

INSTRUCTION MANUAL

Model 244

High Voltage Supply

(and Model 2441 Overload Protection Option)

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SPECIFICATIONS

OUTPUT:

Voltage: -200 to -2200 volts in 20-volt steps

Current: 10 milliamperes maximum

Polarity: Negative with respect to chassis

ACCURACY: $\pm 1\%$ of dial setting

RESOLUTION: A 0-25 volt "Trim" potentiometer permits interpolation between steps with a resolution of better than 100 millivolts.

STABILITY: $\pm 0.005\%$ per hour after a two-hour warm-up; $\pm 0.01\%$ the first hour or in subsequent 8-hour periods after a one-hour warm-up.

LINE REGULATION: $\pm 0.001\%$ for a 10% change in line voltage.

LOAD REGULATION: $\pm 0.001\%$ for a 5-milliamperere load change.

RIPPLE AND NOISE: Less than 0.5 millivolt rms above 5 Hz.

OVERLOAD: Electronic current limiting with automatic recovery.

METER: Provides check on output voltage.

CONNECTORS: Output (on rear) MHV series (UG-931/U)

POWER: 105-125 or 210-250 volts (switch-selected); 50-60 Hz; 90 watts.

DIMENSIONS: 6-1/4" high x 8-7/8" wide x 14-7/8" deep (158 x 225 x 378 mm)

WEIGHT: net weight, 13 pounds (6,0 kg).

ACCESSORIES FURNISHED: Mating Connector (MHV series, UG-932A/U)

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Model 244 is a negative-polarity high-voltage supply that provides accurate, stable outputs from -200 to -2200 volts d-c at up to 10 mA maximum.

1-2. FEATURES.

a. In-line Calibrated Dials.- Two dials set the output voltage in 200 and 20-volt steps. Trim Control permits interpolation between 20-volt setting, with 100 millivolt resolution.

b. Overload Protection.- Repeated or continuous overloads will not damage the instrument. Protection circuit limits the output current to less than 13 milliamperes with automatic recovery when overload is removed.

c. Stability.- Solid-state design, stable range

resistors, and selected zener diode provide voltage stability of $\pm 0.005\%$ for 8-hour periods after one-hour warm-up.

d. Model 244i Overload Protection Option.- An optional protection circuit is available (on special order) which can be used to limit the current of the Model 244 when monitored by a Keithley picoammeter such as the Model 414A.

1-3. APPLICATIONS.

a. The Model 244 has been designed primarily for negative-polarity high voltage biasing for photo-multiplier applications.

b. The stability, regulation and low noise also make it suitable for use with photocells, ion chambers and resistivity measurements.

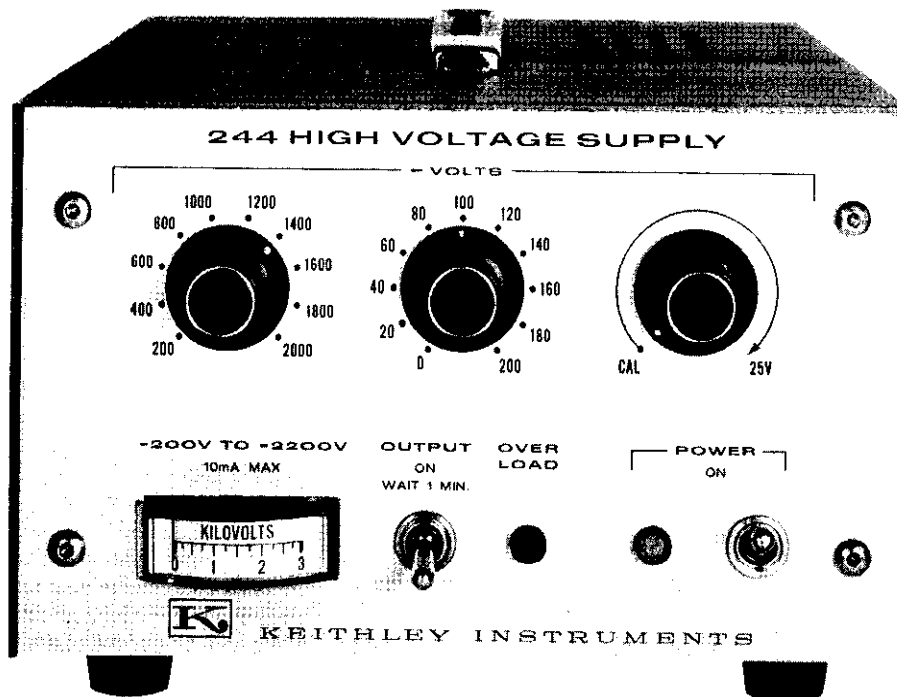


TABLE 1-1.
Front Panel Controls.

Control	Functional Description	Paragraph
POWER Switch (S102)	Controls the a-c line power to all circuits.	2-2e
POWER ON Indicator (DS101)	Pilot light glows orange when Power Switch is ON.	2-2f
OUTPUT Switch (S101)	Controls the a-c power to the high voltage section.	2-2g
Voltage Dials (S103, S104)	Sets output voltage from -200 to -2200 volts.	2-4a
Trim Control (R146)	Permits interpolation between steps with 0-25 volts maximum trim.	2-4b
OVERLOAD Indicator	Pilot light glows when output current exceeds 11 mA approximately.	2-3c
Meter (M101)	Indicates the magnitude of selected voltage.	2-3a

TABLE 1-2.
Rear Panel Connections.

Control	Functional Description	Paragraph
OUTPUT Receptacle (J101)	Voltage output.	2-1a
117V/234V Switch (S103)	Sets instrument for either 117 or 234 V a-c power.	2-1b
Fuse (F101)	117V Operation: 3/4A, slow-blow. 234 Operation: 3/8A, slow-blow.	2-1c
Overload Input (Cover)	Cover plate for optional Model 2441 installation.	2-5c

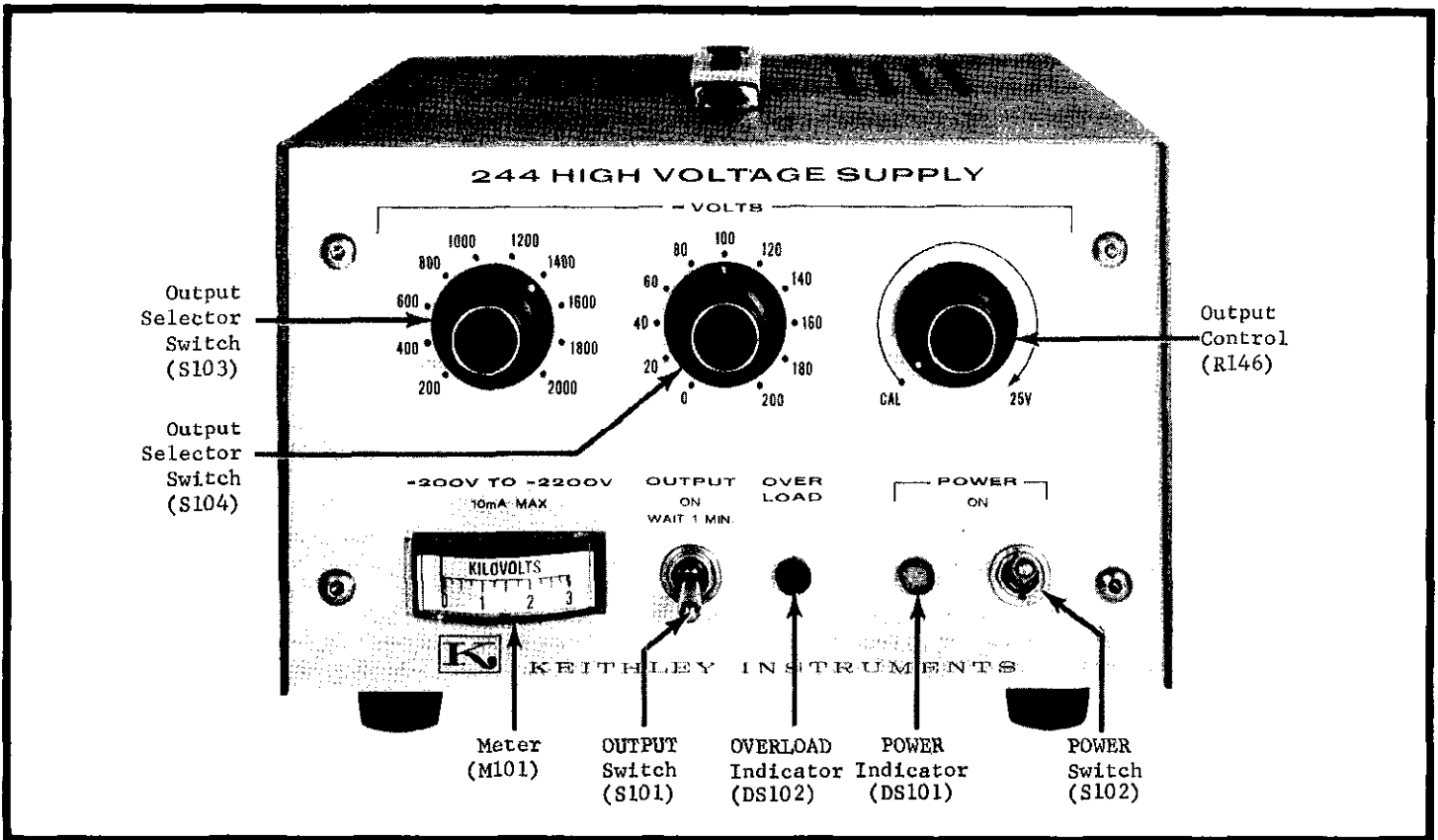


FIGURE 2. Front Panel Controls.

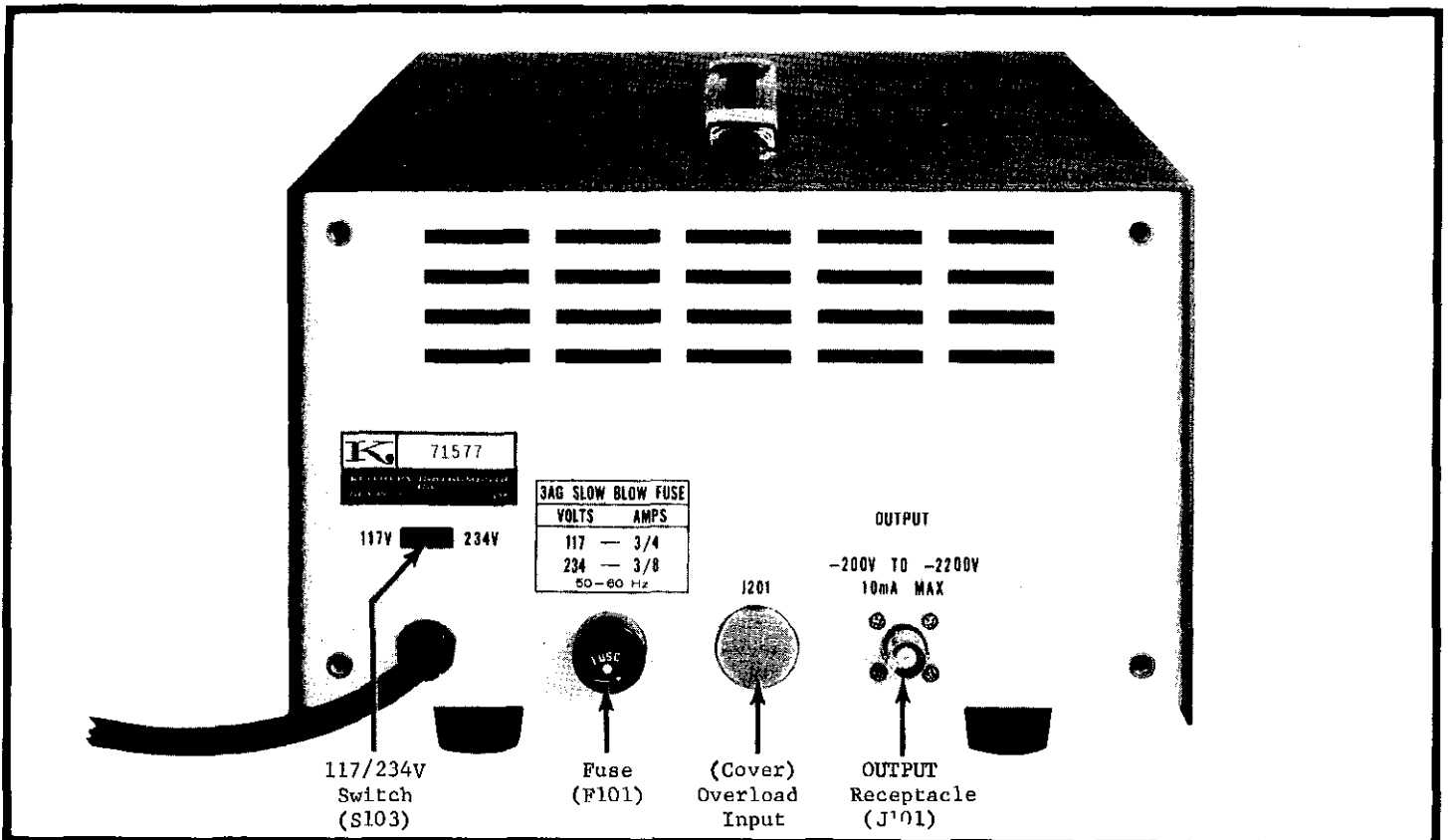


FIGURE 3. Rear Panel Connections.

SECTION 2. OPERATION**2-1. CONNECTIONS.**

a. **Output Receptacle.**- A rear panel mounted MHV teflon-insulated receptacle provides connection to the load circuit. The outer shell of the receptacle is connected to chassis.

b. **Coaxial Cables.**- Use coaxial cables which are rated for greater than 2200 volts for safe operation. Coaxial cables provide best noise immunity for critical measurements.

c. **Earth Ground.**- For maximum operator safety use the 3-wire power cord with third wire solidly connected to earth ground.

2-2. PRELIMINARY PROCEDURES.

a. The instrument is shipped in operating condition with all components installed for immediate use.

b. Set the 117-234 volt switch for operating line voltage.

c. Check the fuse for proper type and rating.

d. Provide adequate ventilation for the instrument. Air flow should be maintained along the top and bottom surfaces.

NOTE

If air flow is constricted the internal temperature will rise above normal design limits causing degradation of critical components.

e. Set the front panel controls as follows:

POWER Switch	Off
Voltage Dials	2-0-0
OUTPUT Switch	Off

f. Connect the line cord and set the POWER Switch to ON. (The POWER indicator should be lighted.)

NOTE

The meter should indicate 0 KILOVOLTS.

g. After a preliminary one minute warmup period, place the OUTPUT Switch to ON position. Allow another warmup period (30 minutes) for the high voltage section to stabilize. The meter should indicate approximately one minor division or 200 volts.

2-3. OPERATING CHECK-OUT.

a. **Meter Indication.**- When the OUTPUT Switch is ON the meter should indicate the dialed voltage.

b. **Output Voltage.**- Connect an accurate voltmeter such as Keithley Model 153 to the output to verify the power supply voltage accuracy. The Trim Control should be set to CAL position. Measure the Model 244 output for dial settings of 200, 500, and 1000 volts. Accuracy should be $\pm 1\%$ of dial setting.

c. **Current Limit.**- (Refer also to paragraph 2-5 for a more complete discussion of the overload current operation.)

1. Connect an accurate ammeter such as a Keithley Model 153 in series with an adjustable resistance decade box. Set the dialed voltage on the Model 244 at -200 volts with the OUTPUT Switch "OFF". Apply the -200 volt output to the resistance decade box set at 20 kilohms. The ammeter should indicate 10 mA when the OUTPUT Switch is placed "ON". The OVERLOAD Indicator should not be lighted. Decrease the resistance load until the OVERLOAD Indicator is lighted. The ammeter should indicate between 11 mA and 12 mA.

NOTE

Resistor load power dissipation is approximately 2.2 Watts.

2. Connect an ammeter and 50 kilohm resistive load to the output of the Model 244. Set the dialed voltage on the Model 244 at -200 volts with the OUTPUT Switch "OFF". Place the OUTPUT Switch to "ON" position. Reduce the load to zero ohms (short circuit) and measure the output current. The ammeter should indicate less than 14 milliamperes with the Model 244 OVERLOAD Indicator lighted.

2-4. SETTING OUTPUT VOLTAGE. The setting of the Voltage Dials and Trim Control determines the magnitude of the output.

a. The two Voltage Dials set the output from -200 to -2200 volts d-c in calibrated 200 and 20-volt steps. With the Trim Control in CAL position the output is set by the Voltage Dials within specified accuracy.

b. The Trim Control interpolates between 20-volt settings with 100 millivolt resolution. The Trim Control range is 0 to 25 volts.

2-5. OVERLOAD PROTECTION.

a. The Model 244 has an overload current limiting circuit which limits the output short-circuit current to a maximum 14 milliamperes. The circuit is adjusted so that the OVERLOAD Indicator will be lighted when the output current exceeds 11 milliamperes. When the overload is removed the Model 244 will automatically reset to normal operation and the OVERLOAD Indicator will turn off.

b. Current Limiting Characteristic.- The Model 244 current limiting is shown graphically by the typical V-I characteristic curves in Figure 4. The OVERLOAD Indicator is factory-adjusted to turn on at approximately 11 milliamperes. However the output voltage remains constant for current exceeding 11 milliamperes as shown. The current limiting occurs typically from 11.3 to 12.2 milliamperes depending on the dialed voltage.

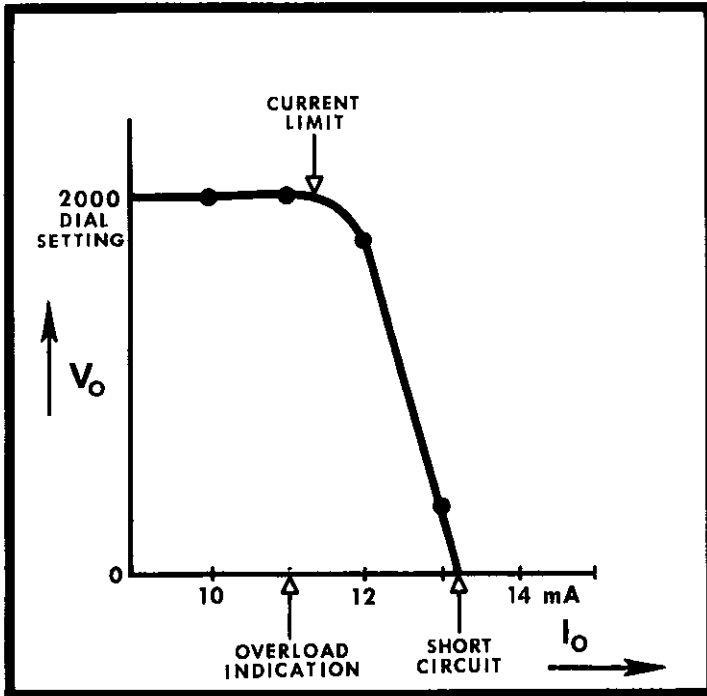


FIGURE 4. Current Limiting.

c. Model 244l Overload Protection Option.- An optional protection circuit is available which can be used to limit the current of the Model 244 when monitored by a Keithley picoammeter such as the Model 414A. Consult your Keithley representative or the Sales Service Department for further information regarding the Model 244l Option.

2-6. CAPACITIVE LOADS.

a. When a capacitive load is connected to the output, Model 244 will deliver a charging current up to 14 milliamperes maximum until the dialed voltage is developed across the load. During the charging time the OVERLOAD Indicator will be lighted as long as the output current exceeds 11 milliamperes. The OVERLOAD Indicator will turn off automatically when the charging current is reduced to less than 11 milliamperes.

b. Before reducing the dialed voltage with large capacitive loads (exceeding 1 joule of energy), set the OUTPUT Switch to "OFF". Readjust the dialed voltage and set the OUTPUT Switch to "ON".

NOTE

A resonant condition (with increased output noise) could result for large capacitive loads. If this should occur, change the load capacitance slightly to remove the resonant condition and reduce the output noise.

2-7. OUTPUT NOISE. The Model 244 output ripple and noise is less than 0.5 millivolt rms above 5Hz with maximum load. The output noise is typically 200 μ V rms with no load. Transient power line noise will tend to increase the output noise.

2-8. SHORT-TERM STABILITY. The Model 244 stability is specified to be $\pm 0.005\%$ per hour worst-case after a two-hour warm-up. After warm-up, the short-term stability is typically 0.003% per hour for constant line voltage, load, and ambient temperature.

2-9. TEMPERATURE COEFFICIENT. The temperature coefficient is typically 30 PPM/ C (with a maximum temperature coefficient not to exceed 60 ppm/ C).

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL.

a. The Model 244 High Voltage Supply has been designed to provide an accurate voltage from -200 to -2200 volts d-c. A simplified circuit diagram is shown in Figure 5.

b. The Model 244 is composed of high and low voltage supply sections and various other circuits for control and overload protection. These circuits include the following.

1. High voltage supply.
2. Low voltage supply.
3. Series high voltage regulator.
4. Error amplifier.
5. Reference supply.
6. Overload circuit.
7. Voltage Divider.

c. Over-all Operation. The output voltage is

selected by the front panel dials which control the voltage divider. The error amplifier senses any difference between the voltage across the divider string (which is connected to the output) and the fixed reference supply. The amplified difference drives the series regulator circuit to correct the output voltage. The overload circuit senses the output load current and controls the current within design limits. This circuit also provides an overload indication.

3-2. HIGH VOLTAGE SECTION. The high voltage is developed by a voltage doubler circuit composed of diodes D101, D102, D103, and D104 and filter capacitors C113 and C114. The filtered d-c voltage (approximately 3200 volts) is applied between the - OUTPUT and the anode of the series pass element (tube V101). The high voltage section is controlled by the OUTPUT Switch S101 which provides ON/OFF control of the a-c power to transformer T101.

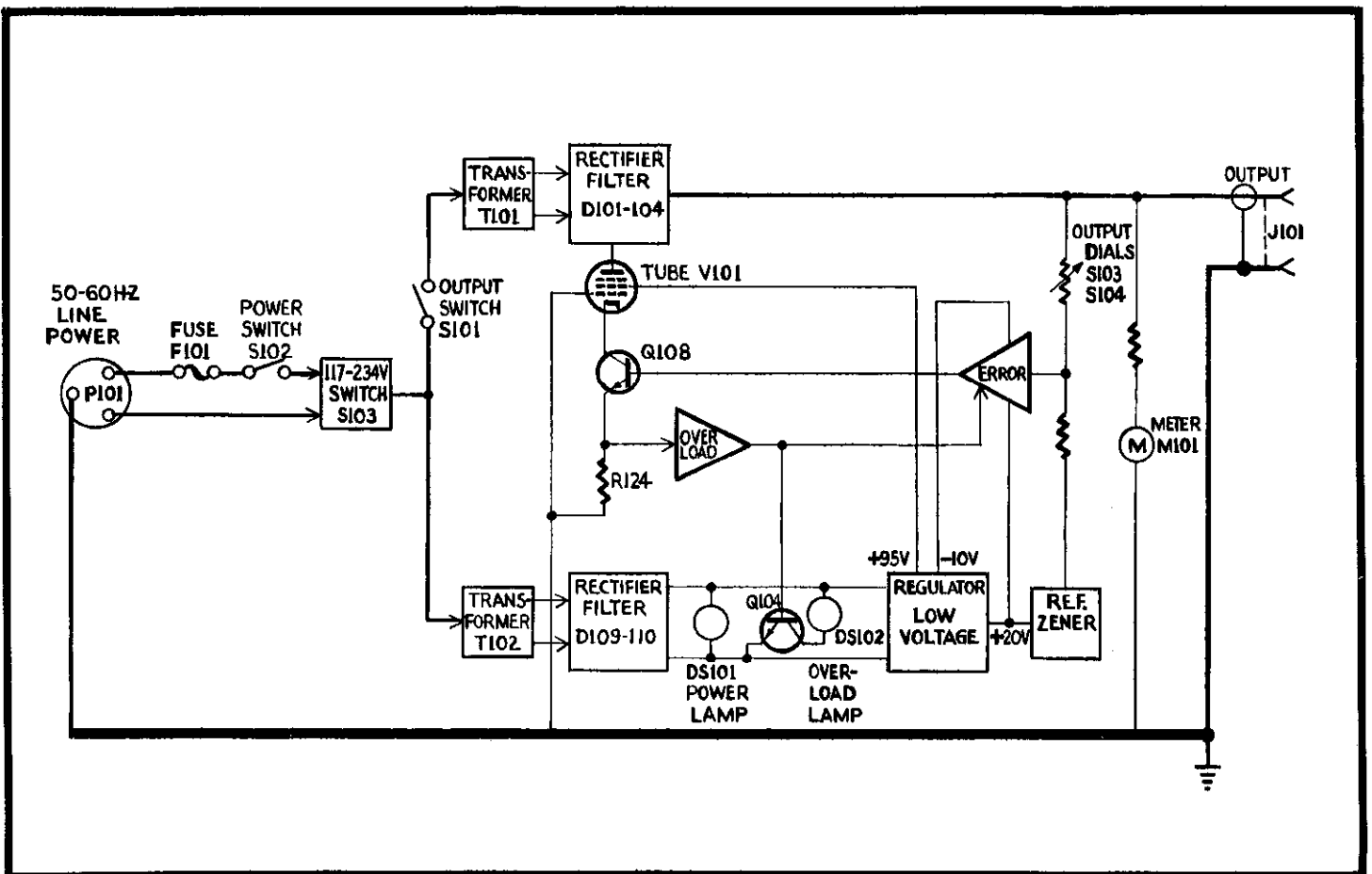


FIGURE 5. Simplified Circuit Diagram.

3-3. SERIES HIGH VOLTAGE REGULATOR. The series regulator tube V101 is biased by the collector voltage of transistor Q108 to form a "cascode amplifier" with the output load serving as the plate resistor. The Model 244 - OUTPUT is effectively the algebraic sum of the unregulated high voltage (3200 V) and the drop across V101 and Q108. When the OUTPUT Switch S101 is off (e.g. no plate voltage is on V101) the voltage at pin 8 (Screen Voltage) of V101 will be significantly less than nominal + 95 volts since the tube current will cause a voltage drop across R169.

3-4. VOLTAGE CONTROL. The output voltage is divided by a resistor divider composed of resistors R146 through R167 located on switches S102, S103, and S104. The sampling voltage is compared with the reference supply voltage. (The reference supply is composed of zener D119 and resistors R140 through R145). The difference voltage is amplified by the error amplifier (transistors Q110, Q111, Q112, and Q113) which drives cathode biasing transistor Q108. Diodes D114 through D117 and resistors R115, R117, R139, and R144 protect the comparator and zener reference from switching transients when the output is changed. Diode D111 prevents a reverse bias on transistor Q109 beyond its breakdown voltage.

3-5. CURRENT CONTROL.

a. The output current is sensed by measuring the voltage drop across resistor R124. A current limit amplifier consisting of Q107 controls the error amplifier through diode D112. When the current through R124 exceeds approximately 11 milliamperes, transistor Q107 forward biases D112 and turns off the error amplifier which reduces the Model 244 through the action of V101.

b. Overload Indication.- The OVERLOAD Indicator DS102 is driven by transistors Q104, Q106, and Q107. Transistor Q105 is an emitter-follower which biases Q106 to insure that the OVERLOAD Indicator turns on before the current limiting actually occurs. (The OVERLOAD Indicator is designed to turn on at approximately 11 milliamperes load current.)

3-6. LOW VOLTAGE SECTION. The low voltage for the control circuitry is obtained from a full-wave rectifier composed of diodes D109 and D110 and filter capacitor C115.

a. + 95 v d-c. This voltage is applied to a bias screen on V101. The + 95 v is developed across R113 and D105.

b. + 20 v d-c. This voltage is regulated by zener diode D105. A regulated current source (25ma) supplies a constant current for zener diodes D105 and D106. The current source is composed of transistors Q101, Q102, and Q103 and reference zener D107. The regulated current is sampled at R116 and compared to zener D107 by transistor Q102. The action of Q101 and Q102 regulates the current through D105, D106, and R113.

c. - 10 v d-c. This voltage is regulated by zener diode D106.

NOTE

The a-c power to the high and low voltage sections is controlled by the POWER ON Switch S102. The POWER ON Indicator DS101 is driven by the low voltage d-c supply.

SECTION 4. ACCESSORIES

4-1. GENERAL. The following Keithley accessories can be used with the Model 244 to provide additional convenience and versatility.

4-2. OPERATING INSTRUCTIONS. A separate Instruction Manual is supplied with each accessory giving complete operating information.

Model 4003A Rack Mounting Kit

Description:

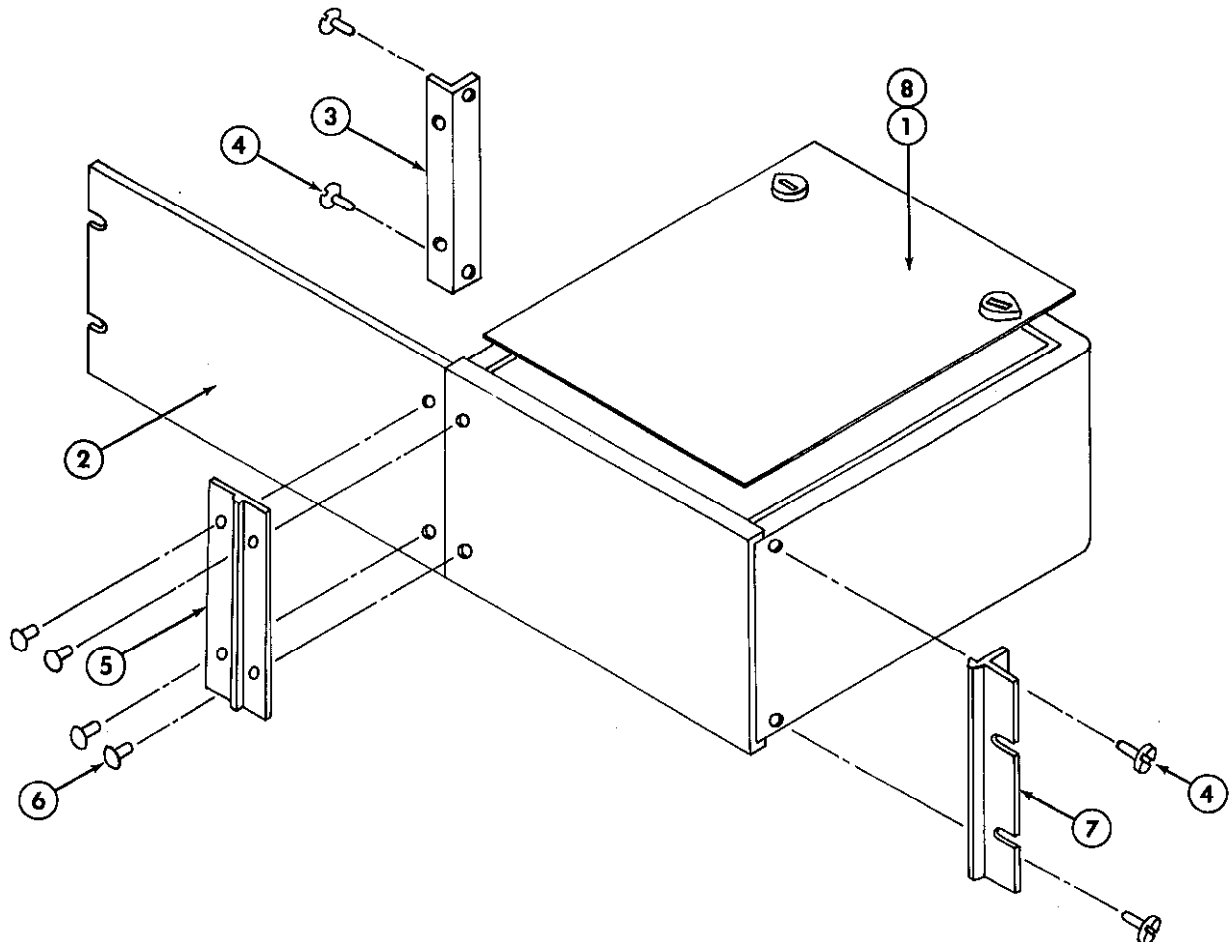
The Model 4003A is a rack mounting kit with overall dimensions, 5-1/4 inches high x 19 inches wide. Two top covers are provided for use with either 10 inch or 13 inch deep instruments.

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:

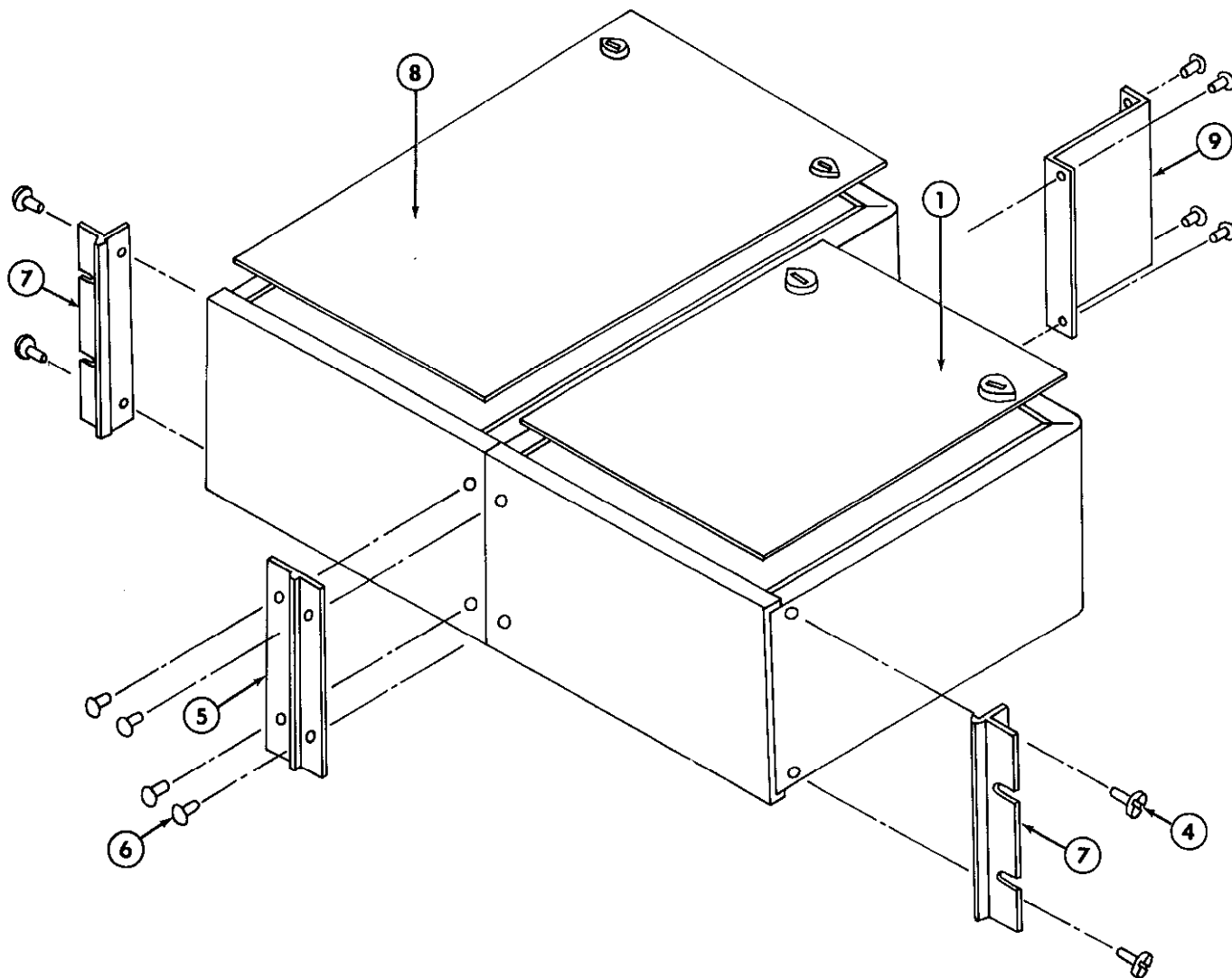
The Model 4004A is a rack mounting kit with overall dimensions, 5-1/4 inches high x 19 inches wide. Two top covers are provided for use with either 10 inch or 13 inch deep instruments.

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



Model 2441 Overload Protection Option

Description:

The Model 2441 when factory installed on the Model 244 provides automatic current limiting of the Model 244 output.

Specifications:

OVERLOAD: Model 2441 circuitry provides automatic current limiting of the Model 244 when the overload input voltage to the Model 2441 exceeds approximately +1.4 volts.

SENSITIVITY: An overload input voltage from +1.4V to +2.0V (+1.7 volts typically) will cause current limiting of the Model 244 output.

OVERLOAD INDICATIONS: The overload lamp will indicate whenever the Model 244 is in a current limiting mode.

NOTE

The Model 244 will deliver a calibrated voltage as long as the overload lamp is off (or the overload input voltage does not exceed +1.2 volts).

NOISE IMMUNITY: An 8V p-p at 60 Hz overload input signal will not operate overload.

RESPONSE TIME: Time for a 2.5V peak pulse to activate 2441 is typically 0.25 seconds (10-90%).

Typical Operation:

NOTE

The picoammeter (such as Model 414A) has a 1 volt output for full scale input on the range selected. If the current monitored by the Model 414A increases to approximately 170% of full scale the Model 414A output of the 1.7 volts will activate the Model 2441 circuit. Any further increase in the current monitored by the picoammeter will ultimately be limited to no more than 200% of the full scale range of the picoammeter. However current limiting of the Model 244 will occur whenever the Model 244 output exceeds 11 milliamperes or the Model 2441 is activated.

a. Connect the recorder output of a Keithley picoammeter such as the Model 414A or equivalent to the Overload Protection Input receptacle J201. See Figure 1.

b. Select the full scale current range on the picoammeter for desired operating range.

c. Recorder output of 414A should be in 1 volt mode.

d. Operate the Model 244 as described in Section 2.

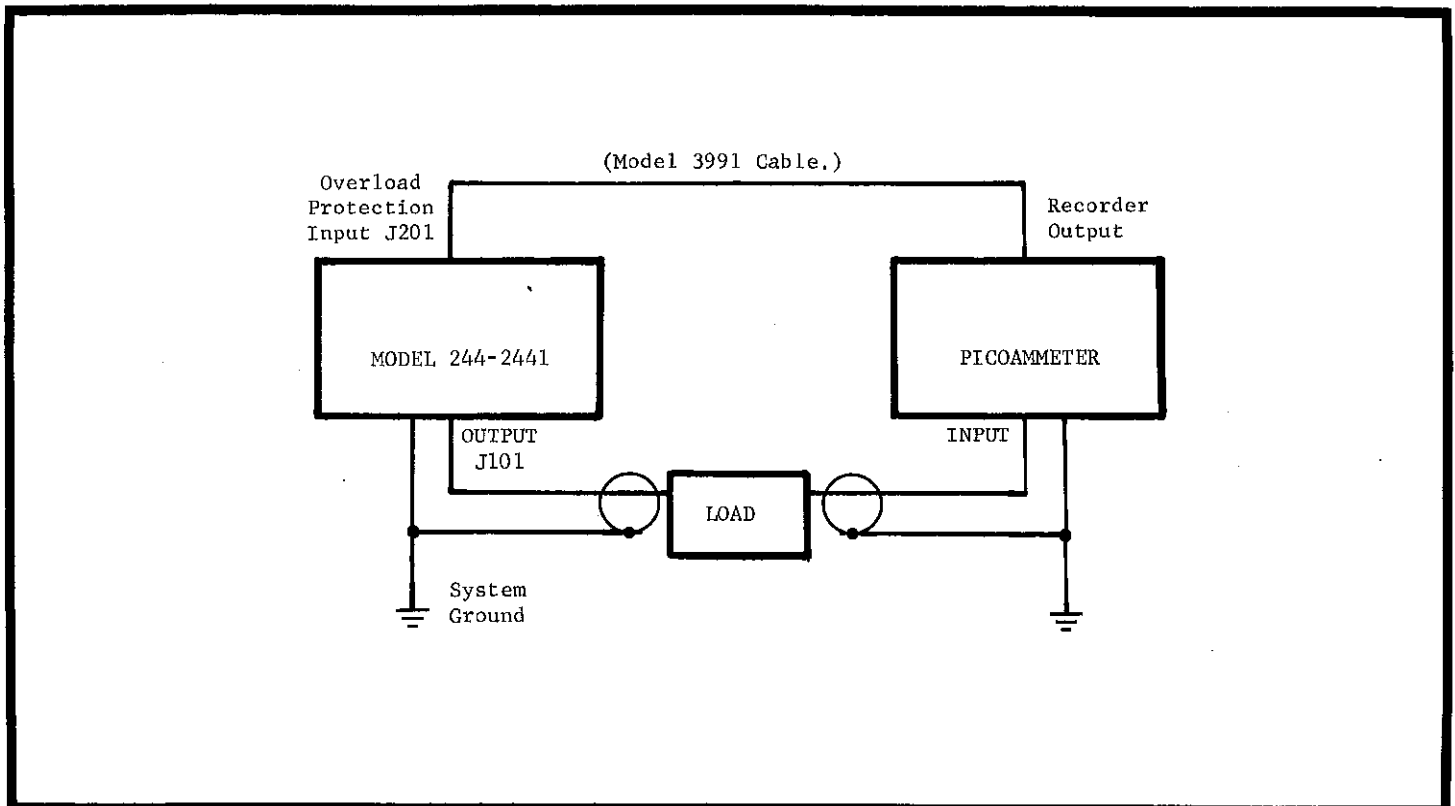


FIGURE 6. Overload Protection Connection Diagram.

Theory of Operation for Model 2441: (See Schematic 24640A.)

a. The Model 2441 Option provides current limiting control when used with a picoammeter with a 1 volt output. The Overload Protection Input J201 requires an input signal between 1.4 to 2.0 volts d-c. The Model 2441 circuit activates the Model 244 control circuit by means of transistor switch Q202. The Model 2441 filter circuit prevents false overloads due to 60 Hz noise while not affecting the response which is approximately 0.25 seconds (10-90% rise time).

b. The 2441 Circuit is composed of an emitter follower transistor Q201 which drives a transistor switch Q202 which is paralleled with the Model 244 overload transistor switch Q107. A filter circuit is composed of R203 and C201.

Replaceable Parts for Model 2441:

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.
J201	Connector	APH	80-PC2M	CS-233
--	Cable, 3 ft., (mates with J201)	K-I	--	3991
Q201	Transistor	F-I	2N3565	TG-39
Q202	Transistor	F-I	2N3565	TG-39
R201	Resistor, 1M Ω , 10%, 1/2W	A-B	EB	R1-1M
R202	Resistor, 3.9K Ω , 10%, 1/2W	A-B	EB	R1-3.9K
R203	Resistor, 1K Ω , 10%, 1/2W	A-B	EB	R1-1K
R204	Resistor, 10K Ω , 10%, 1/2W	A-B	EB	R1-10K
R205	Resistor, 100K Ω , 10%, 1/2W	A-B	EB	R1-100K
C201	Capacitor, 22 μ f, 20V	U-C	K22J20K	C80-22M
--	Stand off	K-I	--	ST-25
J107	Connector	K-I	--	Special

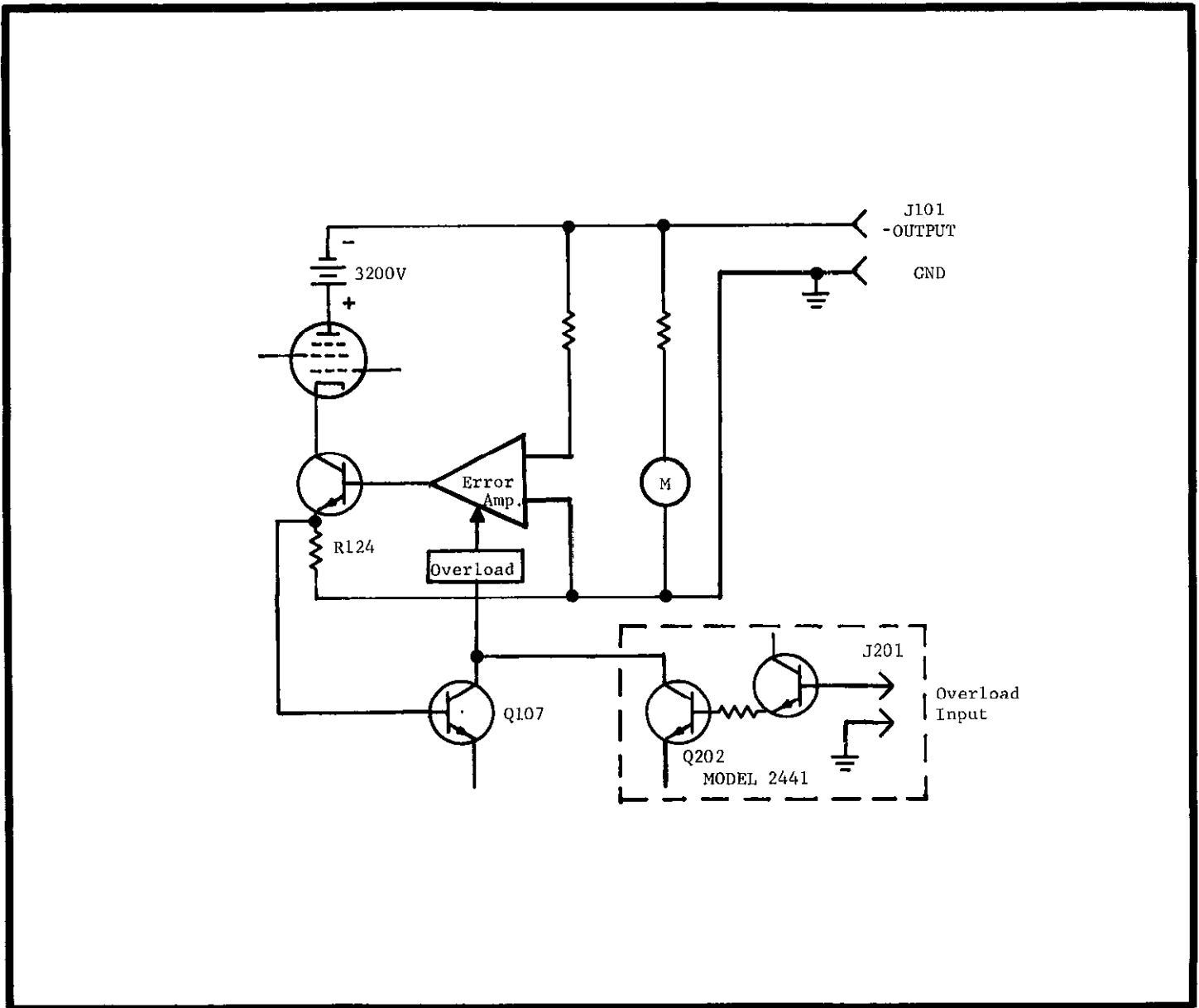


FIGURE 7. Overload Protection Circuit Diagram.

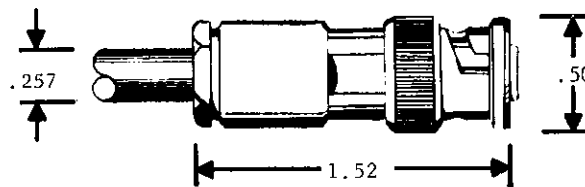
MHV Connector, CS-191

Description:

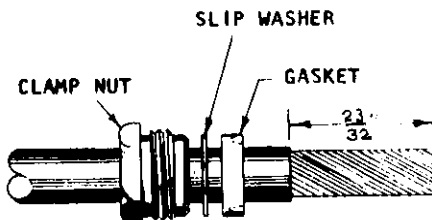
The MHV Connector supplied with the instrument is a UG-932A/U teflon insulated male connector. This part is available by ordering part no. CS-191.

Application:

The connector should be used with low noise coaxial cables such as RG58A/U or RG59/U. The cable size used with this connector should not exceed .257in. O.D.



Assembly Instructions:



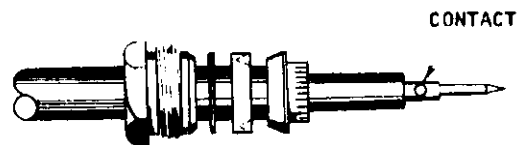
1. Cut cable end square place clamp nut, slip washer and gasket over jacket. Strip jacket $23/32$ " as shown.



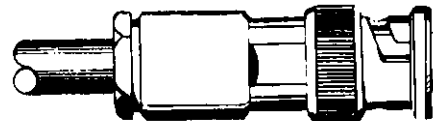
2. Comb out braid and taper forward. Then place braid clamp over braid against jacket cut.



3. Fold braid back over braid clamp and trim as shown. Cut dielectric and center conductor to $7/64$ " dimension then strip dielectric to .470 dimension.



4. Solder contact to center conductor.



5. Slide back end parts forward then thread assembly into connector and lock securely. Vee gasket must be split by braid clamp.

SECTION 5. REPLACEABLE PARTS

5-1. REPLACEABLE PARTS LIST: This section contains a list of components used in this instrument for user reference. The Replaceable Parts List describes the individual parts giving Circuit Designation, Description, Suggested Manufacturer (Code Number), Manufac-

turer's Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable. The complete name and address of each Manufacturer is listed in the CODE-TO-NAME Listing following the parts list.

TABLE 5-1.
Abbreviations and Symbols

A	ampere	F	farad	Ω	ohm
CbVar	Carbon Variable	Fig	Figure	p	pico (10^{-12})
CerD	Ceramic Disc	Gcb	Glass enclosed Carbon	PC	Printed Circuit
Cer Trimmer	Ceramic Trimmer	k	kilo (10^{-3})	Poly	Polystyrene
Comp	Composition	μ	micro (10^{-6})	Ref.	Reference
DCb	Deposited Carbon	M	Meg (10^6)	TCu	Tinner Copperweld
Desig.	Designation	Mfr.	Manufacturer	V	volt
EAL	Electrolytic, Aluminum	MtF	Metal Film	W	watt
ETB	Electrolytic, tubular	My	Mylar	WW	Wirewound
ETT	Electrolytic, tantalum	No.	Number	WWVar	Wirewound Variable

5-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as discussed in Section 3. Refer to Table 5-2 which identifies all schematic part numbers included.

Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

5-3. HOW TO USE THE REPLACEABLE PARTS LIST. This Parts List is arranged such that the individual types of components are listed in alphabetical order. The parts for the instrument's Main Chassis are listed followed by printed circuit boards and other sub-assemblies.

b. When ordering parts, include the following information.

5-4. HOW TO ORDER PARTS.

1. Instrument Model Number.
2. Instrument Serial Number.
3. Part Description.
4. Schematic Circuit Designation.
5. Keithley Part Number.

a. Replaceable parts may be ordered through the

c. All parts listed are maintained in Keithley Spare Parts Stock. Any part not listed can be made available upon request. Parts identified by the Keithley Manufacturing Code Number 80164 should be ordered directly from Keithley Instruments, Inc.

TABLE 5-2.

Description	Circuit Designation	Schematic Part Number
Power Supply	PC-270	24317E

TABLE 5-3.
Mechanical Parts List

Description	Quantity Per Assembly	Keithley Part No.	Fig. No.
1) Chassis	1	24304C	7
11) Front Panel	1	24306C	6,7
Top Cover Assembly	---	19057	6
12) Cover, Sheet Metal	1	19055C	
13) Screws	4	---	
Handle Assembly	---	---	6
14) Handle	1	HH-18	
15) Screws #6-32x3/8" R. H. Slotted	2	---	
Bottom Cover Assembly	---	---	7
2) Cover	1	19062B	
3) Fastener	2	FA-54	
Feet Assembly	---	---	7
4) Feet	4	FE-5	
5) Ball	4	FE-6	
6) Screws #8-32x3/8" Phillips, Pan Head	4	---	
Tilt Bail Assembly	---	---	7
7) Bail	1	17147B	
8) Right Assembly	1	19206B	
9) Left Assembly	1	19205B	
10) Screws #6-32x1/4" Phillips, Pan Head	2	---	

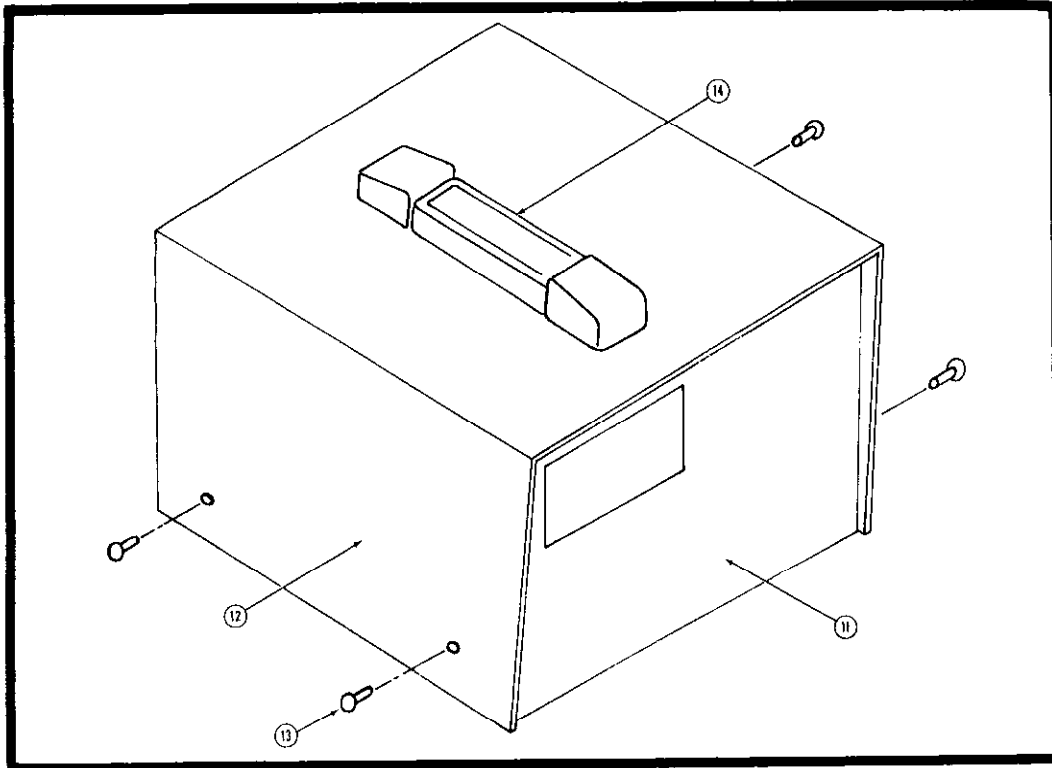


FIGURE 8. Top Cover Assembly.

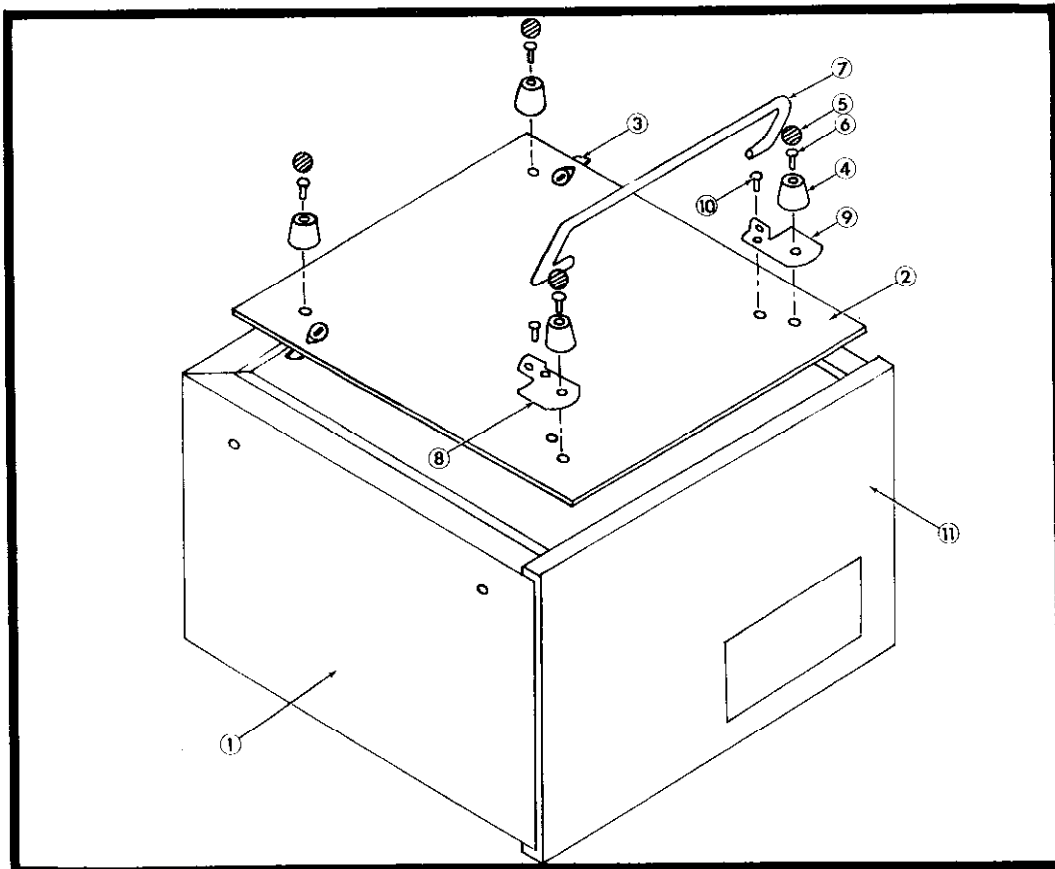


FIGURE 9. Bottom Cover Assembly.

MAIN CHASSIS PARTS LIST
(PC-258, PC-270)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C101	0.1 μ F	15V	EAL	SPG	89D159	C93-.1M	10
C102	0.1 μ F	15V	EAL	SPG	89D159	C93-.1M	10
C103	0.1 μ F	15V	EAL	SPG	89D159	C93-.1M	10
C104	0.1 μ F	15V	EAL	SPG	89D159	C93-.1M	10
C105	.02 μ F	600V	CerD	ERI	ED-.02	C22-.02M	10
C106	0.1 μ F	250V	MtF	APX	C280AE	C178-.1M	
C107	0.1 μ F	250V	MtF	APX	C280AE	C178-.1M	
C108	22 ρ F	600V	CerD	ERI	ED-47	C22-22P	
C109	33 ρ F	600V	CerD	ERI	ED-33	C22-33P	
C110	.02 μ F	600V	CerD	ERI	ED-.02	C22-.02M	
C111	100 ρ F	600V	CerD	ERI	ED-100	C22-100P	
C112	0.1 μ F	4000V	Film	PCI	LQ40104X	C192-.1M	
C113	1.0 μ F	2000V	Film	PCI	LQ20105X	C191-1M	
C114	1.0 μ F	2000V	Film	PCI	LQ20105X	C191-1M	
C115	40 μ F	350V	ETB	SPG	TVA1611	C23-40M	
C116	0.1 μ F	4000V	Film	PCI	LQ40104X	C192-.1M	
C117	0.1 μ F	250V	MtF	APX	C280AE	C178-.1M	

CONNECTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
J101	Receptacle, 10-Pin	BRG	20052	CS-237	3
J102	Connector, Mini-PV	BRG	47439	CS-236	10
J103	Connector, Mini-PV (Soldered)	BRG	47439	CS-236	10
J104	Connector, Mini-PV (Soldered)	BRG	47439	CS-236	10
J105	Connector, Mini-PV (Soldered)	BRG	47439	CS-236	10
J106	Connector, Mini-PV (Soldered)	BRG	47439	CS-236	10
J107	-	K-I	-	24658A	10
J108	Receptacle, female	APH	UG-931/U	CS-190	10
----	Connector, male (mate for J108)	APH	UG-932A/U	CS-191	10

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D101	Rectifier, 2500V, 300mA	S-T	3CFS25	RF-49	10
D102	Rectifier, 2500V, 300mA	S-T	3CFS25	RF-49	10
D103	Rectifier, 2500V, 300mA	S-T	3CFS25	RF-49	10
D104	Rectifier, 2500V, 300mA	S-T	3CFS25	RF-49	10
D105	Zener	ITT	ZV20	DZ-25	10
D106	Zener	DIC	1N3020A	DZ-39	10
D107	Zener	DIC	1N713	DZ-14	10
D108	Silicon	T-I	1N645	RF-14	10
D109	Rectifier, 1A, 800V	MOT	1N4006	RF-38	10
D110	Rectifier, 1A, 800V	MOT	1N4006	RF-38	
D111	Silicon	T-I	1N645	RF-14	
D112	Silicon	T-I	1N645	RF-14	
D113	Silicon	T-I	1N914	RF-28	
D114	Silicon	T-I	1N645	RF-14	
D115	Silicon	T-I	1N645	RF-14	
D116	Silicon	T-I	1N645	RF-14	
D117	Rectifier, 1A, 800V	MOT	1N4006	RF-38	
D118	Rectifier, 1A, 800V	MOT	1N4006	RF-38	
D119	Zener	MOT	1N938	DZ-6	
D120*	Zener, 47V	S-T	VR47	25725A	

*Selected at factory

MISCELLANEOUS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
DS101	Pilot Lamp, Neon, White Lens	I-D	2100	PL-49	2
DS102	Pilot Lamp, Neon, Red Lens	I-D	2100	PL-50	2
DS103	Pilot Lamp, Neon	G-E	NE-83	PL-41	10
F101	Fuse, Slow-Blow, 0.75 A, 250V	BUS	MDL	FU-19	3
M101	Meter	K-I	---	ME-87	2
T101	Transformer	K-I	---	TR-134	10
T102	Transformer	K-I	---	TR-131	10
V101	Vacuum Tube	K-I	---	EV-8068	10

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R101	100 Ω	10%, 1/4 W	Comp	OHM	RC07	R76-100	10
R102	1K Ω	10%, 1/4 W	Comp	OHM	RC07	R76-1K	10
R103	4.7M Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7M	10
R104	4.7M Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7M	10
R105	4.7M Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7M	10
R106	4.7M Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7M	10
R107	4.7M Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7M	10
R108	4.7M Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7M	10
R109	600K Ω	1%, 1/2 W	DCb	DLE	DCF-1/2	R12-600K	10
R110	600K Ω	1%, 1/2 W	DCb	DLE	DCF-1/2	R12-600K	10
R111	600K Ω	1%, 1/2 W	DCb	DLE	DCF-1/2	R12-600K	10
R112	600K Ω	1%, 1/2 W	DCb	DLE	DCF-1/2	R12-600K	10
R113	2.5K Ω	5%, 10 W	WW	OHM	D57F	R5-2.5K	10
R114	2K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-2K	10
R115	1K Ω	1%, 1/8 W	MtF	IRC	CEA	R88-1K	10
R116	402 Ω	1%, 1/2 W	MtF	IRC	CEC	R94-402	10
R117	1K Ω	1%, 1/8 W	MtF	IRC	CEA	R88-1K	10
R118	33K Ω	10%, 1/2 W	Comp	A-B	EB	R1-33K	10
R119	220K Ω	10%, 1/2 W	Comp	A-B	EB	R1-220K	10
R120	4.02K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-4.02K	10
R121	47K Ω	10%, 1/2 W	Comp	A-B	EB	R1-47K	10
R122	47K Ω	10%, 1/2 W	Comp	A-B	EB	R1-47K	10
R123	47K Ω	10%, 1/2 W	Comp	A-B	EB	R1-47K	10
R124	*Selected Ω	1%, 1/2 W	MtF	IRC	CEC	R94*	10
R125	4.7K Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7K	10
R126	4.7K Ω	10%, 1/2 W	Comp	A-B	EB	R1-4.7K	10
R127	14K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-14K	10
R128	15K Ω	10%, 1/2 W	Comp	A-B	EB	R1-15K	10
R129	30.1K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-30.1K	10
R130	45.3K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-45.3K	10
R131	47K Ω	10%, 1/2 W	Comp	A-B	EB	R1-47K	10
R132	33K Ω	10%, 1/2 W	Comp	A-B	EB	R1-33K	10
R133	18K Ω	10%, 1/2 W	Comp	A-B	EB	R1-18K	10
R134	120K Ω	10%, 1/2 W	Comp	A-B	EB	R1-120K	10
R135	1.5M Ω	1%, 1/2 W	MtF	IRC	CEC	R94-1.5M	10
R136	475K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-475K	10
R137	1K Ω	1%, 1/2 W	MtF	IRC	CEC	R94-1K	10
R138	1K Ω	20%, 2W	WW Var	CTS	INS-115	RP50-1K	10
R139	1K Ω	10%, 1/2 W	Comp	A-B	EB	R1-1K	10
R140	604 Ω	1%, 1/8 W	MtF	IRC	CEA	R88-604	10

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R141	604 Ω	1%, 1/8 W	MtF	IRC	CEA	R88-604	10
R142	604 Ω	1%, 1/8 W	MtF	IRC	CEA	R88-604	10
R143	16.5K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-16.5K	10
R144	100 Ω	10%, 1 W	Comp	A-B	GB	R2-100	10
R145	1K Ω	20%, 2 W	WW Var	CTS	INS-115	RP50-1K	10
R146	50K Ω	2 W	Cermet Var	CTS	550	RP87-50K	2
R147	402K Ω	0.5%, 1/2 W	MtV	DLE	MMF1/2T9	R171-402K	10
R148	402K Ω	0.5%, 1/2 W	MtV	DLE	MMF1/2T9	R171-402K	10
R149	402K Ω	0.5%, 1/2 W	MtV	DLE	MMF1/2T9	R171-402K	10
R150	402K Ω	0.5%, 1/2 W	MtV	DLE	MMF1/2T9	R171-402K	10
R151	402K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-402K	10
R152	402K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-402K	10
R153	402K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-402K	10
R154	402K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-402K	10
R155	402K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-402K	10
R156	402K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T9	R171-402K	10
R157	Not Used						
R158	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172-40.2K	10
R159	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R160	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R161	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R162	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R163	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R164	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R165	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R166	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R167	40.2K Ω	0.5%, 1/2 W	MtF	DLE	MMF1/2T2	R172	10
R168	Not Used						
R169	33K Ω	10%, 1/2 W	Comp	A-B	EB	R1-33K	10
R170	600K Ω	1%, 1/2 W	DCb	DLE	DCF-1/2	R12-600K	10
R171	47K Ω	1%, 1/2 W	DCb	DLE	DCR-1/2	R12-600K	10
R172	100 Ω	10%, 1/4 W	Comp	OHM	RCO7	R76-100	10
R173	100 Ω	10%, 1/4 W	Comp	OHM	RCO7	R76-100	10
R174	10 MΩ	10%, 1/4 W	Comp	OHM	RCO7	R76-10M	10

TRANSISTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q101	Silicon NPN, TO-92 Case	MOT	2N3904	TG-47	10
Q102	Silicon NPN, TO-5 Case	RCA	40346	21676A*	10
Q103	---	RCA	40317	TG-43	10
Q104	---	RCA	40346	TG-44	10
Q105	Silicon	F-I	2N3565	TG-39	10
Q106	Silicon - PNP	MOT	MP5L51	TG-72	10
Q107	Silicon	F-I	2N3565	TG-39	10
Q108	---	K-I	---	21676A	10
Q109	Silicon	F-I	2N3565	TG-39	10
Q110	Silicon	F-I	2N5139	TG-66	10
Q111	Silicon	F-I	2N5139	TG-66	10
Q112	Silicon	F-I	2N3565	TG-39	10
Q113	Differential Amp.	F-I	IT122	TG-73	10

*Selected Part TG-44

SWITCHES

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
S101	Toggle type, OUTPUT			SW238	2
S102	Toggle type, POWER	AHT	20994LH	SW4	2
S103	Rotary type, 200 V steps			SW321	2
S104	Rotary type, 20 V steps			SW323	2
S105	Slide type, 117V/234V	K-I	---	24665A	3

SECTION 6. CALIBRATION

TEST 6-1.
Test Equipment

Description	Mfr.	Type
Electrometer	Keithley	610B
Voltmeter, TRMS	Ballantine	323-01
Voltmeter, Differential	Keithley	662
Oscilloscope	Tektronix	561
Voltmeter DVM	Keithley	160
Microvoltmeter	Keithley	155
Variable Transformer	Variac	-
Line Voltage Monitor	RCA	-
Voltage Divider (See Fig. 9)	Keithley	HV-1
Loading Box (See Fig. 8)	Keithley	LB-1
Nanovolt Source	Keithley	260

6-1. TEST PROCEDURES.

a. General.

1. Maintain caution and always turn 244 OUTPUT switch off before working inside chassis and after each step in this procedure.

2. The 244 has a unipolar negative output in which LO and the 244 chassis are the same.

3. Before calibrating the 244 visually inspect it for incorrect wiring, interchanged parts, diodes in backwards, bridged or broken tapes. Also mechanically inspect for smoothly operating controls.

4. Make certain that the 117-234 volt switch is in the 117 volt position before calibrating the 244.

b. Preliminary Calibration.

1. Power Supplies.

a). Install one EV-8068 Power Tube (V101) and clamp in place. Make certain that all controls are full CCW and that the Power and output switches are in the off position.

b). Plug the 244 into a variac and turn power on. Connect DVM between TP-H and ground (chassis). DVM should read -9 volts to -11 volts. Ripple should be no more than 5 mV peak-to-peak.

c). Connect DVM between TP-F and ground (chassis). DVM should read +18 volts to +22 volts. Ripple should be no more than 10 mV peak-to-peak.

2. Amplifier Operation.

a). Output switch on 244 must still be in the OFF position.

b). Connect 155 Microvoltmeter HI to TP-J and LO chassis and set range to 1 volt. Reading on 155 should be .8 volts to 1 volt.

c). Place Nanovolt Source switch in the OFF position and connect HI of source to TP-E of 244, LO to chassis.

d). Set dials of Nanovolt Source to 40 mV. Set switch to (-) polarity turn dial up to 60 mV. Reading on 155 should now drop to zero somewhere between 40 mV and 60 mV indicating amplifier is operating correctly. If 1 volt is sluggish when dropping to zero amplifier is not operating properly.

e). Place Nanovolt Source to the OFF position and disconnect the Nanovolt Source and the 155 from the 244.

3. Zener Current Adjust. Connect DVM HI to TP-F and LO to TP-G. Set Zener Adj. R138 for +7.99 volts to +8.01 volts.

4. Calibrate Adjust.

a). Place cap on plate of V101 power tube.

b). With 244 OUTPUT switch still off connect HI of DVM to side of R113 power resistor closest to side panel of 244 and LO to chassis. Reading should be +76 volts to +92 volts.

c). Vary line voltage from 105 volts to 125 volts. Reading should not change more than 200mV. Return line voltage to 117 V ac.

d). Set controls on 244 for -1000 volts. 25 volt cal control FULL CCW.

CAUTION

If 244 meter swings full scale when OUTPUT switch is turned on turn switch OFF IMMEDIATELY, otherwise irreparable damage to range resistors can occur.

e). Turn 244 OUTPUT switch on DVM reading should now rise 5 to 10 volts. Ripple should be more than 50 mV peak-to-peak.

f). Turn the 244 OUTPUT switch off. Connect the HV-1 to the 244 output and the dc output on the HV-1 to the 662. Set the 662 controls as follows:

RANGE FULL SCALE	-50 volts
NULL FULL SCALE	-100 mV
DIALS	-10.000
POLARITY	(-)

g). Turn the 244 OUTPUT switch on and set Cal. Pot. R145 for -10 volts +10 mV reading on 662. Cut jumpers across R140, R141 and R142 as necessary to set Cal. Pot. Turn 244 OUTPUT switch off.

5. Overload Calibration.

a). Connect Loading Box LB-1 Fixture to output of 244 and set for - and 1k-3kV. Set Voltage Output for -2000 Volts. Turn 244 OUTPUT switch on.

b). Adjust load until 244 overload light comes on. If meter on test fixture now reads 11.0 mA to 11.9 mA resistor R124 is already optimum value. If reading is not within this range replace R124 with one selected from table below. Turn OUTPUT switch OFF before changing resistors.

Current in mA	R124 in OHMS
10.2 - 11.0	42.2
11.0 - 11.9	45.3 already installed
11.9 - 12.9	48.7
12.9 - 13.9	52.3
13.9 - 15.0	56.2

c). If overload current is less than 10.2 mA or greater than 15.0 mA change Q107 as I_{OL} dependent on V_{ebo} of Q107. Turn 244 OUTPUT switch OFF.

6. Short Circuit Output Current.

a). Set 610B on 30 mA range (Multiplier -30 Range 10^{-3} Amperes Meter -) connect to output jack on 244.

b). Set all controls on 244 fully CCW and turn 244 OUTPUT switch on. 610B should read 12.0 mA to 14.0 mA and over load light should come on. If reading is higher change Q107. Turn 244 OUTPUT switch OFF.

7. Load Dependent Oscillations.

a). Connect Decade Capacitor Box to 244 output through MHV TEE Connector.

b). Set oscilloscope as follows:

TIME BASE	1 MS/DIV
TRIGGER	INTERNAL
VERTICAL SENSITIVITY	1 MV/DIV

c). Connect oscilloscope to 244 output through MHV TEE Connector. Set 244 for -200 volts and turn OUTPUT switch on.

d). Step Decade Capacitor Box from zero to 1.0 MF in 0.1 MF steps while observing scope. No oscillations should occur. Disregard line spikes which may or may not appear.

e). Turn output switch OFF.

8. 234 Volt Operation.

a). Turn 244 Power Off and unplug from variac. Set 117-234 volt switch on rear of 244 to the 234 volt position. Set 244 controls for -200 volt output. Plug 244 into 234 volt line and turn Power Switch on.

b). Set the 661 controls as follows:

RANGE FULL SCALE	500 volts
NULL FULL SCALE	10 volts
DIALS	200.00
POLARITY	(-)

c). Connect the 662 and High Voltage Divider Fixture HV-1 to Output of 244 through MHV TEE Connector. Connect Scope to ac out connector on HV-1.

d). Set scope controls as follows:

TIME BASE	1 MS/DIV
TRIGGER	INTERNAL
VERTICAL SENSITIVITY	1 MV/DIV

e). Turn 244 output on. 662 should read -200 +1 volt. Set Short-Open Switch on HV-1 to open. Noise observed on scope should be less than 200 microvolts. Set Short-Open Switch on HV-1 to Short.

f). Turn 244 output and power switches off. Unplug 244 from 234 volt line. Set 117-234 volt switch back to 117 position.

c. Final Calibration.

1. Re-check Zener Adjust and Calibrate.

2. Load Regulation.

a). Connect Loading Box LB-1 Fixture to 244 output through MHV TEE Connector and set for - and 1k-3kV. Set 244 controls for -2000 volts.

b). Connect HV-1 Divider to 244 output through MHV TEE Connector and connect HV-1 DC output to 662.

c). Set controls on 662 as follows:

RANGE FULL SCALE 50 volts
 NULL FULL SCALE 1 mV
 DIALS 20.000
 POLARITY (-)

d). Turn 244 OUTPUT on. 662 should now read zero center scale, if not set dials on 662 until zero reading is obtained.

e). Adjust Load Box between 0 mA and 10 mA. Reading on 662 shall not change more than +4 major divisions.

f). Adjust Load Box for 0 mA. Load and vary line voltage from 105 VAC to 125 VAC. Reading on 662 shall not change more than +2 major divisions. Return line voltage to 117 VAC.

g). Turn 244 output off.

3. Accuracy.

a). Connect output of 244 to input of HV-1 100:1 Divider. Connect output of HV-1 to input of 662.

b). Set 244 to -200 volts. Set the 662 controls as follows:

RANGE FULL SCALE 5 Volts
 NULL FULL SCALE 1 Volt
 DIALS 2.0000
 POLARITY (-)

c). Turn 244 output switch on. The 662 should now read -2 volts. Turn 244 CAL-25V pot full CW. The 662 should now read -2.2000 volts to -2.2500 volts. Return CAL-25V pot full CCW. Turn 244 output switch off.

d). Set 661 controls as follows:

RANGE FULL SCALE 5 Volts
 NULL FULL SCALE 100 mV
 DIALS 2.2000
 POLARITY (-)

e). Set 244 controls for -220 volts and turn 244 output switch on.

f). Step 662 and 244 thru settings listed in Table 6-2 take reading shown. Reading must be within range given. Turn output off when completed.

TABLE 6-2.
 Accuracy Check.

<u>662</u>	<u>244</u>	<u>Reading</u>	
2.2000	220	2.178	- 2.222
2.4000	240	2.376	- 2.424
2.6000	260	2.574	- 2.626
2.8000	280	2.772	- 2.828
3.0000	300	2.970	- 3.030
3.2000	320	3.168	- 3.232
3.4000	340	3.366	- 3.434
3.6000	360	3.564	- 3.636
3.8000	380	3.762	- 3.838
4.0000	400	3.960	- 4.040
2.0000	200	1.980	- 2.020
4.0000	400	3.960	- 4.040
Change 662 to 50 volts Range Full Scale			
6.000	600	5.940	- 6.060
8.000	800	7.920	- 8.080
10.000	1000	9.900	- 10.100
Change 662 to 1 volt Null Full Scale			
12.000	1200	11.880	- 12.120
14.000	1400	13.860	- 14.140
16.000	1600	15.840	- 16.160
18.000	1800	17.820	- 18.180
20.000	2000	19.800	- 20.200

4. Output Noise.

a). Set 244 for -2000 volt output. Connect 244 output to input of HV-1 and TRMS voltmeter to ac out connector. Set TRMS voltmeter on 300 volt range.

b). Turn 244 output switch on. Place short-open switch on HV-1 to open and step TRMS voltmeter to 1 mV range. Meter should read no higher than 500 microvolts.

1. Vary line voltage from 105 VAC to 125 VAC.

2. Return line voltage to 117 VAC.

c). Place open-short switch on HV-1 to short and turn 244 output and power switches off. Unplug 244 from Variac.

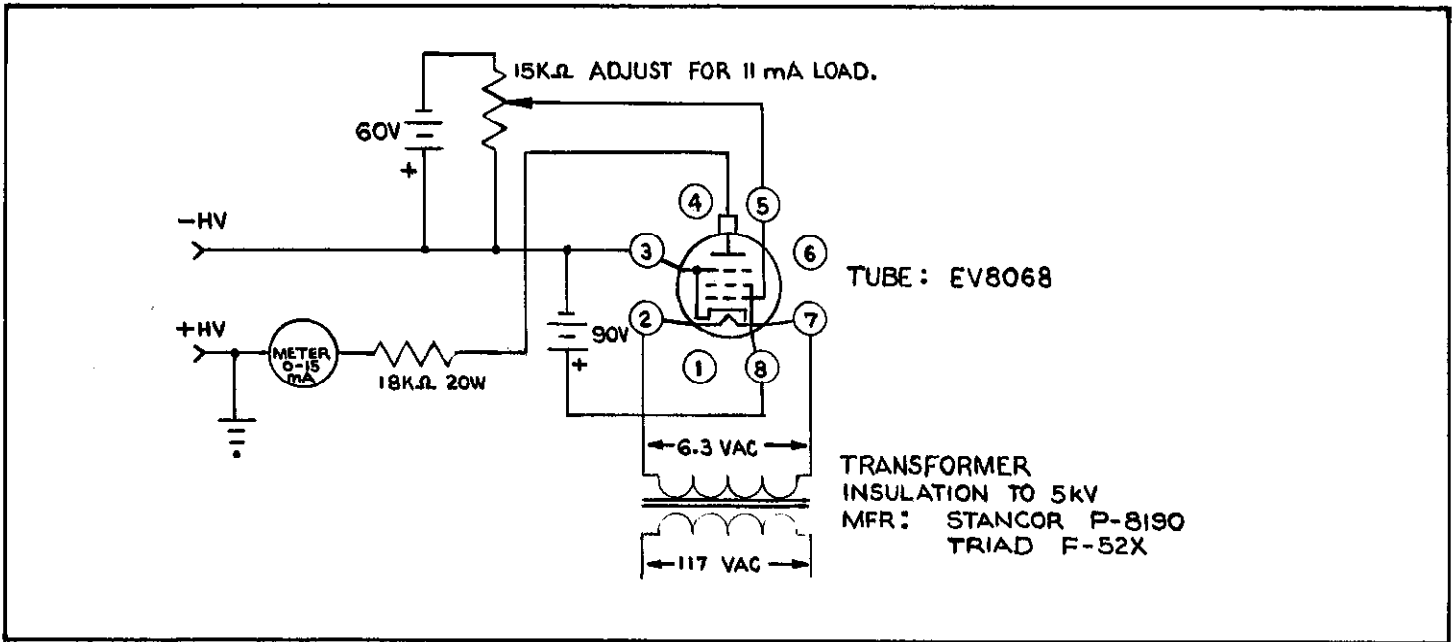


FIGURE 10. Circuit for Load Box LB-1.

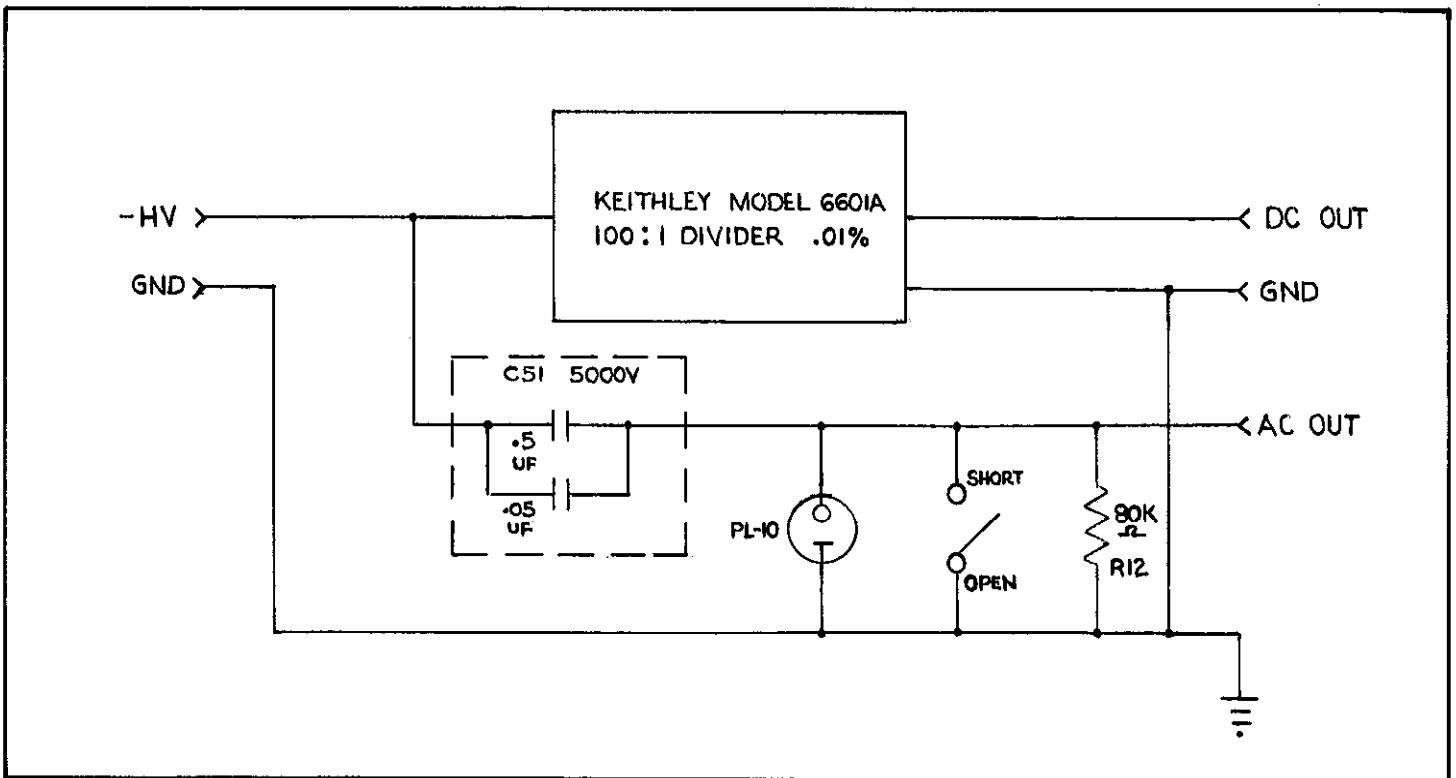


FIGURE 11. Circuit for Divider HV-1.

TABLE 6-3.
Cross-Reference of Manufacturers

CODE	NAME AND ADDRESS
A-B	Allen-Bradley Corp. Milwaukee, WI 53204
AHT	Arrowhart, Inc. Hartford, CT 06106
APH	Amphenol Broadview, IL 60153
APX	Amperex Elkgrove Village, IL 60007
BRG	Berg Electronics Inc. New Cumberland, PA 17070
BUS	Bussman Mfg. Div. St. Louis, MO 63017
CTS	CTS Corporation Elkhart, IN 46514
DIC	Dickson Electronics Corp. Scottsdale, AZ 85252
DLE	Dale Electronics Inc. Columbus, NE 68601
ERI	Erie Technological Products, Inc. Erie, PA 16512
F-I	Fairchild Instruments Corp. Mountain View, CA 94043
G-E	General Electric Company Syracuse, NY 13201
I-D	Industrial Devices, Inc. Edgewater, NJ 07020
IRC	IRC Division Burlington, IA 52601
ITT	ITT Semiconductors Lawrence, MA 01841
K-I	Keithley Instruments, Inc. Cleveland, OH 44139
MOT	Motorola Semiconductor Products, Inc. Phoenix, AZ 85008
OHM	Ohmite Mfg. Co. Skokie, IL 60076
PCI	Plastic Capacitors, Inc. Chicago, IL 60614
RCA	RCA Corporation Moorestown, NJ 08050
S-T	Sarkes Tarsian, Inc. Bloomington, IN 47401
SPG	Sprague Electric Company Visalia, CA 93278
T-I	Texas Instruments, Inc. Dallas, TX 75231

CODE-TO-NAME LIST

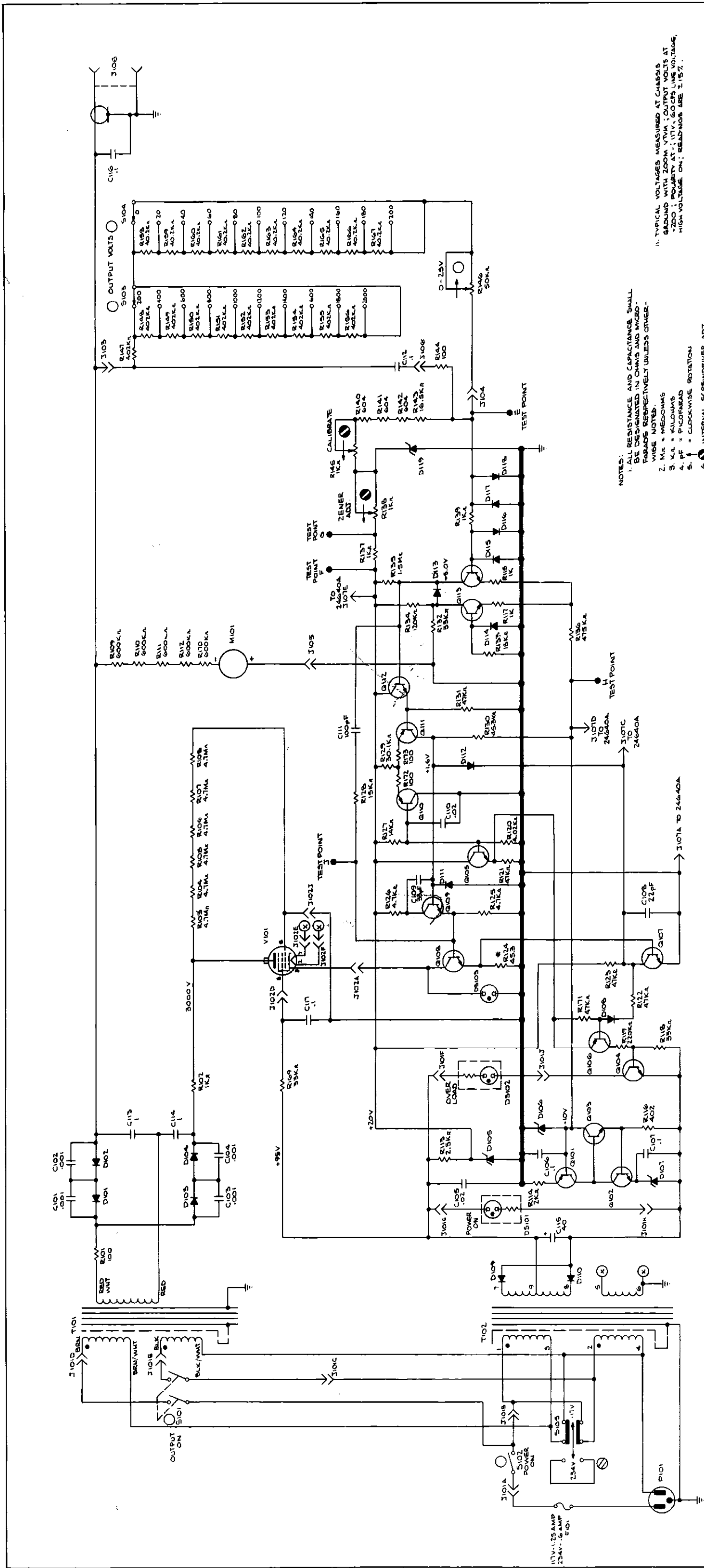
CODE TO NAME List of Suggested Manufacturers.
Reference: Federal Supply Code for Manufacturers, Cataloging Handbook H4-2.

00656	Aerovox Corp. 740 Belleville Ave. New Bedford, Mass. 02741	07137	Transistor Electronics Corp. Hwy. 169 - Co. Rd. 18 Minneapolis, Minn. 55424	14659	Sprague Electric Co. P.O. Box 1509 Visalia, Calif. 93278
00686	Film Capacitors, Inc. 100 Eighth St. Passaic, N.J.	07263	Fairchild Camera & Inst. Corp. 313 Frontage Road Mountain View, Calif.	15238	ITT Semiconductors Div. of ITT Corp. Lawrence, Mass. 01841
01121	Allen-Bradley Corp. 1201 South 2nd St. Milwaukee, Wisc. 53204	07716	IRC, Inc. 2850 Mt. Pleasant Burlington, Iowa 52601	15909	Daven Div. of T.A. Edison Ind. McGraw Edison Co. Livingston, N.J.
01295	Texas Instruments, Inc. Semiconductor-Components Div. Dallas, Texas 75231	08811	GL Electronics Div. of GL Industries, Inc. Westville, N.J. 08093	16170	Teledyne Systems Co. Communications Div. Los Angeles, Calif. 90066
01686	RCL Electronics, Inc. 195 McGregor St. Manchester, N.H. 03102	09052	Gulton Industries, Inc. Alkaline Battery Div. Metuchen, N.J.	17554	Components, Inc. Smith St. Biddeford, Ma. 04005
02101	Varo Inc. Electrokinetics Div. Santa Barbara, Calif. 93102	09823	Burgess Battery Co. Div. of Servel Inc. Freeport, Ill.	23020	General Reed Co. 174 Main St. Metuchen, N.J. 08840
02660	Amphenol Corp. 2801 South 25th Ave. Broadview, Ill. 60153	09922	Burndy Corp. Richards Ave. Norwalk, Conn. 06852	24655	General Radio Co. 22 Baker Ave. West Concord, Mass. 01781
02734	Radio Corp. of America Defense Electronic Products Camden, N.J.	10582	CTS of Asheville Inc. Mills Gap Road Skyland, N.C.	27682	Hathaway Instruments, Inc. 5800 E. Jewell Ave. Denver, Colorado 80222
02735	Radio Corp. of America Receiving Tube Div. Somerville, N.J.	11502	IRC Inc. Greenway Road Boone, N.C. 28607	28520	Heyman Mfg. Co. 147 N. Michigan Ave. Kenilworth, N.J.
02777	Hopkins Engineering Co. 12900 Foothill Blvd. San Fernando, Calif. 91342	11837	Electro Scientific Indus., Inc. 13645 NW Science Park Dr. Portland, Or. 97229	29309	Richey Electronics Inc. 1307 Dickerson Rd. Nashville, Tenn. 37213
02985	Tepro Electric Corp. 5 St. Paul St. Rochester, N.Y. 14604	12040	National Semiconductor Corp. Commerce Drive Danbury, Conn. 06813	35529	Leeds and Northrup 4901 Stenton Ave. Philadelphia, Pa. 19144
03508	General Electric Co. Semiconductor Products Dept. Syracuse, N.Y. 13201	12065	Transitron Electronic Corp. 144 Addison St. East Boston, Mass.	37942	Mallory, P. R. and Co., Inc. 3029 E. Washington St. Indianapolis, Ind. 46206
04009	Arrow-Hart & Hegeman Electric Co. 103 Hawthorne St. Hartford, Conn. 06106	12697	Clarostat Mfg. Co., Inc. Lower Washington St. Dover, N.H. 03820	44655	Ohmite Mfg. Co. 3601 Howard St. Skokie, Ill. 60076
04713	Motorola Semiconductor Prod. Inc. 5005 E. McDowell Rd. Phoenix, Ariz. 85008	12954	Dickson Electronics Corp. 302 S. Wells Fargo Ave. Scottsdale, Ariz.	53201	Sangamo Electric Co. 1301 North 11th Springfield, Ill. 62705
05079	Transistor Electronics, Inc. 1000 West Road Bennington, Vt. 05201	13050	Potter Co. Highway 51 N. Wesson, Miss. 39191	54294	Shallcross Mfg. Co. 24 Preston St. Selma, N.C.
05397	Union Carbide Corp. Electronics Div. New York, N.Y. 10017	13327	Solitron Devices, Inc. 256 Oak Tree Road Tappan, N.Y. 10983	56289	Sprague Electric Co. North Adams, Massachusetts
06751	Components, Inc. Arizona Div. Phoenix, Ariz. 85019	13934	Midwec Corp. 602 Main Oshkosh, Nebr. 69154	58474	Superior Electric Co., The 383 Middle St. Bristol, Conn. 06012
06980	Varian Assoc. EIMAC Div. 301 Industrial Way San Carlos, Calif. 94070	14655	Cornell-Dubilier Electric Corp. 50 Paris Street Newark, N.J.	61637	Union Carbide Corp. 270 Park Ave. New York, N.Y. 10017

REPLACEABLE PARTS

CODE TO NAME List (Continued).

63060	Victoreen Instrument Co. 5806 Hough Ave. Cleveland, Ohio 44103	75042	IRC Inc. 401 North Broad St. Philadelphia, Pa. 19108	86684	Radio Corp. of America Electronic Components & Devices Harrison, N.J.
70309	Allied Control Co., Inc. 2 East End Ave. New York, N.Y.	75915	Littlefuse, Inc. 800 E. Northwest Hwy. Des Plaines, Ill. 60016	87216	Philco Corp. Lansdale Div., Church Rd. Lansdale, Pa. 19446
70903	Belden Mfg. Co. 415 So. Kilpatrick Chicago, Ill. 60644	76055	Mallory Controls, Div. of Mallory P. R. & Co., Inc. Frankfort, Ind.	90201	Mallory Capacitor 3029 East Washington Indianapolis, Ind. 46206
71002	Birnbach Radio Co., Inc. 147 Hudson St. New York, N.Y.	76493	Miller, J. W. Co. 5915 S. Main St. Los Angeles, Calif. 90003	90303	Mallory Battery Co. Tarrytown, New York
71279	Cambridge Thermionic Corp. 430 Concord Avenue Cambridge, Mass.	76545	Mueller Electric Co. 1583 E. 31st St. Cleveland, Ohio 44114	91637	Dale Electronics, Inc. P.O. Box 609 Columbus, Nebr. 68601
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.	77764	Resistance Products Co. 914 S. 13th St. Harrisburgh, Pa. 17104	91662	Elco Corp. Willow Grove, Pennsylvania
71450	CTS Corp. 1142 W. Beardsley Ave. Elkhart, Ind.	79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.	91737	Gremar Mfg. Co., Inc. 7 North Ave. Wakefield, Mass.
71468	ITT Cannon Electric, Inc. 3208 Humbolt St. Los Angeles, Calif. 90031	80164	Keithley Instruments, Inc. 28775 Aurora Road Cleveland, Ohio 44139	91802	Industrial Devices Inc. 982 River Rd. Edgewater, N.J. 07020
71590	Centralab Div. of Globe-Union, Inc. Milwaukee, Wisc. 53212	80294	Bourns, Inc. 6135 Magnolia Ave. Riverside, Calif. 92506	91929	Honeywell Inc. Micro Switch Div. Freeport, Ill. 61032
71785	Cinch Mfg. Co. and Howard B. Jones Div. Chicago, Ill. 60624	81073	Grayhill, Inc. 561 Hillgrove Ave. La Grange, Ill. 60525	93332	Sylvania Electric Products, Inc. Semiconductor Products Div. Woburn, Mass.
72619	Dialight Corp. 60 Stewart Ave. Brooklyn, N.Y. 11237	81483	International Rectifier Corp. 1523 East Grand Ave. El Segundo, Calif.	93656	Electric Cord Co. 1275 Bloomfield Ave. Caldwell, N.J.
72653	G-C Electronics Co. 400 S. Wyman Rockford, Ill. 61101	82389	Switchcraft, Inc. 5527 N. Elston Ave. Chicago, Ill. 60630	94144	Raytheon Co., Industrial Operation Components Div. Quincy, Mass.
72699	General Instrument Corp. Capacitor Division Newark, N.J. 07104	83125	General Instrument Corp. Capacitor Division Darlington, S.C. 29532	94154	Tung-Sol Electric, Inc. Newark, New Jersey
72982	Erie Technological Prods Inc. 644 W. 12th St. Erie, Pa. 16512	83330	Smith, Herman H., Inc. 812 Snediker Ave. Brooklyn, N.Y. 11207	94310	Tru-Ohm Products Memcor Components Div. Huntington, Ind. 46750
73138	Beckman Instruments, Inc. Helipot Division Fullerton, Calif. 92634	83594	Burroughs Corp. Electronic Components Div. Plainfield, N.J. 07061	94696	Magnecraft Electric Co. 5579 North Lynch Chicago, Ill.
73445	Amperex Electronic Co., Div. of North American Philips Co., Inc. Hicksville, N.Y.	83701	Electronic Devices, Inc. Brooklyn, New York	95348	Gordos Corp. 250 Glenwood Ave. Bloomfield, N.J. 07003
73690	Elco Resistor Co. 1158 Broadway New York, N.Y.	84171	Arco Electronics, Inc. Community Drive Great Neck, N.Y. 11022	95712	Dage Electric Co., Inc. Hurricane Road Franklin, Ind.
74276	Signalite Inc. 1933 Heck Ave. Neptune, N.J. 07753	84411	TRW Capacitor Div. 112 W. First St. Ogallala, Nebr.	97933	Raytheon Co. Components Div. Semiconductor Operation Mountain View, Calif.
74970	Johnson, E. F., Co. 297 Tenth Ave. S.W. Waseca, Minn. 56093	84970	Sarkes Tarzian, Inc. E. Hillside Dr. Bloomington, Ind.	99120	Plastic Capacitors, Inc. 2620 N. Clybourn Ave. Chicago, Ill.



NOTES:

1. ALL RESISTANCE AND CAPACITANCE SHALL BE IN OHMS UNLESS OTHERWISE SPECIFIED. PARAGRAPHS REFERRED TO UNLESS OTHERWISE SPECIFIED.
2. M.A. = MEGOHMS
3. K.A. = KILOHMS
4. P.F. = PULSED
5. ↑ = CLOCKWISE ROTATION
6. ○ = INTERNAL SCREWDRIVER ADJ.
7. ○ = FRONT PANEL CONTROL
8. ○ = REAR PANEL CONTROL
9. * INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION.
10. CONNECTOR J101 FOR SPECIAL EXTERNAL OVERLOAD CIRCUIT MODEL 24A1

11. TYPICAL VOLTAGES MEASURED AT CHASSIS GROUND WITH LOADS IN OUTPUT VOLTS AT 100% LOAD. TYPICAL CURRENTS AT HIGH VOLTAGE ON READINGS ARE 1.5%.

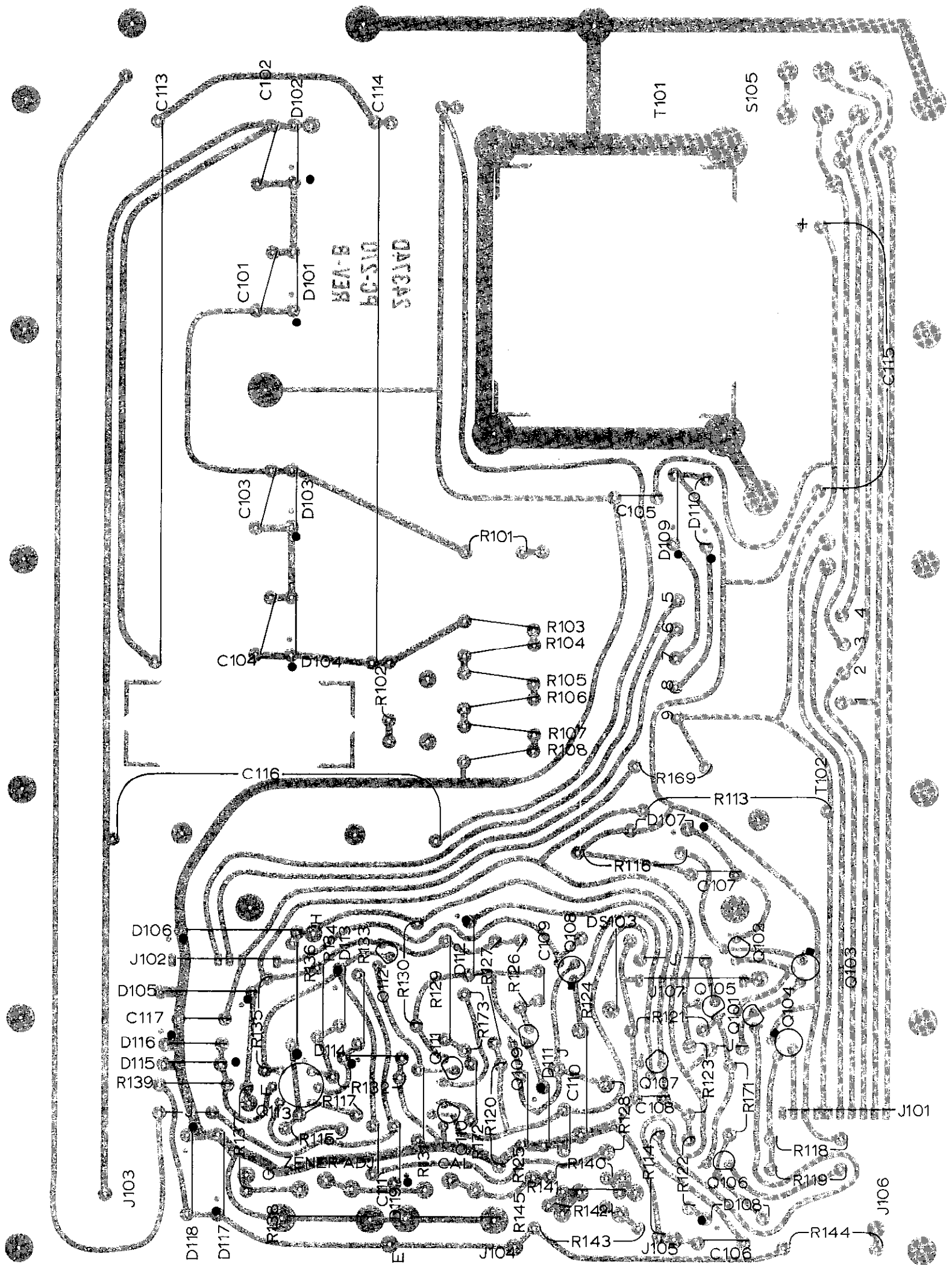
HIGHEST SCHEMATIC DESIGNATIONS

R105	D105	C101	D101	D102	D103	D104
V101	M101	P101	T101	F101	F102	F103

SCHEMATIC DESIGNATIONS NOT USED

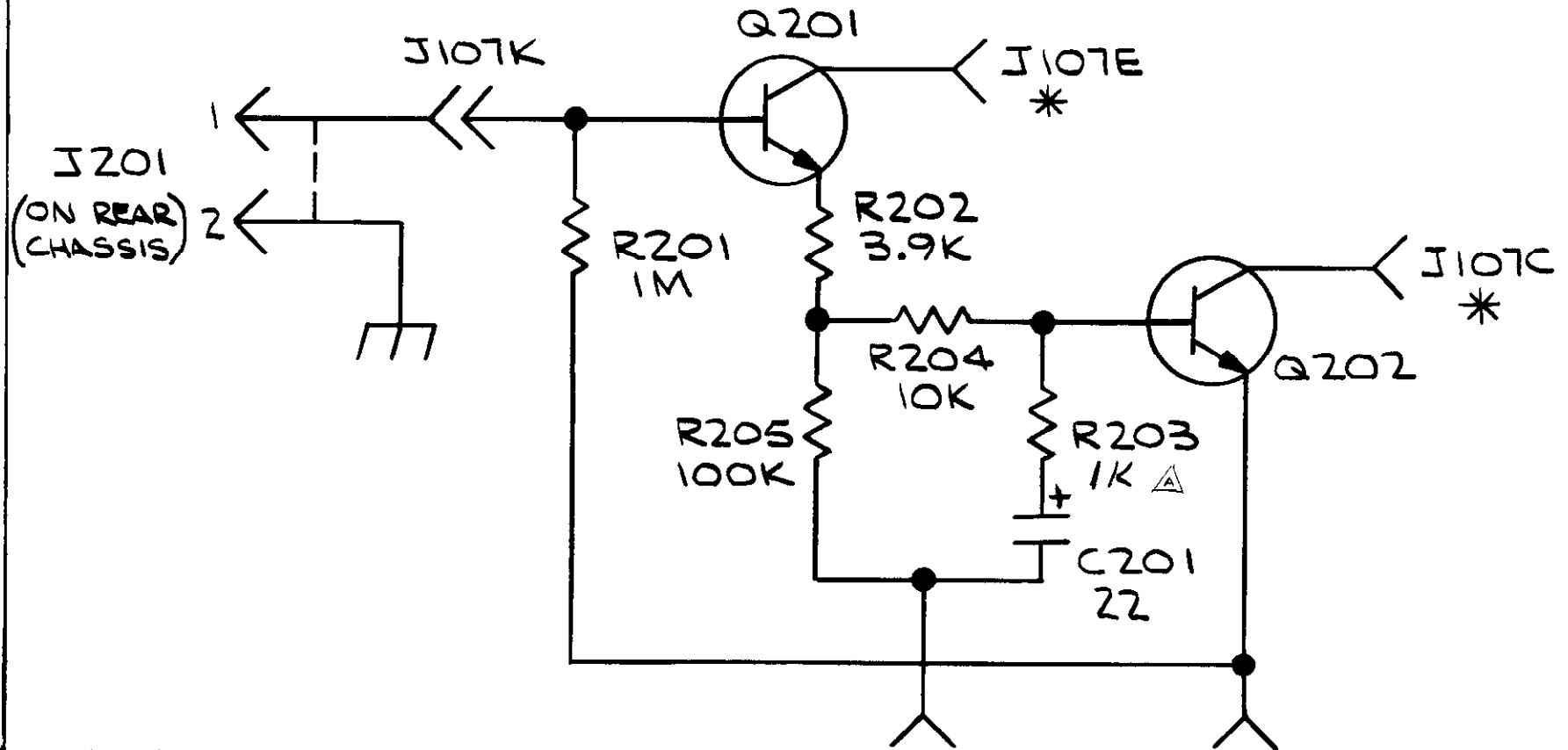
R107	R108					
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REITZLEY
 TITLE: SCHEMATIC (POWER SUPPLY)
 PART NUMBER: 2431E
 DATE: 11/16/56
 DRAWN BY: J. J. ...
 CHECKED BY: ...
 APPROVED BY: ...




24640A
ON

LTR.	ECO NO.	REVISION	DATE
R		WAS 470	TCS 7-22-70



NOTES:
* MOTHER BOARD SCHEMATIC
24317E

2441		1
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 3.24.70	SCALE	TITLE SCHEMATIC
 KEITHLEY INSTRUMENTS CLEVELAND, OHIO	XX = ± 015 ANG = ± 1°	DRN. D.L.	ENG. APPR. RCD	EXTERNAL CURRENT LIMIT
	XXX = ± .005 FRAC = ± 1/64	MATERIAL		NO. 24640A
	SURFACE MAX 63 ✓	FINISH		

REPAIR AND CALIBRATION FORM

For repair or calibration, please fill out this form and return it with your instrument to:
 Sales Service Department
 Keithley Instruments, Inc.
 28775 Aurora Road
 Cleveland, Ohio 44139

R- _____
 Do not write in this space.

User's Name _____ Telephone _____ Ext. _____
 Company _____ Address _____
 Division _____ City _____ State _____ Zip _____
 Date _____ Model No. _____ Serial No. _____

1. Reason for Return
 Repair and Recalibration
 Recalibration only (No report, except as specified in item 4 on reverse)*
 *If repairs are necessary to meet specifications, they will be in addition to the calibration.
2. Calibration Report Desired
 Report of Calibration Certified Traceable to N.B.S.
 Calibration Report
 Certificate of Compliance
 None
 (for details, see reverse side of this form)

3. To help repair the instrument, briefly describe the problem: _____

4. Is the problem Constant Intermittant
 Under what conditions does the problem occur:
 a) Control setting _____ e) Line voltage _____
 _____ f) Other (such as line transients, line variations, etc.) _____
 b) Approx. Temperature _____ °F
 c) Approx. Temperature variation ± _____ °F
 d) Approx. Humidity (high, medium, low) _____

5. Please draw a block diagram of the system using the Keithley. List any other pertinent data which can help in the repair. Include charts or other data if available.
 Signal Source _____
 Source Impedance _____
 Readout Device:
 Recorder
 Oscilloscope
 Other
 None
 Lengths & Types of Connecting Cables _____

6. What repairs or modifications have been made on this instrument which are not on file with the Keithley Repair Department? _____

7. Please enclose any other pertinent data and charts which you feel might help the Repair and Calibration Department

 Signature Title

cut along dotted line

CALIBRATIONS AVAILABLE AT KEITHLEY INSTRUMENTS.

Listed and defined below are the four types of calibrations and their associated report formats which are presently available at Keithley Instruments. They fall into the following categories:

1. Report of Calibration Certified Traceable to the National Bureau of Standards
2. Calibration Report
3. Certificate of Compliance
4. Recalibration

All calibration and certification performed by Keithley Instruments is in accord with MIL-C-45662A.

Prices shown below are in addition to repair charges for any work necessary to place a customer's unit into first class condition prior to the calibration.

f. Report of Calibration Certified Traceable to the National Bureau of Standards.

This is a completely documented report, including all basic errors or deviations from nominal settings on appropriate ranges, terminals, dials, etc. Work is performed using the primary standards of the company with secondary transfers kept to a minimum. The NBS test numbers for the latest recalibration of the primary standards are furnished.

By definition, the above is performed in our Standards Laboratory so that random operator induced error is minimized and maximum protection to the equipment used is maintained.

This type of calibration is not recommended for instruments with a basic inaccuracy of 1% or greater. The precision involved in this report makes it uneconomical for such instruments. The Calibration Report listed below (No. 2) would be better suited in this case.

As of 11/1/69 the Report of Calibration Certified Traceable to the National Bureau of Standards is available on the following instruments at the prices listed:

Model 140	\$275	Model 5155 (Complete Set) . . .	\$295
Model 260	\$225	Model 5155-10 ⁸	\$ 50
Model 261	\$375	Model 5155-10 ⁹	\$ 50
Model 515	\$375	Model 5155-10 ¹⁰	\$ 50
Model 630	\$275	Model 5155-10 ¹¹	\$ 60
Model 660A	\$250	Model 5155-10 ¹²	\$ 60
Model 662	\$275	Model 5155-10 ¹³	\$ 80

2. Calibration Report.

This report shows only the cardinal range, terminal, dial, etc. errors as determined by production calibration equipment and personnel. The production equipment is maintained traceable by transfer techniques against the primary standards maintained by the company. We attest to this fact and list basic deviations from nominal but the conditions of calibration are not as precisely controlled as the previous report nor are NBS test numbers supplied.

This report is available for any instrument in our line. As of November 1, 1969, only the following price has been established for this report:

Model 261 \$ 55
Prices for other units can be estimated upon request.

3. Certificate of Compliance.

This is merely a restatement of the basic guarantee that the instrument was calibrated on equipment that is maintained by our standards personnel against primary standards. No report is issued.

This Certificate of Compliance is available at no charge for any instrument with the exception of the Model 261.

A newly purchased Model 261 or one returned for repair or recalibration is automatically supplied with a Calibration Report (as described in (2) above). The nature of this instrument makes it necessary to complete this report to ascertain specified accuracy. This Calibration Report is forwarded to the customer with the instrument. The \$55 charge is incorporated as part of the normal calibration charge of the Model 261.

4. Recalibration.

This is a recalibration of the instrument according to our factory calibration procedures. The prices for this as of November 1, 1969 are as follows:

Model 260	\$ 85	(No report supplied. A Certificate of Compliance can be had at no charge if requested).
Model 261	\$ 55	(Calibration Report as described in (2) above is supplied. See (3) for explanation).

All other instruments are on a time and material basis for the particular unit involved.

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139
SERVICE FORM

MODEL NO. _____ SERIAL NO. _____ P.O. NO. _____ DATE _____ R-

NAME _____ PHONE _____

COMPANY _____

ADDRESS _____ CITY _____ STATE _____ ZIP _____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

4. Describe input signal source levels, frequencies, etc. _____

5. List and describe all cables used in the experiment (length, shielding, etc.).

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

7. Environment:
Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
What power line voltage is used? _____ Variation? _____ Frequency? _____
Ambient temperature? _____ °F. Variation? _____ °F. Rel. Humidity? _____
Other _____

8. Additional Information. (If special modifications have been made by the user, please describe below.) _____