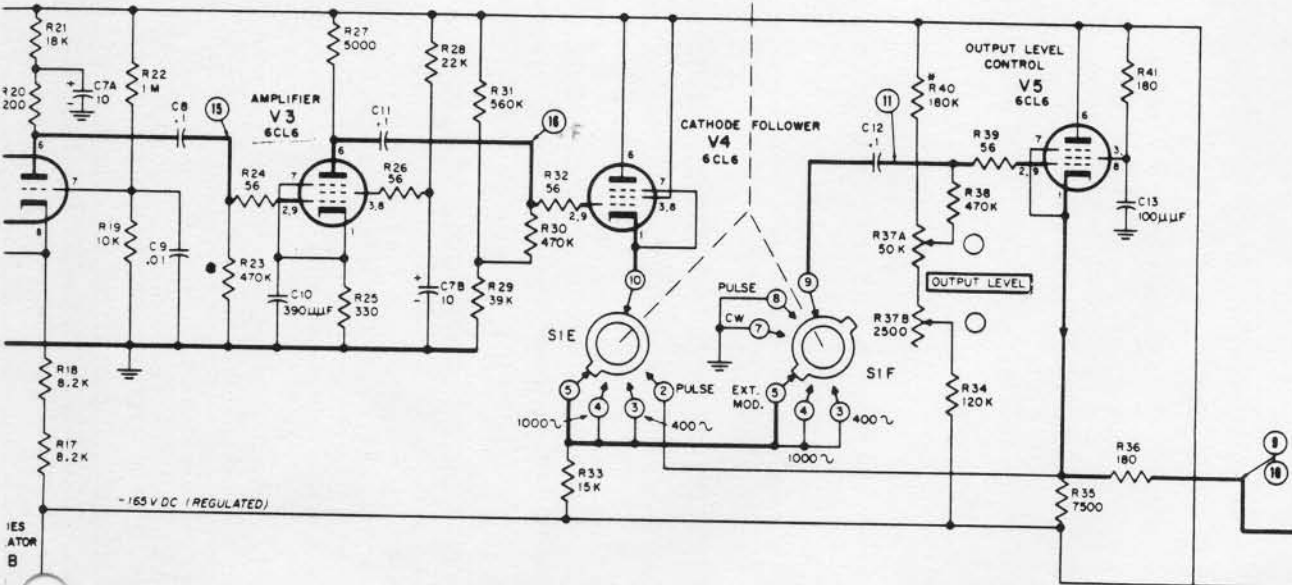
--- REGULATED POWER SUPPLY ---



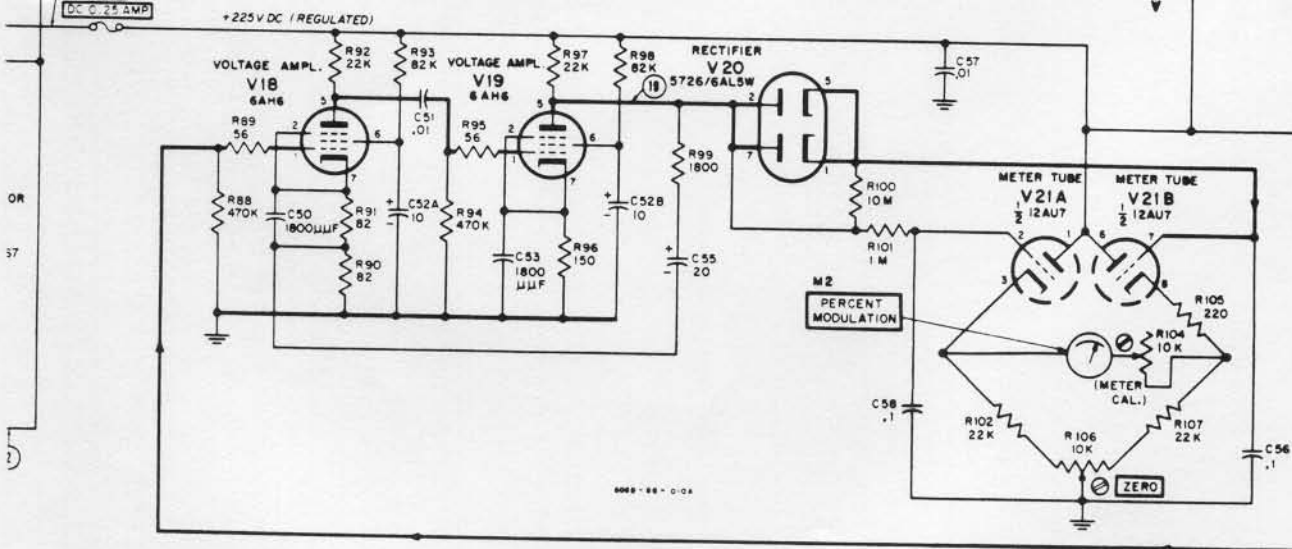
SCHEMATIC ENCLOSED IN DASHED LINES IS PRIMARY CONNECTIONS FOR HPSA INSTRUMENTS ONLY.



MODULATOR



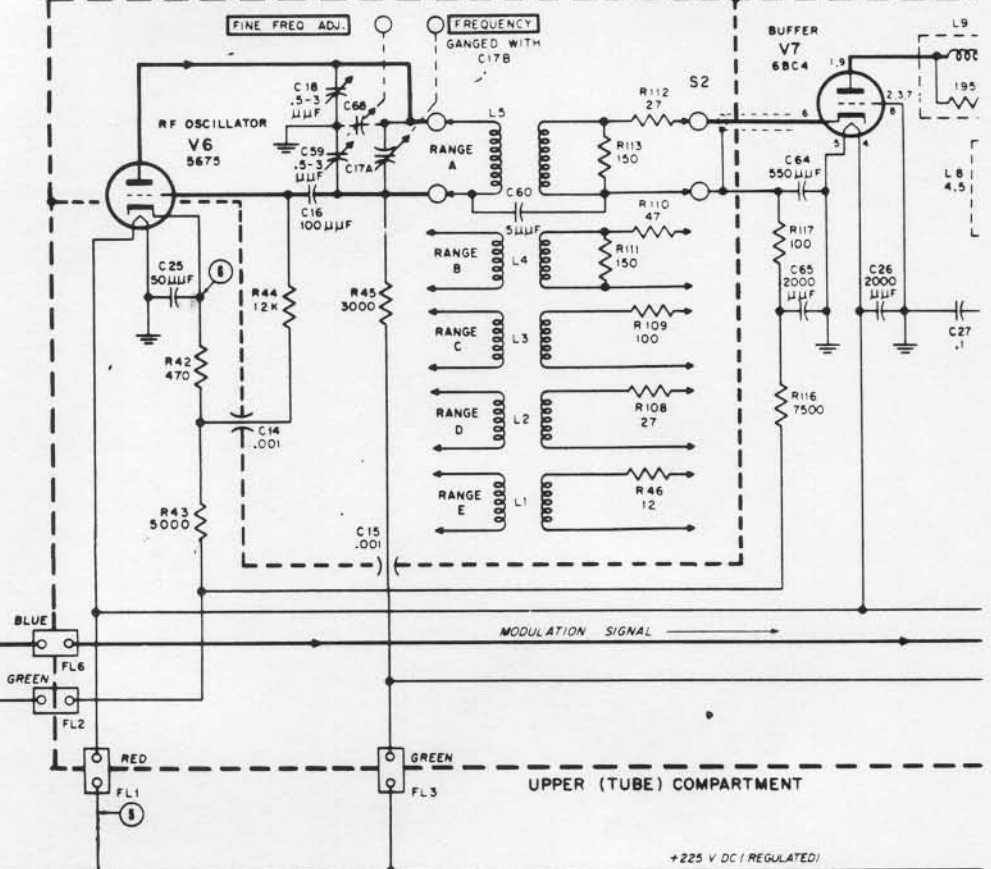
MODULATION METER AMPLIFIER



12.0 VAC

RF OSCILLATOR TUNING COMPARTMENT

RF GENERATOR ASSEM



+225 V DC (REGULATED)

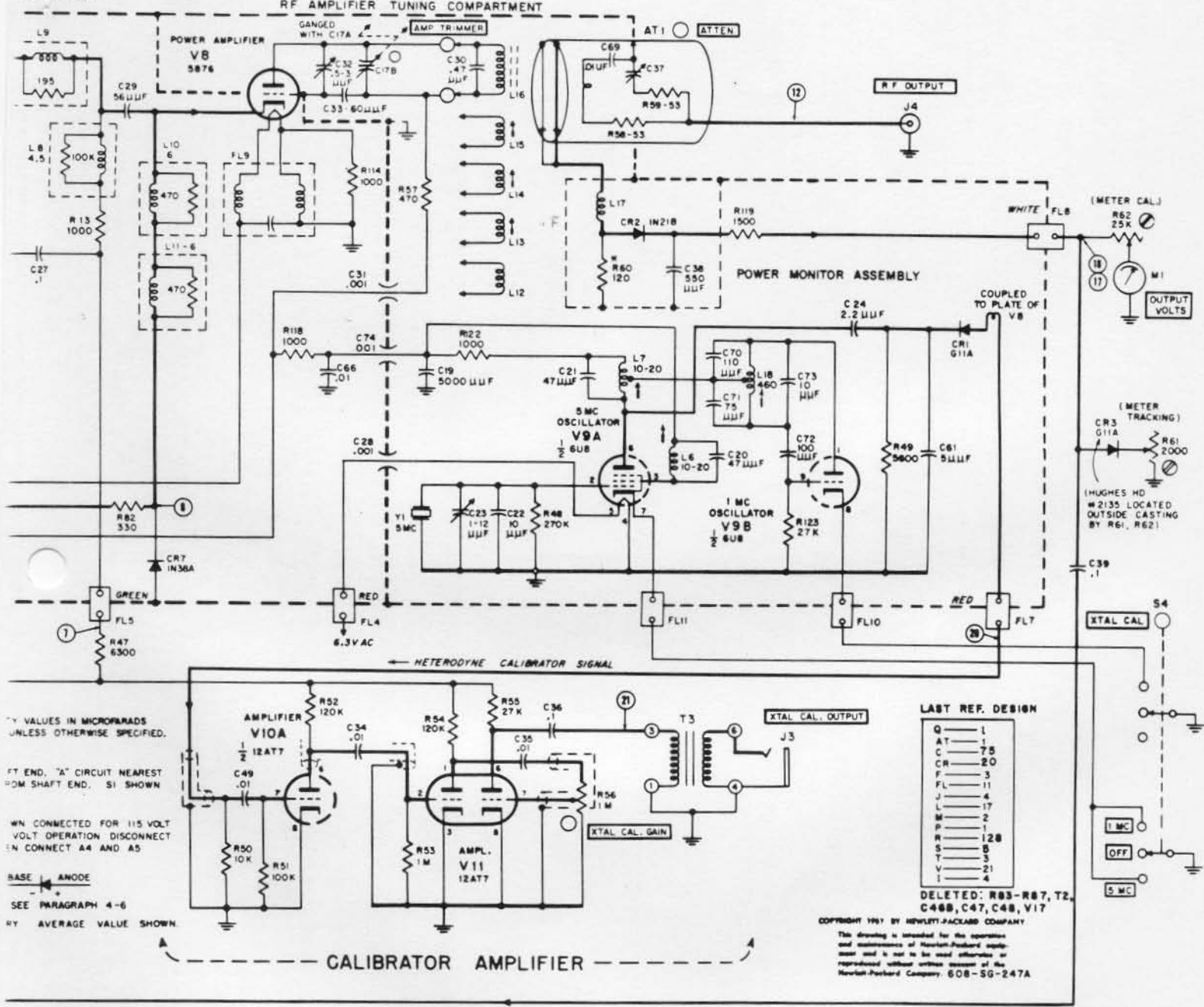
NOTES:

1. RESISTANCE VALUES IN OHMS, CAPACITY VALUE AND INDUCTANCES IN MICROHENRIES UNLESS K=1000 --- = GROUND
 2. WAFER SWITCHES VIEWED FROM SHAFT END. "B" CIRCUIT SECOND FROM SHAFT IN MAX. CW (EXT. MOD.) POSITION.
 3. POWER TRANSFORMER PRIMARY SHOWN ON OPERATION. TO CONNECT FOR 230 VOLT D A4 FROM A1 AND A5 FROM A2, THEN CONN TOGETHER.
 4. POLARITY OF CRYSTAL DIODES
- ① SYSTEM ANALYSIS CHECK POINT, SEE PA
 * VALUE ADJUSTED AT THE FACTORY AV

BRN

GY

SEMBLY



ALL VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

FT END, "A" CIRCUIT NEAREST FROM SHAFT END. S1 SHOWN

SWN CONNECTED FOR 115 VOLT OPERATION DISCONNECT SWN CONNECT A4 AND A5

BASE ANODE
 SEE PARAGRAPH 4-6

RY AVERAGE VALUE SHOWN

LAST REF. DESIGN

Q	1
AT	1
C	75
CR	20
F	3
FL	11
J	4
L	17
M	2
P	1
R	128
S	5
T	3
V	21
I	4

DELETED: R83-R87, T2, C46B, C47, C48, V17

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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. Ⓢ 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	Ⓢ STOCK NO.	TQ	RS	MFG.
AT1	Attenuator Assembly	608D-34	1	1	28480
C1	Capacitor: fixed, paper, 0.1 μ f, $\pm 10\%$, 400 vdcw	0160-0013	9	2	56289
C2, 3	Capacitor: fixed, silver mica, .0056 μ f, $\pm 1\%$, 300 vdcw	0140-0071	2	1	00656
C4	Capacitor: fixed, silver mica, 470 μ f, $\pm 5\%$, 500 vdcw	0140-0085	1	1	76433
C5	Capacitor: fixed, paper, 0.22 μ f, $\pm 10\%$, 400 vdcw	0160-0018	1	1	56289
C6	Capacitor: fixed, mica, 1800 μ f, $\pm 10\%$, 500 vdcw	0140-0020	3	1	76433
C7A, B	Capacitor: fixed, electrolytic, dual section, 10 μ f/sect., 450 vdcw	0180-0018	4	1	14655
C8	Same as C1				
C9	Capacitor: fixed, ceramic, .01 μ f tol. -0%, +100%, 1000 vdcw	0150-0012	10	3	56289
C10	Capacitor: fixed, mica 390 μ f, $\pm 5\%$, 500 vdcw	0140-0016	1	1	76433
C11, 12	Same as C1				
C13	Capacitor: fixed, mica, 100 μ f, $\pm 10\%$, 500 vdcw	0140-0054	1	1	76433
C14, 15	Capacitor: fixed, ceramic, feed-thru type 1000 μ f, $\pm 20\%$, 500 vdcw	0150-0019	5	2	72982
C16	Capacitor: fixed, ceramic, 100 μ f, $\pm 10\%$, 500 vdcw	0150-0028	1	1	56289
C17A, B	This capacitor is not replaceable				
C18	Capacitor: variable, trimmer, 0.5-3 μ f	0133-0001	3	1	14674
C19	Capacitor: fixed, ceramic, .005 μ f, 500 vdcw	0150-0014	1	1	04222
C20, 21	Capacitor: fixed, ceramic, 47 μ f, $\pm 5\%$, 500 vdcw	0150-0010	2	1	04222
C22	Capacitor: fixed, ceramic, 10 μ f, $\pm 0.5 \mu$ f, 500 vdcw	0150-0009	1	1	04222
C23	Capacitor: variable, air 1 to 12 μ f	0133-0002	1	1	14674

* 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	MFG.
C24	Capacitor: fixed, titanium dioxide dielectric, 2.2 μ f, \pm 10% 500 vdcw	0150-0015	1	1	78488
C25	Capacitor: fixed, mica dielectric, 50 μ f, \pm 10%, 500 vdcw, (Part of V6 mounting part not separately replaceable.)				28480
C26	Capacitor: fixed, ceramic, disc type, 2000 μ f, \pm 20%, 1000 vdcw	0150-0023	2	1	04222
C27	Same as C1				
C28	Same as C14				
C29	Capacitor: fixed, silver mica, 56 μ f, \pm 10%, 500 vdcw	0140-0074	1	1	53021
C30	Capacitor: fixed, titanium dioxide dielectric, .47 μ f, \pm 5%, 500 vdcw	0150-0021	1	1	78488
C31	Same as C14				
C32	Same as C18				
C33	Capacitor: fixed, mica dielectric, 60 μ f, \pm 10%, 500 vdcw		1	1	28480
C34, 35	Same as C9				
C36	Same as C1				
C37	Capacitor: slug attenuator, part of Attenuator Probe Assembly		1	1	28486
C38	Capacitor: fixed, silver mica, 550 μ f, \pm 10%, 500 vdcw	0140-0069	2	1	53021
C39	Same as C1				
C40	Capacitor: fixed, electrolytic, 80 μ f, 450 vdcw	0180-0020	2	1	14655
C41	Same as C9				
C42	Same as C40				
C43, 44	Same as C9				
C45	Capacitor: fixed, electrolytic, 45 μ f, 450 vdcw	0180-0019	1	1	14655
C46, A, B	Same as C7 A, B				

* 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	MFG.
C49	Same as C9				
C50	Capacitor: fixed, mica, 1800 μ f, \pm 10%, 500 vdcw	0140-0020	2	1	76433
C51	Same as C9				
C52, A, B	Same as C7 A, B				
C53	Same as C50				
C54	This circuit reference not assigned				
C55	Same as C7				
C56	Same as C1				
C57	Same as C9				
C58	Same as C1				
C59	Same as C18				
C60	Capacitor: fixed, ceramic dielectric, 5 μ f, \pm 0.5 μ f, 500 vdcw	0150-0003	1	1	72982
C61	Capacitor: fixed, ceramic dielectric, feed-thru insulator, 5 μ f, \pm 5%, 500 vdcw	0340-0005	1	1	72656
C62, 63	These circuit references not assigned				
C64	Same as C38				
C65	Same as C26				
C66	Same as C9				
C67	This circuit reference not assigned				
C68	Special trimmer, FINE FREQUENCY ADJUST	608D-59H	1	1	28480
C69	Capacitor: fixed, mylar dielectric, 0.01 μ f, \pm 5%, 50 vdcw, part of Attenuator Probe Assembly	0170-0067	1	1	84411
C70	Capacitor: fixed, ceramic dielectric, 110 μ f, \pm 2%, 500 vdcw	0150-0006	1	1	04222

* 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	MFG.
C71	Capacitor: fixed, ceramic dielectric, 75 μ f, 500 vdcw, NPO	0150-0038	1	1	72982
C72	Capacitor: fixed, ceramic dielectric, 100 μ f, 500 vdcw, NPO	0150-0037	1	1	72982
C73	Capacitor: fixed, ceramic dielectric, 10 μ f, \pm 1 μ f, 500 vdcw	0150-0032	1	1	72982
C74	Capacitor: fixed, 1000 μ f Same as C14	0180-0057			
CR1	Rectifier, crystal: germanium diode	1910-0011	2	2	82577
CR2	Rectifier, crystal: silicon diode 1N21B	1900-0001	1	1	94991
CR3	Same as CR1				
CR4, 5, 6	These circuit references not assigned				
CR7	Diode, Germanium	1910-0002	1	1	94991
CR8 thru CR11	Rectifier, silicon 500V PIV, 500 ma	1901-0009			81483
CR12 thru CR15	Rectifier, silicon 400V PIV, 500 ma	1901-0007			81483
CR16-CR19	Rectifier	1901-0026	4	4	
CR20	Diode, reference, 9V \pm 10%	1902-0037	1	1	
F1	Fuse, cartridge: 3.2A, 115V operation or Fuse, cartridge: 1.6A, 230V operation	2110-0013	1	10	75915
		2110-0005			75915
F2	This circuit reference not assigned				
F3	Fuse, cartridge: .25 amp	2110-0004	1	10	75915
FL1	Filter, R. F., "A", red	608A-27A	3	1	28480
FL2, 3	Filter, R. F., "D", green	608A-27D	5	1	28480
FL4	Same as FL1				
FL5	Same as FL2				
FL6	Filter, R. F., blue	608D-27C	1	1	28480
FL7	Same as FL1				
FL8	Filter, R. F., white	608D-27B	1	1	28480
FL9	Filter, R. F., choke, includes R114	608D-60D	1	1	28480
FL10, 11	Same as FL2				

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.
I1	Lamp, incandescent: 10 watt, 250V	2140-0007	1	1	24455
I2	This circuit reference not assigned				
I3, 4	Lamp, incandescent: 6-8V, .15 amp, #47	2140-0009	2	2	24455
J1, 2	Connector, BNC, female, panel jack (EXT. PULSE, EXT. MOD.)	1250-0001	2	1	91737
J3	Jack, telephone: (XTAL CAL. OUTPUT)	1251-0071	1	1	82389
J4	Panel jack body: type N (RF OUTPUT)	G-76A	1	1	28480
J4A	Bead "A" (large)	G-76A-2	1	1	28480
J4B	Bead "B" (small)	G-76A-3	1	1	28480
J4C	Spacer	G-76A-4	1	1	28480
J4D	Bushing	G-76A-1	1	1	28480
J4E	Center contact, female: for output connector	1250-0017	1	1	91737
L1 thru L5	Part of Turret Assembly Oscillator, replace as a unit	608D-60B	1	1	28480
L6	Coil, variable: 10-20 μ h	9140-0008	1	1	98405
L7	Coil, R. F., variable, 10.5-20 μ h	9140-0035	1	1	98405
L8	Choke, R. F., 4.5 μ h	608D-60C	1	1	28480
L9	Choke, R. F., .04 μ h	608D-60J	1	1	28480
L10, 11	Choke, R. F., 6 μ h	608D-60K	2	1	28480
L12 thru L16	Part of Turret Assembly, Amplifier, replace as a unit	608D-60A	1	1	28480
L17	Part of Bolometer assembly, replace as a unit				
L18	Coil, R. F., variable, 450-500 μ h	9140-0036	1	1	98405
M1	Meter, microammeter, 50 microamp, output volts	1120-0046	1	1	65092
M2	Meter, milliammeter, 1 milliamp, percent modulation	1120-0040	1	1	65092
P1	Power, cable	8120-0015	1	1	83148
Q1	Transistor, PNP	1850-0098			
R1	Resistor: fixed, composition, 56,000 ohms, $\pm 10\%$, 1 W	0690-5631	2	1	01121

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- Total quantity used in the instrument.

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	⊕ STOCK NO.	TQ	RS	MFG.
R2	Resistor: variable, composition, 20,000 ohms, $\pm 20\%$, 1/3 W	2100-0160	1	1	71450
R3	Resistor: fixed, deposited carbon, 28.4K ohms, $\pm 1\%$, 1/2 W	0727-0184	2	1	19701
R4	Resistor: fixed, deposited carbon, 75,000 ohms, $\pm 1\%$, 1 W	0730-0058	2	1	19701
R5	Same as R3				
R6	Same as R4				
R7	Resistor: variable, composition, 2000 ohms, $\pm 20\%$	2100-0010	2	1	12697
R8	Resistor: fixed, composition, 680 ohms, $\pm 10\%$, 1 W	0690-6811	5	2	01121
R9	Resistor: fixed, composition, 150,000 ohms, $\pm 10\%$, 1 W	0690-1541	3	1	01121
R10	Resistor: fixed, composition, 1500 ohms, $\pm 10\%$, 1 W	0690-1521	2	1	01121
R11	Resistor: fixed, composition, 1 megohm, $\pm 10\%$, 1 W	0690-1051	7	2	01121
R12	Resistor: fixed, composition, 100,000 ohms, $\pm 10\%$, 1 W	0690-1041	1	1	01121
R13	Same as R8				
R14	Resistor: fixed, composition, 12,000 ohms, $\pm 10\%$, 2 W	0693-1231	2	1	01121
R15	Resistor: fixed, composition, 470,000 ohms, $\pm 10\%$, 1 W	0690-4741	4	1	01121
R16	Resistor: fixed, composition, 56 ohms, $\pm 10\%$, 1/2 W	0687-5601	7	2	01121
R17, 18	Resistor: fixed, composition, 8200 ohms, $\pm 10\%$, 2 W	0693-8221	2	1	01121
R19	Resistor: fixed, composition, 10,000 ohms, $\pm 10\%$, 1 W	0690-1031	2	1	01121
R20	Resistor: fixed, composition, 2200 ohms, $\pm 10\%$, 2 W	0693-2221	1	1	01121
R21	Resistor: fixed, composition, 18,000 ohms, $\pm 10\%$, 2 W	0693-1831	1	1	01121

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	⊕ STOCK NO.	TQ	RS	MFG.
R22	Same as R11				
R23	Same as R15				
R24	Same as R16				
R25	Resistor: fixed, composition, 330 ohms, $\pm 10\%$, 1 W	0690-3311	1	1	01121
R26	Same as R16				
R27	Resistor: fixed, wirewound, 5000 ohms, $\pm 1\%$, 5 W	0811-0006	1	1	91637
R28	Resistor: fixed, composition, 22,000 ohms, $\pm 10\%$, 2 W	0693-2231	5	2	01121
R29	Resistor: fixed, composition, 39,000 ohms, $\pm 10\%$, 1 W	0690-3931	1	1	01121
R30	Same as R15				
R31	Resistor: fixed, composition, 560,000 ohms, $\pm 10\%$, 1 W	0690-5641	1	1	01121
R32	Same as R16				
R33	Resistor: fixed, wirewound, 15,000 ohms, $\pm 10\%$, 10 W	0816-0013	1	1	34534
R34	Resistor: fixed, composition, 120,000 ohms, $\pm 10\%$, 1 W	0690-1241	3	1	01121
R35	Resistor: fixed, wirewound, 7500 ohms, $\pm 5\%$, 20 W	0818-0009	1	1	34534
R36	Resistor: fixed, composition, 180 ohms, $\pm 10\%$, 1 W	0690-1811	1	1	01121
R37 A, B	Resistor: variable, carbon, 2 sections, 2000 - 50,000 ohms	2100-0052	1	1	12697
R38	Same as R15				
R39	Same as R16				
R40	Resistor: fixed, composition, 180,000 ohms, $\pm 10\%$, 1 W	0690-1841	1	1	01121
R41	Resistor: fixed, composition, 180 ohms, $\pm 10\%$, 1/2 W	0687-1811	1	1	01121

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG
R42	Resistor: fixed, composition, 470 ohms, $\pm 10\%$, 2 W	0693-4711	1	1	01121
R43	Resistor: fixed, wirewound, 5000 ohms, $\pm 10\%$, 10 W	0816-0006	1	1	34534
R44	Same as R14				
R45	Resistor: fixed, wirewound, 3000 ohms, $\pm 10\%$, 10 W	0816-0002	1	1	34534
R46	Resistor: fixed, composition, 12 ohms, $\pm 10\%$, 1/2 W	0687-1201	1	1	01121
R47	Resistor: fixed, wirewound, 6300 ohms, $\pm 10\%$, 10 W	0816-0017	1	1	04534
R48	Resistor: fixed, composition, 270,000 ohms, $\pm 10\%$, 1/2 W	0687-2741	1	1	01121
R49	Resistor: fixed, composition, 5600 ohms, $\pm 10\%$, 1/2 W	0687-5621	1	1	01121
R50	Same as R19				
R51	Resistor: fixed, composition, 100,000 ohms, $\pm 10\%$, 1/2 W	0687-1041	1	1	
R52	Same as R34				
R53	Same as R11				
R54	Same as R34				
R55	Resistor: fixed, composition, 27,000 ohms, $\pm 10\%$, 2 W	0693-2731	1	1	01121
R56	Resistor: variable, composition, 1 megohm, $\pm 20\%$, 1/4 W	2100-0159	1	1	71450
R57	Resistor: fixed, composition, 470 ohms, $\pm 10\%$, 1 W	0690-4711	1	1	01121
R58, 59	Resistor: fixed, deposited carbon, 53.3 ohms, $\pm 1\%$, 1/8 W part of Attenuator Probe Assembly	0721-0006	2	1	19701
R60	Resistor: fixed, composition, 120 ohms, $\pm 10\%$, 1/4 W Electrical value adjusted at factory	0684-1211	1	1	01121

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.
R61	Same as R7				
R62	Resistor: variable, composition, 25,000 ohms, $\pm 20\%$, 1 W	2100-0009	1	1	71590
R63, 64	These circuit references not assigned				
R65	Resistor: fixed, composition, 12,000 ohms, $\pm 10\%$, 1 W	0690-1231	1	1	01121
R66	Same as R9				
R67	Resistor: fixed, composition, 1.8 megohms, $\pm 10\%$, 1 W	0690-1851	1	1	01121
R68	Same as R8				
R69	Same as R11				
R70	Same as R9				
R71	Resistor: variable, composition, linear taper, 50,000 ohms, $\pm 20\%$, 1/3 W	2100-0157	2	1	71450
R72	Resistor: fixed, composition, 220,000 ohms, $\pm 10\%$, 1 W	0690-2241	1	1	01121
R73	Resistor: fixed, composition, 27,000 ohms, $\pm 10\%$, 1 W	0690-2731	1	1	01121
R74	Resistor: fixed, composition, 68,000 ohms, $\pm 10\%$, 2 W	0693-6831	1	1	01121
R75	Resistor: fixed, composition, 33,000 ohms, $\pm 10\%$, 1 W	0690-3331	1	1	01121
R76	Same as R11				
R77	Same as R8				
R78	Same as R11				
R79	Same as R72	0690-2241	2	1	
R80	Same as R71				
R81	Same as R79				
R82	Resistor: fixed, composition, 330 ohms, $\pm 10\%$, 1 W	0690-3311	1	1	01121
R83	Same as R75				

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.
R88	Resistor: fixed, composition, 470,000 ohms, $\pm 10\%$, 1/2 W	0687-4741	2	1	01121
R89	Same as R16				01121
R90, 91	Resistor: fixed, composition, 82 ohms, $\pm 10\%$, 1 W	0690-8201	2	1	01121
R92	Same as R28				
R93	Resistor: fixed, composition, 82,000 ohms, $\pm 10\%$, 1 W	0690-8231	2	1	01121
R94	Same as R88				
R95	Same as R16				
R96	Resistor: fixed, composition, 150 ohms, $\pm 10\%$, 1 W	0690-1511	2	1	01121
R97	Same as R28				
R98	Same as R93				
R99	Resistor: fixed, composition, 1800 ohms, $\pm 10\%$, 1 W	0690-1821	1	1	01121
R100	Resistor: fixed, composition, 10 megohms, $\pm 10\%$, 1 W	0690-1061	1	1	01121
R101	Same as R11				01121
R102	Same as R28				
R103	This circuit reference not assigned				
R104	Resistor: variable, composition, linear taper, 10,000 ohms, $\pm 20\%$ 1/2 W	2100-0156	1	1	71450
R105	Resistor: fixed, composition, 220 ohms, $\pm 10\%$, 1 W	0690-2211	1	1	01121
R106	Same as R104				

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.
R107	Same as R28				
R108	Resistor: fixed, composition, 27 ohms, $\pm 10\%$, 1/4 W	0684-2701	2	1	01121
R109	Resistor: fixed, composition, 100 ohms, $\pm 10\%$, 1/4 W	0684-1011	1	1	01121
R110	Resistor: fixed, composition, 47 ohms, $\pm 10\%$, 1/4 W	0684-4701	1	1	01121
R111	Resistor, fixed, composition, 150 ohm $\pm 10\%$, 1/4 W	0684-1501			01121
R112	Same as R108				
R113	Same as R96				
R114	Part of FL9				
R115	Same as R1				
R116	Resistor: fixed, wirewound, 7500 ohms, $\pm 10\%$, 10 W	0816-0007	1	1	34534
R117	Resistor: fixed, composition, 100 ohms, $\pm 10\%$, 1/2 W	0687-1011	1	1	01121
R118	Same as R8				
R119	Same as R10				
R120, 121	These circuit references not assigned				
R122	Resistor: fixed, composition, 1000 ohms, $\pm 10\%$, 1/2 W	0687-1021	1	1	01121
R123	Resistor: fixed, composition, 27,000 ohms, $\pm 10\%$, 1/2 W	0687-2731	1	1	01121
R124	Resistor: fixed, wirewound, 60 ohms, $\pm 5\%$, 40 W	0818-0027	1	1	94310
R125	Resistor: fixed, wirewound, 100 ohms, $\pm 10\%$, 20 W	0819-0019	1	1	34534
R127	Resistor: fixed, average value 7 ohms	0813-0017			
R128	Resistor: fixed, composition, 15,000 ohm	0773-0006			
S1	Switch, rotary: 5 position, (MOD SELECTOR)	3100-0097	1	1	76854
S2	This circuit reference not assigned				
S3	Switch, toggle: DPST (on-off)	3101-0003	1	1	04009
S4	Switch, toggle: DP3T (XTAL CAL 1 MC - OFF - 5MC)	3101-0012	2	1	04009
S5	Same as S4 (used in hpsa instruments only in place of S3)		1	1	
T1	Transformer, power	9100-0047	1	1	98734

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	⊕ STOCK NO.	TQ	RS	MFG
T3	Transformer, audio: xtal calibrator output	9120-0018	1	1	98734
V1	Tube, electron: 6BQ7A	1932-0021	1	1	33173
V2	Tube, electron: 12AU7	1932-0029	2	2	33173
V3, 4, 5	Tube, electron: 6CL6	1923-0029	3	3	33173
V6	Tube, electron: 5675	1921-0001	1	1	86684
V7	Tube, electron: 6BC4	1921-0004	1	1	86684
V8	Tube, electron: 5876	1921-0002	1	1	86684
V9	Tube, electron: 6U8	1933-0004	1	1	33173
V10, 11	Tube, electron: 12AT7	1932-0027	2	2	33173
V12	Tube, electron: 6AU6	1923-0021	2	2	33173
V13	Tube, electron: 6080	1932-0010	2	2	33173
V14	Same as V12				
V15	Tube, electron: 5651	1940-0001	1	1	
V16	Same as V13				
V18, 19	Tube, electron: 6AH6	1923-0017	2	2	33173
V20	Tube, electron: 6AL5 or 5726	1930-0013 or 1930-0009	1	1	33173 33173
V21	Same as V2				
XV1 thru XV5	Socket, tube: noval	1200-0008	9	1	91662
XV6	Socket, tube: pencil triode filament contact assembly	1200-0010	2	1	71785
XV7	Same as XV1				
XV8	Same as XV6				
XV9	Socket, tube: 9 pin miniature	1200-0003	1	1	71785
XV10, 11	Same as XV1				
XV12	Socket, tube: 7 pin miniature	1200-0009	6	1	91662

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	④ STOCK NO.	TQ	RS	MFG.
XV13	Socket, tube: octal	1200-0005	2	1	61662
XV14,15	Same as XV12				
XV16	Same as XV13				
XV18, 19 20	Same as XV12				
XV21	Same as XV1				
Y1	Crystal, quartz	0410-0009	1	1	
XY1	Socket, crystal	1200-0028	1	1	71785
Z1	Turret Assembly: Oscillator	608D-60B	1	0	28480
Z2 thru Z4	These circuit references not assigned				
Z5	Turret Assembly: Amplifier	608D-60A	1	0	28480
MISCELLANEOUS					
	Attenuator, knob and dial assembly	608D-40A	1	0	28480
	Attenuator, drive pulley	608D-34F	1	0	28480
	Attenuator drive cable	G-18B	1	1	28480
	Bezel, frequency window	608D-83E	1	0	28480
	Body, oscillator, tube socket	608D-59A	1	1	28480
		-3			
	Bolometer Assembly	608D-95A	1	1	28480
	Capacitor Assembly, attenuator	608A-95B	1	1	28480
	Fuse, Safety, 1/16 amp, 4-10 ohm used in 608A-95A Fuseholder	2110-0026	1	1	

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.
	Cam, frequency adjust	608D-59H	1	0	28480
	Clamp, tube: (V13, V16)	1400-0032	2	0	91506
	Clamp, tube, spring (short)	1400-0004	12	0	92196
	Clamp, tube, spring (medium)	1400-0005	3	0	92196
	Clip for bolometer filter	608A-28C -1	1	1	28480
	Contact Assembly: for oscillator pick-up coil	608D-100K	1	1	28480
	Contact, silver button soldered to tuning capacitor stators	608D-7M	1	1	28480
	Contact, oscillator grid	608A-100V	1	0	28480
	Contact, oscillator tube socket	608D-59A -2	1	0	28480
	Contact, amplitude cathode	608A-100W	1	0	28480
	Crank, handle	G-74AE	1	0	28480
	Coupler, flexible, bellows type	G-32K	1	0	28480
	Detent arm, range switch	608D-59C	1	0	28480
	Fuseholder	1400-0084	2	1	75915
	Gear, frequency stop	G-24C-2	1	0	28480
	Gear, worm, oscillator drive	608D-24A	1	0	28480
	Gear, frequency drive	608D-37B	1	0	28480
	Insulator, card, attenuator	608A-34C	1	0	28480
	Insulator, standoff, cylindrical shape	0340-0020	2	0	72656
	Insulator, shoulder bushing	0340-0005	2	0	72656
	Insulator, standoff, cylindrical shape, 1/2 inch long x 1/2 inch dia	0340-0007	1	0	71590

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.
	Insulator, standoff, .625 inches long	0340-0006	8	0	71590
	Knob: OUTPUT LEVEL	G-74B	1	0	28480
	Knob: OUTPUT LEVEL (skirted)	G-74L	1	0	28480
	Knob: FINE FREQ. ADJUST	G-74D	1	0	28480
	Knob: MOD. LEVEL, AMP. TRIMMER, XTAL. CAL. GAIN	G-74F	3	0	28480
	Knob: MOD. SELECTOR,	G-74N	1	0	28480
	Knob: FREQ. RANGE	G-74AD	1	0	28480
	Knob: frequency, complete with vernier dial	608D-95B	1	0	28480
	Lampholder: candelabra base	1450-0013	1	1	95263
	Lampholder: dial illuminating	1450-0009	1	1	95263
	Light, indicator (red)	1450-0003	1	1	72619
	Lubricant, "Molly"	850-137	1	1	28480
	Roller, detent	608D-59D	1	0	28480
	Rotor, attenuator cap	1490-0012	1	0	48620
	Spring, lock	1460-0013	1	0	91260
	Screw, captive, for cabinet with knurled head	608D-44K	4	0	28480
	Spacer, bakelite oscillator tube	608D-59A- 4	1	0	28480
	Shaft, amplifier drive	608D-37A	1	0	28480
	Shaft, frequency vernier, bakelite	608D-37P	1	0	28480

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TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS	MFG.	
	Shield, crystal calibrator	608D-55B	1	0	28480	
	Shield, tube (V109)	1220-0009	1	0		
	Socket: for bolometer crystals	608A-28D	1	1	28480	
	Wrench, spanner	612A-38A	1	0	28480	
	Window, dial, for dished attenuator dial	G-99M	1	0	28480	

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