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HEWLETT-PACKARD
MAY 1960

206A

LOW DISTORTION AUDIO SIGNAL GENERATOR

SERIALS PREFIXED: 010

OPERATING AND SERVICING MANUAL

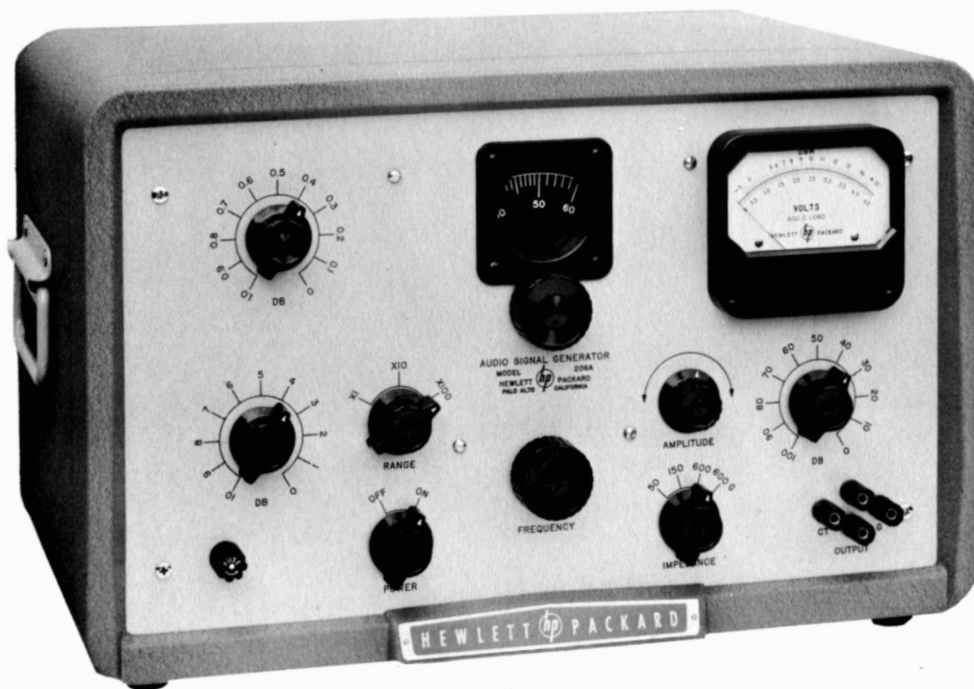


OPERATING AND SERVICING MANUAL



MODEL 206A
LOW DISTORTION
AUDIO SIGNAL GENERATOR

SERIALS PREFIXED: 010 -



SPECIFICATIONS

FREQUENCY RANGE:	20 cps to 20 kc in 3 ranges.
CALIBRATION:	Directly in cycles for the lowest range, from 20 to 200 cps. X10 and X100 multiplier provided for higher ranges. Each range covers approximately 270 degrees of the 6" dial.
CALIBRATION ACCURACY:	±1%.
FREQUENCY STABILITY:	±2% including warm-up drift.
OUTPUT:	±15 dbm (0 dbm = 1 mw) into impedance of 50, 150 and 600 ohms. Approximately 10 volts open circuit. Output is center tapped and balanced to ground. Internal impedance matches load impedance.
FREQUENCY RESPONSE:	Better than ±0.2 db, 30 cps to 15 kc, with output meter kept at constant level (Ref: 1 kc).
DISTORTION:	Less than 0.1% at frequencies above 50 cps and less than 0.25% from 20 cps to 50 cps.
HUM LEVEL:	At least 75 db below the output signal or more than 100 db below zero level, whichever is the larger.
OUTPUT METER:	Calibrated in dbm (0 dbm = 1 mw) and also in volts at 600 ohm level. Readability at least 0.2 db at all points above 50% scale reading.
OUTPUT ATTENUATORS:	111 db in 0.1 db steps. Accuracy approximately 0.1 db.
POWER SUPPLY:	115/230 volts ±10%, 50/1,000 cps, 140 watts.
DIMENSIONS:	Cabinet Mount: 12-3/4" high, 20-3/4" wide, 14" deep. Rack Mount: 10-1/2" high, 19" wide, 13-3/8" deep behind panel.
WEIGHT:	Cabinet Mount: Net 57 lbs. Shipping 78 lbs. Rack Mount: Net 50 lbs. Shipping 72 lbs.
ACCESSORIES AVAILABLE:	Model AC-16A Cable Assembly, two dual banana plugs. Model AC-16B Cable Assembly, dual banana plug to BNC.

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SECTION I
GENERAL DESCRIPTION

1-1 GENERAL

The Model 206A Low Distortion Audio Signal Generator provides a precise source of continuously variable audio-frequency voltage suitable for use in making accurate gain or frequency response measurements of high-quality audio circuits. Any desired frequency within a range of 20 to 20,000 cycles/second is made available by an extremely low-distortion resistance-capacity oscillator within the instrument. A voltmeter, calibrated both in volts and dbm, is provided to measure the output of the oscillator output amplifier. Following the voltmeter is an attenuator which permits the output level to be reduced in .1 db steps to a maximum of 111 db. A line-matching transformer and associated switch permits the signal generator output to be coupled to a balanced line of 50, 150, or 600 ohms. An unbalanced 600-ohm output which bypasses the line-matching transformer also is provided.

The Model 206A is suitable for FM transmitter maintenance, studio amplifier and console testing, as a low-distortion signal source for bridge measurements, as a transmission-measuring set, and for any application requiring a low-distortion, accurately-known audio test signal.

SECTION II
OPERATING INSTRUCTIONS

2-1 INSPECTION

This instrument was thoroughly tested and inspected before being shipped from the factory. After the instrument is unpacked, it should be carefully checked for any damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" section on the last page of this instruction book.

2-2 CONTROLS AND TERMINALS

FUSE

The fuseholder, located on the control panel, contains a cartridge fuse of the Slo-Blo type. For 115-volt operation, a 1.6-ampere fuse is used, and for 230-volt operation, an .8-ampere fuse of the same type is used. Characteristics of the Slo-Blo fuse used in the Model 206A are given in the Table of Replaceable Parts.

POWER

This rotary switch controls the power supplied to the instrument from the power line. Illumination of the tuning dial window provides indication that the power switch is turned on.

IMPEDANCE

The setting of this four-position rotary switch indicates the impedance at the output binding posts. In three positions (50, 150, and 600) the switch connects windings of the impedance-matching transformer to the OUTPUT binding posts for balanced 50-ohm, 150-ohm, or 600-ohm operation. In the fourth position, 600G, the switch bypasses the impedance-matching transformer and arranges the output circuit for 600-ohm unbalanced operation.

CT OUTPUT G

The Model 206A binding posts will accept either a banana plug or wire. The terminals are so arranged that any double banana plug with 3/4 inch spacing may be used to connect to any pair of adjacent terminals.

An additional set of binding posts, identical in type and arrangement with those on the control panel, is provided at the rear of the instrument. This set of four terminals is connected in parallel with the binding posts on the control panel.

- CT - This binding post is the impedance-matching transformer center-tap terminal.
- OUTPUT - These two binding posts are the output terminals for the Model 206A Signal Generator.
- G - This binding post is connected to the chassis. By patching to terminal G any of the binding posts may be connected to the chassis.

RANGE

This rotary switch controls the magnitude of the resistance in the frequency-determining circuits. The position of the RANGE switch indicates the multiplying factor for the tuning dial indication.

FREQUENCY

This knob is the fine control for adjusting the capacity in the frequency-determining circuits of the Model 206A.

The coarse control for the frequency-determining capacity adjustment is directly connected to the tuning dial and capacitor drive mechanism. The coarse control is the knob immediately below the tuning dial.

The tuning dial is calibrated in cycles per second for the lowest range, and its indication multiplied by the factor indicated by the RANGE switch will give the actual output frequency of the oscillator.

AMPLITUDE

This knob varies the setting of the variable resistor which controls the level of the input to the output amplifier. The voltage level of the amplifier output is indicated by the meter on the control panel.

0-1 DB, 0-10 DB, 0-100 DB

These three dials are the controls for the three-section attenuator, which is inserted in the output path between the output meter and the line-matching transformer. The attenuation in db inserted in the circuit is equal to the sum of the three control knob settings, and the reading of the output meter minus the inserted attenuation is the level of the signal at the generator OUTPUT binding posts. The attenuator provides a means for reducing the output voltage, in .1 db steps, to a maximum of 111 db below the level indicated by the meter.

POWER CABLE

The three-conductor power cable is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin, added to a standard two-blade a-c plug, which grounds the instrument chassis when used with the appropriate receptacle. To use this NEMA plug in a standard two-contact outlet, it is recommended that instead of breaking off the ground terminal, 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 ground for the protection of operating personnel.

2-3 OPERATION

The procedure for operating the Model 206A Low Distortion Audio Signal Generator is as follows.

1. General

With the instrument plugged into a power source of specified voltage and frequency, and the power switch at ON allow a warm-up period of a few minutes. Specified accuracy of $\pm 2\%$ will be obtained after a few minutes warmup. For maximum accuracy, however, allow a 20-30 minute warmup.

NOTE

If a 230-volt power source is used, check (1) that power transformer T1 is strapped for 230-volt operation (strapping options are shown on the schematic diagram), and (2) that fuse F1 is an .8-ampere Slo-Blo fuse.

2. Selecting Frequency

The desired output frequencies are obtained by the combined use of the FREQUENCY controls and the RANGE switch. The frequencies from 20 cps to 20,000 cps are covered in three ranges as follows:

X1	Range: 20 cps to 200 cps
X10	Range: 200 cps to 2,000 cps
X100	Range: 2,000 cps to 20,000 cps

The FREQUENCY tuning dial is calibrated in cycles per second for the lowest or X1 range. The higher ranges multiply the calibration of the tuning dial by the indicated factors of 10 or 100. For example, to select a frequency of 400 cps, set the tuning dial to 40 and the RANGE switch to X10. A frequency of 10,000 cps is selected by setting the tuning dial to 100 and the RANGE switch to X100.

3. Connecting the Load

Connect the load to the OUTPUT binding posts. If the impedance of the load is 50, 150, or 600 ohms, the instrument can be set (see par. 5 below) to match the load impedance.

4. Setting the Output Voltage Level

To keep hum at a satisfactory level below that of the output voltage, the output from the amplifier should be maintained at a relatively high level and then reduced to the desired level by means of the attenuator.

In following the procedure for setting the output voltage level, it is important to understand the position of the meter in the output circuit and also the calibration of the meter. The meter is across the output of the output amplifier, ahead of the attenuator, but is so calibrated that when the attenuator is set for zero attenuation and the instrument is working into a matched resistive load, the level of the signal at the OUTPUT binding posts may be read on the meter in dbm. To convert the dbm reading to volts, quick-reference graphs have been provided at the end of this section. (When working into a matched 600-ohm load with the attenuator at zero attenuation, the voltage at the OUTPUT binding posts may be read directly on the meter.)

The following procedure should be used for setting the output voltage level:

- a. Set the level of the output amplifier. Use the output meter reading as an indication of the amplifier output, and adjust the level by means of the AMPLITUDE control (on the con-

trol panel). Unless the noise level in the output signal is non-critical, the output amplifier always should be adjusted for a meter indication of +15 dbm.

- b. Determine the level in dbm for the output voltage desired. The quick-reference graphs referred to above are arranged to show the relationship between db referred to 1 milliwatt into a matched load and the voltage across a corresponding matched load. To determine the level in dbm for an output voltage of .23 volts into 600 ohms, for example, refer to the graph and find the level in dbm for .23 volts into 600 ohms. The level will be found to be -10.5 dbm.
- c. Compute the amount of attenuation required to bring the output down to the desired level. With the output from the amplifier at +15 dbm, attenuation of 25.5 db will be required to bring the output to -10.5 dbm at the OUTPUT binding posts (+15 dbm minus 25.5 db equals -10.5 dbm).
- d. Set the attenuator for the loss required. The loss inserted by the attenuator is the sum of the settings of the dials. Using as an example the condition described above where a loss of 25.5 db is required, all three dials will be set for loss (20 db + 5 db + .5 db equals 25.5 db).

NOTE

A method for determining the voltage across a non-matching load is described below in paragraph 5. Setting Output Impedance.

5. Setting Output Impedance

The output impedance of the generator is determined by the setting of the IMPEDANCE switch. For balanced 50-, 150-, or 600-ohm operation, set the IMPEDANCE switch to 50, 150, or 600. For balanced-to-ground operation, patch binding post CT to binding post G.

For 50- or 150-ohm unbalanced operation, set the IMPEDANCE switch to the 50 or 150 position, and connect the lower OUTPUT binding post to ground at terminal G.

For 600-ohm unbalanced operation, set the IMPEDANCE switch to 600G. At the 600G position, the IMPEDANCE switch connects the lower OUTPUT binding post to the G binding post. (In the 600G position, the matching transformer is bypassed, and an advantage in distortion and frequency-response characteristics is obtained.)

The calibration of the voltmeter and attenuator is correct only when the instrument is working into a matched resistive load. The VOLTS calibration of the meter is correct only when working into a 600 ohm load; the DBM calibration is correct when working into a 50-, 150-, or 600-ohm load provided the IMPEDANCE switch is in the position which matches the output impedance to the load.

If it is desired to work the generator into resistive loads other than 50, 150, or 500 ohms, the following method may be used to compute the voltage across the external load.

- a. With the RANGE switch and FREQUENCY controls set for the desired output frequency, set the IMPEDANCE switch for the impedance nearest that of the load into which the generator will be working.
- b. Choose the output level in dbm and add 15 (the reading of the output meter) to it. Set the attenuator dials for the sum.
- c. Refer to the voltage graph, and obtain the voltage across the generator output impedance at the chosen output level. (The generator output impedance is the setting of the IMPEDANCE switch; the output level is +15 dbm minus the setting of the attenuator dials.) For example, if the IMPEDANCE switch is set for 150 and the output level is -10 dbm (attenuator dials set for 25 db), the graph shows the voltage across the generator output impedance to be .125 volt.
- d. Multiply by two the voltage across the generator output impedance to obtain the open circuit voltage.
- e. The voltage across the external resistive load may now be calculated, using the following formula:

$$E_L = \frac{E_{oc}}{R_L + R_o} R_L$$

Where E_L is the voltage across the external resistive load

E_{oc} is the open circuit voltage

R_L is the external resistive load

R_o is the output impedance of the generator

For example, assume the output meter indicates + 15 dbm, the attenuator dials are set for 25 db, the external resistive load is 250 ohms, and the generator IMPEDANCE switch is set at 150.

A. To obtain the open circuit voltage of the generator:

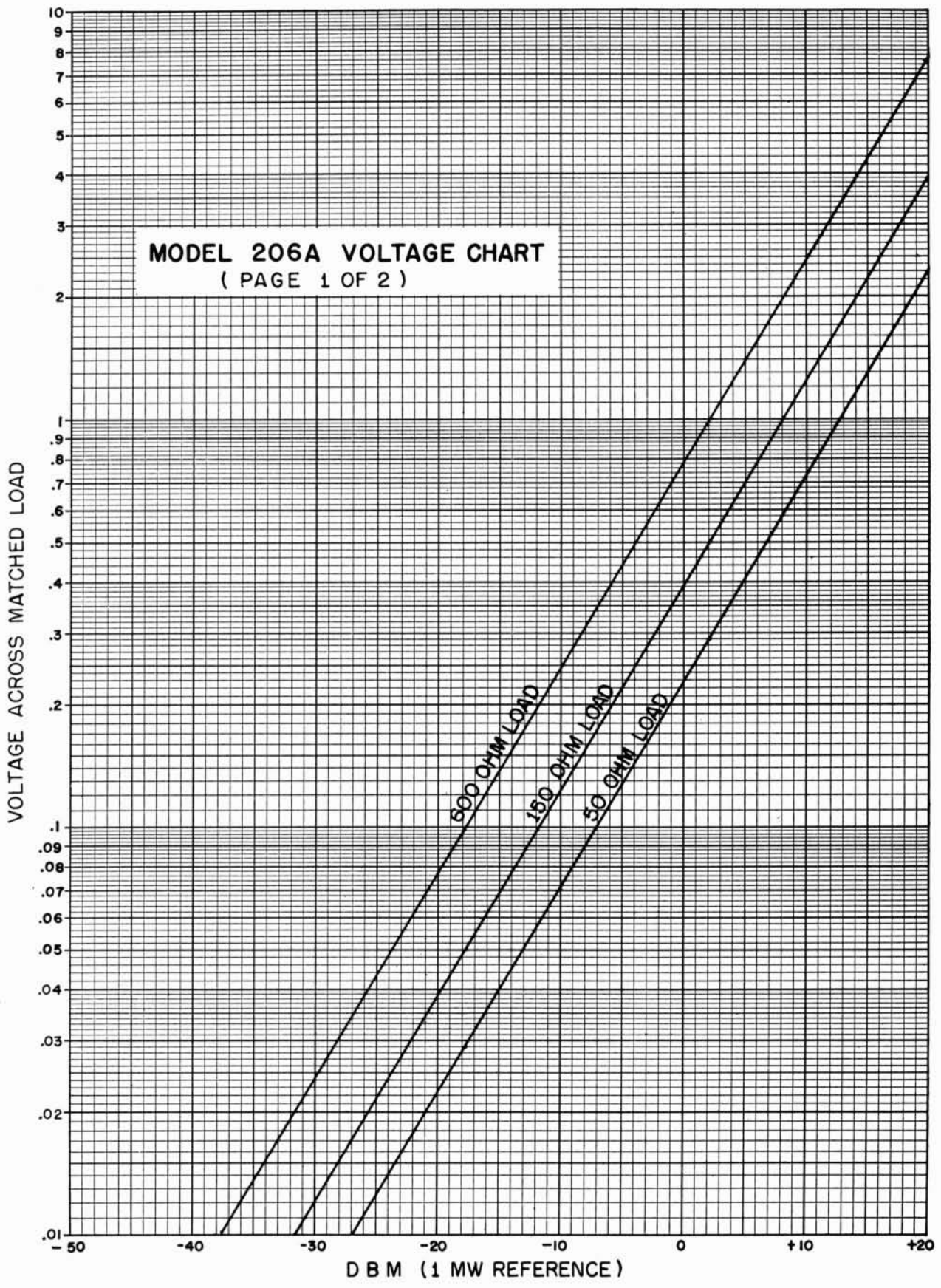
1. The reading of the output meter minus the attenuator setting gives an output level of -10 dbm (+15 dbm minus 25 db).
2. The voltage at -10 dbm across the generator output impedance (150 ohms) is .125 volts. Twice .125 volt is .25 volt, the open circuit voltage.

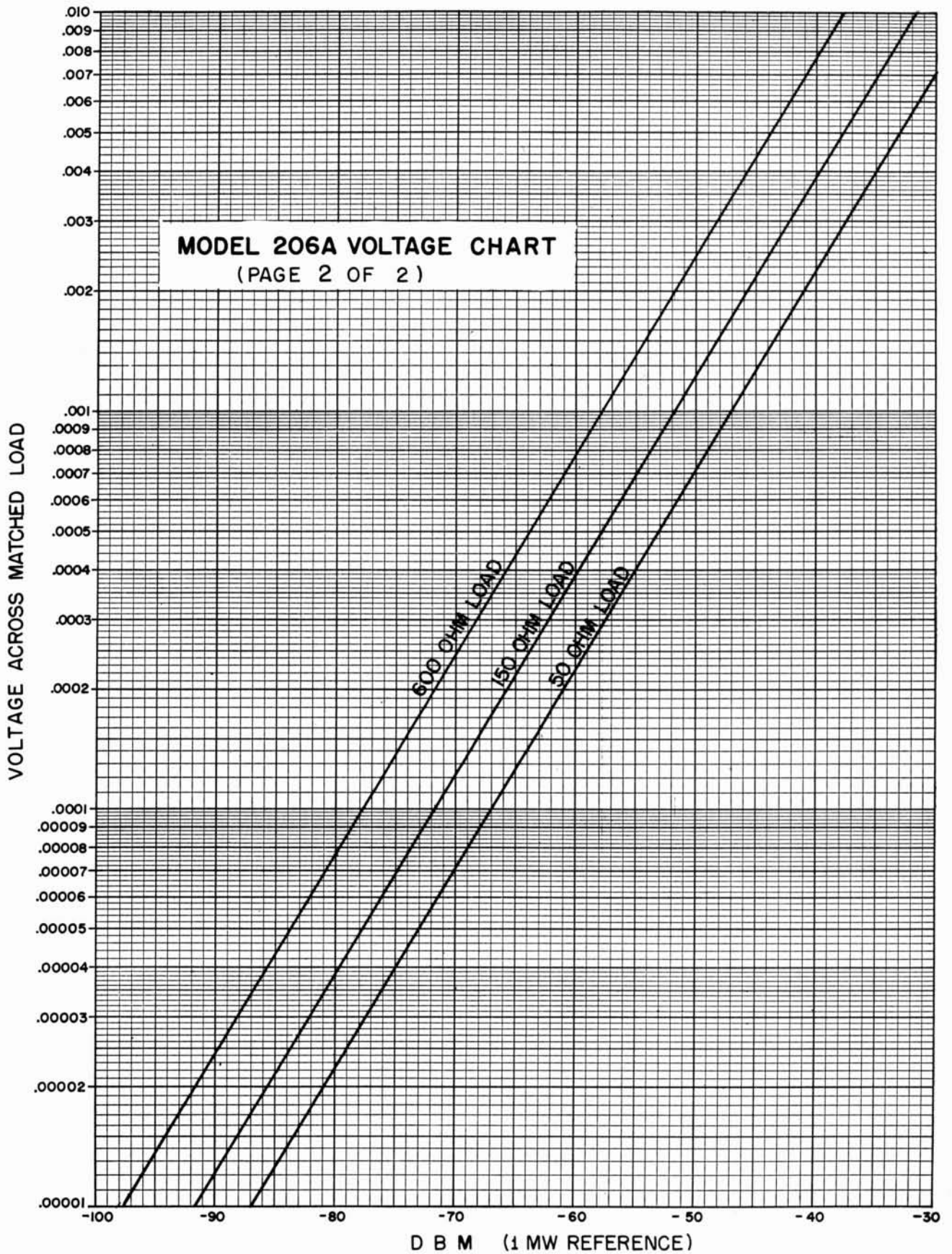
B. Applying the formula:

$$E_L = \frac{.25}{250 + 150} \times 250, \text{ or } .156 \text{ volt}$$

CAUTION

When using low output levels of -40 dbm or below (attenuator set for 55 db or more), do not use the 600G position of the IMPEDANCE switch if the accuracy of calibration of the output attenuator is important. If it is desired to have a 600-ohm single-ended output at a low level, use the 600 position of the IMPEDANCE switch, and connect the lower OUTPUT binding post to ground via the G binding post.





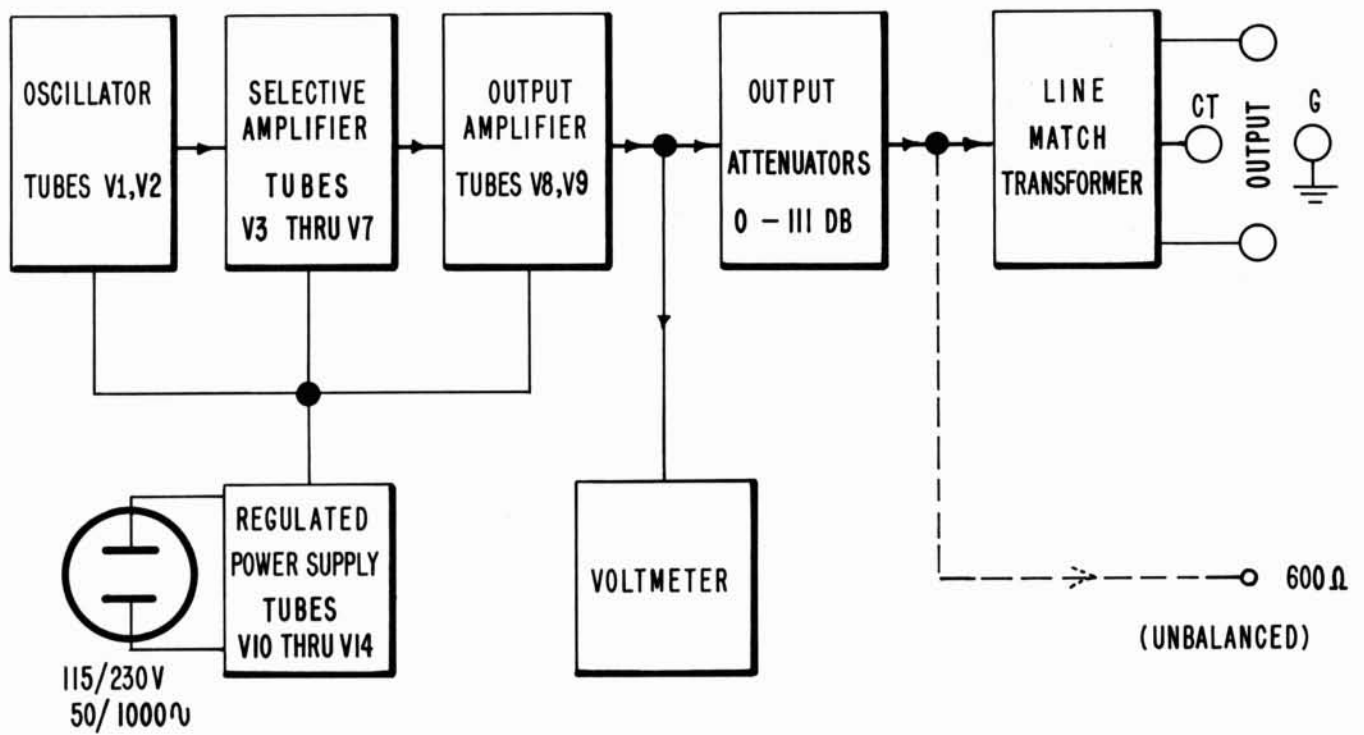


Fig. 2. Model 206A Block Diagram

SECTION III

CIRCUIT DESCRIPTION

3-1 GENERAL

The circuit of the Model 206A is shown schematically in a diagram at the back of this manual and in block-diagram form in Fig. 2.

The instrument includes an oscillator, a selective amplifier, and a regulated power supply. In the generator output path there is a rectifier-type voltmeter, a three-section attenuator, and an impedance-matching transformer.

The oscillator is variable, and may be tuned for the production of any signal voltage in the 20 to 20,000 cps range. The output from the oscillator passes to the selective amplifier, the tuning section of which is tracked with that of the oscillator. Similar components are used in the frequency-determining networks of the two circuits, and setting the FREQUENCY controls and RANGE switch for a particular frequency tunes both circuits. The selective-amplifier circuitry reduces to a fraction of a percent the harmonic voltages present in the wave generated by the oscillator. The low-distortion output from the selective amplifier is passed to the output amplifier, the input of which may be adjusted by means of the AMPLITUDE control. The level of the signal voltage from the output amplifier is indicated by the voltmeter. An attenuator, which may be set for up to 111 db in attenuation, provides a facility for reducing the output voltage as low as approximately 12 microvolts across 600 ohms. The signal voltage may be coupled to the output terminals via an impedance-matching transformer, or passed directly to a single-ended termination which presents an impedance of 600 ohms. The transformer is arranged to present an impedance of 50, 150, or 600 ohms, depending upon the position of the IMPEDANCE switch.

The facilities of the Model 206A and design of the circuit provide a stable low-distortion audio-frequency voltage which is adjustable as to frequency, voltage level, and output impedance. A built-in regulated power supply furnishes voltages for the vacuum tube circuits.

3-2 OSCILLATOR

The Model 206A oscillator circuit includes pentodes V1 and V2 arranged as a two-stage amplifier with both positive and negative feedback loops. The frequency-selective network is in the positive feedback loop. The network is a resistance-capacity combination

which is tuned to the desired frequency by operation of the FREQUENCY controls and RANGE switch. Negative feedback is applied via variable resistor R18 and resistor R17 to the cathode of V1. Distortion in the oscillator output is minimized by the negative feedback.

The resistance network which determines the amount of negative feedback includes lamp R13, which is a thermally-sensitive resistance. The resistance of lamp R13 varies in such manner as to compensate for variations in output amplitude, thus holding constant the amplitude of oscillations, and ensuring a constant and stable output over a wide frequency range. The lamp used in the Model 206A has sufficient thermal inertia to ensure the desired resistance characteristics even at low frequencies.

The output from the oscillator is passed to the selective amplifier.

3-3 SELECTIVE AMPLIFIER

The selective amplifier includes tubes V3 to V7. The circuit is so arranged that any incoming frequencies other than the fundamental are filtered, amplified, and returned as a negative feedback to the first stage (V3). A practical reduction of 10 db or more in distortion is obtained by this arrangement.

Tubes V3 and V4 are conventional voltage amplifiers, while V5 is a cathode follower with a Wien bridge in its cathode circuit. The Wien bridge is tuned to a null at the fundamental frequency so that the fundamental is eliminated from the voltage present in the last two stages of the amplifier. Any harmonics that may be present are not eliminated, however, and are amplified by tube V6 which is connected across the bridge.

Pentode V6 is a conventional voltage amplifier which feeds tube V7. Pentode V7 is a cathode follower, the output of which is returned to the cathode of V3. The circuit V7 is in phase with the cathode circuit of V3, providing overall negative feedback at all frequencies except that to which the bridge is balanced. Since the output from the selective amplifier is taken from the top (rather than the arms) of the bridge, the amplifier as a whole exhibits a selective characteristic with respect to the fundamental frequency.

The frequency to which the selective amplifier is tuned is determined by the R and C values in the Wien bridge. The variable capacitors used in the bridge are so arranged that they track with the variable capacitors in the oscillator circuit, and the resistance network in the bridge also is arranged to track with that of the oscillator circuit. Thus adjustment of the frequency-determining network in the oscillator section also adjusts the RC network in the selective-amplifier circuit. Tracking is set at the factory for the life of the instrument.

The output from cathode follower V5 is coupled by capacitor C12 to the output amplifier.

3-4 OUTPUT AMPLIFIER

The output amplifier includes tubes V8 and V9. The signal incoming from the selective amplifier is passed to the grid of V8 via variable resistor R57, the setting of which is adjusted by the AMPLITUDE control on the control panel. Thus, by adjusting the input to the output amplifier, the AMPLITUDE control becomes, in effect, the gain control for the instrument.

Pentode V8 operates as a driver for high-mu pentode V9, the power output tube. Pentode V9 is connected as a triode to allow the tube to work into very low impedance loads without generating appreciable distortion. Negative feedback from V9, applied via capacitor C19 and resistor R67 to the cathode of V8, is used to minimize distortion.

The output of V9 is passed, via a rectifier-type voltmeter, an attenuator, and an impedance-matching transformer to the OUTPUT binding posts.

3-5 VOLTMETER

The voltmeter circuit includes variable resistor R69, a germanium diode full-wave rectifier, and a one-milliampere meter connected across the rectifier bridge. Resistor R69 is provided for adjustment of the meter calibration. The meter is arranged to indicate the output voltage directly in volts across 600 ohms and in dbm, with 0 dbm equal to 1 milliwatt into 600 ohms.

3-6 ATTENUATOR

The attenuator has three sections, each of which is controlled by its own dial. One section is of an L-type configuration, with ten steps of .1 db each. The other two sections are bridged-T configurations, one of ten 1 db steps and the other of ten 10 db steps. The three attenuators provide from .1 db to 111 db attenuation of the output voltage.

3-7 IMPEDANCE-MATCHING TRANSFORMER

Connections to impedance-matching transformer T2 are established by the IMPEDANCE switch, S2. In the 50, 150, and 600 positions of the switch: (1) the output voltage is passed to the primary winding of transformer T2 and (2) the secondary of T2 is connected to the OUTPUT binding posts.

The secondary winding of the impedance-matching transformer is balanced, and has three sets of taps so arranged that proper termination is provided for 50, 150, or 600 ohm balanced operation. A center tap is provided for use when balanced-to-ground operation is desired. For unbalanced 50 or 150 ohm operation, one side of the line circuit may be connected to ground by connecting one of the OUTPUT binding posts to the G binding post. (For unbalanced 600 ohm operation for output levels higher than -40 dbm, the IMPEDANCE switch may be set to the 600G position, in which setting transformer T2 is bypassed and the switch connects one side of the line circuit to ground.)

Transformer T2 is constructed with a high permeability core to provide uniform frequency response especially at low levels and low frequencies. However, where it is desired to eliminate even the possibility of slight distortion or frequency-response errors that might be caused by the transformer, and an unbalanced circuit can be used, the transformer may be bypassed by use of the 600G position of the IMPEDANCE switch.

3-8 POWER SUPPLY

The power supply includes a conventional full-wave rectifier using a dual diode tube with a two-section pi filter for removing the AC components of the rectified wave. The voltage output of the circuit is regulated by a conventional electronic voltage regulator consisting of tubes V11 to V14.

SECTION IV
MAINTENANCE

4-1 COVER REMOVAL

Rack Model:

1. To remove the dust cover, loosen and remove the four screws which fasten the cover to the back of the instrument, and slide the cover toward the rear of the instrument.
2. To remove the bottom plate, turn the instrument on its back, loosen and remove the four screws which fasten the plate to the bottom of the instrument, and lift off the plate.

Metal Cabinet:

1. At the back of the instrument, remove the four screws which fasten the rear cover to the chassis. Remove the rear cover.
2. Turn the instrument on its back. Remove the two large Allen setscrews on the bottom, next to the control panel. Lift the cabinet off the instrument.

4-2 TUBE REPLACEMENT

Any tube in the Model 206A may be replaced with a tube having corresponding RETMA standard characteristics. All tubes are accessible when the dust cover or cabinet is removed. Location of tubes is shown in Fig. 3.

Whenever a tube in the oscillator, selective amplifier, or output amplifier circuit is replaced, harmonic distortion in the output voltage should be measured with a distortion analyzer such as a Hewlett-Packard Model 330B, 330C, or 330D. A replacement tube having any serious departure from its average type characteristics can cause an increase in harmonic distortion in the output voltage. Distortion should measure less than .1% at frequencies above 50 cps, and less than .25% at frequencies from 20 to 50 cps.

Replacement of any tube in the voltage regulator (tubes V11 to V14) may cause a change in the level of the regulated voltage. Whenever a tube in the regulator circuit is changed, therefore, the level of

the regulated voltage should be measured and adjusted as necessary, as described in paragraph 4-6. When any tube in the regulator circuit is replaced, a check also should be made to make certain that the regulated voltage remains essentially constant when the line voltage is varied from 105 to 125 volts (or from 210 to 250 volts, on 230 volt operation). Since failure to regulate over this range usually is a function of tubes, regulator tubes should be replaced as necessary to obtain satisfactory regulation.

If tube V3, V4, V5, V6, or V7 is replaced, the gain of the selective amplifier should be checked as described in paragraph 4-8.

4-3 REPLACEMENT OF LAMP R13

Lamp R13 has an extremely long life, theoretically almost infinite, and should not have to be replaced. Since the lamp controls the amount of negative feedback in the oscillator circuit, if for any reason the lamp should fail, the voltage generated at the output of tube V2 should be measured after the replacement lamp has been installed.

Measurement and adjustment of the oscillator output are described in paragraph 4-7. If the adjustment does not bring the oscillator output voltage within the specified limits, the replacement lamp should be rejected and another lamp installed. The test procedure should then be repeated.

4-4 VARIABLE RESISTORS

Should any of the variable resistors require replacement, connection should be made as shown in Fig. 7.

If resistor R18 is replaced, the oscillator output voltage should be measured and adjusted as described in paragraph 4-7.

If resistor R69 in the voltmeter circuit is replaced, the procedure for calibrating the voltmeter (see paragraph 4-10) should be performed.

If resistor R81 in the voltage regulator circuit is replaced check the level of the regulated voltage and adjust R81 as necessary, as described in paragraph 4-6.

If resistor R96 is replaced readjust the gain of the selective amplifier, as described in paragraph 4-8.

If resistor R74 is replaced, check the 600G output as described in paragraph 4-11.

If resistor R79 in the filament supply is replaced, readjust the hum balance as described in paragraph 4-9.

If resistor R39 or R93 should ever require replacement, the generator should be returned to the factory for readjustment or, if qualified personnel is available, the procedure for centering the selective amplifier output level for the three ranges, described in paragraph 4-12, may be performed.

4-5 CAPACITOR DRIVE

The special wire cable arrangement used for rotating the two tuning capacitors in the Model 206A has a life far beyond the life of the equipment. However should any drive failure ever occur the instrument should be returned to the factory for repair. Under no circumstances should adjustment of the drive be attempted, since such an attempt will destroy the calibration of the instrument.

4-6 ADJUSTMENT OF REGULATED POWER SUPPLY VOLTAGE LEVEL

The level of the regulated output voltage may be measured either at the cathode of tube V11 or V12.

1. Turn the POWER switch to ON, and allow a few minutes for warmup.
2. Connect a voltmeter to pin 8 of V11 or V12. The voltage between the cathode and ground should measure 240 volts ± 5 volts.
3. Adjust resistor R81 (located as shown in Fig. 4) as necessary to bring the voltage within the proper range.

4-7 ADJUSTMENT OF OSCILLATOR OUTPUT

1. Connect a high-impedance vacuum tube voltmeter, such as a Hewlett-Packard Model 400B, C, or D to the center tap of variable resistor R18 (Fig. 4). With the Model 206A generating 1,000 cycles, the voltage from the center tap of R18 to ground should measure 21 volts ± 1 volt.
2. Adjust variable resistor R18 to obtain 21 volts ± 1 volt.

4-8 ADJUSTMENT OF SELECTIVE AMPLIFIER GAIN

With oscillator output voltage at the proper level (paragraph 4-7), if the output of the instrument falls below rated level or the output waveform shows clipping, the gain of the selective amplifier may need readjustment. Proceed as follows:

1. With the generator set to deliver 1,000 cycles, connect a high-impedance vacuum tube voltmeter to pin 4 of tube V3, and measure the input to the selective amplifier.
2. Connect the voltmeter to pin 8 of tube V5, and measure the amplifier output. The gain through the amplifier should be approximately 24 db (± 5 db).
3. If amplifier gain is too low or too high, adjust variable resistor R96 (Fig. 4) to obtain approximately a 24 db gain.

NOTE

If with a gain of 24 db the waveform at the OUTPUT terminals shows clipping, lower the gain of the amplifier until clipping stops.

4-9 ADJUSTMENT OF HUM BALANCE

Variable resistor R79 (Fig. 4) provides an adjustment for minimizing the beat between the oscillator and the power supply frequency. Either of two methods may be used for the adjustment.

1. If a distortion analyzer such as a Hewlett-Packard Model 330B or 330C is available, adjust resistor R79 for minimum distortion in the output waveform with the instrument generating 5 to 20 cycles above or below the power line frequency.
2. If a distortion analyzer is not available, output amplitude variation (60-cycle beat) may be observed on a sensitive high-impedance vacuum tube voltmeter, and resistor R79 adjusted for minimum variation in output amplitude with the instrument tuned to a frequency near that of the power line. For example, where the power line frequency is 60 cycles, the Model 206A should be tuned with the FREQUENCY dial for maximum beat (approximately 58 cycles), and then resistor R79 should be adjusted for minimum beat.

4-10 CALIBRATION OF VOLTMETER

Calibration of the control panel voltmeter is set at the factory, and unless one of the crystal diodes in the rectifier circuit requires replacement or the voltmeter should be smashed, it is unlikely that the voltmeter will require recalibration during the life of the Model 206A. To recalibrate the voltmeter, a comparison meter standardized for 4 volts at 100 cycles is required.

1. Set the IMPEDANCE switch to 600. Connect the standardized voltmeter and a 600-ohm load to the OUTPUT terminals.
2. Set the Model 206A for an output of 100 cycles.
3. Turn the AMPLITUDE control to zero (maximum counterclockwise) position. Check that the three attenuator dials are set to 0. Set the control panel voltmeter pointer to zero with the zero adjust screw (located at a midpoint on the face of the meter, below the window).
4. Adjust the AMPLITUDE control to obtain an indication of exactly 4 volts on the external voltmeter. If the internal voltmeter does not indicate exactly 4 volts also, adjust resistor R69 to obtain exactly a 4-volt indication on the internal meter.

4-11 ADJUSTMENT OF OUTPUT AT 600G

This equalization adjustment has been set at the factory, and it is improbable that it will require readjustment. Should line-matching transformer T2 ever be replaced, however, equalization of the 600 and 600G outputs may be obtained by the following procedure.

1. Connect a high-impedance vacuum tube voltmeter and a 600-ohm load to the OUTPUT terminals.
2. Set the Model 206A for an output of 1,000 cycles. Set the IMPEDANCE switch at 600.
3. Adjust the AMPLITUDE control to obtain an indication of 4 volts on the external voltmeter.
4. Switch the IMPEDANCE control to 600G, and adjust resistor R74 (located as shown in Fig. 4) until a 4-volt indication is obtained on the external voltmeter. Repeat until there is no change between the output levels at the 600 and 600G positions.

4-12 ADJUSTMENT FOR CENTERING SELECTIVE AMPLIFIER OUTPUT LEVEL

CAUTION

THIS ADJUSTMENT HAS BEEN SET AT THE FACTORY AND, UNLESS THE RANGE SWITCH OR ONE OF THE TUNING CAPACITORS HAS BEEN REPLACED, THE ADJUSTMENT SHOULD NEVER UNDER ANY CIRCUMSTANCES BE CHANGED. IF REPLACEMENT OF THE RANGE SWITCH OR TUNING CAPACITOR EVER SHOULD BE NECESSARY, IT IS RECOMMENDED THAT THE INSTRUMENT BE RETURNED TO THE FACTORY FOR THE REPLACEMENT AND NECESSARY READJUSTMENTS.

Variable resistor R39 for the X1 range, variable capacitor C4 for the X10 range, and variable resistor R93 for the X100 range are used for centering the output level. First a reference is set on the X10 range with the FREQUENCY dial at 20. By means of capacitor C4 the other end of the X10 range is adjusted against the reference. Then resistors R39 and R93 are adjusted as necessary to center the change of output level versus frequency around the reference set on the X10 range. The following procedure may be used.

1. Set the RANGE switch at X10 and the FREQUENCY dial at 20, to obtain a frequency of 200 cycles. Set the IMPEDANCE switch at 600 and connect a 600-ohm load across the OUTPUT terminals. Adjust the AMPLITUDE control to obtain an indication of 4 volts on the control panel voltmeter.
2. Set the FREQUENCY dial at 200 on the X10 range, to obtain a frequency of 2,000 cycles. Adjust capacitor C4 as necessary to again obtain a 4-volt indication on the voltmeter.
3. Using the level set at 20 on the X10 range as a reference, adjust R39 and R93 on the X1 and X100 ranges respectively to center the change of output level versus frequency around the reference, within approximately ± 1 db.

4-13 RECALIBRATION

If the Model 206A ever should need recalibration, write to the manufacturer for information or return the instrument to the factory for recalibration. A reasonable charge will be made for this service.

4-14 LUBRICATION OF TUNING CAPACITOR DRIVE ASSEMBLY

The tuning capacitor drive assembly should be lubricated once a month if the instrument is in constant use, or every six months if the instrument has only occasional use. Before lubrication, all dust and dirt that have collected on the tuning mechanism should be removed. Lubricate the following:

1. Vernier drive shaft bearing, one drop.
2. Idler pulley (below the pilot lamp socket), one drop.
3. Spring loaded take-up pulley (on the back of the FREQUENCY dial tuning control [coarse] shaft), one drop next to casting.

The most satisfactory oil for this purpose is Lubriplate #3, manufactured by the Fiske Brothers Refining Co., Newark, New Jersey.

TROUBLE SHOOTING CHART (CONT'D.)

SYMPTOMS	POSSIBLE CAUSE	TEST PROCEDURE AND REMEDIES
Instrument operating, high amount of distortion present in output. (Cont'd.)	<p>Incorrect gain through selective amplifier section. (Cont'd.)</p> <p>Distortion in intermediate or output amplifiers.</p>	<p>2. With V6 in circuit, at 1 kc gain from grid of V3 to cathode of V5 should drop to approximately 24 db (see Adjustment of Selective Amplifier Gain par. 4-8).</p> <p>a. Replace V6 and/or V7. b. Blow dust out of tuning capacitor C3.</p> <p>3. Check DC voltages in selective amplifier section. Replace defective part and reset gain (par. 4-8).</p> <p>Replace each tube (V3 to V9) individually and recheck distortion.</p>
Instrument operating, high distortion and/or high output voltage on one range only.	Defective resistor in selective amplifier tuned bridge.	<p>For range in trouble, measure resistors in amplifier section of RANGE switch, and R39 or R93.</p> <p>Replace defective resistor. (Ordinarily replacement of a Wilkor with a Wilkor of the same marked value will be satisfactory. If not, replace RANGE switch assembly. See CAUTION preceding par. 4-12.)</p>
Noise and instability of output waveform.	<p>AMPLITUDE control (R57) dirty or worn.</p> <p>C10, C11, or C26 leaky.</p> <p>Short or dust in tuning capacitor C3.</p>	<p>Check resistance between center tap of R57 and ground for smooth variation with rotation of AMPLITUDE control. (Disconnect instrument from power line when making resistance measurements.)</p> <p>Replace R57.</p> <p>Test by substituting capacitor of same value known to be good.</p> <p>Check visually. Remove short, and/or blow dust out of tuning capacitor C3.</p>
Calibration off on all ranges.	Tuning capacitor C1 damaged or slipping.	<p>Check visually.</p> <p>1. Reset position of tuner, and tighten Allen setscrews on tuner drive.</p> <p>2. Replace tuning capacitor C1. (See CAUTION preceding par. 4-12.)</p>
Voltage at OUTPUT terminals below rated level.	<p>Oscillator output voltage low.</p> <p>Selective amplifier gain too low.</p>	<p>Measure voltage from center tap of R18 to ground; should be 27-29 volts (see par. 4-7).</p> <p>1. Check V1 and V2. 2. Adjust R18. 3. Check lamp R13. See par. 4-3.</p> <p>See Adjustment of Selective Amplifier Gain. Par. 4-8. Adjust R96.</p>
Waveform at OUTPUT terminals shows clipping.	Selective amplifier gain too high.	<p>See Adjustment of Selective Amplifier Gain, par. 4-8. Adjust R96.</p>

TROUBLE SHOOTING CHART (CONT'D.)

SYMPTOMS	POSSIBLE CAUSE	TEST PROCEDURE AND REMEDIES
<p>Calibration off on one range.</p>	<p>Wilkor resistor on RANGE switch changed value.</p>	<p>For defective range, measure resistors on RANGE switch.</p> <p>Ordinarily replacement with Wilkor of same marked value will be satisfactory; if not replace RANGE switch assembly. (See CAUTION preceding paragraph 4-12.)</p>

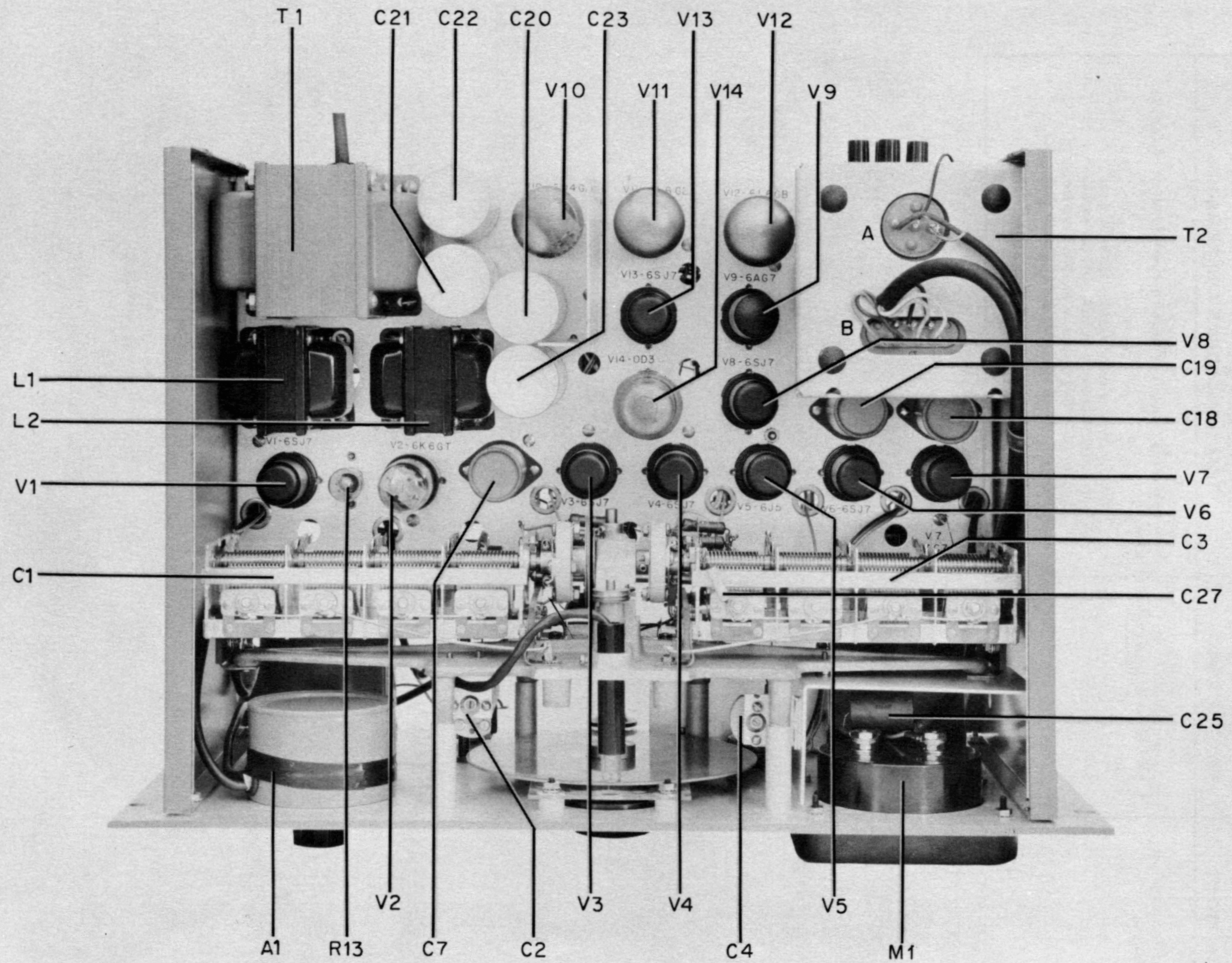


Fig. 3. Model 206A Top View Cover Plate (or Cabinet) Removed

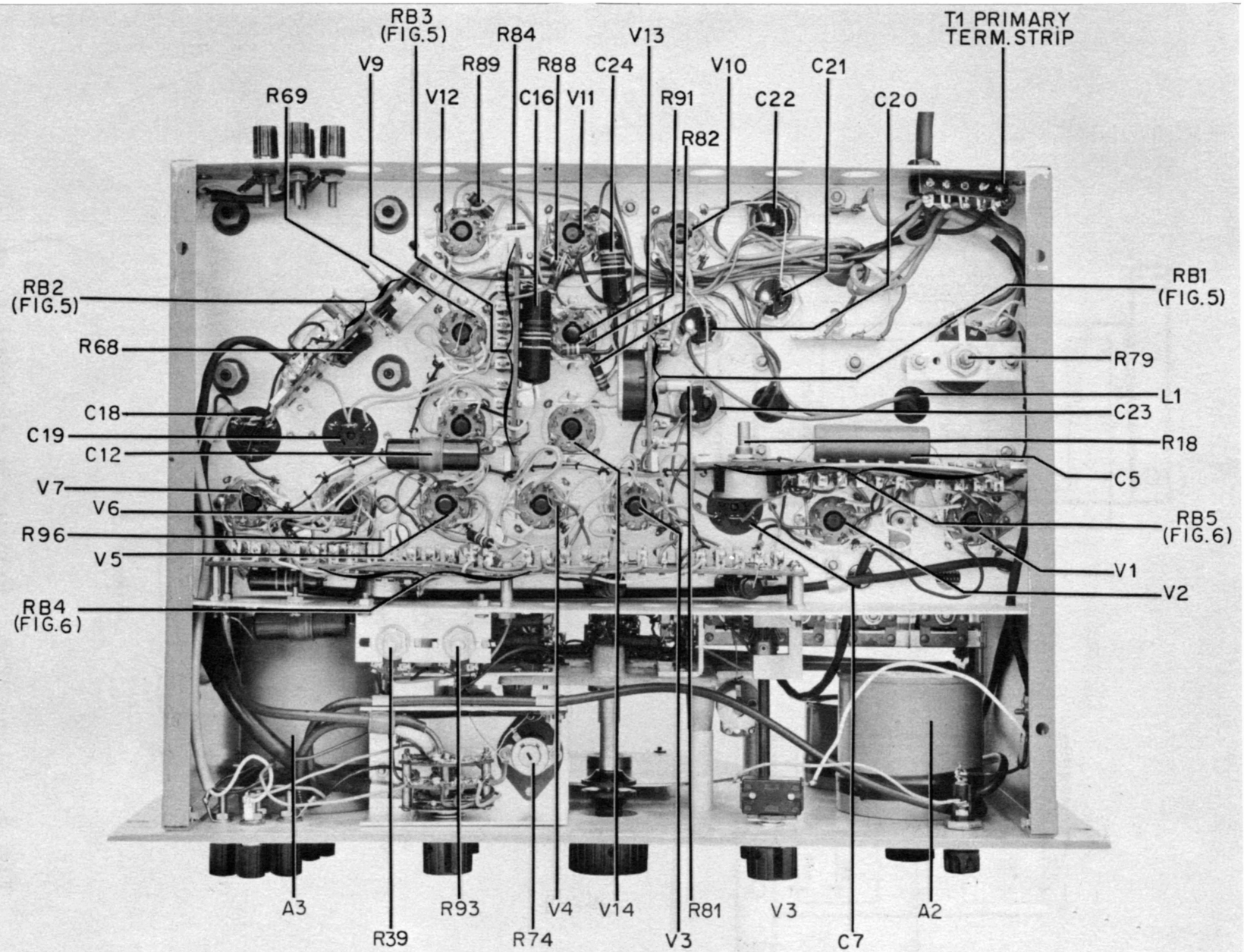


Fig. 4. Model 206A Bottom View Bottom Plate (or Cabinet) Removed

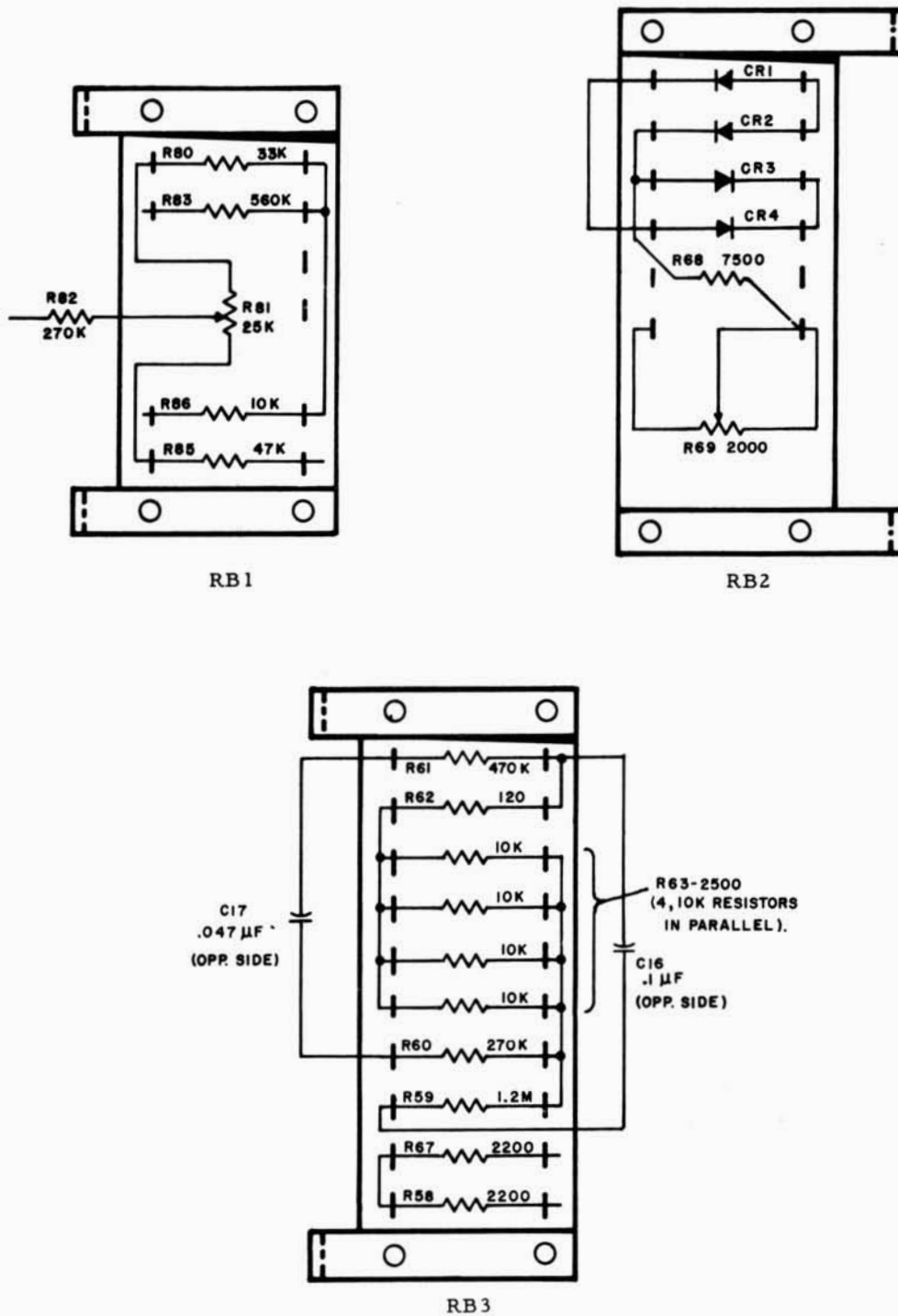


Fig. 5. Model 206A Resistor Board Detail

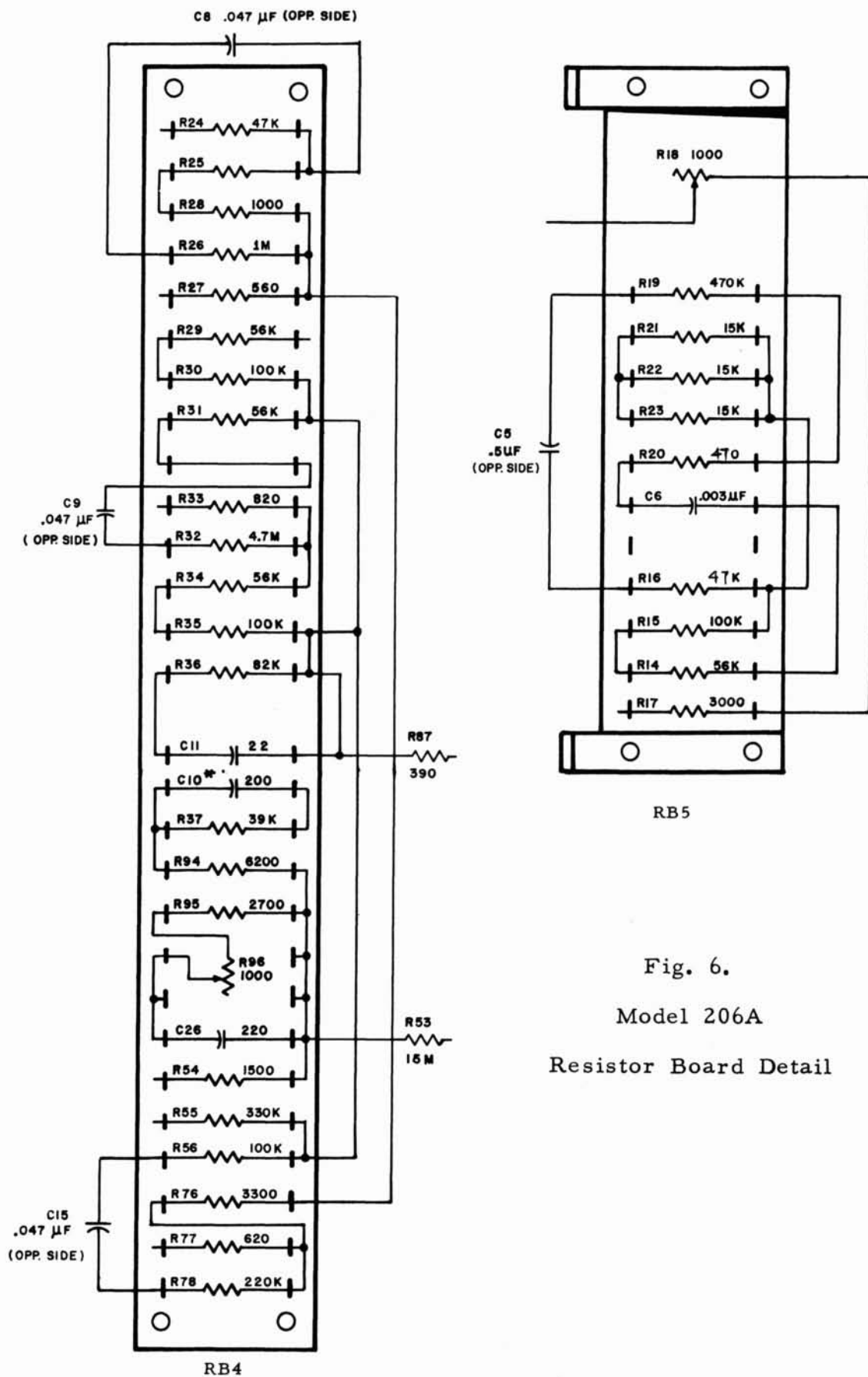


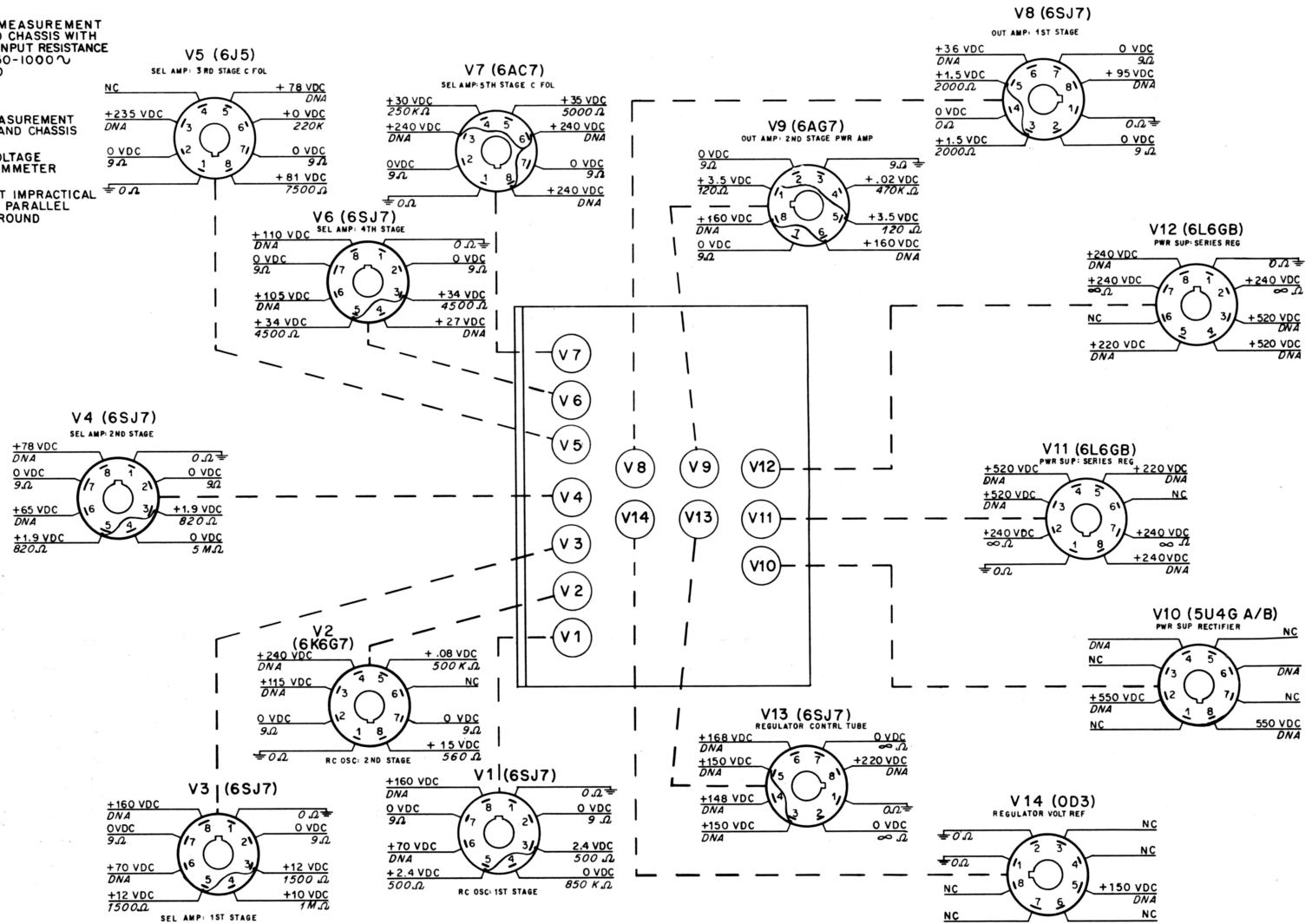
Fig. 6.
Model 206A
Resistor Board Detail

NOTES:

- CONDITIONS OF DC VOLTAGE MEASUREMENT
 1. BETWEEN INDICATED POINT AND CHASSIS WITH VOLTMETER OF 122 MEGOHMS INPUT RESISTANCE
 2. LINE VOLTAGE 115/230 VOLTS, 50-1000 \sim
 3. AMPLITUDE CONTROL AT ZERO
 4. RANGE SWITCH AT X10
 5. FREQUENCY DIAL AT 100

- CONDITIONS OF RESISTANCE MEASUREMENT
 1. BETWEEN INDICATED POINT AND CHASSIS WITH OHMMETER
 2. DISCONNECTED FROM LINE VOLTAGE
 3. CAPACITORS CHARGED BY OHMMETER BEFORE READINGS TAKEN

DNA = RESISTANCE MEASUREMENT IMPRACTICAL DUE TO HIGH CAPACITANCE IN PARALLEL WITH HIGH RESISTANCE TO GROUND

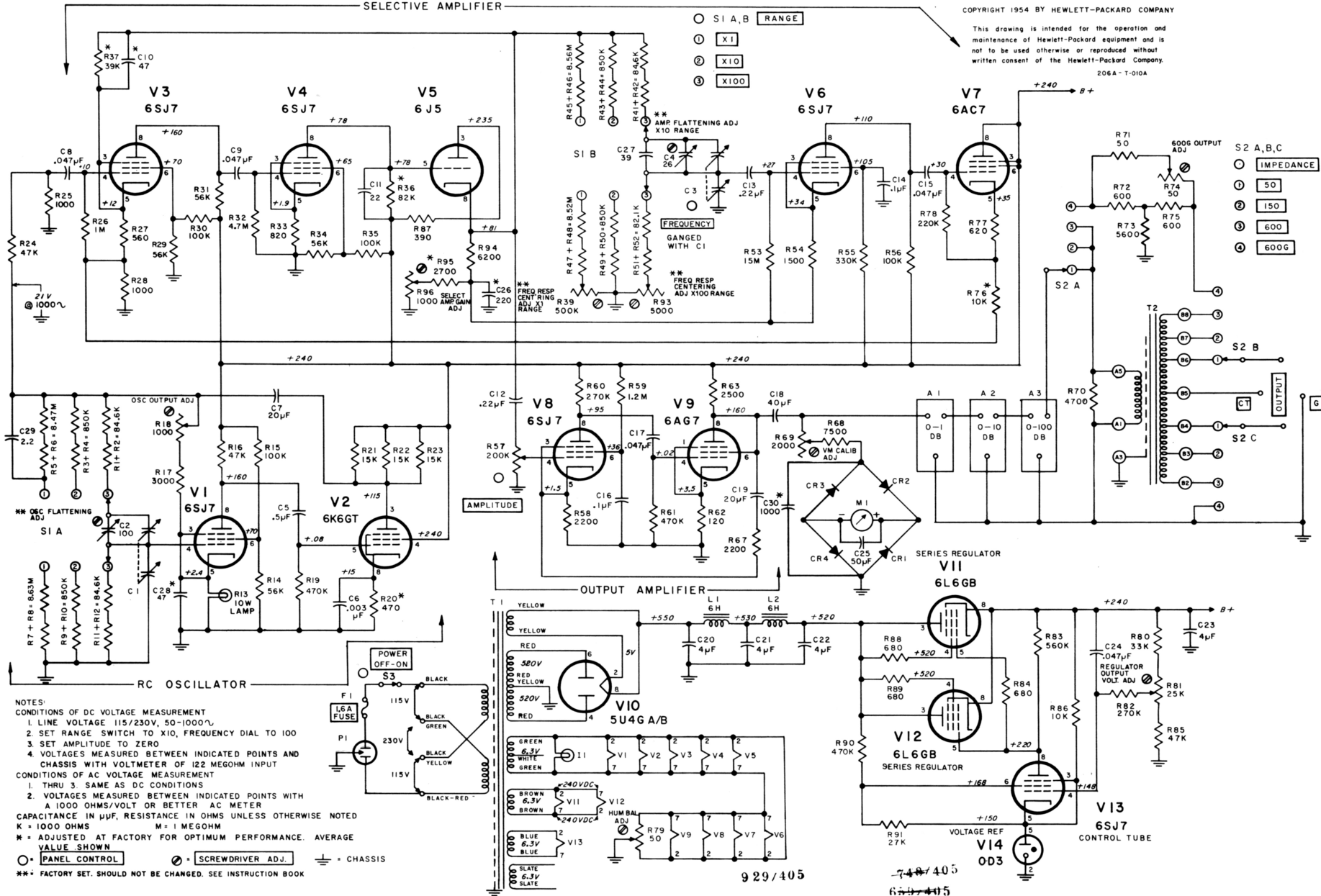


Voltage and Resistance Diagram

SELECTIVE AMPLIFIER

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206A-T-010A



Model 206A Schematic Diagram

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		
A1, 2, 3	Attenuator, set of three, including 0-100 db, 0-10 db, 0-1 db HP*	26A-3A	1	1		
C1	Capacitor: variable, air, four sections, 12.4-535 pf per section W*	0121-0002	1	1		
C2	Capacitor: variable, air, 7.5 pf to 102.7 pf AA*	0121-0008	1	1		
C3	Capacitor: variable, air, four sections, 12.4-535 pf per section W*	0121-0004	1	1		
C4	Capacitor: variable, air, 3.6 pf to 26 pf AA*	0121-0006	1	1		
C5	Capacitor: fixed, paper, .5 μ f \pm 10%, 400 vdcw Z*	0160-0024	1	1		
C6	Capacitor: fixed, paper, .003 μ f \pm 10%, 600 vdcw A*	0160-0008	1	1		
C7	Capacitor: fixed, electrolytic, 20 μ f, 450 vdcw CC*	0180-0011	2	1		
C8, C9	Capacitor: fixed, paper, .047 μ f \pm 10%, 600 vdcw CC*	0160-0005	5	2		
C10	Capacitor: fixed, mica, 47 pf 500 vdcw V*	0140-0039	1	1		
C11	Capacitor: fixed, mica, 22 pf \pm 10%, 500 vdcw V*	0140-0026	1	1		
C12, C13	Capacitor: fixed, paper, .22 μ f \pm 10%, 400 vdcw CC*	0160-0018	2	1		
C14	Capacitor: fixed, paper, .1 μ f \pm 10%, 600 vdcw CC*	0160-0001	1	1		
C15	Same as C8					
C16	Same as C14					
C17	Same as C8					
C18	Capacitor: fixed, electrolytic, 40 μ f, 450 vdcw Q*	0180-0024	1	1		
C19	Same as C7					
C20, 21, 22, 23	Capacitor: fixed, paper, .4 μ f \pm 10%, 600 vdcw Z*	0160-0077	4	1		
C24	Same as C8					
C25	Capacitor: fixed, electrolytic, 50 μ f, 50 vdcw X*	0180-0029	1	1		

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	⊕ STOCK NO.		RS		
C26	Capacitor: fixed, mica, 220 pf, ±10%, 500 vdcw V*	0140-0031	1	1		
C27	Capacitor: fixed, ceramic, 39 pf, ±5%, 500 vdcw A*	0150-0002	1	1		
C28	Capacitor: fixed, mica, 47 pf, ±10%, 500 vdcw Optimum value selected at factory. Average value shown. V*	0140-0032	1	1		
C29	Capacitor: fixed, titanium dioxide, 2.2 pf, ±10%, 500 vdcw DD*	0150-0015	1	1		
C30	Capacitor: 1,000 pf Optimum value selected at factory. Average value shown. -----					
CR1, 2, 3, 4	Diode: germanium diode, Type 2135 BU*	1910-0011	4	4		
F1	Fuse: 1.6A, slow blow, for 115V operation E*	2110-0005	1	10		
	Fuse: 0.8A, slow blow, for 230V operation T*	2110-0020	1	0		
	Lamp, incandescent: 6-8v, 2 pin base, GE #12 N*	2140-0012	1	1		
L1, 2	Reactor: 6 H @ 125 MA, 240 ohms HP*	9110-0002	2	1		
M1	Meter: 0-4, 5V into 600 Ω , -5/+15 dbm HP*	1120-0013	1	1		
P1	Power Cable: Cornish	8120-0015	1	1		
R1 to 12	Part of Range Switch Assembly; see S1					
R13	Lamp: 10 W, 250V, candelabra base O*	2140-0007	1	1		
R14	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W B*	0690-5631	4	1		
R15	Resistor: fixed, composition, 100,000 ohms ±10%, 2 W B*	0693-1041	1	1		
R16	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W B*	0690-4731	3	1		
R17	Resistor: fixed, wirewound, 3,000 ohms ±5%, 1 W R*	0812-0010	1	1		
R18	Resistor: variable, wirewound, linear taper 1,000 ohms ±10%, 2 W, I*	2100-0004	1	1		
R19	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W B*	0690-4741	3	1		
R20	Resistor: fixed, composition, 470 ohms ±10%, 1 W Optimum value selected at factory. Average value shown. B*	0690-4711	1	1		
R21, 22, 23	Resistor: fixed, composition, 15,000 ohms ±10%, 2 W B*	0693-1531	3	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS		
R24	Same as R16					
R25	Resistor: fixed, composition, 1,000 ohms ±10%, 1 W B*	0690-1021	2	1		
R26	Resistor: fixed, composition, 1 megohm ±10%, 1 W B*	0690-1051	1	1		
R27	Resistor: fixed, composition, 560 ohms ±10%, 1 W B*	0690-5611	1	1		
R28	Same as R25					
R29	Same as R14					
R30	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W B*	0690-1041	3	1		
R31	Same as R14					
R32	Resistor: fixed, composition, 4.7 megohms ±10%, 1/2 W B*	0687-4751	1	1		
R33	Resistor: fixed, composition, 820 ohms ±10%, 1 W B*	0690-8211	1	1		
R34	Same as R14					
R35	Same as R30					
R36	Resistor: fixed, composition, 82,000 ohms ±5%, 1 W Optimum value selected at factory. Average value shown. B*	0689-8235	1	1		
R37	Resistor: fixed, composition, 39,000 ohms ±10%, 1 W Optimum value selected at factory. Average value shown. B*	0690-3931	1	1		
R38	This circuit reference not assigned					
R39	Resistor: variable, composition, linear taper 500,000 ohms, ±20%, 1/4 W BO*	2100-0015	1	1		
R40	This circuit reference not assigned					
R41 to 52	Part of Range Switch Assembly; see S1					
R53	Resistor: fixed, composition, 15 megohms ±10%, 1/2 W B*	0687-1561	1	1		
R54	Resistor: fixed, composition, 1,500 ohms ±10%, 1 W B*	0690-1521	1	1		
R55	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W B*	0687-3341	1	1		
R56	Same as R30					
R57	Resistor: variable, composition, linear taper 200,000 ohms ±20%, 1/4 W I*	2100-0014	1	1		

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	⊗ STOCK NO.	TQ	RS		
R58	Resistor: fixed, composition, 2,200 ohms ±10%, 1 W B*	0690-2221	2	1		
R59	Resistor: fixed, composition, 1.2 megohms ±10%, 1 W B*	0690-1251	1	1		
R60	Resistor: fixed, composition, 270,000 ohms ±10%, 1 W B*	0690-2741	2	1		
R61	Same as R19					
R62	Resistor: fixed, composition, 120 ohms ±10%, 1 W B*	0690-1211	1	1		
R63	Resistor: 2,500 ohms, Four of following connected in parallel: fixed, composition, 10,000 ohms ±10%, 2W B*	0693-1031	4	1		
R64, 65, 66	These circuit references not assigned					
R67	Same as R58					
R68	Resistor: fixed, composition, 7,500 ohms ±1%, 1 W NN*	0730-0024	1	1		
R69	Resistor: variable, composition, linear taper 2,000 ohms ±20%, 1/4 W I*	2100-0010	1	1		
R70	Resistor: fixed, composition, 4700 ohms ±10%, 1 W B*	0690-4721	1	1		
R71	Resistor: fixed, wirewound, 50 ohms, part of S2					
R72	Resistor: fixed, wirewound, 600 ohms, part of S2					
R73	Resistor: fixed, wirewound, 5600 ohms, part of S2					
R74	Resistor: variable, wirewound, linear taper, 50 ohms, 2 W HP*	2100-0020	1	1		
R75	Resistor: 600 ohms, part of S2					
R76	Resistor: fixed, composition, 10,000 ohms ±10%, 1 W Optimum value selected at factory. Average value shown. B*	0690-1031	1	1		
R77	Resistor: fixed, composition, 620 ohms ±5%, 1 W B*	0689-6215	1	1		
R78	Resistor: fixed, composition, 220,000 ohms ±10%, 1 W B*	0690-2241	1	1		
R79	Resistor: variable, wirewound, linear taper 50 ohms ±10%, 3 W I*	2100-0002	1	1		
R80	Resistor: fixed, composition, 33,000 ohms ±10%, 1 W B*	0690-3331	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	TQ	RS		
R81	Resistor: variable, composition, 25,000 ohms $\pm 20\%$, 1 W, linear taper BO*	2100-0009	1	1		
R82	Same as R60					
R83	Resistor: fixed, composition, 560,000 ohms $\pm 10\%$, 1 W B*	0690-5641	1	1		
R84	Resistor: fixed, composition, 680 ohms $\pm 10\%$, 1/2 W B*	0687-6811	1	1		
R85	Same as R16					
R86	Resistor: fixed, composition, 10,000 ohms $\pm 10\%$, 2 W B*	0693-1031	1	1		
R87	Resistor: fixed, composition, 390 ohms $\pm 10\%$, 1 W B*	0690-3911	1	1		
R88, 89	Resistor: fixed, composition, 680 ohms $\pm 10\%$, 1 W B*	0690-6811	2	1		
R90	Same as R19					
R91	Resistor: fixed, composition, 27,000 ohms $\pm 10\%$, 1 W B*	0690-2731	1	1		
R92	This circuit reference not assigned					
R93	Resistor: variable, composition, linear taper 5000 ohms, $\pm 20\%$, 1/2 W G*	2100-0011	1	1		
R94	Resistor: fixed, composition, 6,200 ohms $\pm 5\%$, 1 W B*	0869-6225	1	1		
R95	Resistor: fixed, composition, 2,700 ohms $\pm 10\%$, 1 W Optimum value selected at factory. Average value shown. B*	0690-2721	1	1		
R96	Resistor: variable, composition, linear taper 1000 ohms, $\pm 20\%$, 1/2 W G*	2100-0036	1	1		
S1	Rotary Switch Assembly: RANGE Switch, includes switch and frequency-determining resistors for oscillator (R1 through R12) and selective amplifier (R41 through R52) circuits HP*	26A-19W	1	1		
S2	Rotary Switch Assembly: IMPEDANCE Switch, includes resistors R71 through R75 HP*	26A-19A	1	1		
S3	Switch, toggle: SPST D*	3101-0001	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS		
T1	Power Transformer HP*	9100-0080	1	1		
T2	Imped. Match. Transformer: audio HP*	9120-0021	1	1		
V1	Tube, electron: 6SJ7 ZZ*	1923-0037	6	6		
V2	Tube, electron: 6K6GT ZZ*	1923-0033	1	1		
V3, 4	Same as V1					
V5	Tube, electron: 6J5 ZZ*	1921-0008	1	1		
V6	Same as V1					
V7	Tube, electron: 6AC7 ZZ*	1923-0014	1	1		
V8	Same as V1					
V9	Tube, electron: 6AG7 ZZ*	1923-0016	1	1		
V10	Tube, electron: 5U4GB ZZ*	1930-0008	1	1		
V11, 12	Tube, electron: 6L6GB ZZ*	1923-0034	2	2		
V13	Same as V1					
V14	Tube, electron: OD3 ZZ*	1940-0009	1	1		
	<u>MISCELLANEOUS</u>					
	Binding Post Assembly: black (G) HP*	AC-10C	1	1		
	Binding Post Assembly: red (OUTPUT, CT) HP*	AC-10D	3	1		
	Cable, Capacitor Drive HP*	G-18A	1	1		
	Fuseholder T*	1400-0007	1	1		
	Jewel AD*	1450-0020	1	1		
	Lampholder AD*	1450-0022	1	0		
	Knob (AMPLITUDE control) HP*	G-74K	1	0		
	Knob (POWER, RANGE, IMPEDANCE, DB controls) HP*	G-74K	6	0		
	Knob (FREQUENCY controls, coarse and fine) HP*	G-74R	2	0		

* 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.

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

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

