INSTRUCTION MANUAL

Model 160

Digital Multimeter

(and Model 163

Digital Voltmeter)

PRINTED MAY 1976, CLEVELAND, OHIO, U.S.A.

CONTENTS

ILLUSTRATIONS

SPECIFICATIONS

AS A DC VOLTMETER
RANGE: ±1 microvolt per digit (1 mV full range) to ±1000 volts full range in seven decade ranges. 100% overranging on all except the 1000-volt range.
ACCURACY: ±(0.1% of reading, +1 digit) on all ranges.
INPUT RESISTANCE: 10 megohms on the 10-millivolt and higher ranges, 1 megohm on the 1-millivolt range.
AC REJECTION:
NMRR: Greater than 80 dB above one digit for a voltage of line frequency or twice line frequency on the most sensitive range, decreasing to 60 dB on the 100-millivolt and higher ranges. 1000 volts peak-to-peak maximum.
CMRR: Greater than 120 dB above one digit at dc and 40 to 100 Hz ac. 500 volts dc, 100 volts peak-to-peak ac maximum.
SETTLING TIME: *Less than 2 seconds to rated accuracy.*
MAXIMUM OVERLOAD: 100 volts continuous input on 1-volt to 1000-volt ranges. 1000 volts momentary, 300 volts continuous on lower ranges.
AS A DC AMMETER (Model 160 only)
RANGE: ±0.1 nanoampere per digit (0.1 μA full range) to ±1 ampere full range in eight decade ranges. 100% overranging on all ranges.
ACCURACY: ±(0.2% of reading +1 digit) on the 100-nanoampere to 10-milliampere ranges. ±(0.3% of reading +1 digit) on the 0.1 and 1-ampere ranges.
INPUT RESISTANCE: 100 kilohms on the 0.1-microampere range, decreasing to 0.1 ohm on the 100-milliampere and 1-ampere ranges.
NMRR: 60 dB above one digit for a current of line frequency or twice line frequency.
MAXIMUM OVERLOAD: 50 times full scale continuous on all ranges up to a maximum of 3 amperes.
AS AN OHMMETER (Model 160 only)
RANGE: 0.1 ohm per digit (100 Ω full range) to 1000 megohms full range in eight decade ranges. 100% overranging on all ranges.
ACCURACY: ±(0.3% of reading +1 digit +0.1 ohm) on the 100-ohm to 1-megohm ranges, *decreasing to ±10% on the 100-megohm* range. The 1000-megohm range is intended for relative resistance measurements only (±50%).

VOLTAGE ACROSS UNKNOWN: 100 mV at full scale, 1.5 volts maximum into an open circuit.
MAXIMUM OVERLOAD: 20 volts momentary, 1 volt continuous.
GENERAL
ANALOG OUTPUT: ±1 volt dc at up to 1 milliampere for full scale input, 100% overranging on all ranges except the 1000-volt range.
POLARITY: Automatic.
ZERO STABILITY: ±0.3 microvolt/°C, ±2 microvolts/day after 1-hour warm-up.
OFFSET CURRENT: Typically less than 10 picoamperes.
ACCURACY STABILITY: ±0.01%/°C (±0.06%/°C on ohms). Accuracy (rated at 23°C ambient after a 30-minute warm-up) is maintained for at least 6 months.
DISPLAY: 3 digits plus 1 overrange digit;
polarity and overload indication;
2 readings per second.
ISOLATION: Circuit ground to chassis ground: greater than 100 megohms shunted by less than 0.02 microfarad. Circuit ground may be floated up to ±500 volts with respect to chassis ground in the voltage and current modes.
POWER: 105-125 or 210-250 volts (switch selected), 50-60 Hz, 20 watts.
DIMENSIONS, WEIGHT: 3½ in. half-rack overall bench size 4¼ in. high x 9 in. wide x 10½ in. deep (105 x 225 x 265 mm); net weight 7 pounds (3,1 kg).

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL.

a. The Keithley Model 160 is a completely solid-state, line operated multimeter with the accuracy and convenience of a digital display. It has seven d-c voltage ranges from 1 millivolt full scale to 1000 volts full scale with 100% overranging on every range except 1000 volts. The Model 160 also measures from 100 nanoamperes full scale to 1 ampere with 100% overranging on each range. The ohms ranges are from 100 ohms full scale to 1000 megohms also with 100% overranging.

b. The Keithley Model 163 is a Voltmeter-Only version of the Model 160 Digital Multimeter. It has all the main features of the Model 160 except the ammeter and ohmmeter functions are deleted.

c. With the use of Keithley Model 1601 AC/DC Probe, a-c measurements can be made from 0.1 volt to 250 volts rms over a span of 45 Hz to 45 kHz. A probe-mounted switch provides convenient selection of a-c or d-c operation without disconnecting the probe.

1-2. FEATURES.

a. Accuracy is ±0.1% ±1 digit on any voltage range.

b. Input is protected for ±1000 volts continuous input on 1-volt to 1000 volt ranges. Rated at ±300 volts continuous input on 1 millivolt range.

c. Zero stability is ±2 microvolts/day after one hour warmup.

d. Single RANGE Control is designated in convenient engineering units.

e. Circuit low to chassis ground isolation permits safe off-ground measurements up to ±500 volts.

f. Instrument operates from either 50 or 60 Hz, 117 or 234 volt power.

g. Convenient recorder output is ±1 volt at 1 milliampere.

h. Model 1602 Digital Output Kit provides optional BCD Output.

1-3. APPLICATIONS. The Model 160 is a general purpose instrument - used in Basic Research, Electronics Development, and Process Control.

1. In the Research Lab - When used with a suitable probe, transducer, or electronic circuit, Model 160 can be used to indicate digitally, volts, amps, or ohms, or through conversion, any physical parameter such as temperature, pressure, rpm, etc.

2. In Electronics Development Activity - Useable for basic electrical measurements of voltage, current, or resistance. Especially suited for in-circuit resistance measurements.

3. In Process Control Activity - Adaptable for OEM equipment where repetitive measurements are needed with analog or digital printout.

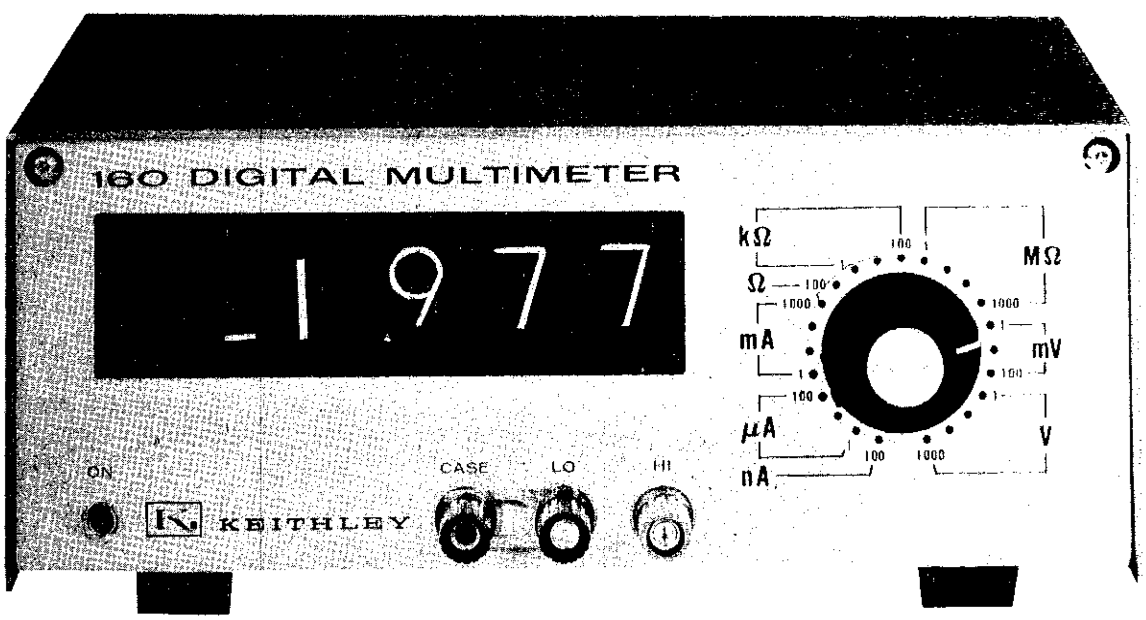


FIGURE 1. Model 160 Digital Multimeter - Front Panel

TABLE 1-2.

Front Panel Controls and Terminals. (Refer also to Figure 2). This Table briefly describes the function of the controls and terminals on the front panel. The paragraph indicated describes in detail the operation of the controls.

Control	Functional Description	Paragraph
Range Switch	Selects the full scale range and parameter to be measured (volts, amperes, or ohms).	2-2
Power Switch	Controls a-c line power to instrument (ON/OFF).	2-2
High Terminal (Red)	Connects input high to signal source.	2-1
Low Terminal (Black)	Connects input low to signal source. Circuit low is connected to chassis ground when the shorting link is connected between LO and CASE.	2-1
Case Terminal (Green)	Connection to case ground.	2-1
Polarity Indicator	Indicates polarity of the input signal.	2-2
Numerical Readout	Indicates magnitude of input signal.	2-8

TABLE 1-3.

Rear Panel Controls and Terminals. (Refer also to Figure 3). This Table briefly describes the function of the controls and terminals on the rear panel. The paragraph indicated describes in detail the operation of the controls.

Control	Functional Description	Paragraph
AC POWER Cord 50-60 Hz	Connects a-c line power to instrument.	2-4
117V-234V Switch	Sets instrument for either 117 or 234V a-c line power. NOTE: Earlier versions of the Model 160 or 163 have a rear panel switch that connects LO to CASE. When operating these versions the switch should be set to FLOAT when using the instruments for off-ground measurements.	2-3
ZERO Control	Screwdriver adjustment for fine zero.	2-3
OUTPUT Receptacle	Connects analog output to recording device. Output is ±1 volt d-c at up to 1 milliampere.	2-10
BCD OUTPUT	Cover plate for PRINTER/CONTROL connector furnished only with optional Model 1602 Digital Output Kit.	2-12

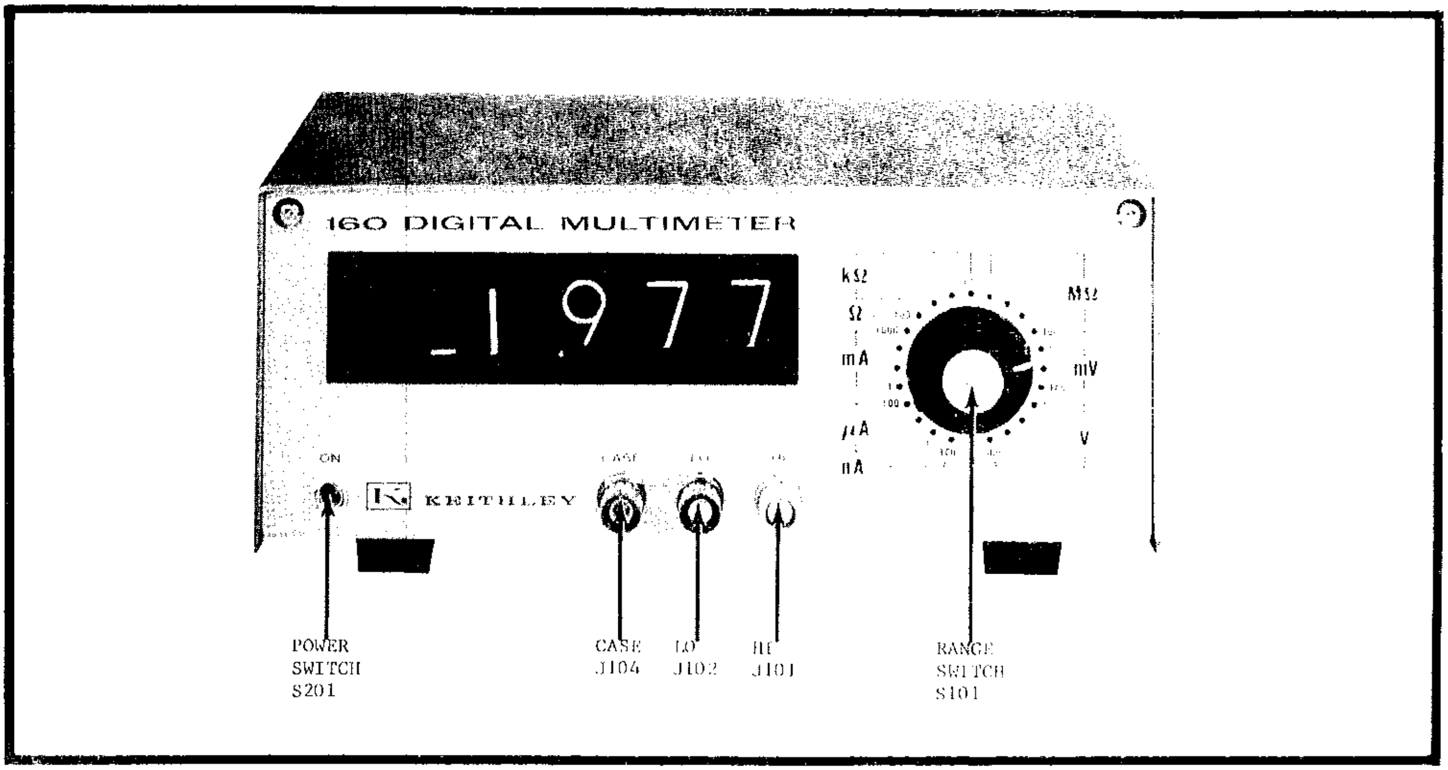


FIGURE 2. Model 160 Front Panel Controls and Terminals.

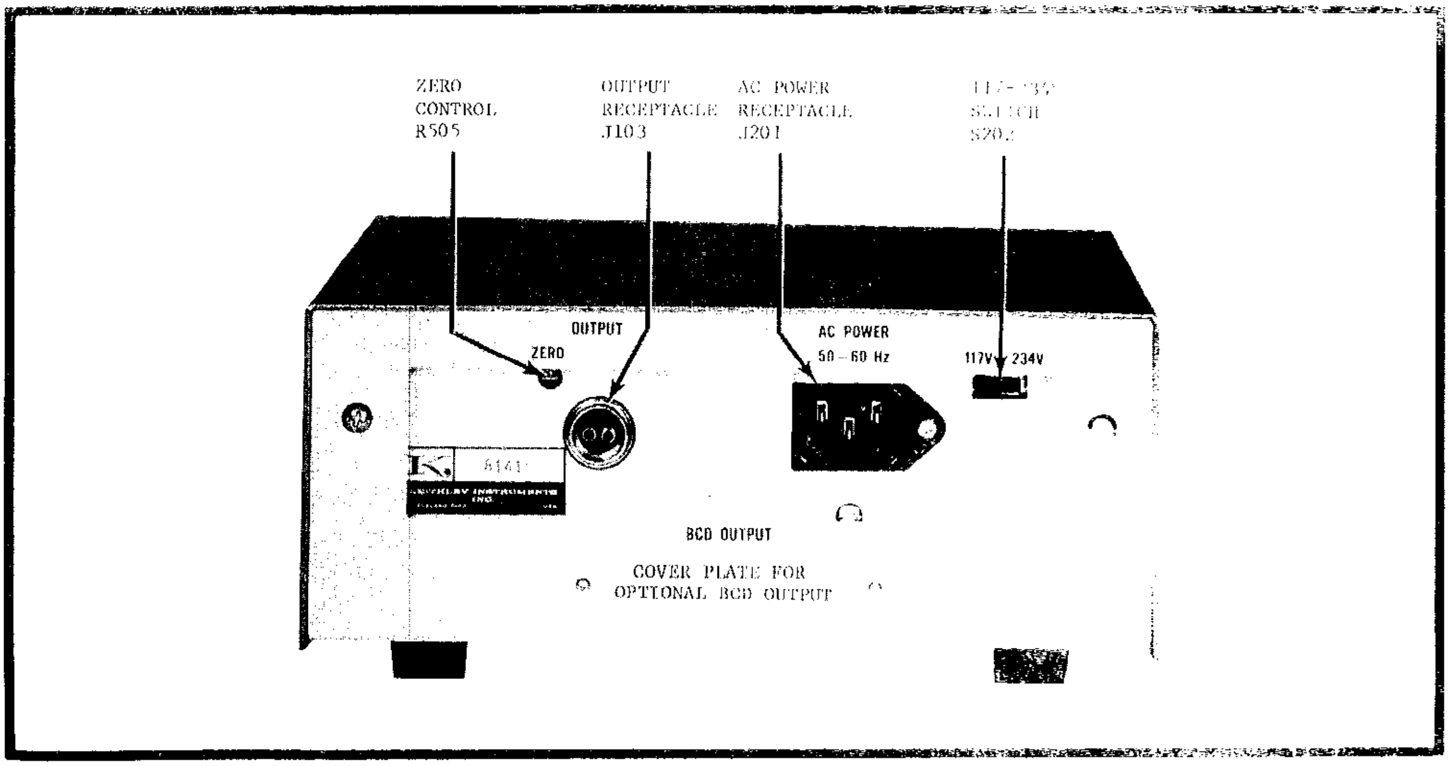


FIGURE 3. Model 160, 163 Rear Panel Controls and Terminals.

SECTION 2. OPERATION

2-1. INPUT CONNECTIONS.

a. Binding Post Terminals. Three binding posts are provided on the front panel for all input connections. The terminals are color coded as follows: Red = Input High, Black = Input Low, Green = Case ground.

b. Noise Considerations. The limit of resolution in voltage and current measurements is determined largely by the noise generated in the source. Stray low-level noise is present in some form in nearly all electrical circuits. The instrument does not distinguish between stray and signal voltages since it measures the net voltage. When using the 1 mV and 10 mV ranges, consider the presence of low-level electrical phenomena such as thermocouples (thermoelectric effect), flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors (dielectric absorption), and battery action of two terminals (galvanic action).

1. Thermal EMFs. Thermal emfs (thermoelectric potentials) are generated by thermal differences between two junctions of dissimilar metals. To minimize the drift caused by thermal emfs, use copper leads to connect the circuit to the instrument. The rear panel ZERO control can be used to buck out a constant thermal offset voltage if necessary. The Keithley accessory Model 1483 Low Thermal Connection Kit contains all necessary materials for making very low thermal copper crimp connections for minimizing thermal effects.

2. A-C Electric Fields. The presence of electric fields generated by power lines or other sources can have an effect on instrument operation. A-C voltages which are very large with respect to the full-scale range sensitivity could drive the a-c amplifier into saturation, thus producing an erroneous d-c output.

NOTE

The instrument provides attenuation of line frequency noise superimposed on an input signal. The a-c rejection is specified as follows:

NMRR: Greater than 80 dB above one digit for a voltage of line frequency or twice line frequency on the most sensitive range, decreasing to 60 dB on the 100-millivolt and higher ranges. 1000 volts peak-to-peak maximum.
CMRR: Greater than 120 dB above one digit at dc and 40 to 100 Hz ac. 500 volts dc, 100 volts peak-to-peak ac maximum.

Proper shielding as described in paragraph 2-1,c can minimize noise pick-up when the instrument is in the presence of large a-c fields or when very sensitive measurements are being made.

3. Magnetic Fields. The presence of strong magnetic fields can be a potential source of a-c noise. Magnetic flux lines which cut a conductor can produce large a-c noise especially at power line frequencies. The voltage induced due to magentic flux is proportional to the area enclosed by the circuit as well as the rate of change of magnetic flux. For example, the motion of a 3-inch diameter loop in the earth's magnetic field will induce a signal of several tenths of a microvolt. One way to minimize magnetic pickup is to arrange all wiring so that the loop area enclosed is as small as possible (such as twisting input leads). A second way to minimize magnetic pickup is to use shielding as described in paragraph 2-1, c.

c. Shielding.

1. Electric Fields. Shielding is usually necessary when the instrument is in the presence of very large a-c fields or when very sensitive measurements are being made. The shields of the measurement circuit and leads should be connected together to ground at only one point. This provides a "tree" configuration, which minimizes ground loops.

2. Magnetic Fields. Magnetic shielding is useful where very large magnetic fields are present. Shielding, which is available in the form of plates, foil or cables, can be used to shield the measuring circuit, the lead wires, or the instrument itself.

3. Other Considerations.

a) Voltmeter Measurements. Use shielded input leads when source resistances are greater than 1 Kilohm or when long input cables are used.

b) Current Measurements (Model 160 only). On the mA and μA current ranges, no special shielding precautions need be taken. However, on the 100 nanoampere range, shielded input leads are recommended.

c) Resistance Measurements (Model 160 only). Shielding of input leads and source are recommended for measurements on the 10 megohm through 1000 megohm ranges to prevent erroneous readings.

2-2. FRONT PANEL CONTROLS.

a. The Power Switch is an ON/OFF toggle switch that controls the a-c line power to the instrument.

NOTE

The Polarity Indicator serves as a pilot light.

b. The Range Switch is a convenient single T-handle knob that controls the full scale range of the parameter to be measured.

1. The range switch dial is marked in engineering units for voltage, current, and resistance, that is mV, V (Voltage), nA, µA, mA (Current) and Ω, kΩ, MΩ (Resistance). For each parameter, rotating the knob clockwise switches to the less sensitive range.

2. The voltage sectors of the Range Switch are designated in millivolts (mV) and volts (V) for full scale ranges from 1 millivolt to 1000 volts. A full stop at the 1000 volt range prevents inadvertant switching to the nanoampere ranges with clockwise switch rotation.

3. The resistance (ohms) sectors of the Range Switch (Model 160 only) are designated in ohms (Ω), kilohms (KΩ), and megohms (MΩ) for full scale ranges from 100 ohms to 1000 megohms.

4. The current (amperes) sectors of the Range Switch (Model 160 only) are designated in nanoamperes (nA), microamperes (µA), and milliamperes (mA), for full scale ranges from 100 nanoamperes to 1000 milliamperes.

c. Digital Display. The digital display uses three full digits plus an overrange "1".

2-3. REAR PANEL CONTROLS.

a. The 117-234 Volt Switch sets the instrument for either 117 or 234V rms a-c line power at 50 or 60 Hz.

NOTE

> The front panel Power Switch is fused for both 117 and 234V operation. The fuses are installed on printed circuit board PC-254 and can be serviced by removing the top cover. The rear panel 117-234 Volt Switch connects either a 1/4 A (FU-33) or 1/2 A (FU-35) fuse for the selected line voltage.

b. The ZERO Control provides fine zero adjustment (usually required only for extreme changes of ambient temperature). This adjustment requires a screwdriver or similar tool.

2-4. PRELIMINARY OPERATING PROCEDURES.

a. Check the 117-234V Switch for the proper a-c line voltage.

b. Connect the line cord to either 117 or 234V a-c power line.

c. Set the Power Switch to ON. Allow a 30 minute warmup period for measurements on 10 mV and lower ranges.

2-5. VOLTMETER OPERATION.

a. The instrument can be conveniently used for d-c voltage measurements from ±1 microvolt to ±1000 volts by connecting the source to the front panel binding post terminals.

b. Overload Recovery. The instrument will recover from 300-volt overloads within five seconds on the 1 mV range. Up to 1000 volts peak may be applied momentarily on any range without damaging the instrument.

c. Input resistance is 10 megohms on the 10 millivolt and higher ranges, 1 megohm on the 1-millivolt range. For 10 mV and higher ranges, a 1000 ohm source resistance will introduce only 0.01% error. To maintain rated accuracy on the 1 mV range, the source resistance should not exceed 100 ohms.

d. The instrument low terminal can be floated ±500 volts above CASE ground for voltage measurements. Refer to paragraph 2-9 for complete instructions.

e. The Model 1601 AC/DC Probe permits convenient a-c voltage measurements from 0.1 volt to 250 volts rms over a span of 45 Hz to 45 kHz. A probe-mounted switch provides convenient selection of a-c or d-c operation without disconnecting the probe. Therefore, the probe may be permanently attached.

2-6. AMMETER OPERATION (Model 160 only).

a. The Model 160 can be conveniently used for d-c current measurements from ±0.1 nanoampere to ±1 ampere with 100% overranging on all ranges.

b. Connect the input terminals so as to place the Multimeter in series with the current to be measured.

c. The current accuracy is specified as ±0.2% of reading, ±1 digit on all ranges. Since the accuracy is specified at the input terminals, the loading effects as shown in Figure 4 should be considered. Refer also to Table 2-1 for resistance and sensitivity on each range.

d. The Model 160 low terminal can be floated ±500 volts above CASE ground for current measurements. Refer to paragraph 2-9 for complete instructions.

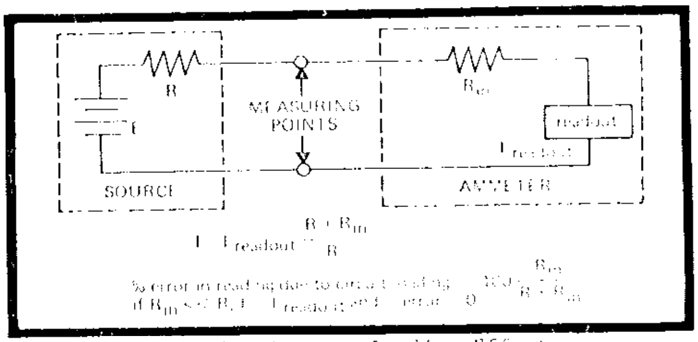


FIGURE 4. Ammeter Loading Effects.

TABLE 2-1.

Full Scale Range Amperes	Shunt Resistor Ohms (R_{in})	Sensitivity
1×10^{-7}	10^5	10 mV
1×10^{-6}	10^4	10 mV
1×10^{-5}	10^3	10 mV
1×10^{-4}	10^2	10 mV
1×10^{-3}	10	10 mV
1×10^{-2}	1	10 mV
1×10^{-1}	.1	10 mV
1	.1	100 mV

2-7. OHMMETER OPERATION (Model 160 only).

a. The Model 160 can be conveniently used for resistance measurements from 0.1 ohm to 2000 megohms by connecting the unknown resistor across the front panel binding post terminals.

b. Voltage across the unknown is 100 millivolts at full-scale with 1.5 volts maximum into an open circuit. Thus the current through the unknown is determined by dividing the 100 millivolts by the full scale resistance.

c. Maximum overload across the input terminals is 20 volts momentary and 1 volt continuous.

d. Accuracy is specified as shown in Table 2-2.

TABLE 2-2.

Full Scale Range	Decimal Point Position	Accuracy of Reading*
100 Ω	XX.X	±0.3% ±0.1 Ω
1 KΩ	.XXX	±0.3%
10 KΩ	X.XX	±0.3%
100 KΩ	XX.X	±0.3%
1 MΩ	.XXX	±0.3%
10 MΩ	X.XX	±0.3%
100 MΩ	XX.X	±10%
1000 MΩ	XXX	±50%
		*(±1 digit on all ranges.)

2-8. DIGITAL DISPLAY OPERATION.

a. Voltmeter Digital Display.

1. When the Range Switch is placed in Voltage positions 1 mV through 1000V, the digital display indicates the actual voltage measured.

2. The Range Switch is designated in convenient engineering units, mV (millivolts) and V (volts) with the decimal point automatically positioned in the display.

3. The full-scale voltage range is determined by the Range Switch. Refer to Table 2-3 for the full-scale voltage ranges available.

TABLE 2-3.

Full Scale Range Volts	Decimal Point Position	Range Switch Designation
1×10^{-3}	.XXX	mV
1×10^{-2}	X.XX	mV
1×10^{-1}	XX.X	mV
1	.XXX	V
10	X.XX	V
100	XX.X	V
1000	XXX	V

4. An overrange display up to a maximum of 1999 is provided by an overrange "1" indicator as shown in Table 2-4.

NOTE

The maximum continuous input voltage is ±1000 volts on the 1000 volt range.

For an input greater than 1999, all digits will be blanked except the overrange "1" indicator. The polarity indicator will remain lighted indicating the correct polarity. To remove an overload condition, change the Range Switch to a less sensitive position or decrease the input signal magnitude.

TABLE 2-4.

Input Volts	Digital Readout	Range Switch Designation
1.999×10^{-3}	1.999	mV
1.999×10^{-2}	19.99	mV
1.999×10^{-1}	199.9	mV
1.999	1.999	V
19.99	19.99	V
199.9	199.9	V
1000	1000	V

b. Ammeter Digital Display (Model 160 only).

1. When the Range Switch is placed in Amperes positions 100 nA through 1000 mA, the Multimeter digital display indicates the voltage across a calibrated, self-contained resistor. The Range Switch automatically selects the calibrated range resistor for current measurements from 1×10^{-7} to 1 ampere full scale.

2. The Range Switch is designated in convenient engineering units, nA (nanoamperes), µA (microamperes) and mA (milliamperes) with the decimal point automatically positioned in the display.

3. The full-scale current is determined by the Range Switch. Refer to Table 2-5 for the full-scale current ranges available on the Model 160.

TABLE 2-5.

Full Scale Range Amperes	Decimal Point Position	Range Switch Designation
1×10^{-7}	XX.X	nA
1×10^{-6}	.XXX	μA
1×10^{-5}	X.XX	μA
1×10^{-4}	XX.X	μA
1×10^{-3}	.XXX	mA
1×10^{-2}	X.XX	mA
1×10^{-1}	XX.X	mA
1	XXX	mA

4. The overranging feature of the instrument permits 100% overrange with a 1999 maximum display using all four digits. An input greater than 1999 will cause a blanking of the three righthand readouts the same as for voltage measurements.

c. Ohmmeter Display (Model 160 only).

1. When the Range Switch is placed in Ohms positions 100 Ω through 1000 MΩ, the Multimeter digital display designates the voltage across the unknown resistor with a fixed current applied.

2. The Range Switch is designated in convenient engineering units, Ω (ohms), KΩ (kilohms) and MΩ (megohms) with the decimal point automatically positioned in the readout.

3. The full-scale resistance is determined by the Range Switch. Refer to Table 2-6 for the full-scale resistance ranges available on the Model 160.

TABLE 2-6.

Full Scale Range Ohms	Decimal Point Position	Range Switch Designation
1×10^{2}	XX.X	Ω
1×10^{3}	.XXX	KΩ
1×10^{4}	X.XX	KΩ
1×10^{5}	XX.X	KΩ
1×10^{6}	.XXX	MΩ
1×10^{7}	X.XX	MΩ
1×10^{8}	XX.X	MΩ
1×10^{9}	XXX	MΩ

4. The overranging feature of the instrument permits 100% overrange with a 1999 maximum display using all four digits. An input greater than 1999 will cause a blanking of the three righthand readouts the same as for voltage measurements.

2-9. FLOATING OPERATION.

a. The low terminal can be floated above CASE ground by removing the shorting link between the LO and CASE. Isolation from circuit ground to chassis ground is greater than 100 megohms shunted by less than 0.02 microfarad. Circuit ground may be floated up to ±500 volts with respect to chassis ground in the voltage and current modes.

b. When the instrument is used for off-ground voltage or current measurements, the low terminal is at floating potential. The instrument case ground should be connected to earth ground through the CASE TERMINAL on the front panel. The shorting link should be disconnected so that LO to CASE is floating.

2-10. ANALOG OUTPUT. The instrument has an analog output of ±1 volt (not inverting) at up to 1 milliampere for recording purposes. For off-ground operation, the analog ±1 volt OUTPUT should not be connected unless an external recorder is capable of floating at ±500 volts with greater than 100 megohms isolation as the Keithley Model 370 recorder.

2-11. ZERO ADJUSTMENTS.

a. Short the input terminals with a low thermal connection - preferably a short copper wire or clip leads.

b. Set the front panel Range Switch to the 1 mV range.

c. If the digital display does not indicate zero, use the rear panel ZERO Control to adjust the instrument. Zero is indicated by flashing ± polarity lights.

d. Set the Range Switch to voltage positions 1 mV to 1000V while checking the readout so that zero is indicated on all ranges.

NOTE

If there is an off zero reading on the 1 volt range, it will be necessary to adjust the CURRENT OFFSET ADJ on the underside of the chassis. Refer to Figure 13.

e. Set the Range Switch to Ohms positions 1000 MΩ to 100 Ω while checking the readout so that zero is indicated on all ranges (Model 160 only).

NOTE

If clip leads are used on the input terminals, the lead resistance may be indicated on the 100 Ω range since the last digit sensitivity is 0.1 Ω per digit.

f. Set the Range Switch to Amperes positions 1000 mA to 100 nA while checking the readout so that zero is indicated on all ranges (Model 160 only).

g. Remove the short circuit at the input terminals.

1. Volts Ranges. The instrument will normally read off zero a small amount on the 1 mV through 100 mV ranges because of sensitivity to random noise. The readout should remain at zero on the ranges 1V through 1000V.

2. Ohms Ranges (Model 160 only). All Ohms ranges should indicate a readout overload where all digits except a "1" in the overrange position are blanked.

The + polarity indicator should also be lighted.

3. Amperes Ranges (Model 160 only). All current ranges should indicate a zero readout.

h. After the preceding checkout is made, the instrument should be useable for all measurements with no further adjustments necessary.

2-12. DIGITAL OUTPUTS AND EXTERNAL CONTROLS.

a. General.

1. The Model 1602 Digital Output Kit provides optional BCD outputs and controls.

2. Included is a 50-pin PRINTER/CONTROL Connector (receptacle) for mounting on the instrument rear panel.

3. An output buffer card plugs into a prewired connector on the chassis for either factory or user installation. Buffer card replaces PC-255 interconnecting card.

b. Output Codes and Levels.

1. The PRINTER/CONTROL Outputs are Binary Coded Decimal (BCD) Signals with 1-2-4-8 standard code.

2. The standard signal levels are as follows:

Output Logic "1" > +5 volts with less than 100 microamperes leakage.
Output Logic "0" < +0.5 volts with +50 milliamperes maximum allowable current.

3. The Buffer Stages utilize "Open Collector" output transistors. Therefore, the user must supply a pull-up resistor R and external voltage V_{EXT} for each buffered output as shown in Figure 5.

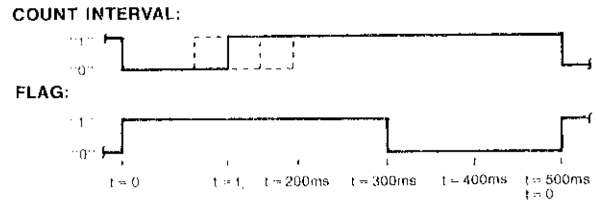
c. Output Information.

The Model 1602 Digital Output Kit provides various BCD outputs and controls as described in Tables 2-7 and 2-8.

TABLE 2-7.

specifications, model 1602

DIGITAL OUTPUT: BCD (1, 2, 4, 8) open-collector logic (Motorola MC858P) represents each of 3 digits, overrange digit, overload ("1"), polarity (+ = "1"), and decimal position (2 bit code).
TIMING OUTPUTS: Timing for one Conversion Cycle.



t_1 proportional to display, 100 ms = full scale, 200 ms max.
CLOCK: Internal clock pulses (10 kHz count rate).

REQUIRED CONTROL LOGIC LEVEL:
OPEN CIRCUIT > 4 kilohms* or + 2.1 to + 12 volts.
CLOSURE < 0.5 volt while sinking 7 milliamperes current.
*Pull-up provisions permit lower resistances to be used.

OUTPUT LOGIC LEVELS:
OUTPUT LOGIC STATE "1" = open transistor collector to ground with less than 100 microamperes leakage. + 6 volts maximum allowable applied voltage.
OUTPUT LOGIC STATE "0" = transistor switch closure to ground with less than 0.5 volt saturation voltage. + 35 milliamperes maximum allowable current.

REMOTE CONTROLS:
STROBE: Closure to ground sets logic states for data transfer. Open circuit to ground causes all output lines except "Flag" to be in logic state "1"
HOLD: Closure to ground retains result of last conversion in both the BCD output and display and places "Flag" in logic state "1".

CONNECTORS:
OUTPUT: 50-pin Amphenol Micro-Ribbon type 57-40500. Mating connector supplied.

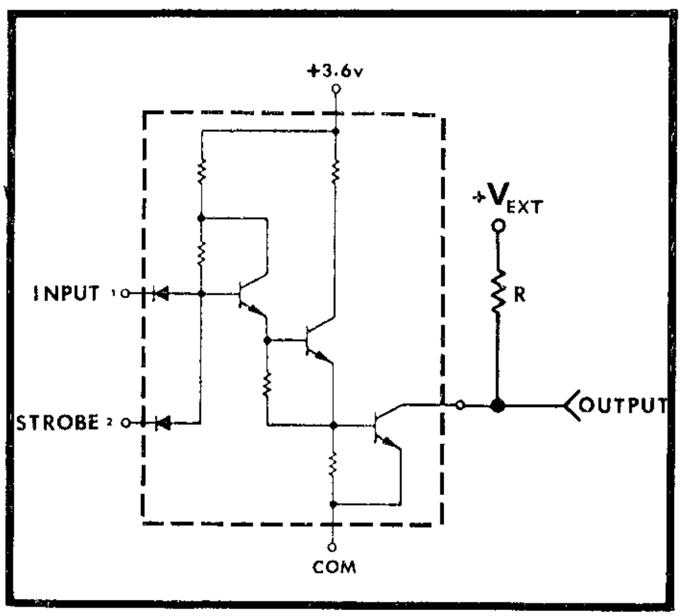


FIGURE 5. Model 1602 Output Buffer Stage.

TABLE 2-8.
Model 1602 PRINTER/CONTROL Connector Pin Identification

Pin No.	Output	Function	Pin No.	Output	Function
1	1×10^0	Data	26	Common	---
2	2×10^0	Data	27	Common	---
3	4×10^0	Data	28	Blank	---
4	8×10^0	Data	29	10 KHz	Clock
5	1×10^1	Data	30	Blank	---
6	2×10^1	Data	31	Blank	---
7	4×10^1	Data	32	Blank	---
8	8×10^1	Data	33	Blank	---
9	1×10^2	Data	34	Blank	---
10	2×10^2	Data	35	Blank	---
11	4×10^2	Data	36	Blank	---
12	8×10^2	Data	37	Blank	---
13	1×10^3	Data	38	Blank	---
14	+ = Logic "1"	Polarity	39	Blank	---
15	1×10^0	Decimal Point	40	Blank	---
16	2×10^0	Decimal Point	41	Blank	---
17	Blank	---	42	Blank	---
18	Logic "1"	Overload	43	Blank	---
19	Blank	---	44	Vcc?	Do not use
20	Count Interval	See Table 2-7.	45	Blank	---
21	Blank	---	46	Blank	---
22	Blank	---	47	Hold	See Table 2-7.
23	Flag	See Table 2-7.	48	Blank	---
24	Common	---	49	Strobe	See Table 2-7.
25	Common	---	50	Blank	---

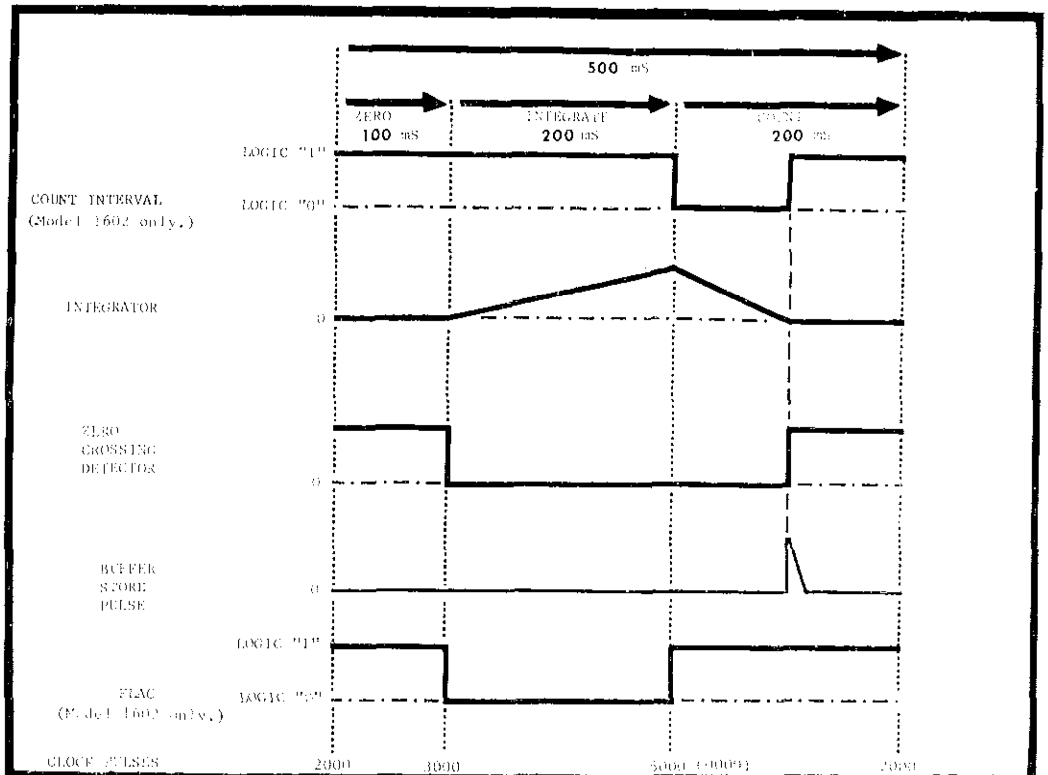


FIGURE 6. Timing Diagram.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL.

a. The basic digital voltmeter consists of two sections packaged together in one chassis: 1) analog amplifier 2) analog to digital converter.

b. The analog amplifier is a variable-gain chopper amplifier.

c. The analog-to-digital converter is a dual-slope integrating type converter with two readings/second conversion rate. A BCD output and external control options are available when used with the Model 1602 Digital Output Kit.

3-2. ANALOG AMPLIFIER OPERATION. The analog amplifier is shown in the simplified block diagram, Figure 7.

a. Voltage Amplifier Operation. The amplifier has a full-scale sensitivity variable from 1 millivolt to 100 millivolts. Above 100 millivolts the input signal is divided down to the 100 mV full-scale level. The signal flow path can be described as follows: An input signal applied at the Input High terminal is attenuated by a resistor divider. The signal is filtered and applied to a modulator circuit. The a-c signal is then amplified and demodulated. A final variable gain d-c amplifier provides a d-c signal for the Analog output and A-to-D converter. The output is fedback to provide overall gain stability.

1. Input Resistor Divider. The input signal is attenuated by a divider network for RANGE Switch 1V, 10V, 100V and 1000V full-range positions.

2. Filter Network. The filter network provides filtering of Normal Mode noise.

3. Modulator Circuit. This circuit converts the low level d-c input to an a-c signal.

4. A-C Amplifier. This circuit uses negative feedback to provide gain accuracy and stability.

5. Demodulator Circuit. The demodulator is synchronized with the input modulator. It converts the amplified a-c signal to a d-c signal.

6. D-C Amplifier. This amplifier provides additional gain to drive the A to D converter and Analog recorder output.

7. Chopper Drive Circuit. This circuit generates the drive voltage for the mod-demod choppers.

NOTE

The circuit description for the ammeter and ohmmeter functions apply only for the Model 160 Digital Multimeter. Refer to Figure 8.

b. Ammeter Operation (Model 160 only). The instrument operates as an ammeter by detecting the voltage drop across a known shunt resistor. The sensitivity and resistor values are shown in Table 3-1.

c. Ohmmeter Operation (Model 160 only). The instrument provides a known constant current which is applied to the unknown resistance. The voltage output is proportional to the resistance measured.

3-3. ANALOG AMPLIFIER CIRCUITRY.

a. General. The circuits described in this section are located on the various sub-assemblies listed below and in Table 7-3 of Section 7.

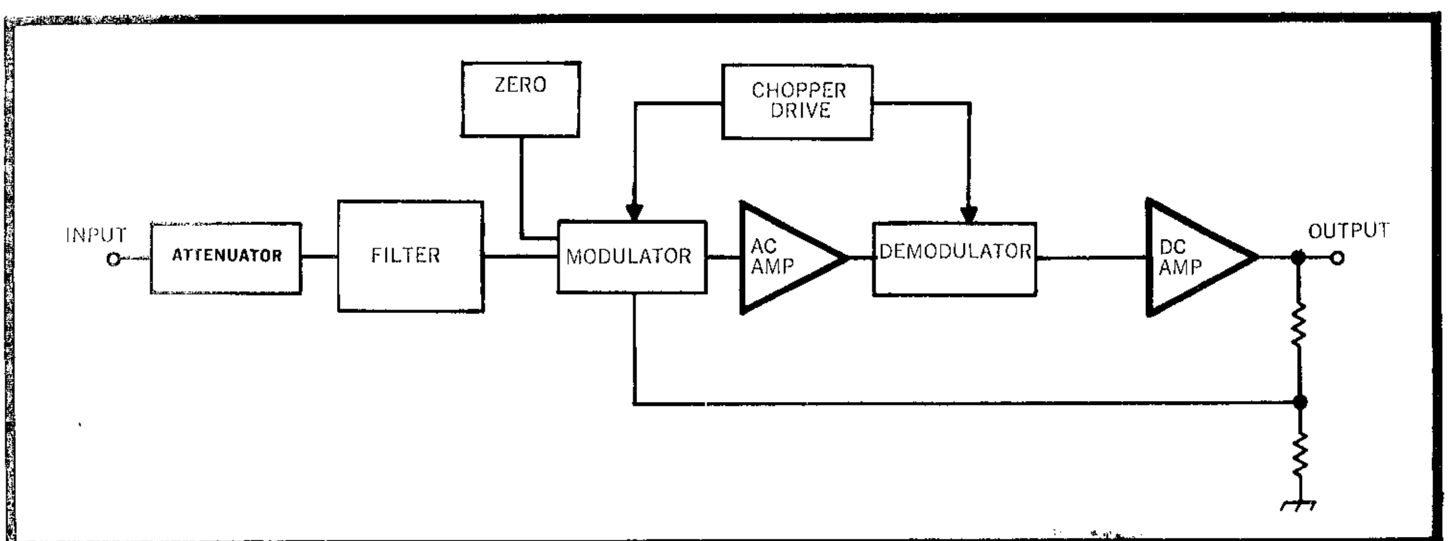


FIGURE 7. Analog Amplifier Block Diagram.

TABLE 3-1.

Full Scale Range Amperes	Shunt Resistor Ohms	Voltage Sensitivity
1×10^{-7}	10^5	10 mV
1×10^{-6}	10^4	10 mV
1×10^{-5}	10^3	10 mV
1×10^{-4}	10^2	10 mV
1×10^{-3}	10	10 mV
1×10^{-2}	1	10 mV
1×10^{-1}	.1	10 mV
1	.1	100 mV

1. Mother Board, PC-254.

2. Analog Amplifier, PC-251.

3. Connector Board, PC-255.

b. Voltage Amplifier Circuit. The voltage amplifier circuit is composed of a chopper amplifier with fractional feedback. The feedback resistors are selected by the Range Switch so as to maintain low feedback current. The feedback network, composed of resistors R513, R516, R519 and R703, is formed from the output of the d-c amplifier to the low side of the modulator.

1. Input Resistor Divider. The chopper amplifier has a minimum gain of 10 and a full-scale output voltage of ±1 volt. Thus it is necessary to attenuate signals greater than 100 millivolts to prevent saturation of the chopper amplifier. The input attenuator resistors R101, R102, and R103 through R111 are switched by the Range Switch S101.

2. Filter Network. The filter network provides NMRR as specified for line frequency voltages (either 50 or 60 Hz). The filter is a 2-section RC ladder filter composed of resistors R501 and R502 and capacitors C501 and C502.

3. Modulator Circuit. The modulator circuit utilizes MOS FET chopper switches to provide low offset voltage and current, low input noise, and low drive power. A series-shunt chopper configuration maintains high input impedance. Transistors Q701 and Q702 form the chopper.

4. A-C Amplifier. The a-c amplifier is a low noise amplifier composed of transistors Q703 and Q704 and an integrated circuit QA702.

5. Demodulator Circuit. The demodulator utilizes an FET shunt switch which is synchronized with the input modulator. The FET Q705 switching action creates a rectified d-c signal with a large chopper frequency a-c component. Resistors R717 and R718 with capacitor C710 provide a filtering action of the demodulated signal.

6. D-C Amplifier. The d-c amplifier utilizes an integrated circuit QA703 to provide d-c gain and capability of up to 1 milliampere at the analog output.

7. Chopper Drive Circuit. The chopper frequency signal is derived from the Oscillator circuit. Transistors Q706 and Q707 provide opposite phase square waves used to drive MOS-FET chopper transistors Q701 and Q702. Transistor Q708 provides a demodulator drive signal for FET Q705 which is synchronous with the modulator drive signals. Flip-Flop circuits QA701A and QA701B divide down the 909.09 Hz from the oscillator by 4:1 for a chopper drive of approximately 227.3 Hz.

8. Zero Adjustment Circuit. This circuit provides

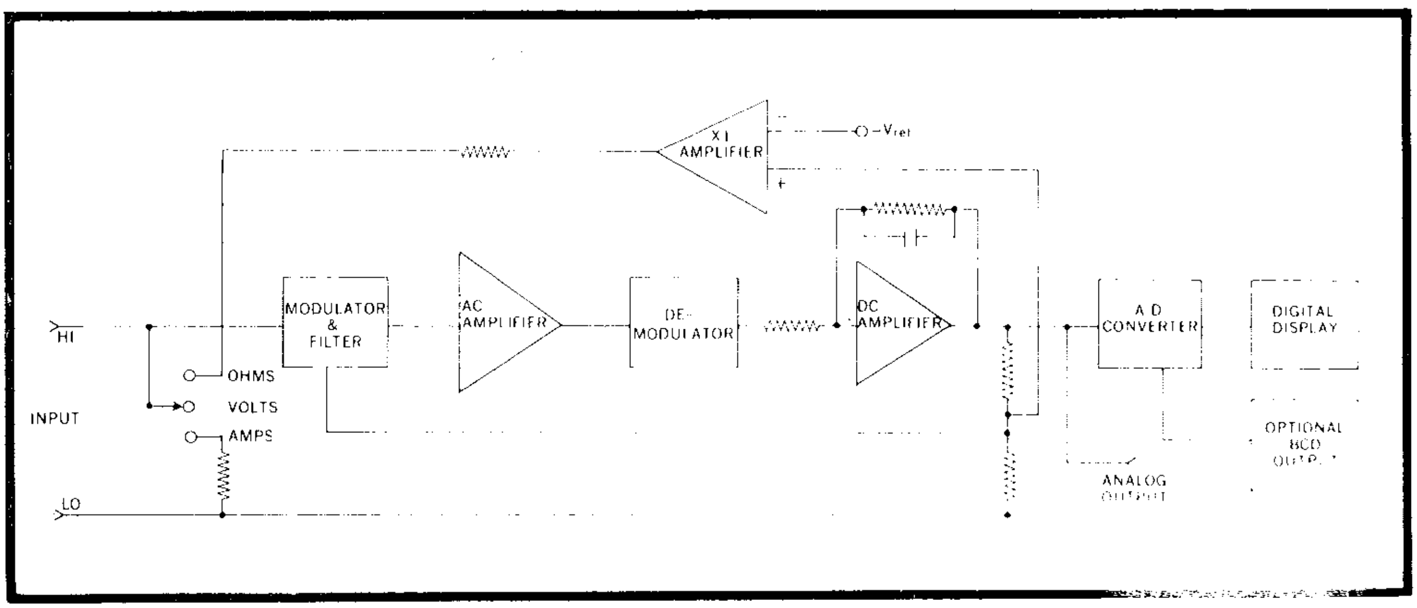


FIGURE 8. Multimeter Block Diagram.

limited adjustment of zero offset. It is composed of potentiometer R505 and resistors R503, R504, R506, R508 and R509.

c. Ammeter Circuit (Model 160 only). The instrument utilizes the chopper amplifier described above with various Range shunt resistors R116 through R122. The chopper amplifier functions as a voltage amplifier to provide an analog recorder output and drive for the A-to-D converter.

d. Ohmmeter Circuit (Model 160 only). The instrument provides a constant-current using a voltage reference amplifier and series resistor R. The reference voltage E limits the open-circuit voltage to 1.5 volts maximum. The voltage reference is composed of integrated circuit QA704 and reference diode D702.

3-4. ANALOG-TO-DIGITAL CONVERTER OPERATION.

a. General.(refer to Figure 9 for a detailed block diagram of the A-to-D converter) The analog-to-digital converter uses a dual slope integration technique which has inherent line frequency noise rejection. The analog signal is applied to the integrator for 200 milliseconds which is an even multiple of the line frequency of 50 or 60 Hz. The analog signal is then removed from the integrator input. The voltage on the integrator is then driven to zero to complete the voltage-to-time conversion. The time interval to reach a "Zero Crossing" is counted and displayed on the "Digital Readout" in proportion to the original analog signal. Before the sequence is repeated, the integrator is rezeroed. (Refer to the Timing Diagram shown in Figure 6.)

b. The A-to-D Converter is composed of eight major circuits.

1. Oscillator or Clock
2. BCD Counter
3. Program/Decoder
4. Integrator
5. Zero Crossing Detector
6. Buffer/Storage Register
7. Decoder/Driver
8. Numerical Readout.

c. Oscillator or Clock. The Oscillator produces pulses at a rate of 10 kilohertz for either 50 or 60 Hz operation.

d. BCD Counter. The BCD Counter counts the Clock pulses with a total range of 5000 counts. The Counter is composed of 4 individual counters designated 1, 10, 100, and 1000.

1. The "1", "10", and "100" counters have a capacity of ten counts each.

2. The "1000" counter has a capacity of five counts.

3. The total capacity of all four counters is 5000 counts.

e. Program/Decoder. The Program/Decoder circuit produces event commands to control the overall sequence of events for a complete A-to-D conversion.

TABLE 3-2.

Command	Function
2	ZERO
3,4	INTEGRATE
0,1	COUNT

f. Integrator. The Integrator circuit operation is composed of three periods (refer to Figure 6).

1. Zero Period. During this period the integrator amplifier is zeroed by a feedback rezeroing circuit as shown in Figure 10. Switches S_a, S_b, and S_d are open to prevent integrator charging.

2. Integration Period. During this period switches S_b, S_c, and S_d are open. Switch S_a is closed to permit charging by the analog voltage for an even multiple of the line frequency.

3. Discharge Period. During this period, switch S_a is open to prevent further charging by the analog signal. Either switch S_c or S_d is closed to drive the Integrator voltage to zero. A reference current of opposite polarity to the input current is applied through either switch S_c or S_d. The Discharge Period ends when the Zero Crossing Detector circuit detects a zero Integrator output.

g. Zero Crossing Detector. The Zero Crossing Detector circuit provides a "High" or "Low" level output depending on the polarity of the detected input. Refer to Table 3-3 for a description of voltage outputs of the Zero Crossing Detector.

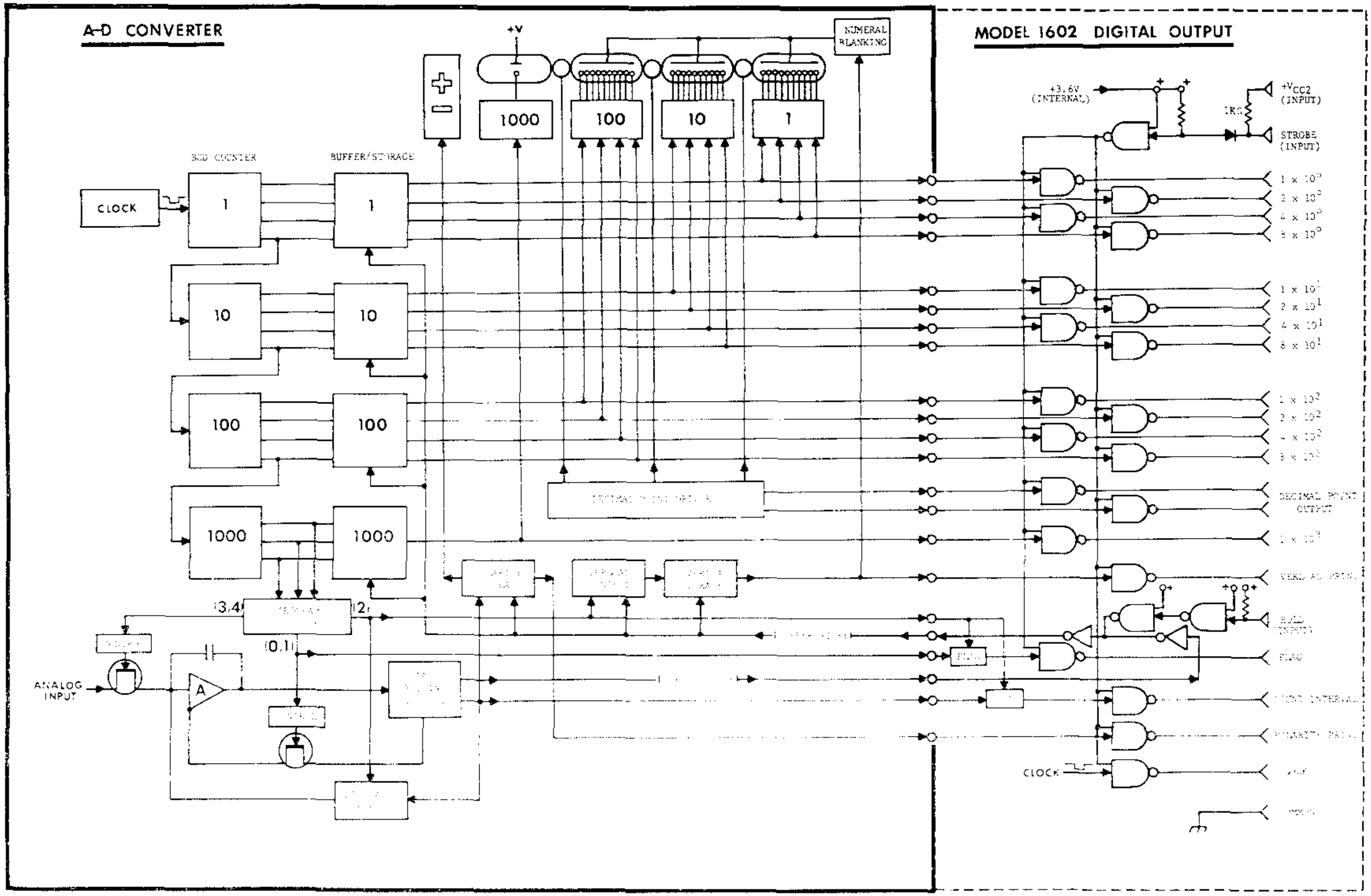
TABLE 3-3.
Zero Crossing Detector Output Levels.

M	N	B	C
0V	-0.5V	+1.5V	0V
0V	+3.5V	0V	+1.5V

h. Buffer/Storage Register. The Buffer/Storage Register is composed of "flip-flops" arranged to copy the states of the various BCD counters. The Buffer/Storage Register requires a Buffer Store command before any information can be transferred. The "flip-flop" circuits provide coded information for Decoder/Driver and the BCD outputs.

i. Decoder/Driver. The Decoder/Driver circuit decodes the BCD information from the Storage Register into ten-line decimal code. The Driver circuit then drives the proper numeral in each of the Numerical Readout tubes.

j. Numerical Readout. The Numerical Readout con-



Block Diagram
FIGURE 9. Analog-to-Digital Converter and
Model 1602 Output Buffer

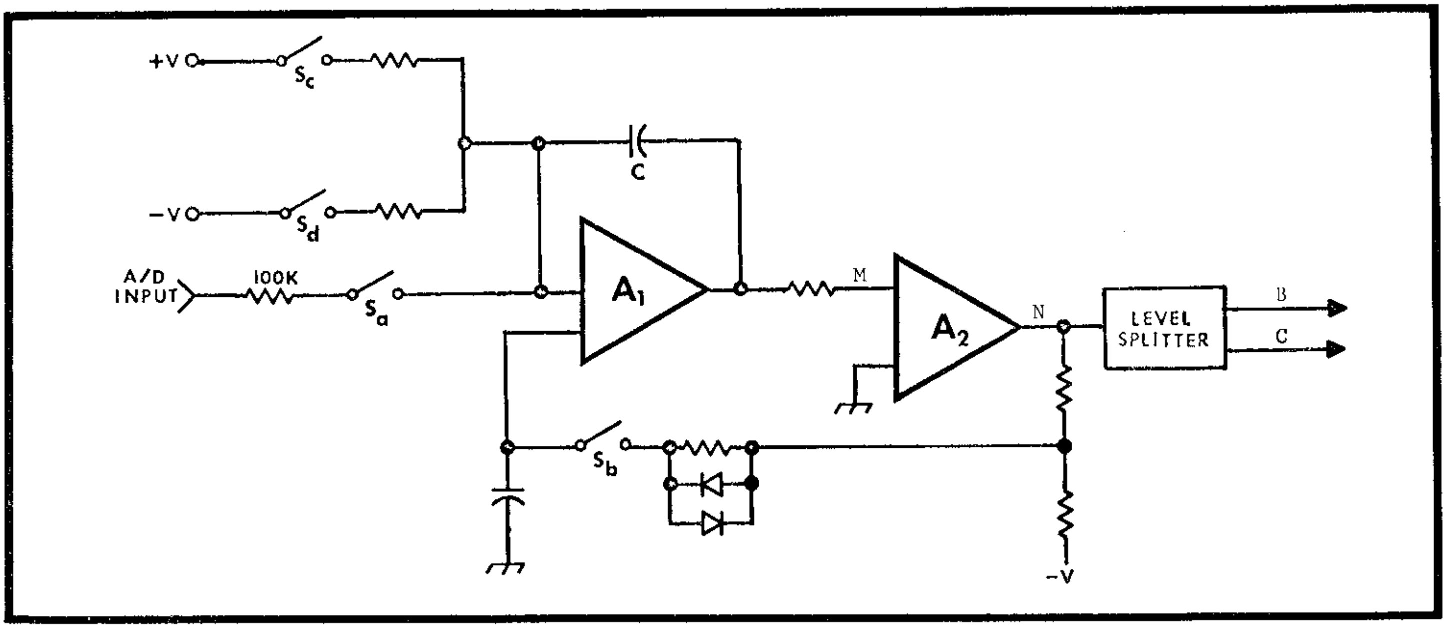


FIGURE 10. Integrator Block Diagram.

sists of four numerical indicators and one polarity indicator driven by the Decoder/Driver, Polarity and Overload Drivers.

k. Summary of Operation. The operation of the A-to-D Converter can be described by considering a typical conversion cycle.

1. The Clock provides pulses at a rate of 10 kilohertz.

2. The BCD Counter serves as a master timing control for the A-to-D conversion cycle. The timing is accomplished by the "1000" counter which has five coded states, namely 0, 1, 2, 3, and 4.

3. The Program/Decoder controls the sequence of commands based on the coded states from the BCD Counter. The decoded commands are described as shown in Table 3-2. The "2" command initiates the integrator ZERO period which removes any residual charge on the integrator capacitor. The "3,4" command initiates the INTEGRATE period which permits an integration of the analog signal. At the end of the INTEGRATE period, the "0,1" command initiates the COUNT period.

4. When the "3,4" command is given, the integrator is charged by the analog signal for a period of 200 milliseconds.

5. When the "0,1" command is given, the analog signal is removed and the integrator output is driven to zero by a reference current. The Zero Crossing Detector senses a zero crossing of the Integrator output and removes the reference current. The Detector provides outputs as shown in Table 3-3. The +1.5 volt levels are provided for control of the Integrator and Polarity Storage Register. A pulse command is also produced to initiate a Buffer/Store.

6. When the Buffer/Store command is given, the Buffer/Storage Register copies the BCD Counter states at that instant of time. The BCD coded information in the Register is then available for the Decoder/Driver and external printout.

7. The Decoder/Driver decodes the Buffer/Storage output and drives the Numerical Readout for a digital display.

8. The conversion cycle is completed when the BCD Counter reaches 2000 counts and the Program/Decoder provides a "2" command to initiate a new conversion cycle.

3-5. ANALOG-TO-DIGITAL CONVERTER CIRCUITRY.

a. General. The circuits described in this section are located on the various sub-assemblies listed below and in Table 7-3 of Section 7.

1. Tube Board, PC-248
2. Integrator Board, PC-250
3. Oscillator Circuit, PC-254.

b. Oscillator Circuit. The Oscillator circuit is located on a portion of printed circuit assembly PC-254. Refer to schematic diagram P/N 24691E for this circuit. Transistors Q601 and Q602, capacitors C601, C602, and C603 and resistors R606 and R607 form an oscillator. Potentiometer R605 is used to provide internal screwdriver adjustment of the oscillator frequency. Transistor Q603 serves as an emitter-follower to reduce output impedance. The chopper drive is obtained by dividing down the oscillator frequency from 10 Kilohertz to 909.09 Hz using integrated circuit QA801, a 11:1 Divider circuit.

c. Tube Board. The Tube board contains portions of five major circuits: the BCD Counter, the Program/Decoder, the Buffer/Storage Register, the Decoder Driver, and the Numerical Readout.

1. BCD Counter.

a) The Decade Counters designated "1", "10", and "100" are composed of individual integrated circuit modules QA308, QA309, and QA310 respectively.

b) The "1000" Counter is composed of integrated circuit modules QA301A, QA302A, and QA302B.

2. Program/Decoder. This circuit is composed of gates QA304A, QA304C, QA305 (B, C, D, E, F) QA306A and QA307B.

3. Buffer/Storage Register. This circuit is composed of integrated circuit modules QA311, QA312, and QA313.

4. Decoder Driver. This circuit is composed of integrated circuits QA314, QA315, and QA316.

5. Numerical Readout. V301, V302, V303 are Readout Tubes for Units, Tens, and Hundreds respectively.

6. Other circuits contained on the Tube Board are described as follows.

a) Overrange Indicator Circuit. This circuit is composed of integrated circuit module QA301B, transistor Q301 and overload indicator DS301.

b) Polarity Indicator Circuit. This circuit is composed of transistors Q305 and Q306 and Polarity indicator module DS302.

c) Display Rate/Hold Circuit. Gates QA303 (A, B, C, D) and QA304B, QA306B, and QA307A provide capability for Display Rate and Hold functions when used with additional Output Buffer circuits.

d. Integrator Board. The Integrator Board contains portions of three major circuits: the Integrator circuit, the Zero Crossing Detector Circuit, and the Feedback Rezeroing Circuit.

1. Integrator Circuit. (Refer to Figure 10 for identification of switches S_a, S_b, S_c, and S_d). The operation of the Integrator is controlled by the positions of switches S_a, S_b, S_c, and S_d. Switch S_a is Q401. Switch S_b is transistor Q411. Transistors Q404, Q405, Q408, Q409, and Q410 are control circuits arranged to control the proper FET switches depending on the signals at pins 12 and 13. The integrator amplifier consists of transistors Q402 and Q403 and integrated circuit QA401. The feedback capacitor is C406. Switches S_c and S_d control the current for 9-volt zener diodes D401 and D402. Resistors R403, R404, R405, R409, R410, and R411 are full-scale calibration resistors. Potentiometers R402 and R408 are internal screwdriver calibration adjustments.

2. Zero Crossing Detector Circuit. The high gain amplifier is composed of cascaded amplifiers QA402 and QA403. Diode D411 provides a 6-volt bias supply for QA403 and the output resistor network R444 and R445. The level-splitter circuit consists of diodes D414 and D415, resistors R443 and R446 and gates QA404 (A and B).

3. Feedback Rezeroing Circuit. This circuit provides rezeroing of the Integrator circuit using negative feedback from the Zero Crossing Detector output. Transistor Q411 is the equivalent of Switch S_b in Figure 10. Resistor R434 and capacitor C414 form a feedback-loop filter circuit. Diodes D407 and D408 provide fast response for large input offsets due to input overloads.

3-6. POWER SUPPLIES.

a. ±15 Volt Supply.

1. The ±15 volt supplies tap a-c power from a secondary winding of transformer T201. Diodes D203 (A, B, C, and D) and capacitors C204, C205, C209, and C210 compose a full-wave rectifier with filtering.

2. The +15 volt regulator circuit utilizes integrated circuit QA201 which drives transistor Q206 to series regulate the output voltage. Potentiometer R209 provides calibration adjustment of the +15 volt supply. (Internal screwdriver adjustment).

3. Transistors Q211 and Q212 form a differential amplifier which compares the voltage at R218 with respect to low. The difference voltage is amplified by transistor Q210 and fed to Darlington transistor pair, Q207 and Q208, which series regulate the -15 volt output. Transistor Q209 limits the current output to approximately 200 milliamps.

b. +3.6 Volt Supply.

1. The +3.6 volt supply taps a-c power from a secondary of transformer T201. Diodes D201 and D202 and capacitor C201 form a full-wave rectifier with filtering.

2. Transistor Q205 amplifies the difference between the +3.6 output and a reference voltage derived from the +15 volt supply and determined by resistors R203 and R204. The difference voltage is amplified by transistor Q204 which drives a Darlington transistor pair, Q201 and Q202. The Darlington pair series regulates the +3.6 volt output.

3. Transistor Q203 limits the output current to about 3 amperes.

c. +210 Volt Output. The +210 volt supply is an unregulated voltage supply using the half-wave filtered voltage at diode D206 and capacitor C212.

d. +170 Volt Output.

1. Regulator. The +170 volts is derived from the +210 volts at emitter of Q302 which series regulates the +170V. Transistor Q303 provides a reference for the base of transistor Q302.

2. Blanking Circuit. This circuit controls the +170 voltage for the three right hand readout tubes. The "Q" output of QA307B drives the base of transistor Q304 for normal regulator operation. When an overload occurs, the "Q" output is low turning off transistor Q304. This results in a drop of the +170 volt output causing blanking of the readout tubes.

SECTION 4. ACCESSORIES

MODEL 1601 AC-DC PROBE

GENERAL. The Model 1601 is a combination ac-dc probe that enables the user to measure voltages from 45 Hz to 45 kHz when used with either the Model 160 or 163. The slide switch (S101) can be used to select either AC mode or straight-through DC Mode.

SPECIFICATIONS:

DC MODE: Straight-through probe does not alter any Model 160 or 163 specifications except: 1. 150 picofarads input capacitance, 2. 0.5 ampere maximum current, 3. 0.3 ohm resistive offset, 4. ±20 microvolts thermal offset.

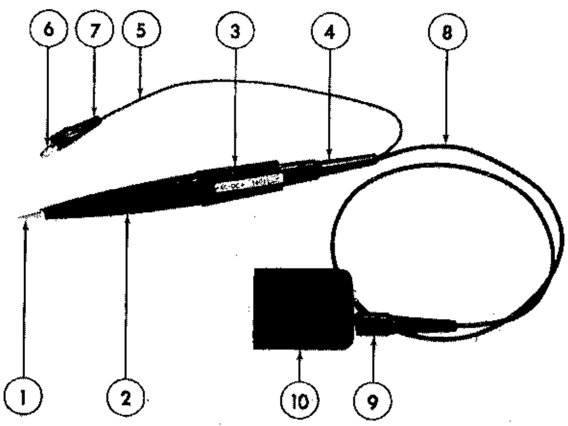
AC MODE (Voltage only):
ACCURACY (400 Hz): ±1% of reading or ±0.1 volt, whichever is greater (rms of sine wave to dc conversion).
FREQUENCY RESPONSE: -2% at 45 Hz and 45 kHz.
RANGE: 250 volts rms maximum.
MAXIMUM OVERLOAD: Peak ac plus dc bias must not exceed 400 volts.
INPUT IMPEDANCE: 0.5 megohm, shunted by less than 20 picofarads.
OUTPUT IMPEDANCE: Output must be shunted by 10.2 megohms ±1% for rated accuracy (Model 160 and 163 impedance on 1000, 100 and 10-volt ranges). 10% variation in the 10.2 megohms causes 1% additional error.

CONNECTOR: Shielded Banana Plug

DIMENSIONS, WEIGHT: 6" long x 3/4" diameter (150 x 20 mm), 3-ft. (1 m) cable, net weight 1/4 pound (0.1 Kg).

MECHANICAL PARTS LIST:

Item No.	Description	Keithley Part No.
1	Tip	24654B
2	Body, Front	24656C
3	Body, Rear	24655C
4	Strain Relief	18676B
5	Cable, Ground (13" long)	SC-33
6	Clip, Alligator (Ground)	AC-10
7	Insulator (Black)	AC-11
8	Cable (40" long)	SC-30
9	Strain Relief	18676B
10	Can Shield	25128A



ELECTRICAL PARTS LIST: (See schematic 24669C)

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.
J101	Banana Plug (2 req'd)	74970	108-750-2	BG-3
S101	Switch, AC-DC	80164	-	SW-334
C101	Capacitor, .047 μF	97419	M2W-F	C197-.047M
C102	Capacitor, 0.1 μF	13050	MW1A	C86-.1M
D101	Transistor	07263	2N3565	TG-39
D102	Transistor	07263	2N3565	TG-39
D103	Diode	04713	1N4006	RF-38
R101	Resistor, 3.92 MΩ	91637	DC-1/4	R178-3.92M
R102	Resistor, Selected in Test	07716	CEA	R88
R103	Resistor, 1 MΩ	91637	MFF-1/8	R179-1M
R104	Resistor, 100 Ω	44655	RC07	R76-100

MAINTENANCE:
Since the probe assembly should provide good service with normal handling no maintenance is usually necessary. The probe body (Items 2 and 3) is fastened together at the factory using a special solvent. Therefore the probe should not be disassembled. If repair is necessary contact the Keithley Representative in your area.

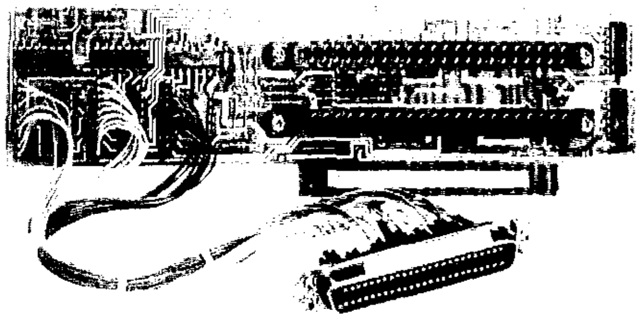
Model 1602 Digital Output

Installation: The 1602 Digital Output Option is available either factory or field installed in a Model 160 or 163.

Applications: The 1602 can be used whenever binary coded decimal outputs are needed for digital recording or computing.

Specifications: The 1602 specifications are given in Table 2-7 of the Instruction Manual.

Connections: Digital BCD outputs and controls are provided through a 50-pin receptacle (J1006) installed on the rear panel of the instrument. The mating connector is a Keithley Part No. CS-220.



Model 1603 Extender Card Kit

Description:

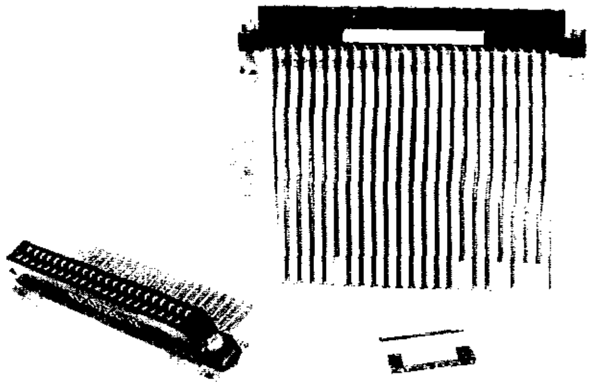
The 1603 Kit consists of two types of printed circuit board extender cards and a shorting adapter.

Parts List:

1 Extender Card, 44-pin, Keithley No. 24681C
2 " " 22-pin " " 24570B
3 Shorting Adapter, Keithley No. 24789A

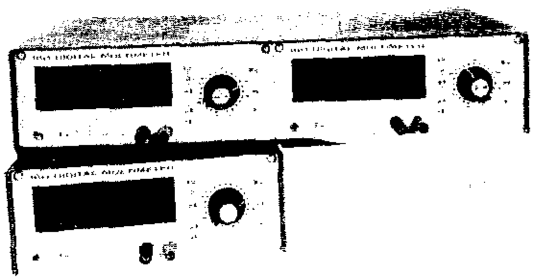
Application:

These extender cards facilitate testing and troubleshooting of Models 160 and 163. Access to all pin connections is provided. The shorting adapter is used to connect power to the instrument.



Model 1005 Rack Mounting Kit.

<u>General</u>: The Keithley Model 1005 Rack Mounting Kit has been designed for rack mounting either the Model 160 Digital Multimeter or Model 163 Digital Voltmeter. The Kit includes all necessary parts for rack mounting either one instrument or two instruments side-by-side. Rack height is 3-1/2 inches with 10-1/2 inches depth measured from the front panel.



SECTION 5. SERVICING

5-1. GENERAL. This section contains procedures for servicing the instrument in the event of a malfunction.

5-2. SERVICING SCHEDULE. This instrument requires no periodic maintenance beyond the normal care required for high-quality electronic equipment.

5-3. PARTS REPLACEMENT. Replace components using only those parts specified in the REPLACEABLE PARTS LIST or their equivalents.

5-4. ASSEMBLY

WARNING

Use care when troubleshooting an instrument connected to line power and/or with Power switch on. Whenever resistance checks are made, remove all power to the instrument and discharge power supply capacitors through a low value resistor.

a. Top Cover Assembly. To gain access to test points and adjustments on printed circuit board PC-254, remove the top cover by removing four slotted head type screws as shown in Figure 17. Refer to Figure 16 for calibration controls and test points.

b. Chassis Assembly. To gain access to the remaining printed circuit boards the following procedure should be used.

1. Remove the front panel Range knob assembly as shown in Figure 11b. Loosen the two set screws holding the switch coupler to the switch shaft using a 1/16 hex size (Allen Head) screw driver. Figure 11a shows the proper orientation of the Range knob for reassembly.

2. Remove the front panel Allen Head screws in two places as shown in Figure 11b using a 3/32 hex size screw driver.

3. Remove the rear panel Phillips head screws in two places as shown in Figure 11b.

4. Remove connector J906 which is wired to the front panel Power ON switch as shown in Figure 12. Replace connector with Shorting Adapter 24789A (from Model 1603 Extender Card Kit) which will apply power to the instrument. Caution! To turn off power to the instrument remove the Shorting Adapter.

5. Separate the circuit board assembly from the chassis as shown in Figure 12.

c. Printed Circuit Board Installation. The location of all circuit boards is shown in Figure 13. To gain access to circuit boards PC-248, PC-250, and PC-255 the following procedure should be used.

1. Remove the two Phillips head screws from the underside of PC-254 as shown in Figure 13.

2. Remove the slotted screw and nut holding PC-248 and PC-250.

3. Remove the long slotted screw and fastener as shown in Figure 13.

4. Remove the two standoffs holding PC-248 and PC-250.

5. Remove circuit board PC-255 and replace with Extender Card 24681C (from Model 1603 Extender Card Kit).

5-5. CALIBRATION CONTROLS.

a. Offset Current Adjust (R733). This control is a screw driver adjustment accessible from the bottom cover as shown in Figure 15.

b. Ohms Cal Adjust (R738). This control is a screw driver adjustment accessible from the bottom cover as shown in Figure 15.

c. DC Balance Adjust (R722). This control is an adjustment accessible from the bottom cover as shown in Figure 15. Caution! Use an insulated screw driver to avoid contacting the chassis.

d. 15V Adj (R209). This control is located on PC-254. Remove the top cover for access to the control.

e. CLOCK Adj (R605). This control is located on PC-254. Remove the top cover for access.

f. 1V, 10V, 100V, 1000V Controls (R111, R108, R106 R104). These controls are also located on PC-254.

g. +CAL, -CAL Adjust. These controls are located on PC-250.

5-6. COMPONENT LAYOUTS AND OUTLINE DRAWINGS.

a. Component Layouts. The component layouts identify all parts on the printed circuit boards using circuit designations from the schematic diagrams.

b. Outline Drawings. The outline drawings identify the various pins for integrated circuits and transistors used in this instrument. The case outlines are adapted from JEDEC standards for integrated circuit and transistor packages.

TABLE 5-2.

Trouble-Shooting Procedure

Difficulty	Probable Cause	Solution
No front panel display illumination.	Power failure	Check fuse. If blown, check for an internal short (broken wire, loose hardware, etc.). Replace fuse by removing top cover and unsoldering pig-tail fuse.
"	210V supply failure	Check 210V supply voltage on PC-254. If low, check rectifier diode D206. Replace with Keithley Part No. RF-17.
"	Line switch set at 234V with 117V line input.	Set switch to 117V.
Overload indication when input is shorted.	Analog amplifier out of balance.	Check integrated circuit QA703 on analog board PC-251. Replace with Keithley Part No. IC-2. If difficulty remains, check MOS FET transistor Q701 and Q702. Replace with Keithley Part No. TG-51. NOTE: These transistors are sensitive to static charges. Therefore, drain static charge from hands and/or tools using a foil grounding surface. Disconnect the soldering iron from power before using.
"	Transistors Q402 and Q403	Check for zero voltage level on pin 6 of integrated circuit QA401. If not at zero, replace transistors with Keithley Part No. TG-71.
"	Oscillator Circuit (Clock)	Check CLOCK frequency at CLOCK test point. Frequency should be 10 kHz ±20 Hz. If out of tolerance, recalibrate as in Section 6. If clock frequency is missing, check transistors Q601, Q602 and Q603. Replace with Keithley No. TG-62.
Ohms ranges inaccurate. (Voltage ranges are normal)	Ohms reference amplifier	Check integrated circuit QA704. NOTE: Integrated circuit may have failed due to voltage applied in ohms mode. Replace QA704 with Keithley Part No. IC-2. Also replace resistor R745 with Keithley Part No. R168-10K. Recalibrate OHMS circuit. Select R739 as necessary.
Current reading inaccurate on one range only.	Shunt resistor out of tolerance.	Replace shunt resistor for that particular range. Resistors R116 through R122.
Overrange "1" not lighted when it should indicate.	Transistor Q301 or integrated circuit QA301.	Replace transistor Q301 if open from collector to emitter (Keithley Part No. TG-67). Otherwise, replace QA301 with Keithley Part No. IC-9.
Overrange "1" lighted continuously when it should <u>not</u> indicate.	Transistor Q301 or integrated circuit QA301.	Replace as above if Q301 is shorted from collector to emitter.
Polarity signs remain lighted or do not light at all.	Transistors Q305 and Q306. Integrated circuit QA305.	Replace transistors Q305 and Q306 with Keithley Part No. TG-67. Replace QA305 with Keithley No. IC-7.
Digital readouts incorrect.	Decoder driver circuit	Replace either QA314, QA315, or QA316 with Keithley Part No. IC-3. (These integrated circuits are <u>not</u> soldered because of plug-in sockets.)
"	Decade Counter circuit	Replace either QA308, QA309, or QA310 with Keithley Part No. IC-17.
"	Buffer Storage circuit	Replace either QA311, QA312, or QA313 with Keithley Part No. IC-16.

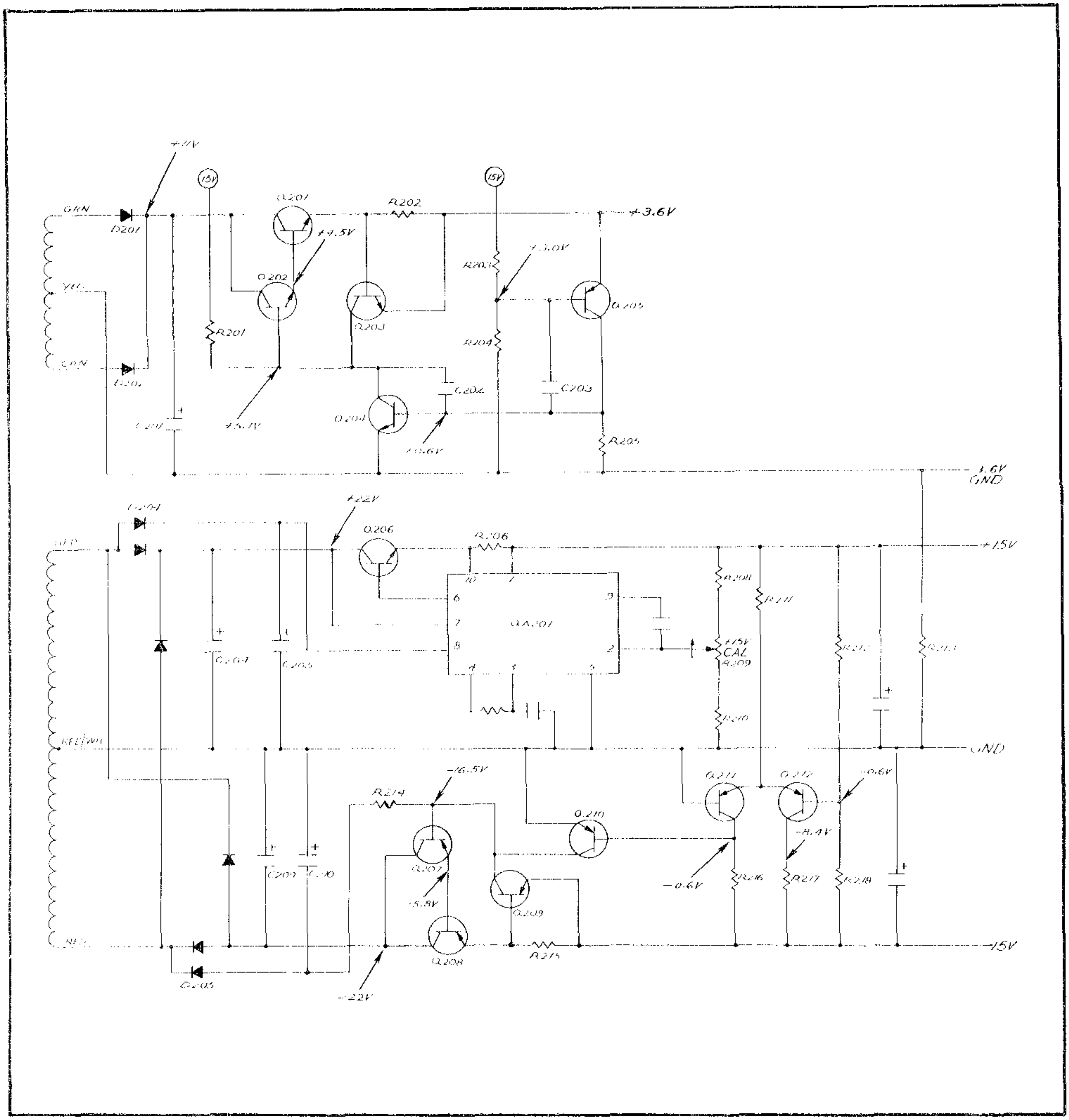


FIGURE 14. Power Supply Voltages.

SECTION 6. CALIBRATION

6-1. GENERAL. This section contains procedures for checking the instrument to verify operation within specifications.

6-2. TEST EQUIPMENT. Use test equipment recommended in Table 6-1 for accuracy verification.

6-3. PROCEDURES.

a. Preliminary.

1. Warm-up Period. With Power Switch ON, allow the instrument to warm-up for a minimum of 30 minutes.

2. Power Supply Checkout. All the power supply voltages can be measured at test points on printed circuit board PC-254 as shown in Figure 16.

TABLE 6-2.
Power Supply Voltages

Nominal Voltage	Test Point	Voltage Limits
+15.00V dc	+15V	+14.95 to +15.05
-15.0V dc	-15V	-14.6 to -15.4
+3.6V dc	+3.6V	+3.4 to +3.8
+210V dc	+210V	+205 to +230
+170V dc	+170V	+165 to +175

b. Adjustments.

1. Power Supply. The +15V supply should be adjusted for +15.00V dc ±0.050V using potentiometer R209 on PC-254 as shown in Figure 16. The -15V and +3.6V supplies cannot be adjusted since the +15V supply is used as a reference voltage.

2. Clock Frequency. Measure the clock frequency at the "CLOCK" test point on PC-254 as shown in Figure 16. The frequency should be adjusted for a nominal 10 kHz, ±20 Hz using potentiometer R605 on PC-254 as shown in Figure 16.

3. Zero Adjust. Place a shorting wire across the Input Terminals (red and black). Connect voltmeter (A) to the analog OUTPUT (J103). Adjust the rear-panel ZERO Control (R505) for zero on the 1 mV range.

4. The output should be adjusted within ±1 millivolt.

5. DC Balance. With voltmeter (A) connected to the OUTPUT adjust the OFFSET CURRENT ADJ Control (R733) for zero on the 1V range. The OUTPUT should be adjusted within ±1 millivolt on the 1mV range and within ±0.1 millivolt on the 1V range. Repeat the adjustments of R505 and R733 until the OUTPUT is within tolerance on both the 1 mV and 1V ranges simultaneously.

NOTE
If the OUTPUT cannot be adjusted to within ±1mV on the 1mV range, adjust zero pot R505 to approx. midrange (7 turns). Place a jumper between input low and the junction of R503 and C504 on PC-254. Also short the input terminals of the Model 160. Set RANGE Switch to 100mV and adjust DC Balance pot R722 (located on PC-251) for zero at the OUTPUT. Remove jumper at R503 and repeat steps 4 and 5.

6. Analog Calibration.

a). Voltage Ranges. Connect voltmeter (A) to the analog OUTPUT. Connect voltage source (C) to the Input Terminals (red and black). Measure the analog OUTPUT voltage for each range as described in Table 6-3. On the 100 mV, 10 mV, and 1 mV ranges wire jumpers are used for calibration. On the 1V, 10V, 100V, and 1000V ranges potentiometers R111, R108, R106, and R104 should be adjusted.

b). Resistance Ranges (Model 160 only). Connect decade resistance box (D) to the Input Terminals. Measure the analog OUTPUT for each range as described in Table 6-4. Adjust the OHMS CAL potentiometer (R738) for an OUTPUT of +1V ±1.0 millivolt on the 1 kΩ range only. The remaining resistance ranges cannot be adjusted.

c). Current Ranges (Model 160 only). Connect current source (E) to the Input Terminals. Measure the analog OUTPUT for each current range as described in Table 6-5. No calibration adjustments can be made on any of the current ranges.

7. Digital Calibration.

a). Zero Check. Connect a shorting wire across Input Terminals. Adjust the rear-panel ZERO Control so that the Digital Display reading is 0-0-0-0 on the 1 mV range with the Polarity Indicator alternating plus and minus. Measure the analog OUTPUT voltage which should be within ±1 millivolt of zero.

b). Full-Scale Indication. Connect voltage source (C) to the Input Terminals and adjust the source for +1.9992V measured at the analog OUTPUT. Adjust the -CAL Control (R402) so that the Digital Display has a reading which alternates between 1-9-9-9 and a blanked display (with only the overrange "1" lighted). Apply a negative input and adjust the +CAL Control (R408).

c). Linearity Indication. Connect an accurate voltage source (C) to the Input Terminals and adjust for an analog OUTPUT of +0.9992V on the 1V range. Verify that the Digital Display reading is 0-9-9-9. Readjust the voltage source for an analog OUTPUT of +0.9998V on the 1V range. Verify a change of the Digital Display from 0-9-9-9 to 1-0-0-0.

TABLE 6-1.

Test Equipment

Code Letter	Instrument Type	Specification	Manufacturer and Model No.	Use
A	Voltmeter, Digital	$\pm$1μV to $\pm$1000V $\pm$0.1% of reading	Keithley, Model 160	Zero Adjustment
B	Voltmeter, Differential	limit of error $\pm$0.01% of reading or 10μV	Keithley, Model 662	Voltage Calibration Current " Resistance "
C	Voltage Source	.003% voltage mode 10, 100, 1000 volts	Fluke, Model 3330B Voltage Source	Voltage Calibration 10, 100, 1000 volts
			ESI type SR-1010 Divider Ratio	.001, .01, .1, 1 volts
D	Resistance Box	$\pm$.02% accuracy 10 megohms maximum	General Radio Type 1433 Decade Resistor	Resistance and Current Calibration
E	Current Source	.006% 0.1mA to 100mA	Fluke, Model 3330B Current Source	Current Calibration 0.1mA to 100mA ranges
		.003% voltage mode .02% resistance accuracy	Fluke, Model 3330B Voltage Source (1.01V) General Radio Type 1433 Decade Resistor	Current Calibration .001 to .01mA ranges

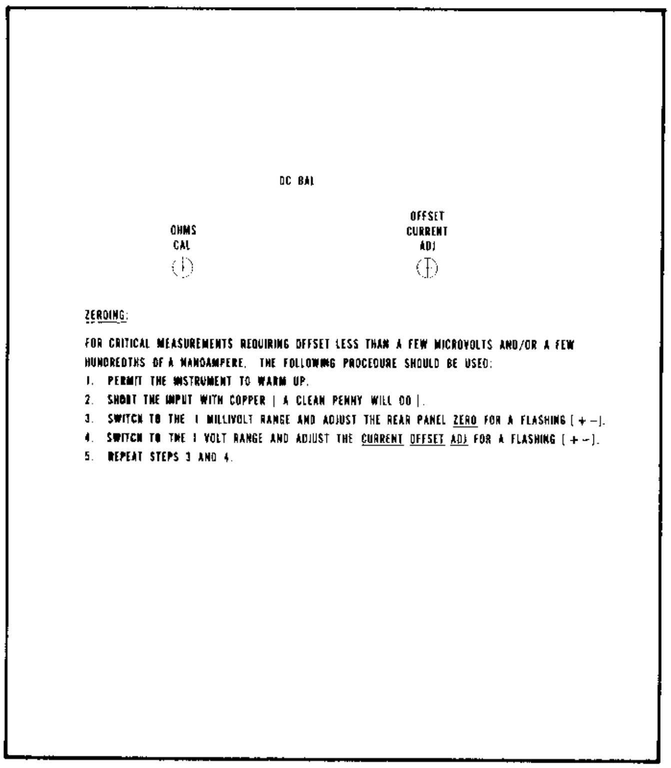


FIGURE 15. Chassis, Bottom View.

TABLE 6-3.
Voltage Range Calibration.
Summary of Calibration Controls and Test Points.

Range Setting	Input Source	Source Accuracy	Analog OUTPUT Voltage	Analog OUTPUT Accuracy	Ref. Desig.	Control
100mV	100mV	±.01%	1.000V	±1mV	R520, R521	Jumper
10mV	10mV	±.01%	1.000V	±1mV	R517, R518	Jumper
1mV	1mV	±.01%	1.000V	±1mV	R514, R515	Jumper
1V	1V	±.01%	1.000V	±1mV	R111	1V CAL
10V	10V	±.01%	1.000V	±1mV	R108	10V
100V	100V	±.01%	1.000V	±1mV	R106	100V
1000V	1000V	±.01%	1.000V	±1mV	R104	1000V

TABLE 6-4.
Resistance Range Calibration.
Summary of Calibration Controls and Test Points.

Range Setting	Input Source	Source Accuracy	Analog OUTPUT Voltage	Analog OUTPUT Accuracy	Ref. Desig.	Control
1KΩ	1KΩ	±.01%	1.000V	±1mV	R738	OHMS CAL
100Ω	100Ω	±.02%	1.000V	±1mV	---	None
10KΩ	10KΩ	±.02%	1.000V	±4mV	---	None
100KΩ	100KΩ	±.02%	1.000V	±3mV	---	None
1MΩ	1MΩ	±.02%	1.000V	±3mV	---	None
10MΩ	10MΩ	±.4%	1.000V	±40mV	---	None
100MΩ	100MΩ	±1%	1.000V	±100mV	---	None
1000MΩ	1000MΩ	±3%	1.000V	±500mV	---	None

TABLE 6-5.
Current Range Calibration.
Summary of Calibration Controls and Test Points.

Range Setting	Input Source	Source Accuracy	Analog OUTPUT Voltage	Analog OUTPUT Accuracy
0.1μA	0.1μA	±.02%	1.000V	±2mV
1μA	1μA	±.02%	1.000V	±2mV
10μA	10μA	±.02%	1.000V	±2mV
100μA	100μA	±.02%	1.000V	±2mV
1mA	1mA	±.02%	1.000V	±2mV
10mA	10mA	±.02%	1.000V	±2mV
100mA	100mA	±.02%	1.000V	±3mV
1000mA	1000mA	±.02%	1.000V	±3mV
1000mA	100mA	±.02%	0.100V	±0.3mV

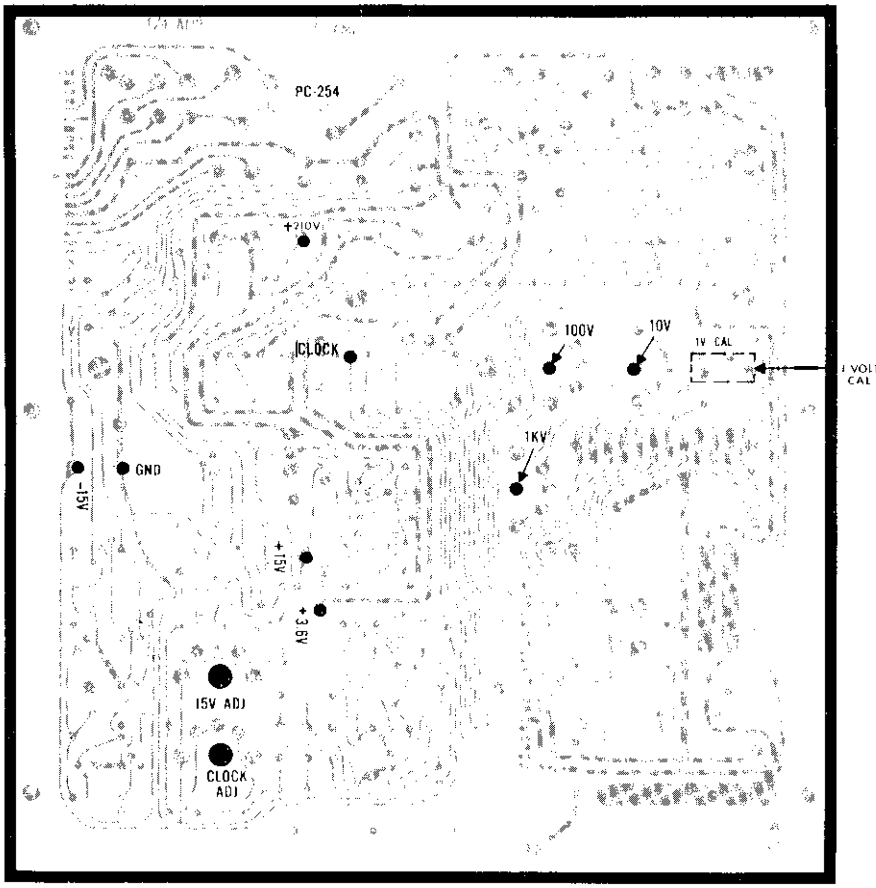


FIGURE 16. Calibration Controls.

SECTION 7. REPLACEABLE PARTS

7-1. 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), Manufacturer Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable.

TABLE 7-1.
Abbreviations and Symbols

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

7-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as described in Section 3. Refer to Table 7-2 which identifies all schematic part numbers included.

7-3. 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. Refer to Table 7-3 for listing of circuit designation series assigned to each major sub-assembly.

7-4. HOW TO ORDER PARTS.

a. Replaceable parts may be ordered through the Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

b. When ordering parts, include the following information.

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

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 7-2.

Description	Circuit Designation	Schematic Part Number
Switching - Main Chassis	Front Panel	24687E
Power Supply	PC-254	24694D
Connectors	PC-254, PC-255	24692D
Analog Amplifier	PC-251	24691E
Integrator Board	PC-250	24690E
Tube Board	PC-248	24688D
Tube Board	PC-248	24689D
Switching (Model 163)	-	24693D
Digital Output (Model 1602)	PC-287	24685D
AC-DC Probe (Model 1601)	-	24669C

TABLE 7-3.

Circuit Desig.	Description	Connector Plug-In	Series	Page No.
-	Main Chassis	-	100	30
PC-254	Power Supply	-	200	30
PC-248	Tube Board	J802	300	31
PC-250	Integrator Board	J801	400	32
PC-254	Input Filter	-	500	30
PC-254	Oscillator	-	600	30
PC-251	Analog Amplifier	J902	700	33
PC-255	Connector Board	J901	800	30
PC-254	Connectors	-	900	30

TABLE 7-4.
Mechanical Parts List

Description	Quantity Per Assembly	Keithley Part No.	Fig. No.
1 Chassis	1	25122B (160) 25123B (163)	17, 18
Cover Assembly			17
2 Cover, sheet metal	1	24008C	
3 Screws, #6 x 3/8" slotted , Pan Head	4	-	
Feet Assembly			18
4 Feet	4	24322B	
5 Ball	4	FE-6	
6 Screws, #6 x 7/16" Phillips, Flat Head	4	-	
Tilt Bail Assembly			18
7 Bail	1	17147B	
8 Kep nut, #6	4	-	
Cover Plate Assembly, Rear Panel			3
Cover Plate	1	24294A	
Screws, #6 x 1/4", Slotted	4	-	

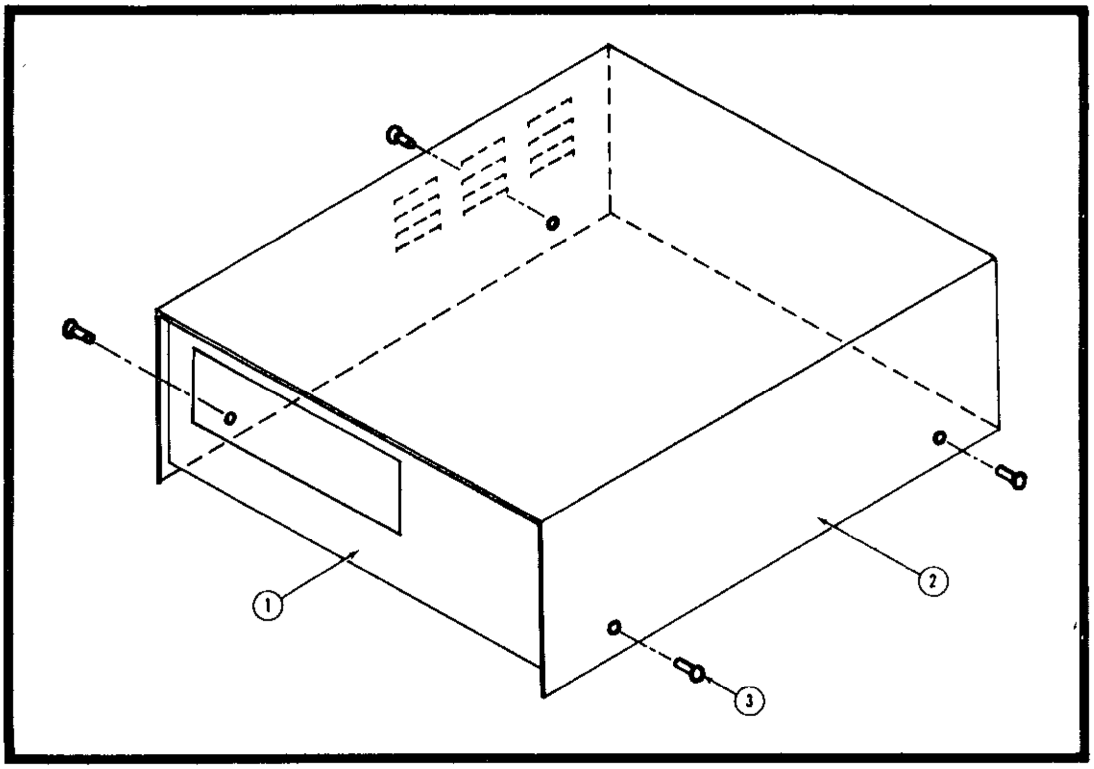


FIGURE 17.
Cover Assembly. Refer to Table 7-4.

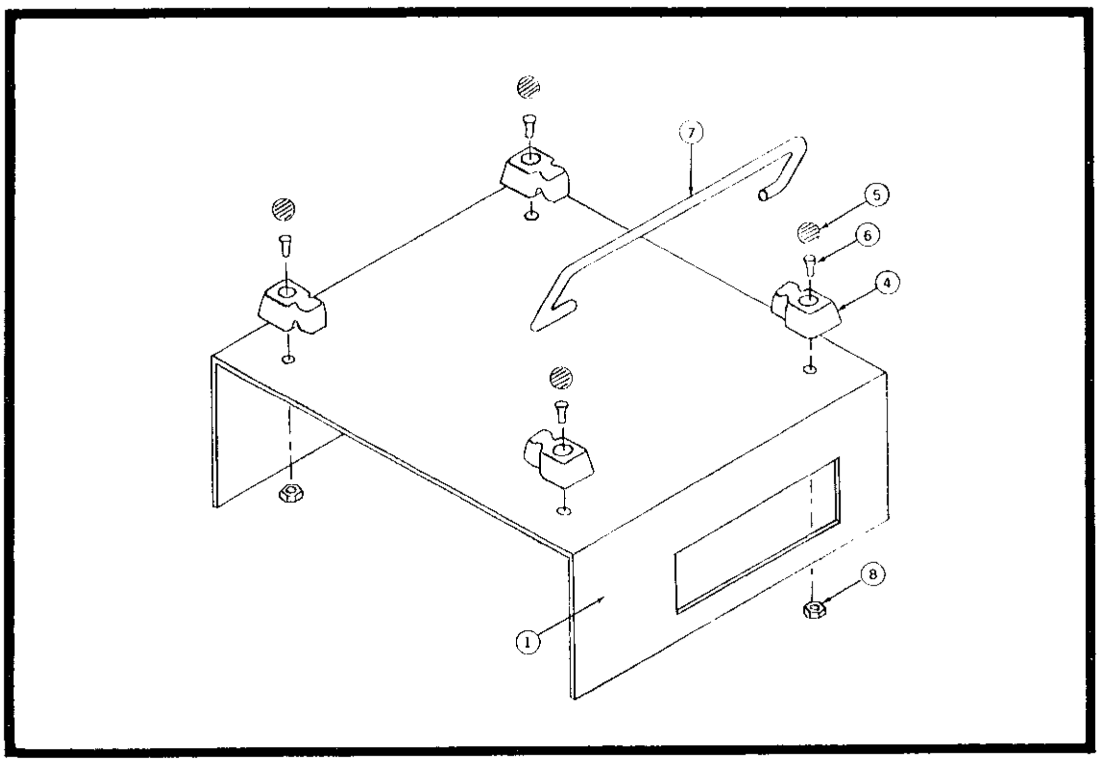


FIGURE 18.
Chassis Bottom View - Tilt Bail and Feet Assemblies. Refer to Table 7-4.

Model 1005 Rack Mounting Kit

General: The Keithley Model 1005 Rack Mounting Kit has been designed for rack mounting either the Model 160 Digital Multimeter or Model 163 Digital Voltmeter. The Kit includes all necessary parts for rack mounting either one instrument or two instruments side-by-side. Rack height is 3-1/2 inches with 10-1/2 inches depth measured from the front panel.

Assembly:

Single Rack Mounting. Refer to Figure 19.

1. Install brace "G" using hardware supplied ("J", "K", "H") as shown.
2. Install side plate "F" using hardware "E" supplied with the instrument.
3. Install side plate "B" using hardward "E" supplied with the instrument.

Dual Rack Mounting. Refer to Figure 20.

1. Remove individual top covers from both instruments.

*2. Install shield plate "M" as shown. Loosen the screw on the rear panel of the chassis to allow clearance for the shield plate. Tighten screw when shield is in place.

3. Install bottom plate "C" using hardware "D".
4. Install special top cover "A".
5. Install side plate "B" in two places using hardware "E" supplied with the instrument.
6. Store individual covers and extra hardware for future conversion back to bench mounting.

*NOTE: Shield plate "M" is used to shield sensitive circuitry in the instrument from the transformer circuit on the adjacent instrument when dual rack mounting.

TABLE 7-5.
Model 1005 Rack Mounting Kit Parts List.

Description	Quantity Per Assembly	Keithley Part No.	Figure No.
Dual Rack Mounting Assembly	---	24724C	20
A) Cover	1	24705D	
B) Side Plate	2	24707C	
C) Bottom Plate	1	24709B	
D) Screw, #6x1/4, Phillips, Pan Head	4	---	
E) Screw, #6x3/8, Phillips, Pan Head	4	---	
M) Shield Plate	1	24805B	
Single Rack Mounting Assembly	---	24724C	19
F) Side Plate, Single	1	24706C	
G) Brace	1	24708B	
H) Kep Nut, #8-32	2	---	
J) Screw, #8-32x3/8, Phillips, Flat Head	1	---	
K) Screw, #8-32x3/8, Button Head	1	---	

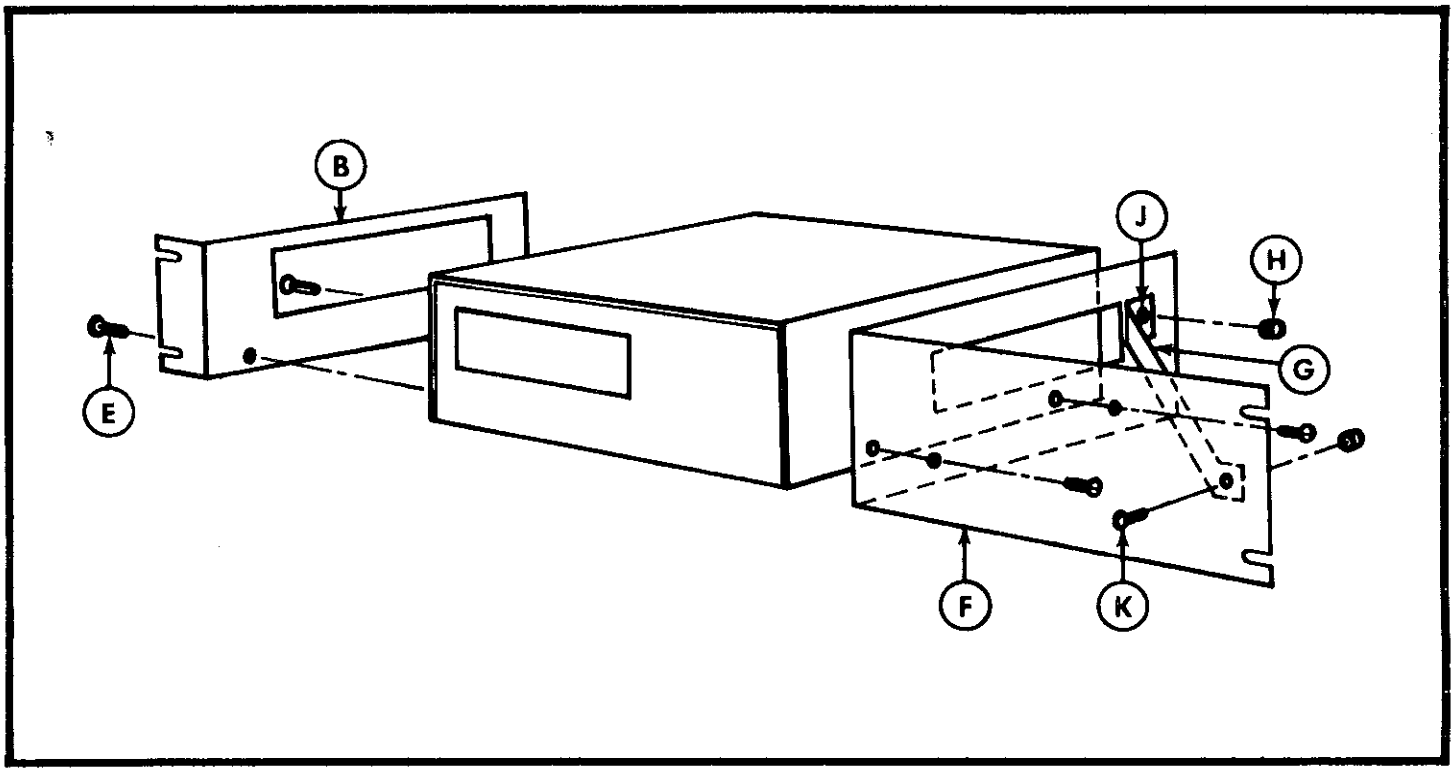


FIGURE 19. Model 1005 Rack Mounting Kit (Single).
(Refer to Table 7-5.)

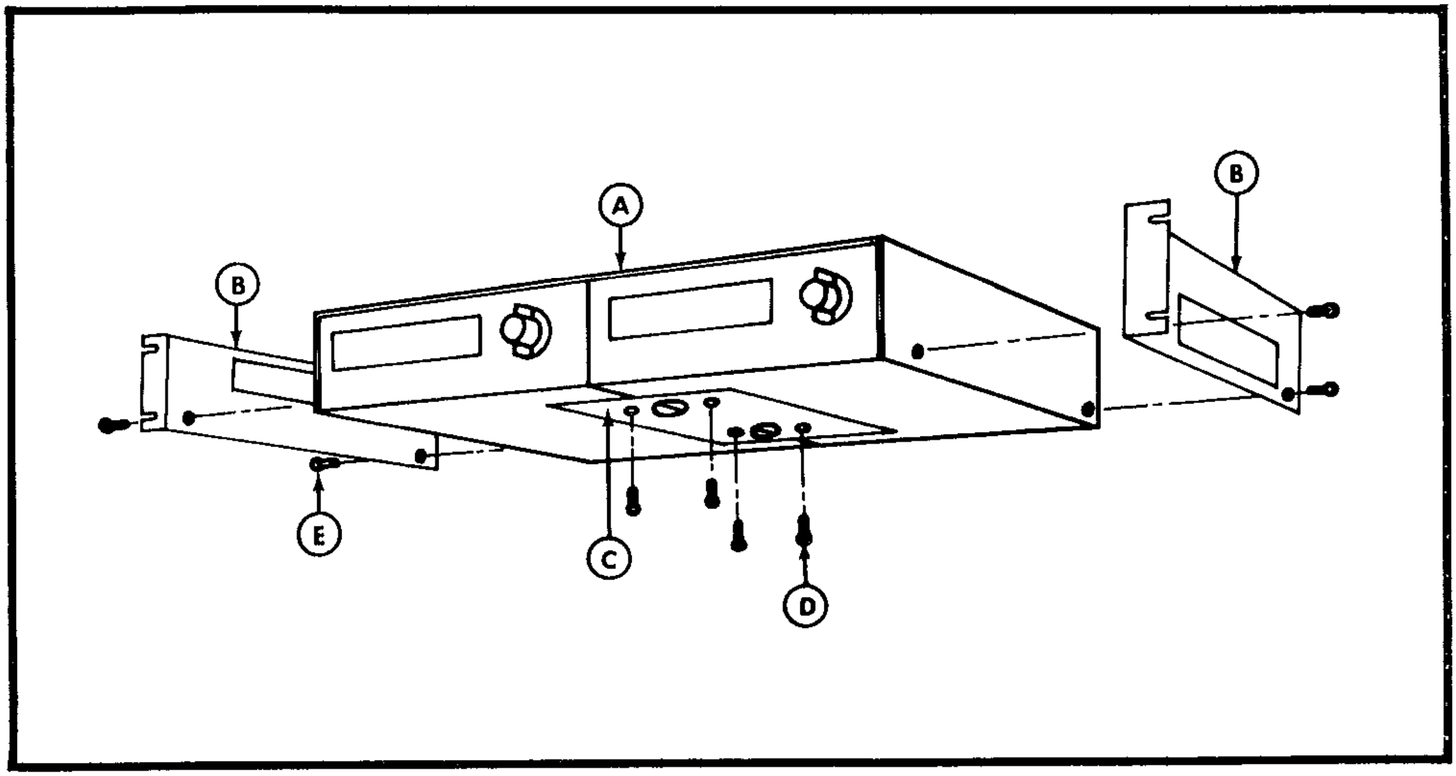


FIGURE 20. Model 1005 Rack Mounting Kit (Dual).
(Refer to Table 7-5.)

Components located on Mother Board, PC-254.
(Circuit designations are found on schematics 24687E, 24694D, 24691E)

C101	D204	Q206	R118	R504
C102	D205	Q207	R119	R505
C103	D206	Q208	R120	R506
		Q209	R121	R508
C201	D501	Q210	R122	R509
C202	D502	Q211	R123	R510
C203		Q212		R511
C204	D601		R201	R512
C205	D602	Q601	R202	R513
C206	D603	Q602	R203	R514
C207		Q603	R204	R515
C208	F201		R205	R516
C209	F202	QA201	R206	R517
C210			R207	R518
C211	J201	R101	R208	R519
C212	J202	R102	R209	R520
	J203	R103	R210	R521
C501	J204	R104	R211	
C502	J205	R105	R212	R601
C503		R106	R213	R602
C504	J901	R107	R214	R603
	J902	R108	R215	R604
C601	J903	R109	R216	R605
C602	J904	R110	R217	R606
C603	J905	R111	R218	R607
C604	J906	R112	R219	R608
C605		R113	R220	R609
	Q202	R114		R610
D201	Q203	R115	R501	R611
D202	Q204	R116	R502	
D203	Q205	R117	R503	S202

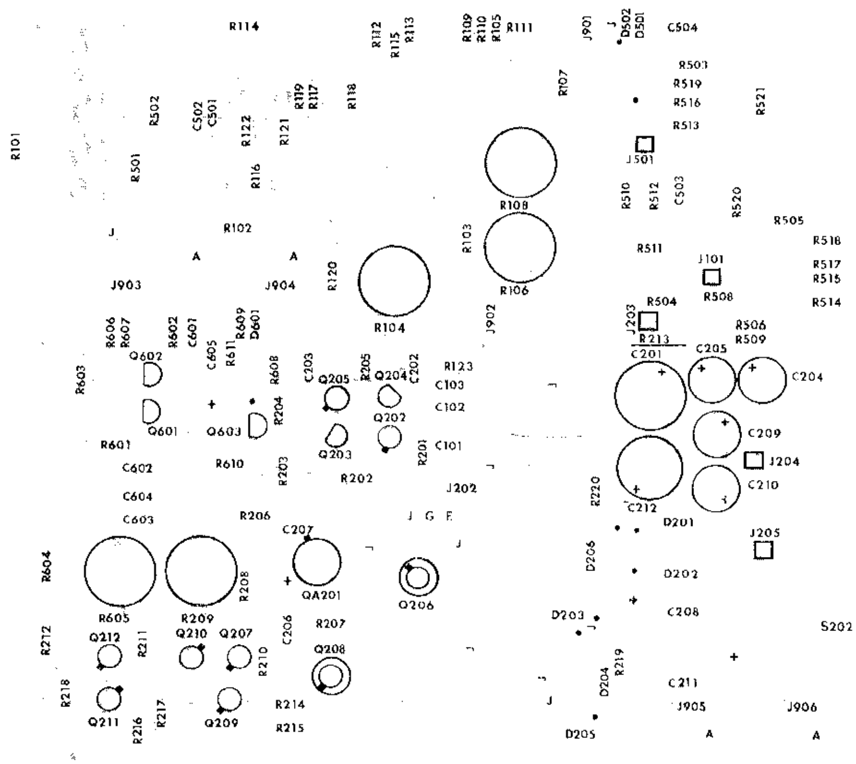


FIGURE 21. Component Layout, PC254.

Components located on Tube Board, PC-248.
(Circuit designations are found on schematics 24688D, 24689D)

C301	Q304	QA307	R301	R312
C302	Q305	QA308	R302	R313
C303	Q306	QA309	R303	R314
		QA310	R304	R315
DS301	QA301	QA311	R305	
DS302	QA302	QA312	R306	V301
	QA303	QA313	R307	V302
Q301	QA304	QA314	R309	V303
Q302	QA305	QA315	R310	
Q303	QA306	QA316	R311	

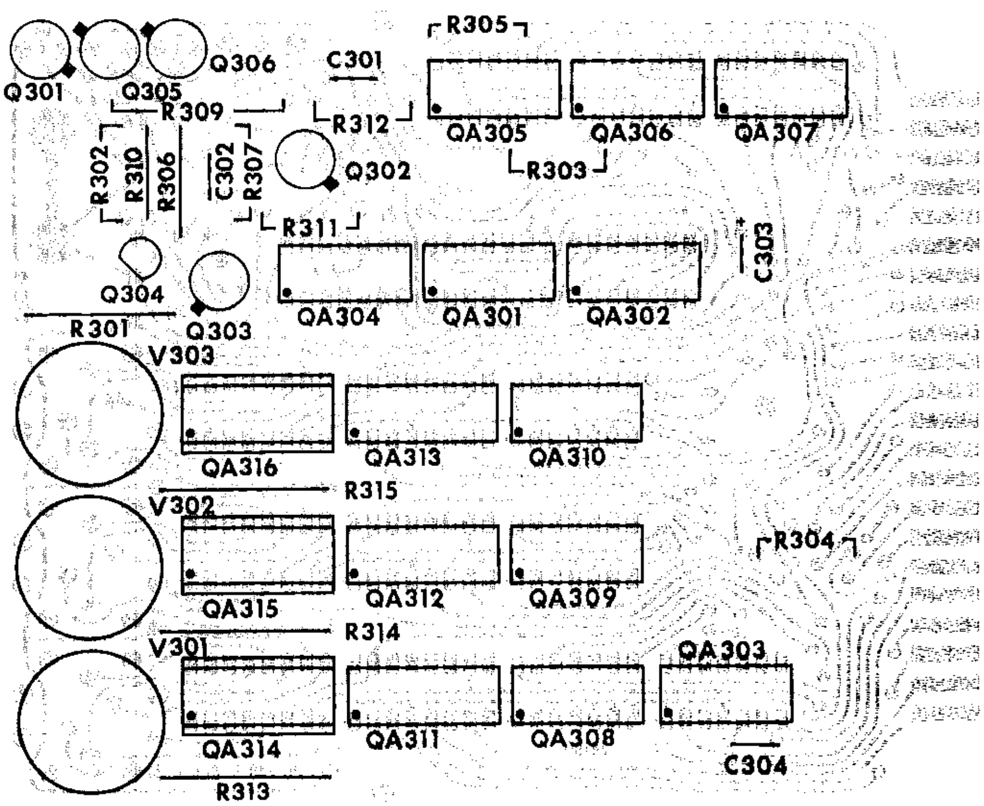


FIGURE 22. Component Layout, PC248

Components located on Integrator Board, PC-250.
(Circuit desingations are found on schematic 24690E).

C401	D404	Q411	R412	R438
C402	D405	Q412	R413	R439
C403	D406	Q413	R414	R440
C404	D407	Q414	R415	R441
C405	D408	Q415	R416	R442
C406	D409	Q416	R417	R443
C407	D410		R418	R444
C409	D411	QA401	R419	R445
C410	D412	QA402	R420	R446
C411	D413	QA403	R421	R447
C412	D414	QA404	R422	R448
C413	D415		R423	R449
C414	D416	R401	R424	R450
C415	D417	R402	R428	R451
C416		R403	R429	R452
C417	Q401	R404	R430	R453
C418	Q402	R405	R431	R454
C419	Q403	R406	R432	R455
C420	Q404	R407	R433	R456
	Q405	R408	R434	R457
D401	Q408	R409	R435	R458
D402	Q409	R410	R436	
D403	Q410	R411	R437	

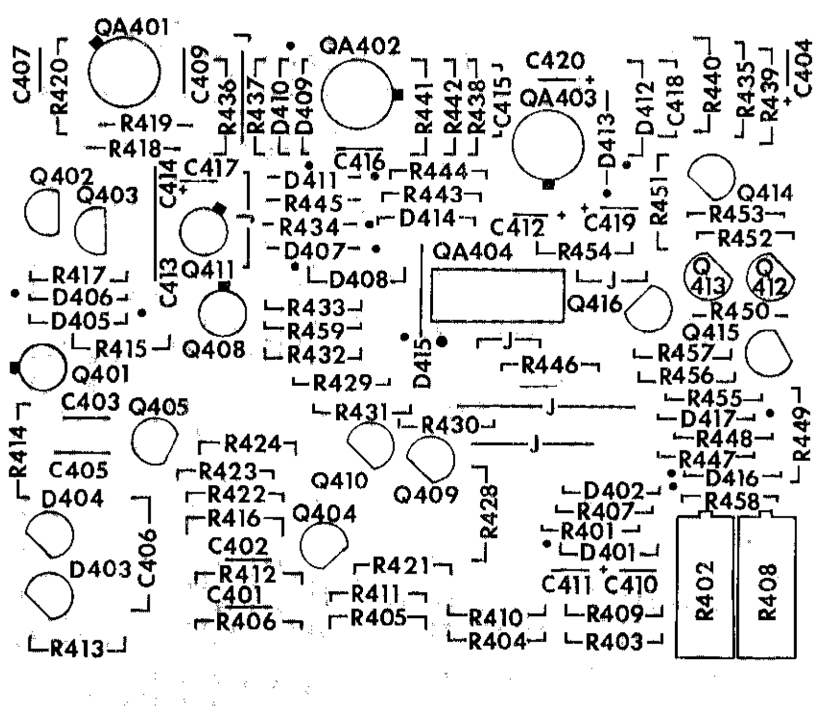


FIGURE 23. Component Layout, PC250

Components Located on Analog Board, PC-251.
(Circuits designations are found on schematic 24691E).

C702	Q706	R720
C703	Q707	R721
C704	Q708	R722
C705		R723
C706	QA701	R724
C707	QA702	R725
C708	QA703	R726
C709	QA704	R727
C710		R728
C711	R701	R729
C712	R702	R730
C713	R703	R731
C714	R704	R732
C715	R705	R733
C716	R706	R734
C717	R707	R735
C718	R708	R736
C719	R709	R737
C720	R710	R738
	R711	R739
D701	R712	R740
D702	R713	R741
	R714	R742
Q701	R715	R743
Q702	R716	R745
Q703	R717	R746
Q704	R718	R747
Q705	R719	R748

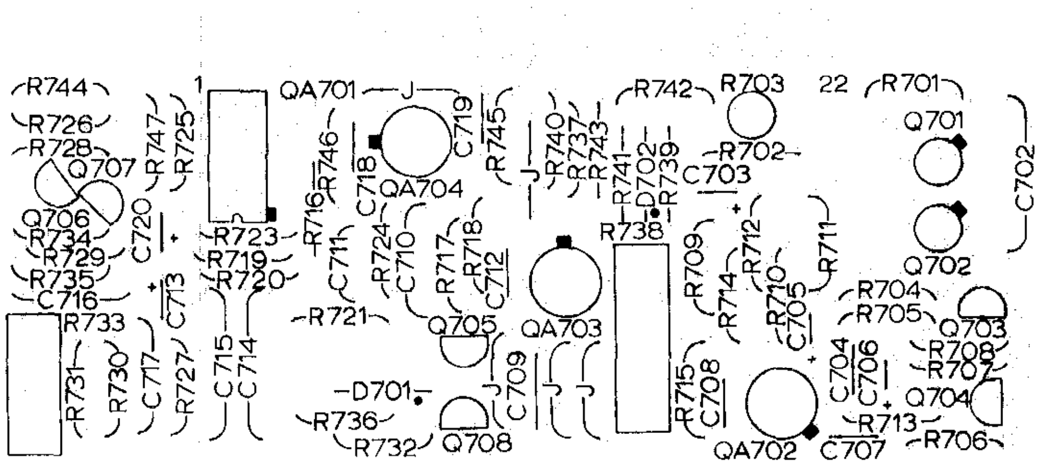


FIGURE 24. Component Layout, PC251

CAPACITORS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
C101	.0047 µF, 500V, CerD	72982	801-Z5U0-472M	C22-.0047M	7
C102	.0047 µF, 500V, CerD	72982	801-Z5U0-472M	C22-.0047M	..
C103	.0047 µF, 500V, CerD	72982	801-Z5U0-472M	C22-.0047M	..
C201	2000 µF, 15V, EAL.	29309	3675020015C	C93-2000M	1
C202	220 pF, 1000V, CerD.	71590	DD-221	C64-220P	3
C203	150 pF, 1000V, CerD.	71590	DD-151	C64-150P	1
C204	200 µF, 35V, EAL	90201	MTV200N35	C177-200M	4
C205	200 µF, 35V, EAL	90201	MTV200N35	C177-200M	..
C206	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	11
C207	470 pF, 1000V, CerD.	71590	DD-471	C64-470P	1
C208	125 µF, 15V, ETB	73445	C426-125µF	C3-125M	2
C209	200 µF, 35V, EAL	90201	MTV200N35	C177-200M	..
C210	200 µF, 35V, EAL	90201	MTV200N35	C177-200M	..
C211	125 µF, 15V, ETB	73445	C426-125µF	C3-125M	..
C212	15 µF, 300V, EAL	90201	PTC015M300	C173-15M	1
C301	.0022 µF, 500V, CerD	72982	831-Z5U0-222M	C22-.0022M	1
C302	100 pF, 1000V, CerD.	71590	DD-101	C64-100P	2
C303	0.22 µF, 10V, ETT.	17554	TSD210226	C180-0.22M	1
C304	10 pF, 1000V, CerD	71590	DD-100	C64-10P	3
C401	10 pF, 1000V, CerD	71590	DD-100	C64-10P	..
C402	10 pF, 1000V, CerD	71590	DD-100	C64-10P	..
C403	100 pF, 1000V, CerD.	71590	DD-101	C64-100P	..
C404	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C405	1.5 pF, 600V, CerD	71590	TCZ-15	C77-1.5P	1
C406	1 µF, 100V, My		MF825	C185-1M	1
C407	.001 µF, 1000V, CerD	72982	808-000-Z5R0102K	C64-.001M	1
C408	Not Used	.....	......	....	..
C409	220 pF, 1000V, CerD.	71590	DD-221	C64-220P	..
C410	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C411	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C412	22 µF, 10V, ETT.	17554	TSD2-10	C180-22M	1
C413	5 pF, 1000V, CerD.	71590	DD-050	C64-5P	1
C414	1 µF, 50V, CerF.	72982	8131050651105M	C237-1M	1
C415	.0047 µF, 500V, CerD	72982	801-Z5U0-472M	C22-.0047M	..
C416	390 pF, 1000V, CerD.	71590	DD-391	C64-390P	1
C417	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C418	0.1 µF, 250V, MtF.	73445	C280AE	C178-.1M	3
C419	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C420	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C501	0.1 µF, 200V, My	13050	SM2A-.1µF	C143-.1M	2
C502	0.1 µF, 200V, My	13050	SM2A-.1µF	C143-.1M	..
C503	2 µF, 100V, My		MF1195-2µF	C188-2M	1
C601	.047 µF, 200V, My.	13050	SM2A-.047µF	C143-.047M	1
C602	500 pF, 500V, Silver Mica.	14655	CD19FD501F03	C209-500P	2
C603	500 pF, 500V, Silver Mica.	14655	CD19FD501F03	C209-500P	..
C604	1500 pF, 500V, Silver Mica	14655	CD19FD152F03	C209-1500P	1
C605	10 µF, 20V, ETT.	17554	TSD1-20	C179-10M	..
C701	Not Used	.....	......	....	..
C702	0.01 µF, 200V, My.	13050	SM1A-.01µF	C47-.01M	1
C703	10 µF, 20V, ETT.	17554	TSD1-20-10µF	179-10M	..
C704	0.0047 µF, 500V, CerD.	72982	801-Z5U0-472M	C22-.0047M	..
C705	1.2 µF, 20V, ETT	17554	TSD1-20-1.2µF	C179-1.2M	2
C706	1.2 µF, 20V, ETT	17554	TSD1-20-1.2µF	C179-1.2M	..

CAPACITORS (Cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
C707	0.0047 µF, 500V, CerD.	72982	801-Z5U0-472M	C22-.0047M	..
C708	220 pF, 1000V, CerD.	71590	DD-221	C64-220P	..
C709	0.1 µF, 250V, MtF.	73445	C280AE-.1µF	C178-.1M	..
C710	0.22 µF, 250V, MtF	73445	C280AE-.22µF	C178-.22M	1
C711	0.1 µF, 250V, MtF.	73445	C280AE-.1µF	C178-.1M	..
C801	0.001 µF, 1000V, CerD.	72982	808000-Z5R0-102K	C64-.001M	1

DIODES

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
D201	Rectifier.	13327	1N4139	RF-34	2
D202	Rectifier.	13327	1N4139	RF-34	..
D203	Full Wave Bridge Rectifier	83701	PD-10	RF-36	1
D204	Rectifier.	01295	1N645	RF-14	5
D205	Rectifier.	01295	1N645	RF-14	..
D206	Rectifier, 1A, 800V.	04713	1N4006	RF-38	1
D401	Zener, 9V, 1/2W.	04713	1N936	DZ-5	3
D402	Zener, 9V, 1/2W.	04713	1N936	DZ-5	..
D403	Transistor, Base-Emitter NPN, Case TO-106.	07263	2N3565	TG-39	2
D404	Transistor, Base-Emitter NPN, Case TO-106.	07263	2N3565	TG-39	..
D405	Rectifier.	01295	1N914	RF-28	13
D406	Rectifier.	01295	1N914	RF-28	..
D407	Rectifier.	01295	1N914	RF-28	..
D408	Rectifier.	01295	1N914	RF-28	..
D409	Rectifier.	01295	1N914	RF-28	..
D410	Rectifier.	01295	1N914	RF-28	..
D411	Zener, 9.1V.	06751	1N713A	DZ-38	1
D412	Rectifier.	01295	1N914	RF-28	..
D413	Rectifier.	01295	1N914	RF-28	..
D414	Rectifier.	01295	1N914	RF-28	..
D415	Rectifier.	01295	1N914	RF-28	..
D416	Rectifier.	01295	1N914	RF-28	..
D417	Rectifier.	01295	1N914	RF-28	..
D501	Rectifier.	01295	1N645	RF-14	..
D502	Rectifier.	01295	1N645	RF-14	..
D601	Rectifier.	01295	1N914	RF-28	..
D701	Rectifier.	01295	1N645	RF-14	..
D702	Zener, 9V, 1/2W.	04713	1N936	DZ-5	..

LAMPS & FUSES

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
DS301	Lamp, (OVERRANGE).	80164	PL-42	PL-42	1
DS302	Lamp, (POLARITY)	80164	PL-48	PL-48	1
F201	Fuse, 1/4A, 250V, 3AG, Slo-Blo	71400	MDV-1/4A	FU-33	1
F202	Fuse, 1/2A, 250V, 3AG, Slo-Blo	71400	MDV-1/2A	FU-35	1

CONNECTORS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
J101	Binding Post, (HI) Red	58474	DF21RC	BP-11R	1
J102	Binding Post, (LO) Black	58474	DF21BC	BP-11B	1
J103	Connector, Analog Output	02660	80PC2F	CS-32	1
J104	Binding Post, (CASE) Green	58474	DF21GC	BP-11G	1
J201	Connector, Female, Berg.				
J202	Connector, 5-pin	22526	20052	CS-237	5
J203	Test Point				
J204	Test Point				
J205	Test Point				
J801	Connector, 22-pin, card-edge type.	09922	PSC4SS2212	CS-182	3
J802	Connector, 44-pin, card-edge type.	09922	PSC4DD2212	CS-205	1
J901	Connector, 22-pin, card-edge type.	09922	PSC4SS2212	CS-182	..
J902	Connector, 22-pin, card-edge type.	09922	PSC4SS2212	CS-182	..
J903	Receptacle, 10-pin	22526	20052	CS-237	..
J904	Receptacle, 10-pin	22526	20052	CS-237	..
J905	Receptacle, 10-pin	22526	20052	CS-237	..
J906	Receptacle, 10-pin	22526	20052	CS-251	..
P201	Receptacle, 3-pin, Line Voltage.	82389	EAC301	CS-254	1

TRANSISTORS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
Q201	Power, NPN, Case TO-66	02735	40312	TG-54	1
Q202	NPN, Case TO-104	02734	2N5183	TG-68	1
Q203	NPN, Case TO-106	07263	2N3565	TG-39	2
Q204	NPN, Case TO-106	07263	2N3565	TG-39	..
Q205	PNP, Case R110	07263	S17638	TG-33	6
Q206	NPN, Case TO-5	02734	40317	TG-43	1
Q207	PNP, Case R110	07263	S17638	TG-33	..
Q208	NPN, Case TO-5	02734	40319	TG-50	1
Q209	PNP, Case R110	07263	S17638	TG-33	..
Q210	PNP, Case R110	07263	S17638	TG-33	..
Q211	PNP, Case R110	07263	S17638	TG-33	..
Q212	PNP, Case R110	07263	S17638	TG-33	..
Q301	NPN, Case TO-104	04713	2N5551	TG-67	3
Q302	NPN, Case TO-5	02735	40346	TG-44	2
Q303	NPN, Case TO-5	02735	40346	TG-44	..
Q304	NPN, Case TO-106	07263	2N5134	TG-65	6
Q305	NPN, Case TO-104	04713	2N5551	TG-67	..
Q306	NPN, Case TO-104	04713	2N5551	TG-67	..
Q401	N-Chan, FET.	04713	2N4220	TG-42	3
Q402	FET, Case TO-92.	01295	T1S70	TG-71	2
Q403	FET, Case TO-92.	01295	T1S70	TG-71	..
Q404	PNP, Case TO-106	07263	2N5139	TG-66	4
Q405	NPN, Case TO-106	07263	2N5134	TG-65	..
Q406	Not Used	.....	......	....	..
Q407	Not Used	.....	......	....	..
Q408	N-Chan, FET.	04713	2N4220	TG-42	..
Q409	PNP, Case TO-106	07263	2N5139	TG-66	..
Q410	NPN, Case TO-106	07263	2N5134	TG-65	..
Q411	N-Chan, FET.	04713	2N4220	TG-42	..
Q412	NPN, Case TO-106	07263	2N5134	TG-65	..
Q413	PNP, Case TO-106	07263	2N5139	TG-66	..
Q414	NPN, Case TO-106	07263	2N5134	TG-65	..
Q415	PNP, Case TO-106	07263	2N5139	TG-66	..
Q416	NPN, Case TO-106	07263	2N5134	TG-65	..

TRANSISTORS (Cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
Q601	NPN, Case TO-92.	04713	2N5089	TG-62	6
Q602	NPN, Case TO-92.	04713	2N5089	TG-62	..
Q603	NPN, Case TO-92.	04713	2N5089	TG-62	..
Q701	N-Chan FET (Selected*)	94145	RN1030	TG-51 (24598A)*	2
Q702	N-Chan FET (Selected*)	94145	RN1030	TG-51 (24598A)*	..
Q703	NPN, Case TO-92 (Selected*).	04713	2N5089	TG-62 (24219A)*	..
Q704	PNP, Case TO-92.	04713	2N5087	TG-61	2
Q705	N-Chan FET	04713	MPF-103	TG-41	1
Q706	NPN, Case TO-92.	04713	2N5089	TG-62	..
Q707	NPN, Case TO-92.	04713	2N5089	TG-62	..
Q708	PNP, Case TO-92.	04713	25087	TG-61	..

INTEGRATED CIRCUITS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
QA201	Regulator, 10-pin Case TO-100.	07263	U5R772-339	IC-14	1
QA301	Dual J-K Flip-Flop, 14-pin DIP	04713	MC891P	IC-9	4
QA302	Dual J-K Flip-Flop, 14-pin DIP	04713	MC891P	IC-9	..
QA303	Quad 2-input NOR, 14-pin DIP	04713	MC824P	IC-5	3
QA304	Quad 2-input NOR, 14-pin DIP	04713	MC824P	IC-5	..
QA305	Hex Inverters, 14-pin DIP.	04713	MC889P	IC-7	1
QA306	Dual J-K Flip-Flop, 14-pin DIP	04713	MC891P	IC-9	..
QA307	Dual J-K Flip-Flop, 14-pin DIP	04713	MC891P	IC-9	..
QA308	Decade Counter, 14-pin DIP	04713	MC880P	IC-17	3
QA309	Decade Counter, 14-pin DIP	04713	MC880P	IC-17	..
QA310	Decade Counter, 14-pin DIP	04713	MC880P	IC-17	..
QA311	Quad Latch, 16-pin DIP	04713	MC867P	IC-16	3
QA312	Quad Latch, 16-pin DIP	04713	MC867P	IC-16	..
QA313	Quad Latch, 16-pin DIP	04713	MC867P	IC-16	..
QA314	Decoder/driver, 16-pin DIP	07263	UGB996079X	IC-3	3
QA315	Decoder/driver, 16-pin DIP	07263	UGB996079X	IC-3	..
QA316	Decoder/driver, 16-pin DIP	07263	UGB996079X	IC-3	..
QA401	Amplifier, 8-pin, Case TO-99	07263	U5B770939X	IC-1	3
QA402	Amplifier, 8-pin, Case TO-99	07263	U5B770939X	IC-1	..
QA403	Diff. Comparator, 8-pin, Case TO-99.	07263	U5B771039X	IC-4	1
QA404	Quad 2-input, NAND, 14-pin DIP	04713	MC824P	IC-5	..
QA701	Dual J-K Flip-Flop, 14-pin DIP	04713	MC890P	IC-8	1
QA702	Amplifier, 8-pin, Case TO-99	07263	U5B770939X	IC-1	..
QA703	Amplifier, 8-pin, Case TO-99	12040	LM301AH	IC-2	2
QA704	Amplifier, 8-pin, Case TO-99	12040	LM301AH	IC-2	..
QA801	Binary Counter, 14-pin DIP	04713	MC-877P	IC-21	1

RESISTORS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
R101	10MΩ, 1%, 1/2W, MtF.	07716	MEH-10MΩ	R170-10M	1
R102	200kΩ, 1%, 1/2W, MtF	07716	MEH-200KΩ	R94-200K	1
R103	1kΩ, 0.1%, 1/2W, MtF	91637	MFF-1KΩ	R169-1K	2
R104	50Ω, 20%, 2W, WW	71450	1NS-115-50Ω	RP50-50	1
R105	10kΩ, 0.1%, 1/2W, MtF.	91637	MFF-10K	R169-10K	2
R106	500Ω, 20%, 2W, WW.	71450	1NS-115-500Ω	RP50-500	1
R107	100kΩ, 0.1%, 1/2W, MtF	91637	MFF-100KΩ	R169-100K	2
R108	5kΩ, 20%, 2W, WW	71450	1NS-115-5KΩ	RP50-5K	2
R109	1MΩ, 0.1%, 1/2W, MtF	91637	MFF-1MΩ	R169-1M	2
R110	100kΩ, 1%, 1/8W, MtF	07716	CEA-100KΩ-1%	R88-100K	4
R111	50kΩ, 20%, 1.75W, Cermet	73138	77PR-50KΩ	RP64-50K	1
R112	10^7Ω, 1%, 1W, DCb.	91637	DC-1-10^7Ω	R13-10^7	1
R113	10^9Ω, 20%, 1/2W, Comp.	75042	GBT-10^8Ω	R37-10^9	2
R114	10^8Ω, 1%, 2W, DCb.	91637	DC-2-10^8Ω	R14-10^8	1
R115	1MΩ, 0.1%, 1/2W, MtF	91637	MFF-1MΩ	R169-1M	..
R116	100kΩ, 0.1%, 1/2W, MtF	91637	MFF-100KΩ	R169-100K	..
R117	10kΩ, 0.1%, 1/2W, MtF.	91637	MFF-10KΩ	R169-10K	..
R118	1kΩ, 0.1%, 1/2W, MtF	91637	MFF-1KΩ	R169-1K	..
R119	99.9Ω, 0.1%, 1/2W, MtF	91637	MFF-99.9Ω	R169-99.9	1
R120	0.1Ω, 0.1%, 5W, WW	02985	TS-5W-.1Ω	R167-.1	1
R121	1Ω, 0.1%, 1/4W, WW	01686	7009-1Ω	R95-1	1
R122	10Ω, 0.1%, 1/4W, WW.	01686	7009-10Ω	R95-10	1
R123	220Ω, 10%, 1/4W, Comp.	01121	CB-221-10%	R76-220	1
R201	6.8kΩ, 10%, 1/4W, Comp	01121	CB-682-10%	R76-6.8K	1
R202	0.2Ω, 10%, TCu	91637	CW-2-.2Ω	R151-0.2	1
R203	10kΩ, 1%, 1/8W, MtF.	07716	CEA-10K-1%	R88-10K	3
R204	2.49kΩ, 1%, 1/8W, MtF.	07716	CEA-2.49K-1%	R88-2.49K	1
R205	1kΩ, 10%, 1/4W, Comp	01121	CB-102-10%	R76-1K	5
R206	3Ω, 1%, 1/2W, DCb.	91637	DCF-1/2-3Ω	R12-3	2
R207	1.8kΩ, 10%, 1/4W, Comp	01121	CB-182-10%	R76-1.8K	1
R208	3.32kΩ, 1%, 1/8W, MtF.	07716	CEA-3.32K-1%	R88-3.32K	1
R209	1kΩ, 20%, 2W, WW	71450	1NS-115-1K	RP50-1K	1
R210	3.01kΩ, 1%, 1/8W, MtF.	07716	CEA-3.01K-1%	R88-3.01K	3
R211	15kΩ, 10%, 1/4W, Comp.	01121	CB-153-10%	R76-15K	1
R212	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5K-1%	R88-7.5K	8
R213	10Ω, 10%, 1/2W, Comp	01121	EB-100-10%	R1-10	1
R214	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	8
R215	3Ω, 1%, 1/2W, DCb.	91637	DCF-1/2-3Ω	R12-3	..
R216	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	..
R217	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K-10%	..
R218	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5K-1%	R88-7.5K-1%	..
R219	82Ω, 10%, 1/2W, Comp	01121	EB-82R-10%	R1-82	1
R220	1MΩ, 10%, 1/4W, Comp	01121	CB-105-10%	R76-1M	2
R301	100kΩ, 10%, 1W, Comp	01121	GB-104-10%	R2-100K	1
R302	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	9
R303	3.3kΩ, 10%, 1/4W, Comp	01121	CB-332-10%	R76-3.3K	2
R304	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R305	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R306	100kΩ, 10%, 1/2W, Comp	01121	EB-104-10%	R1-100K	1
R307	47kΩ, 10%, 1/4W, Comp.	01121	CB-473-10%	R76-47K	3
R308	Not Used	.....	....	....	..
R309	80.6kΩ, 1%, 1/2W, MtF.	07716	CEC-80.6K-1%	R94-80.6K	1
R310	7.87kΩ, 1%, 1/8W, MtF.	07716	CEA-7.8K-1%	R88-7.87K	1
R311	1kΩ, 10%, 1/4W, Comp	01121	CB-102-10%	R76-1K	..
R312	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R313	10kΩ, 1%, 1/2W, MtF.	07716	CEC-10K-1%	R94-10K	3
R314	10kΩ, 1%, 1/2W, MtF.	07716	CEC-10K-1%	R94-10K	..
R315	10kΩ, 1%, 1/2W, MtF.	07716	CEC-10K-1%	R94-10K	..

RESISTORS (Cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
R401	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	6
R402	10kΩ, 20%, Cermet.	73138	77PR-10KΩ	RP64-10K	2
R403	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5kΩ-1%	R88-7.5K	..
R404	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5KΩ-1%	R88-7.5K	..
R405	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5KΩ-1%	R88-7.5K	..
R406	Selected*Ω, 1%, 1/8W, MtF.	91637	MFF-1/8-*	R177*	..
R407	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	..
R408	10kΩ, 20%, Cermet.	73138	77PR10KΩ	RP64-10K	..
R409	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5KΩ-1%	R88-7.5K	..
R410	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5KΩ-1%	R88-7.5K	..
R411	7.5kΩ, 1%, 1/8W, MtF	07716	CEA-7.5KΩ-1%	R88-7.5K	..
R412	Selected*Ω, 1%, 1/8W, MtF.	91637	MFF-1/8-*	R177-*	..
R413	49.9kΩ, 1%, 1/8W, MtF.	91637	MFF-1/8-49.9K	R177-49.9K	2
R414	49.9kΩ, 1%, 1/8W, MtF.	91637	MFF-1/8-49.9K	R177-49.9K	..
R415	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	6
R416	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R417	1kΩ, 10%, 1/4W, Comp	01121	CB-102-10%	R76-1K	..
R418	301kΩ, 1%, 1/8W, MtF	07716	CEA-301K-1%	R88-301K	2
R419	301kΩ, 1%, 1/8W, MtF	07716	CEA-301K-1%	R88-301K	..
R420	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R421	680Ω, 10%, 1/4W, Comp.	01121	CB-681-10%	R76-680	3
R422	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	..
R423	4.7kΩ, 10%, 1/4W, Comp	01121	CB-472-10%	R76-4.7K	4
R424	4.7kΩ, 10%, 1/4W, Comp	01121	CB-472-10%	R76-4.7K	..
R425	Not Used	.....	....	....	..
R426	Not Used	.....	....	....	..
R427	Not Used	.....	....	....	..
R428	680Ω, 10%, 1/4W, Comp.	01121	CB-681-10%	R76-680	..
R429	4.7kΩ, 10%, 1/4W, Comp	01121	CB-472-10%	R76-4.7K	..
R430	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	..
R431	4.7kΩ, 10%, 1/4W, Comp	01121	CB-472-10%	R76-4.7K-10%	..
R432	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R433	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R434	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R435	47Ω, 10%, 1/4W, Comp	01121	CB-47R-10%	R76-47	4
R436	47Ω, 10%, 1/4W, Comp	01121	CB-47R-10%	R76-47	..
R437	2.2kΩ, 10%, 1/4W, Comp	01121	CB-222-10%	R76-2.2K	3
R438	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R439	47Ω, 10%, 1/4W, Comp	01121	CB-47R-10%	R76-47	..
R440	47Ω, 10%, 1/4W, Comp	01121	CB-47R-10%	R76-47	..
R441	8.87kΩ, 1%, 1/8W, MtF.	07716	CEA-8.87K-1%	R88-8.87K	1
R442	3.01kΩ, 1%, 1/8W, MtF.	07716	CEA-3.01K-1%	R88-3.01K	..
R443	2.2kΩ, 10%, 1/4W, Comp	01121	CB-222-10%	R76-2.2K	..
R444	2.49kΩ, 1%, 1/8W, MtF.	07716	CEA-2.49K-1%	R88-2.49K	1
R445	10kΩ, 1%, 1/8W, MtF.	07716	CEA-10K-1%	R88-10K	..
R446	2.2kΩ, 10%, 1/4W, Comp	01121	CB-222-10%	R76-2.2K	..
R447	237Ω, 1%, 1/8W, MtF.	07716	CEA-237-1%	R88-237	2
R448	56kΩ, 10%, 1/4W, Comp.	01121	CB-563-10%	R76-56K	2
R449	1kΩ, 1%, 1/8W, MtF	07716	CEA-1K-1%	R88-1K	2
R450	4.99kΩ, 1%, 1/8W, MtF.	07716	CEA-4.99K-1%	R88-4.99K	2
R451	27kΩ, 10%, 1/4W, Comp.	01121	CB-273-10%	R76-27K	1
R452	82kΩ, 10%, 1/4W, Comp.	01121	CB-823-10%	R76-82K	1
R453	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	..
R454	680Ω, 10%, 1/4W, Comp.	01121	CB-681-10%	R76-680	..
R455	237Ω, 1%, 1/8W, MtF.	07716	CEA-237-1%	R88-237	..
R456	56kΩ, 10%, 1/4W, Comp.	01121	CB-563-10%	R76-56K	..
R457	4.99kΩ, 1%, 1/8W, MtF.	07716	CEA-4.99K-1%	R88-4.99K	..
R458	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..

RESISTORS (Cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
R501	150kΩ, 10%, 1/2W, Comp	01121	EB-150K-10%	R1-150K	1
R502	10kΩ, 10%, 1/2W, Comp.	01121	EB-10K-10%	R1-10K	1
R503	1MΩ, 1%, 1/8W, MtF	07716	CEA-1MΩ-1%	R88-1M	1
R504	49.9kΩ, 1%, 1/8W, MtF.	07716	CEA-49.9K-1%	R88-49.9K	2
R505	100kΩ, 20%, Cermet	73138	77PR-100K	RP64-100K	1
R506	49.9kΩ, 1%, 1/8W, MtF.	07716	CEA-49.9K-1%	R88-49.9K	..
R507	Not Used	.....	....	....	..
R508	1.5kΩ, 1%, 1/8W, MtF	07716	CEA-1.5K-1%	R88-1.5K	2
R509	1.5kΩ, 1%, 1/8W, MtF	07716	CEA-1.5K-1%	R88-1.5K	..
R510	10MΩ, 10%, 1/4W, Comp.	01121	CB-106-10%	R76-10M	1
R511	10^8Ω, 20%, 1/2W, Comp.	75042	GBT-10^8Ω	R37-10^8	1
R512	10^9Ω, 20%, 1/2W, Comp.	75042	GBT-10^9Ω	R37-10^9	..
R513	89.9kΩ, 0.1%, 1/2W, MtF.	91637	MFF-89.9K	R169-89.9K	1
R514	100Ω, 1%, 1/8W, MtF.	07716	CEA-100-1%	R88-100	3
R515	100Ω, 1%, 1/8W, MtF.	07716	CEA-100-1%	R88-100	..
R516	8.99kΩ, 0.1%, 1/2W, MtF.	91637	MFF-8.99K	R169-8.99K	1
R517	10Ω, 10%, 1/4W, Comp	01121	CB-10R-10%	R76-10	2
R518	10Ω, 10%, 1/4W, Comp	01121	CB-10R-10%	R76-10	..
R519	899Ω, 0.1%, 1/2W, MtF.	91637	MFF-899	R169-899	1
R520	1Ω, 1%, 1/2W, DCb.	91637	DCF-1/2-1Ω	R12-1	2
R521	1Ω, 1%, 1/2W, DCb.	91637	DCF-1/2-1Ω	R12-1	..
R601	3.01kΩ, 1%, 1/8W, MtF.	07716	CEA-3.01K-1%	R88-3.01K	..
R602	113kΩ, 1%, 1/8W, MtF	07716	CEA-113K-1%	R88-113K	1
R603	100Ω, 1%, 1/8W, MtF.	07716	CEA-100-1%	R88-100	..
R604	6.98kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-6.98K	R168-6.98K	1
R605	5kΩ, 20%, 2W, WW	71450	1NS-115-5K	RP50-5K	..
R606	32.4kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-32.4K	R168-32.4K	2
R607	32.4kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-32.4K	R168-32.4K	..
R608	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R609	3.9kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-3.9K	1
R610	47Ω, 10%, 1/4W, Comp	01121	CB-152-10%	R76-47	1
R611	10kΩ, 1%, 1/8W, MtF.	07716	CEA-10K-1%	R88-10K	..
R701	47kΩ, 10%, 1/4W, Comp.	01121	CB-473-10%	R76-47K	..
R702	1kΩ, 10%, 1/4W, Comp	01121	CB-102-10%	R76-1K	..
R703	100Ω, 0.05%, 1/4W, WW.	17870	1352-100Ω	R157-100	1
R704	1MΩ, 10%, 1/4W, Comp	01121	CB-105-10%	R76-1M	..
R705	1kΩ, 10%, 1/4W, Comp	01121	CB-102-10%	R76-1K	..
R706	100kΩ, 1%, 1/8W, MtF	07716	CEA-100K-1%	R88-100K	..
R707	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	..
R708	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	..
R709	3.3kΩ, 10%, 1/4W, Comp	01121	CB-332-10%	R76-3.3K	..
R710	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	..
R711	1MΩ, 10%, 1/4W, Comp	01121	CB-105-10%	R76-1M	1
R712	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	..
R713	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R714	470kΩ, 10%, 1/4W, Comp	01121	CB-474-10%	R76-470K	1
R715	33kΩ, 10%, 1/4W, Comp.	01121	CB-333-10%	R76-33K	..
R716	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R717	56kΩ, 10%, 1/4W, Comp.	01121	CB-563-10%	R76-56K	1
R718	47kΩ, 10%, 1/4W, Comp.	01121	CB-473-10%	R76-47K	..
R719	68kΩ, 10%, 1/4W, Comp.	01121	CB-683-10%	R76-68K	2
R720	680Ω, 10%, 1/4W, Comp.	01121	CB-681-10%	R76-680	2
R721	680Ω, 10%, 1/4W, Comp.	01121	CB-681-10%	R76-680	..
R722	500Ω, 1/4W, Carbon	76055	MTC52L1-500Ω	RP59-500	1
R723	68kΩ, 10%, 1/4W, Comp.	01121	CB-683-10%	R76-68K	..
R724	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R725	47Ω, 10%, 1/4W, Comp	01121	CB-47R-10%	R76-47	2

RESISTORS (Cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
R726	470Ω, 10%, 1/4W, Comp.	01121	CB-471-10%	R76-470	2
R727	4.75kΩ, 1%, 1/8W, MtF.	07716	CEA-4.75K-1%	R88-4.75K	2
R728	49.9kΩ, 1%, 1/8W, MtF.	07716	CEA-49.9K-1%	R88-49.9K	2
R729	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R730	1kΩ, 1%, 1/8W, MtF	07716	CEA-1K-1%	R88-1K	..
R731	4.75kΩ, 1%, 1/8W, MtF.	07716	CEA-4.75K-1%	R88-4.75K	..
R732	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	..
R733	50kΩ, 20%, 0.75W, Cermet	73138	77PR-50KΩ	RP64-50K	1
R734	49.9kΩ, 1%, 1/8W, MtF.	07716	CEA-49.9K-1%	R88-49.9K	..
R735	100kΩ, 1%, 1/8W, MtF	07716	CEA-100K-1%	R88-100K	..
R736	100kΩ, 10%, 1/4W, Comp	01121	CB-104-10%	R76-100K	..
R737	1kΩ, 1%, 1/8W, MtF	07716	CEA-1K-1%	R88-1K	..
R738	2kΩ, 20%, 0.75W, Cermet.	73138	77PR-2K	RP64-2K	1
R739	8.06kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-8.06K	R168-8.06K	1
R740	9.9kΩ, 0.1%, 1/8W, MtF	91637	MFF-1/8-9.9K	R168-9.9K	1
R741	100Ω, 0.1%, 1/8W, MtF.	91637	MFF-1/8-100	R168-100	1
R742	10kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-10K	R168-10K	3
R743	10kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-10K	R168-10K	..
R744	Not Used	.....	....	....	..
R745	10kΩ, 0.1%, 1/8W, MtF.	91637	MFF-1/8-10K	R168-10K	..
R746	1.5kΩ, 10%, 1/4W, Comp	01121	CB-152-10%	R76-1.5K	..
R747	47Ω, 10%, 1/4W, Comp	01121	CB-47R-10%	R76-47	..
R748	470Ω, 10%, 1/4W, Comp.	01121	CB-471-10%	R76-470	..
R801	10kΩ, 10%, 1/4W, Comp.	01121	CB-103-10%	R76-10K	..

MISCELLANEOUS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Qty.
S101	Switch, Rotary (RANGE) 160 only	80164	SW-319A	SW-319A	1
S201	Not Used	.....	......	....	..
S202	Switch	80164	SW-318	SW-318	1
T201	Transformer	80164	TR-130	TR-130	1
V301	Tube, Readout	80164	EV-841	EV-841	3
V302	Tube, Readout	80164	EV-841	EV-841	..
V303	Tube, Readout	80164	EV-841	EV-841	..
S101	Switch Rotary (Range) 163 only			SW322A	1

Model 1602 Digital Output, PC-287.

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
C1001	1.2 μF	20 V	ETT	17554	TSD1-20	C179-1.2M
C1002	.001 μF	1000 V	CerD	72982	801000X5F0102K	C22-.001M
C1003	.0022 μF	1000 V	CerD	72982	811000X5F0222K	C22-.0022M

CONNECTORS

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
J1001	Receptacle, 10-Pin	22526	20052	CS-237
J1002	Receptacle, 10-Pin	22526	20052	CS-237
J1003	Receptacle, 10-Pin	22526	20052	CS-237
J1004	Receptacle, 22-Pin	09922	PSC4SS2212	CS-182
J1005	Receptacle, 44-Pin	09922	PSC4DD2212	CS-205
J1006	Receptacle, 50-Pin	02660	57405001	CS-221
	Plug, Mate of J1006, (Not Supplied)	02660	57305001	CS-220

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
D1001	Germanium, 20V, 50mA	15238	1N3592	RF-39
D1002	Germanium, 20V, 50mA	15238	1N3592	RF-39
D1003	Germanium, 20V, 50mA	15238	1N3592	RF-39
D1004	Germanium, 20V, 50mA	15238	1N3592	RF-39
D1005	Germanium, 20V, 50mA	15238	1N3592	RF-39
D1006	Silicon	01295	1N914	RF-28
D1007	Silicon	01295	1N914	RF-28
D1008	Silicon	01295	1N914	RF-28
D1009	Silicon	01295	1N914	RF-28
D1010	Silicon	01295	1N914	RF-28
D1011	Silicon	01295	1N914	RF-28
D1012	Silicon	01295	1N914	RF-28

INTEGRATED CIRCUITS

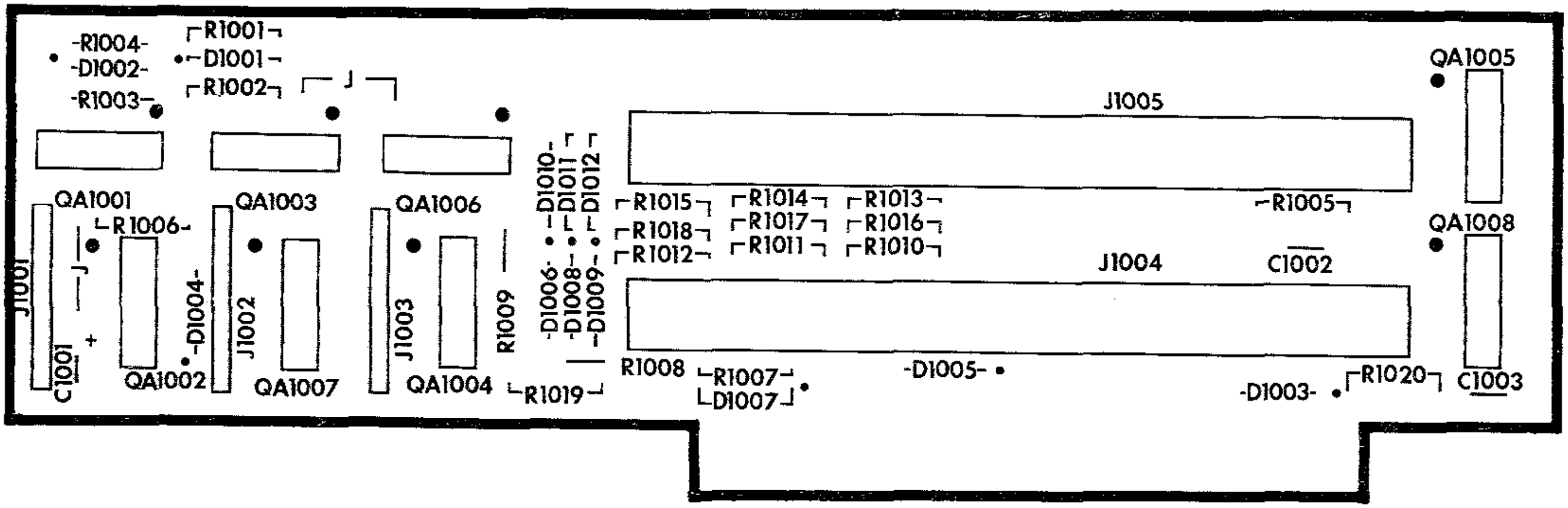
Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
QA1001	Quad, NAND Gate, 14-Pin DIP, TO-116	04713	MC858P	IC-22
QA1002	Quad, NAND Gate, " " "	04713	MC858P	IC-22
QA1003	Quad, NAND Gate, " " "	04713	MC858P	IC-22
QA1004	Quad, NAND Gate, " " "	04713	MC858P	IC-22
QA1005	Inverter-Flip-Flop, 14-Pin DIP, TO-116	04713	MC887P	IC-23
QA1006	Quad, NAND Gate, 14-Pin DIP, TO-116	04713	MC858P	IC-22
QA1007	Quad, NAND Gate, " " "	04713	MC858P	IC-22
QA1008	Binary Counter, 14-Pin DIP, TO-116	04713	MC877P	IC-21

Model 1602 Digital Output, PC-287.

RESISTORS

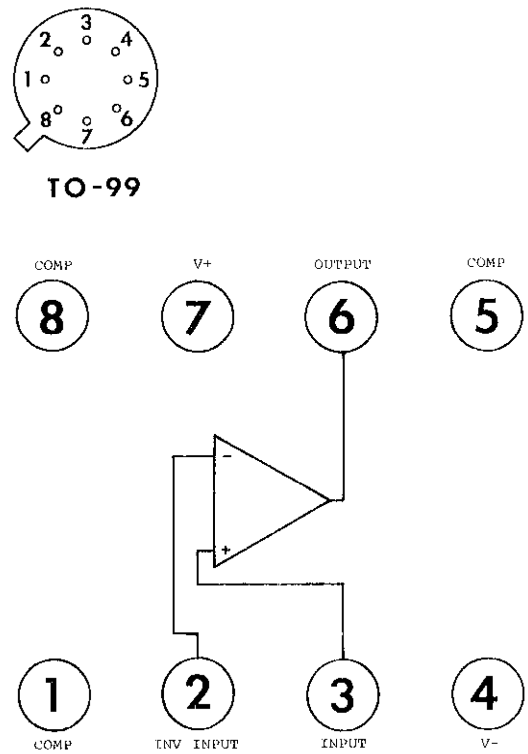
Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.
R1001	3.3 KΩ	10%, 1/4 W	Comp	44655	RC07-332-10%	R76-3.3K
R1002	1.5 KΩ	10%, 1/4 W	Comp	44655	RC07-152-10%	R76-1.5K
R1003	1.5 KΩ	10%, 1/4 W	Comp	44655	RC07-152-10%	R76-1.5K
R1004	3.3 KΩ	10%, 1/4 W	Comp	44655	RC07-332-10%	R76-3.3K
R1005	1.5 KΩ	10%, 1/4 W	Comp	44655	RC07-152-10%	R76-3.3K
R1006	1 KΩ	10%, 1/4 W	Comp	44655	RC07-102-10%	R76-1K
R1007	560 KΩ	10%, 1/4 W	Comp	44655	RC07-561-10%	R76-560
R1008	10 KΩ	10%, 1/8 W	Comp	01121	BB-103-10%	R143-10K
R1009	10 KΩ	10%, 1/8 W	Comp	01121	BB-103-10%	R143-10K
R1010	100 KΩ	10%, 1/4 W	Comp	44655	RC07-104-10%	R1-100K
R1011	27 KΩ	10%, 1/4 W	Comp	44655	RC07-273-10%	R76-27K
R1012	15 KΩ	10%, 1/4 W	Comp	44655	RC07-153-10%	R76-15K
R1013	47 KΩ	10%, 1/4 W	Comp	44655	RC07-473-10%	R1-47K
R1014	15 KΩ	10%, 1/4 W	Comp	44655	RC07-153-10%	R76-15K
R1015	8.45 KΩ	1%, 1/8 W	MtF	07716	CEA-8.45KΩ	R88-8.45K
R1016	100 KΩ	10%, 1/4 W	Comp	44655	RC07-104-10%	R1-100K
R1017	27 KΩ	10%, 1/4 W	Comp	44655	RC07-273-10%	R76-27K
R1018	15 KΩ	10%, 1/4 W	Comp	44655	RC07-153-10%	R76-15K
R1019	10 KΩ	10%, 1/4 W	Comp	44655	RC07-103-10%	R76-10K
R1020	10 KΩ	10%, 1/4 W	Comp	44655	RC07-103-10%	R76-10K

FIGURE 25. Model 1602 Digital Output.



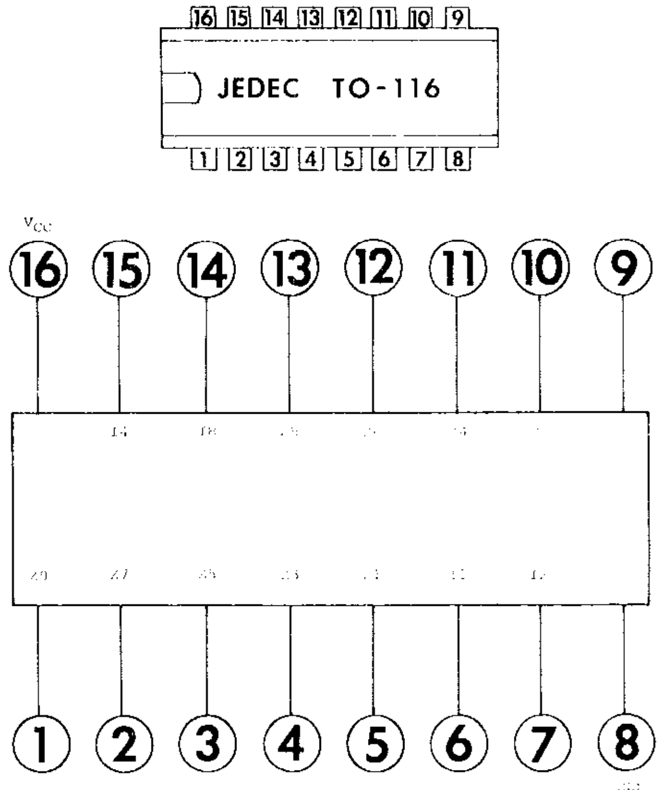
Component Designations, PC-287.

KEITHLEY PART NO. IC-1,2



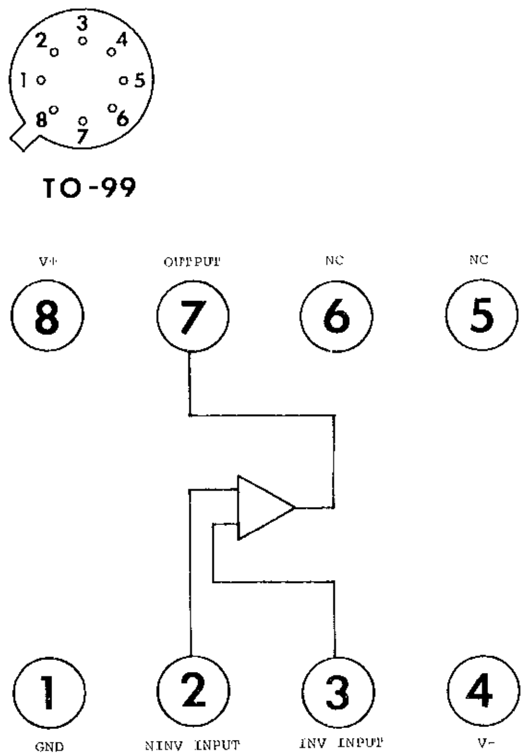
OPERATIONAL AMPLIFIER

KEITHLEY PART NO. IC-3



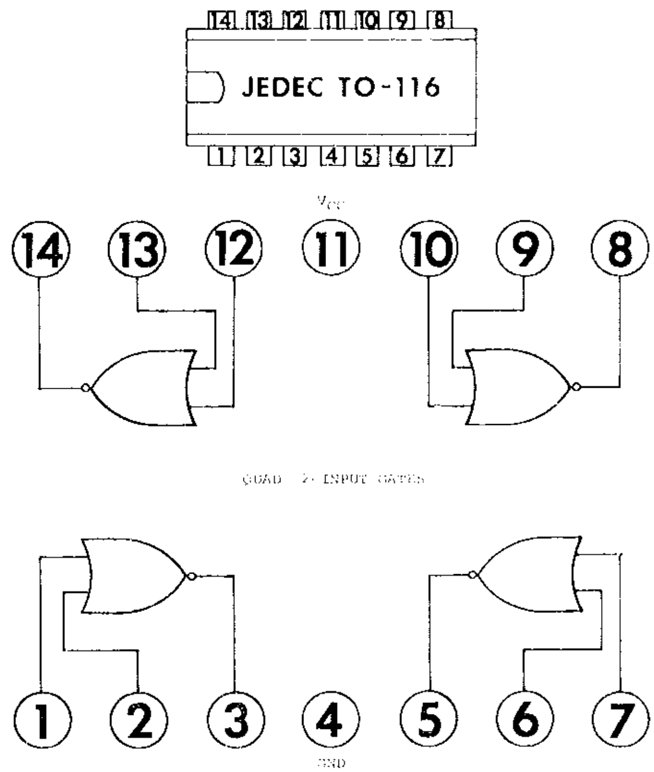
DECIMAL DECODER/DRIVER

KEITHLEY PART NO. IC-4

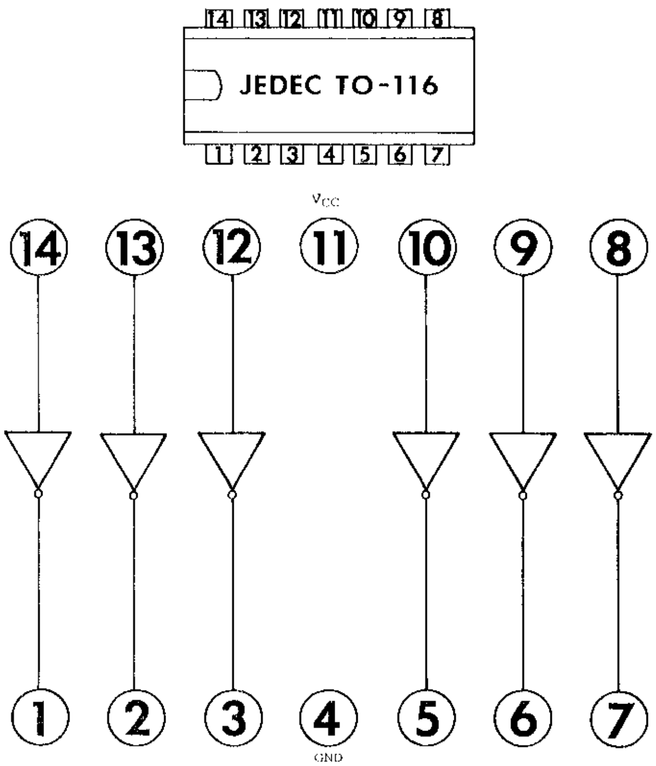


DIFFERENTIAL COMPARATOR

KEITHLEY PART NO. IC-5

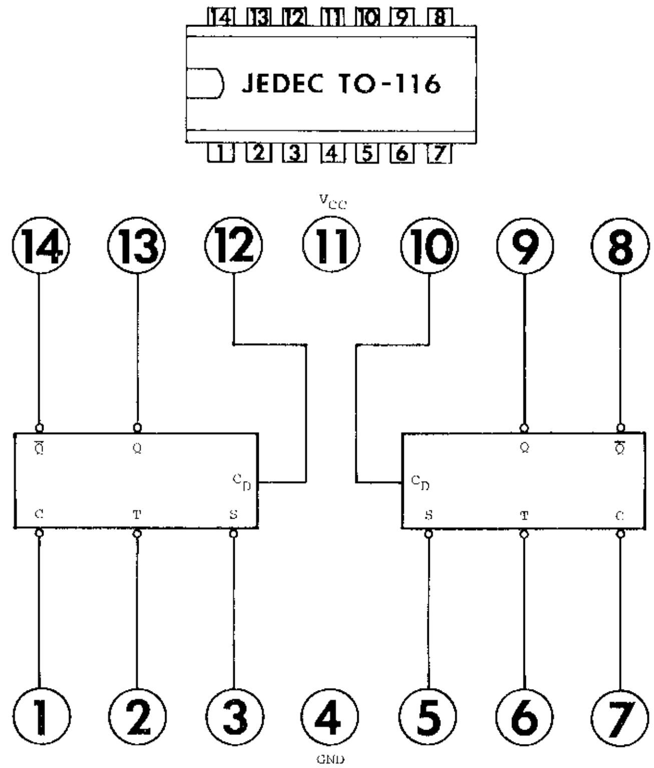


KEITHLEY PART NO. IC-7



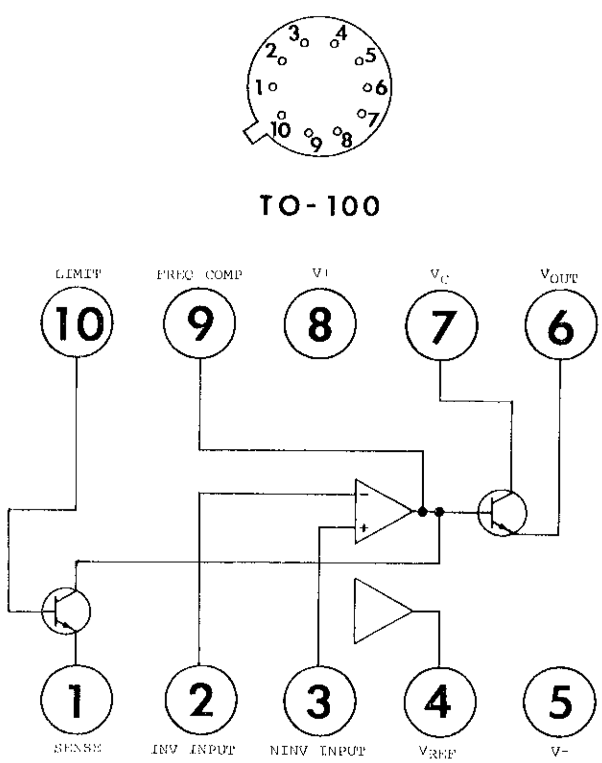
HEX INVERTER AMPLIFIER

KEITHLEY PART NO. IC-8,9



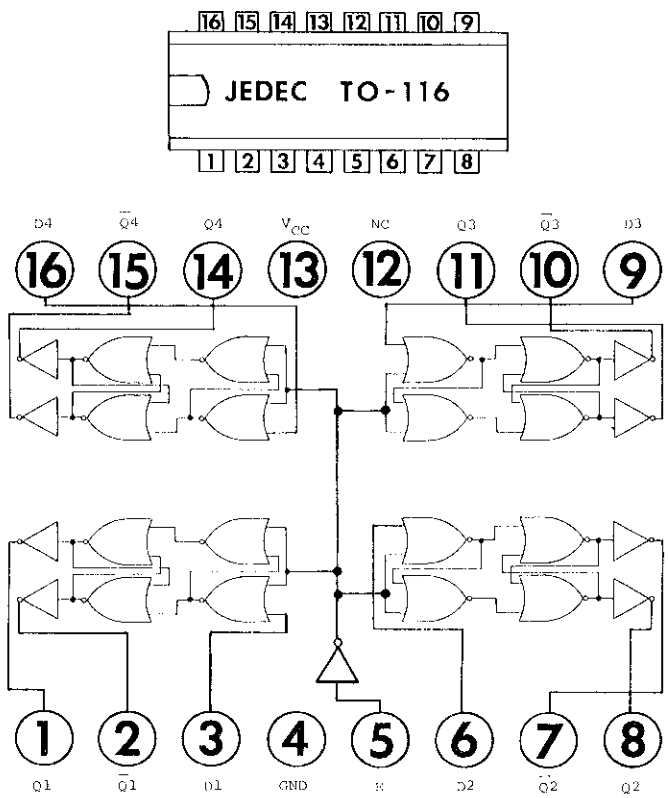
DUAL J-K FLIP FLOPS

KEITHLEY PART NO. IC-14



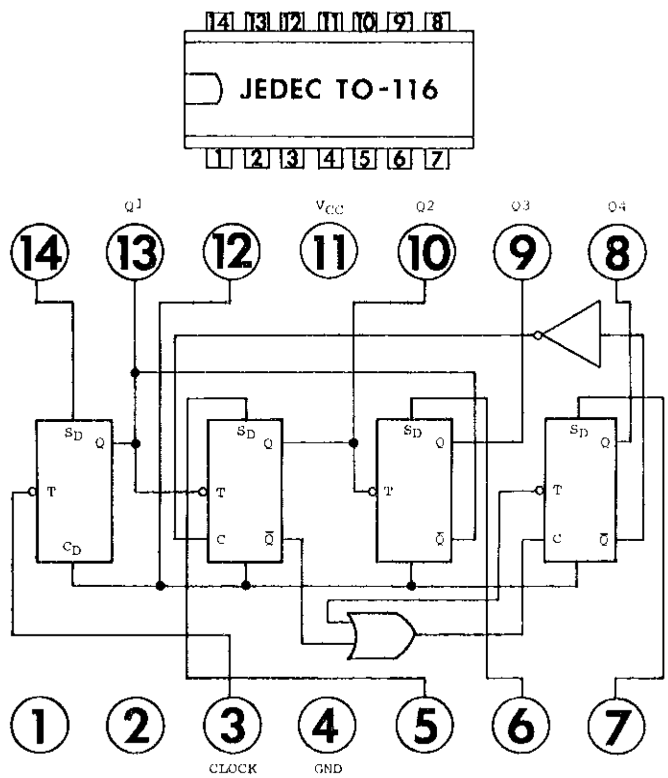
REGULATOR

KEITHLEY PART NO. IC-16



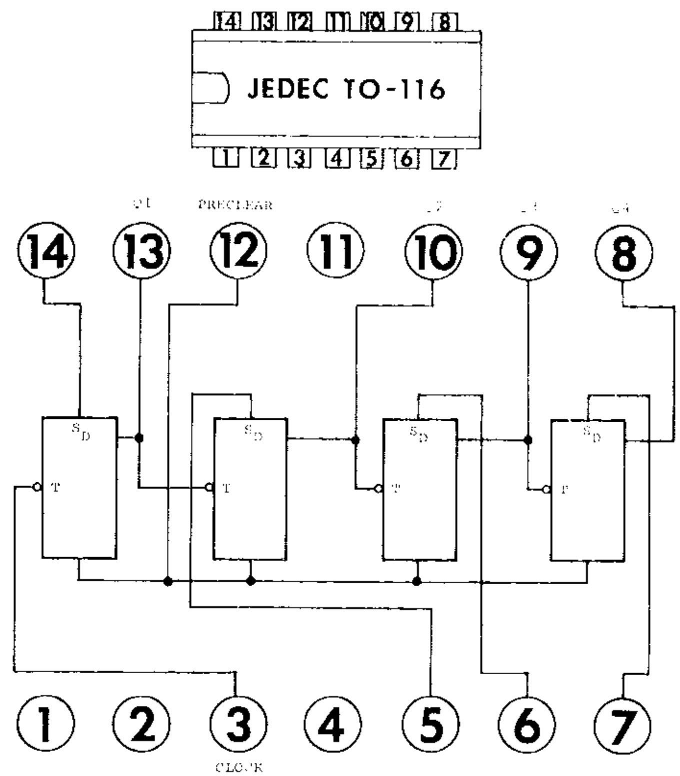
QUAD LATCH

KEITHLEY PART NO. IC-17



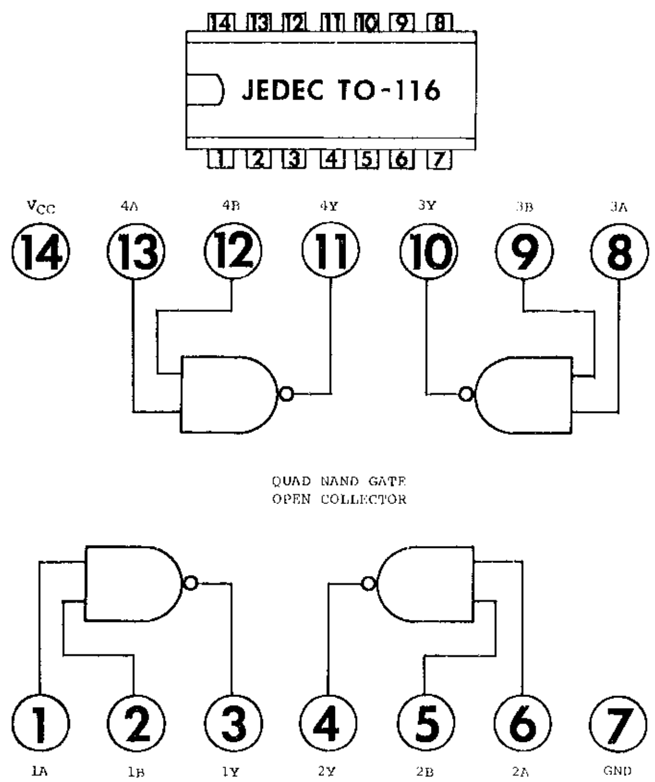
DECADE UP COUNTER

KEITHLEY PART NO. IC-21



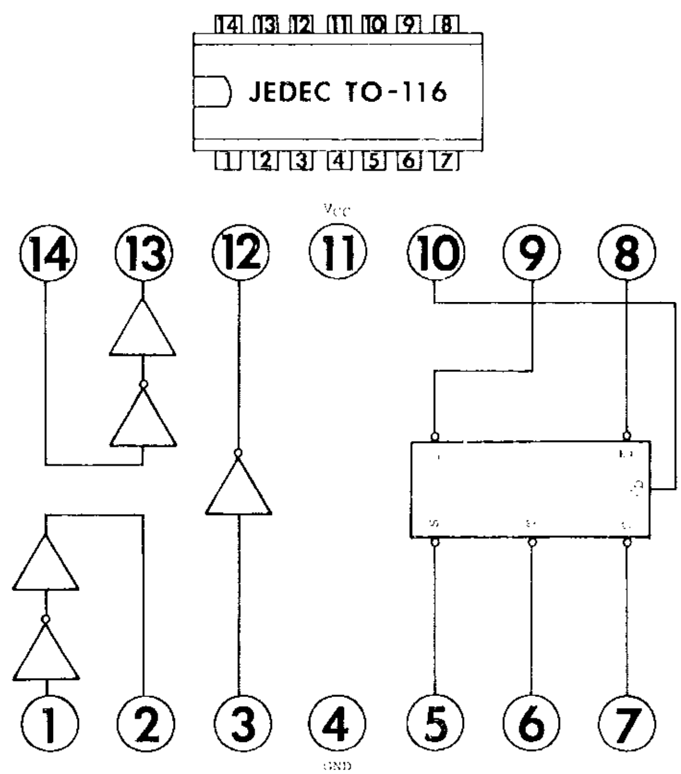
BINARY COUNTER

KEITHLEY PART NO. IC-22

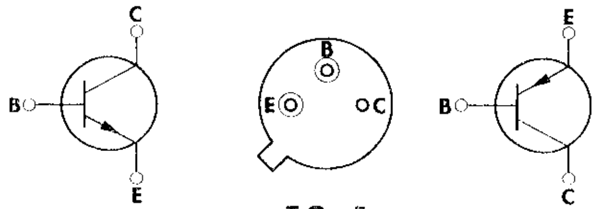


QUAD NAND GATE
OPEN COLLECTOR

KEITHLEY PART NO. IC-23

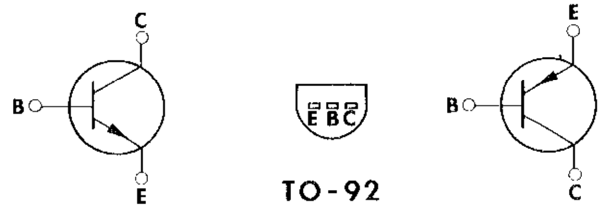


LEAD DESIG. TO-5



TO-5

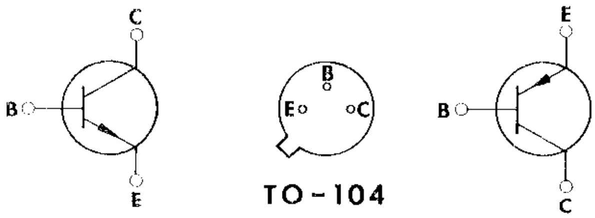
LEAD DESIG. TO-92



TO-92

BOTTOM VIEW

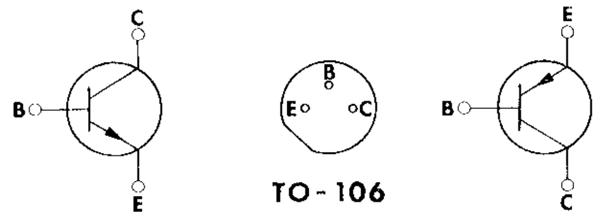
LEAD DESIG. TO-104



TO-104

BOTTOM VIEW

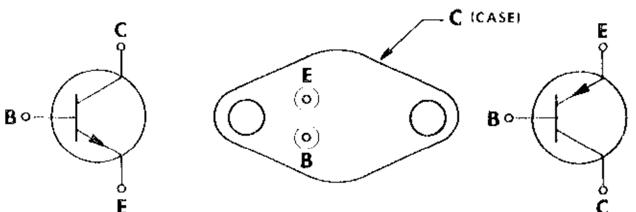
LEAD DESIG. TO-106



TO-106

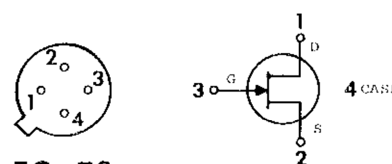
BOTTOM VIEW

LEAD DESIG. TO-66



TO-66

KEITHLEY PART NO. TG-42

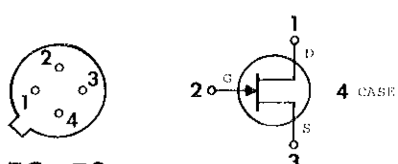


TO-72

BOTTOM VEIW

N-CHANNEL JFET

KEITHLEY PART NO. TG-51

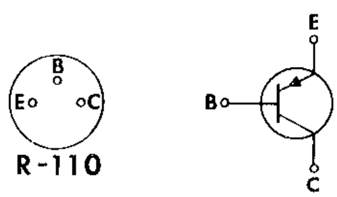


TO-72

BOTTOM VIEW

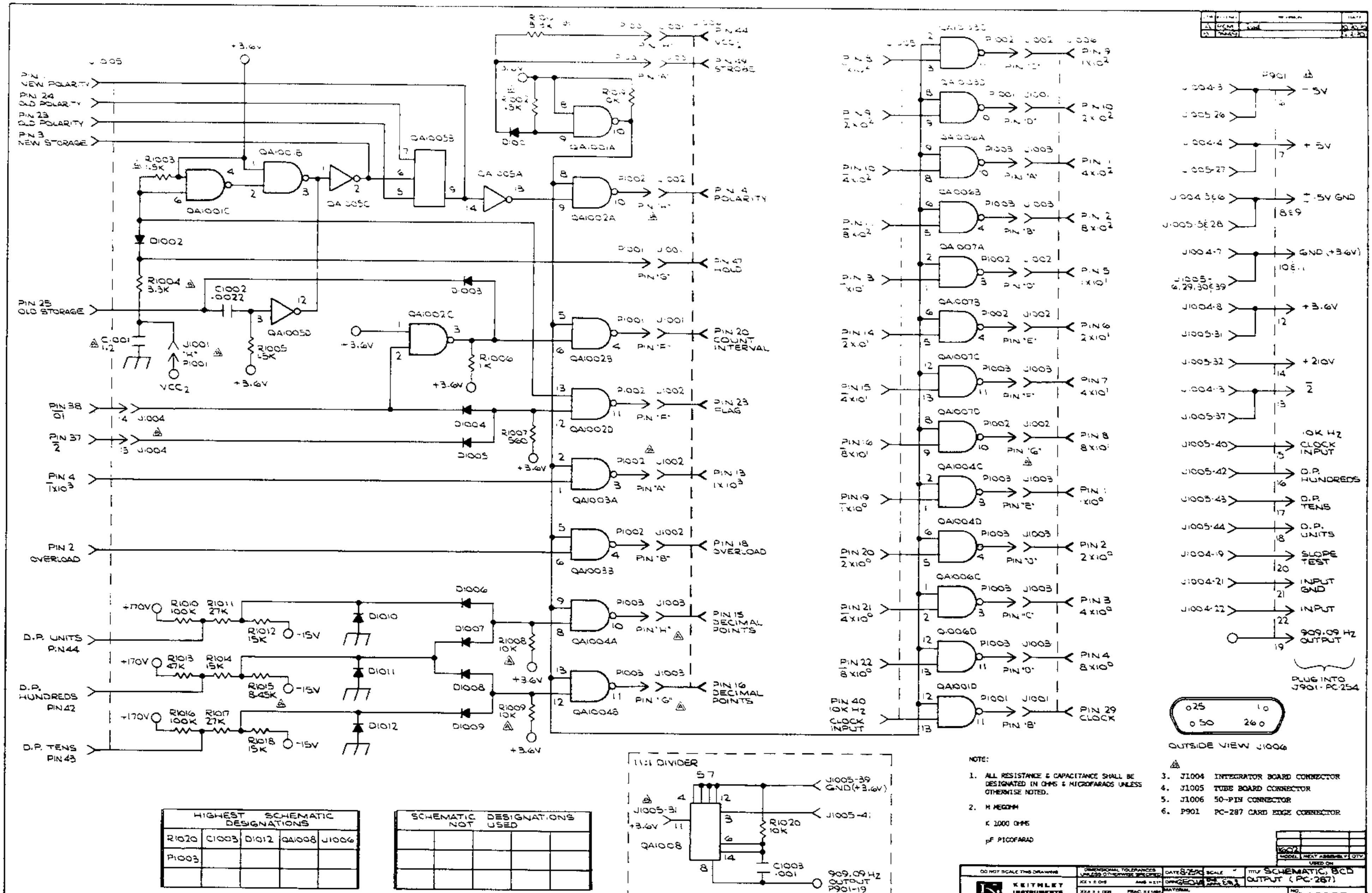
N-CHANNEL FET

KEITHLEY PART NO. TG-33



R-110

BOTTOM VIEW



HIGHEST SCHEMATIC DESIGNATIONS				
R1020	C1003	D1012	QA1008	J1006
P1003				

SCHEMATIC DESIGNATIONS NOT USED					

NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. M MEGOHM

   K 1000 OHMS

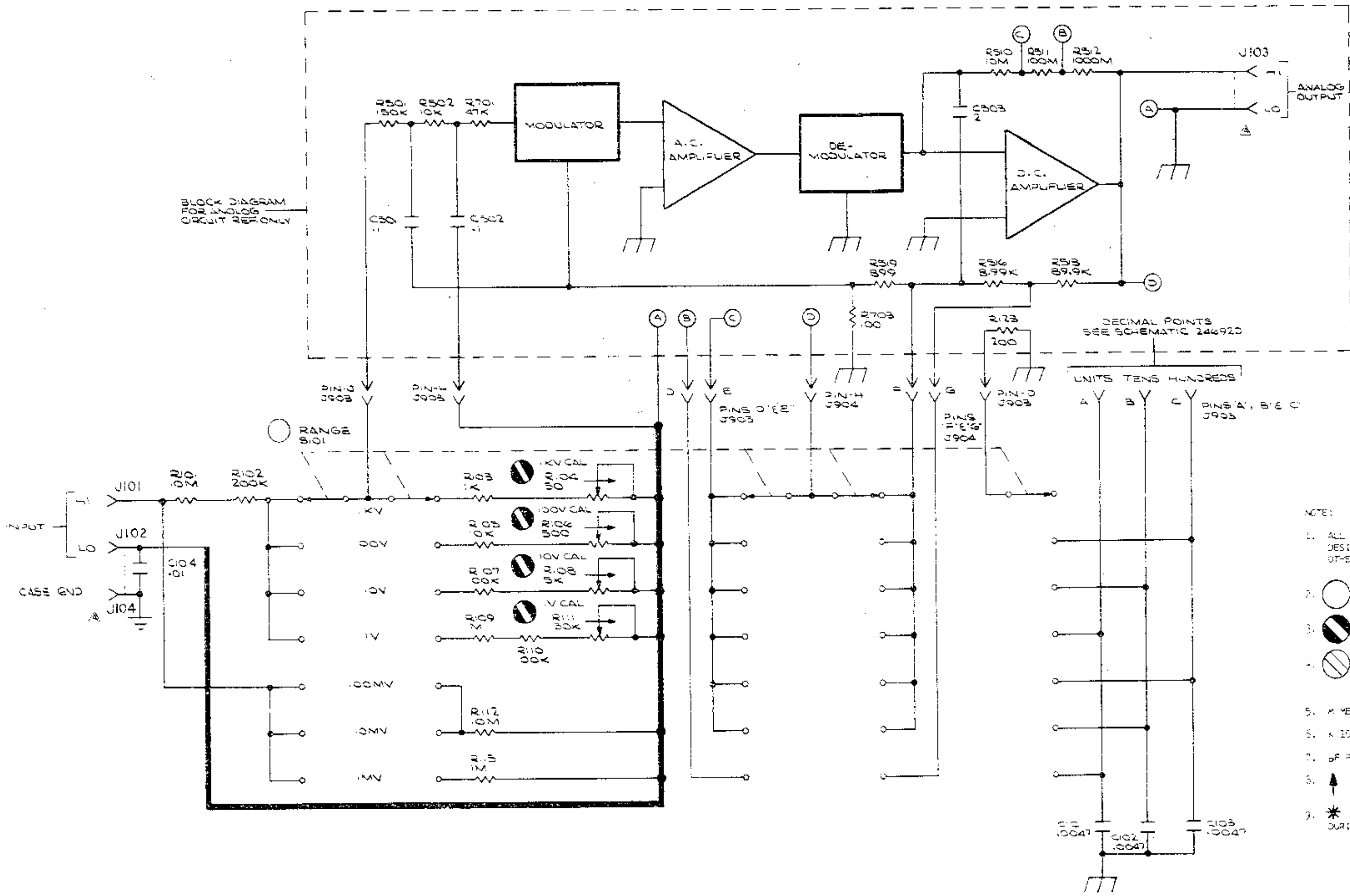
   pF PICOFARAD
3. J1004 INTEGRATOR BOARD CONNECTOR
4. J1005 TUBE BOARD CONNECTOR
5. J1006 50-PIN CONNECTOR
6. P901 PC-287 CARD EDGE CONNECTOR

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

SCHEMATIC, BCD OUTPUT (PC-287)

NO. 24685D



NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ◯ FRONT PANEL CONTROL.
3. INTERNAL SCREWDRIVER ADJ.
4. REAR PANEL ADJ.
5. M MEGOHM
6. K 1000 OHMS
7. pF PICOFARAD
8. CLOCKWISE ROTATION
9. ✱ INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION.

HIGHEST SCHEMATIC DESIGNATIONS				
R123	C104	S102	J101	J904

SCHEMATIC DESIGNATIONS NOT USED				
R113	R117	R120	S102	
R114	R118	R121		
R116	R119	R122		

LTR	ECO NO.	REVISION	DATE
A	1159		4-21-71

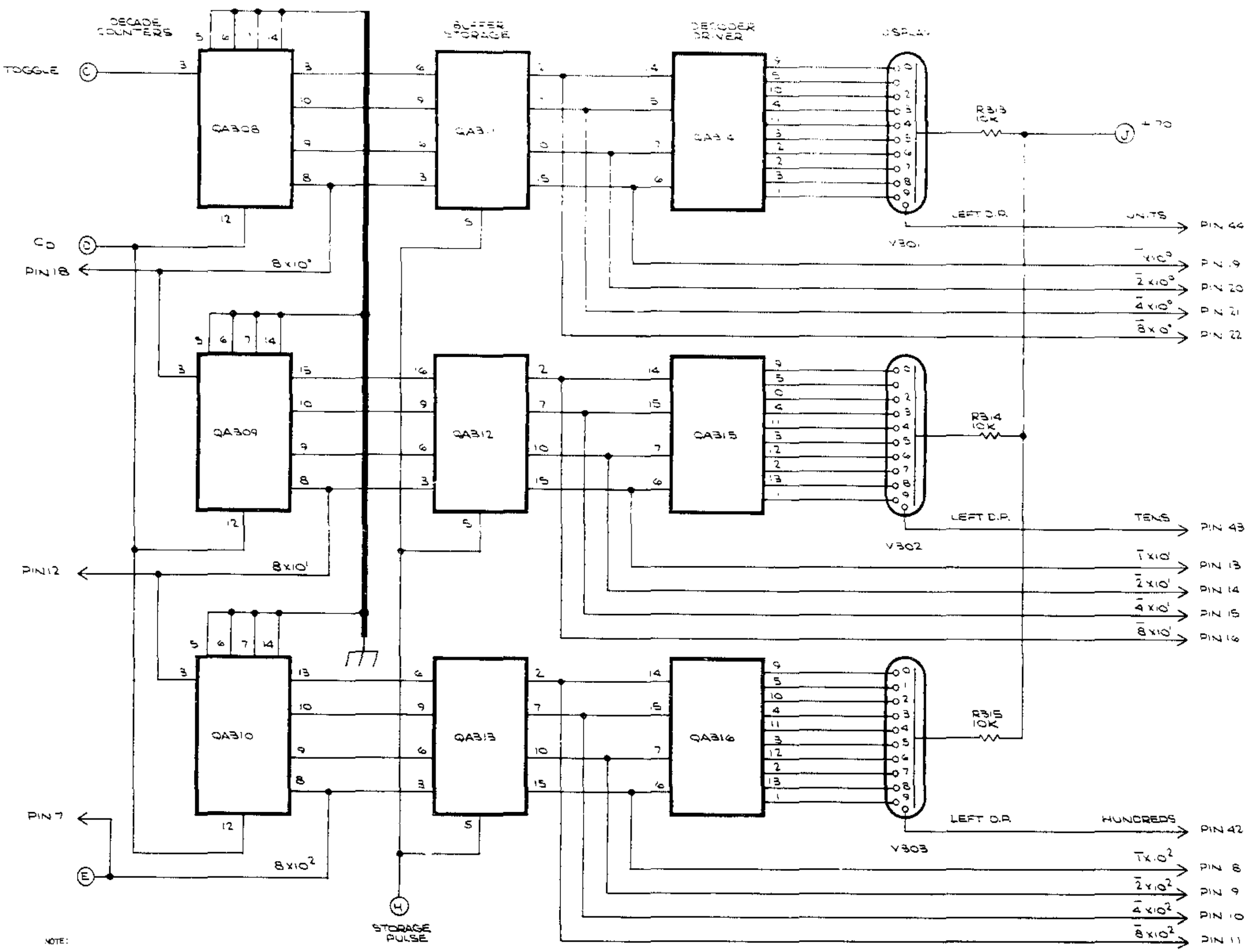
DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC, SWITCHING

NO. 24693D

USED ON: 163



NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. K 1000 OHMS

HIGHEST REFERENCE DESIGNATION					
R315	QA316	V303			

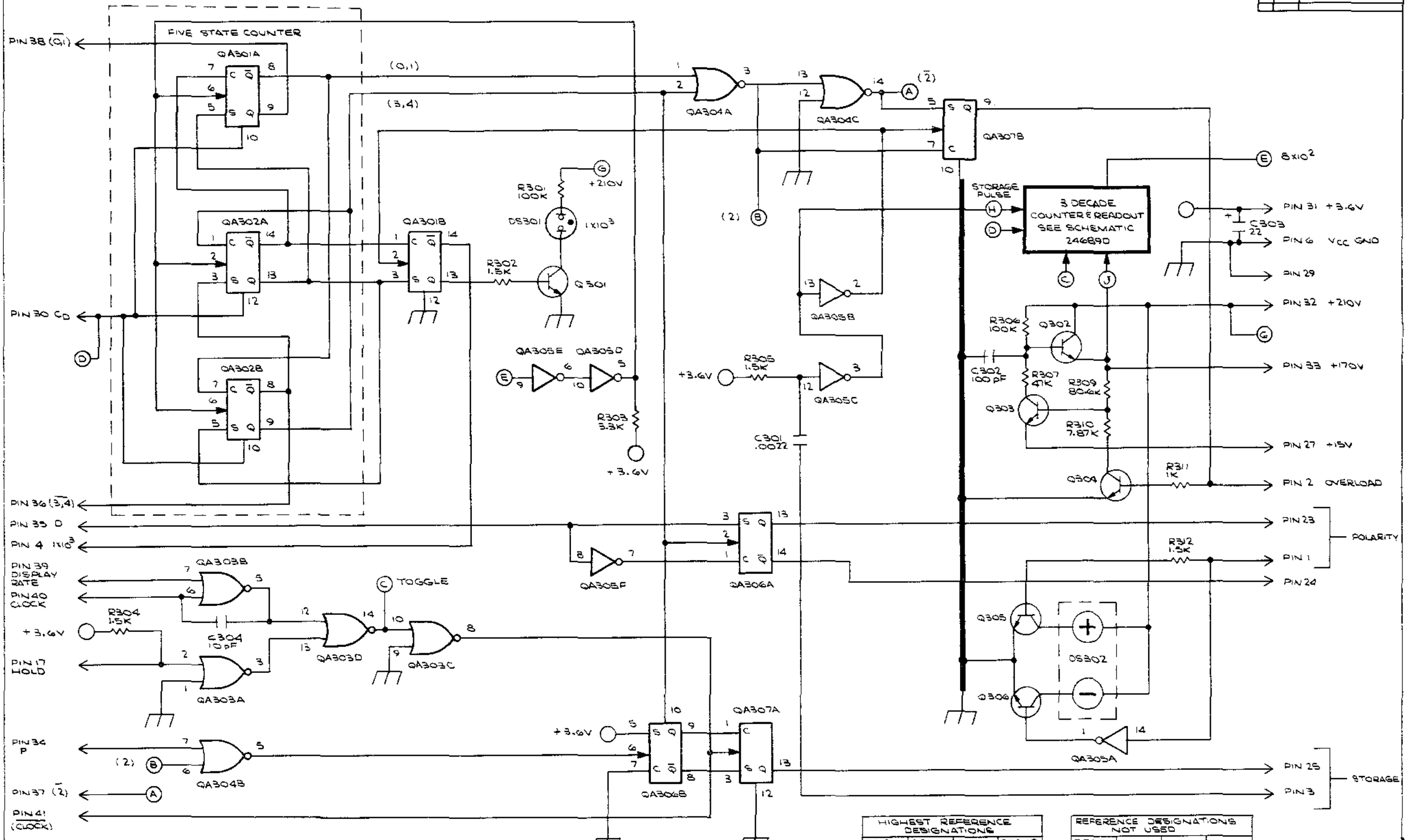
REFERENCE DESIGNATIONS NOT USED						

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC, TUBE BOARD PC-248

NO. 24689D



HIGHEST REFERENCE DESIGNATIONS			
R312	C304	Q306	DS302
QA307B			

REFERENCE DESIGNATIONS NOT USED			
R308			

NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED
2. M MEGOHM
3. K 1000 OHMS
4. pF PICOFARAD

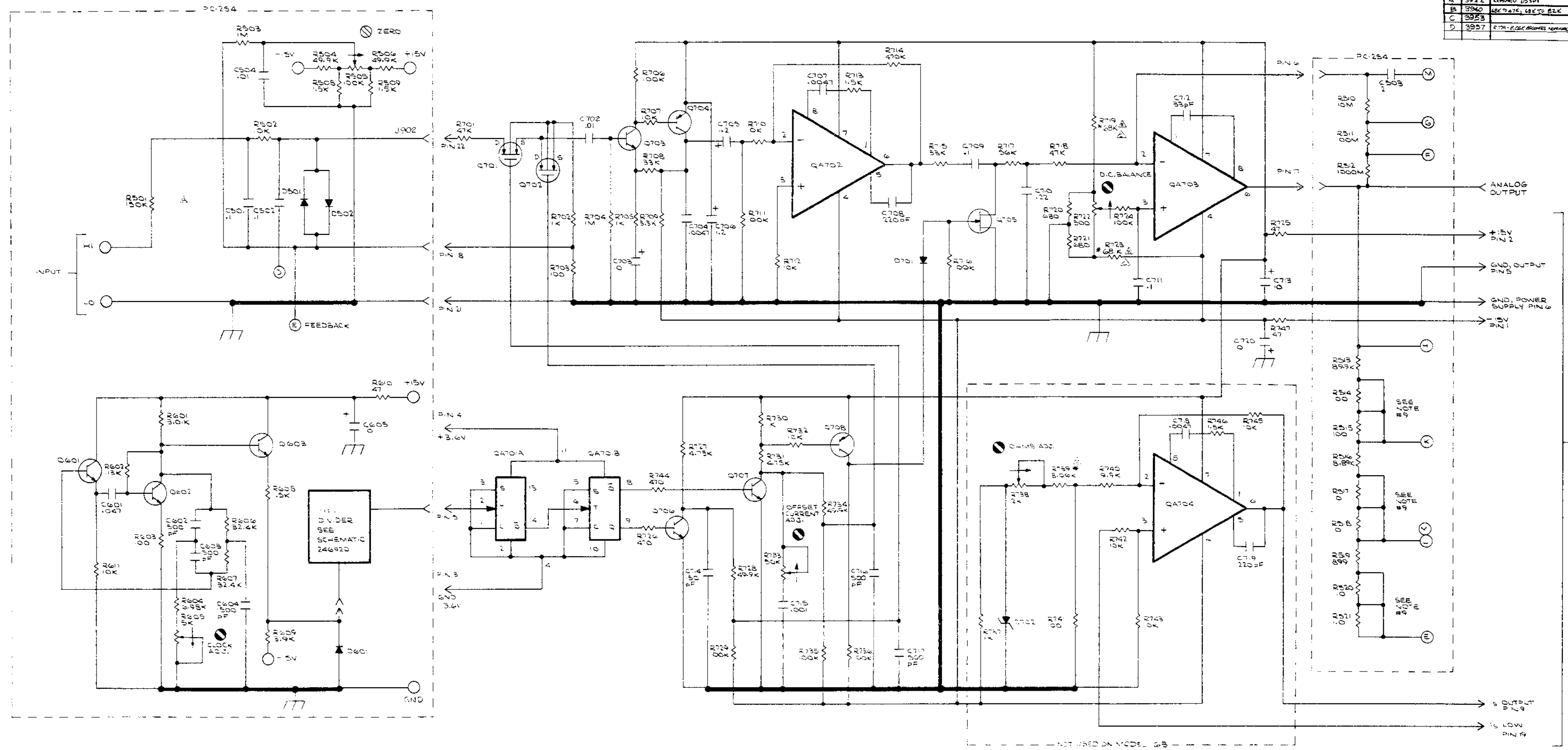
DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

TITLE SCHEMATIC, TUBE BOARD PC-248

NO. 24688D

LTR	ECO NO.	REVISION	DATE
A	3922	REMOVED D5501	8-5-70
B	3940	68K TO 47K, 68K TO 82K	10-19-70
C	3953		1-4-71
D	3957	R739 - 8.06K BECOMES NOMINAL VALUE	1-27-71



NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. REAR PANEL ADJ.
4. M MEGOHM
5. K 1000 OHMS
6. pF PICOFARAD
7. CLOCKWISE ROTATION
8. ✱ INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION.
9. JUMPERS CLIPPED DURING FINAL CALIBRATION IF NECESSARY.

HIGHEST SCHEMATIC DESIGNATIONS					
R52	C504		J901	D502	
R6	C605	D60	Q603		
R747	C720	D702	Q708	QA704	

SCHEMATIC DESIGNATIONS NOT USED			
[illegible]	[illegible]		
R507			
[illegible]			

MODEL	NEXT ASSEMBLY	QTY
163		
160		
USED ON		

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

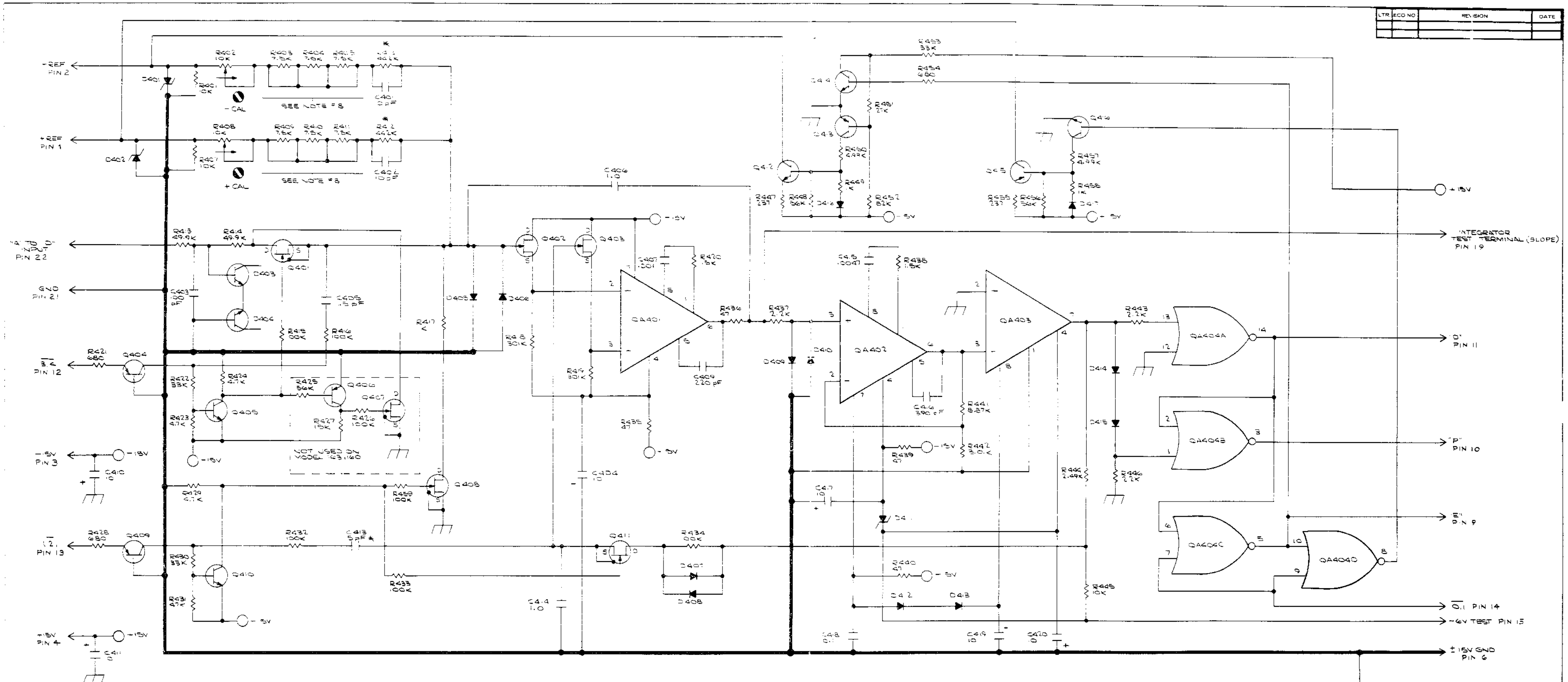
DATE 5-70 | SCALE | DWN | ENG APPR

MATERIAL — | FINISH —

SURFACE MAX

TITLE SCHEMATIC, ANALOG AMPLIFIER PC-251

NO. 24691E



NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHMS
5. pF PICOFARAD
6. CLOCKWISE ROTATION
7. ✱ INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION.
8. JUMPERS CLIPPED DURING FINAL CALIBRATION IF NECESSARY.

HIGHEST REFERENCE DESIGNATIONS					
R459	C420	D417	Q416	QA404D	

REFERENCE DESIGNATIONS NOT USED					
C408					

LTR	ECO NO	REVISION	DATE

MODEL	NEXT ASSEMBLY	QTY
163		1
160		1

USED ON

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND OHIO

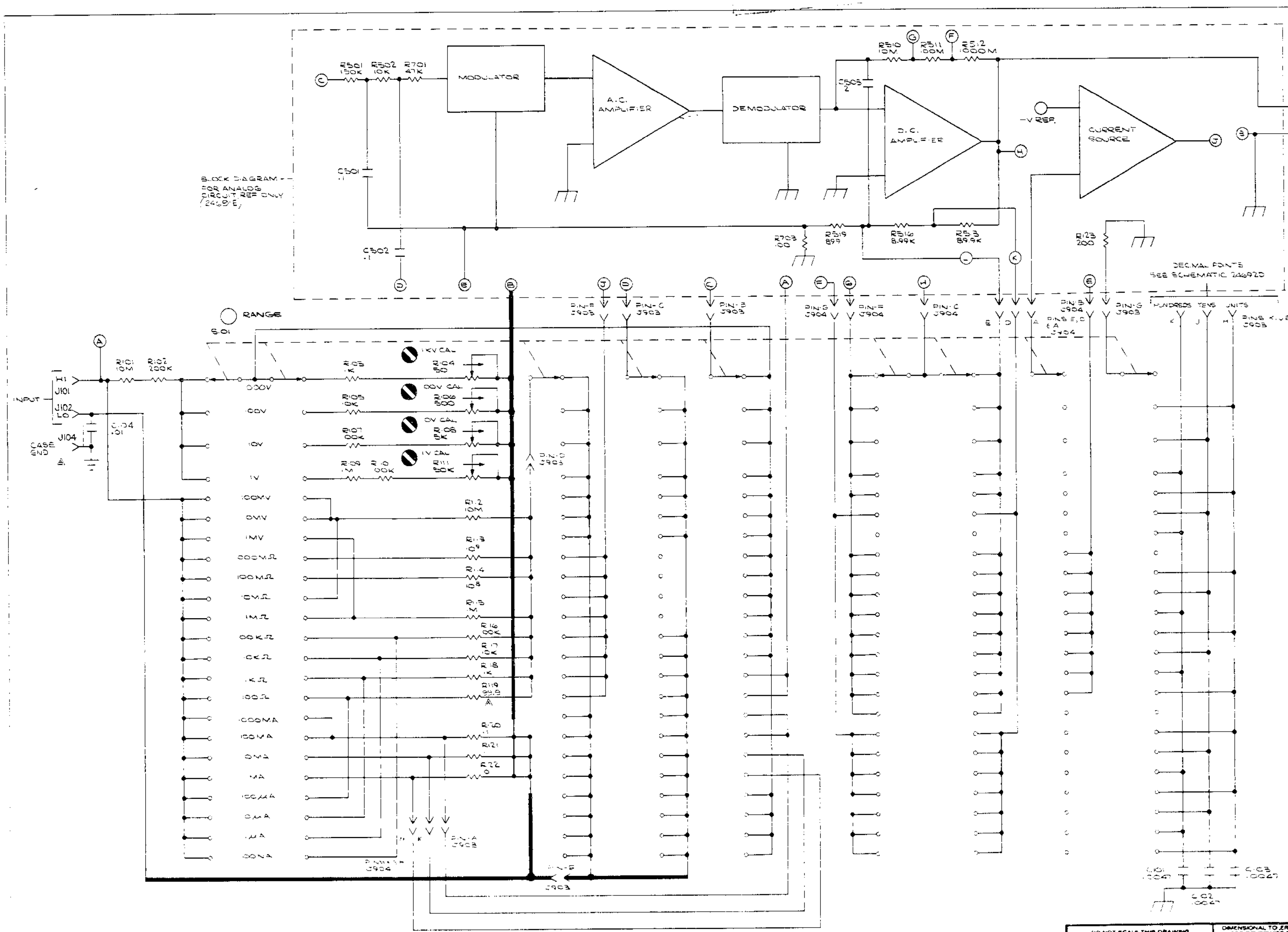
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ± .015 — ANG = ±1°
XXX = ± .005 — FRAC = ±1/64
SURFACE MAX 63

DATE 3-2-70 SCALE —
DRN GECHA ENG. APPR.
MATERIAL —
FINISH —

TITLE SCHEMATIC, INTEGRATOR BOARD

NO 24690E

LTR	ECO NO.	REVISION	DATE
A	3957	[illegible]	[illegible]
B	3971		[illegible]



NOTE:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHMS
5. pF PICOFARAD
6. CLOCKWISE ROTATION
7. FRONT PANEL CONTROL.

HIGHEST REFERENCE DESIGNATION				
R123	S102	C104	J904	

REFERENCE DESIGNATIONS NOT USED				
C102				

160		
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND OHIO

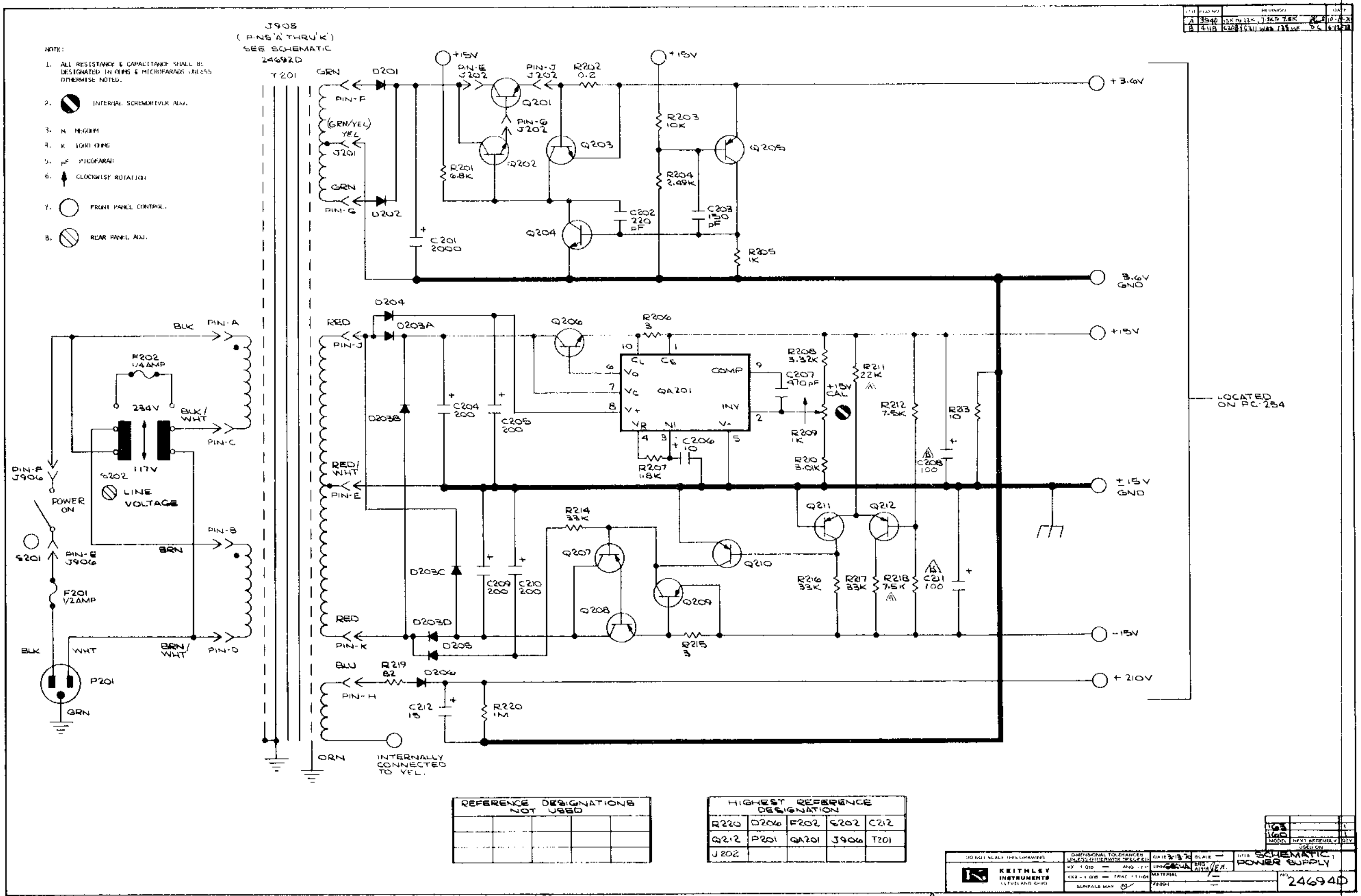
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ±.015 — ANG = ±1°
XXX = ±.005 — FRAC = ±1/64
SURFACE MAX

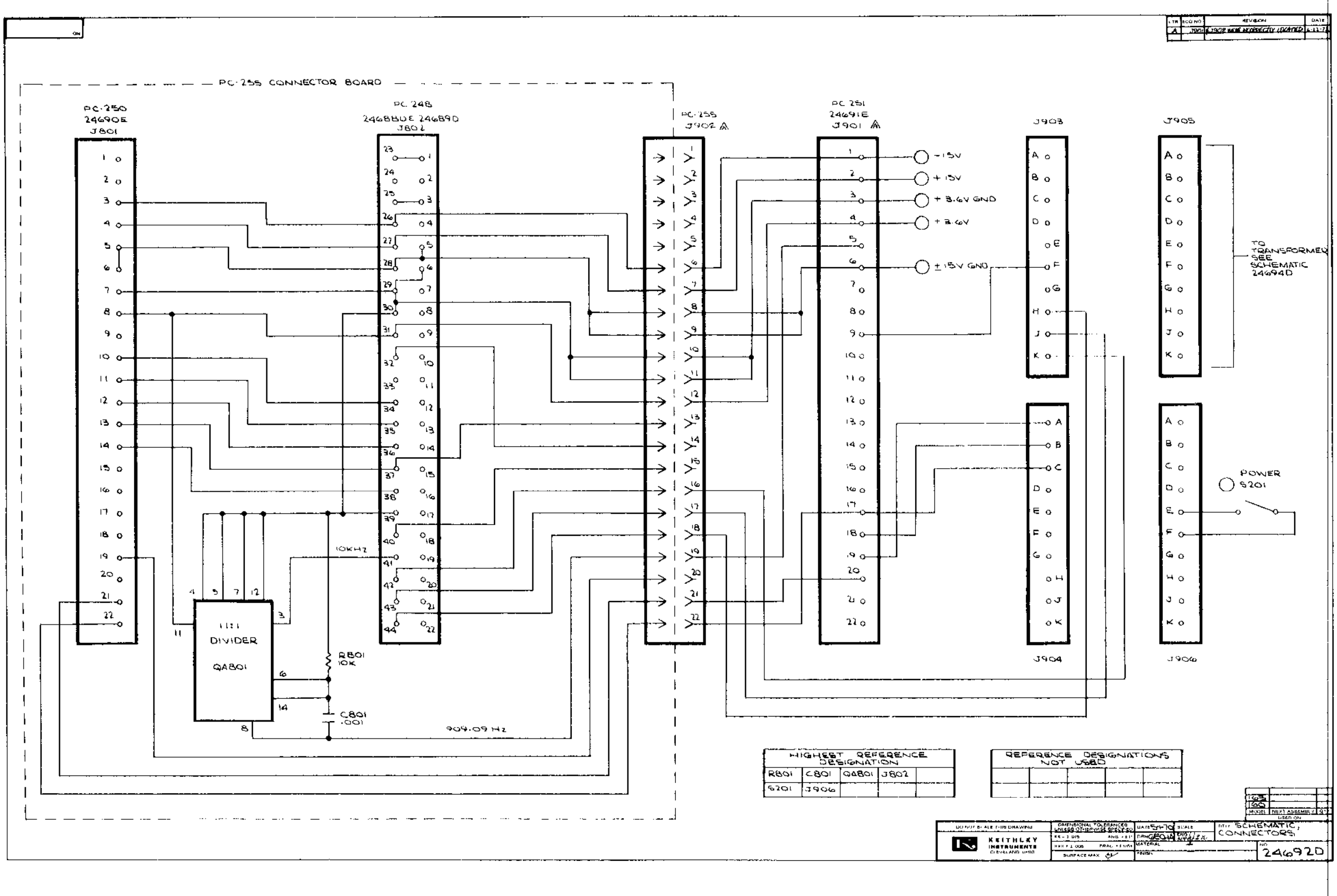
DATE 3-9-70 | SCALE —
DRN GEO-A | ENG APPR

MATERIAL
FINISH

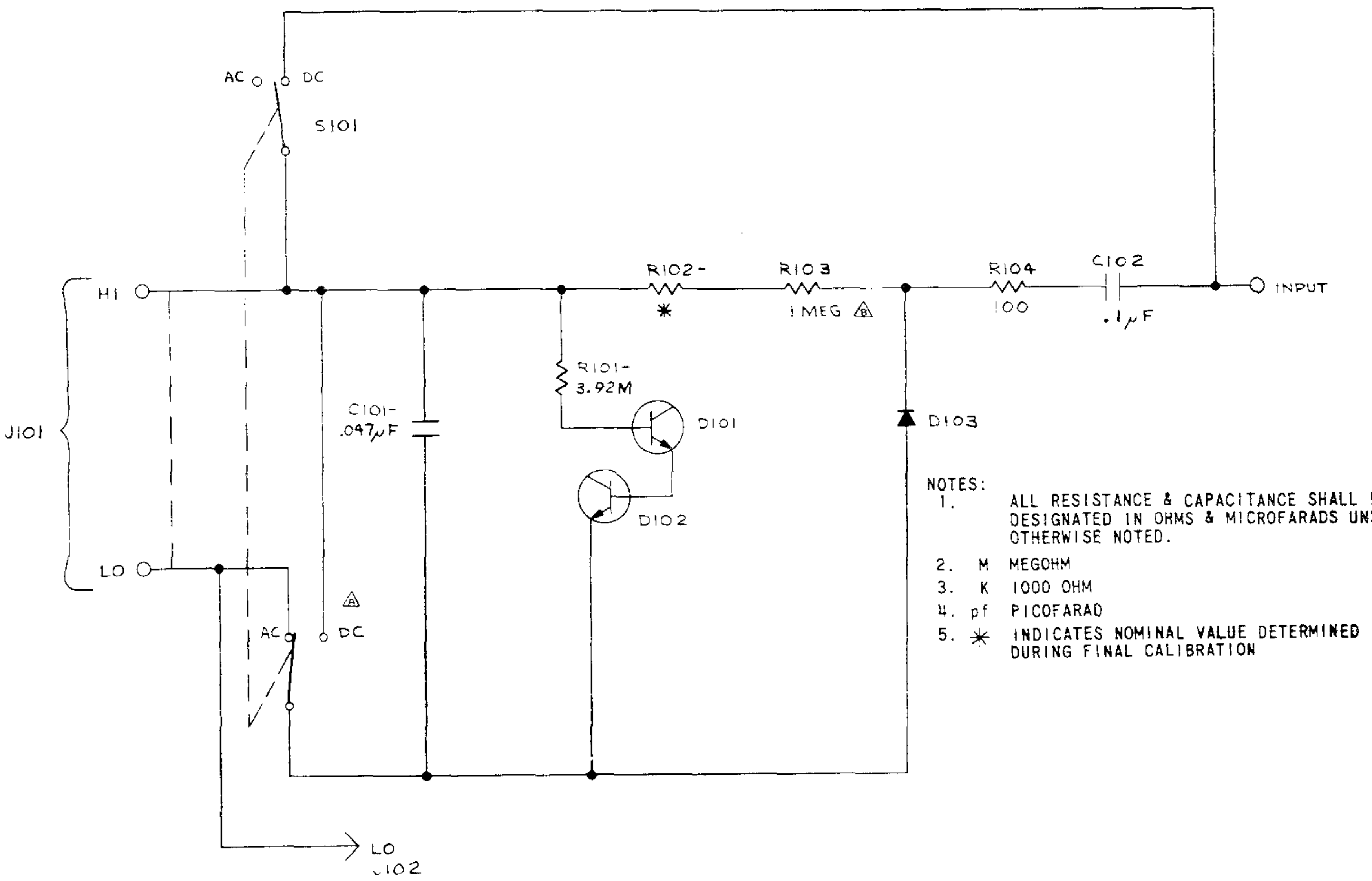
TITLE SCHEMATIC, SWITCHING

NO 24687E


NOTE:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
7. FRONT PANEL CONTROL
8. REAR PANEL ADJ.
J908 (PINS 'A' THRU 'K') SEE SCHEMATIC 24692D
T201
QA201
+3.6V
3.6V GND
+15V
±15V GND
-15V
+210V
LOCATED ON PC-254
LINE VOLTAGE
POWER ON
INTERNALLY CONNECTED TO YEL.
REFERENCE DESIGNATIONS NOT USED
HIGHEST REFERENCE DESIGNATION
R220 D206 F202 S202 C212
Q212 P201 QA201 J906 T201
J202
KEITHLEY INSTRUMENTS CLEVELAND, OHIO
SCHEMATIC, POWER SUPPLY
24694D


PC-255 CONNECTOR BOARD
PC-250 24690E J801
PC-248 24688DE 24689D J802
PC-255 J902
PC-251 24691E J901
J903
J905
J904
J906
-15V
+15V
+3.6V GND
+3.6V
±15V GND
TO TRANSFORMER SEE SCHEMATIC 24694D
POWER S201
DIVIDER QA801
R801 10K
C801 .001
10KHZ
909.09 Hz
HIGHEST REFERENCE DESIGNATION
R801 C801 QA801 J802
S201 J906
REFERENCE DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS CLEVELAND, OHIO
SCHEMATIC, CONNECTORS
24692D

LTR	ECN NO.	REVISION	DATE
A	PCN 1225	ADDED POLE TO S101	5-29-70
B	PCN 1289	CHG R103 - 453K TO R103 - 1MEG	10-1-70



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. M MEGOHM
3. K 1000 OHM
4. pf PICOFARAD
5. ✱ INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION

REFERENCE DESIGNATIONS NOT USED				

HIGHEST REFERENCE DESIGNATION				
J102	S101	C102	R104	D103

MODEL	NEXT ASSEMBLY	QTY
1601		1

USED ON

KEITHLEY INSTRUMENTS

DATE 5-11-70 | DRN RGJ

SCHEMATIC, AC-DC PROBE

NO. 24669C

TABLE 5-1.

Chassis Part Identification

Item No.	Description	Keithley Part No.
1	Chassis	24010B
11	Screw, Hex socket	#8 x 3/8
12	Screw, Phillips head	#8 x 5/8
13	Knob	KN-33
14	Switch coupler	24583A
15	Printed Circuit Board	PC-254
16	Switch, S101	SW-319
17	Cable harness	---
18	Connector (J906)	CS-237
19	Shorting Adapter	24789A
20	Printed Circuit Board	PC-251
21	Printed Circuit Board	PC-255
22	Printed Circuit Board	PC-248
23	Printed Circuit Board	PC-250
24	Screw, slotted	#4 x 2-1/4
25	Fastener, hex nut	#4-40
26	Standoff (2 req'd)	24193A
27	Screw, Phillips head	#6 x 5/16
28	Screw, slotted	#6 x 5"
29	Fastener	FA-107

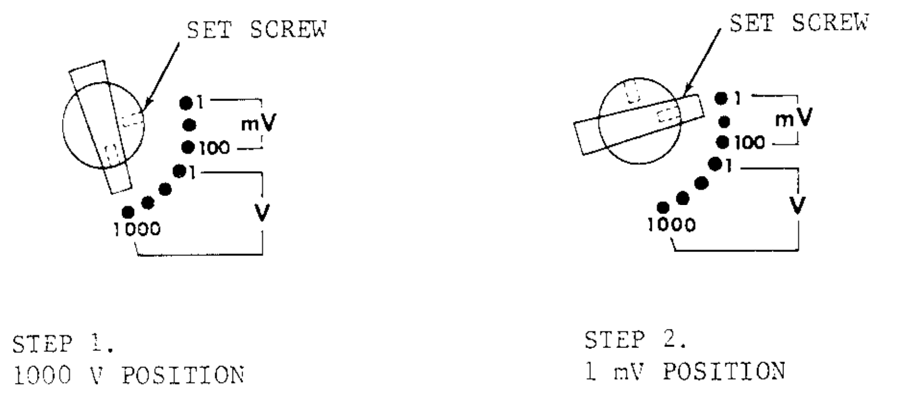


FIGURE 11a. Range Knob Assembly.

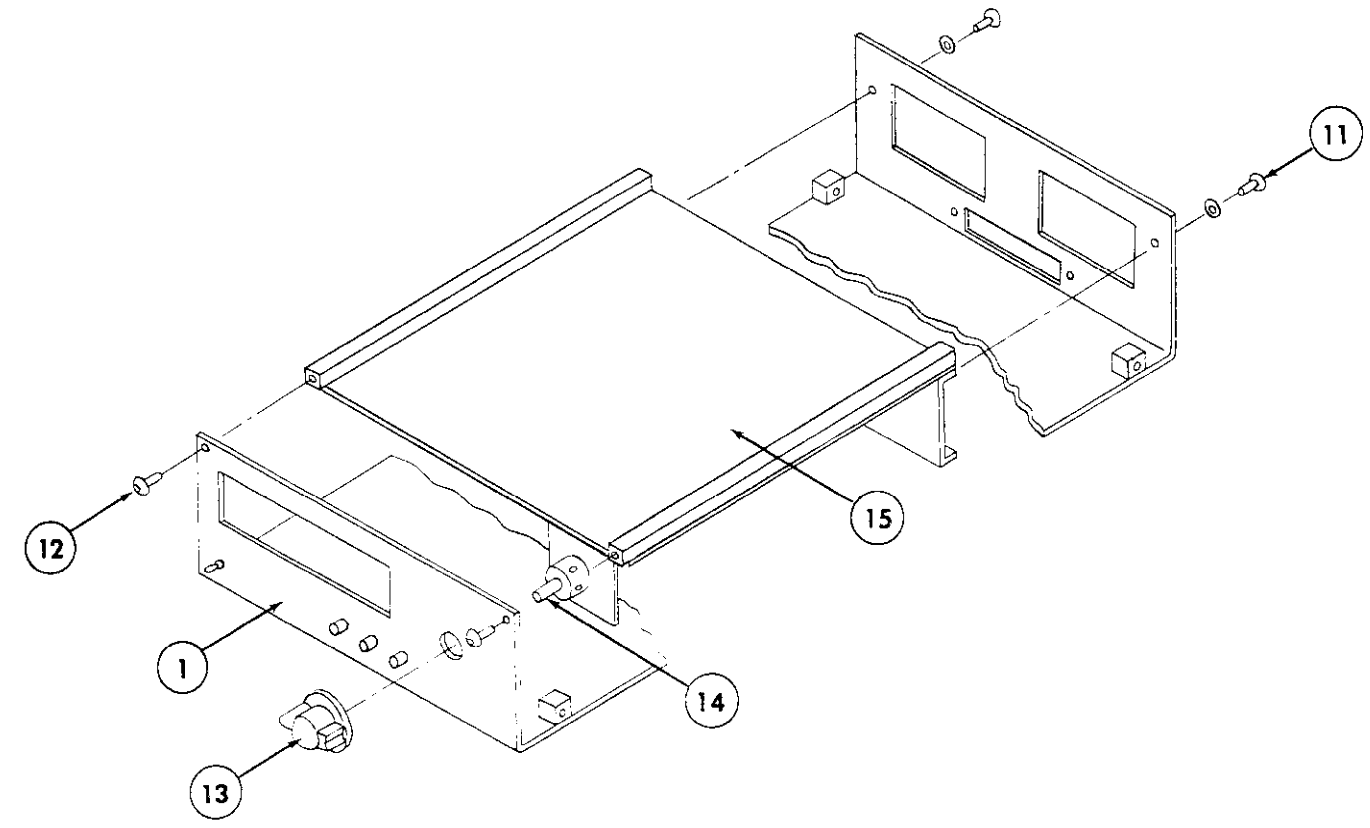


FIGURE 11b. Chassis Assembly.

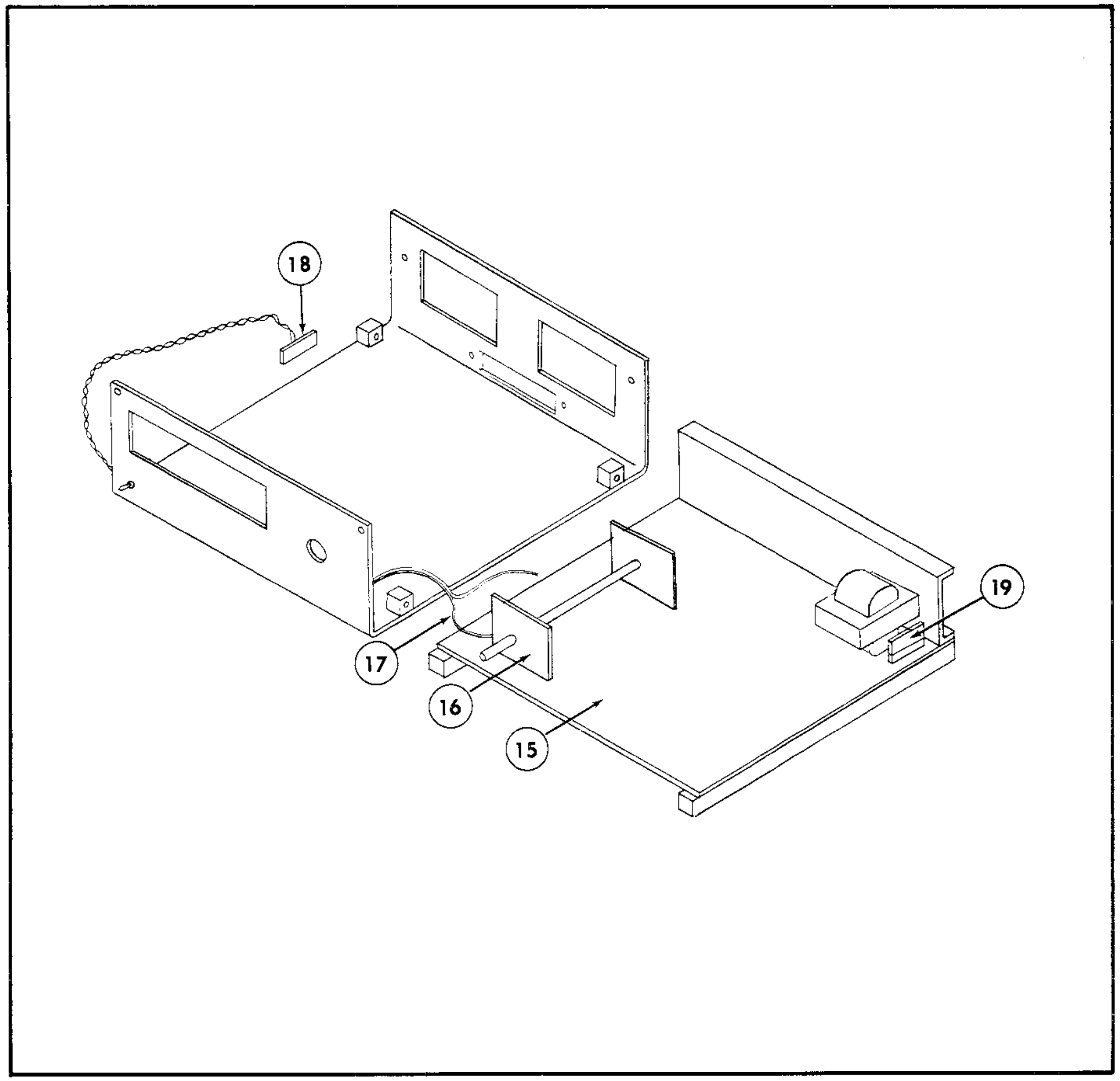


FIGURE 12. Chassis Disassembly.

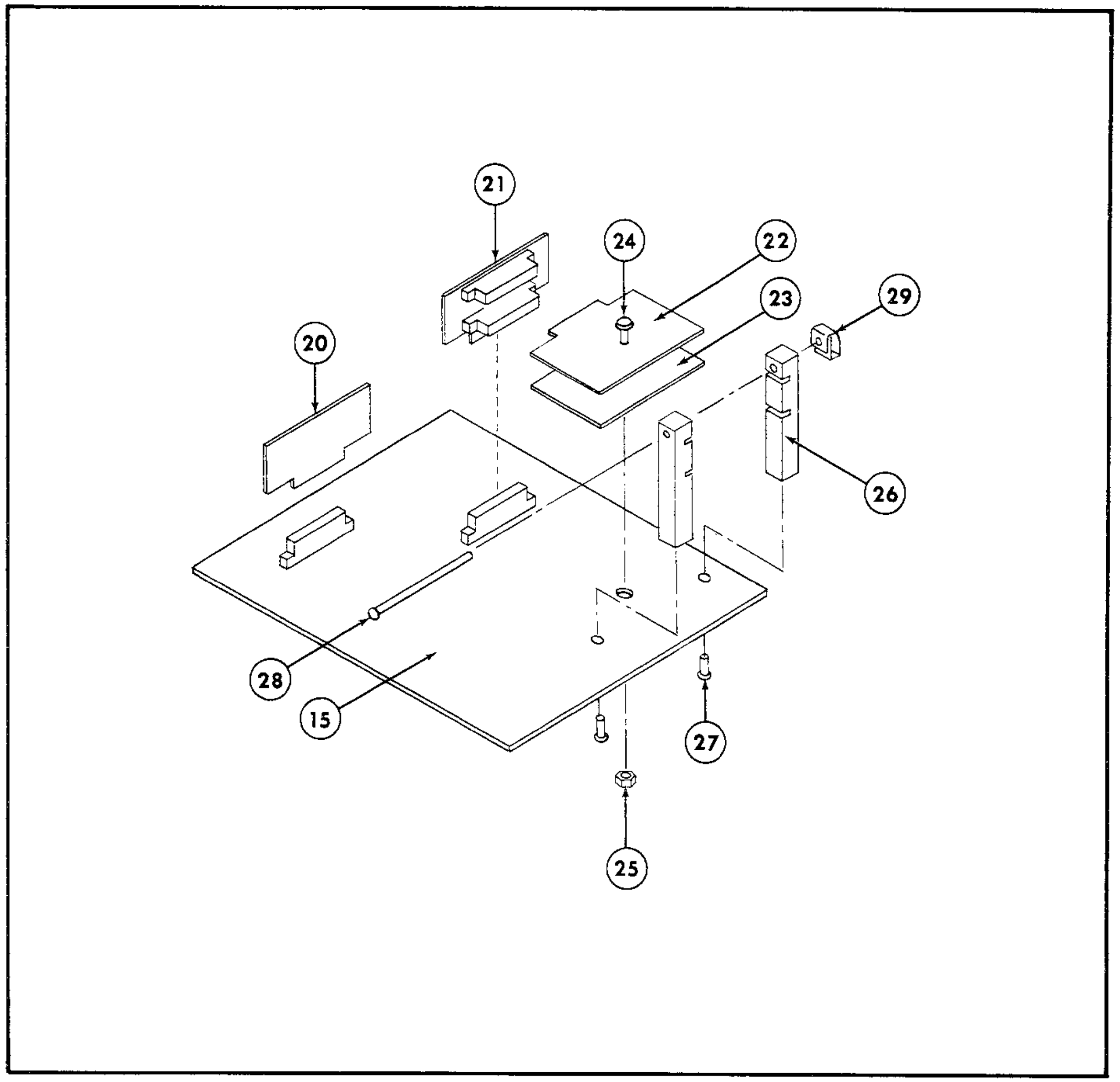


FIGURE 13. PC Board Locations.

Chassis Part Identification

Item No.	Description	Keithley Part No.
1	Chassis	24010B
11	Screw, Hex socket	#8 x 3/8
12	Screw, Phillips head	#8 x 5/8
13	Knob	KN-33
14	Switch coupler	24583A
15	Printed Circuit Board	PC-254
16	Switch, S101	SW-319
17	Cable harness	---
18	Connector (J906)	CS-237
19	Shorting Adapter	24789A
20	Printed Circuit Board	PC-251
21	Printed Circuit Board	PC-255
22	Printed Circuit Board	PC-248
23	Printed Circuit Board	PC-250
24	Screw, slotted	#4 x 2-1/4
25	Fastener, hex nut	#4-40
26	Standoff (2 req'd)	24193A
27	Screw, Phillips head	#6 x 5/16
28	Screw, slotted	#6 x 5"
29	Fastener	FA-107

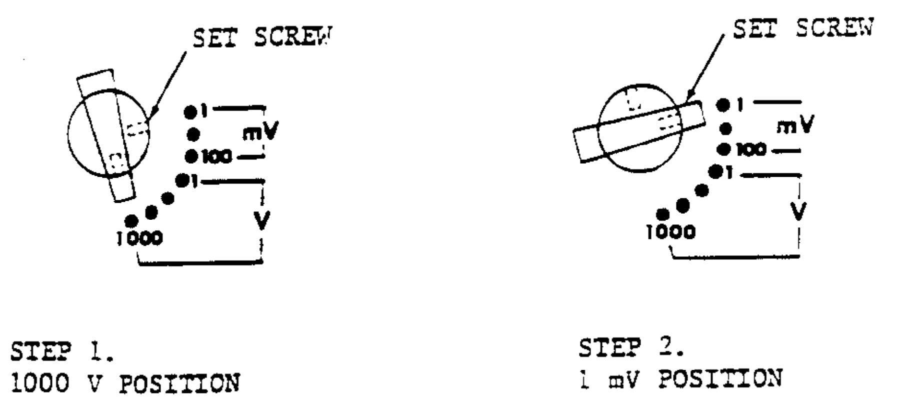


FIGURE 11a. Range Knob Assembly.

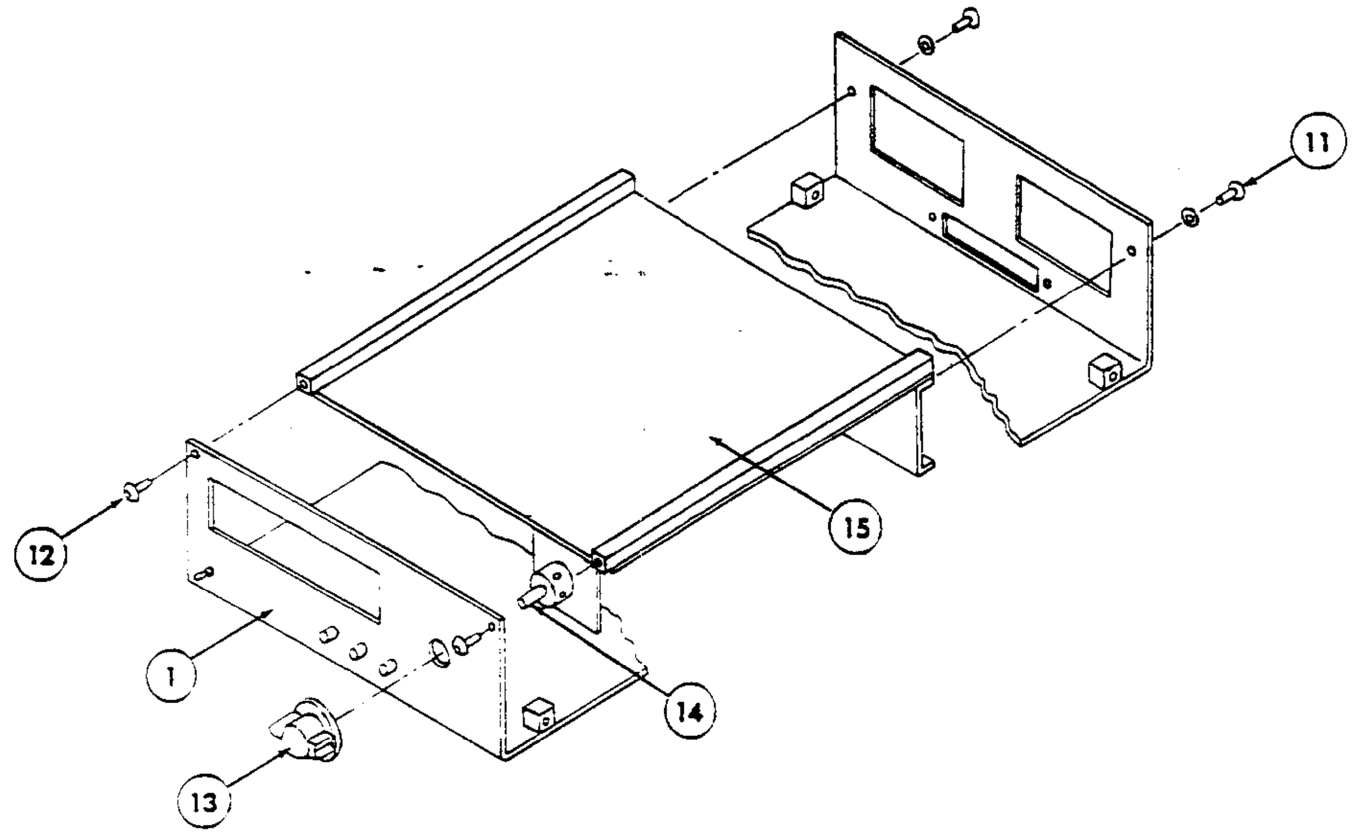


FIGURE 11b. Chassis Assembly.

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.) ____________________

   ____

   ____ REV 0774