INSTRUCTION MANUAL

MODEL 151

MICROVOLTMETER

CONTENTS

SECTION 1 - INTRODUCTION

The Keithley Model 151 Null Detector is a stable, low-level DC amplifier with high input resistance and low noise. Careful shielding, filtering, and guarding permit floating operation, as in a bridge null detector, with excellent rejection to extraneous voltages.

With a power sensitivity of 10^{-17} watt, a response speed of one second, lack of overshoot and a zero-centered meter, the 151 may be used in applications where a suspension galvanometer might be employed, or in other applications where a galvanometer is not sufficiently sensitive, fast or rugged.

Five non-linear ranges are provided which have the same center-scale sensitivity as the linear ranges, but are compressed in a quasi-logarithmic way to three decades on each range. These ranges permit speedier null-searching than the linear scales, without sacrificing sensitivity at null.

Two zero controls for open and short-circuit inputs allow proper zeroing for any source resistance even in the presence of bridge thermal emf's eliminating the need for disconnecting bridge voltage to set zero.

Although designed for null detector applications, the Model 151 is also useful as a dc voltmeter with a maximum full-scale sensitivity of 100 microvolts and as an ammeter with a maximum full-scale sensitivity of 10 micro-microamperes.

The 151 has a full-scale output of 10 volts at up to one milliampere. This is sufficient to drive one milliampere recorders as well as servo-rebalance recorders and oscilloscopes.

RANGE:

Linear: 0.1 millivolt full scale to 10 volts on zero-center meter. 11 overlapping ranges in 1x and 3x steps.
Non Linear: Five ranges of 0.001, 0.01, 0.1, 1.0 and 10 volts full scale, each covering 3 decades.

ACCURACY:

Linear ranges: ±3% of full scale exclusive of noise and drift.
Non-linear ranges: ±10% of input exclusive of noise and drift.

ZERO DRIFT: Less than 10 microvolts per day after 30-minute warm-up.

INPUT NOISE (with input shorted): Less than 2% of full scale on all ranges.

INPUT RESISTANCE: 10 megohms on all ranges.

LINE FREQUENCY REJECTION: 2,000:1

COMMON MODE REJECTION: With 1-megohm source resistance. dc:5,000,000:1. Line frequency: 500,000:1.

ISOLATION: Circuit ground to chassis ground: Approximately 10^9 ohms shunted by 0.02 microfarad. Circuit ground may be floated up to ±500 volts dc or peak with respect to chassis ground.

RISE TIME (10% to 90%): Approximately 1 second on all ranges.

OVERVOLTAGE: 200 volts steady, 400 volts transient.

ZERO ADJUST: For both open and short-circuit inputs.

RECORDER OUTPUT:

Output: ±10 volts dc at up to 1 milliampere for full-scale meter deflection.
Resistance: Less than 50 ohms within the amplifier pass band.

Gain on linear ranges: $\dfrac{\text{10 volts}}{\text{Range setting in volts}}$

LINE STABILITY: A 10% change in line voltage will cause less than a 2% of full-scale shift on all ranges.

CONNECTORS: Input: Binding posts. Output: Amphenol 80-PC2F.

POWER: 105-125 or 210-250 volts, 60 cps, 50 watts. 50-cps models available.

DIMENSIONS, WEIGHT: 10 inches high x 6-1/2 inches wide x 8-1/2 inches deep; net weight, 11-1/2 pounds.

ACCESSORIES SUPPLIED: Mating output connector.

SECTION III -- OPERATION

A. OPERATING CONTROLS

The operating controls of the Model 151 are listed below:

ON - OFF SWITCH;

RANGE SWITCH: Selects both the linear and the logarithmic ranges.

SHORT CIRCUIT ZERO: Sets the meter zero with the input shorted. This control compensates for thermal EMF's in the connected circuit and the amplifier input.

OPEN CIRCUIT ZERO: Sets the meter zero with open or high resistance input. This control compensates for any leakage currents present in the external circuit.

B. PRELIMINARY SET UP

Connect to the power line. Unless otherwise marked, the unit is wired for 117 v., 60 cps power. To convert to 220 volt and/or 50 cps operation, consult MAINTENANCE section. A three-wire line cord is furnished which grounds the cabinet. If a three-wire receptacle is not available, use the two pin adapter furnished, and ground the third lead to an external ground for the best operation. If open circuit unbalance is encountered, reverse line cord.

Set the range switch to the 10 volt linear range. Turn on the power. In about 30 seconds the meter will zero. Short the input and turn to the .1 millivolt range. Zero the meter with the SHORT CIRCUIT ZERO. Open the input and zero the meter with the OPEN CIRCUIT ZERO. In the first 30 minutes of operation some zero drift may occur and it may be desirable to reset the zeros.

C. USE OF ZERO CONTROLS

The stability of the Model 151 is such that, after 30 minutes of operation, only infrequent attention need be given to either zero control except occasionally on the most sensitive ranges. The two zero controls, however, allow the user to maintain a constant zero with varying input resistances.

The short circuit zero bucks out low impedance voltages such as generated by thermal EMF's. The open circuit zero is a current buckout control for balancing any current generated by chemical effects or leakage. In normal practice, if zeroing is required, the SHORT CIRCUIT ZERO is sufficient. However, in the case of a critical null balance application where it is necessary to eliminate zero shift over a range of input resistances, this can be assured by balancing the null detector using the SHORT CIRCUIT ZERO at the lowest impedance involved and the OPEN CIRCUIT ZERO at the highest impedance involved.

D. INPUT RESISTANCE AND SOURCE IMPEDANCE RESTRICTIONS

The input resistance of the Model 151 is 10 megohms, within 5% on the most sensitive range and within 1% on all other ranges. Other than the consideration of circuit loading and speed of response (See F.), there are no source impedance restrictions.

E. CURRENT MEASUREMENT

Since the input resistance is a constant 10 megohms, the Model 151 may be used to measure current with a maximum sensitivity of 10^{-11} amperes full scale. Since the tolerance on input resistance is 5% on the most sensitive range, an accuracy of about 7% can be expected there. On all other ranges an accuracy of 4% is possible.

F. SPEED OF RESPONSE

The specification in Section II is for low impedance input. With an open-circuit input, speed is about 5 seconds to 90% of final value.

G. LINE FREQUENCY REJECTION

The specification for 60 cps rejection are given in Section II. The rejection is high enough so that usually no precautions are necessary with regard to 60 cps pick-up. While the input filter is specially peaked at 60 cps for maximum rejection, there is sufficient rejection at other harmonics to make pickup troubles unlikely.

H. FLOATING OPERATION

The common mode rejection to DC as well as 60 cps is extremely high in the Model 151 as specified in Section II. The instrument will operate with no difficulty up to 500 volts from ground. For floating operation, remove the shorting link between the LO and G terminals at the front of the instrument.

I. RECORDING

The output at the recorder terminals for full scale is 10 volts at up to 1 milliampere. Since the output has a common ground with the input, when recording, either the Model 151 must be grounded or the recorder input capable of being floated. It shoud be remembered that, with a recorder connected to the output, the system rejection will be no better than that of the recorder.

SECTION IV - CIRCUIT DESCRIPTION

The Model 151 is a narrow-band chopper amplifier employing negative feedback to stabilize the gain and increase the input resistance.

A. INPUT CIRCUIT

The input circuit contains the dc to ac modulator, the range switch, and input filter to reject spurious ac signals, and the zero controls.

The modulator used in the Model 151 employs two photoconductive cells PD 101 and PD 102 (refer to circuit schematic diagram at the rear of this manual) which are alternately switched by two neon lamps NE 101 and NE 102 operated from the ac line. The action is similar to a single-pole double-throw mechanical chopper with the result that the dc input is converted into an ac signal.

Spurious ac signals are prevented from entering the input by means of a low-pass filter consisting of R108 and C104 and a "twin-tee" filter consisting of R101 through R105 and C101 through C103 which is tuned to the line frequency. R104 and R102 are set at the factory for maximum rejection to line frequency.

Below 10 millivolts, the sensitivity is changed by altering the feedback factor. Above 10 millivolts an input divider is used. The input divider is formed by R153 through R159. The total resistance of this divider is 10 megohms which is always across the input.

The zeroing circuits consist of batteries BA101 and BA102 and resistors R138 through R148. R139 together with R138 and the bias batteries form a current source which bucks out any spurious currents appearing at the input. R148 and either R147 or R148, depending on range, place a voltage in series with the low side of the modulator and buck-out any spurious EMF's appearing at the input.

As indicated on the circuit schematic, critical parts of the input circuit are surrounded by a separate shield connected to the LO terminal. This shield largely accounts for the high in-phase rejection.

B. AC AMPLIFIER

The AC amplifier consists of V1 and V2. The total gain is approximately 500,000. The first stage tube is not specially selected, although a tube may have to be rejected for excessive hum pick-up which results in excessive zero offset. Due to the excellent internal shielding of the first stage tube, it is not necessary to use dc on the first stage filament. The time constants of the amplifier are selected to give as narrow a pass-band as possible around the carrier frequency.

C. DEMODULATOR CIRCUIT

The demodulator circuit employs a four-diode bridge circuit with silicon diodes. A balanced configuration is used so that careful balance of the transformer secondary is not necessary.

The demodulator is driven synchronously with the neon lamps which switch the input modulator. The modulator output is a pulsating dc signal which is fed through R119 to the input grid of the dc amplifier.

D. DC AMPLIFIER

The dc amplifier is required for two reasons. At the carrier frequency, the dc amplifier is a feed back integrator. The integrating capacitor, C115, is in a local feedback loop from output cathods to input grid. The gain of the dc amplifier is about 500 so that the value of C115 is effectively multiplied by 500, eliminating the need for a large value of capacity for filtering. At dc, the demodulated signal is amplified, increasing the loop gain by about 500. This additional feedback results in a very high input resistance for the null-detector. Exclusive of the divider, the input resistance is in excess of 300 megohms on most ranges.

The dc amplifier circuit is conventional and consists of V3 connected as a differential amplifier, V4 used as a dc amplifier, and the output cathode-follower. R128, DC AMP BAL, adjusts the balance of the dc amplifier. Once set, this control requires very infrequent adjustment. A misadjustment is evident if, on the 10v log range the meter is not exactly on zero.

E. THE WHOLE LOOP DESCRIPTION

Sections of the amplifier are combined. The input filter removes any high frequency components from the input signal. The modulator converts the filtered dc signal to ac, which is amplified by the ac amplifier. The output of the ac amplifier is converted into a pulsating dc signal filtered by the dc amplifier acting as an integrator, and further amplified by the dc amplifier.

The output signal is fed back to the input by means of R160 through R164 and R149 through R152. The feedback is applied to the low end of PD102, the modulator diode. Applying feedback at this point not only stabilizes the gain, but raises the input resistance very substantially.

The sensitivity is changed from .1 millivolt to 10 millivolts by changing the feedback factor. An input divider is used above 10 millivolts.

The "logarithmic" ranges are obtained through the use of a non-linear "thyrite" resistor R166 in the feedback loop.

On some ranges, when the feedback factor becomes too large, it is necessary to decrease the gain of the ac amplifier. This is done by shunting pin 7 of V2 to ground with a small value of resistance, R167.

F. POWER SUPPLY

Despite the high sensitivity, no regulation is employed in the power supply. The plus and minus supplies are derived from standard rectifier-filter transformer combination. Points W and V on the same transformer winding are used to drive the modulator and demodulator.

SECTION V -- MAINTENANCE

A. GENERAL

The only periodic maintenance the Model 151 requires is replacement of BA101 and BA102, the zero set batteries, at intervals of about two or three years. If the zeroing controls become inoperative, the batteries need replacement.

The modulator and other components have an indefinite life and should not be tampered with unless there is a failure.

B. TROUBLE-SHOOTING PROCEDURE

If the instrument is inoperative but replacement of tubes does not cure the trouble, the following step-by-step procedure is indicated.

1. Check the B-plus and B-minus voltages at the junctions of R170, C120-B and R171, C119B. These should agree within about 10% of the voltages indicated on the schematic. If these are markedly different, check the fuse and then the ac voltage from the transformer (about 234 v to ground). Then check the selenium rectifiers and the filter capacitors.

2. If the proper voltages are present in the power supply

   a. Remove V-4, the 12AT7, from its socket, short the output terminals and the input terminals.

   b. Connect an oscillosope to the plate of V2-B (pin 6). Rotate the SHORT CIRCUIT ZERO to one end of its travel. If the ac amplifier is functioning and the bias batteries BA1 and BA2 are providing voltage, a 60 cps carrier signal, proportional in amplitudeto the rotation of the potentiometer (until the amplifier saturates), should be seen. By returning the short circuit zero control to midposition, it should be possible to reduce the signal to the point where it disappears in the first stage tube noise. If this occurs, the ac amplifier is functioning. Proceed to the instructions in paragraph D.

   c. If there is an ac signal present at the output which is not affected by the short-circuit zero control, short pin 9 of V-1 to ground. You will have to remove the input stage shield to do this. Replace it when observing the output with the oscilloscope on pin 6 of V-2. If the signal is no longer present and just background tube noise is seen, either the modulator is defective or the input circuit is open somewhere between C105 and the input terminals.

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If shorting the grid does not remove the ac signal, move the short to the grid of V-2a (pin 2). If the hum now disappears, either V1 is defective, C107 is open, or there is excessive hum in B-plus. If the hum does not disappear, V2 is defective or there is excessive hum in the power supply. (At the plus terminal of C106, the hum should be less than 100 microvolts RMS. At the plus terminal of C120A it should be less than 5 millivolts RMS).

If the signal still persists, remove V2 from its socket and short pin 2 or V3 to ground. The residual signal from the demodulator should not exceed about 1 volt, peak to peak. If the signal seen is still very large, replace defective diodes RF105 through 108. (The diodes are rated to pass about 1 milliampere at a five volt forward voltage and should have about a 100 megohm back resistance).

It is also possible that the siganl observed at the plate of V2B will be very small in amplitude and not affected by the short-circuited zero control. In this case either V1 or V2 is not amplifying. To check this, place the oscilloscope at high sensitivity at the plate of V1 (pin 6) and rotate the short circuit zero control. If the signal appears and is capable of being nulled, V2B is at fault. Once the defective amplifier stage is located, the operating points may be checked against the Voltage-Resistance Diagram at the rear of the manual, and the defect located.

d. If no defect has been found in the ac amplifier or the demodulator, replace V4 and unshort the output. Short pin 2 of V3 to ground. Locate R128 (DC AMP BAL). On the bench model, this control is accessible from the rear; on the rack model, the control is located on a ceramic board to the left rear of the instrument. If the dc amplifier is functioning it will be possible to swing the meter pointer through zero and against both stops, although the action of the control will be very coarse.

If it is not possible to swing through zero, measure the voltage at pin 6 of V3B. When varying R128, this voltage should swing through 100 volts. If it will not pass through 100 volts of the resistors associated with the stage have changed value. Check according to the schematic and the Voltage-Resistance Diagram.

If the plate of V3 can be moved as indicated, move the voltmeter to pin 2 of V4A. The voltage should pass through zero as R128 is varied, and at least 20 volts in the negative direction. In the positive direction, the grid will be damped by drawing grid current a few tenths of a volt above zero. If the above is not possible, check R129, or the voltage across C119-C (about 270v).

Now measure V4, pin 1. This voltage should also swing through 100 volts. If not, check as for the previous stage.

Finally check pin 7 of V4B. Since this is the output cathode follower it should swing both plus and minus at least 20 volts upon manipulation of R128. If it does not, either V4B is defective or R134 is open.

e. In some cases, the instrument acts as if it is extremely sensitive, and a signal much smaller than the normal full scale signal drives the output full scale.

The cause in this case is lack of negative feedback from the output to the input. It may only occur on some ranges. It is probably due either to a defective switch contact or an open feedback resistor, breaking the feedback loop. It must be traced by checking with the schematic and locating the resistors in question.

Circuit Desig.	Description	Part No.
BA-101	Battery, Mercury energizer, 1.34V (Mallory RM-12RT-2)	BA-11
BA-102	Battery, Mercury energizer, 1.34V (Mallory RM-12RT-2)	BA-11
C-101	.047 mfd. Mylar 200 V. 5% Capacitor	C47-.047
C-102	Sames as C-101	
C-103	.1 mfd. Mylar 200 V. 5% Capacitor	C47-.1
C-104	.1 mfd. Mylar 200 V. 20% Capacitor	C66-.1
C-105	Same as C-104	
C-106	40 mfd. Dry Electrolytic Capacitor	C27-40
C-107	200 mfd. Electrolytic Upright Capacitor	C48-200
C-108	.1 mfd. Paper Metalized Capacitor	C18-.1
C-109	.02 mfd. Ceramic Disc. Capacitor	C22-.02
C-110	2.0 mfd. Metal Tubular Capacitor	C39-2
C-111	.01 mfd. Ceramic Disc. Capacitor	C22-.01
C-112	Same as C-111	
C-113	Same as C-110	
C-114	Same as C-108	
C-115	.047 mfd. Mylar 200 V. 20% Capacitor	C66-.047
C-116	.001 mfd. Ceramic Disc. Capacitor	C220.001
C-117	.0047 mfd. Ceramic Disc. Capacitor	C22-.005
C-118	Same as C-116	
C-119-A	30.0 mfd. Upright Can, Twist Lock Capacitor	C52-30/30/30
C-119-B	Same as C-119-A	
C-119-C	Same as C-119-A	

REPLACEABLE PARTS LIST - MODEL 151

Circuit Desig.	Description		Part No.
C-120-A	40.0 mfd. Electrolytic Upright Can	Capacitor	C33-40/40/20
C-120-B	Same as C-120-A		
C-120-C	20.0 mfd. Electrolytic Upright Can	Capacitor	C33-40/40/20
C-121	Same as C-109		
FU-1	Fuse, $\frac{1}{2}$ ampere - 3AG		FU-4
ME-1	Meter for Model 151		ME-21
ME-1	Meter for Model 151-R		ME-22
ME-1	Meter for Model 151-C		ME-32
NE-101 PD-101	#1510, Light Modulator		CV-4
NE-102 PD-102	#1510, Light Modulator		CV-4
PL-1	Pilot Light		PL-8
R-101	25K. Deposited Carbon, ½ watt, 1% For 50 cycle Operation, R101 is 30K	Resistor	R12-25K
R-102	10K. Composition, Slotted Shaft	Potentiometer	RP16-10K
R-103	48K. Deposited Carbon, ½ watt, 1%	Resistor	R12-48K
R-104	20K. Carbon, [illegible] watt	Potentiometer	RP7-20K
R-105	54K. Deposited Carbon, ½ watt, 1% for 50 cycle Operation, R105 is 65K	Resistor	R12-54K
R-106	333K. Deposited Carbon, ½ watt, 1%	Resistor	R12-333K
R-107	18K.ohm Composition, ½ watt, 10%	Resistor	R1-18K
R-108	390K. ohm Composition, ½ watt, 10%	Resistor	R1-390K
R-109	1M. Deposited Carbon, ½ watt, 1%	Resistor	R12-1M
R-110	5 Wire Wound, 5 watt, 3%	Resistor	R4A-5

Circuit Desig.	Description		Part No.
R-111	220 K ohm composition, ½w. 10%	Resistor	R1-220K
R-112	3.33 M ohm Deposited Carbon, ½w. 1%	Resistor	R12-3.33K
R-113	1 M ohm - Same as R-109		
R-114	4.7 K ohm Composition, ½w. 10%	Resistor	R1-4.7K
R-115	1 M ohm Composition, ½w. 10%	Resistor	$1-1M
R-116	Same as R-115		
R-117	47 K ohm Composition, ½w. 10%	Resistor	R1-47K
R-118	Same as R-115		
R-119	Same as R-130		
R-120	Same as R-114		
R-121	100 K ohm Composition, ½w. 10%	Resistor	R1-100K
R-122	Same as R-121		
R-123	Same as R-121		
R-124	15 K ohm Composition, ½w. 10%	Resistor	R1-15K
R-125	470 K ohm Composition, ½w. 10%	Resistor	R1-470K
R-126	.5M ohm Deposited Carbon, ½w. 1%	Resistor	R12-500K
R-127	50 K ohm Deposited Carbon, ½w. 1%	Resistor	R12-50K
R-128	100 K ohm resistor is combined with R-165 as a dual unit.		
R-129	Same as R-109		
R-130	2.2 M ohm Deposited Carbon, ½w. 1%	Resistor	R12-2.2M
R-131	100 K ohm Deposited Carbon, ½w. 1%	Resistor	R12-100K
R-132	Same as R-109		
R-133	Same as R-130		
R-134	50 K ohm Wire Wound, 5 watt	Resistor	R4-50K
R-135	22 K ohm Composition, ½w. 10%	Resistor	R1-22K

Circuit Desig.	Description		Part No.
R-136	94.5 K ohm Deposited Carbon, ½w. 1%	Resistor	R12-94.5K
R-137	15 K Wire Wound, 2 watt	Potentiometer	RP17-15K
R-138	10 K Same as R-102		
R-139	1000 M ohms Composition, ½w. 20%	Resistor	R37-10^9
R-142	68 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-68K
R-143	Same as R-142		
R-144	10 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-10K
R-145	Same as R-144		
R-146	Same as R-102		
R-147	150 K Ohms Deposited Carbon, ½w. 1%	Resistor	R12-150K
R-148	30 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-30K
R-149	10.67 ohms Deposited Carbon, ½w. 1%	Resistor	R12-10.67
R-150	96 ohms Deposited Carbon, ½w. 1%	Resistor	R12-96
R-151	10 ohms Deposited Carbon, ½w. 1%	Resistor	R12-10
R-152	100 ohms Carbon, Printed Circuit	Potentiometer	RP12-100
R-153	9.9 K ohms Deposited Carbon, 1/2 w. 1%	Resistor	R12-9.9K
R-154	9 M ohms Deposited Carbon, ½w. 1%	Resistor	R12-9M
R-155	150 K ohms Composition, ½w. 10%	Resistor	R1-150K
R-156	667 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-667
R-157	233 K ohms Deposited Carbon, ½w, 1%	Resistor	R12-233K
R-158	66.7 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-66.7K
R-159	23.3 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-23.3K
R-160	Same as R-109		

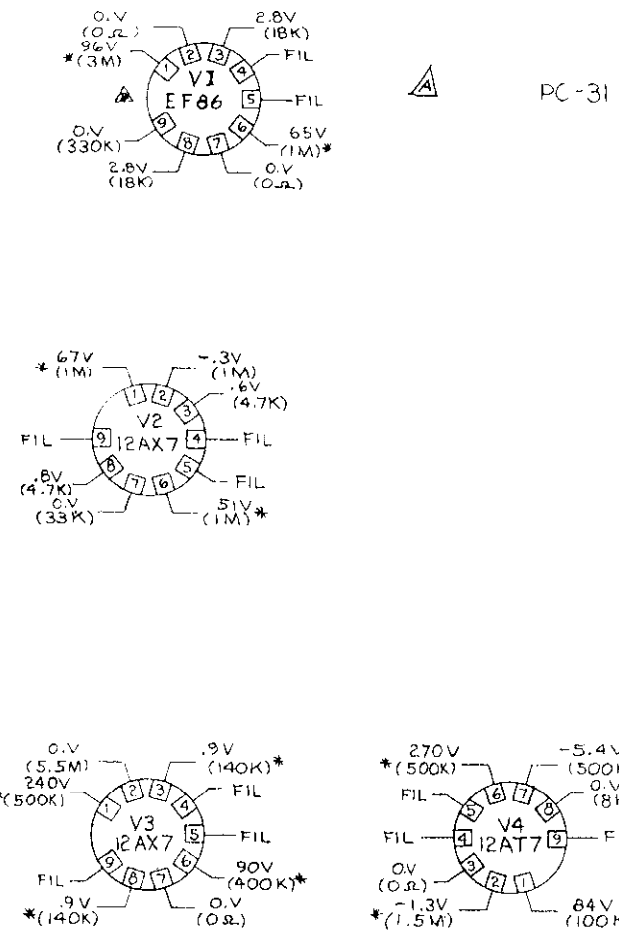
Circuit Desig.	Description		Part No.
R-161	Same as R-106		
R-162	Same as R-131		
R-163	33.3 K ohms Deposited Carbon, ½w. 1%	Resistor	R12-33.3K
R-164	9.9K ohms Deposited Carbon, 1/2 w. 1%	Resistor	R12-9.9K
R-165	2 M ohms variable	Resistor	RP18-2M
R-166	G. E. Thyrite	Resistor	RT-1
R-167	33 K ohms Composition, ½w. 10%	Resistor	R1-33K
R-168	47 ohms Composition, ½w. 10%	Resistor	R1-47
R-169	Same as R-168		
R-170	8.2 K ohms Composition, 2 w. 10%	Resistor	R3-8.2K
R-171	1 K ohms Composition, 1 w. 10%	Resistor	R2-1K
R-172	Same as R-121		
RF-101	Rectifier		RF-18
RF-102	Same as RF-101		
RF-103	Same as RF-101		
RF-104	Same as RF-101		
RF-105	Rectifier, matched with RF-106		14168A
RF-106	Rectifier, matched with RF-105		14168A
RF-107	Rectifier, matched with RF-108		14168A
RF-108	Rectifier, matched with RF-107		14168A
RF-109	Rectifier		RF-20
RF-110	Rectifier		RF-20
SW-1	Range Switch		SW-75
SW-2	Power Switch		SW-24
T-1	Power Transformer		TR-30

REPLACEABLE PARTS LIST - MODEL 151

Circuit Desig.	Description	Part No.
V-1	~~6084~~ EF86 Vacuum Tube	EV ~~6084~~ EF86
V-2	~~12-AX7~~ 7025 Vacuum Tube	EV ~~12-AX7~~ 7025
V-3	Same as V-2	
V-4	12-AT7 Vacuum Tube	EV 12-AT7

MODEL 151 NULL DETECTOR
VOLTAGE AND RESISTANCE CHART

MEASUREMENTS MADE FROM TUBE PIN TO LO WITH INPUT SHORTED AND RANGE SWITCH IN 10V POSITION.
RESISTANCE MEASUREMENTS - SAME AS ABOVE.
RESISTANCES MARKED WITH AN ASTERISK WERE MEASURED AFTER FILTER CAPACITORS WERE COMPLETELY DISCHARGED
ALL MEASUREMENTS ARE APPROXIMATE AND WERE MADE WITH A 11 MEGOHM INPUT RESISTANCE VTVM



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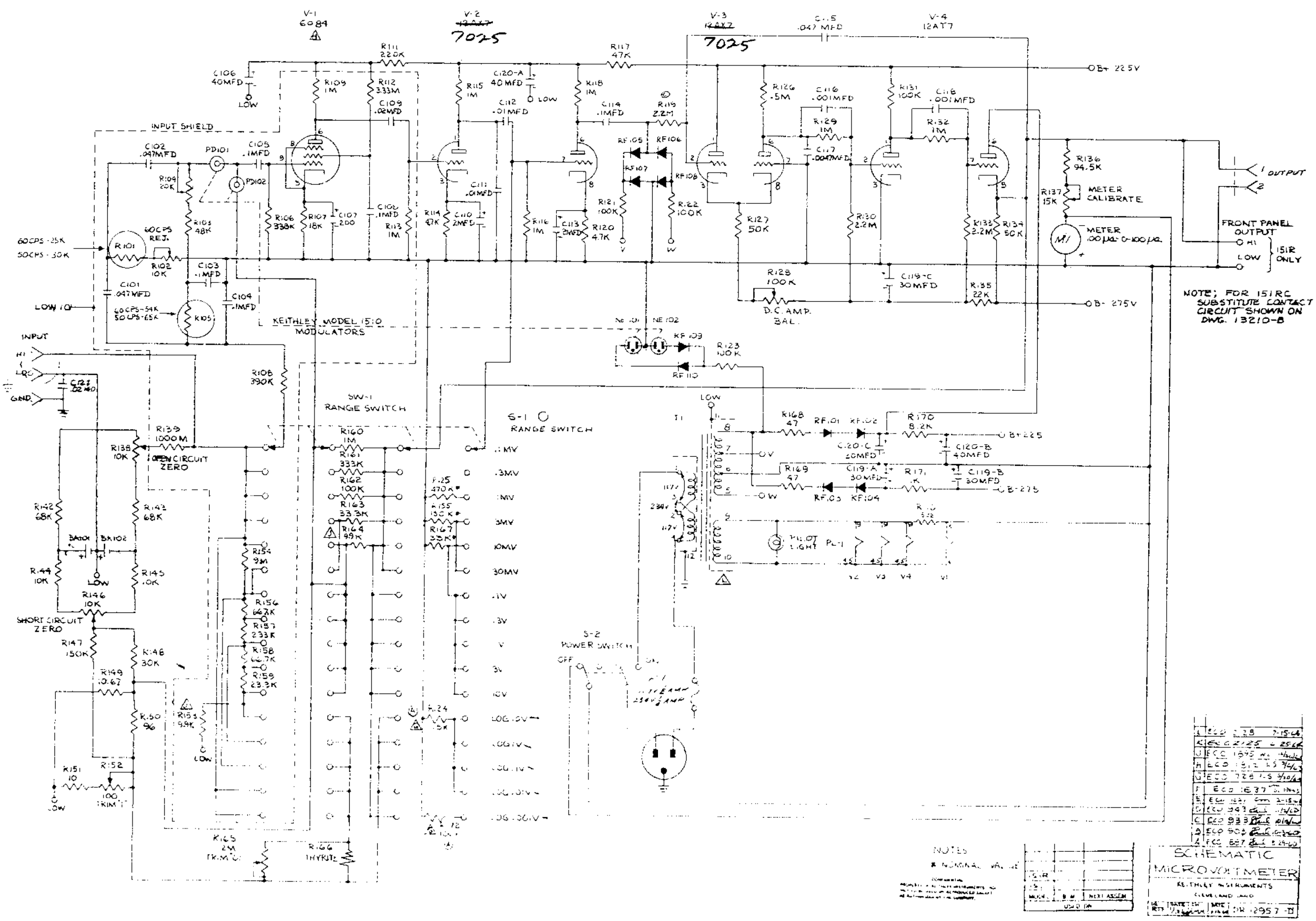
DRAWN: RJF DATE: 3/17/66
KEITHLEY INSTRUMENTS, INC. CLEVELAND, OHIO
DRAWING NUMBER

A ECO 1812 9/1/63
B ECO 2396


V-1 6084
V-2 7025
V-3 7025
V-4 12AT7
INPUT SHIELD
KEITHLEY MODEL 1510 MODULATORS
60CPS REJ.
60CPS-25K
50CPS-30K
60CPS-54K
50CPS-65K
LOW
INPUT
HI
LO
GND.
SW-1 RANGE SWITCH
S-1 RANGE SWITCH
.1MV
.3MV
1MV
3MV
10MV
30MV
.1V
.3V
1V
3V
10V
OPEN CIRCUIT ZERO
SHORT CIRCUIT ZERO
D.C. AMP. BAL.
METER CALIBRATE
METER 100 μa 0-100 μa
FRONT PANEL OUTPUT
HI
LOW
151R ONLY
OUTPUT
B+ 225V
B- 275V
NOTE; FOR 151RC SUBSTITUTE CONTACT CIRCUIT SHOWN ON DWG. 13210-B
S-2 POWER SWITCH
OFF
PILOT LIGHT
PL-1
NOTES
SCHEMATIC
MICROVOLTMETER
KEITHLEY INSTRUMENTS
DR 12957-B