

INSTRUCTION MANUAL

Digital Multimeter

Model 179/179-20A

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THIRD PRINTING, FEBRUARY 1980, CLEVELAND, OHIO U. S. A.

DOCUMENT NO. 28973

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# SPECIFICATIONS

## DC VOLTAGE

| RANGE  | MAXIMUM READING | ACCURACY (12 months)<br>18°-28°C<br>±(% rdg + digits) | MAXIMUM ALLOWABLE INPUT |
|--------|-----------------|-------------------------------------------------------|-------------------------|
| 200mV  | 199.99          | 0.04% + 3d                                            | 1200V momentary         |
| 2 V    | 1.9999          | 0.04% + 1d                                            | 1200V momentary         |
| 20 V   | 19.999          | 0.04% + 1d                                            | 1200V                   |
| 200 V  | 199.99          | 0.04% + 1d                                            | 1200V                   |
| 1200 V | 1200.0          | 0.04% + 1d                                            | 1200V                   |

Temperature Coefficient (0°-18° and 28°-55°C):  
 $\pm(0.006\% + 0.2 \text{ digit})/^{\circ}\text{C}$  except  $\pm(0.005\% + 0.4 \text{ digit})/^{\circ}\text{C}$  on the 200mV range.

Input Resistance:  $10\text{M}\Omega \pm 0.1\%$

Normal Mode Rejection Ratio:  
 Greater than 60dB at 50Hz and 60Hz.  
 Common Mode Rejection Ratio (1k $\Omega$  unbalance):  
 Greater than 120dB at DC, 50Hz and 60Hz.  
 Settling Time: 1 second to within 1 digit of final reading.

## AC VOLTAGE

| RANGE  | MAXIMUM READING | ACCURACY (12 months)<br>(above 2000 counts)<br>18°-28°C; 100Hz-10kHz<br>±(% rdg + digits) | TEMPERATURE COEFFICIENT<br>0°-18° and 28°-55°C<br>±(% rdg + digits)/°C |
|--------|-----------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 200mV  | 199.99          | 0.7% + 15d                                                                                | 45Hz-10kHz 0.15% + 3d                                                  |
| 2 V    | 1.9999          | 0.6% + 15d                                                                                | 10kHz-20kHz 0.15% + 3d                                                 |
| 20 V   | 19.999          | 0.5% + 15d                                                                                | 0.07% + 2d                                                             |
| 200 V  | 199.99          | 0.5% + 15d                                                                                | 0.07% + 2d                                                             |
| 1000 V | 1000.0          | 0.5% + 15d                                                                                | 0.05% + 2d                                                             |

Extended Frequency Accuracy:  
 -45Hz-100Hz)  $\pm(0.7\% + 15 \text{ digits})$   
 (10kHz-20kHz)  $\pm(0.8\% + 15 \text{ digits})$  on the 20V and higher ranges,  $\pm(1.5\% + 15 \text{ digits})$  on the 2V range,  $\pm(2\% + 15 \text{ digits})$  on the 200mV range.

Response: True root mean square.  
 Crest Factor: 3.

Input Impedance:  
 $1\text{M}\Omega \pm 1\%$  shunted by less than 75pF.  
 Maximum Allowable Input Voltage:  
 1000V rms, 1400V peak, 10<sup>7</sup>V/Hz maximum.  
 Common Mode Rejection Ratio (1k $\Omega$  unbalance):  
 80dB at DC, 50Hz and 60Hz.  
 Settling Time: 2.5 seconds to within 10 digits of final reading.

## DC AND TRMS AC CURRENT

| RANGE       | MAXIMUM READING | ACCURACY (12 months)<br>18°-28°C<br>±(% rdg + digits) | MAXIMUM VOLTAGE BURDEN | SHUNT RESISTANCE |
|-------------|-----------------|-------------------------------------------------------|------------------------|------------------|
|             |                 | DC                                                    |                        |                  |
| 200 $\mu$ A | 199.99          | 0.2% + 2d                                             | 0.2 V                  | 1k $\Omega$      |
| 2mA         | 1.9999          | 0.2% + 2d                                             | 0.2 V                  | 100 $\Omega$     |
| 20mA        | 19.999          | 0.2% + 2d                                             | 0.2 V                  | 10 $\Omega$      |
| 200mA       | 199.99          | 0.2% + 2d                                             | 0.25V                  | 1 $\Omega$       |
| 2000mA      | 1999.9          | 0.2% + 2d                                             | 0.5 V                  | 0.1 $\Omega$     |
| 20 A**      | 19.999          | 0.5% + 2d                                             | 0.65V                  | 0.01 $\Omega$    |

\*Add 0.1% rdg above 15A for self-heating.  
 \*\*20A range on Model 179-20A only.

Temperature Coefficient (0°-18° and 28°-55°C):  
 DC  $\pm(0.01\% + 0.2 \text{ digits})/^{\circ}\text{C}$ .  
 AC  $\pm(0.07\% + 2 \text{ digits})/^{\circ}\text{C}$ .  
 Crest Factor: 3.  
 Settling Time: DC: 1 second to within 1 digit of final reading.  
 AC: 2.5 seconds to within 10 digits of final reading.

MAXIMUM INPUT: 2A, 250V DC or rms (fuse protected) except for 20A range.  
 15A continuous, 20A for 1 minute (50% duty cycle).  
 250V dc or rms (fuse protected) on 20A range.

## RESISTANCE

| RANGE          | MAXIMUM READING | ACCURACY (12 months)<br>18°-28°C<br>±(% rdg + digits) | MAXIMUM VOLTAGE ACROSS UNKNOWN ON RANGE | TEMPERATURE COEFFICIENT<br>0°-18° and 28°-55°C<br>±(% rdg + digits)/°C | NOMINAL APPLIED CURRENT |
|----------------|-----------------|-------------------------------------------------------|-----------------------------------------|------------------------------------------------------------------------|-------------------------|
|                |                 | HI $\Omega$ LO $\Omega$                               | HI $\Omega$ LO $\Omega$                 | HI $\Omega$ LO $\Omega$                                                | HI $\Omega$ LO $\Omega$ |
| 2k $\Omega$    | 1.9999          | — 0.15% + 15d                                         | — 0.2V                                  | — 0.02% + 2d                                                           | — 100 $\mu$ A           |
| 20k $\Omega$   | 19.999          | 0.04% + 1d 0.15% + 15d                                | 2V 0.2V                                 | 0.003% + 0.2d 0.02% + 2d                                               | 100 $\mu$ A 10 $\mu$ A  |
| 200k $\Omega$  | 199.99          | 0.04% + 1d 0.15% + 15d                                | 2V 0.2V                                 | 0.003% + 0.2d 0.02% + 2d                                               | 10 $\mu$ A 1 $\mu$ A    |
| 2000k $\Omega$ | 1999.9          | 0.04% + 1d 0.15% + 15d                                | 2V 0.2V                                 | 0.003% + 0.2d 0.03% + 2d                                               | 1 $\mu$ A 0.1 $\mu$ A   |
| 20M $\Omega$   | 19.999          | 0.10% + 1d —                                          | 2V —                                    | 0.02% + 0.2d —                                                         | 0.1 $\mu$ A —           |

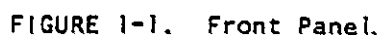
Maximum Allowable Input:  
 450V rms sustained, 1kV DC or peak AC momentary.  
 Maximum Open-Circuit Voltage: 5 volts.

Settling Time: 1 second to within 1 digit of final reading except 2 seconds on the 20M $\Omega$  range.

## GENERAL

DISPLAY: Five 0.5" LED digits, appropriate decimal position and polarity indication.  
 CONVERSION PERIOD: 400 milliseconds.  
 ENVIRONMENT:  
 Operating: 0°C to 55°C.  
 0% to 80% relative humidity up to 40°C.  
 Storage: -25°C to +65°C.

POWER: 105-125 or 210-250 volts (switch selected), 90-110V available, 50-60Hz, 7 watts. Optional 6 hour battery pack, Model 178B.  
 DIMENSIONS, WEIGHT: 85mm high x 235mm wide x 275mm deep (3-1/2 in. x 9-1/4 in. x 10-3/4 in.)  
 Net weight: 1.7kg (3 lbs. 13 oz.)  
 OVER RANGE INDICATION: Display blinks all zeros above 19999 counts.  
 MAXIMUM COMMON MODE VOLTAGE: 1400V peak.



## SECTION 1. GENERAL INFORMATION.

1-1. INTRODUCTION. The Models 179 and 179-20A are versatile digital multimeters useful for measurement of ac and dc voltage, ac and dc current and resistance. The Model 179-20A is identical to the Model 179, except for an added 20-ampere range. This extra range uses separate input terminals and allows continuous measurement of up to 15A ac/dc, or intermittent duty measurements up to 20A ac/dc. The Model 179-20A is treated by the exception method in this manual. That is, information headed by Model 179-20A applies only to the Model 179-20A. Information headed by Model 179 is common to both the Model 179 and the Model 179-20A. Ranges and accuracies for both models are listed in the Table of Specifications on page v. Ranges and functions are selected with front panel pushbuttons. The decimal point is also positioned by the selected range pushbutton. Polarity of the measured signal is automatically displayed.

1-2. WARRANTY INFORMATION. The Warranty is given on the inside front cover of this Instruction Manual. If there is a need to exercise the Warranty, contact the Keithley Representative in your area to determine the proper action to be taken. Keithley maintains service facilities in the United Kingdom and West Germany, as well as in the United States. Check the inside front cover of the Instruction Manual for addresses.

1-3. CHANGE NOTICES. Improvements or changes to the instrument which occur after printing of the Instruction Manual will be explained on a Change Notice sheet attached to the inside back cover.

## IMPORTANT

The  symbol can be found in various places in this Instruction Manual. Carefully read the associated CAUTION statements with regard to proper use and handling of the instrument. Damage to the instrument may occur if these precautions are ignored.

The  symbol can be found in various places in this Instruction Manual. This symbol indicates those areas on the instrument which are potential shock hazards. Carefully read the associated WARNING statements with regard to proper use and handling of the instrument. Serious personal injury may result if these precautions are ignored.

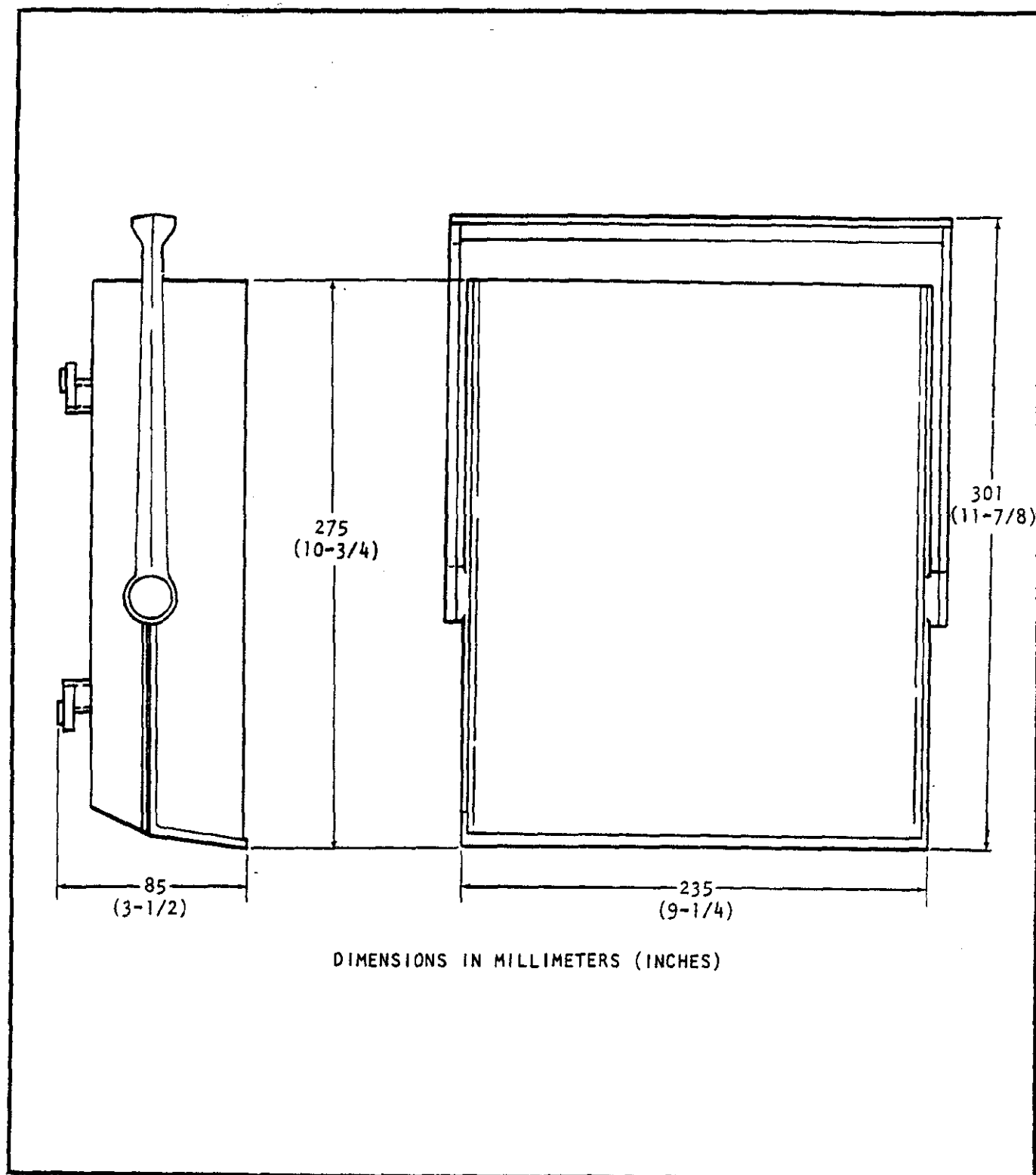


FIGURE 1-2. Dimensional Data



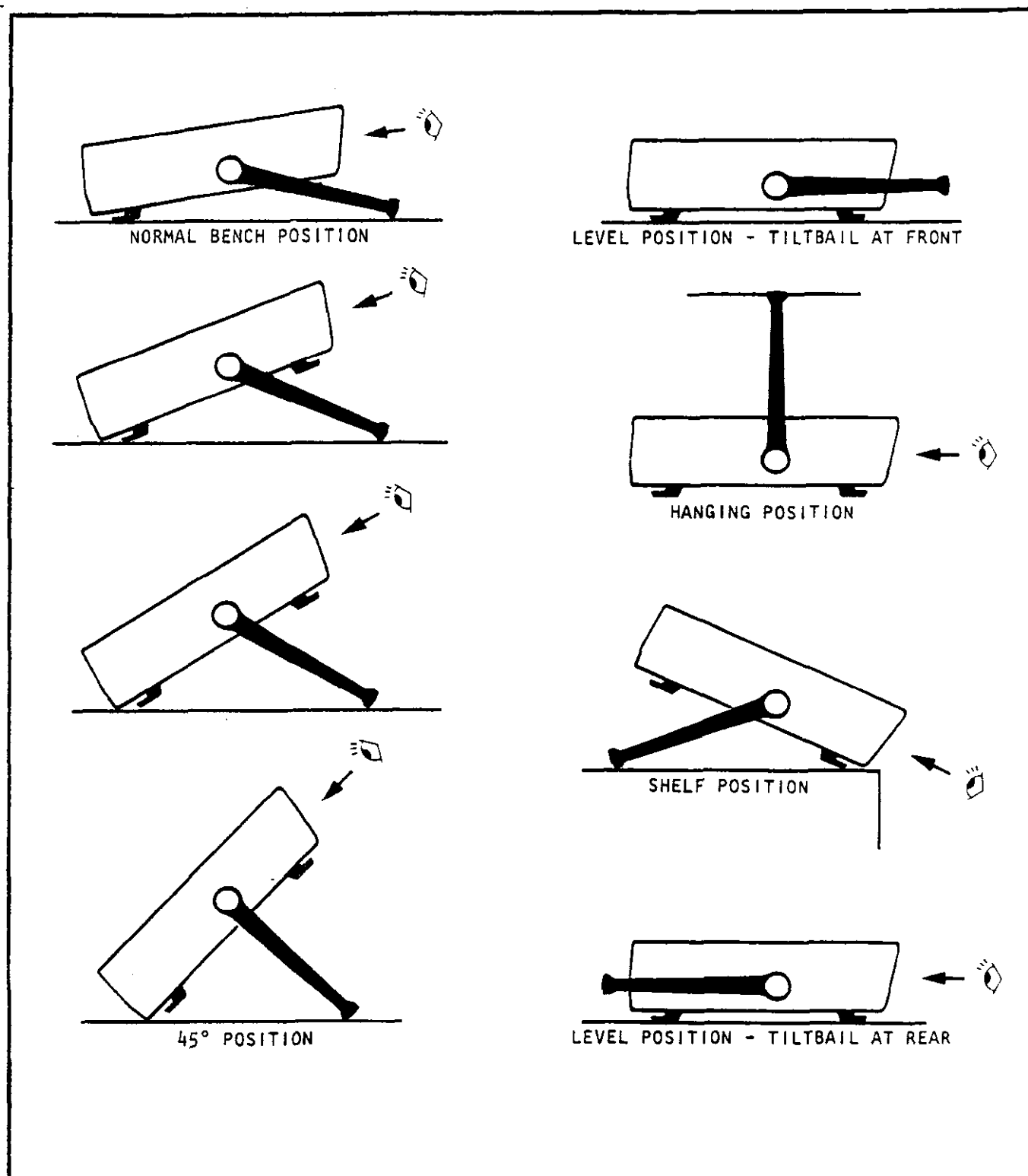


FIGURE 1-3. Tilt Bail Positions.



## SECTION 2. OPERATION.

2-1. GENERAL. This section provides information needed for incoming inspection and preparation for use.

2-2. INSPECTION. The Model 179 was carefully inspected both mechanically and electrically before shipment. Upon receiving the instrument, check for any obvious damage which may have occurred during transit. Report any damages to the shipping agent. To verify the electrical specifications, follow the procedures given in Section 3.

2-3. PREPARATION FOR USE. The Model 179 is shipped ready-to-use. The instrument may be powered from line voltage or from rechargeable batteries (when the optional Model 1788 Rechargeable Battery Set is installed).

2-4. OPERATION ON LINE POWER. The Model 179 DMM is provided with a three-wire line cord which mates with third-wire grounded receptacles. Connect the instrument to ac line power as follows:

## CAUTION



Connect only to the line voltage selected. Application of incorrect voltage can damage the instrument.

a. Set the LINE VOLTAGE switch on the back of the instrument to correspond to the line voltage available. Ranges are 105 to 125 volts and 210 to 250 volts ac as shown in Figure 2-1.

## WARNING



Ground the instrument through a properly grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction.

b. Plug the power cord into a properly grounded outlet. Operate the 179 DMM as described in SECTION 2-7.

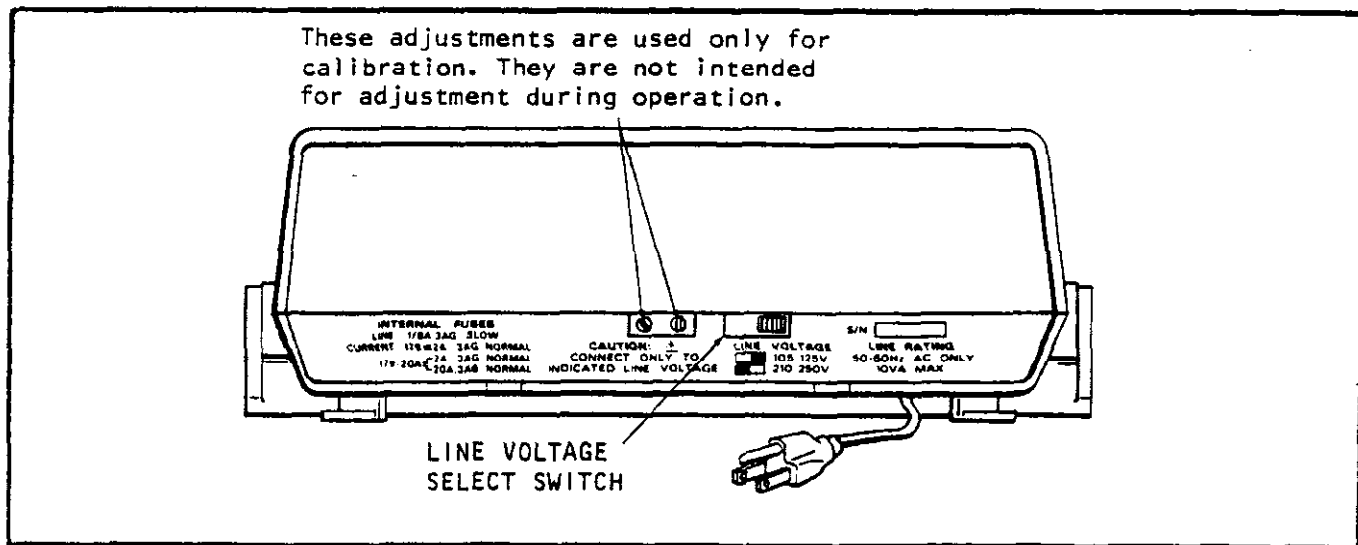


FIGURE 2-1. Rear View Showing Line Switch.

2-5. OPERATION ON BATTERY PACK POWER. The Model 179 DMM may also be operated from rechargeable sealed lead-acid batteries contained in the optional Model 1788 Battery Pack. The battery pack will operate the 179 DMM for up to 6 hours. Circuits within the battery pack will automatically shut down the instrument when the battery charge is insufficient to maintain accurate readings. Refer to Figure 2-2 and install the battery pack as follows:



## WARNING

Disconnect the line cord before removing the case cover.

- a. Turn off the power and disconnect the line cord. Remove four screws from the bottom of the case and separate the top cover from the bottom cover.
- b. Lift off the calibration shield, and save it for later use. The four plastic spacers must remain in place on the upright studs projecting through the main circuit board.

## NOTE

Do not discard the calibration shield. This shield must be installed during calibration, as described in Section 4.

- c. Set the BAT/LINE switch to the BAT position shown in Figure 2-2. Note that the battery pack will not operate properly if this switch is not in the BAT position.
- d. Remove fuse F301 on the battery pack.
- e. Install the battery pack in the instrument so that it rests on the plastic spacers. The ground clip must make contact with the upper side of the battery pack plate.
- f. Carefully align the battery pack plug with connector P1004 on the circuit board. Push the plug firmly onto the connector until the lip on the plug engages the lip on the connector to lock the plug in place.

## CAUTION



Make sure the connector is aligned so that all pins mate properly, otherwise, damage to the DMM will result.

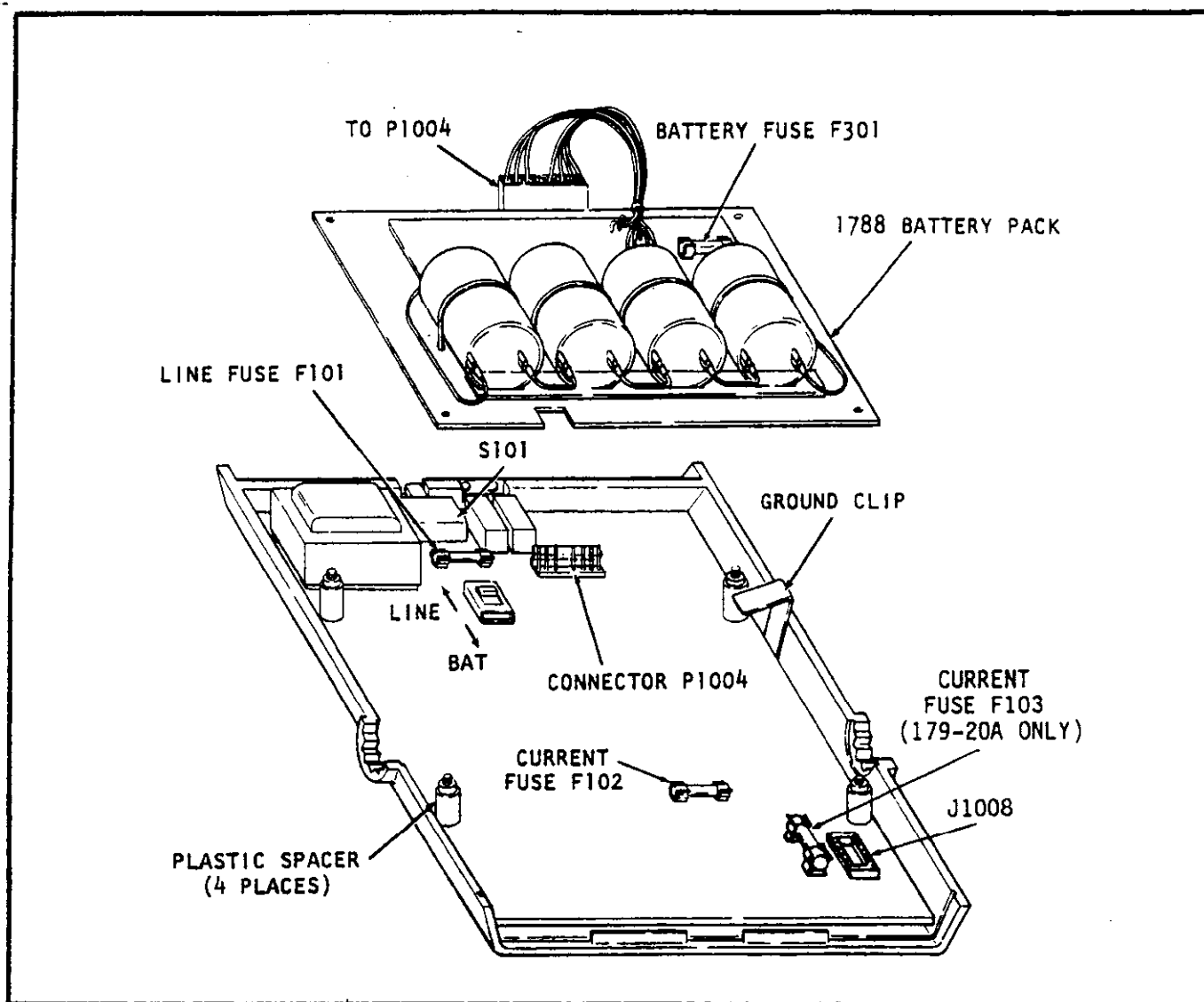
- g. Install fuse F301. Reinstall top cover and secure with four screws.
- h. Charge the battery pack as described in Paragraph 2-6.

2-6. BATTERY CHARGING. The Model 1788 Battery Pack contains an integral battery charger. To charge or recharge the battery pack, install the battery pack in the 179 DMM as described above and proceed as follows:

- a. Connect the instrument to line power as described in Paragraph 2-4.
- b. With the power switch off, the battery charge circuitry is automatically energized to charge the battery at the maximum rate. When the battery pack is first installed, or if it has completely discharged, allow it to charge for at least 14 hours in this condition.

## NOTE

For maximum battery life, do not allow the battery pack to remain completely discharged. Constant charging will not harm either the battery pack or the instrument.



**FIGURE 2-2. Battery Pack Installation**

c. When the 179 DMM is in use on line power, the battery charger maintains a trickle charge on the battery pack.

**2-7. OPERATING INSTRUCTIONS.** Refer to Figure 2-3 and operate the DMM as follows:

- a. Turn on the power by depressing the ON/OFF pushbutton.
- b. Select the function with the AC/DC,  $\Omega$ , V, or A pushbuttons.
- c. Select the range by depressing the appropriate pushbutton. For resistance measurements only, also set the LO/HI pushbutton as desired.
- d. Connect the source to the INPUT terminals. Accessories described in Paragraph 2-14 should be used as required.

CAUTION

MAXIMUM RATINGS: 

DCV (200mV, 2V): 450V rms continuous; 1200V peak, for 8 seconds per minute.  
(20-1200V): 1200V peak.

ACV (All Ranges): 1000V rms; 1400V peak;  $10^7$ V·Hz.

DCA,ACA (200μA-2000mA): 2A, 250V DC or rms (fuse protected)  
(20A): 15A continuous, 20A for 1 minute (50% duty cycle),  
250V dc or rms (fuse protected)

Ω (All Ranges): 450V rms sine wave; 1000V peak, for 8 seconds per minute.

2-8. DC VOLTAGE MEASUREMENT. Use the Model 179 DMM to measure dc volts as follows:

- Turn on power and set the AC/DC pushbutton to the out or DC position. Depress the V pushbutton.
- Select the desired range from the five ranges available. The maximum reading is 19999. Overrange is indicated by a flashing 0000 except on the 1000 volt range.

CAUTION

 Do not exceed the maximum ratings. Instrument damage may occur.

- Negative polarity is displayed automatically. Positive polarity is implied when the minus (-) display is off.
- Zero the instrument as described in Paragraph 2-14, before the first use whenever the instrument is used outside the temperature range of 18° to 28°C, and approximately weekly during normal use.

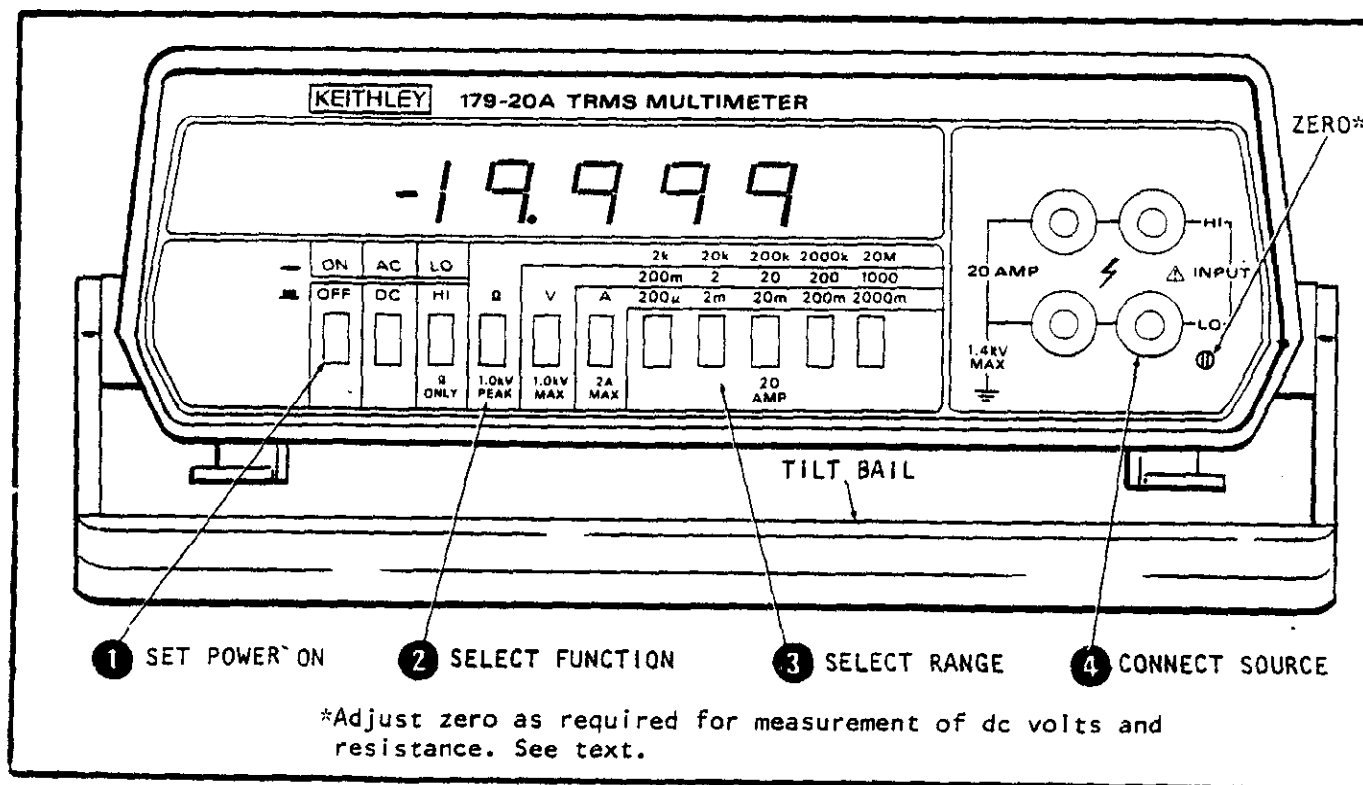


FIGURE 2-3. Operating Controls.

2-9. AC VOLTAGE MEASUREMENT. Use the Model 179 DMM to measure ac volts as follows:

- a. Turn on power and set the AC/DC pushbutton to the in or AC position. Depress the V pushbutton.

**CAUTION**

 Do not exceed the maximum ratings. Instrument damage may occur.

- b. Select the desired range from the five ranges available. The maximum reading is 19999. Overrange is indicated by a flashing 0000 except on the 1000 volt range. The instrument measures the true root mean square of a signal within the frequency range of 45 to 20k hertz. Maximum crest factor for rated accuracy is 3.

- c. The Model 1682 RF Probe (see Paragraph 2-15) should be used to measure ac voltages with a frequency of 20k to 100M hertz.

- d. Refer to Paragraph 2-13 for TRMS measurements of a signal with both ac and dc components.

2-10. RESISTANCE ( $\Omega$ ) MEASUREMENT. Use the 179 DMM to measure resistance as follows:

- a. Turn on power and depress the  $\Omega$  pushbutton.

**CAUTION**

 Do not exceed the maximum ratings. Instrument damage may occur.

- b. Select the desired range from the five ranges available. The maximum reading is 19999. Overrange is indicated by a flashing 0000. Use the LO/HI pushbutton as follows:

- 1) Use the HI mode for measurements in the 20k, 200k, 2000k and 20M ohm ranges. Full range voltage drop is 2 volts and is sufficient to cause forward conduction of semiconductor junctions. The HI terminal is positive.

- 2) Use the LO mode for measurements in the 2k, 20k, 200k and 2000k ohm ranges. Full range voltage drop is 200 millivolts. Depressing 2k automatically selects LO mode; 20M selects HI mode. Maximum open circuit voltage is 5V on all ranges.

- c. Zero the instrument as described in Paragraph 2-14 before the first use whenever the instrument is used outside the temperature range of 18° to 28°C, and approximately weekly during normal use.

2-11. CURRENT MEASUREMENT (AC or DC). Use the Model 179 or 179-20A to measure ac or dc as follows:

**NOTE**

To prevent measurement errors when using the Model 179-20A, connect the current test leads to either the 20A jacks or the normal INPUT jacks. Disconnect all circuits from the unused jacks.

- a. Turn on power and set the AC/DC pushbutton to the desired AC or DC position. Depress the A pushbutton.

**CAUTION**

 Do not install larger capacity fuses than those supplied. F102 (2A) and F103 (20A, supplied with Model 179-20A only) protect the instrument against overcurrent. Normal acting fuses are used.

- b. Select the desired range from the five/six ranges available. (On the Model 179-20A, the 20mA/20A pushbutton selects the 20mA range for the normal INPUT jacks and the 20A range for the 20A jacks). Connect the source to the INPUT jacks for current measurements up to 2000mA. (For current measurements between 2000mA and 20A, connect the source to the 20A

jacks on the Model 179-20A). The maximum reading is 19999. Overrange is indicated by a flashing 0000. Overload is fuse protected. When using the 20A current range of the Model 179-20A, up to 15A may be applied continuously without degradation of the measurement due to self-heating effects. For currents between 15A and 20A, specified accuracy can only be obtained when measurements are limited to a 50% duty cycle (i.e., apply the current for a maximum of one minute and then allow at least one minute for cooling before making the next measurement).

2-12. TRMS MEASUREMENT. The Model 179 measures the ac component of a waveform and does not measure the dc component. For ac + dc measurements, use the procedure discussed in a. below.

NOTE

Accuracy is specified for 2000 counts and above. The method of calibrating the converter may yield an offset up to 50 digits with the input shorted. This does not affect the instrument accuracy.

a. Use the 179 DMM to measure TRMS on a signal which has both ac and dc components as follows:

1. Turn on the power. Measure and record the ac and dc components separately.
2. Compute the rms value from the following equation:

$$E_{RMS} = \sqrt{E_{DC}^2 + E_{AC}^2}$$

b. The crest factor (CF) is the ratio of the peak voltage to the rms voltage as follows:

$$CF = \frac{V_{PEAK}}{V_{RMS}}$$

1. Typical crest factors are as follows:

|                                                           |                                   |
|-----------------------------------------------------------|-----------------------------------|
| Sine wave                                                 | $CF = \sqrt{2}$                   |
| Square wave                                               | $CF = 1$                          |
| Triangular wave                                           | $CF = \sqrt{3}$                   |
| Positive pulse train<br>(duty cycle for $CF = 3$ is 0.11) | $CF = 1/\sqrt{\text{duty cycle}}$ |

NOTE

There will be some additional measurement error for signals with a crest factor greater than 3 ( $CF > 3$ ).

2-13. ZERO ADJUSTMENT. The front panel zero adjustment nulls input offset on the 20, 200 and 1200 dc voltage ranges and on all resistance ranges. Typically, this adjustment need not be performed more often than once a week unless the instrument is operated at ambient temperatures outside the range of 18° to 28°C. Zero the instrument as follows:

- a. Turn on the power and select L0  $\Omega$  and the 200k range.
- b. Plug in test leads and short them. Adjust the zero adjustment pot (R149) to obtain a reading of 0000  $\pm 3$  digits.

NOTE

The zero adjustment may also be used for lead compensation on a particular  $\Omega$  range.



2-14. **ACCESSORIES.** A wide range of accessories is available to facilitate the use of the Model 179 DMM, extend its range, and adapt it for additional uses.

a. Model 1600 High Voltage Probe. The Model 1600 High Voltage Probe (shown in Figure 7) extends the measurable dc voltage range up to 40 kilovolts. It has a 1000:1 division ratio, so that a reading of 1 volt on the DMM corresponds to 1 kilovolt (1000 volts). To use the probe, select DCV and the required range, connect the high voltage probe banana plug to the instrument, connect the alligator clip to source low, and touch the probe tip to source high.

SPECIFICATIONS:

Voltage Range: 0 to 40,000 volts DC.

Input Resistance: 1000 megohms.

Division Ratio: 1000:1.

Ratio Accuracy:

±1.5% at 25kV, decreasing to

±2.0% at 20kV and 30kV,

±3.0% at 10kV and 40kV, and

±4.0% at 1kV.

Ratio Stability: ±0.01% per °C; ±0.1% per year.

Heating Effects: Self-heating due to application of high voltage for period in excess of 1 minute will cause a maximum of 0.2% additional error at 40kV (error is less at lower voltage).

**WARNING**

⚡ Be sure alligator clip is connected to source low before touching probe tip to source high. A shock hazard or damage to instrument may result.

b. Model 1651 50-Ampere Shunt. The Model 1651 50-Ampere Shunt (shown in Figure 2-5) permits current measurements from 0-50A dc and from 20-50A ac. The shunt has a resistance of 0.001 ohm ±1%, so that a 50-ampere current will correspond to a reading of 50 millivolts (0.0500 volt). Set the DMM to ACV or DCV and select the required range. To use the shunt, connect the leads furnished with the shunt from the shunt screw terminals to the DMM input terminals. Use separate leads (not furnished) to connect the source to the hex head bolts. Be sure to use leads with a capacity of 50 amperes, or as needed.

c. Model 1681 Clip-On Test Lead Set. This set (shown in Figure 2-5) contains two leads with banana plugs at one end and spring-action clip-on probes at the other end. Plug the leads into the DMM and attach the probes to the source.

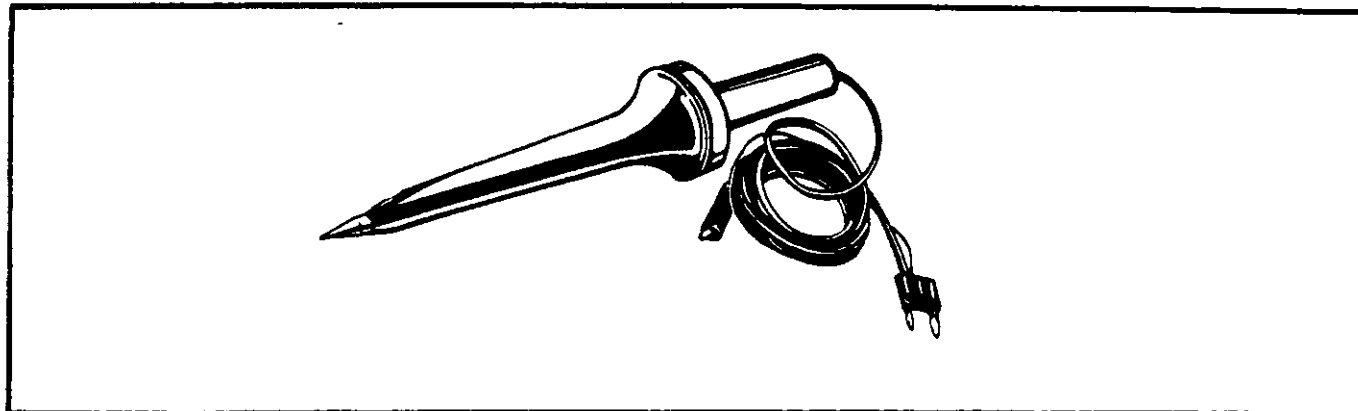


FIGURE 2-4. Model 1600 High Voltage Probe.

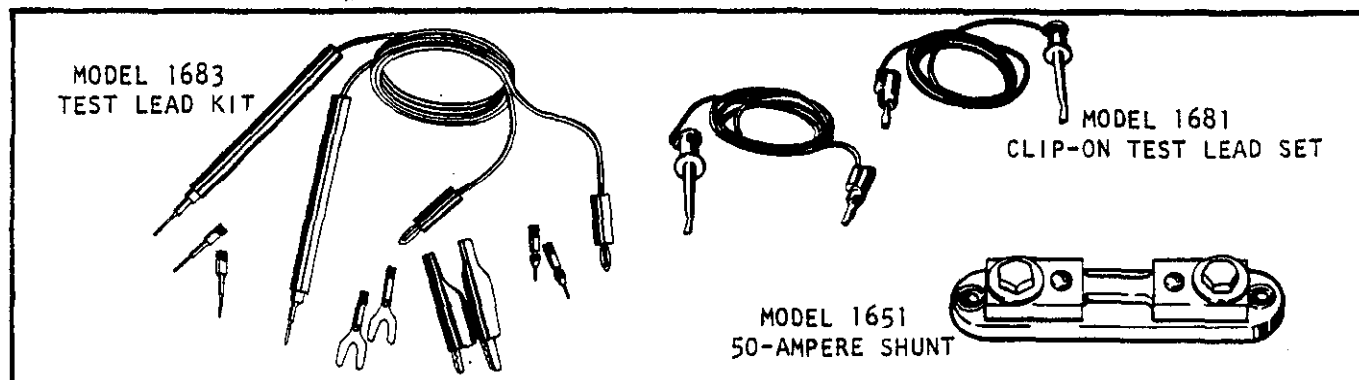


FIGURE 2-5. Accessories.

d. Model 1683 Universal Test Lead Kit. This kit (shown in Figure 2-5) contains two test leads, 14 tips, two probes, four banana plugs, two spade lugs, and two phone tips to permit connection of the DMM to virtually any source within its range.

e. Model 1682 RF Probe. The Model 1682 RF Probe (shown in Figure 2-6) permits measurement of ac voltages at frequencies of 20 kilohertz to 100 megahertz. Connect the probe to the input terminals and select ACV and the appropriate range.

#### SPECIFICATIONS:

Voltage Range: 0.25 to 30 volts rms.

Transfer Accuracy:  $\pm 0.5\text{dB}$ , 100kHz to 100MHz peak responding calibrated in rms of a sine wave.

Input Impedance: 4 megohm shunted by 3pF.

Maximum Allowable Input: 30V rms AC, 200V DC.

Accessories Supplied: straight tip, hook tip, ground clip, hi adapter, banana plug adapter.

f. Model 1685 Clamp-On AC Current Probe. The Model 1685 Clamp-On AC Current Probe (Shown in Figure 2-6) permits measurement of ac current by clamping around a single conductor, eliminating the need to interrupt the current path. Plug the ac current probe into the DMM and select ACV and the appropriate range. The DMM will display 0.1 volt rms per ampere.

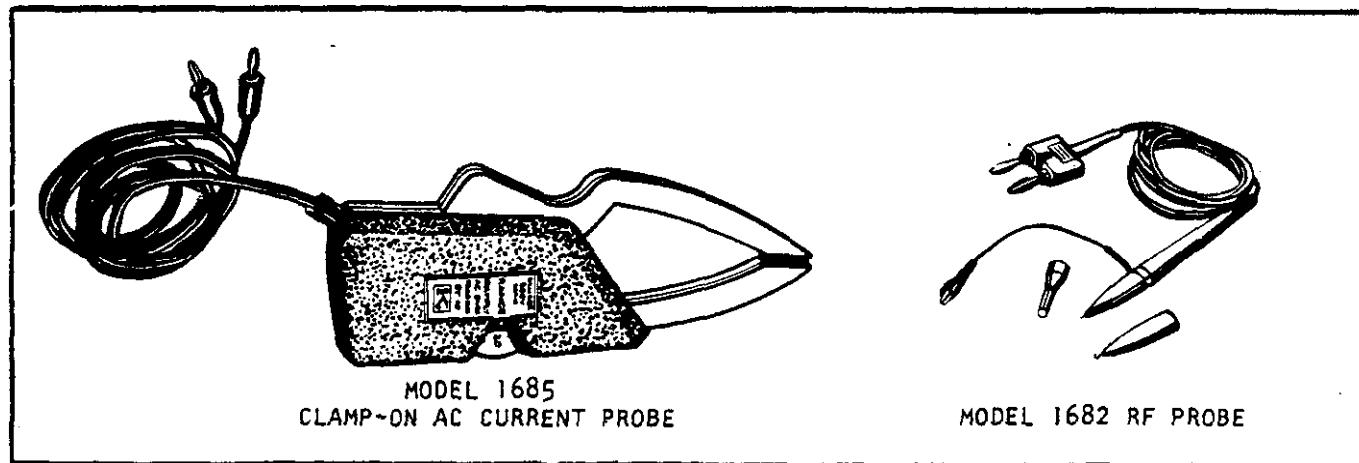


FIGURE 2-6. Model 1682 RF Probe and Model 1685 Clamp-On AC Current Probe.

**SPECIFICATIONS:**

Range: 2, 20 and 200 amperes rms.  
Accuracy:  $\pm 4\%$  of ranges at 60Hz.  $\pm 6\%$  of range at 50Hz.  
Temperature Coefficient:  $\pm 0.05\%/^{\circ}\text{C}$  on the 20 and 200 ampere ranges.  $\pm 0.3\%/^{\circ}\text{C}$  on the 2 ampere range.  
Maximum Allowable Current: 300 amperes rms.  
Maximum Conductor Voltage: 600 volts rms.  
Conversion Ratio: 0.1 volt rms per ampere.

g. Model 1684 Carrying Case. The Model 1684 Carrying Case (Shown in Figure 2-7) is a hard vinyl case with a fitted foam insert to help protect the 179 DMM from damage. There is also room in the case for the service manual and other small accessories.

h. Models 1010 and 1017 Rack Mounting Kits. The rack mounting kits (shown in Figure 2-7) permit mounting one or two Model 179 DMM's in a rack for convenient viewing.

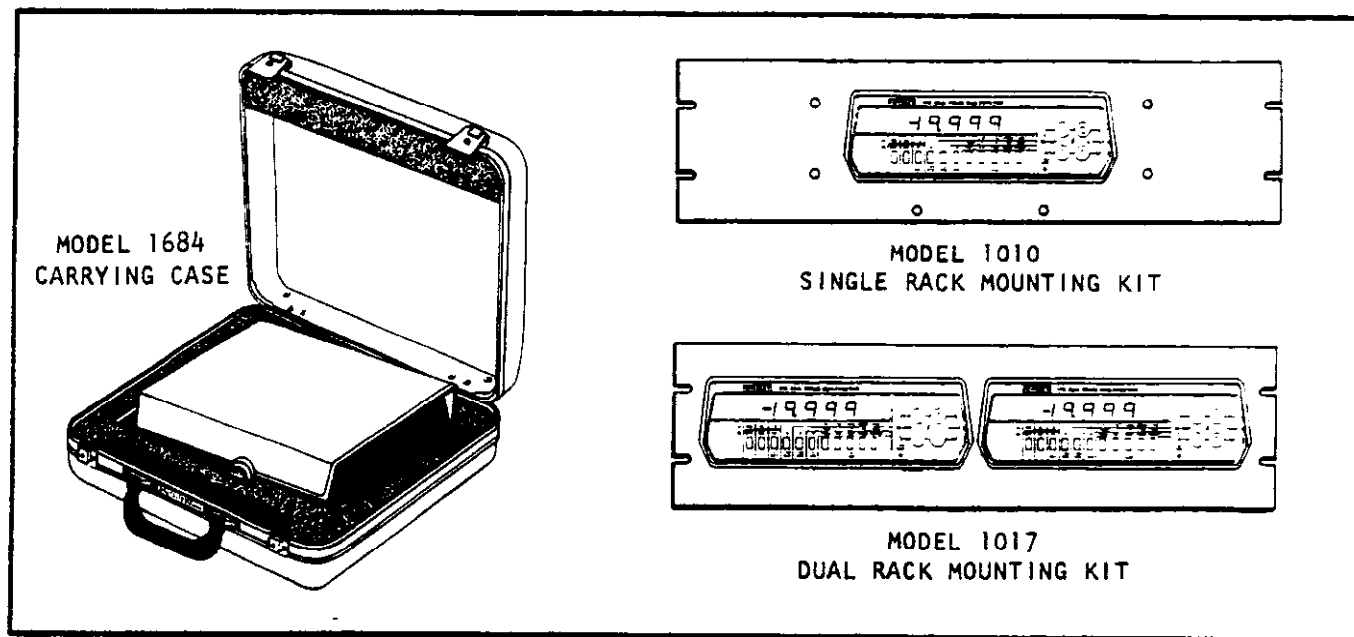


FIGURE 2-7. Carrying Case and Rack Mounting Kits.



**SECTION 3. PERFORMANCE VERIFICATION.**

3-1. **GENERAL.** Performance verification should be performed upon receipt of the instrument to ensure that no damage or misadjustment has occurred during transit. Verification may also be performed whenever there is question of the instrument's accuracy, and following calibration, if desired.

**NOTE**

For instruments that are still under warranty (less than 12 months since date of shipment), if the instrument's performance falls outside specifications at any point, contact your Keithley representative or the factory immediately.

3-2. **RECOMMENDED TEST EQUIPMENT.** Recommended test equipment for performance verification is listed in Table 3-1. Alternate test equipment may be used. However, if the accuracy of the alternate test equipment is not at least 10 times better than the instrument specifications, additional allowance must be made in the readings obtained.

3-3. **ENVIRONMENTAL CONDITIONS.** All measurements should be made at an ambient temperature within the range of 18° to 28°C (65° to 82°F), and a relative humidity of less than 80%.

3-4. **PERFORMANCE VERIFICATION PROCEDURE.** Use the following procedures to verify the basic accuracy of the Model 179 DMM for voltage, resistance and current measurements. If the instrument is out of specifications at any point, perform a complete calibration as described in Section 4, unless the instrument is still under warranty, as noted above.

**TABLE 3-1.**  
**Recommended Test Equipment For Performance Verification.**

| ITEM | DESCRIPTION             | SPECIFICATION                                 | MFR.     | MODEL     |
|------|-------------------------|-----------------------------------------------|----------|-----------|
| A    | DC Calibrator           | 0.1V, 1V, 10V, 100V, 1000V<br>±0.002% or 20µV | Fluke    | 343A      |
| B    | AC Calibrator           | 0.1V, 1V, 10V, 100V<br>±0.022%                | H-P      | 745A      |
| C    | AC Calibrator/Amplifier | 1000V @ ±0.04%                                | H-P      | 745A/746A |
| D    | Decade Resistor         | 1.9KΩ, 19KΩ, 190KΩ<br>1.9MΩ, 19MΩ, ±0.01%     | ESI      | RS725     |
| E    | Current Calibrator      | 100µA, 1mA, 10mA, 100mA,<br>1A, 10A, ±0.03%   | VALHALLA | 2500E     |

**NOTE**

Performance verification should be performed by qualified personnel using accurate and reliable test equipment.

a. Initial Conditions. Before beginning the verification procedure the instrument must meet the following conditions:

- 1) If the instrument has been subjected to extremes of temperature, allow internal temperatures to stabilize for one hour minimum at the environmental conditions specified in Paragraph 3-3.
- 2) Turn on the 179 DMM and allow it to warm up for 10 minutes. The instrument may be operated from either line power or from battery pack power, as long as the battery pack has been fully charged as described in Paragraph 2-6.
- 3) Zero the instrument as described in Paragraph 2-14.

WARNING



Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

b. DC Volts Checkout.

- 1) Select dc voltage readings with the AC/DC and V pushbuttons.
- 2) Connect the DC Calibrator (Item A, Table 3-1) to the instrument.
- 3) Select the 200mV range, and apply positive 100 mVdc to the DMM. The reading must be within the limits specified in Table 3-2.
- 4) Select each remaining range and apply the required voltage as specified in Table 3-2, verify that the reading is within specifications.
- 5) Repeat all checks with negative voltage.

TABLE 3-2.  
DC Voltage Performance Check

| Range  | Applied Voltage | Allowable Readings at 18° to 28°C |
|--------|-----------------|-----------------------------------|
| 200 mV | 100.00 mV       | 99.93 to 100.07                   |
| 2 V    | 1.0000 V        | 0.9995 to 1.0005                  |
| 20 V   | 10.000 V        | 9.995 to 10.005                   |
| 200 V  | 100.00 V        | 99.95 to 100.05                   |
| 1200 V | 1000.0 V        | 999.5 to 1000.5                   |

c. AC Volts Checkout.

- 1) Select ac voltage readings with the AC/DC and V pushbuttons.
- 2) Connect the AC Calibrator (Item B, Table 3-1) to the DMM. Set the calibrator frequency to 1 kHz.
- 3) Set the DMM to the 200 mV range and apply 100 mV ac to the DMM. The reading must be within the limits specified in Table 3-3.
- 4) Select the 2, 20 and 200 volt ranges and apply the required voltages as specified in Table 3-3. Verify that the readings are within specifications.

5) To check the 1000 volt range, connect the AC Calibrator Amplifier (Item C, Table 3-1) to the output of the AC Calibrator per the manufacturer's instructions. Set it for an output of 1000 volts ac rms and verify that the DMM readings is within the specified limits.

TABLE 3-3.  
AC Voltage Performance Check

| Range  | Applied Voltage | Allowable Readings at 18° to 28°C |
|--------|-----------------|-----------------------------------|
| 200 mV | 100.00 mV       | 99.15 to 100.85 mV                |
| 2 V    | 1.0000 V        | 0.9925 to 1.0075 V                |
| 20 V   | 10.000 V        | 9.935 to 10.065 V                 |
| 200 V  | 100.00 V        | 99.35 to 100.65 V                 |
| 1000 V | 1000.0 V        | 993.5 to 1006.5 V                 |

d. Resistance Checkout.

- 1) Select resistance readings by pressing the  $\Omega$  pushbutton.
- 2) Set the HI/LO pushbutton to HI and select the 20k  $\Omega$  range.
- 3) Connect the decade resistor (Item D, Table 3-1) to the DMM.
- 4) Set the decade resistor to zero and measure the resistance of the test leads. Subtract this reading from the displayed reading in all of the following steps.
- 5) Set the decade resistor to 19.000 k $\Omega$ . Verify that the reading is within the limits specified in Table 3-4.
- 6) Select the next range and measure the next resistance as specified in Table 3-4. Verify that each reading is within specifications. Test each item in the table, switching the HI/LO pushbutton as indicated.

TABLE 3-4.  
Resistance Performance Check

| HI/LO | Range           | Resistance        | Allowable Reading at 18° to 28°C |
|-------|-----------------|-------------------|----------------------------------|
| HI    | 20 k $\Omega$   | 19.000 k $\Omega$ | 18.990 to 19.010 k $\Omega$      |
| HI    | 200 k $\Omega$  | 190.00 k $\Omega$ | 189.90 to 190.10 k $\Omega$      |
| HI    | 2000 k $\Omega$ | 1.9000 M $\Omega$ | 1899.0 to 1901.0 k $\Omega$      |
| HI    | 20 M $\Omega$   | 19.000 M $\Omega$ | 18.980 to 19.020 M $\Omega$      |
| LO    | 2 k $\Omega$    | 1.9000 k $\Omega$ | 1.8957 to 1.9043 k $\Omega$      |
| LO    | 20 k $\Omega$   | 19.000 k $\Omega$ | 18.957 to 19.043 k $\Omega$      |
| LO    | 200 k $\Omega$  | 190.00 k $\Omega$ | 189.57 to 190.43 k $\Omega$      |
| LO    | 2000 k $\Omega$ | 1900.0 k $\Omega$ | 1895.7 to 1904.3 k $\Omega$      |

e. DC Current Checkout.

- 1) Select dc current readings with the AC/DC and A pushbuttons.
- 2) Connect the dc current source (Item E, Table 3-1) to the DMM.
- 3) Select the 200  $\mu$ A range and apply a current of 100.00  $\mu$ A to the DMM. The reading must be within the limits in Table 3-5.
- 4) Select each range and apply the required current as specified in Table 3-5. Verify that the reading is within specifications.

f. Analysis. If the instrument is out of specified limits at any point in Tables 3-2 through 3-5, calibrate the DMM as described in Section 4. If the unit is still under warranty, refer to the note in Paragraph 3-1.

TABLE 3-5.  
DC Current Performance Check

| Range       | Applied Current | Allowable Reading at 18° to 28°C |
|-------------|-----------------|----------------------------------|
| 200 $\mu$ A | 100.00 $\mu$ A  | 99.78 to 100.22 $\mu$ A          |
| 2 mA        | 1.0000 mA       | 0.9788 to 1.0022 mA              |
| 20 mA       | 10.000 mA       | 9.978 to 10.022 mA               |
| 200 mA      | 100.00 mA       | 99.78 to 100.22 mA               |
| 2000 mA     | 1000.0 mA       | 997.8 to 1002.2 mA               |
| 20 A        | 10.000 A        | 9.948 to 10.052 A                |



SECTION 4. CALIBRATION

4-1. GENERAL. Calibration should be performed yearly (every 12 months) or whenever performance verification (See Section 3) indicates that the Model 179 DMM is out of specifications. If any step in the calibration procedure cannot be performed properly, refer to Section 5 for Troubleshooting Information or contact your Keithley representative or the factory.

4-2. RECOMMENDED TEST EQUIPMENT. Recommended test equipment for calibration is listed in Table 4-1. Alternate test equipment may be used. However, the accuracy of the alternate test equipment must be at least 10 times better than the instrument specification, or equal to Table 4-1 specifications.

TABLE 4-1.  
Recommended Test Equipment For Calibration.

| Item | Description     | Specification                                                  | Mfr.  | Model |
|------|-----------------|----------------------------------------------------------------|-------|-------|
| A    | DC Calibrator   | 0.1V, 1V, 10V, 100V, 1000V<br>$\pm 0.002\%$ or $20\mu\text{V}$ | Fluke | 343A  |
| B    | AC Calibrator   | 0.1V, 1V, 10V, 100V<br>$\pm 0.022\%$                           | H-P   | 745A  |
| C    | Decade Resistor | 1.9K $\Omega$ , 190K $\Omega$ , $\pm 0.01\%$                   | ESI   | RS725 |

4-3. ENVIRONMENTAL CONDITIONS. Calibration should be performed under laboratory conditions having an ambient temperature of  $20^{\circ}$  to  $26^{\circ}\text{C}$  ( $68^{\circ}$  to  $78^{\circ}\text{F}$ ), and a relative humidity of less than 80%.

4-4. CALIBRATION PROCEDURE. Perform the following adjustments to calibrate the 179 DMM and restore its operation to specified limits.

a. Calibration Shield Installation. If the Model 1788 Battery Pack is installed in the instrument it must be removed and the calibration shield reinstalled before calibration.

WARNING



Disconnect the line cord before removing the case cover.

1) Turn off the power and disconnect the line cord. Remove four screws from the bottom of the case and separate the top cover from the bottom cover.

2) Push back the ground clip (shown in Figure 2-2) from the upper side of the battery pack and remove the battery pack from the spacers.

3) Calibration may be performed on battery power as long as the battery pack is sufficiently charged. Leave the battery pack plugged into the instrument, but set the battery pack behind the DMM on the bench or table.

4) Set the calibration shield in place on the spacers. The shield should read correctly when viewed from the front of the instrument.

5) Slide the ground clip over the top of the calibration shield so that it contacts the upper surface of the shield.

6) If battery power is not to be used, plug in the line cord.

b. Calibration Instructions.

WARNING



Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

1) Refer to Table 4-2 and perform the listed adjustments in the sequence indicated. Note that the step sequence is also indicated on the calibration shield by boxed numerals. The sequence must be followed exactly because the adjustments are inter-related and dependent on the preceeding steps.

2) If the indicated adjustment cannot be made to obtain the specified reading, refer to Section 2-5 for Troubleshooting Information.

TABLE 4-2.

Calibration Procedure

| Step | Function    | Range          | Input           | Adjustment Point | Desired Reading                            | Test Equipment*    |
|------|-------------|----------------|-----------------|------------------|--------------------------------------------|--------------------|
| 1    | DC V        | 2 V            | +1.9 V          | R107             | 1.9000                                     | DC Calibrator (A)  |
| 2    | DC V        | 200 mV         | +190 mV         | R108             | 190.00                                     | DC Calibrator      |
| 3    | DC V        | 2 V            | +1.9 V          | R107             | 1.9000                                     | DC Calibrator      |
| 4    | $\Omega$ LO | 200 k $\Omega$ | Short           | R149             | Set Front Panel Zero to Mechanical Center. | None               |
| 5    | $\Omega$ LO | 200 k $\Omega$ | Short           | R112             | 00.0 $\pm$ 10 digits                       | None               |
| 6    | $\Omega$ LO | 200 k $\Omega$ | Short           | R149             | 00.00 $\pm$ 2 digits                       | None               |
| 7    | $\Omega$ HI | 200 k $\Omega$ | 190 k $\Omega$  | R127             | 190.00                                     | Decade Resistor(C) |
| 8    | $\Omega$ LO | 2 k $\Omega$   | 1.9 k $\Omega$  | R129             | 1.9000                                     | Decade Resistor    |
| 9    | DC V        | 200 V          | +190 V          | R103             | 190.00                                     | DC Calibrator      |
| 10   | DC V        | 20 V           | +19 V           | R126             | 19.000                                     | DC Calibrator      |
| 11   | DC V        | 1000 V         | +1000 V         | R128             | 1000.0                                     | DC Calibrator      |
| 12   | AC V        | 20 V           | 1 V at 1 kHz    | R142             | 1.000                                      | AC Calibrator (B)  |
| 13   | AC V        | 20 V           | 10 V at 1 kHz   | R143             | 10.000                                     | AC Calibrator      |
| 14   | AC V        | 20 V           | 1 V at 1 kHz    | R142             | 1.000                                      | AC Calibrator      |
| 15   | AC V        | 20 V           | 10 V at 1 kHz   | R143             | 10.000                                     | AC Calibrator      |
| 16   | AC V        | 200 V          | 100 V at 10 kHz | C106             | 100.00                                     | AC Calibrator      |
| 17   | AC V        | 20 V           | 10 V at 10 kHz  | C112             | 10.000                                     | AC Calibrator      |
| 18   | AC V        | 2 V            | 1 V at 10 kHz   | C111             | 1.0000                                     | AC Calibrator      |

\* See Table 4-1.

**SECTION 5. TROUBLESHOOTING.**

5-1. GENERAL. The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital electronic principles and components used in a precision electronic test instrument. Instructions have been written to assist in isolating the defective circuit or subcircuit. Isolation of the specific defective component has been left to the technician.

**NOTE**

For instruments that are still under warranty (less than 12 months since date of shipment), if the instrument's performance falls outside specifications at any point, contact your Keithley representative or the factory immediately.

5-2. TROUBLESHOOTING PROCEDURE. This section contains tables listing step-by-step checks of the major DMM circuits described in Section 6, Theory of Operation. Proceed as follows:

- a. In general, start troubleshooting with Table 5-1, Line Power Checks, to verify that the power supplies are providing the specified voltage to the electronic components.
- b. If trouble occurs on battery power only, or if battery operating time is substantially less than 6 hours after overnight charging, test the batteries and charging circuit per Table 5-2.
- c. Proper operation of the A/D converter & display should be verified before troubleshooting the signal conditionings. Check these circuits per Tables 5-4 and 5-3, respectively.
- d. Problems with ac voltage ranges may involve the ac attenuator, the ac amplifier, or the ac converter. Check these circuits per Table 5-6 and 5-8.
- e. Check the dc voltage attenuator per Table 5-5 if problems occur with the dc voltage ranges. Check the resistance circuit per Table 5-7 if resistance measurements are erratic.
- f. If problems occur with current readings, check the current shunts and related circuits per Table 5-9.
- g. All measurements are referenced to analog common (ground clip).

TABLE 5-1.  
Line Power Checks

| Step | Item/Component                     | Required Condition                                  | Remarks                                        |
|------|------------------------------------|-----------------------------------------------------|------------------------------------------------|
| 1    | S101 line switch                   | Must be set to 105-125V or 210-250V as appropriate. |                                                |
| 2    | S102 LINE/BAT switch               | Must be set to BAT for use with battery pack.       |                                                |
| 3    | F101 line fuse                     | Continuity.                                         |                                                |
| 4    | P1007 line cord                    | Plugged into live receptacle.                       |                                                |
| 5    |                                    | Turn on power.                                      |                                                |
| 6    | +5V pad*                           | +5 volts $\pm 10\%$ .                               | Output of VR104.                               |
| 7    | VR104, IN<br>C108-2200 $\mu$ F (+) | +7 volts Minimum.                                   | Output of CR101,<br>input to VR104.            |
| 8    | +15V pad*                          | +15 volts $\pm 10\%$ .                              | Output of VR102.                               |
| 9    | TP1*                               | +17.5 volts minimum.                                | Output of CR102,<br>input to VR102.            |
| 10   | -15V pad*                          | -15 volts $\pm 10\%$ .                              | Output of VR101.                               |
| 11   | TP2*                               | -17.5 volts minimum.                                | Output of CR102,<br>input to VR101.            |
|      |                                    |                                                     | NOTE: Hot regulator may indicate shorted load. |

\* On main printed circuit board..

TABLE 5-2.  
 Battery Power Checks

| Step | Item/Component                                    | Required Condition                                                                                                            | Remarks                                                                                                                                                                                                             |
|------|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    |                                                   | Check AC line power per Table 5-1.                                                                                            |                                                                                                                                                                                                                     |
| 2    |                                                   | Turn off power.                                                                                                               |                                                                                                                                                                                                                     |
| 3    | S102 LINE/BAT switch                              | Move to BAT.                                                                                                                  |                                                                                                                                                                                                                     |
| 4    | P1007 line cord                                   | Plugged into live receptacle.                                                                                                 | Charge circuit checks.                                                                                                                                                                                              |
| 5    | F301                                              | Remove fuse and connect ammeter to fuse clip. 0 to 500mA charging rate, varies with line voltage and battery state of charge. | No charge, see step 5A. Correct charging but short battery operating time, see step 6.                                                                                                                              |
| 5A   | BT301 Batteries                                   | Full charge is $\approx 9.8$ volts over 4 cells. R301 adjusts charging rate (float voltage).                                  | If voltage is low and adjustment of R301 does not start charging, see steps 7 and following. If voltage is low and adjustment of R301 does start charging, see Table 5-10 for adjustment of battery charge voltage. |
| 6    | Each battery cell voltage <u>during</u> charging. | Less than 3 volts for any cell.                                                                                               | High voltage or zero indicates damaged cell.                                                                                                                                                                        |
| 7    | Q301 anode                                        | Full wave rectified voltage, 15 VDC nominal.                                                                                  | Output of CR101.                                                                                                                                                                                                    |
| 8    | C304 +                                            | +17.5 volts minimum.                                                                                                          | Output of CR102. Triggers Q301 gate thru R306 and CR301 unless Q302 is on.                                                                                                                                          |
| 9    | Q302                                              | Should saturate only when battery approaches full charge.                                                                     |                                                                                                                                                                                                                     |
| 10   | VR301                                             | 8.2V zener.                                                                                                                   |                                                                                                                                                                                                                     |
| 11   |                                                   | Unplug line cord & turn power on.                                                                                             | Discharge checks.                                                                                                                                                                                                   |
| 12   | P1004 pin 8 or U301 pin 11                        | 100 kHz 5V square wave.                                                                                                       | Clock input. If no input, see step 12A.                                                                                                                                                                             |
| 12A  | VR104, IN                                         | +7 volts minimum.                                                                                                             | Battery voltage input to VR104.                                                                                                                                                                                     |
| 13   | Q307 and Q308 base                                | Square wave, $\pm 0.7$ volts at 25 kHz.                                                                                       | Output of U301, $\div 4$ .                                                                                                                                                                                          |
| 14   | Q307, Q308 collector                              | Must oscillate from saturation to twice battery voltage ( $\approx 19$ volts) at 25 kHz.                                      | Inverter.                                                                                                                                                                                                           |
| 15   | C304, C305                                        | $\pm 17.5$ volts minimum ( $\pm 25$ volts typical with fully charged bat.).                                                   | Inverter Output, input to VR101 & VR102                                                                                                                                                                             |

TABLE 5-3.  
Display

| Step | Item/Component               | Required Condition                                  | Remarks                                                                                                                                       |
|------|------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1    |                              | Turn on power. Any function or range except OHMS.   |                                                                                                                                               |
| 2    | +5V* or J1001, pin 5         | +5 volts $\pm 10\%$ .                               | If low, check per Table 5-1.                                                                                                                  |
| 3    | U202, pins 2, 6, 7, 9 and 13 | Digit drive LOW = Enabled.                          | LED cathode.                                                                                                                                  |
| 4    | U201, pins 1, 2, 6 and 7     | HI = Enabled.                                       | BCD input to segment decoder/driver.                                                                                                          |
| 5    | U201, pin 4                  | Positive-going signal lasting for 200 clock pulses. | Leading digit suppression. Output of U107A.                                                                                                   |
| 6    | J1002, pin 9                 | Polarity line (SIGN) HI = off<br>LO = -.            | NOTE: Polarity output (in at J1002, pin 9) is inverted for VDC on 20 volt and higher ranges. Polarity output is disabled on AC and $\Omega$ . |
| 7    | J1001, pins 1, 2, 3 and 4.   | Appropriate DP line high (on).                      |                                                                                                                                               |

\* On main printed circuit board.

TABLE 5-4.  
A/D Converter

| Step | Item/Component          | Required Condition                                           | Remarks                                                                                                                   |
|------|-------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| 1    |                         | Turn on Power. Select 2 volt DC range and short inputs.      | On this function and range (also on 200 mV DC), input HI connects thru R106, R136, and R135G to A/D, without attenuation. |
| 2    | Display                 | .0000 $\pm$ 1 digit.                                         |                                                                                                                           |
| 3    | TP10*                   | 0.0000 volts.                                                | A/D signal input.                                                                                                         |
| 4    | TP8*                    | +1.00 volt.                                                  | Reference output.                                                                                                         |
| 5    | TP3*                    | +100 millivolts.                                             | Reference output.                                                                                                         |
| 6    | TP4*                    | 6.3 $\pm$ 0.25 volts.                                        | Reference zener voltage.                                                                                                  |
| 7    | U106, pin 7             | +1.00 volt.                                                  | Reference input to U106.                                                                                                  |
| 8    | CLK*                    | 0 to +5V square wave at 100 kHz.                             | Clock input.                                                                                                              |
| 9    | TP6*                    | +1.0 $\pm$ 0.1 volt.                                         | Stored autozero voltage.                                                                                                  |
| 10   | U103, pin 11            | +1.0 $\pm$ 0.1 volt.                                         | $\Sigma$ -node voltage to integrator in U103.                                                                             |
| 11   | TP7*                    | -1.2 $\pm$ 0.2 volt.                                         | U103 integrator output voltage.                                                                                           |
| 12   | U104, pins 2, 3, and 6  | +1 volt.                                                     | Buffer voltage on U104.                                                                                                   |
| 13   | External voltage source | Apply +1.9000 volts. Display must read 1.9000 $\pm$ 1 digit. | Calibration point.                                                                                                        |
| 14   | TP7*                    | Waveform per Figure 5-1.                                     | Integrator output.                                                                                                        |
| 15   | U103, pin 2             | Waveform per Figure 5-1 during ramping of integrator output. | Comparator output.                                                                                                        |
| 16   |                         | Select 200 mV range and short inputs.                        |                                                                                                                           |
| 17   | Display                 | 00.00 $\pm$ 3 digits.                                        | Proceed if out-of-limits. Change selected value of R145 if tests 18-26 meet required conditions.                          |
| 18   | TP10*                   | 0.0000 volts.                                                | A/D signal input.                                                                                                         |

\* On main printed circuit board.

TABLE 5-4.  
A/D Converter, continued

| Step | Item/Component          | Required Condition                                             | Remarks                                       |
|------|-------------------------|----------------------------------------------------------------|-----------------------------------------------|
| 19   | U106, pin 7             | +0.100 volt.                                                   | Reference input to U106.                      |
| 20   | U103, pin 11            | +1.000 $\pm$ 0.1 volt.                                         | $\Sigma$ -node voltage to integrator in U103. |
| 21   | TP7*                    | -1.2 $\pm$ 0.2 volts.                                          | U103 integrator output voltage.               |
| 22   | U104, pins 2, 3         | +100 millivolts.                                               | Buffer voltage on U104.                       |
| 23   | U104, pin 6             | +1 volt.                                                       | Buffer voltage.                               |
| 24   | External voltage source | Apply +190 millivolts. Display must read 190.00 $\pm$ 1 digit. | Calibration point.                            |

\* On main printed circuit board.

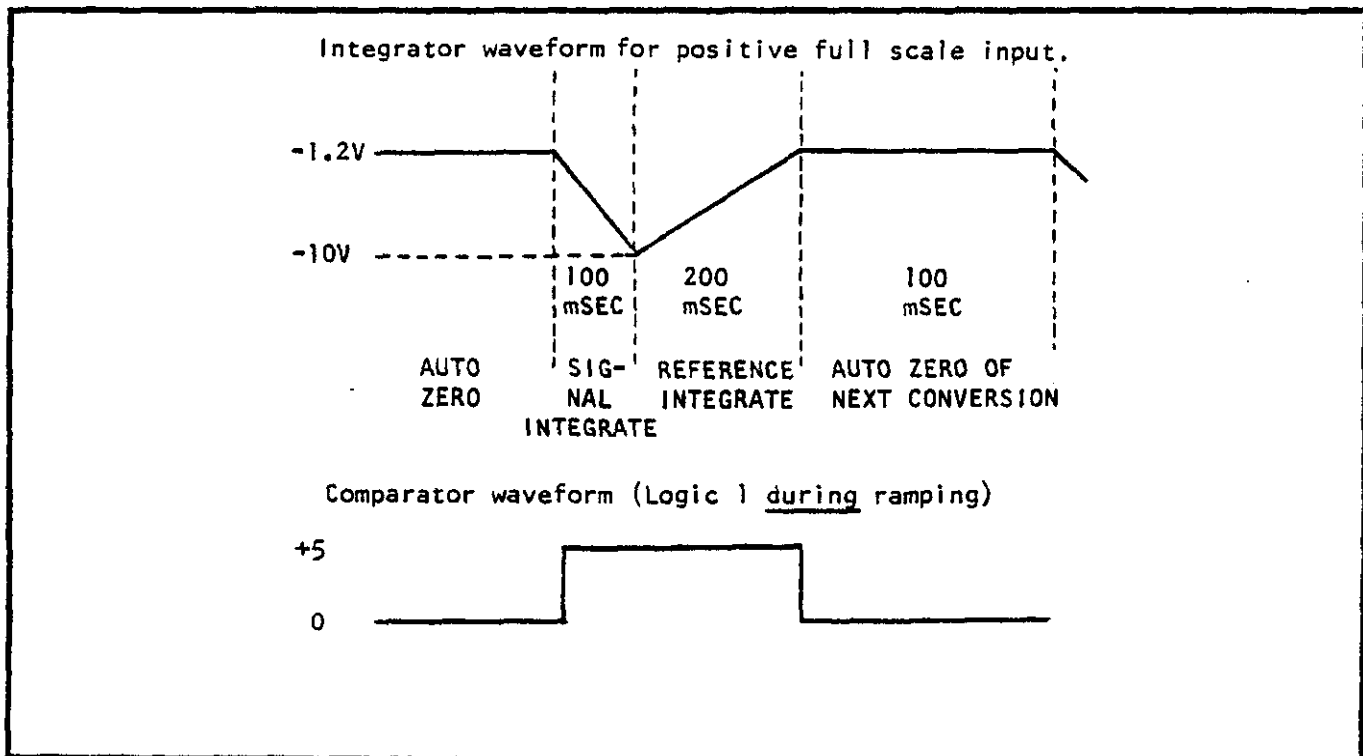


FIGURE 5-1. Integrator and Comparator Waveforms.



TABLE 5-5.  
DC Volts Attenuator

| Step | Item/Component          | Required Condition                                       | Remarks                                                   |
|------|-------------------------|----------------------------------------------------------|-----------------------------------------------------------|
| 1    |                         | Turn on power. Select 20 VDC range, and short inputs.    |                                                           |
| 2    | R149                    | Front panel adjustment must zero the display.            |                                                           |
| 3    | U101, pin 2             | 0.000 $\pm$ 0.005 volts.                                 |                                                           |
| 4    | External voltage source | Apply +10 volts from H1 to L0.                           | Calibrated input.                                         |
| 5    | TP5*                    | -1 volt                                                  | Output of U101.                                           |
| 6    | External voltage source | (Apply +100 and +1000 volts on 200 and 1000 volt ranges. | Calibrated input.                                         |
| 7    | TP5*                    | -1 volt                                                  | Output of U101 and feedback components, including relays. |

\* On main printed circuit board.

TABLE 5-6.  
AC Volts Attenuator and X10 Amplifier

| Step | Item/Component          | Required Condition                                               | Remarks                                                                 |
|------|-------------------------|------------------------------------------------------------------|-------------------------------------------------------------------------|
| 1    |                         | Turn on power. Select 2 VAC range.                               | NOTE: Full scale inputs should produce $\approx 2$ volts output at TP9. |
| 2    | External voltage source | Apply 1 volt rms at 1 kHz.                                       | Calibrated input.                                                       |
| 3    | TP9* & TP5              | 1 volt rms.                                                      | Output of U101 and feedback components.                                 |
| 4    | External voltage source | 10, 100 and 1000 volts rms on 20, 200 and 1000 volt ranges.      | Calibrated input.                                                       |
| 5    | TP9* & TP5              | 1 volt rms on all ranges except 200 millivolts.                  | Output of U102 and feedback components, including relays.               |
| 6    | External voltage source | Apply 1, 10, 100V @ 20kHz on 2, 20 and 200V ranges respectively. | C106, C111, C112, C113, and C114.                                       |
| 7    | External voltage source | Apply 10V @ 45Hz on 20V range.                                   | C105, C115, C116.                                                       |
| 8    |                         | Select 200 mV range.                                             |                                                                         |
| 9    | External voltage source | 100 millivolts at 1 kHz.                                         | Calibrated input.                                                       |
| 10   | TP5*                    | 100 millivolts rms.                                              | Output of U101 and feedback components.                                 |
| 11   | TP9*                    | 1 volt rms.                                                      | Output of U102.                                                         |

\* On main printed circuit board.

**TABLE 5-7.**  
**Resistance Circuit.**

| Step | Item/Component          | Required Condition                                                     | Remarks                                                                                                             |
|------|-------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| 1    |                         | Turn on power. Select $\Omega$ , HI and 200k range. Short inputs.      |                                                                                                                     |
| 2    | U101, pin 2             | Continuity to input HI.                                                | K105.                                                                                                               |
| 3    | TP10*                   | 0.0 volt.                                                              | A/D input.                                                                                                          |
| 4    | $\Omega$ switch, pin 11 | +1 volt.                                                               | Reference voltage.                                                                                                  |
| 5    | INPUT HI to LO          | Remove short and measure open circuit voltage; must be +2 to +5 volts. | R150 & R151.                                                                                                        |
| 6    | 100k resistor           | Apply to input.                                                        | Calibrated resistance.                                                                                              |
| 7    | TP10*                   | -1 volt.                                                               | A/D input.                                                                                                          |
| 8    |                         | Select LO range.                                                       |                                                                                                                     |
| 9    | $\Omega$ switch, pin 11 | +100 millivolts.                                                       | Reference voltage.                                                                                                  |
| 10   | TP10*                   | -100 millivolts.                                                       | A/D input.                                                                                                          |
| 11   |                         | Test other ranges in similar manner as needed.                         | NOTE: Reference loading by the current setting resistor does not affect readout since A/D converter is ratiometric. |

\* On main printed circuit board.

TABLE 5-8.  
AC Converter

| Step | Item/Component          | Required Condition                  | Remarks                  |
|------|-------------------------|-------------------------------------|--------------------------|
| 1    |                         | Turn on power. Select 20 VAC range. |                          |
| 2    | External voltage source | 10 volts rms, 1 kHz,                | Calibrated input.        |
| 3    | TP9*                    | 1 volt rms (approximate).           | Input to converter.      |
| 4    | U105, pin 6 or TP10*    | +1 volt DC.                         | Output of U105.          |
| 5    | R143                    | Gain adjustment must operate.       |                          |
| 6    | Repeat steps 4 & 5      | 10 volts rms, 45 Hz.                | Low frequency response.  |
| 7    | Repeat steps 4 & 5      | 10 volts rms, 20 kHz.               | High frequency response. |

\* On main printed circuit board.

TABLE 5-9.  
Current Shunts

| Step | Item/Component               | Required Condition                                      | Remarks                               |
|------|------------------------------|---------------------------------------------------------|---------------------------------------|
| 1    | F102                         | Continuity.                                             |                                       |
| 2    | R123, R124, R137, R138, R139 | Correct shunt value for specified range. See schematic. | Measure with ohmmeter.                |
| 3    |                              | Turn on power. Select DCA and 200 $\mu$ A range.        |                                       |
| 4    | External voltage source      | 0 to 3 volts.                                           | Clamping must occur at $\pm 2$ volts. |

TABLE 5-10.  
Adjustment of Battery Charge Voltage

| Step | Item/Component | Required Condition                                                           | Remarks                                                                                                                                                                                                                                                                     |
|------|----------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | R301           | Instrument off.                                                              | Fully charged cells require several minutes to reach this level. Discharged cells require several hours.<br> CAUTION: charging to >10V for longer than 30 min. will reduce battery life. |
| 2    |                | Turn full CCW (maximum charge rate).                                         |                                                                                                                                                                                                                                                                             |
| 3    |                | Monitor battery voltage for > 9.8V.                                          |                                                                                                                                                                                                                                                                             |
| 4    | R301           | When cells reach 9.8V, turn DMM on and adjust to maintain 9.8V across BT301. |                                                                                                                                                                                                                                                                             |



SECTION 6. THEORY OF OPERATION.

6-1. GENERAL. This section contains circuit descriptions for the Model 179 DMM and for the Model 1788 Battery Pack. An overall block diagram of signal flow is provided in Figure 6-1. The overall schematic diagram, drawing 28992E, is contained in the back of this manual.

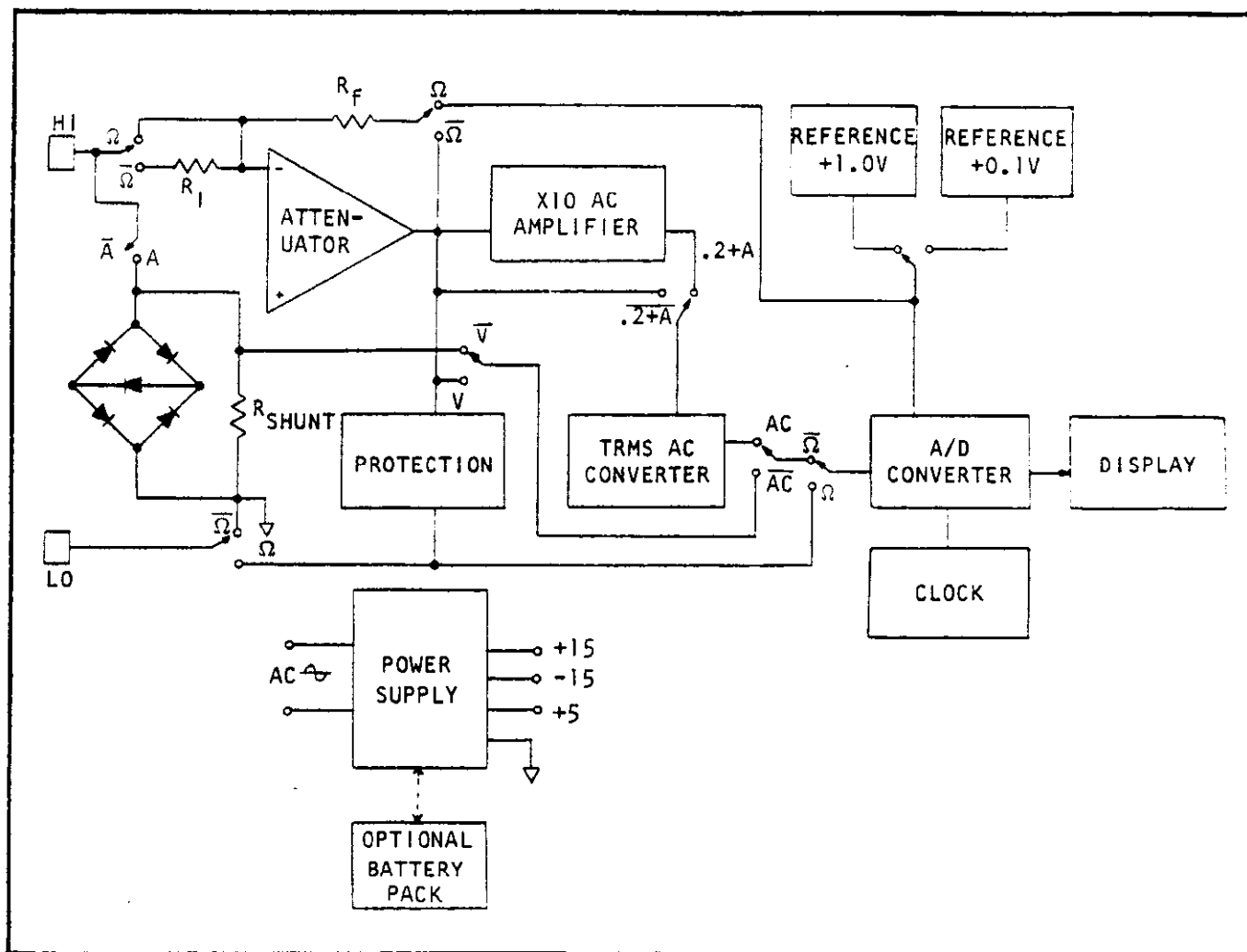


FIGURE 6-1. Simplified Signal Flow Block Diagram, Model 179 DMM

6-2. OVERALL OPERATION. The Model 179 DMM uses a 2-volt or 200-millivolt full scale analog-to-digital (A/D) converter with a 4-1/2 digit multiplexed display. Signal conditioning permits the A/D converter to handle full scale ac and dc voltage and current measurements over 5 decades, and to measure resistance over 5 ranges.

a. Signal Conditioning. Signal conditioning includes dc attenuation (except on the 2 volt and 200 millivolt ranges), ac attenuation and X10 amplification, ac-to-dc conversion, ohms conversion and current shunts as shown in Figure 6-2.

1) In the DCV mode, signal conditioning to the A/D converter is an active attenuator, except on the two lowest ranges. The A/D input is  $-V_{HI-LO} \cdot \frac{R_f}{R_I}$ , except on the lowest

ranges or under overload conditions. In the DCA mode, the voltage developed across the shunt resistor is applied directly to the A/D converter at 200 millivolts full scale.

2) In the ACV mode, ac inputs pass through the attenuator on all ranges. The input is scaled to 2 volts rms full scale, including X10 amplification for the 200 millivolt range. The TRMS converter outputs a positive dc signal proportional to the true root mean square ac signal. This DC signal is the A/D input. In the ACA mode, shunt voltage is treated as a 200 millivolt signal.

b. Ohms Conversion. Resistance measurements are made by configuring the attenuator as a resistance-to-voltage converter. Attenuator stage voltage feedback resistors  $R_f$  function as amplifier input resistance connected to either the 0.1 volt reference (LO) or the 1.0 volt reference (HI). The unknown resistance is connected as a feedback resistor around the attenuation amplifier. The resulting voltage applied to the A/D converter is proportional to the unknown resistance.

c. A/D Converter. The A/D converter is a large scale integration (LSI) ratiometric device. Converter output is a multiplexed 5 digit binary coded decimal (BCD) number which is equal to the ratio of input voltage to reference voltage. A separate clock circuit supplies a 100 kHz timing input to the integrated circuit, which also multiplexes the BCD output. Full scale A/D inputs for various ranges and functions are listed in Table 6-1.



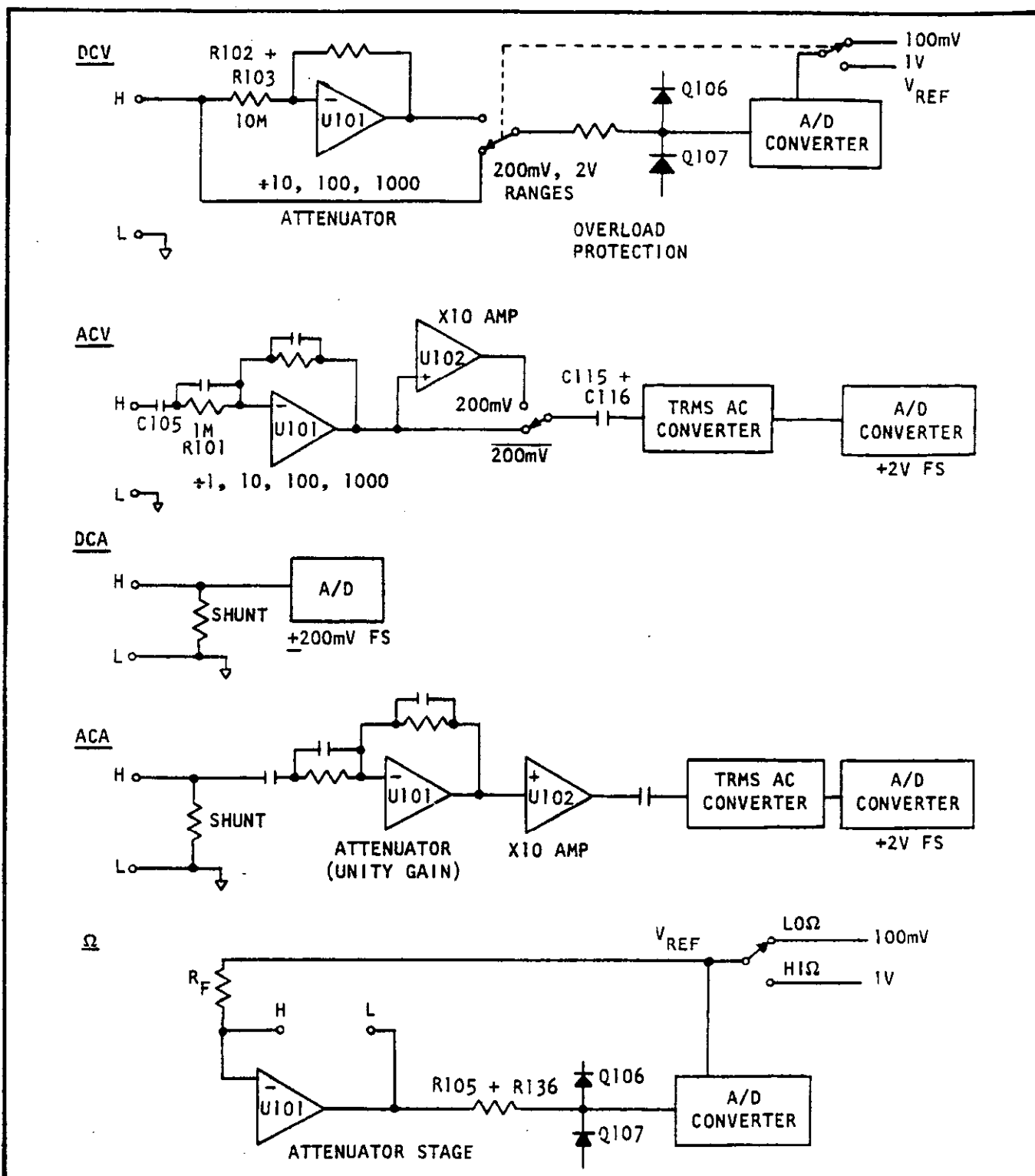


FIGURE 6-2. Attenuation and Ohms Conversion.

TABLE 6-1.  
Full Scale A/D Inputs.

| Function | Range                | Full Scale A/D Input | Reference Voltage |
|----------|----------------------|----------------------|-------------------|
| DCV      | 200 mV               | 200 mV               | 0.1 V             |
| DCV      | 2, 20, 200<br>1200 V | 2 V                  | 1.0 V             |
| ACV      | All                  | 2 V                  | 1.0 V             |
| DCA      | All                  | 200 mV               | 0.1 V             |
| ACA      | All                  | 2 V                  | 1.0 V             |
| $\Omega$ | HI                   | 2 V                  | 1.0 V             |
|          | LO                   | 200 mV               | 0.1 V             |

6-3. ATTENUATION. When measuring ac and dc voltages, input signal conditioning is provided by inverting amplifier U101 and additional components as described below.

a. DC. Input resistance is set by R102 and R103. During calibration, R103 is adjusted to obtain a total input resistance of 10 M $\Omega$ . Both fine and coarse zero adjustments are provided since an amplifier output resolution of 10 microvolts is required for LO resistance measurements.

1) On the 2 volt and 200 millivolt ranges, input HI is connected to the A/D converter through protection resistors R106, R135G and R136. Diode-connected FET's Q106 and Q107 clamp the A/D input during overload.

2) On the 20, 200 and 1200 volt ranges, the amount of attenuation is selected by switching feedback resistors into the attenuator with relays K101, K102 and K103. Gain setting components and attenuation values are listed in Table 6-2.

TABLE 6-2.  
DC Attenuation and Gain Setting Components.

| Range  | Gain Set Components | Relay/Switch | Attenuation                  |
|--------|---------------------|--------------|------------------------------|
| 200 mV |                     |              | } Signal bypasses attenuator |
| 2 V    |                     |              |                              |
| 20 V   | R118, R126          | K101         | 0.1                          |
| 200 V  | R119, R127          | K102         | 0.01                         |
| 1200 V | R120, R128          | K103         | 0.001                        |

b. AC Volts. Input resistance is  $1\text{M}\Omega$  (R101). Shunt capacitance is typically less than 75 pF. Additional conditioning is as follows.

1) For all ranges except the 200 millivolt range, the amount of attenuation is selected by switching feedback resistors into the attenuator with relays K101 through K104. For the 200 millivolt range, non-inverting X10 amplifier U102 boosts the signal to 2 volts full scale. Gain setting components and attenuation values are listed in Table 6-3.

TABLE 6-3.  
AC Attenuation Gain Setting Components

| Range  | Gain Set Components | Relay Energized | Attenuation | Freq. Comp. Capacitors |
|--------|---------------------|-----------------|-------------|------------------------|
| 200 mV | R118, R126          | K101            | 1 (X10*)    | C106, C111             |
| 2 V    | R118, R126          | K101            | 1           | C106, C111             |
| 20 V   | R119, R127          | K102            | 0.1         | C106, C112             |
| 200 V  | R120, R128          | K103            | 0.01        | C106, C113             |
| 1000 V | R121, R122, R129    | K104            | 0.001       | C106, C114             |

\* Signal applied to X10 ac amplifier U102.

2) On the 200 millivolt and 2 volt ranges, high frequency compensation is adjusted with capacitor C111, as shown in Table 6-3. On the 20 volt range, adjustment is performed with C112. On the 200 and 1000 volt ranges, adjustment is performed with C106. Some low frequency rolloff is introduced by input blocking capacitor C105, and ac converter input capacitors C115 and C116.

6-4. AC CONVERSION. The ac converter is a monolithic TRMS module. Output  $V_{dc} = \sqrt{\text{Avg}(V_{in})^2}$ . Potentiometer R143 provides gain adjustment, and R142 establishes output zero. Settling time and ripple are determined by C110 and C120. Low frequency rolloff is a function of C120.

6-5. OHMS CONVERSION. During calibration, the  $10\text{M}\Omega$  input resistance (R102 and R103) and all attenuator feedback resistors are adjusted for both ratio and absolute value. Therefore, these resistors can also serve as reference (current setting) for resistance measurements. In the  $\Omega$  mode, the attenuation (feedback) resistors are disconnected from the output of the attenuation amplifier (U101) and are connected instead to the A/D converter reference voltage. Since two reference voltages and two A/D converter gains are available, the Model 179 DMM provides the option of measuring resistance with the sense current reduced by a factor of 10.

a. Range Selection. Operation of the range pushbuttons selects range resistors to provide the reference current listed in Table 6-4. Operation of the HI/LO pushbutton selects the 1 volt or 0.1 volt reference, respectively. Relay K105 is always energized in the  $\Omega$  mode.

TABLE 6-4.  
Resistance Range Setting Components

| Range           | Range Resistors  | Relay/Switch                                   | Nom. $I_{REF}$<br>in HI $\Omega$ | Nom. $I_{REF}$<br>in LO $\Omega$ |
|-----------------|------------------|------------------------------------------------|----------------------------------|----------------------------------|
| 2 k $\Omega$    | R121, R122, R129 | K104                                           | -                                | 100 $\mu$ A                      |
| 20 k $\Omega$   | R120, R128       | K103                                           | 100 $\mu$ A                      | 10 $\mu$ A                       |
| 200 k $\Omega$  | R119, R127       | K102                                           | 10 $\mu$ A                       | 1 $\mu$ A                        |
| 2000 k $\Omega$ | R118, R126       | K101                                           | 1 $\mu$ A                        | 0.1 $\mu$ A                      |
| 20 M $\Omega$   | R102, R103       | 1000 switch,<br>pins 17, and<br>$\Omega$ 8, 9. | 0.1 $\mu$ A                      | -                                |

b.  $\Omega$  Circuit. For resistance measurements, relay K105 and terminals 4, 5, and 6 of the  $\Omega$  pushbutton connect the input HI terminal directly to the amplifier summing node. Input LO is disconnected from ground and is connected to the A/D converter input through the protection components described below. The unknown resistance ( $R_x$ ) then becomes the amplifier feedback resistance.

1) Current flow in the unknown resistance is from input HI to input LO. At full scale, the voltage across  $R_x$  is either 2 volts (HI) or 200 millivolts (LO). Reference source loading does not affect accuracy since the A/D converter is ratiometric.

2) The HI terminal is clamped to analog common by Q101 and Q102. The instrument protection network at the amplifier output consists of a pulldown resistance (R104 and CR103, CR104 and CR105). R104 sinks approximately 150 microamps. During in-range measurements, this current is supplied by the reference voltage through CR105 and voltage through the amplifier (U101) and CR104. Overloads with input HI positive are sustained by CR105; diodes CR103 and CR104 sustain negative overloads. Open circuit voltage is set to less than 5V by R150 and R151 through CR103 and CR105. A/D protection in  $\Omega$  is the same as in V except R105 is substituted for R106.

6-6. A/D CONVERTER. The A/D converter operates on the dual slope principle. The timing is divided into three periods as described below. Operation with high and low reference voltages is described separately in subparagraph d.

a. Auto-Zero. The auto-zero period (A, Figure 6-3) is 100 milliseconds in length, which corresponds to 10,000 clock pulses. During this period, reference voltage  $V_{REF}$  (see subparagraph d) is stored on capacitor C124. Capacitor C117 stores  $V_{REF} + V_{OS1} - V_{OS2}$ .

b. Signal-Integrate. The signal-integrate period (B, Figure 6-3) is 100 milliseconds in length. The A/D input is buffered by U104 (see subparagraph d) and integrated by U103. Positive signals generate a negative-going ramp at the integrator output (pin 14), while negative signals produce a positive-going ramp. The level of the integrated signal at the end of the signal-integrate period is proportional to the average of the applied signal during this period. Since signal integration continues for 100 milliseconds, the A/D converter exhibits high normal mode rejection for ac signals in multiples of 10 hertz, particularly the 50 and 60 hertz line frequencies.

c. Reference-Integrate. The reference-integrate period (C or D, Figure 6-3) is 200 milliseconds or 20,000 counts in length. During this period, the integrator is returned to baseline level by applying a reference voltage of a polarity opposite to that of the signal. A positive-going ramp is obtained by grounding the buffer input, while a negative going ramp is produced by the integration of  $2 \times V_{REF}$  (that is,  $V_{REF}$  + the voltage stored on C124). The time, or number of clock pulses required for discharge is proportional to the signal input. Digital output is from latches within U106 which store the number of clock pulses required for the integrator to return to baseline level. The maximum count during this period is 20,000 which corresponds to a discharge period of 200 milliseconds or full scale input.

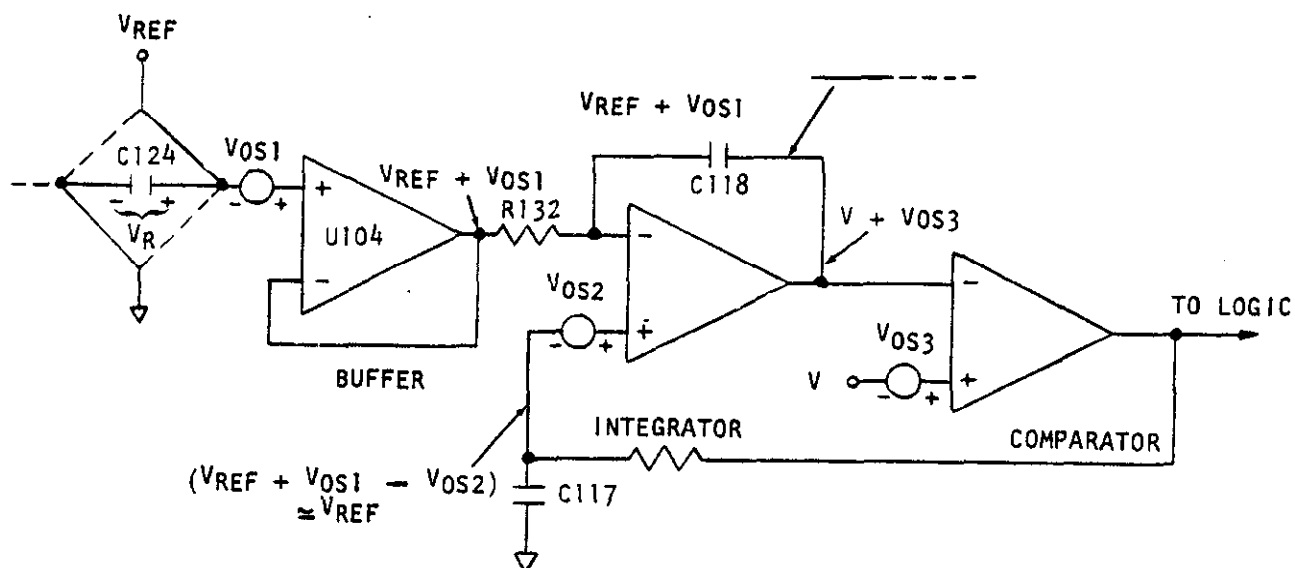
d. Reference Voltages. Reference voltage  $V_{REF}$  may be either 1 volt or 0.1 volt. Switching through the pushbuttons turns on either Q104 (for 1 volt) or Q103 (for 0.1 volt). The voltages are provided by a divider across a temperature compensated zener diode. An operational amplifier on U103 provides the zener with a self-regulating bias. Use of the 0.1 volt reference increases converter sensitivity to 200 millivolts full scale, permitting accurate 10 ohms operation, 10 microvolt resolution on dc voltage measurements, and dc amperage measurements with a full scale burden of 200 millivolts. Increased sensitivity is accomplished by switching input buffer U104 into a gain-of-10 configuration by turning on Q105. Auto-zero charging on C124 is to a 100 millivolt reference instead of a 1 volt reference. Integrator and comparator voltage levels are unaffected by buffer gain. Buffer offset voltage is zeroed, and resistors R146 plus R144 or R145, which are selected at test, null any remaining zero offset on the 200 millivolt range.

6-7. DISPLAY. Five light-emitting diodes (LED) are driven by U201, which is a CMOS BCD-to-seven segment decoder/driver with bipolar current-sourcing outputs. Segment currents are limited to approximately 20 milliamperes peak by resistor network R202. The LED readout is a multiplexed, common-cathode configuration with Darlington array U202 sequentially sinking current from each digit. Blanking of the overrange digit is accomplished by gates U107A and U107B. Emitter-follower Q108 ensures that CMOS-compatible levels are maintained on U107A, pin 1, regardless of the loading of U202. The minus polarity readout is blanked on ac voltage and resistance ranges by contacts on the pushbutton switch. Proper decimal point position is determined by the combination of function and range selected.

6-8. CURRENT MEASUREMENTS. In the A mode, the signal is switched into one of five current shunts ahead of the attenuator section. For dc current measurements, the shunt voltage drop is applied directly to the A/D converter input at 200 millivolts full scale. For ac current measurements, the shunt voltage drop is treated as a 200 millivolt ac signal and passes through the ac attenuator and the X10 ac amplifier. Overload clamping occurs at three diode drops which is a level high enough to permit high crest factor current waveforms. On the Model 179-20A, a sixth current shunt is added and the principle of operation is the same as that described above.

6-9. AC POWER SUPPLY. When the DMM is operated from ac line power, the power supply furnishes +5, +15, and -15 volts from regulators VR104, VR102 and VR101, respectively. Full-wave rectified ac from bridge rectifiers CR101 and CR102 is filtered by reservoir capacitors C108, C104 and C103 and is applied to the linear voltage regulators.

## A. AUTO-ZERO (10k COUNTS)



## B. SIGNAL INTEGRATE (10k COUNTS)

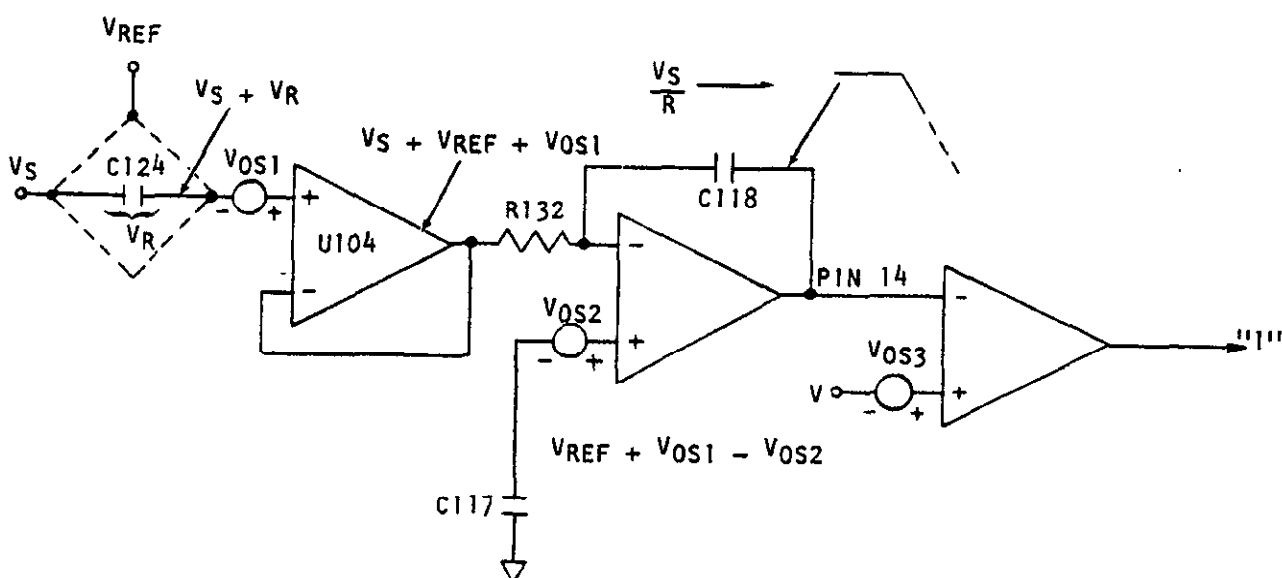
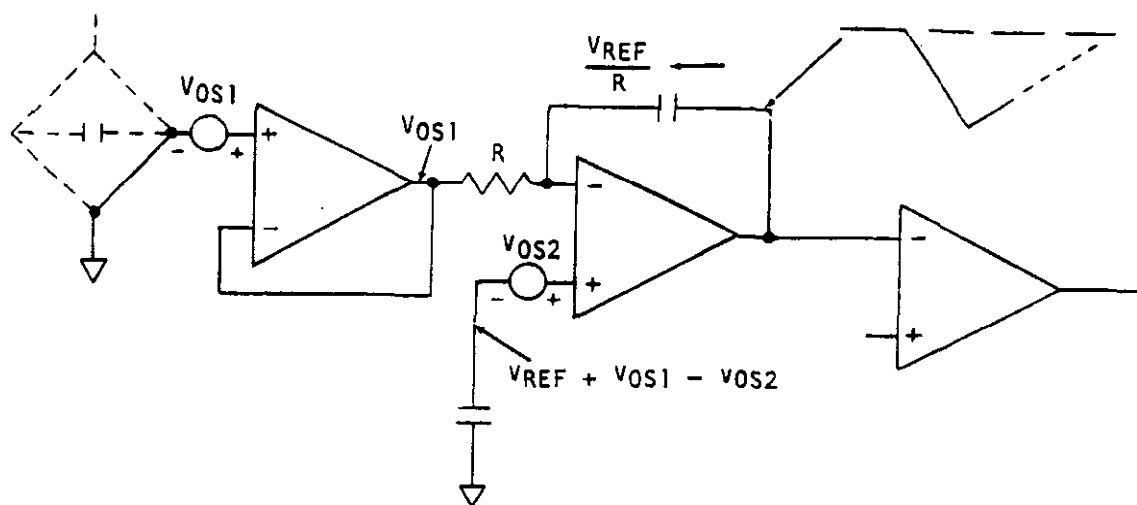


FIGURE 6-3. A/D Converter Function (Sheet 1 of 2)

C. NEGATIVE REFERENCE INTEGRATE (20k COUNTS AT FULL SCALE)  
(POSITIVE INPUTS-TO A/D)



D. POSITIVE REFERENCE INTEGRATE (20k COUNTS AT FULL SCALE)  
(NEGATIVE INPUTS TO A/D)

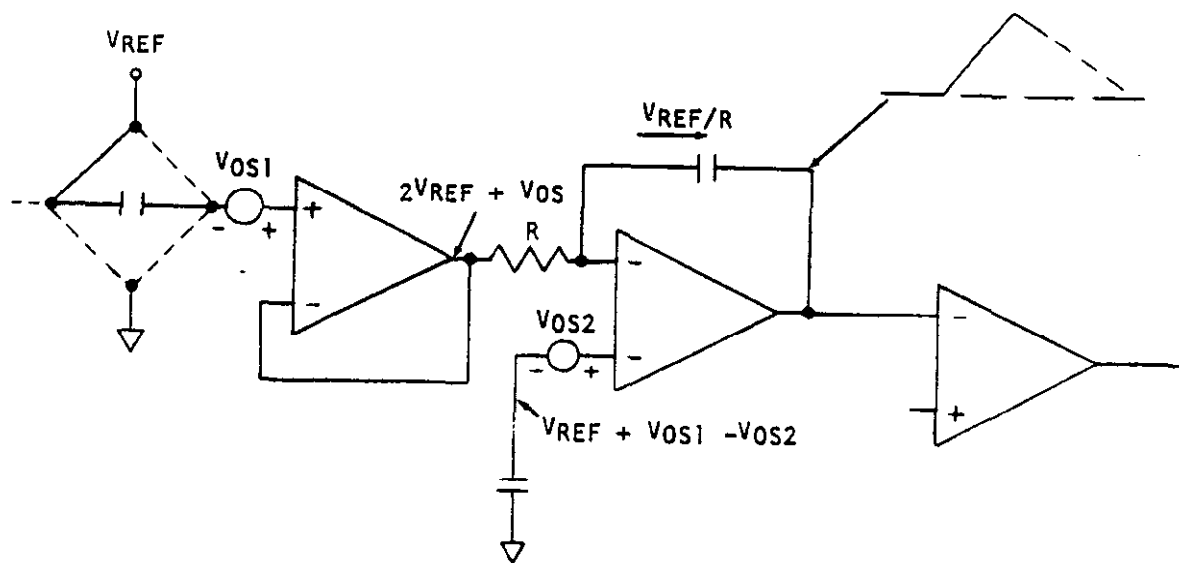


FIGURE 6-3. A/D Converter Function (Sheet 2 of 2)

6-10. MODEL 1788 BATTERY PACK. When the Model 1788 Battery Pack is installed in the DMM, S102 must be set to the BAT position to provide additional secondary voltage for battery charging. S102 also switches the input to VR104 from bridge rectifier CR101 to batteries BT301. Four 2-volt, 2.5 ampere-hour lead-acid cells supply approximately 9.8 volts at full charge. After six hours of use on battery power, the battery pack should be recharged to ensure long battery life.

a. Battery Charging Circuit. While the DMM is plugged into line power and the battery pack is installed, battery charging proceeds as follows:

1) Full-wave rectified voltage from CR101 is applied to the anode of Q301, which is an SCR which regulates charging voltage. When Q301 is triggered on by a sufficient gate-cathode voltage differential, the batteries receive charge. Charging continues as long as the bridge output voltage exceeds battery voltage by 1 volt or more. Resistor R304 limits charging current when recharging a set of completely discharged cells. A filtered positive output from CR102 (or T301) provides the necessary gate turn-on bias through R306 and diode CR301. Resistor R303 ensures proper high-temperature operation of Q301.

2) When the battery voltage reaches the preset float voltage of 9.8 volts, zener VR301 conducts sufficient current to turn on Q302 and thus remove the gate trigger voltage from Q301. Float voltage is adjusted with R301. This is a factory adjustment which normally does not need field readjustment.

b. Battery Operation and Shutdown Circuit. The DMM operates as follows on battery power:

1) When the power is turned on, the batteries are connected to the input of VR104 to supply +5 volts for the logic, display and the clock circuit. The clock output is applied to the A/D converter as described in Paragraph 6-6 and also to U301, which is a divide-by-four binary counter. The outputs of U301 drive a dc-to-dc inverter which is synchronized to the A/D converter to filter out inverter noise. The 25 kilohertz operating frequency is optimal for the small transformer size, and results in low switching losses. Blocking capacitors C301 and C302 protect Q307 and Q308 from damage if the drive is lost. Two half-wave rectifiers (CR304 and CR305) on the secondary of T301 provide rectified ac to filter capacitors C304 and C305 which provide power to +15 and -15 volt regulators VR102 and VR101.

2) To prevent permanent loss of battery capacity caused by deep discharge, a shutdown circuit stops operation on battery power when the battery voltage drops below approximately 7.2 volts. Shutdown is performed by micropower voltage detector U302. The open-collector output (U302, pin 4) saturates low and turns off pass transistor Q309 when the input voltage (at U302, pin 3) drops below 1.15 volts (typical). Resistor R314 provides sufficient hysteresis to prevent discharge from resuming when the battery voltage rises following disconnection of the load.



## SECTION 7. REPLACEABLE PARTS

7-1. GENERAL. This section contains information for ordering replacement parts. The parts list is arranged in alphabetical order of their Circuit Designations.

7-2. ORDERING INFORMATION. To place an order or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering, include the following information:

- a. Instrument Model Number.
- b. Instrument Serial Number.
- c. Part Description.
- d. Circuit Designation (if applicable).
- e. Keithley Part Number.

7-3. MODEL 1789 MAINTENANCE KIT. The Model 1789 contains a complement of spare parts that will maintain up to ten Models 178, 179, or 179-20A DMMs (or any combination thereof) for approximately one year. Specify Model 1789 Maintenance Kit when ordering.

7-4. FACTORY SERVICE. If the instrument is to be returned to the factory for service, please complete the Service Form which follows this section, and return it with the instrument.

7-5. SCHEMATIC.

a. Model 179 4-1/2 digit TRMS Multimeter: Schematic No. 28992E (Page 7-10). This schematic also describes the Model 1788 Rechargeable Battery Pack.

7-6. COMPONENT LAYOUT.

- a. Model 179 4-1/2 Digit TRMS Multimeter (Page 7-11).
- b. Model 1788 Rechargeable Battery Pack (Page 7-13).

7-7. SPECIAL HANDLING OF STATIC SENSITIVE DEVICES. CMOS devices are designed to function at very high impedance levels for low power consumption. For this reason, a normal static charge build up on your person or clothing can be sufficient to destroy these devices. The following steps list the static sensitive devices in your Model 179 and provide instruction on how to avoid damaging them when they must be removed/replaced.

- a. Static sensitive devices:

| <u>Keithley<br/>Part Number</u> | <u>Reference<br/>Designation</u> |
|---------------------------------|----------------------------------|
| IC-102                          | U107                             |
| IC-103                          | U301                             |
| IC-168                          | U201                             |

b. The above integrated circuits should be handled and transported only in protective containers. Typically they will be received in metal tubes or static protective foam. Keep the devices in their original containers until ready for use.

c. Remove the devices from their protective containers only at a properly grounded work bench or table, and only after grounding yourself by using a wrist strap.

d. Handle the devices only by the body. Do not touch the pins.

e. Any printed circuit board into which a device is to be inserted must also be grounded to the bench or table.

f. Use only anti-static type solder suckers.

g. Use only grounded tip soldering irons.

h. After soldering the device into the board, or properly inserting it into the mating receptacle, the device is adequately protected and normal handling can be resumed.

TABLE 7-1.  
Cross-Reference of Manufacturers

| MFR.<br>CODE | NAME AND ADDRESS                                     | FED.<br>SUPPLY<br>CODE | MFR.<br>CODE | NAME AND ADDRESS                                     | FED.<br>SUPPLY<br>CODE |
|--------------|------------------------------------------------------|------------------------|--------------|------------------------------------------------------|------------------------|
| A-B          | Allen-Bradley Corp<br>Milwaukee, WI 53204            | 01121                  | DLE          | Dale Electronics Inc.<br>Columbus, NE 68601          | 91637                  |
| A-D          | Analog Devices Inc.<br>Norwood, MA 02026             | 24355                  | DTN          | Dielettron (Consolidated)<br>New York City, NY 10013 |                        |
| ACI          | American Components, Inc.<br>Conshohocken, PA 19428  | 14298                  | ECI          | Electro Cube Inc.<br>San Gabriel, CA 91776           | 14752                  |
| AMP          | Amphenol<br>Broadview, IL 60153                      | 02660                  | EDI          | Electronic Devices, Inc.<br>Yonkers, NY 10710        | 83701                  |
| APX          | Amperex<br>Elk Grove Vlg, IL 60007                   | 73445                  | EFJ          | E. F. Johnson Co.<br>Waseca, MN 56093                | 74970                  |
| BEC          | Beckman Inst. Inc.<br>Fullerton, CA 92634            | 73138                  | ERI          | Erie Technological Prod.<br>Erie, PA 16512           | 72982                  |
| BLD          | Belden Mfg. Co.<br>Chicago, IL 60644                 | 70903                  | F-1          | Fairchild Inst. Corp.<br>Mountain View, CA 94043     | 07263                  |
| BRG          | Berg Electronics Inc.<br>New Cumberland, PA 17070    | 22526                  | FUS          | Bussman Mfg. (Fusetron)<br>St. Louis, MO 63107       | 71400                  |
| BRN          | Bourns, Inc.<br>Riverside, CA 92507                  | 80294                  | G-E          | General Electric Company<br>Syracuse, NY 13201       | 03508                  |
| BUS          | Bussman Mfg. Div.<br>St. Louis, MO 63017             | 71400                  | G-1          | General Instrument Corp.<br>Newark, NJ 07104         | 72699                  |
| C-1          | Components, Inc.<br>Biddeford, ME 04005              | 06751                  | GLD          | Gould, Inc.<br>St. Paul, MN 55165                    | 52431                  |
| C-W          | Continental-Wirt Elec. Corp.<br>Warminster, PA 18974 | 79727                  | H-P          | Hewlett-Packard<br>Palo Alto, Ca 94304               | 50434                  |
| CAD          | Caddock<br>Riverside, CA 92507                       | 19647                  | INT          | Intersil Inc.<br>Cupertino, CA 95014                 | 32293                  |
| CAN          | ITT Cannon Electric<br>Santa Ana, CA 92702           | 71468                  | IRC          | IRC Division<br>Burlington, IA 52601                 | 07716                  |
| CLB          | Centralab Division<br>Milwaukee, WI 53201            | 71590                  | K-1          | Keithley Instruments, Inc.<br>Cleveland, Ohio 44139  | 80164                  |
| CLR          | Clarostat Mfg. Co., Inc.<br>Dover, NH 03820          | 12697                  | L-F          | Littlefuse, Inc.<br>Des Plaines, IL 60016            | 75915                  |
| CTS          | CTS Corporation<br>Elkhart, IN 46514                 | 71450                  | MOL          | Molex<br>Downers Grove, IL 60515                     | 27264                  |
| DIC          | Dickson Electronics Corp.<br>Scottsdale, AZ 85252    | 12954                  | MOT          | Motorola Semi Prod. Inc.<br>Phoenix, AZ 85008        | 04713                  |

TABLE 7-1. (Cont'd)

| MFR.<br>CODE | NAME AND ADDRESS                                 | FED.<br>SUPPLY<br>CODE | MFR.<br>CODE | NAME AND ADDRESS                              | FED.<br>SUPPLY<br>CODE |
|--------------|--------------------------------------------------|------------------------|--------------|-----------------------------------------------|------------------------|
| NAT          | National Semi Corp.<br>Santa Clara, CA 95051     | 27014                  | TEP          | Tepro Electric Corp.<br>Rochester, NY 14606   | 02985                  |
| NCI          | National Components, Inc.<br>West Palm Beach, FL |                        | TPL          | Temple<br>Tecate, CA 92080                    | 29505                  |
| NEL          | Northern Engr. Labs<br>Burlington, WI 53105      | 00815                  | TRW          | TRW Capacitor Div.<br>Ogallala, NB 69153      | 84411                  |
| P&B          | Potter & Brumfield<br>Princeton, IN 47670        | 12300                  | VIS          | Vishay Resistor Products<br>Malvern, PA 19355 | 18612                  |
| PAK          | Paktron<br>Vienna, VA 22180                      |                        | VRN          | Vernitron<br>Laconia, NH 03246                | 13150                  |
| POM          | Pomona Electric<br>Pomona, CA 91766              | 05276                  | WAB          | Wabash-Magnetics<br>Wabash, IN 46992          | 01101                  |
| QTN          | Q-Tron<br>Santa Ana, CA 92705                    | 25525                  |              |                                               |                        |
| RAY          | Raytheon Company<br>Quincy, MA                   | 94144                  |              |                                               |                        |
| RCA          | RCA Corporation<br>Moorestown, NJ 08050          | 02734                  |              |                                               |                        |
| RCL          | RCL Electronics, Inc.<br>Manchester, NJ 03102    | 01686                  |              |                                               |                        |
| SIE          | Siemens Corporation<br>Iselin, NJ 08830          | 25088                  |              |                                               |                        |
| SIG          | Signetics Corp.<br>Sunnyvale, CA 94086           | 18324                  |              |                                               |                        |
| SIL          | Siliconix Inc.<br>Santa Clara, CA 95054          | 17856                  |              |                                               |                        |
| SPG          | Sprague Electric Co.<br>Visalia, CA 93278        | 14659                  |              |                                               |                        |
| SOL          | Solltron Devices Inc.<br>San Diego, CA 92123     | 22229                  |              |                                               |                        |
| STD          | Standard Condensor<br>Chicago, IL                | 97419                  |              |                                               |                        |
| T-I          | Texas Instruments, Inc.<br>Dallas, TX 75231      | 01295                  |              |                                               |                        |
| TEL          | Tel Labs<br>Manchester, NH 03102                 | 94322                  |              |                                               |                        |

## REPLACEABLE PARTS LIST

BATTERIES (BT)  
Model 1788 Battery Pack  
"300" Series (Sch. 28992E-Pg. 7-15)

| Circuit<br>Desig. | Description                                                      | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|------------------------------------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| BT301             | Set of four "D" Cells, 8V                                        | F6               | ---                  | *            |                |                      |
| *                 | Lead-acid "D" cell, 2V, 2.5AH<br>(Used for BT301, four required) |                  |                      | G-E          | GE0225         | BA-33                |

CAPACITORS (C)  
"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                                | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig.   | Keithley<br>Part No.               |
|-------------------|--------------------------------------------|------------------|----------------------|--------------|------------------|------------------------------------|
| C101              | 4.7uF, 20V, ETT . . . . .                  | D-7              | D-4                  | NCI          | KNS475A020K      | C-179-4.7                          |
| C102              | 4.7uF, 20V, ETT . . . . .                  | D-7              | E-4                  | NCI          | KNS475A020K      | C-179-4.7                          |
| C103              | 470uF, 35V, EAL . . . . .                  | C-8              | E-5                  | NIC          | 35ELA470         | C-289-470                          |
| C104              | 470uF, 35V, EAL . . . . .                  | C-8              | E-5                  | NIC          | 35ELA470         | C-289-470                          |
| C105              | 0.1uF, 1000V, MPF . . . . .                | C-3              | F-5                  | STD          | M2W-F-0.1uF      | C-285-.1                           |
| C106              | .25-1.5pF, 2000V, Teflon Trimmer . . . . . | D-2              | F-4                  | EFJ          | 273-101          | C184                               |
| C107              | 1000pF, 500V, ±5%, Polystyrene . . . . .   | D-3              | F-4                  | CLB          | CPR-1000         | C-138-1000                         |
| C108              | 2200uF, 15V, EAL . . . . .                 | C-7              | D-3                  | NAC          | 16FLA2200        | C-290-2200                         |
| C109              | 3.3pF, ±0.5pF, 50VDC, CerD . . . . .       | E-2              | E-3                  | NAC          | DT200-3R3        | C-291-3.3P                         |
| C110              | 1uF, 100V, ±10%, MPF . . . . .             | G-2              | E-3                  | POT          | 4309C-105K       | C-294-1                            |
| C111              | .25-1.5pF, 2000V, Teflon Trimmer . . . . . | D-2              | E-3                  | EFJ          | 273-1-1          | C-184                              |
| C112              | 1.9-15.8pF, 250V, Trimmer . . . . .        | D-2              | E-3                  | EFJ          | 187-0109-005     | C-284                              |
| C113              | 1100pF, 500VDC, ±1%, Silver Mica . . . . . | D-2              | F-3                  | G-1          | RDM19FD112F03    | C-278-110P                         |
| C114              | 1100pF, 500VDC, ±1%, Silver Mica . . . . . | D-1              | F-3                  | G-1          | RDM19FD111F03    | C-278-1100P $\alpha 5 = C-276-110$ |
| C115              | 33uF, 15V, ETT . . . . .                   | F-2              | E-3                  | NCI          | KNS3360015K      | C-228-33                           |
| C116              | 33uF, 15V, ETT . . . . .                   | F-2              | E-3                  | NCI          | KNS3360015K      | C-228-33                           |
| C117              | 1uF, 100V, ±10%, MPF . . . . .             | J-3              | D-2                  | POT          | 4309C-105K       | C-294-1                            |
| C118              | .22uF, 200VDC, ±10%, MPF . . . . .         | J-2              | D-2                  | POT          | 22-200-10-X363UW | C-269-.22                          |
| C119              | NOT USED                                   |                  | ---                  |              |                  |                                    |
| C120              | 1uF, 100V, ±10%, MPF . . . . .             | F-3              | F-1                  | POT          | 4309C-105K       | C-294-1                            |
| C121              | 4.7uF, 20V, ETT . . . . .                  | D-8              | D-2                  | NCI          | KNS475A020K      | C-179-4.7                          |
| C122              | 4.7uF, 20V, ETT . . . . .                  | D-8              | D-2                  | NCI          | KNS475A020K      | C-179-4.7                          |
| C123              | 1uF, 200V, 20%, MPF . . . . .              | G-4              | E-2                  | ECI          | 625B1C104        | C-221-.1                           |
| C124              | 4uF, 100V, 20%, MPF . . . . .              | H-2              | E-1                  | POT          | 0109-5432        | C-294-4                            |
| C125              | 100pF, 1000V, CerD . . . . .               | F-5              | F-2                  | CLB          | DD-101           | C-64-100P                          |

"200" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 485-Pg. 7-14)

|      |                           |     |     |     |             |           |
|------|---------------------------|-----|-----|-----|-------------|-----------|
| C201 | 4.7uF, 20V, ETT . . . . . | K-7 | B-2 | NCI | KNS475A020K | C-179-4.7 |
|------|---------------------------|-----|-----|-----|-------------|-----------|

"300" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 451-Pg. 7-15)

|      |                            |     |     |     |             |           |
|------|----------------------------|-----|-----|-----|-------------|-----------|
| C301 | 4.7uF, 35V, EAL . . . . .  | F-7 | E-3 | NCI | KNS475A020K | C-179-4.7 |
| C302 | 4.7uF, 35V, EAL . . . . .  | F-7 | E-3 | NCI | KNS475A020K | C-179-4.7 |
| C303 | 1.0uF, 250V, MPY . . . . . | F-7 | E-3 | AMP | C280AE/A1M  | C-256-1   |
| C304 | 100uF, 35VC . . . . .      | F-8 | F-4 | NIC | 35-ULA-100  | C-295-100 |
| C305 | 100uF, 35VC . . . . .      | F-8 | F-3 | NIC | 35-ULA-100  | C-295-100 |

DIODES (CR)  
"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                            | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|----------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| CR101             | Bridge Rectifier, 100V, 2A . . . . .   | C-6              | D-5                  | EDI          | PD10           | RF-36                |
| CR102             | Bridge Rectifier, 1A, 400V . . . . .   | C-7              | D-5                  | EDI          | PF40           | RF-46                |
| CR103             | Silicon Rectifier, 1A, 1000V . . . . . | E-3              | F-5                  | T-1          | IN4007         | RF-50                |
| CR104             | Silicon Rectifier, 1A, 1000V . . . . . | E-3              | F-5                  | T-1          | IN4007         | RF-50                |
| CR105             | Silicon Rectifier, 1A, 1000V . . . . . | E-3              | G-5                  | T-1          | IN4007         | RF-50                |
| CR106             | Rectifier, 75mA, 75V . . . . .         | D-8              | D-4                  | T-1          | IN914          | RF-28                |
| CR107             | Rectifier, 75mA, 75V . . . . .         | J-2              | D-2                  | T-1          | IN914          | RF-28                |
| CR108             | Rectifier, 75mA, 75V . . . . .         | J-2              | D-2                  | T-1          | IN914          | RF-28                |

## DIODES (CR) (CON'T)

| Circuit<br>Desig. | Description                        | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| CR109             | Rectifier, 75mA, 75V. . . . .      | K-3              | F-2                  | T-1          | 1N914          | RF-28                |
| CR110             | Rectifier, 75mA, 75V. . . . .      | J-3              | F-2                  | T-1          | 1N914          | RF-28                |
| CR111             | Bridge Rectifier, 5A, 50V. . . . . | A-3              | G-3                  | EDI          | PE05           | RF-48                |
| CR112             | Rectifier, 3A, 50V. . . . .        | A-4              | G-2                  | SOL          | 3A50           | RF-34                |
| CR113             | Rectifier, 75mA, 75V. . . . .      | H-1              | C-2                  | T-1          | 1N914          | RF-28                |

"300" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 451-Pg. 7-15)

|       |                               |     |     |     |       |       |
|-------|-------------------------------|-----|-----|-----|-------|-------|
| CR301 | Rectifier, 75mA, 75V. . . . . | E-6 | D-4 | T-1 | 1N914 | RF-28 |
| CR302 | Rectifier, 75mA, 75V. . . . . | F-7 | E-3 | T-1 | 1N914 | RF-28 |
| CR303 | Rectifier, 75mA, 75V. . . . . | F-7 | E-3 | T-1 | 1N914 | RF-28 |
| CR304 | Rectifier, 75mA, 75V. . . . . | E-8 | F-4 | T-1 | 1N914 | RF-28 |
| CR305 | Rectifier, 75mA, 75V. . . . . | E-8 | F-4 | T-1 | 1N914 | RF-28 |

## DISPLAYS (DS)

"200" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 485-Pg. 7-14)

| Circuit<br>Desig. | Description                   | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|-------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| DS201             | ±1 LED Digit . . . . .        | H-7              | C-2                  | F-1          | FND561         | DD-17                |
| DS202             | 7-Segment LED Digit . . . . . | H-7              | C-2                  | F-1          | FND560         | DD-16                |
| DS203             | 7-Segment LED Digit . . . . . | H-7              | D-2                  | F-1          | FND560         | DD-16                |
| DS204             | 7-Segment LED Digit . . . . . | J-7              | D-2                  | F-1          | FND560         | DD-16                |
| DS205             | 7-Segment LED Digit . . . . . | J-7              | D-2                  | F-1          | FND560         | DD-16                |

## FUSES (F)

"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                             | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|-----------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| F101              | Fuse, 510-810, 1/8A, 250V, 3AG. . . . . | B-7              | D-4                  | BUS          | MDL            | FU-20                |
| F102              | Fuse, 2A, 250V, 3AG. . . . .            | A-3              | F-3                  | LIT          | 312002         | FU-13                |
| F103*             | Fuse, 20A, 250V, 3AB. . . . .           | A-5              | G-2                  | LIT          | 314020         | FU-47                |

\* On Model 179-20A Only

"300" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 451-Pg. 7-15)

|      |                                |     |     |     |        |       |
|------|--------------------------------|-----|-----|-----|--------|-------|
| F301 | 2A, 250V, 3AG, Quick . . . . . | F-6 | C-3 | L-F | 312002 | FU-13 |
|------|--------------------------------|-----|-----|-----|--------|-------|

## CONNECTORS (J)

"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                 | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|-----------------------------|------------------|----------------------|--------------|----------------|----------------------|
| J1001             | 11-Pin Right Angle. . . . . | H-7              | H-5                  | MOL          | 22-15-2111     | CS-348-2             |
| J1002             | 6-Pin Right Angle. . . . .  | H-6              | H-2                  | MOL          | 22-15-2061     | CS-348-1             |
| J1003             | 3-Pin . . . . .             | B-8              | ---                  | MOL          | 2139-3         | CS-287-3             |
| J1004             | 8-Pin . . . . .             | D-8              | D-5                  | MOL          | 2139-8         | CS-287-8             |
| J1005             | Banana Jack, Black. . . . . | A-4              | ---                  | PQM          | 1581           | BJ-11-0              |
| J1006             | Banana Jack, Red. . . . .   | A-3              | ---                  | PQM          | 1581           | BJ-11-2              |
| J1007             | NOT USED                    |                  |                      |              |                |                      |

## RELAYS (K)

"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description             | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|-------------------------|------------------|----------------------|--------------|----------------|----------------------|
| K101              | 5V, Reed Type . . . . . | B-8              | E-4                  | COT          | UF-40097       | RL-56                |
| K102              | 5V, Reed Type . . . . . | B-8              | F-4                  | COT          | UF-40097       | RL-56                |
| K103              | 5V, Reed Type . . . . . | A-8              | F-4                  | COT          | UF-40102       | RL-59                |
| K104              | 5V, Reed Type . . . . . | A-8              | F-4                  | COT          | UF-40102       | RL-59                |
| K105              | 5V, Reed Type . . . . . | A-8              | F-4                  | COT          | UF-40102       | RL-59                |

**CONNECTORS (P)**  
**"1000" Series (Sch. 28992E-Pg. 7-11)**  
**(PC-Board 492-Pg. 7-13)**

| Circuit<br>Desig. | Description         | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|---------------------|------------------|----------------------|--------------|----------------|----------------------|
| P1001             | 6-Pin . . . . .     | H-7              | G-5                  | MOL          | 22-03-2061     | CS-247-1             |
| P1002             | 11-Pin . . . . .    | H-6              | G-2                  | MOL          | 22-03-2061     | CS-347-2             |
| P1003             | MALE . . . . .      | B-8              | D-5                  | MOL          | A-2391-3A      | CS-288-3             |
| P1004             | MALE . . . . .      | D-5              | D-3                  | MOL          | A-2391-8A      | CS-288-8             |
| P1005             | NOT USED            |                  |                      |              |                |                      |
| P1006             | NOT USED            |                  |                      |              |                |                      |
| P1007             | Line Cord . . . . . | B-8              | ---                  | K-1          | ---            | CO-9                 |

**TRANSISTORS (Q)**  
**"100" Series (Sch. 28992E-Pg. 7-11)**  
**(PC-Board 492-Pg. 7-13)**

| Circuit<br>Desig. | Description            | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|------------------------|------------------|----------------------|--------------|----------------|----------------------|
| Q101              | N-Chan, JFET . . . . . | D-3              | E-4                  | INT          | 1TE4392        | TG-77                |
| Q102              | N-Chan, JFET . . . . . | D-3              | E-4                  | INT          | 1TE4392        | TG-77                |
| Q103              | N-Chan, JFET . . . . . | H-2              | D-2                  | INT          | 1TE4392        | TG-77                |
| Q104              | N-Chan, JFET . . . . . | H-2              | C-2                  | INT          | 1TE4392        | TG-77                |
| Q105              | N-Chan, JFET . . . . . | J-3              | D-2                  | INT          | 1TE4392        | TG-77                |
| Q106              | N-Chan, JFET . . . . . | G-3              | E-2                  | K-1          | ---            | TG-128               |
| Q107              | N-Chan, JFET . . . . . | G-4              | F-2                  | K-1          | ---            | TG-128               |
| Q108              | NPN, Switch . . . . .  | H-6              | G-2                  | MOT          | 2N3904         | TG-47                |

**"300" Series (Sch. 28992E-Pg. 7-11)**  
**(PC-Board 451-Pg. 7-15)**

|      |                                    |     |     |     |         |        |
|------|------------------------------------|-----|-----|-----|---------|--------|
| Q301 | Thyristor, SCR . . . . .           | D-6 | C-4 | MOT | 106F1   | TG-132 |
| Q302 | NPN, Switch . . . . .              | E-7 | C-3 | MOT | 2N3904  | TG-47  |
| Q303 | NPN, Switch . . . . .              | E-7 | D-4 | MOT | 2N3904  | TG-47  |
| Q304 | NPN, Switch . . . . .              | E-7 | E-4 | MOT | 2N3904  | TG-47  |
| Q305 | NPN, Switch . . . . .              | E-8 | E-4 | MOT | 2N3904  | TG-47  |
| Q306 | PNP, Silicon, T0-92 Case . . . . . | E-7 | E-4 | K-1 | ---     | TG-53  |
| Q307 | NPN, Switch . . . . .              | F-7 | E-3 | MOT | 2N3725  | TG-131 |
| Q308 | NPN, Switch . . . . .              | F-7 | E-3 | MOT | 2N3725  | TG-131 |
| Q309 | PNP, Silicon . . . . .             | E-6 | D-3 | MOT | MPS-WA5 | TG-133 |
| Q310 | PNP, Silicon, T0-92 Case . . . . . | E-6 | D-3 | K-1 | ---     | TG-53  |

**RESISTORS (R)**  
**"100" Series (Sch. 28992E-Pg. 7-11)**  
**(PC-Board 492-Pg. 7-13)**

| Circuit<br>Desig. | Description                                    | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|------------------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| R101              | 1M $\Omega$ , $\pm 0.5\%$ , 2W, MtF . . . . .  | D-3              | E-4, E-5             | ACI          | PME80T9        | R-267-1M             |
| R102              | 9.88M, $\pm 0.5\%$ , .5W, 1200V, MtF . . . . . | D-2              | F-5                  | TRW          | AR90T10        | R-265-9.88M          |
| R103              | 200K $\Omega$ , 10%, Cermet Trimmer . . . . .  | C-2              | F-5                  | BEC          | 89P            | RP-89-200K           |
| R104              | 100K $\Omega$ , 10%, 2W, Comp. . . . .         | E-4              | F-5                  | A-B          | H8             | R-2-100K             |
| R105              | 47K $\Omega$ , 10%, 2W, Comp. . . . .          | G-4              | F-5                  | A-B          | H8             | R-3-47K              |
| R106              | 47K $\Omega$ , 10%, 2W, Comp. . . . .          | D-4              | G-5                  | A-B          | H8             | R-3-47K              |
| R107              | 100 $\Omega$ , 10%, Cermet Trimmer . . . . .   | J-1              | D-3                  | BRN          | 30-69-P        | RP-64-100            |
| R108              | 200 $\Omega$ , 10%, Cermet Trimmer . . . . .   | J-1              | D-3                  | BRN          | 30-69-P        | R-64-200             |
| R109              | MATCHED SET WITH VR105 . . . . .               | J-1              | D-3                  | TRW          | MAR-5          | R-263-99.8K (28798A) |
| R110              | MATCHED SET WITH VR105 . . . . .               | J-1              | D-3                  | TRW          | MAR-5          | R-263-4.59K (28798A) |
| R111              | 931 $\Omega$ , 1%, 1/8W, MtF . . . . .         | J-1              | D-3                  | IRC          | CEA-T0-931     | R-88-931             |
| R112              | 50K $\Omega$ , 10%, Cermet Trimmer . . . . .   | E-3              | E-3                  | BEC          | 72PMR          | RP-97-50K            |
| R113              | 200K $\Omega$ , 1%, 1/8W, MtF . . . . .        | D-3              | E-3                  | IRC          | CEA-T0-200K    | R-88-200K            |
| R114              | 1.8M, 10%, 1/4W, Comp. . . . .                 | D-3              | E-3                  | MEP          | CR25, 5%       | R-76-1.8M            |
| R115              | 100 $\Omega$ , 1%, 1/8W, MtF . . . . .         | D-3              | E-3                  | IRC          | CEA-T0-100     | R-88-100             |
| R116              | 4.99K $\Omega$ , .1%, 1/10W, MtF . . . . .     | E-2              | E-3                  | TRW          | MAR-5, T13     | R-263-4.99K          |
| R117              | 44.9K $\Omega$ , .1%, 1/10W, MtF . . . . .     | E-2              | E-3                  | TRW          | MAR-5, T13     | R-263-44.9K          |
| R118              | 998K $\Omega$ , .1%, 1/4W, MtF . . . . .       | D-2              | E-3                  | TRW          | MAR-7, T13     | R-264-998K           |
| R119              | 99.8K $\Omega$ , .1%, 1/4W, MtF . . . . .      | D-2              | E-3                  | TRW          | MAR-5, T13     | R-263-99.8K          |
| R120              | 9.98K $\Omega$ , .1%, 1/10W, MtF . . . . .     | D-2              | F-3                  | TRW          | MAR-5, T13     | R-263-9.98K          |
| R121              | 1.002K $\Omega$ , .1%, 1/10W, MtF . . . . .    | D-1              | F-3                  | TRW          | MAR-5, T13     | R-263-1.002K         |
| R122              | 270K $\Omega$ , 10%, 1/4W, Comp. . . . .       | D-1              | F-3                  | MEP          | CR25, 5%       | R-76-270K            |
| R123              | .898 $\Omega$ , .1%, 5W, WW. . . . .           | B-4              | F-3                  | TEP          | TS5-.898       | R-232-.898           |

RESISTORS (R) (CON'T)  
 "100" Series (Sch. 28992E-Pg. 7-11)  
 (PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                           | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|---------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| R124              | 10, .1%, 7.5W, WW, 5-Terminal . . .   | B-4              | F-2                  | TEL          | SPECIAL        | R-262-.1000          |
| R125              | 120, 10%, 1/4W, Comp . . . . .        | G-7              | G-3                  | MEP          | CR25, 5%       | R-76-120             |
| R126              | 5K, 10%, Cermet Trimmer . . . . .     | D-2              | E-3                  | BEC          | 72PMR          | RP-97-5K             |
| R127              | 500, 10%, Cermet Trimmer . . . . .    | D-2              | E-3                  | BEC          | 72PMR          | RP-97-500            |
| R128              | 50, 10%, Cermet Trimmer . . . . .     | D-2              | F-3                  | BEC          | 72PMR          | RP-97-50             |
| R129              | 50K, 10%, Cermet Trimmer . . . . .    | E-1              | F-3                  | BEC          | 72PMR          | RP-97-50K            |
| R130              | 143K, .1%, 1/10W, MtF . . . . .       | J-2              | D-2                  | TRW          | MAR-5, T13     | R-263-143            |
| R131              | 856K, .1%, 1/10W, MtF . . . . .       | J-2              | D-2                  | TRW          | MAR-5, T13     | R-263-856            |
| R132              | 100K, 1%, 1/10W, MtF . . . . .        | J-2              | D-2                  | IRC          | CEA-T0-100K    | R-88-100K            |
| R133              | 26.7, 1%, 1/8W, MtF . . . . .         | J-2              | D-2                  | IRC          | CEA-T0-26.7K   | R-88-26.7K           |
| R134              | 3.01, 1%, 1/8W, MtF . . . . .         | J-3              | E-2                  | IRC          | CEA-T0-3.01K   | R-88-3.01K           |
| R135 (A-J)        | Thick Film Network . . . . .          | SEVERAL          | E-2                  | K-1          | ---            | TF-65                |
| R136              | 47K, 10%, WW, Comp . . . . .          | F-4              | F-2                  | A-B          | HB             | R-3-47K              |
| R137              | 9, 0.5W, .01%, WW . . . . .           | B-4              | F-3                  | TEL          | SA3            | R-252-9              |
| R138              | 900, 0.1%, 1/2W, MtF . . . . .        | C-4              | F-3                  | DLE          | MFF-1/2-T0-900 | R-169-900            |
| R139              | 90, 1/2W, .1%, MtF . . . . .          | B-4              | F-3                  | DLE          | MFF-1/2-T0-90  | R-169-90             |
| R140              | 11K, 1%, 1/8W, MtF . . . . .          | J-1              | D-2                  | IRC          | CEA-T0-11K     | R-88-11K             |
| R141              | 19.6K, 1%, 1/8W, MtF . . . . .        | J-2              | D-2                  | IRC          | CEA-T0-19.6K   | R-88-19.6K           |
| R142              | 50K, 10%, Cermet Trimmer . . . . .    | G-3              | E-2                  | BEC          | 72PMR          | RP-97-50K            |
| R143              | 500, 10%, Cermet Trimmer . . . . .    | G-2              | E-2                  | BEC          | 72PMR          | RP-97-500            |
| R144              | Optional, Factory Selected . . . . .  | H-4              | E-2                  | MEP          | CR25, 5%       | R-76-* (SEL)         |
| R145              | Optional, Factory Selected . . . . .  | H-5              | E-2                  | MEP          | CR25, 5%       | R-76-* (SEL)         |
| R146              | 1, 5%, 1/4W, Comp . . . . .           | H-5              | E-2                  | MEP          | CR25, 5%       | R-76-1               |
| R147              | 47K, 10%, 1/4W, Comp . . . . .        | F-5              | G-2                  | MEP          | CR25, 5%       | R-76-47K             |
| R148              | 22M, 10%, 1/4W, Comp . . . . .        | F-5              | G-2                  | MEP          | CR25, 5%       | R-76-22M             |
| R149              | 200K, 10%, Cermet Trimmer . . . . .   | D-3              | G-1                  | BEC          | 89P            | RP-89-200K           |
| R150              | 3.3K, 5%, 1/4W, Comp . . . . .        | E-3              | F-5                  | MEP          | CR25, 5%       | R-76-3.3K            |
| R151              | 12K, 5%, 1/4W, Comp . . . . .         | F-3              | F-5                  | MEP          | CR25, 5%       | R-76-12K             |
| R152              | (Part of 28798A) . . . . .            | J-1              | D-3                  | K-1          | ---            | R-88-*               |
| R153              | (Part of 28798A) . . . . .            | J-1              | D-3                  | K-1          | ---            | R-88-*               |
| R154              | .01, .25%, 7.5W, WW, 4-Terminal . . . | K-1              | G-2                  | TEL          | SPECIAL        | R-274-.01            |

"200" Series (Sch. 28992E-Pg. 7-11)  
 (PC-Board 492-Pg. 7-13)

|      |                                  |     |     |     |           |          |
|------|----------------------------------|-----|-----|-----|-----------|----------|
| R201 | 120, 1/4W, Comp . . . . .        | H-7 | C-2 | MEP | CR25, 5%  | R-76-120 |
| R202 | 47, Thick Film Network . . . . . | J-7 | E-2 | BEC | 899-3-R47 | TF-64    |

"300" Series (Sch. 28992E-Pg. 7-11)  
 (PC-Board 451-Pg. 7-15)

|      |                                 |     |     |     |             |           |
|------|---------------------------------|-----|-----|-----|-------------|-----------|
| R301 | 20K, 0.5W, POT . . . . .        | E-7 | C-3 | BEC | 72PMR-20K   | RP-97-20K |
| R302 | 330, 10%, 1/4W, Comp . . . . .  | E-7 | C-3 | MEP | CR25, 5%    | R-76-330  |
| R303 | 1K, 10%, 1/4W, Comp . . . . .   | E-6 | D-4 | MEP | CR25, 5%    | R-76-1K   |
| R304 | 3.9K, 20%, 3W, WW . . . . .     | D-6 | D-4 | TEP | TS3         | R-268-3.9 |
| R305 | 4.7K, 10%, 1/4W, Comp . . . . . | E-7 | D-3 | MEP | CR25, 5%    | R-76-4.7K |
| R306 | 33K, 10%, 1/4W, Comp . . . . .  | D-8 | C-3 | A-B | CB-332-10%  | R-76-3.3K |
| R307 | 82K, 10%, 1/4W, Comp . . . . .  | F-7 | E-3 | MEP | CR25, 5%    | R-76-82   |
| R308 | 82K, 10%, 1/4W, Comp . . . . .  | F-7 | E-3 | MEP | CR25, 5%    | R-76-82   |
| R309 | 10, 10%, 1/4W, Comp . . . . .   | D-8 | F-4 | A-B | CB-100-10%  | R-76-10   |
| R310 | 10, 10%, 1/4W, Comp . . . . .   | D-8 | F-4 | A-B | CB-100-10%  | R-76-10   |
| R311 | 100K, 2%, 1/4W, Comp . . . . .  | E-6 | E-3 | MEP | CR25, 5%    | R-76-100K |
| R312 | 100K, 5%, 1/4W, Comp . . . . .  | E-6 | E-3 | MEP | CR25, 5%    | R-76-100K |
| R313 | 6.8M, 5%, 1/4W, Comp . . . . .  | F-6 | E-3 | MEP | CR25, 5%    | R-76-6.8M |
| R314 | 6.8M, 5%, 1/4W, Comp . . . . .  | F-6 | E-3 | MEP | CR25, 5%    | R-76-6.8M |
| R315 | 576K, 1%, 1/8W, Comp . . . . .  | F-6 | E-3 | IRC | CEA-T0-576K | R-88-576K |
| R316 | 100K, 1%, 1/8W, Comp . . . . .  | F-6 | E-3 | IRC | CEA-T0-100K | R-88-100K |

SWITCHES (S)  
 "100" Series (Sch. 28992E-Pg. 7-11)  
 (PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                     | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|---------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| S101              | Line Voltage Selector . . . . . | B-7              | D-4                  | C-W          | GG350PCDPDT    | SW-318               |
| S102              | Line/Battery . . . . .          | C-6              | D-4                  | K-1          | ---            | SW-397               |
| S103              | 11 Station Pushbutton . . . . . | A-5              | G-4                  | K-1          | ---            | SW-402 (27696A)      |



## INSTRUCTION MANUAL

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## REPLACEABLE PARTS

TRANSFORMERS (T)  
"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                         | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|-------------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| T101              | Transformer, Power. . . . .         | C-6              | D-5                  | K-1          | ---            | TR-168               |
| T101              | Transformer, Power (100/200 V). . . | C-6              | D-5                  | K-1          | ---            | TR-169               |

"300" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 451-Pg. 7-15)

|      |                             |     |     |     |     |        |
|------|-----------------------------|-----|-----|-----|-----|--------|
| T301 | Transformer, Power. . . . . | F-7 | F-3 | K-1 | --- | TR-170 |
|------|-----------------------------|-----|-----|-----|-----|--------|

TEST POINTS (TP)  
(Sch. 28992E-Pg. 7-11)

| Circuit<br>Desig. | Description         | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|---------------------|------------------|----------------------|--------------|----------------|----------------------|
| TP1               | Test Point. . . . . | C-8              | ---                  | K-1          | ---            | ---                  |
| TP2               | Test Point. . . . . | C-8              | ---                  | K-1          | ---            | ---                  |
| TP3               | Test Point. . . . . | H-2              | ---                  | K-1          | ---            | ---                  |
| TP4               | Test Point. . . . . | J-1              | ---                  | K-1          | ---            | ---                  |
| TP5               | Test Point. . . . . | E-3              | ---                  | K-1          | ---            | ---                  |
| TP6               | Test Point. . . . . | J-3              | ---                  | K-1          | ---            | ---                  |
| TP7               | Test Point. . . . . | J-2              | ---                  | K-1          | ---            | ---                  |
| TP8               | Test Point. . . . . | H-2              | ---                  | K-1          | ---            | ---                  |
| TP9               | Test Point. . . . . | F-2              | ---                  | K-1          | ---            | ---                  |
| TP10              | Test Point. . . . . | G-3              | ---                  | K-1          | ---            | ---                  |

INTEGRATED CIRCUITS (U)  
"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                         | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No.       |
|-------------------|-------------------------------------|------------------|----------------------|--------------|----------------|----------------------------|
| U101              | Operational AMP 8-Pin, TO-5 . . . . | D-3              | E-4                  | NAT          | LH0022CH       | IC-165                     |
| U102              | Operational AMP 8-Pin, DIP. . . .   | E-2              | E-3                  | NAT          | LM301AN        | IC-167                     |
| U103              | 4-1/2 Digit Analog-Processor. . . . | K-2              | D-2                  | INT          | 8052A          | LSI-12                     |
| U104              | Operational AMP 8-Pin, TO-5 . . . . | H-2              | E-2                  | NAT          | LH0042CH       | IC-175                     |
| U105              | TRMS Converter. . . . .             | F-2              | D-2                  | A-D          | AD536J         | IC-172                     |
| U106              | 4-1/2 Digit Logic Processor . . . . | J-4              | E-2                  | INT          | 7103A          | LSI-11 <i>USE 179A-000</i> |
| U107(A-D)         | 4011 CMOS Unbuffered. . . . .       | SEVERAL          | G-2                  | MOT          | MC14011CP      | IC-102                     |

"200" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 485-Pg. 7-14)

|      |                         |     |     |     |       |        |
|------|-------------------------|-----|-----|-----|-------|--------|
| U201 | Segment Drive . . . . . | K-7 | E-2 | MOT | 4511  | IC-168 |
| U202 | Digit Driver. . . . .   | H-6 | B-2 | T-1 | 75492 | IC-169 |

"300" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 485-Pg. 7-14)

|      |                                     |     |     |     |            |        |
|------|-------------------------------------|-----|-----|-----|------------|--------|
| U301 | Dual D-Type Flip-Flop, 14-Pin DIP . | E-7 | D-3 | RCA | CD4013AE   | IC-103 |
| U302 | 1.1V Micro-Power Detector . . . .   | F-6 | E-3 | INT | ICL8211CPA | IC-177 |

VOLTAGE REGULATORS (VR)  
"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                     | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|---------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| VR101             | -15V, 3-Term. . . . .           | C-8              | E-5                  | MOT          | MC7915CT       | IC-174               |
| VR102             | +15V, 3-Term, LO-Power. . . . . | C-8              | E-5                  | MOT          | MC78L15CP      | IC-170               |
| VR103             | NOT USED                        |                  |                      |              |                |                      |
| VR104             | +5V, 3-Term, TO-220 . . . . .   | D-7              | D-4                  | MOT          | MC7805CT       | IC-93                |
| VR105             | Reference Zener . . . . .       | J-2              | D-2                  | K-1          | ---            | (28798A)             |

"300" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 451-Pg. 7-15)

|       |                           |     |     |     |        |       |
|-------|---------------------------|-----|-----|-----|--------|-------|
| VR301 | 8.2 Volt, Zener . . . . . | E-6 | C-3 | MOT | 1N765A | DZ-61 |
|-------|---------------------------|-----|-----|-----|--------|-------|

REPLACEABLE PARTS

INSTRUCTION MANUAL  
Digital Multimeter  
Model 17J

CRYSTAL (Y)  
"100" Series (Sch. 28992E-Pg. 7-11)  
(PC-Board 492-Pg. 7-13)

| Circuit<br>Desig. | Description                    | Sch.<br>Location | PC-Board<br>Location | Mfr.<br>Code | Mfr.<br>Desig. | Keithley<br>Part No. |
|-------------------|--------------------------------|------------------|----------------------|--------------|----------------|----------------------|
| Y101              | Quartz, $\pm 0.01\%$ , 100kHz. | F-5              | F-1                  | NEL          | NE34PE         | CR-8                 |

326682

## NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K-KILOHMS, M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (P-PICOFARADS)
3.  $\nabla$  DENOTES ANALOG COMMON.
4.  $\nabla$  DENOTES DIGITAL COMMON.
5.  $\nabla$  DENOTES DISPLAY COMMON.
6. \* DENOTES FACTORY SELECTED VALUE.
7.  $\bigcirc$  DENOTES FRONT PANEL CONTROL.
8.  $\bullet$  DENOTES REAR PANEL CONTROL.
9.  $\odot$  DENOTES INTERNAL ADJUST.
10.  $\odot$  DENOTES INTERNAL CONTROL.
11. ALL UNMARKED PUSHBUTTON SWITCH CONTACTS ARE PART OF S103 AND ARE SHOWN IN THE PUSHBUTTON OUT POSITION.
12.  $\square$  THRU  $\square$  DENOTES CALIBRATION ADJUSTMENT.

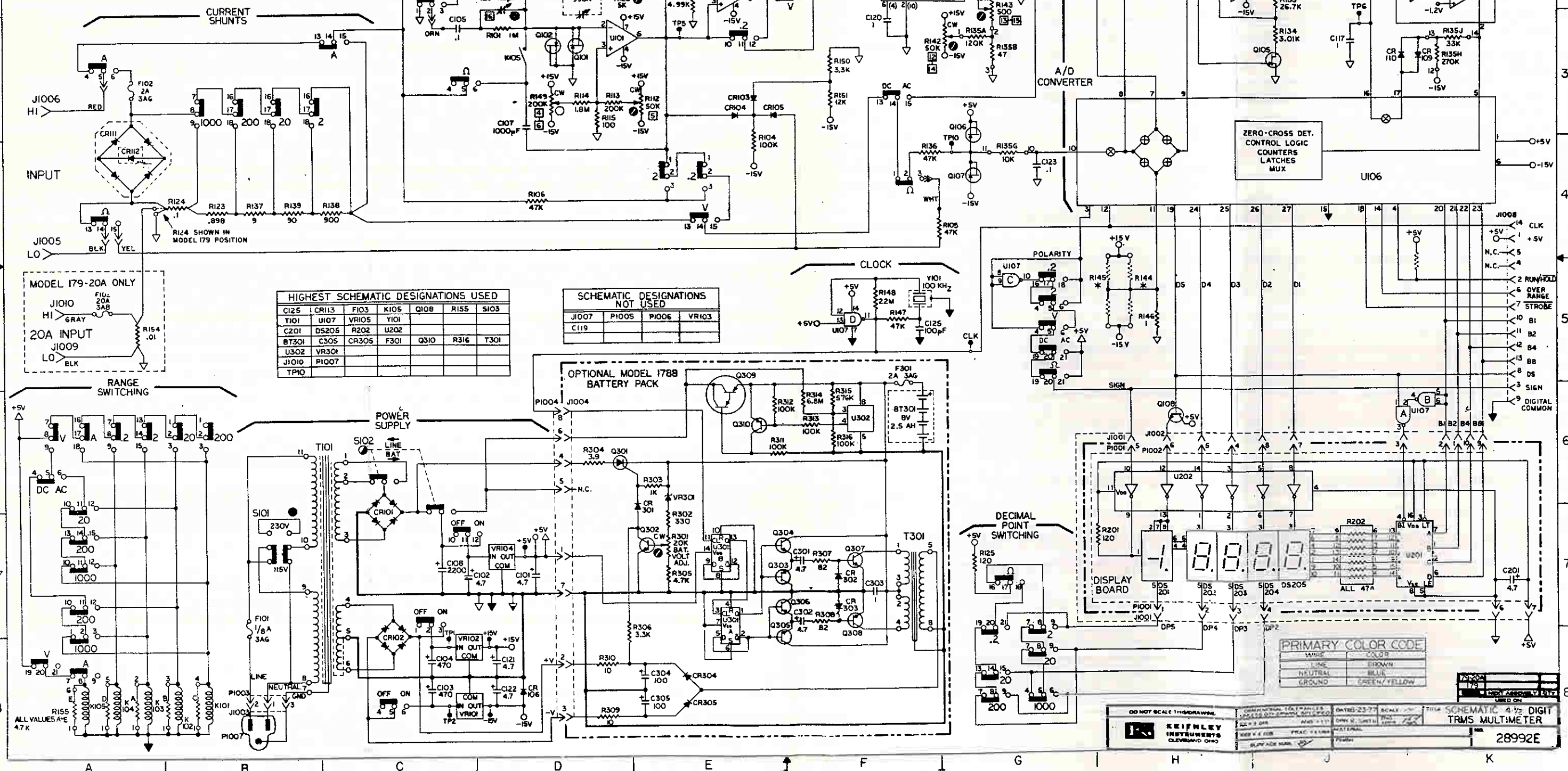
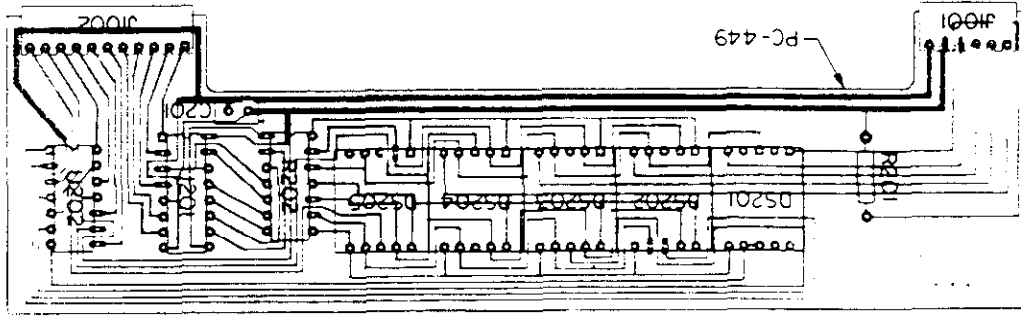


FIGURE 7-1. Schematic Diagram, Model 179 TRMS Multimeter.



2-42  
1-42-5

|                       |  |                                     |  |                                   |  |                                      |  |                                           |  |                                            |  |                                                   |  |                                           |  |                                           |  |                                        |  |                                        |  |                                        |  |                                               |  |                                               |  |                                                 |  |                                                   |  |                                             |  |                                                   |  |                                                   |  |                                                  |  |                                            |  |                                                   |  |                                                     |  |                                              |  |                                                  |  |                                                   |  |                                                  |  |                                             |  |                                                   |  |                                                   |  |                                                  |  |                                            |  |                                                   |  |                                                     |  |                                                 |  |                                                     |  |                                                      |  |                                                     |  |                                                |  |                                                      |  |                                                      |  |                                                     |  |                                               |  |                                                      |  |                                                        |  |                                                 |  |                                                     |  |                                                      |  |                                                     |  |                                                |  |                                                      |  |                                                      |  |                                                     |  |                                               |  |                                                      |  |                                                        |  |                                                 |  |                                                     |  |                                                      |  |                                                     |  |                                                |  |                                                      |  |                                                      |  |                                                     |  |                                               |  |                                                      |  |                                                        |  |                                                 |  |                                                     |  |                                                      |  |                                                     |  |                                                |  |                                                      |  |                                                      |  |                                                     |  |                                               |  |                                                      |  |                                                        |  |                                                 |  |                                                     |  |                                                      |  |                                                     |  |                                                |  |
|-----------------------|--|-------------------------------------|--|-----------------------------------|--|--------------------------------------|--|-------------------------------------------|--|--------------------------------------------|--|---------------------------------------------------|--|-------------------------------------------|--|-------------------------------------------|--|----------------------------------------|--|----------------------------------------|--|----------------------------------------|--|-----------------------------------------------|--|-----------------------------------------------|--|-------------------------------------------------|--|---------------------------------------------------|--|---------------------------------------------|--|---------------------------------------------------|--|---------------------------------------------------|--|--------------------------------------------------|--|--------------------------------------------|--|---------------------------------------------------|--|-----------------------------------------------------|--|----------------------------------------------|--|--------------------------------------------------|--|---------------------------------------------------|--|--------------------------------------------------|--|---------------------------------------------|--|---------------------------------------------------|--|---------------------------------------------------|--|--------------------------------------------------|--|--------------------------------------------|--|---------------------------------------------------|--|-----------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|
| COMPONENT LATENT P-43 |  | 1. 2 BODY<br>2. 2 HEAD<br>3. 2 TAIL |  | 4. 2 EYE<br>5. 2 EAR<br>6. 2 NOSE |  | 7. 2 MOUTH<br>8. 2 JAW<br>9. 2 CHEEK |  | 10. 2 NECK<br>11. 2 SHOULDER<br>12. 2 ARM |  | 13. 2 HAND<br>14. 2 WRIST<br>15. 2 FOREARM |  | 16. 2 ELBOW<br>17. 2 UPPER ARM<br>18. 2 LOWER ARM |  | 19. 2 PALM<br>20. 2 FINGER<br>21. 2 THUMB |  | 22. 2 INDEX<br>23. 2 MIDDLE<br>24. 2 RING |  | 25. 2 PINKY<br>26. 2 LEG<br>27. 2 KNEE |  | 28. 2 ANKLE<br>29. 2 FOOT<br>30. 2 TOE |  | 31. 2 HEEL<br>32. 2 ARCH<br>33. 2 BALL |  | 34. 2 LATERAL<br>35. 2 MEDIAL<br>36. 2 DISTAL |  | 37. 2 PROXIMAL<br>38. 2 ULNAR<br>39. 2 RADIAL |  | 40. 2 TIBIAL<br>41. 2 FIBULAR<br>42. 2 PATELLAR |  | 43. 2 ACROMION<br>44. 2 CLAVICLE<br>45. 2 SCAPULA |  | 46. 2 HUMERUS<br>47. 2 ULNA<br>48. 2 RADIUS |  | 49. 2 CARPUS<br>50. 2 METACARPUS<br>51. 2 PHALANX |  | 52. 2 TARSAL<br>53. 2 METATARSAL<br>54. 2 PHALANX |  | 55. 2 CLAVICLE<br>56. 2 SCAPULA<br>57. 2 HUMERUS |  | 58. 2 ULNA<br>59. 2 RADIUS<br>60. 2 CARPUS |  | 61. 2 METACARPUS<br>62. 2 PHALANX<br>63. 2 TARSAL |  | 64. 2 METATARSAL<br>65. 2 PHALANX<br>66. 2 CLAVICLE |  | 67. 2 SCAPULA<br>68. 2 HUMERUS<br>69. 2 ULNA |  | 70. 2 RADIUS<br>71. 2 CARPUS<br>72. 2 METACARPUS |  | 73. 2 PHALANX<br>74. 2 TARSAL<br>75. 2 METATARSAL |  | 76. 2 PHALANX<br>77. 2 CLAVICLE<br>78. 2 SCAPULA |  | 79. 2 HUMERUS<br>80. 2 ULNA<br>81. 2 RADIUS |  | 82. 2 CARPUS<br>83. 2 METACARPUS<br>84. 2 PHALANX |  | 85. 2 TARSAL<br>86. 2 METATARSAL<br>87. 2 PHALANX |  | 88. 2 CLAVICLE<br>89. 2 SCAPULA<br>90. 2 HUMERUS |  | 91. 2 ULNA<br>92. 2 RADIUS<br>93. 2 CARPUS |  | 94. 2 METACARPUS<br>95. 2 PHALANX<br>96. 2 TARSAL |  | 97. 2 METATARSAL<br>98. 2 PHALANX<br>99. 2 CLAVICLE |  | 100. 2 SCAPULA<br>101. 2 HUMERUS<br>102. 2 ULNA |  | 103. 2 RADIUS<br>104. 2 CARPUS<br>105. 2 METACARPUS |  | 106. 2 PHALANX<br>107. 2 TARSAL<br>108. 2 METATARSAL |  | 109. 2 PHALANX<br>110. 2 CLAVICLE<br>111. 2 SCAPULA |  | 112. 2 HUMERUS<br>113. 2 ULNA<br>114. 2 RADIUS |  | 115. 2 CARPUS<br>116. 2 METACARPUS<br>117. 2 PHALANX |  | 118. 2 TARSAL<br>119. 2 METATARSAL<br>120. 2 PHALANX |  | 121. 2 CLAVICLE<br>122. 2 SCAPULA<br>123. 2 HUMERUS |  | 124. 2 ULNA<br>125. 2 RADIUS<br>126. 2 CARPUS |  | 127. 2 METACARPUS<br>128. 2 PHALANX<br>129. 2 TARSAL |  | 130. 2 METATARSAL<br>131. 2 PHALANX<br>132. 2 CLAVICLE |  | 133. 2 SCAPULA<br>134. 2 HUMERUS<br>135. 2 ULNA |  | 136. 2 RADIUS<br>137. 2 CARPUS<br>138. 2 METACARPUS |  | 139. 2 PHALANX<br>140. 2 TARSAL<br>141. 2 METATARSAL |  | 142. 2 PHALANX<br>143. 2 CLAVICLE<br>144. 2 SCAPULA |  | 145. 2 HUMERUS<br>146. 2 ULNA<br>147. 2 RADIUS |  | 148. 2 CARPUS<br>149. 2 METACARPUS<br>150. 2 PHALANX |  | 151. 2 TARSAL<br>152. 2 METATARSAL<br>153. 2 PHALANX |  | 154. 2 CLAVICLE<br>155. 2 SCAPULA<br>156. 2 HUMERUS |  | 157. 2 ULNA<br>158. 2 RADIUS<br>159. 2 CARPUS |  | 160. 2 METACARPUS<br>161. 2 PHALANX<br>162. 2 TARSAL |  | 163. 2 METATARSAL<br>164. 2 PHALANX<br>165. 2 CLAVICLE |  | 166. 2 SCAPULA<br>167. 2 HUMERUS<br>168. 2 ULNA |  | 169. 2 RADIUS<br>170. 2 CARPUS<br>171. 2 METACARPUS |  | 172. 2 PHALANX<br>173. 2 TARSAL<br>174. 2 METATARSAL |  | 175. 2 PHALANX<br>176. 2 CLAVICLE<br>177. 2 SCAPULA |  | 178. 2 HUMERUS<br>179. 2 ULNA<br>180. 2 RADIUS |  | 181. 2 CARPUS<br>182. 2 METACARPUS<br>183. 2 PHALANX |  | 184. 2 TARSAL<br>185. 2 METATARSAL<br>186. 2 PHALANX |  | 187. 2 CLAVICLE<br>188. 2 SCAPULA<br>189. 2 HUMERUS |  | 190. 2 ULNA<br>191. 2 RADIUS<br>192. 2 CARPUS |  | 193. 2 METACARPUS<br>194. 2 PHALANX<br>195. 2 TARSAL |  | 196. 2 METATARSAL<br>197. 2 PHALANX<br>198. 2 CLAVICLE |  | 199. 2 SCAPULA<br>200. 2 HUMERUS<br>201. 2 ULNA |  | 202. 2 RADIUS<br>203. 2 CARPUS<br>204. 2 METACARPUS |  | 205. 2 PHALANX<br>206. 2 TARSAL<br>207. 2 METATARSAL |  | 208. 2 PHALANX<br>209. 2 CLAVICLE<br>210. 2 SCAPULA |  | 211. 2 HUMERUS<br>212. 2 ULNA<br>213. 2 RADIUS |  | 214. 2 CARPUS<br>215. 2 METACARPUS<br>216. 2 PHALANX |  | 217. 2 TARSAL<br>218. 2 METATARSAL<br>219. 2 PHALANX |  | 220. 2 CLAVICLE<br>221. 2 SCAPULA<br>222. 2 HUMERUS |  | 223. 2 ULNA<br>224. 2 RADIUS<br>225. 2 CARPUS |  | 226. 2 METACARPUS<br>227. 2 PHALANX<br>228. 2 TARSAL |  | 229. 2 METATARSAL<br>230. 2 PHALANX<br>231. 2 CLAVICLE |  | 232. 2 SCAPULA<br>233. 2 HUMERUS<br>234. 2 ULNA |  | 235. 2 RADIUS<br>236. 2 CARPUS<br>237. 2 METACARPUS |  | 238. 2 PHALANX<br>239. 2 TARSAL<br>240. 2 METATARSAL |  | 241. 2 PHALANX<br>242. 2 CLAVICLE<br>243. 2 SCAPULA |  | 244. 2 HUMERUS<br>245. 2 ULNA<br>246. 2 RADIUS |  |
|-----------------------|--|-------------------------------------|--|-----------------------------------|--|--------------------------------------|--|-------------------------------------------|--|--------------------------------------------|--|---------------------------------------------------|--|-------------------------------------------|--|-------------------------------------------|--|----------------------------------------|--|----------------------------------------|--|----------------------------------------|--|-----------------------------------------------|--|-----------------------------------------------|--|-------------------------------------------------|--|---------------------------------------------------|--|---------------------------------------------|--|---------------------------------------------------|--|---------------------------------------------------|--|--------------------------------------------------|--|--------------------------------------------|--|---------------------------------------------------|--|-----------------------------------------------------|--|----------------------------------------------|--|--------------------------------------------------|--|---------------------------------------------------|--|--------------------------------------------------|--|---------------------------------------------|--|---------------------------------------------------|--|---------------------------------------------------|--|--------------------------------------------------|--|--------------------------------------------|--|---------------------------------------------------|--|-----------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|------------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|-----------------------------------------------|--|------------------------------------------------------|--|--------------------------------------------------------|--|-------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------------|--|-----------------------------------------------------|--|------------------------------------------------|--|

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| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |



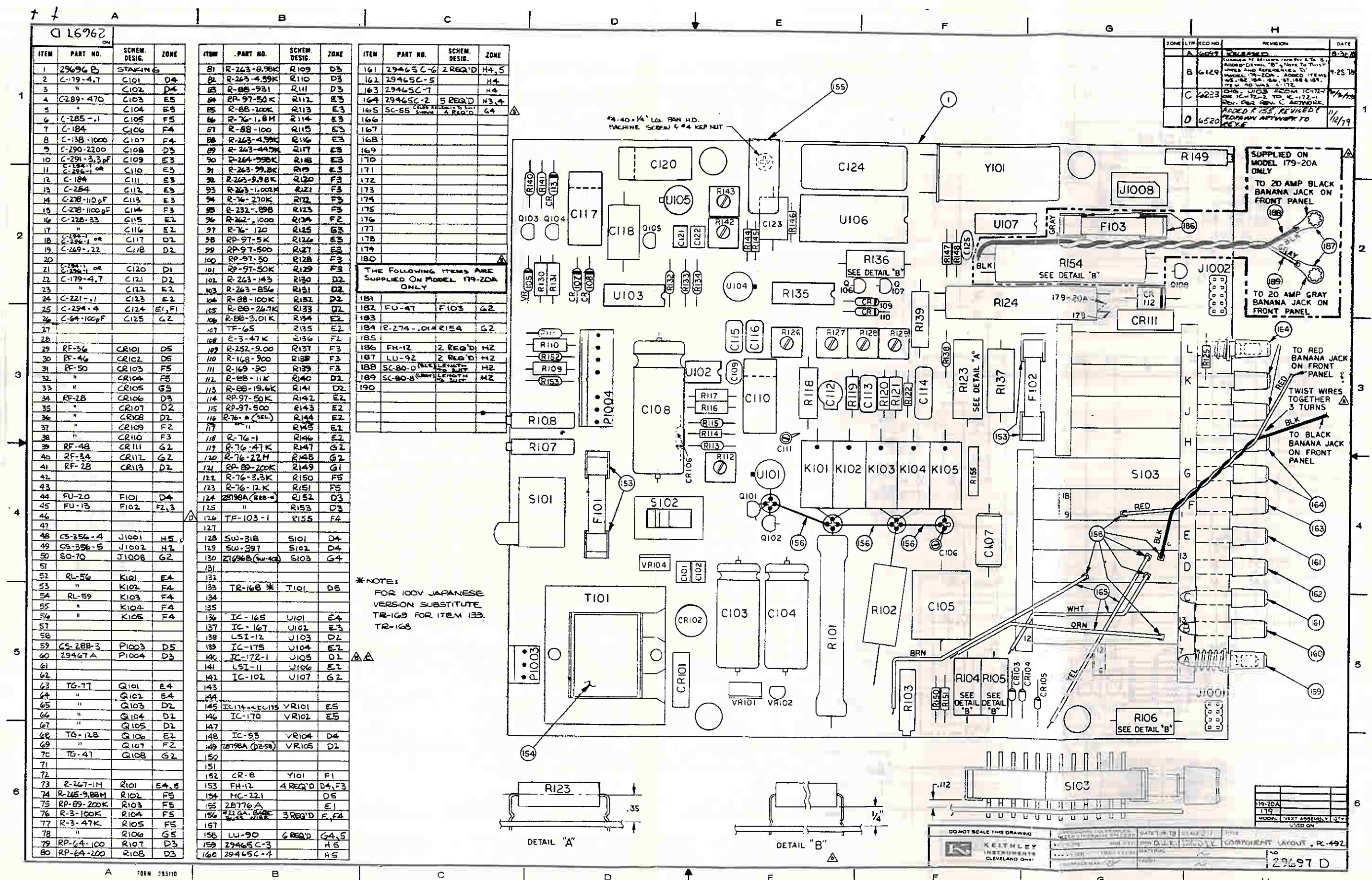


FIGURE 7-2. Component Layout, PC-492, Mother Board.

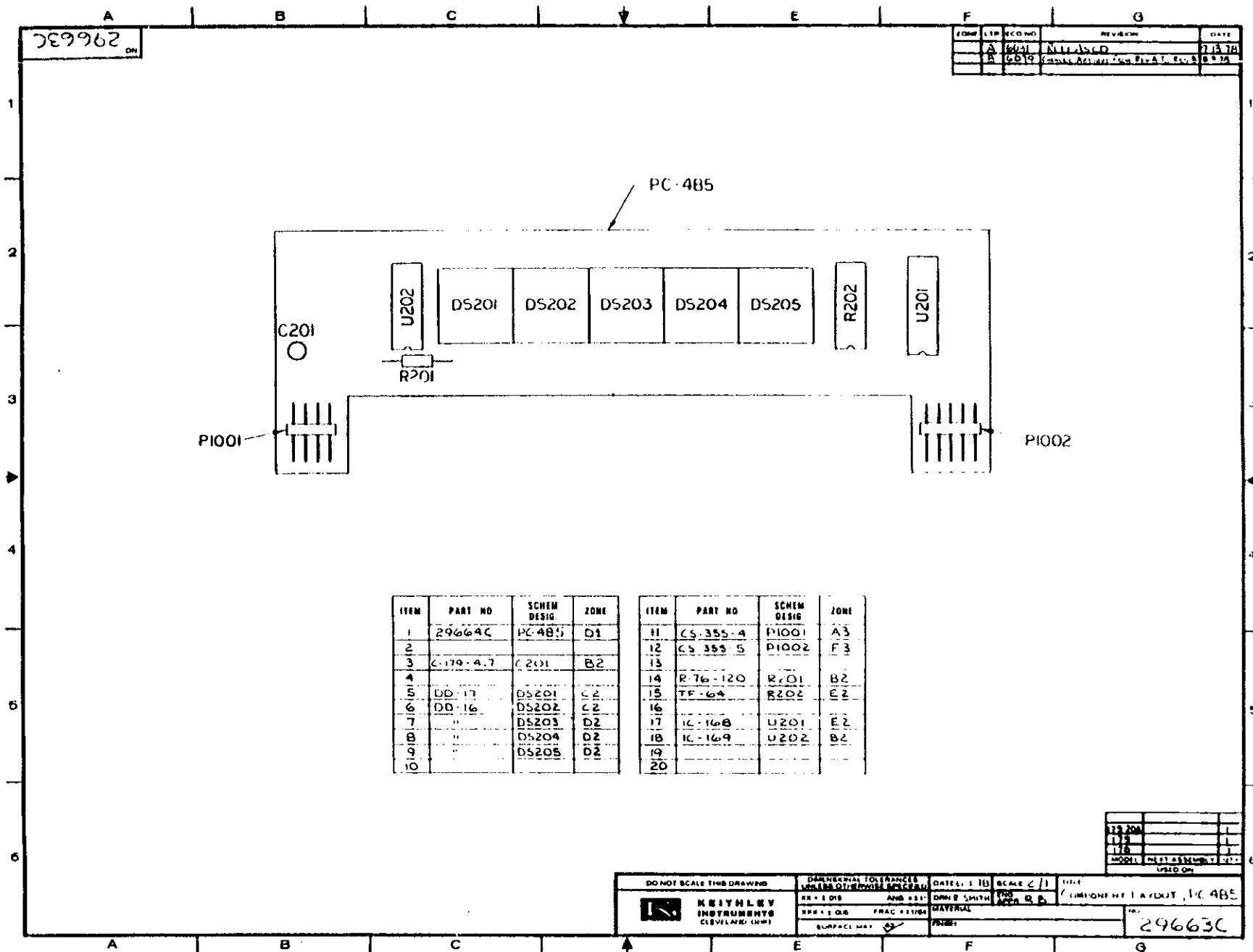


FIGURE 7-3. Component Layout, PC-485, Display Board.

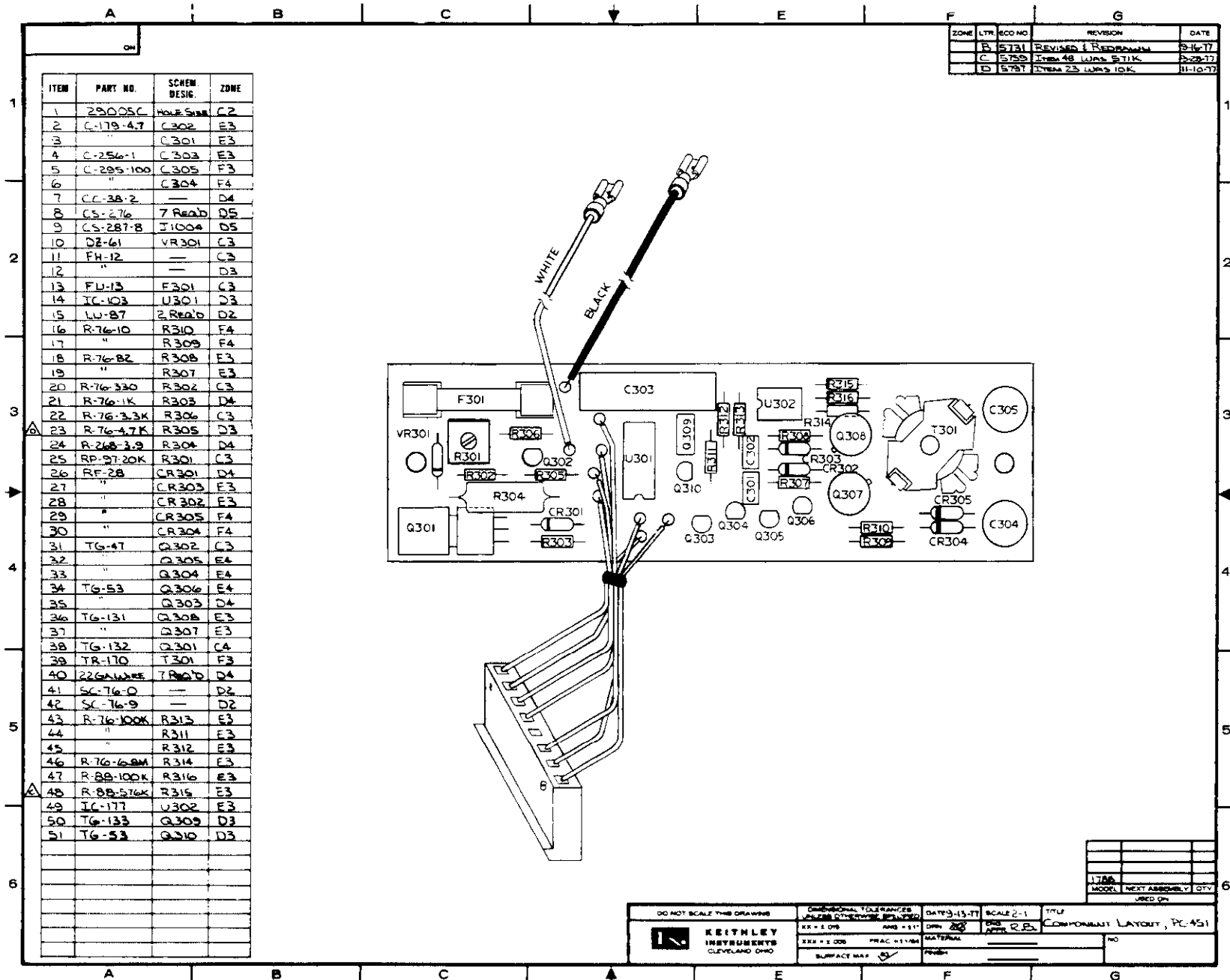


FIGURE 7-4. Component Layout, PC-451, Battery Pack Board.

# SERVICE FORM

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.) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_