

INSTRUCTION MANUAL

MODEL 240A

HIGH VOLTAGE SUPPLY

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SPECIFICATIONS

OUTPUT:**Voltage:** 0 to 1200 volts dc in 1-volt steps.**Current:** 10 milliamperes dc maximum.**Polarity:** Positive or negative with respect to chassis.**ACCURACY:** $\pm 1\%$ of dial setting.**RESOLUTION:** A "Trim" potentiometer permits interpolation between steps with a resolution of better than 5 mv.**STABILITY:** $\pm 0.02\%$ ± 2 millivolts the first hour or in subsequent 8-hour periods, after a 30-minute warmup.**LINE REGULATION:** $\pm 0.005\%$ ± 2 millivolts for 10% change in line voltage.**LOAD REGULATION:** $\pm 0.005\%$ ± 2 millivolts from no load to full load.**RIPPLE AND NOISE:** Less than 1 millivolt rms above 5 cps.**RECOVERY TIME:** No load to full load, less than 35 milliseconds to within 0.1% of no-load output.**OVERLOAD PROTECTION:****Electronic current limiting** to less than 13 milliamperes within 15 milliseconds for 200% or greater overloads.**Automatic recovery** from overload to within 1% of no-load output within $\frac{1}{4}$ second at 1200 volts. Proportionally faster at lower voltages.**CONNECTORS:** Output: Teflon-insulated UHF type.**POWER:** 105-125 or 210-250-volts, 50-60 cps, 65 watts.**DIMENSIONS, WEIGHT:** $5\frac{1}{2}$ " high x $8\frac{3}{4}$ " wide x 13" deep; net weight, 12 pounds.**ACCESSORIES SUPPLIED:** Mating connector.

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Keithley Model 240A is a compact high voltage supply which provides accurate, stable outputs from 0 to 1200 volts dc. Accuracy is $\pm 1\%$ of the dial setting for all outputs. Stability is $\pm 0.02\%$ ± 2 millivolts the first hour or in subsequent 8-hour periods, after a 30-minute warm-up. Line regulation is $\pm 0.005\%$ ± 2 millivolts for a 10% change in line voltage, and load regulation is $\pm 0.005\%$ ± 2 millivolts from no load to full load.

1-2. FEATURES.

a. Three Digit Resolution. Three in-line calibrated dials set the output voltage in 1-volt steps. A TRIM Control permits interpolation between steps with better than 5-millivolt resolution. Output can be selected positive or negative with respect to ground.

b. Overload Protection. Repeated overloading or operation in an overloaded condition for long periods will not damage the Model 240A. Overload protection limits the output current to less than 13 milliamperes and, when the overload is removed, automatically returns the Supply to its set value.

c. Solid-State Design. The circuit for the Model 240A takes advantage of the reliability and stability of a solid-state comparator amplifier, and the high voltage capability of a series regulator tube to provide a high performance circuit.

1-3. APPLICATIONS.

a. General Laboratory Instrument. In the laboratory the Model 240A is a general-purpose high voltage supply. Applications include use in surface and volume resistivity measurements and with high resistance bridges. The Model 240A will supply operating potentials for photomultiplier tubes, electron multipliers, solid-state radiation detectors and ionization chambers. It can also be used in the calibration of meters and electrostatic probes.

b. Production Test Instrument. Typical production testing applications are semiconductor and capacitor leakage measurements. The output of the Voltage Supply may be remotely controlled or programmed by adding a connector to the rear panel.

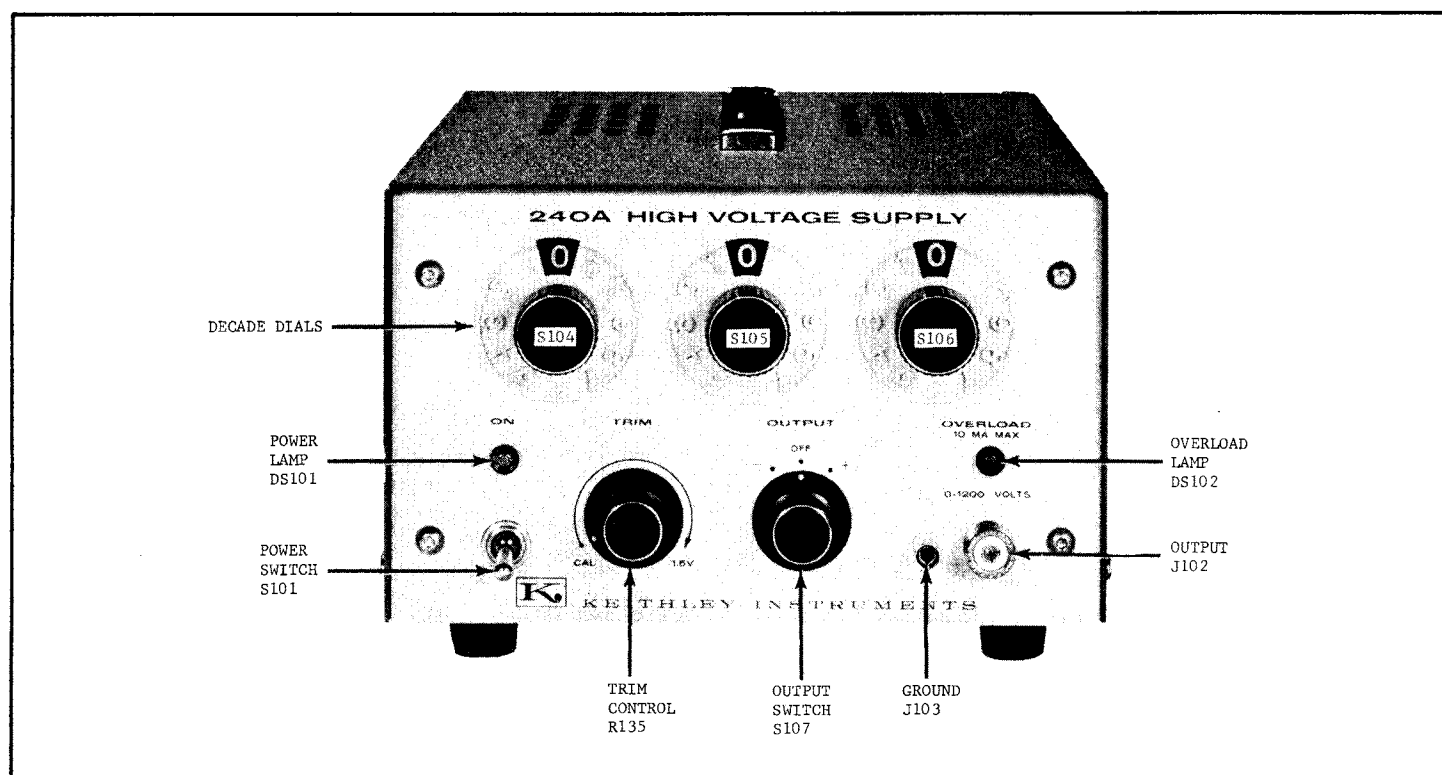


FIGURE 2. Front Panel Controls.

SECTION 2. OPERATION

2-1. FRONT PANEL CONTROLS AND TERMINALS. (See Figure 2).

a. ON Switch. A toggle switch turns on the line power to the entire instrument. Turning the Switch off removes the output power within a short time.

b. ON Pilot Light. The ON Pilot Light glows orange to indicate the Voltage Supply is on, whatever the setting of any control.

c. Voltage Dials. Three skirted dials, calibrated in 100, 10 and 1-volt steps, set the output voltage from 0 to 1200 volts dc. Note the first dial can be set to 11, the other two can be set to 10.

d. TRIM Control. The TRIM Control interpolates between 10volt settings of the Voltage Dials with better than 5-millivolt resolution. The span of the Control is 1.5 volts. The Control has a snap-action CAL position; at this setting the Model 240A output is determined only using the Voltage Dials.

e. OUTPUT Switch. This Switch selects either positive or negative outputs with respect to chassis ground. In the OFF position, there is no output voltage although the instrument is operating. When the Switch is in OFF position, a 220-kilohm resistor shunts the Output Terminals to discharge any capacitive loads present.

f. Output Receptacle. A Teflon-insulated UHF receptacle is mounted on the front panel to supply the output voltage. The shell of the Receptacle is connected to chassis ground. The adjacent binding post allows connectors other than UHF type to be used.

g. OVERLOAD Lamp. The OVERLOAD Lamp comes on when the output exceeds approximately 11 milliamperes; it remains on until the overload condition is removed.

2-2. REAR PANEL CONTROLS AND TERMINALS.

a. OUTPUT Receptacle. A Teflon-insulated UHF connector is mounted on the rear panel. Both the front and rear panel Output Receptacles are connected in parallel with heavy buss.

b. 117-234 Volt Slide Switch. The screwdriver-operated slide switch sets the Model 240A for 117 or 234-volt power lines.

c. Fuse. For 105-125 volt operation, the Model 240A uses a 3/4 ampere slow-blow fuse. For 210-250 volt operation, the Model 240A uses a 3/8-ampere slow-blow fuse.

d. Covered Blank Mounting Hole. A hold is punched in the rear panel to allow mounting of a Cinch-Jones connector. This hole is provided to easily modify the Model 240A for remote voltage control.

2-3. CONNECTIONS.

a. Use coaxial cables to insure good circuit connections and safe operation. Use Teflon or polyethylene-insulated connectors and cables which will withstand more than 1200 volts. Inspect insulation for mechanical or heat damage.

b. Coaxial cables also have the best noise characteristics. If noise is not important, unshielded leads may be used since the output impedance at low frequencies is very low.

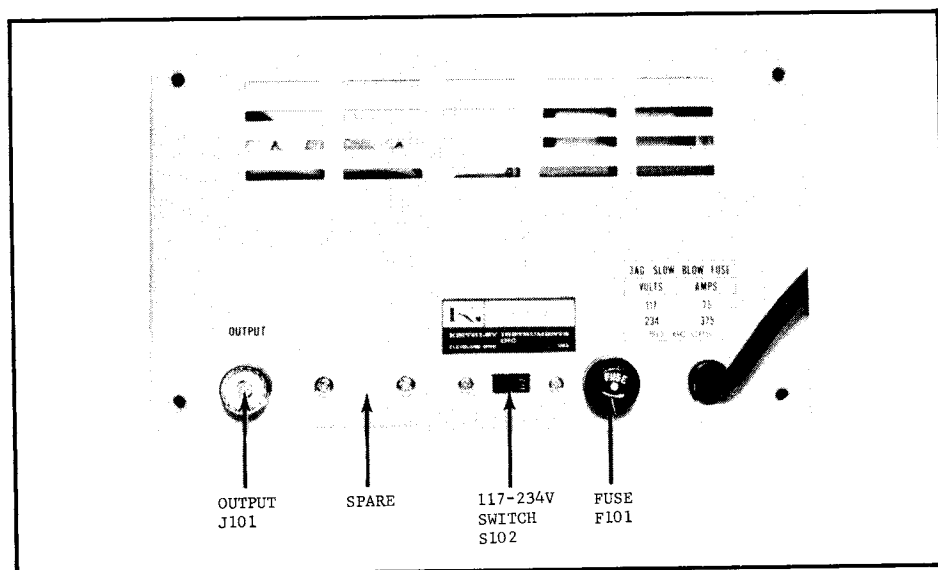


FIGURE 3. Rear Panel Terminals.

2-4. PRELIMINARY PROCEDURES.

a. The Model 240A is shipped in operating condition with all components installed.

b. Check the 117-234 Volt Switch and the Fuse for the proper line voltage. Make sure the Voltage Supply will be properly ventilated when it is operating. Air flow should be available from the bottom, top and rear.

c. Set the front panel controls to:

ON Switch	off
Voltage Switches	000
Trim Control	CAL
OUTPUT Switch	OFF

Plug the power cord into the power line. Turn the ON Switch on and allow the Model 240A to warm up for 30 minutes. The operating checks may be performed if desired.

2-5. OPERATING CHECKS.

a. Zero Balance. Connect the Keithley Model 153 Microvolt-Ammeter or an equivalent instrument to the Model 240A OUTPUT Receptacle. With the Voltage Switches at 000 and the OUTPUT Switch at -, after 30 minutes the output voltage should be less than ± 1 millivolt. If it is more, see paragraph 5-3.

b. Output Voltage. Increase the Model 153 sensitivity to 10 volts or more. Set the Model 240A Voltage Dials to an output equal to full scale on the voltmeter. Make sure the TRIM Control is set to CAL. If the output is not within the accuracy of both instruments, see paragraph 5-4.

c. Current Limit.

1. Use the Model 153 as an ammeter and connect it to the Model 240A OUTPUT Receptacle. Increase the Voltage Supply output using the TRIM Control until the OVERLOAD Lamp lights. Output current should be between -11 and -13 milliamperes. If not, see paragraph 5-5.

2. Set the Model 153 to its 30-milliamperere range. (If another ammeter is used, its voltage drop must be less than 150 millivolts on a scale capable of reading 15 milliamperes). Set the Model 240A output voltage to -100 volts. The OVERLOAD Lamp should light and the output current should be -12.5 ± 0.2 milliamperes.

NOTE

The output noise when the OUTPUT Switch is set to OFF is approximately 3 millivolts rms. This is typical and does not indicate a defective Voltage Supply.

2-6. SETTING OUTPUT VOLTAGE.

a. The setting of the three Voltage Dials and the TRIM Control determines the magnitude of the output voltage. The specified output accuracy of $\pm 1\%$ of Dial setting is assured only when the TRIM Control is set to CAL. At this setting, the TRIM Control is disconnected from the output control circuit.

b. The range of the TRIM Control is from 0 to 1.5 volts. To increase the output voltage less than 20 millivolts, reduce the Voltage Dial setting 1 volt; then use the TRIM Control in the upper portion of its range. The Control has an unusable portion at the very beginning of its range due to the switch action which defines the CAL position.

c. When the OUTPUT Switch is set to OFF, the Model 240A operates as normal except it is not delivering a current to the load. Therefore, the Voltage Dials can be changed and the Model 240A can be allowed to stabilize before a load is applied. Setting the Switch to OFF shunts 220 kilohms across the output terminals to discharge any capacitive load.

d. Relatively little overshoot or undershoot occurs when switching output voltages. For critical loads, however, first turn the OUTPUT Switch to OFF. Set the output voltage and then turn the OUTPUT Switch to the desired polarity.

2-7. OVERLOAD OPERATION.

a. A current limiting circuit provides overload protection for the Model 240A. When output current exceeds approximately 10 milliamperes, the Model 240A enters a constant current mode; the load resistance then determines the voltage across the load. For this mode, the OVERLOAD Lamp will light. Removing the overload or reducing the load automatically resets the Model 240A output to its original value.

b. The Model 240A is factory adjusted to deliver at least 10 milliamperes before the current limiting circuit operates. The OVERLOAD Lamp lights at about 11-milliamperere output. Current limiting action, indicated by an increase in output noise, begins at about 11.5 milliamperes. At short circuit maximum output current is about 12.5 milliamperes.

c. On a typical instrument, maximum short circuit output current can be adjusted anywhere between 6 and 16 milliamperes (paragraph 5-5). This provides a useful current output from about 4 to 14 milliamperes. However, operating the Model 240A at outputs greater than 10 milliamperes may degrade its load regulation specification for 1200-volt outputs and for low power-line voltages, and it may also degrade specifications at all output voltages.

NOTE

For output voltages and capacitive loads exceeding 1 joule of energy, never use the Voltage Dials to reduce the output more than 100 volts at a time or to go to zero output. Use the procedures given in paragraph 2-9.

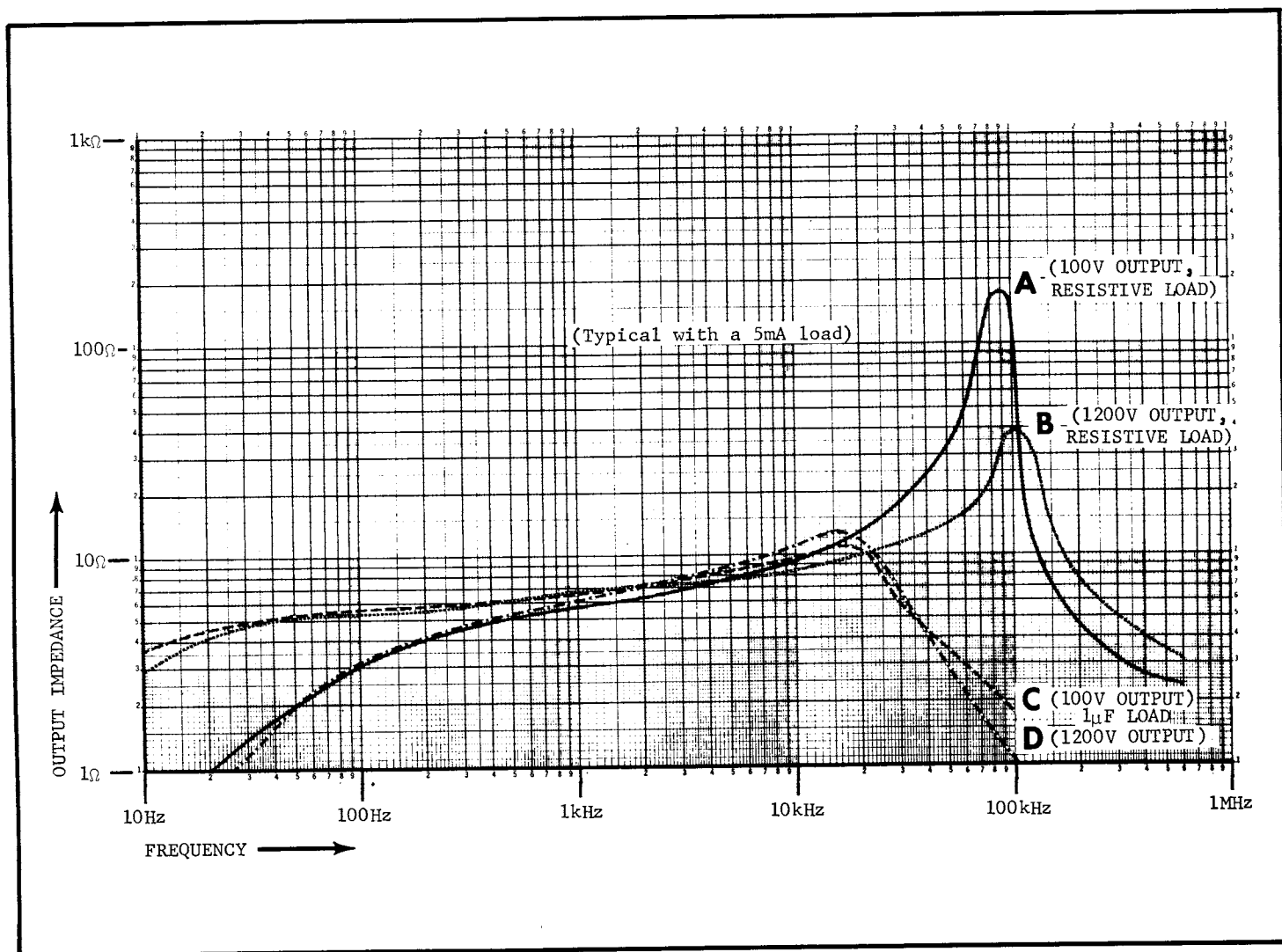


FIGURE 4. Output Impedance VS Frequency.

2-8. OUTPUT IMPEDANCE. Figure 4 illustrates the typical output impedances for the Model 240A. Curves are shown for output voltages of 100 and 1200 volts with and without a 1-microfarad capacitive load. These measurements were taken at a constant 5-milliampere load.

2-9. CAPACITIVE LOADS.

a. Its current limiting circuit enables the Model 240A to charge capacitive loads without difficulty. The OVERLOAD Lamp will light during the time the output current exceeds 11 milliamperes, but the current continues to flow. The Model 240A Voltage Supply does not have to be continually reset while charging a capacitive load.

b. For capacitive loads exceeding 1 joule of energy, change the Model 240A output by first setting the OUTPUT Switch to OFF. Then readjust the Voltage Dials and turn the OUTPUT Switch to the desired polarity. Reducing the output voltage without setting the OUTPUT Switch to OFF could damage the ranging resistors and/or the voltage selection switches.

2-10. OUTPUT NOISE. When the Model 240A operates with no load and from a clean power line, typical output noise at any voltage setting will be less than 10 millivolts peak-to-peak or 0.5 millivolts rms. Transient noise on the power line will tend to increase the peak-to-peak output noise, and if it is sufficiently high, may cause the rms output noise to also increase. As the output current increases, output noise decreases to between 5 and 2 millivolts peak-to-peak.

2-11. SHORT-TERM STABILITY. After a 3-hour warm-up the short term stability of the Model 240A is typically better than 0.003% per hour for output voltages greater than 100 volts and with constant line voltage, load and ambient temperature.

2-12. TEMPERATURE COEFFICIENT. The temperature coefficient of the Model 240A output voltage depends primarily upon the temperature coefficients of the zener reference, the voltage divider resistors, and the voltage control comparator circuit. Using the maximum values for these components, the maximum temperature coefficient for the voltage supply is ± 258 ppm/ $^{\circ}\text{C}$ or $\pm 0.026\%/^{\circ}\text{C}$. Typically, the coefficient will be much lower. Table 1 shows some values which can be expected.

TABLE 1. Typical Values for Temperature Coefficient of Model 240A Output Voltage. The Table shows samples at various settings of the temperature coefficient.

Temperature Change	Temperature Coefficient at Model 240A Voltage Setting of:		
	+100 Volts	+490 Volts	+1200 Volts
50 $^{\circ}\text{C}$ to 25 $^{\circ}\text{C}$	-0.0008%/ $^{\circ}\text{C}$	-0.0009%/ $^{\circ}\text{C}$	-0.0020%/ $^{\circ}\text{C}$
25 $^{\circ}\text{C}$ to 10 $^{\circ}\text{C}$	-0.0014%/ $^{\circ}\text{C}$	-0.0007%/ $^{\circ}\text{C}$	+0.0017%/ $^{\circ}\text{C}$

Since the internal components determine the instrument's performance, the coefficient differs for each particular instrument.

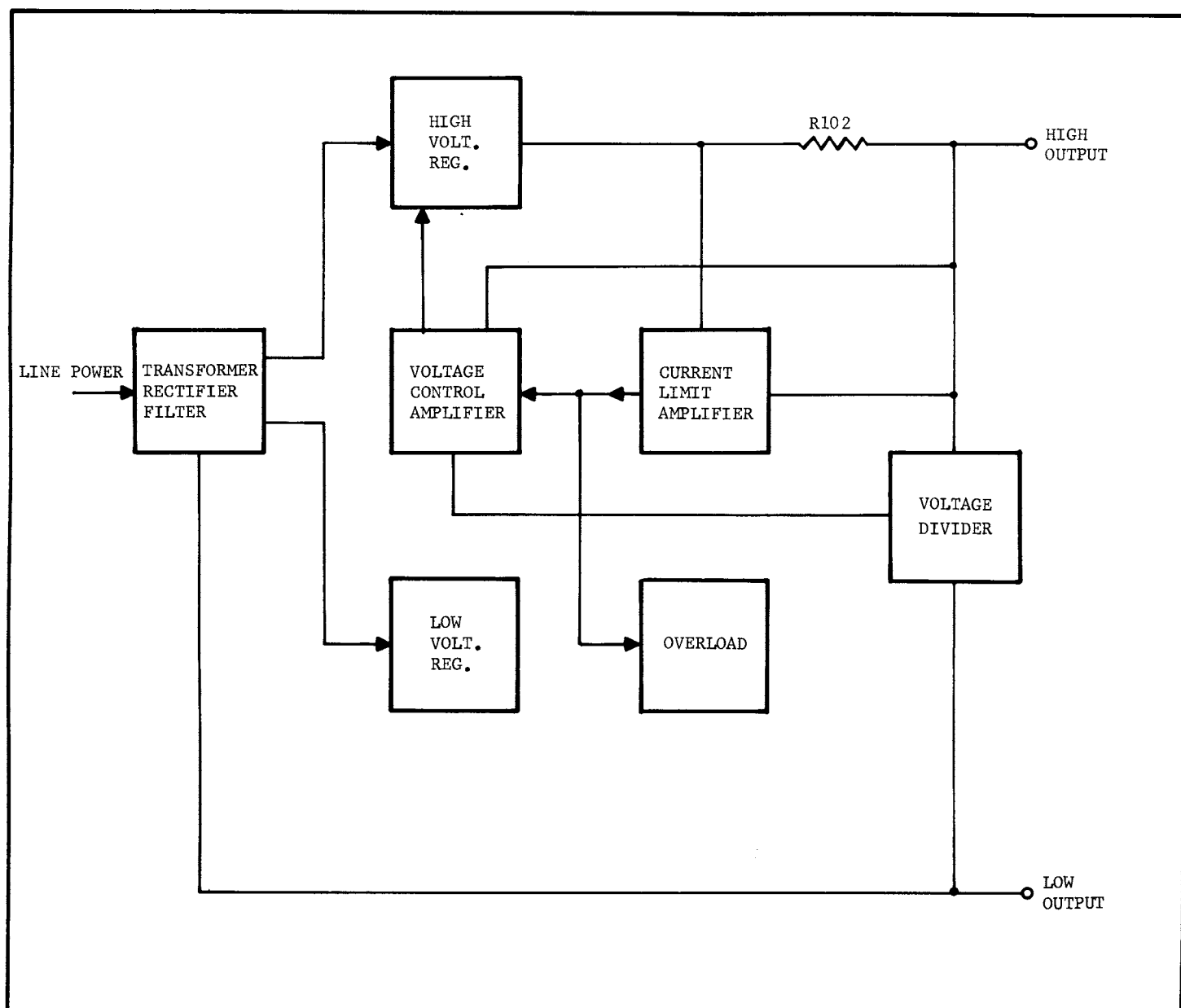


FIGURE 5. Overall Block Diagram.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Keithley Model 240A High Voltage Supply furnishes outputs from 0 to 1200 volts dc. The block diagram (Figure 4) shows the relationship between operating circuits. Setting the sampling resistors in the voltage divider selects the output voltage. Any difference between the voltage drop across a string of calibrating resistors and the zener reference is sensed by the voltage control comparator and amplified. The amplified difference signal is returned to the series regulator. This maintains the output voltage at a constant level determined by the divider ratio selected with the front panel Voltage Dials. The current limit comparator and amplifier prevents the output current from exceeding 12.5 milliamperes.

3-2. HIGH AND LOW VOLTAGE SUPPLIES.

a. High voltage for the series regulator tube is obtained using a voltage doubler circuit, composed of diodes D110 and D111 and filter capacitors C104 through C109. This circuit increases transformer life and reduces corona. Resistors R137 through R142 equalize the voltage across the filter capacitors.

b. Low voltage for the control circuitry is obtained from rectifiers D112 and D113 and filter capacitors C111 and C112. Cascaded regulators V102, V103 and D101, D106 regulate this voltage.

3-3. VOLTAGE CONTROL. The voltage divider consists primarily of zener reference D105, the sampling voltage divider, R149 to R179, and the calibrating resistor divider, R117 to R121. See Figure 11.

a. The front panel Voltage Dials, S104 to S106, set the value of the sampling resistors. Changing the sampling resistors, R149 through R179, varies the output voltage. The output voltage, E_o (Figure 11), assumes a value such that the voltage drop across the calibrating resistors, R117 to R121, is equal to the voltage of the zener reference, D105. The voltage control comparator and amplifier sense any difference between these voltages and correct the voltage, E_i , through the series regulator, V101.

b. The voltage control comparator and amplifier consist of a differential amplifier (transistors Q105 and Q106), current amplifiers (transistors Q103 and Q104), and a voltage amplifier (transistors Q101 and Q102). Its output controls the grid voltage of the series regulator tube, V101. Diodes D103, D104, D108, D109 and D114 and resistors R116 and R183 protect the voltage control comparator and the zener reference from switching transients when the output voltage is changed. Diode D102 prevents a reverse bias on the current amplifier Q104 beyond its breakdown voltage.

3-4. OUTPUT VOLTAGE. When the OUTPUT Switch, S107, is set to either + or -, it grounds one side of the Voltage Supply and connects the other side to the parallel Output Connectors, J101 and J102. Setting the Switch to OFF grounds the negative terminal of the Voltage Supply. The positive terminal is left disconnected, and resistor R180 shunts the Output Connectors to ground.

3-5. CURRENT CONTROL.

a. The output current is sensed by measuring the voltage drop across resistor R102. A current limit comparator and differential amplifier, transistors Q107 and Q108, compares this voltage to that at the tap of potentiometer R126.

b. The comparator control the OVERLOAD Lamp, DS102, and the Voltage Supply operating mode: normal, when there is no overload on the Model 240A; and current limited, when the output current exceeds 10 milliamperes. Selection between modes occurs automatically using a switch composed of diode D107 and the base-emitter of transistor Q104. In the normal mode, the voltage on the anode of diode D107 is less than the voltage on the base of Q104. Therefore, Q104 conducts and D107 does not. In the current limit mode, the voltage on the anode of D107 is higher than that on the base of Q104. D107 conducts and Q104 does not.

c. The neon OVERLOAD Lamp, DS102, is switched on by transistor Q110 turning off. As the lamp begins to ignite, Q110 is turned off hard, causing the lamp to come on to full brilliance. Base current for transistor Q110 is supplied by transistor Q109.

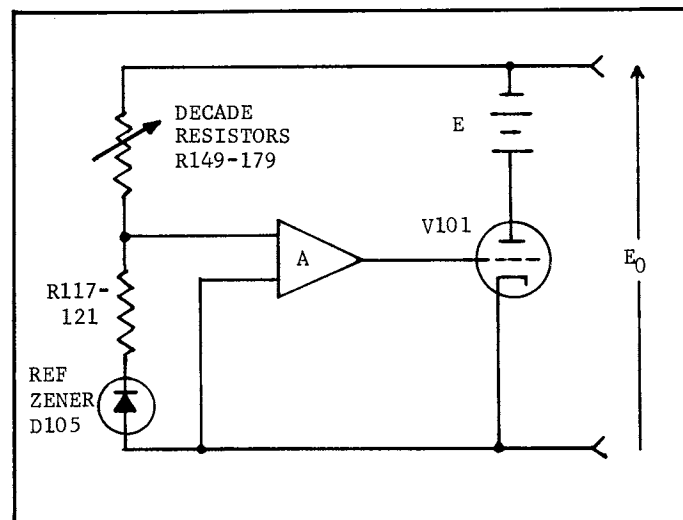


FIGURE 6. Voltage Control Comparator.

SECTION 4. SERVICING

4-1. GENERAL. This Section contains the maintenance and troubleshooting procedures for the Model 240A Voltage Supply. Follow these as closely as possible to maintain the specifications of the instrument.

4-2. SERVICING SCHEDULE. The Model 240A needs no periodic maintenance beyond the normal care required of high-quality electronic equipment. Occasional checks of the output, described in Section 5, will show the need of any adjustments. No part should need frequent replacement under ordinary use.

4-3. PARTS REPLACEMENT.

a. The Replaceable Parts List in Section 7 describes the electrical components of the Voltage Supply. Replace components only as necessary. Use only reliable replacements which meet the specifications.

b. The zener diode, D105, is selected as are diodes D108 and D109; transistors Q105 and Q106 are a matched pair. Order these replacements only from Keithley Instruments, Inc., or its representative, as well as other parts marked for Keithley manufacture (80164) in the Replaceable Parts List.

4-4. TROUBLESHOOTING.

a. The procedures which follow give instructions for repairing troubles which might occur in the Model 240A. Use the procedures outlined and use only specified replacement parts. Table 3 lists equipment recommended for troubleshooting. If the trouble cannot be located or repaired, contact Keithley Instruments, Inc., or its representative.

b. Table 4 lists problems which might occur. If the repair indicated does not work, check through each circuit as described in the following paragraphs. Refer to the description in Section 3 to understand the circuits. The complete circuit diagram, 19197D, is in Section 7.

NOTE

Use extreme caution when working within the Model 240A. High voltages are present at many points. Before removing the cover, make sure the power cord is disconnected. After removing the cover, discharge all metal-cased capacitors before proceeding with repairs. Discharge all high voltages through a bleeder.

4-5. PROCEDURES TO GUIDE TROUBLESHOOTING.

a. Always set the OUTPUT Switch to - when working on the Model 240A. This keeps the voltage control amplifier ground at case potential. When the Switch is at + or OFF, the series regulator low is above case ground by the amount of the output voltage.

b. Before troubleshooting the Voltage Supply, check the external circuits. Check the fuse, power cord, and power source.

c. The schematic diagram 19197D contains the voltages at selected points. These were measured with the Model 153 to $\pm 15\%$, and with the Model 240A controls set:

ON Switch	ON
Voltage Dials	000
TRIM Control	CAL
OUTPUT Switch	-

d. Check the vacuum tube, V101, and the gas tubes, V102 and V103. Check tubes by replacing them. Normally, replacing tubes will clear up any difficulty.

TABLE 3.
Test Equipment

Type	Description	Mfr.	Model No.
VTVM, True RMS	100 μ V to 330 V, 5 Hz to 4 MHz	Ballantine	320A
Microvolt-Ammeter	10 μ V to 1000 V, 10^{-11} A to 0.1A	Keithley	153
Electrometer	1 mV to 100 V, $10^{14}\Omega$ input R	Keithley	610C
Differential Voltmeter	100 μ V to 500 V	Keithley	662
Voltage Divider	100:1, $\pm 0.01\%$	Keithley	6601A
Oscilloscope		Tektronix	504

TABLE 4.
Troubleshooting Guide

Trouble	Probable Cause	Remedy
No output voltage, pilot light off	Line cord not plugged in	Plug in line cord
	117-234 Switch not correctly set	Set Switch to proper voltage
	ON Switch	Set to ON
	Fuse F101 Blown	Replace fuse; if fuse repeatedly blows, check further
No output voltage, repeated fuse failure	V101, V102, V103 or associated circuitry faulty	See paragraph 4-6
No output voltage but pilot light on	Trouble in high or low power supplies or tube filaments	See paragraph 4-6
	Faulty V101	Check, replace if faulty
	Current limiting or voltage control amplifiers defective	See paragraphs 4-7 and 4-8
Output voltage not correct by an approximately constant amount	Zero potentiometer not set	See paragraph 5-3
	Voltage control amplifier will not zero	See paragraphs 4-7 and 4-8
	Output noise high	See paragraph 4-10
Output voltage not correct by an approximately constant percentage of Voltage Dial setting	CAL potentiometer not set	See paragraph 5-4
	Diodes D103, D104, D108 or D109 leaking	Check, replace if faulty
	Faulty Q106	Check, replace if faulty
	Zener D105 or R117, R118, R119, R120 or R121 faulty	Check, replace if faulty
Output voltage not correct for low voltage outputs only	Low grid voltage on V101	Check, replace if faulty
	Amplifier not balanced	See paragraphs 4-7 and 4-8
	Output noise high	See paragraph 4-10
Output voltage not correct at only a few dial settings	Switches S104, S105 or S106 or one of resistors R149 to R179 faulty	Return to factory for repair
Output not correct at high voltage outputs only	High voltage transformer, rectifiers or filters faulty	See paragraph 4-6
	C113 or C114 leaking	Check, replace if faulty
	V101 screen circuit open or tube faulty	Check, replace if faulty
	Amplifier swing not sufficient	See paragraphs 4-7 and 4-8

4-6. TRANSFORMER CHECK. If no output voltage appears and if the fuse repeatedly blows, follow these procedures.

a. Removing tube V101 (Figure 9) from the socket unloads the high voltage and filament winding of the transformer.

b. Removing tubes V102 and V103 (Figure 12) from their sockets unloads the low voltage winding of the transformer.

c. If the fuse continues to blow, the trouble is in the rectifiers, filters, transformers or wiring. The best approach is to disconnect all secondary leads and check the transformer using the Model 610C as an ohmmeter.

4-7. TROUBLESHOOTING THE VOLTAGE CONTROL AMPLIFIER.

a. To troubleshoot the voltage control amplifier, first remove the high voltage. Turn the ON Switch off. Remove tube V101 (Figure 9) from its socket and disconnect the plate cap. Make sure the plate cap is clear of all surrounding components. Place a shorting jumper across either diode D108 or D109 (Figure 11).

b. Set the front panel controls to:

ON Switch	ON
Voltage Dials	000
TRIM Control	CAL
OUTPUT Switch	-

Do not connect anything to the Output Receptacles.

c. Connect the Model 153 between pin 5 of tube V101 and ground. Turn the Model 240A on. Adjust the ZERO potentiometer R114 (Figure 11). Turning the potentiometer should swing the voltage from approximately 0 to -36 volts. Set the potentiometer for -20 volts.

d. If the -20 volts can be set, then the voltage control amplifier will balance at dc and it is probably functioning properly. If the -20 volts cannot be set, the trouble may be in either the voltage control amplifier or in the current limit circuit. See paragraph 4-8.

4-8. TROUBLESHOOTING THE CURRENT LIMIT CIRCUITS.

a. A defective current limit circuit can interfere with the voltage control amplifier. First, see if the voltage control amplifier is operating correctly (paragraph 4-7).

b. Set the front panel controls as in paragraph 4-7, b. Since there is no overload, there should be a reverse voltage across diode D107 (Figure 11). The amplifier should be in its normal mode.

c. If there is not a reverse voltage across D107, disconnect the current limit circuit by disconnecting one end of diode D107. If the voltage control amplifier does not yet balance, the trouble is in the amplifier. If the voltage control amplifier balances, the trouble is in the current limit circuit. Locate the trouble by making voltage measurements within these circuits.

TABLE 5. Current Limit Circuit Voltages. These values were measured with the Model 153 to $\pm 15\%$. The Voltage Dials are set to 000 and the OUTPUT Switch to -. The range from -36 to -44 volts is the limits of the voltages across the zener diode D106. The points B, C, and D are indicated in Figure 7.

Zener Supply Voltage (Pt. A)	Point B	Point C	Point D
-44 volts	-0.42 volt	-0.30 volt	+0.24 volt
-40 volts	-0.03 volt	-0.10 volt	+0.63 volt
-36 volts	+0.61 volt	+0.82 volt	-1.25 volt

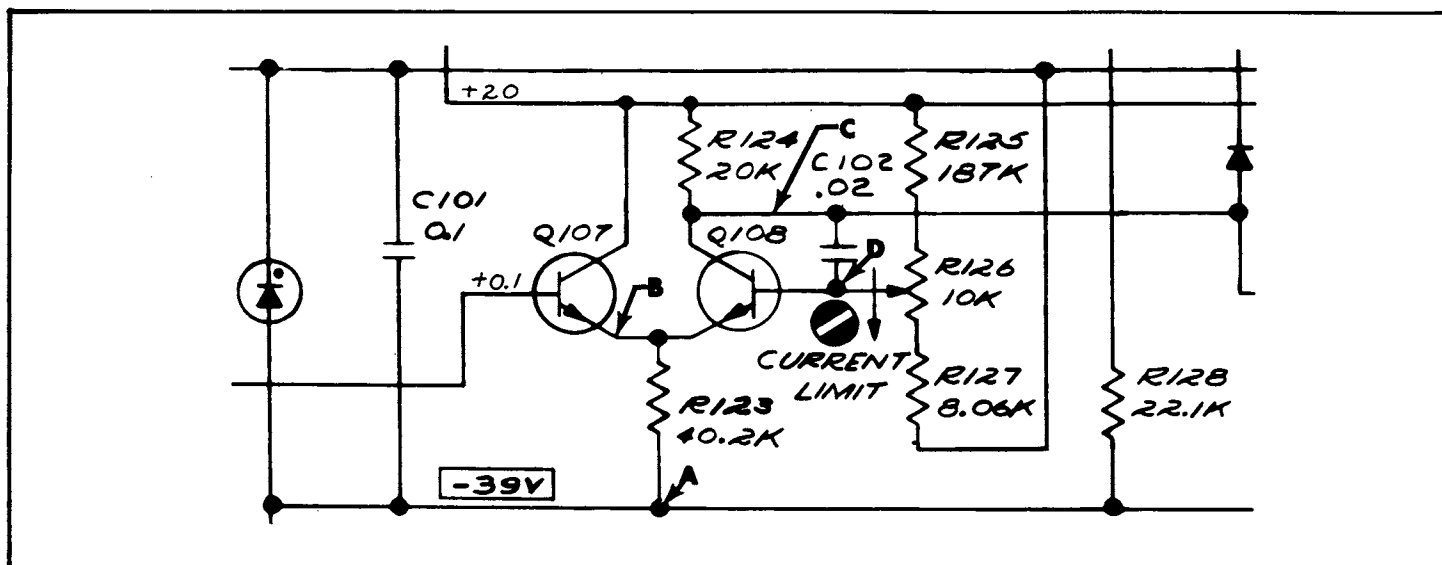


FIGURE 7. Test Points, Current Limit Circuit.

4-9. TROUBLESHOOTING THE OVERLOAD LAMP CIRCUIT.

a. Trouble in the OVERLOAD Lamp driver circuit is indicated by the lamp not lighting when the voltage control amplifier and the current limit circuit are working. The latter circuit is working if output noise increases as the overload increases and current limiting action occurs.

b. In overload condition, the voltage between the emitter and collector of transistor Q110 (Figure 11) should be more than -105 volts. If it is and the lamp will not light, then the lamp is defective.

c. If -105 volts is not present, then either transistor Q109 or Q110 (Figure 11) or the associated circuitry is defective. Measure the voltages within the circuits to locate the trouble.

d. Voltages within the current limit amplifier vary considerably, depending upon the voltage across zener diode D106. Nominally, the voltage is -39 volts. Table 5 gives the correct values for points in Figure 7 for voltages within the limits of the zener if the instrument is working properly.

4-10. OUTPUT NOISE. With a voltage setting of less than 600 volts, the output noise on the Model 240A may be read by connecting the Model 504 oscilloscope or the Model 320A voltmeter across the output terminals of the Model 240A. With a voltage setting greater than 600 volts, use a blocking capacitor box (Figure 8) with the oscilloscope or voltmeter. When using the box keep the switch on the box closed except when reading noise. Excessive power line noise will tend to increase the output noise. The output noise should be less than 10 millivolts peak-to-peak or 1.0 millivolt rms. If the noise is higher, then most likely one of the regulator tubes V102 or V103 is defective. If replacing these tubes does not clear up the trouble, then either the pass tube, V101, is defective or one or more of the amplifier transistors, Q101 through Q106, is defective.

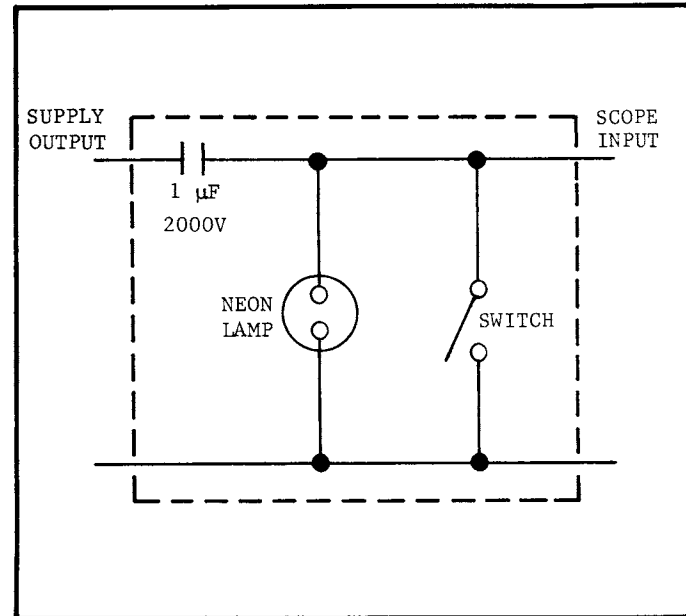


FIGURE 8. Test Box For Noise Check.

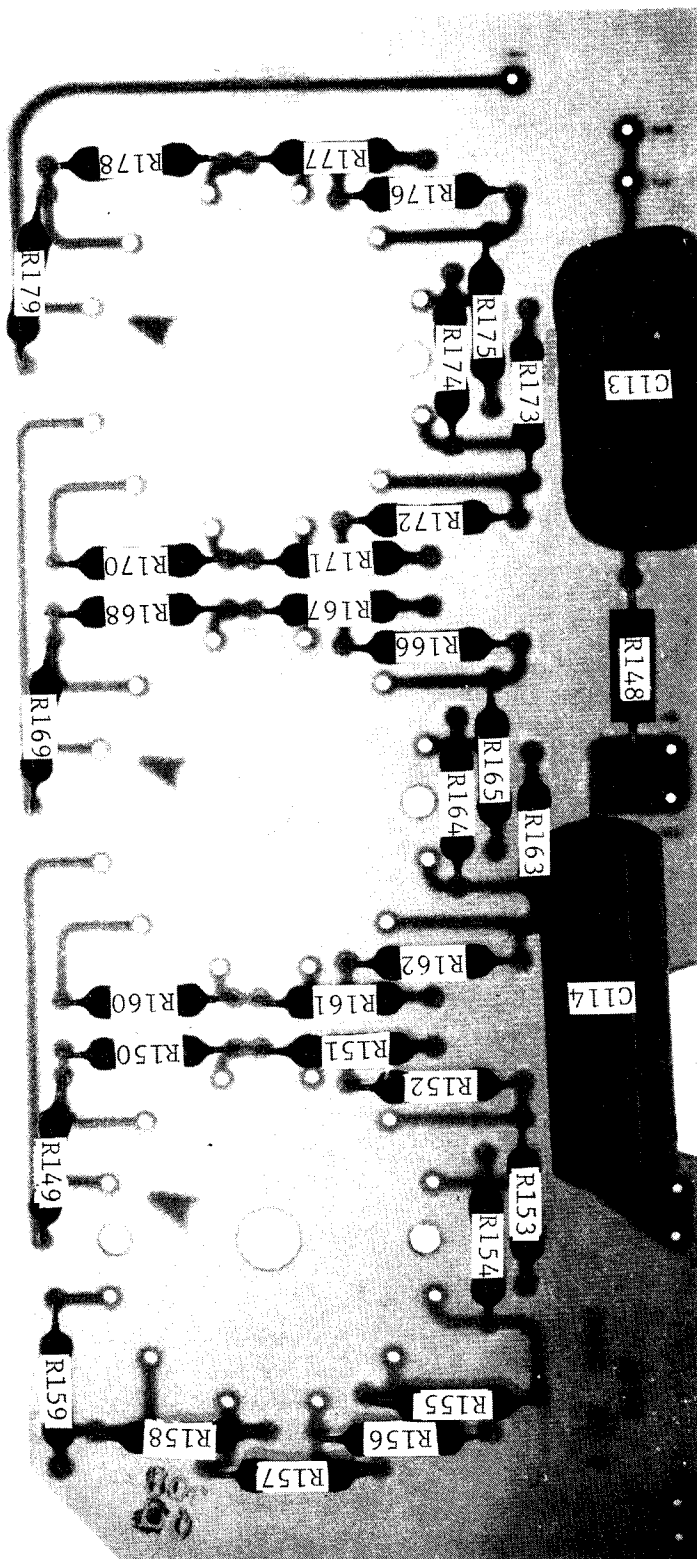


FIGURE 9. Chassis, Top View.

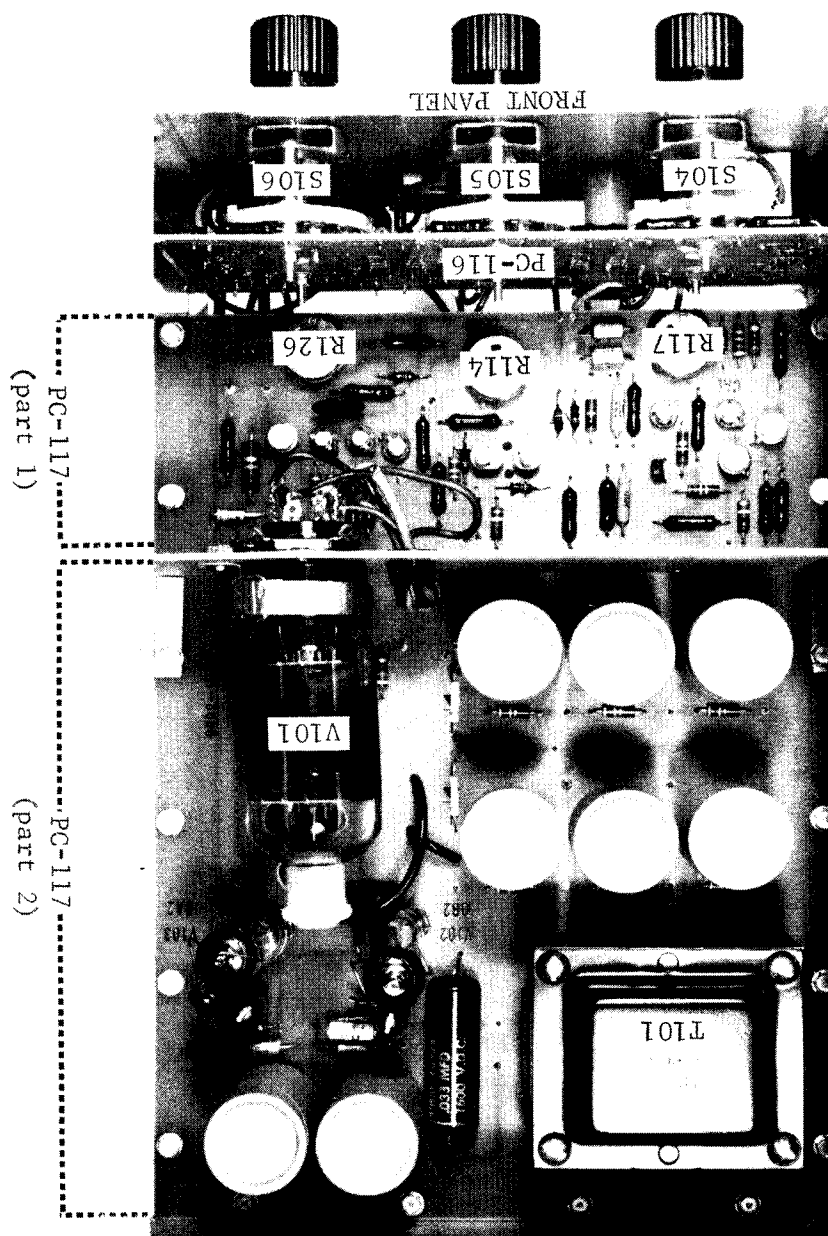


FIGURE 10. Component Layout, PC-116.

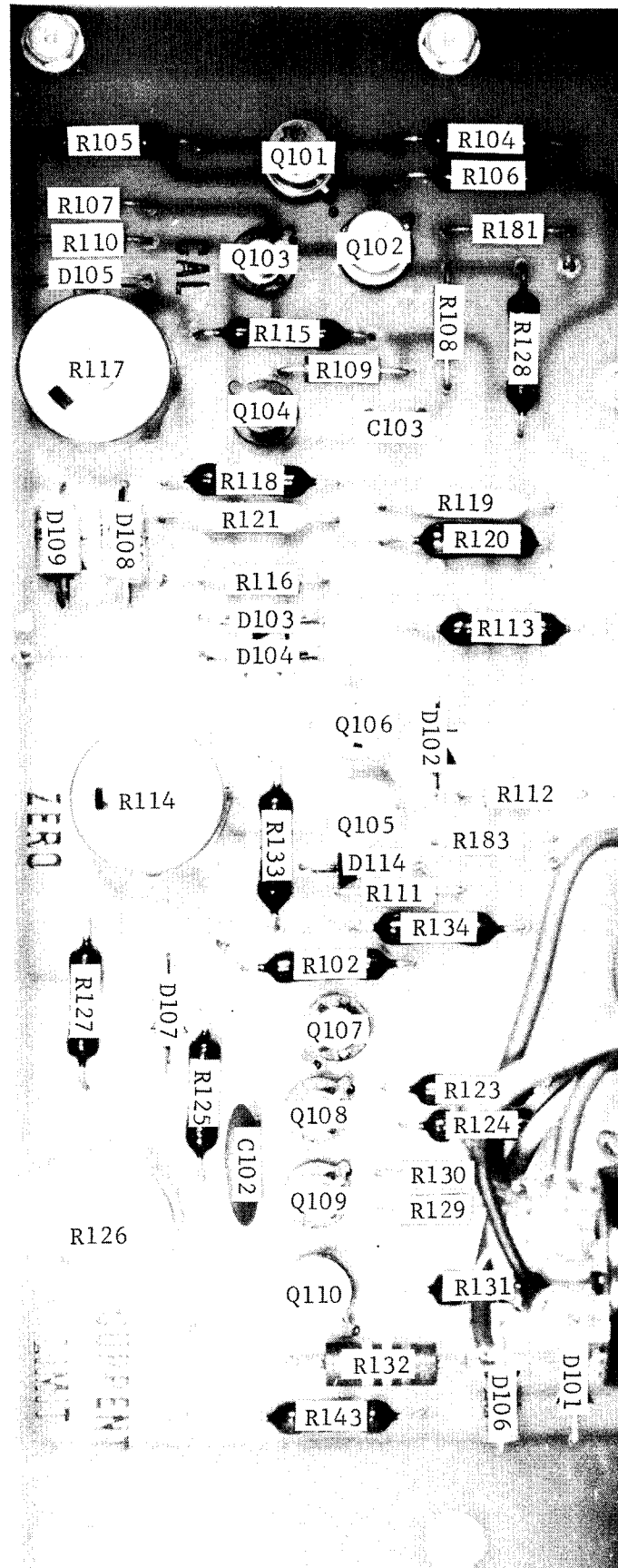


FIGURE 11. Component Layout, PC-117 (Part 1).

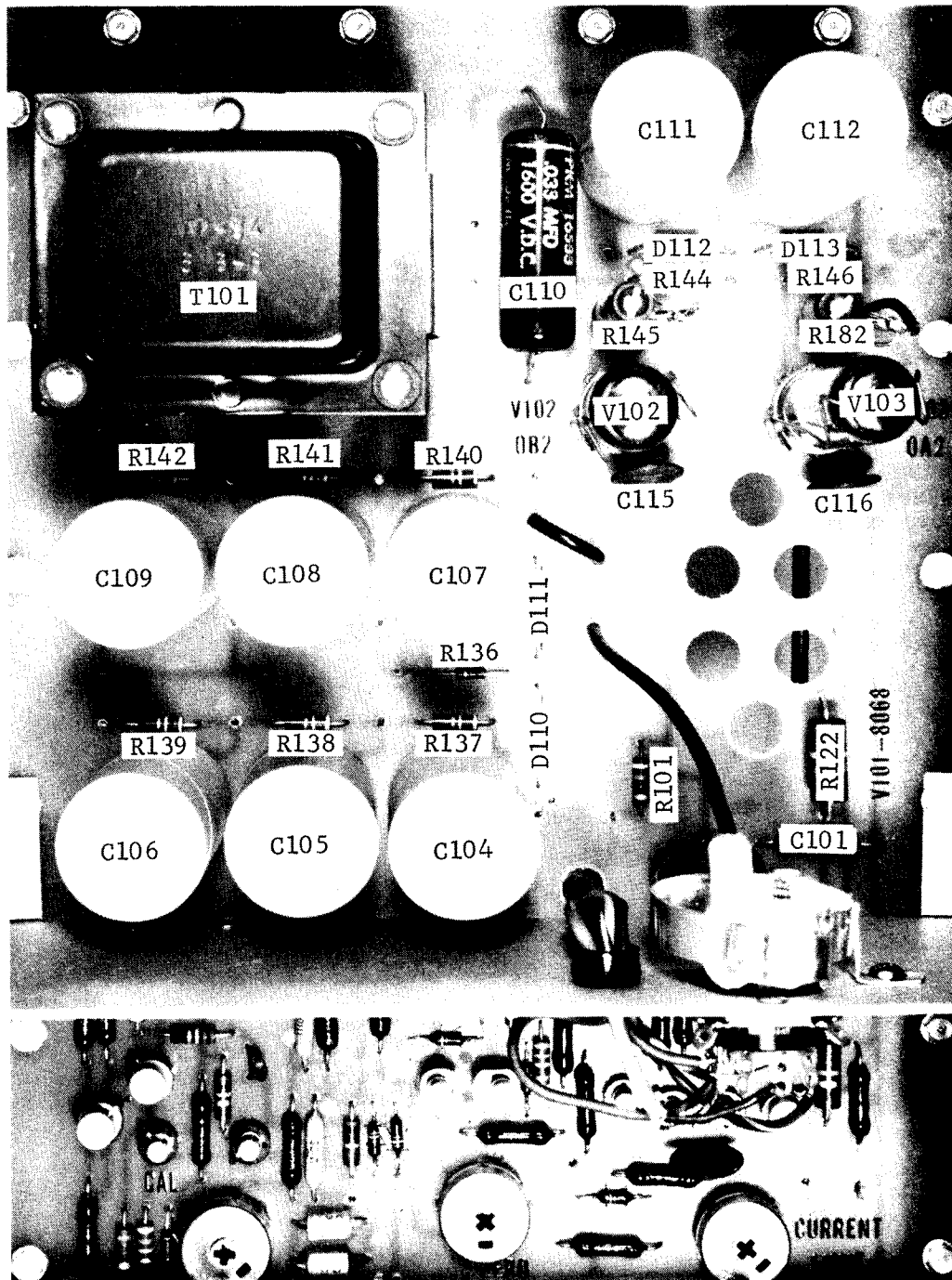


FIGURE 12. Component Layout, PC-117 (Part 2).

SECTION 5. CALIBRATION

5-1. GENERAL.

a. The following procedures are recommended for calibrating the Model 240A. It is also recommended that the equipment listed in Table 3 be used. If difficulty is encountered, contact Keithley Instruments, Inc., or its representative.

b. Before performing any calibration, make sure the Model 240A is in working order. Allow it to stabilize for at least 30 minutes with both covers on.

c. If the instrument is not within specifications after the calibration, follow the troubleshooting procedures or contact Keithley Instruments, Inc., or its representatives.

5-2. CALIBRATION SCHEDULE. Check the accuracy of the output voltage (paragraph 5-4) every six months and recalibrate as necessary. Also, recalibrate the instrument if the series regulator tube, V101, or the zener diode, D105, is replaced.

5-3. ZERO BALANCE ADJUSTMENT.

a. This adjustment sets the Model 240A for no output when the Voltage Dials are set to 000.

b. Set the front panel controls to:

ON Switch	ON
Voltage Dials	000
TRIM Control	CAL
OUTPUT Switch	-

Connect the Model 153 to the Model 240A OUTPUT Receptacle and set it initially to its 10-millivolt range. Adjust the ZERO potentiometer, R114 (Figure 11), for zero output ± 1 millivolt.

5-4. VOLTAGE CALIBRATION.

a. Connect the Model 662 to the Model 240A OUTPUT Receptacle. Allow the Voltage Supply to warm up for at least 30 minutes. Set the front panel controls to:

ON Switch	ON
Voltage Dials	any output above 10 volts
TRIM Control	CAL
OUTPUT Switch	-

b. The Model 662 should read the Model 240A output to $\pm 0.5\%$. If necessary, adjust the output using the CAL potentiometer R117 (Figure 11). If the potentiometer does not have sufficient range, add or remove jumpers across resistors R119, R120 and R121 (see schematic diagram 19197D).

c. For a quick check, measure the output voltage at several different settings. Adjust the CAL potentiometer R117 (Figure 11) for minimum percentage deviation from the dial setting.

d. For best accuracy, check each ranging resistor and then adjust the CAL potentiometer for minimum deviation from the dial setting. Check the resistor by measuring the output voltage at each dial setting for each Voltage Dial. Keep two Dials set to zero and measure the output for each position of the third dial. Output should be within $\pm 0.5\%$ of the setting.

5-5. CURRENT LIMIT CIRCUIT ADJUSTMENT.

a. This adjustment sets the Model 240A current limit circuit for maximum current output. The factor adjustment is for a short circuit current of 12.5 milliamperes, although the adjustment range is from 6 to 16 milliamperes. This range provides a useful output current from about 4 to 14 milliamperes. At outputs above 10 milliamperes, however, some specifications may be degraded. (See paragraph 2-7).

b. Connect the Model 153 to the Model 240A OUTPUT Receptacle. (If an equivalent Ammeter is used, its input drop must be less than 150 millivolts). Initially set the Model 153 sensitivity to 30 milliamperes full scale. Set the Model 240A controls to:

ON Switch	ON
Voltage Dials	100
TRIM Control	CAL
OUTPUT Switch	-

Adjust the CURRENT LIMIT potentiometer R126 (Figure 11) until the output current is 12.5 milliamperes ± 0.2 milliampere.

TABLE 6. Model 240A Internal Controls. The Table lists all internal controls, the figure picturing the location and the paragraph describing the adjustment.

Control	Circuit Desig.	Fig. Ref.	Refer to Paragraph
Zero Adjustment	R114	11	5-3
Calibration Adjustment	R117	11	5-4
Current Limit	R126	11	5-5

SECTION 6. ACCESSORIES

Model 4003A Rack Mounting Kit

Description:

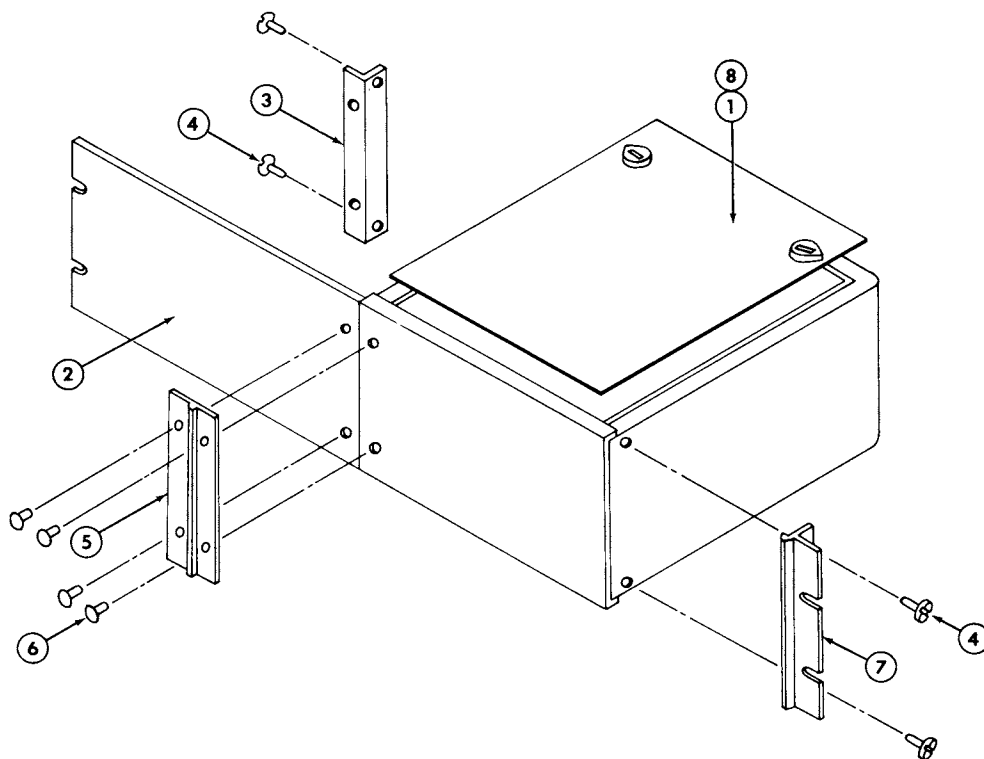
The Model 4003A is a rack mounting kit with overall dimensions, 5-1/4 inches high x 19 inches wide. Two top covers are provided for use with either 10 inch or 13 inch deep instruments.

Application:

The Model 4003A converts the instrument from bench mounting to rack mounting. It is suitable for mounting one instrument in one-half of a standard 19-inch rack.

Parts List:

Item No.	Description	Qty. Per Assembly	Keithley Part No.
1	Top Cover, 10"	1	18554B
2	Panel Adapter Plate	1	17452B
3	Angle Support	1	17476A
4	Screw, #10 x 3/8"	4	---
5	Connecting Plate	1	19126A
6	Screw, #10 x 1/2"	4	---
7	Angle	1	14624B
8	Top Cover, 13"	1	20015B



Model 4004A Dual Rack Mounting Kit

Description:

The Model 4004A is a rack mounting kit with overall dimensions, 5-1/4 inches high x 19 inches wide. Two top covers are provided for use with either 10 inch or 13 inch deep instruments.

Application:

The Model 4004A converts the instrument from bench mounting to rack mounting. It is suitable for mounting two instruments in a standard 19-inch rack.

Parts List:

Item No.	Description	Qty. Per Assembly	Keithley Part No.
1	Top Cover, 10"	2	18554B
4	Screw, #10 x 1/2"	8	---
5	Connecting Plate	1	19126A
6	Screw, #10 x 1/2"	4	---
7	Angle	2	14624B
8	Top Cover, 13"	2	20015B
9	Zee Bracket	1	19144A
10	Plate (not shown)	1	17454A

SECTION 7. REPLACEABLE PARTS

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C101	0.1 μ f	200 v	My	02777	P-12M	C66-.1M	12
C102	.02 μ f	600 v	CerD	72982	ED-.02	C22-.02M	11
C103	100 pf	600 v	CerD	72982	ED-100	C22-100P	11
C104	20 μ f	450 v	EMC	37942	FP 144	C36-20M	12
C105	20 μ f	450 v	EMC	37942	FP 144	C36-20M	12
C106	20 μ f	450 v	EMC	37942	FP 144	C36-20M	12
C107	20 μ f	450 v	EMC	37942	FP 144	C36-20M	12
C108	20 μ f	450 v	EMC	37942	FP 144	C36-20M	12
C109	20 μ f	450 v	EMC	37942	FP 144	C36-20M	12
C110	.033 μ f	1600 v	My	14655	MGT S33	C43-.033M	12
C111	40 μ f	350 v	EMC	14659	TVL 1621	C32-40M	12
C112	40 μ f	350 v	EMC	14659	TVL 1621	C32-40M	12
C113	.047 μ f	1600 v	My	14655	DMPS 16547	C87-.047M	10
C114	.01 μ f	1600 v	My	14655	MGT-S1	C43-.01M	10
C115	.02 μ f	600 v	CerD	72982	ED-.02	C22-.02M	12
C116	.02 μ f	600 v	CerD	72982	ED-.02	C22-.02M	12

DIODES

Circuit Desig.	Type	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
D101	Zener	1N4747	04713	DZ-25	11
D102	Silicon	1N645	01295	RF-14	11
D103	Silicon	1N645	01295	RF-14	11
D104	Silicon	1N645	01295	RF-14	11
D105	Zener	1N936	04713	DZ-5	11
D106	Zener	1N4754	04713	DZ-26	11
D107	Silicon	1N645	01295	RF-14	11
D108	Rectifier, 1A, 800V	1N4006	04713	RF-38	11
D109	Rectifier, 1A, 800V	1N4006	04713	RF-38	11
D110	Rectifier, 2500V, 300mA	3CFS25	S-T	RF-49	12
D111	Rectifier, 2500V, 300mA	3CFS25	S-T	RF-49	12
D112	Rectifier, 1A, 800V	1N4006	04713	RF-38	12
D113	Rectifier, 1A, 800V	1N4006	04713	RF-38	12
D114	Silicon	1N645	01295	RF-14	11
D115	Zener	UZ5806	12969	DZ-28	-

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfr. Code	Keithley Part No.	Fig. Ref.
DS101	Pilot Light, ON (Mfg. No. 2100)	91802	PL-34	2
DS102	Pilot Light, OVERLOAD (Mfg. No. 2100)	91802	PL-35	2
F101	Fuse, slow blow, .75 amp, 117V	71400	FU-19	3
F101	Fuse, slow blow, .375 amp, 234V	71400	FU-18	3
---	Fuse holder (Mfg. No. 342012)	75915	FH-3	
J101	Receptacle, uhf, OUTPUT, (Mil. No. SO-239A)	91737	CS-64	3
---	Plug, uhf, Mate of J101 (Mil. No. 49190)	91737	CS-49	-
---	Dust Cap, 2 req'd (Mfg. No. EC-10)	99017	CAP-1	-
J102	Receptacle, uhf, OUTPUT (Mil. No. SO-239A)	91737	CS-64	2
---	Plug, uhf, Mate of J102 (Mil. No. 49190)	91737	CS-49	-
J103	Binding Post (Mfg. No. 33-286)	08811	BP-15	2
P101	Cord Set, 6 feet (Mfg. No. 4638-13)	93656	CO-5	3
S101	Toggle Switch, SPST, ON (Mfg. No. 20994LH)	04009	SW-4	2
S102	Slide Switch, 117-234 v	80164	SW-151	3
S103	TRIM Control Knob Assembly	80164	14838A	2
---	Trim Potentiometer, R135	71450	RP53-1.65K	-
S104	Rotary Switch, X100 Output Volts	80164	SW-213	2
---	Dial Assembly, X100 (0 - 11)	80164	19196A	-
S105	Rotary Switch, X10 Output Volts	80164	SW-211	2
---	Dial Assembly, X10 (0 - 10)	80164	14829A	-
S106	Rotary Switch, X1 Output Volts	80164	SW-211	2
---	Dial Assembly, X1 (0 - 10)	80164	14829A	-
S107	Rotary Switch less components, OUTPUT	80164	SW-212	2
---	Switch Assembly with components, Output	80164	19467B	-
---	Knob Assembly, Output	80164	14838A	-
T101	Transformer	80164	TR-94	12

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R101	470 Ω	10%, 1/2 w	Comp	01121	EB	R1-470	12
R102	100 Ω	1%, 1/2 w	MtF	07716	CEC	R94-100	11
R103	3 k Ω	10%, 5 w	WW	05766	FRL-5	R131-3K	-
R104	15 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-15K	11
R105	4.99 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-4.99K	11
R106	8.06 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-8.06K	11
R107	8.2 k Ω	10%, 1/2 w	Comp	01121	EB	R1-8.2K	11
R108	680 k Ω	10%, 1/2 w	Comp	01121	EB	R1-680K	11
R109	10 k Ω	10%, 1/2 w	Comp	01121	EB	R1-10K	11
R110	47 k Ω	10%, 1/2 w	Comp	01121	EB	R1-47K	11
R111	33 k Ω	10%, 1/2 w	Comp	01121	EB	R1-33K	11
R112	120 k Ω	10%, 1/2 w	Comp	01121	EB	R1-120K	11
R113	1.5 M Ω	1%, 1/2 w	MtF	07716	CEC	R94-1.5M	11
R114	2 k Ω	20%, 2 w	WW	71450	1NS 115	RP50-2K	11
R115	*1.3 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-1.3K	11

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R116	1 k Ω	10%, 1/2 w	Comp	01121	EB	R1-1K	11
R117	500 Ω	20%, 2 w	WW	71450	1NS 115	RP50-500	11
R118	8.25 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-8.25K	11
R119	301 Ω	1%, 1/2 w	MtF	07716	CEC	R94-301	11
R120	301 Ω	1%, 1/2 w	MtF	07716	CEC	R94-301	11
R121	301 Ω	1%, 1/2 w	MtF	07716	CEC	R94-301	11
R122	12 k Ω	10%, 2 w	Comp	01121	HB	R3-12K	12
R123	40.2 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-40.2K	11
R124	20 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-20K	11
R125	187 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-187K	11
R126	10 k Ω	20%, 2 w	WW	71450	1NS 115	RP50-10K	11
R127	8.06 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-8.06K	11
R128	22.1 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-22.1K	11
R129	4.7 k Ω	10%, 1/2 w	Comp	01121	EB	R1-4.7K	11
R130	220 k Ω	10%, 1/2 w	Comp	01121	EB	R1-220K	11
R131	4.02 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-4.02K	11
R132	56 k Ω	10%, 1 w	Comp	01121	GB	R2-56K	11
R133	1 M Ω	1%, 1/2 w	MtF	07716	CEC	R94-1M	11
R134	1 M Ω	1%, 1/2 w	MtF	07716	CEC	R94-1M	11
R135	1.65 k Ω	10%, 1/2 w	DCb	71450	VF-N45	RP53-1.65K	
R136	100 Ω	10%, 1/4 w	Comp	01121	CB	R76-100	12
R137	470 k Ω	10%, 1/2 w	Comp	01121	EB	R1-470K	12
R138	470 k Ω	10%, 1/2 w	Comp	01121	EB	R1-470K	12
R139	470 k Ω	10%, 1/2 w	Comp	01121	EB	R1-470K	12
R140	470 k Ω	10%, 1/2 w	Comp	01121	EB	R1-470K	12
R141	470 k Ω	10%, 1/2 w	Comp	01121	EB	R1-470K	12
R142	470 k Ω	10%, 1/2 w	Comp	01121	EB	R1-470K	12
R143	1.4 k Ω	1%, 1/2 w	MtF	07716	CEC	R94-1.4K	11
R144	47 Ω	5%, 3 w	WW	44655	4400	R92-47	12
R145	2 k Ω	5%, 10 w	WW	44655	1-3/4-D-57-F	R5-2K	12
R146	1 M Ω	10%, 1/2 w	Comp	01121	EB	R1-1M	12
R147	Not Used						
R148	33 Ω	10%, 1 w	Comp	01121	GB	R2-33	10
R149	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R150	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R151	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R152	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R153	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R154	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R155	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R156	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R157	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R158	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R159	100 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-100K	10
R160	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R161	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R162	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R163	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R164	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R165	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R166	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R167	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R168	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R169	10 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-10K	10
R170	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R171	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R172	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R173	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R174	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R175	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R176	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R177	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R178	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R179	1 k Ω	.5%, 1/2 w	MtF	07716	CEC	R61-1K	10
R180	220 k Ω	10%, 1 w	Comp	01121	GB	R2-220K	
R181	100 k Ω	10%, 1/2 w	Comp	01121	EB	R1-100K	11
R182	2 k Ω	10%, 5 w	WW	05766	FRL-5	R131-2K	12
R183	100 Ω	10%, 1/4 w	Comp	01121	CB	R76-100	11

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q101	2N1381	01295	TG-8	11
Q102	MM4003	MOT	TG-59	11
Q103	A1380	73445	TG-32	11
Q104	A1380	73445	TG-32	11
Q105 (1)	A1380	80164	19447A	11
Q106 (1)	A1380	80164	19447A	11
Q107	A1380	73445	TG-32	11
Q108	A1380	73445	TG-32	11
Q109	A1380	73445	TG-32	11
Q110	MM4003	MOT	TG-59	11

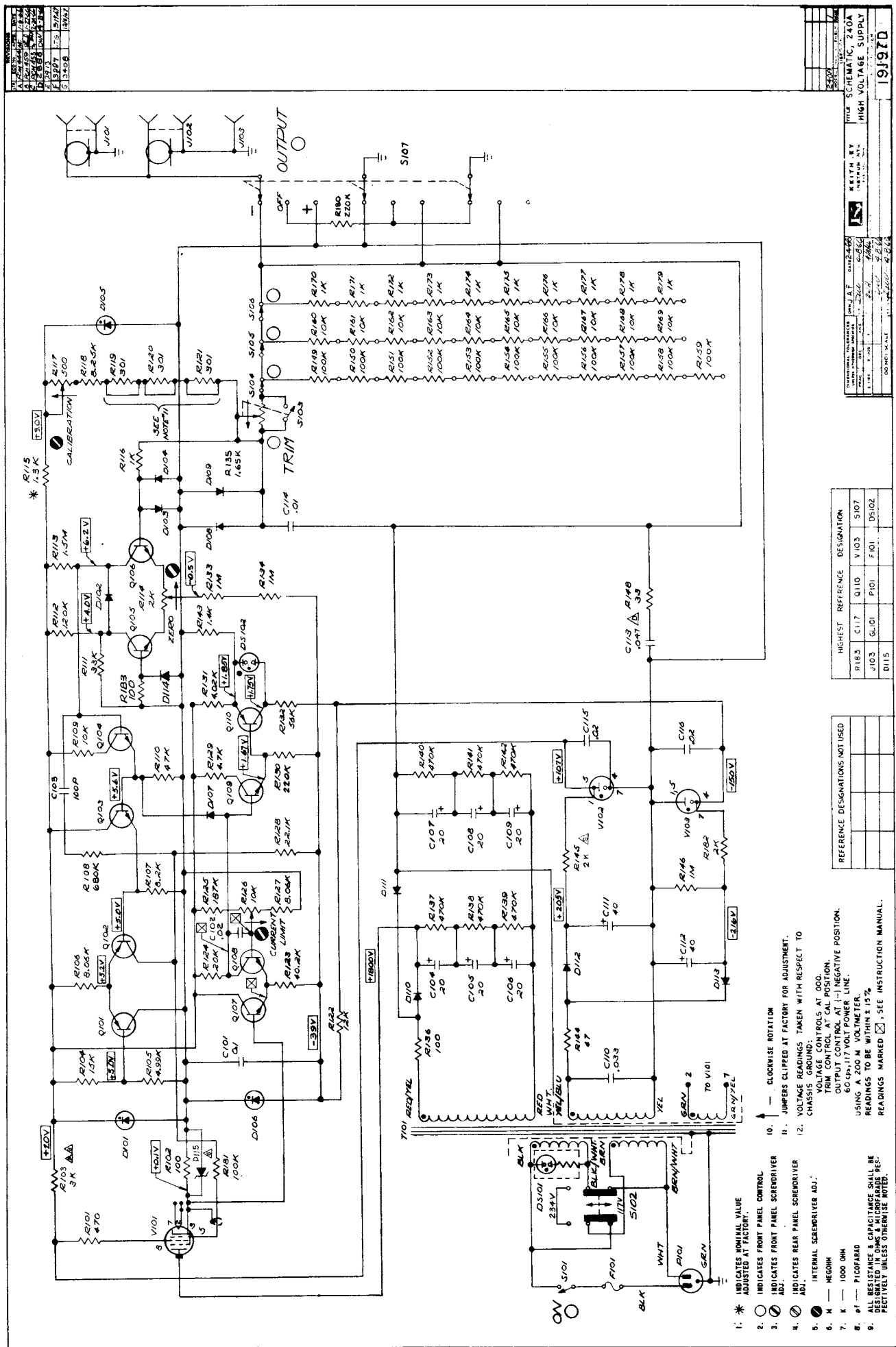
VACUUM TUBES

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
V101	8068	03507	EV-8068	9
V102	OB2	86684	EV-OB2	12
V103	OA2	86684	EV-OA2	12

(1) Transistors Q105 and Q106 are matched (part no. 19447A); order only as a pair from Keithley Instruments, Inc.

TABLE 7.
Code-to-name List of Manufacturers.

01121	Allen-Bradley Corp. Milwaukee, Wis.	37942	Mallory, P. R. and Co., Inc. Indianapolis, Ind.
01295	Texas Instruments, Inc. Semiconductor-Components Division Dallas, Texas	44655	Ohmite Mfg. Co. Skokie, Ill.
02735	Radio Corp. of America Commercial Receiving Tube and Semiconductor Division Somerville, N.J.	71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.
02777	Hopkins Engineering Co. San Fernando, Calif.	71450	CTS Corp. Elkhart, Ind.
03507	G. E. Power Tube Dep't. Schenectady, New York	72982	Erie Technological Products, Inc. Erie, Pa.
04009	Arrow-Hart and Hegeman Electric Co. Hartford, Conn.	73445	Amperex Electronic Co. Division of North American Philips Co., Inc. Hicksville, N.Y.
04713	Motorola, Inc. Semiconductor Product Division Phoenix, Arizona	75915	Littelfuse, Inc. Des Plaines, Ill.
05766	Tru-Seal Div. of Flick-Reedy Corp. Melrose Park, Ill.	80164	Keithley Instruments, Inc. Cleveland, Ohio
07716	International Resistance Co. Burlington, Iowa	86684	Radio Corp. of America Electronic Components and Devices Harrison, N.J.
08811	G-L Electronics Co., Inc. Camden, New Jersey	91737	Gremar Mfg. Co., Inc. Wakefield, Mass.
14655	Cornell-Dubilier Electric Corp. Newark, N.J.	91802	Industrial Devices Inc. Edgewater, N. J.
14659	Sprague Electric Co. Visalia, Calif.	93656	Electric Cord Co. Caldwell, N. J.
15238	ITT Components Selenium Dept. Mfg. Div. of ITT Semiconductor Inc. Lawrence, Mass	99017	Protective Closures Co., Inc. C. A. Plugs Div. Buffalo, New York



240A

DATE	1970
BY	W. J. F.
CHKD BY	W. J. F.
APP'D BY	W. J. F.
TECH. SPEC.	SCHEMATIC, 240A
QTY.	1
REVISION	1
DATE	1970