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Beckman Instructions 3000-940-110-A

BECKMAN

DIGITAL MULTIMETER

SERIES 3000
AND SERIES 300

SERVICE MANUAL

Beckman Instruments, Inc. • Advanced Electro-Products Division • Fullerton, California 92634

SPECIAL PRECAUTIONS

- To avoid electrical shock hazard and/or damage to the instrument, do not measure voltages that might exceed 1500 volts above earth ground.
- Exceeding the maximum input overload limits can damage the Multimeter. When using the A Input Connector during current measurements, operator injury or damage to the instrument may occur if the fuse blows in a circuit which exhibits an open-circuit voltage greater than 250 volts.
- To avoid electrical shock hazard, do not touch test leads, tips, or the circuit being tested, while power is applied to the circuit being measured.
- Use extreme caution when working near high voltage sources. This includes any voltage measurements requiring the use of 200Vac, 1000Vac, 200Vdc, and 1500Vdc ranges.
- Before each instrument use, inspect test leads, connectors, and probes for cracks, breaks, or crazes in the insulation. If any defects are found, replace item immediately.
- When making current measurements, make sure that the Multimeter is connected in series with the load in which the current is to be measured. NEVER connect the Multimeter ACROSS a voltage source. If this is done, it may either blow the overload protection fuse or damage the device being tested.

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SECTION ONE
GENERAL INFORMATION

1.1 INTRODUCTION

The Beckman Series 300 and Series 3000 Digital Multimeters are completely portable, pocket-sized Multimeters. Each model has a 3½-digit LCD readout, and comes equipped with a multi-position tilt stand. The Multimeter is applicable in many areas, including design engineering, production testing, field servicing, and industrial maintenance.

1.2 MODEL DIFFERENCES

1.2.1 TECH ™ 300

The TECH 300 Multimeter is equipped with six functions and 27 ranges — each test position is selected by turning the Function/Range Switch. This model is accurate to ±0.5% of reading in dc volts.

1.2.2 TECH ™ 310 AND MODEL 3010

The Model 3010 and TECH 310 Multimeters have seven functions and 29 ranges, and are accurate to ±0.25% of readings in dc volts.

1.2.3 MODEL 3020

The Model 3020 contains seven functions and 29 ranges, and is accurate to ±0.1% of readings in dc volts.

1.2.4 TECH ™ 330 AND MODEL RMS 3030

The TECH 330 and the Model RMS 3030 Multimeters contain the same features as the Model 3020, with the added capability to measure both ac voltage and current in true rms. The direct-coupled inputs of the meters permit direct measurement of the total (ac + dc) rms value of complex or non-sinusoidal ac waveforms.

1.3 SPECIFICATIONS

Table 1-1 lists the detailed specifications of the Series 300 and Series 3000 Multimeters.

Table 1-1. Multimeter Specifications

GENERAL SPECIFICATIONS

OPERATING TEMPERATURE RANGE
0°C to +50°C

STORAGE TEMPERATURE RANGE
−40°C to +65°C with battery removed

DISPLAY
3½-digit liquid crystal (LCD) with a maximum reading of 1999

POWER
Single, standard 9-volt battery (NEDA 1604)

BATTERY LIFE
Alkaline: 2000 continuous hours, nominal
Zinc-Carbon: 1600 continuous hours, nominal
Under Typical Usage: 2 Years

LOW BATTERY INDICATOR
Decimal point blinks with 200 hours battery life remaining

SHOCK AND VIBRATION
Meets MIL-T-28800 specifications

RELATIVE HUMIDITY
0% to 80%, 0°C to 35°C;
0% to 70%, 35°C to 50°C

TEMPERATURE COEFFICIENT
0°C to 20°C; 30°C to 50°C
Less than 15% of applicable accuracy specification per °C

MAXIMUM COMMON MODE VOLTAGE
1500Vdc or peak ac

DIMENSIONS
6.85 inches (17.4cm) long x 3.65 inches (9.3cm) wide x 1.8 inches (4.6cm) high

WEIGHT
16 ounces (453 grams) including battery

CALIBRATION
Accuracy specifications guaranteed for one (1) year, 20°C to 30°C

MEASUREMENT RATE
Four measurements per second nominal

CASE
High-impact ABS plastic; recessed switch and display

GENERAL SPECIFICATIONS (cont.)

INSTRUMENT INCLUDES
- 9-volt battery
- Spare fuse
- Safety test leads
- Operator's manual

DC VOLTAGE MEASUREMENT SPECIFICATIONS

INPUT IMPEDANCE (ALL RANGES)
22MΩ

NORMAL-MODE REJECTION
Greater than 60dB above 49Hz

COMMON-MODE REJECTION
Greater than 160dB up to 1500Vdc

RESPONSE TIME
Less than 1 second

OVERVOLTAGE PROTECTION
1500Vdc or peak ac, any range

		ACCURACY (1 YEAR, 20°C to 30°C)		
RANGE	RESOLUTION	TECH 300	TECH 310	TECH 330
±200mV ±2V ±20V ±200V ±1500V	100μV 1mV 10mV 0.1V 1V	±(0.5% reading + 1 digit)	±(0.25% reading + 1 digit)	±(0.1% reading + 1 digit)

		ACCURACY (1 YEAR, 20°C to 30°C)	
RANGE	RESOLUTION	MODEL 3010	MODEL 3020 AND RMS 3030
±200mV ±2V ±20V ±200V ±1500V	100μV 1mV 10mV 0.1V 1V	±(0.25% reading + 1 digit)	±(0.1% reading + 1 digit)

Table 1-1. Multimeter Specifications (continued)

AC VOLTAGE MEASUREMENT SPECIFICATIONS

TECH 300

RANGE	RESOLUTION	ACCURACY (1 YEAR, 20°C to 30°C) 45Hz to 2kHz	2kHz to 5kHz	5kHz to 10kHz
200mV	100μV	±(1.5% reading + 4 digits)	±(2.0% reading + 5 digits)	±(3.0% reading + 9 digits)
2V	1mV			
20V	10mV			
200V	0.1V			
1000V	1V			

TECH 310

RANGE	RESOLUTION	ACCURACY (1 YEAR, 20°C to 30°C) 45Hz to 2kHz	2kHz to 5kHz	5kHz to 10kHz
200mV	100μV	±(0.75% reading + 3 digits)	±(1.5% reading + 5 digits)	±(2.5% reading + 9 digits)
2V	1mV			
20V	10mV			
200V	0.1V			
1000V	1V			

TECH 330 Use same chart as Model RMS 3030

Model 3010 and Model 3020

		ACCURACY (1 YEAR, 20°C to 30°C)					
		45Hz to 2kHz		2kHz to 5kHz		5kHz to 10kHz	
RANGE	RESOLUTION	Model 3010	Model 3020	Model 3010	Model 3020	Model 3010	Model 3020
200mV	100μV	±(0.75% reading + 3 digits)	±(0.6% reading + 3 digits)	±(1.5% reading + 5 digits)	±(1.0% reading + 5 digits)	±(2.5% reading + 9 digits)	±(2.0% reading + 9 digits)
2V	1mV						
20V	10mV						
200V	0.1V						
1000V	1V						

Model RMS 3030

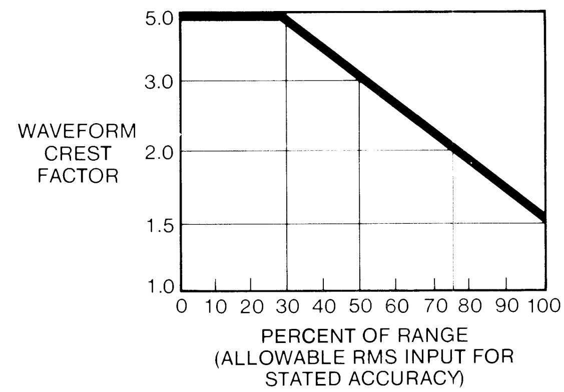
RANGE	RESOLUTION	ACCURACY (1 YEAR, 20°C to 30°C) 45 Hz to 2kHz	2kHz to 5kHz	5kHz to 10kHz	10kHz to 20kHz	20kHz to 40kHz
200mV	100μV	+(0.6% reading + 3 digits)	±(1.0% reading + 4 digits)	±(1.5% reading + 5 digits)	±(2% reading + 7 digits)	±(5% reading + 15 digits)*
2V	1mV					
20V	10mV					
200V	0.1V					
1000V	1V					

Typically, ±3dB at 100kHz

*At 20kHz to 40kHz, the accuracy of the Model 3030 and TECH 330 is not specified except in the 200mV and 2V ranges.

AC VOLTAGE MEASUREMENT SPECIFICATIONS (cont.)

CREST FACTOR (RMS 3030 and TECH 330)
Allowable crest factor (peak/rms ratio) varies from 1.0 to 5.0



CONVERSION TECHNIQUE
Model 3010, Model 3020, TECH 300 and TECH 310:
Average sensing, calibrated to display rms value of sine wave

RMS 3030, TECH 330
True rms responding (ac + dc)

INPUT IMPEDANCE (ALL RANGES)
2.2 megohms shunted by less than 75pF

RESPONSE TIME
Less than 2 seconds (on RMS 3030 and TECH 330, above 10% of fullscale)

OVERLOAD PROTECTION (TECH 300 and TECH 310)
1000Vrms ac (1500V peak) or
250Vdc (5 seconds maximum above 450Vrms on 200mV range)

OVERVOLTAGE PROTECTION (Models 3010 and 3020)
1000Vrms ac (1500V peak) or
250Vdc (5 seconds maximum above 450Vrms on 200mV range)

OVERVOLTAGE PROTECTION (RMS 3030 and TECH 330)
1000Vrms ac (1500V peak) or
1500Vdc (200mV range, 500Vrms or dc maximum)

DC CURRENT MEASUREMENT SPECIFICATIONS

Automatic Polarity Indication (+ and − indicated)

Series 300

RANGE	RESOLUTION	ACCURACY (1 YEAR, 20°C to 30°C) TECH 300	TECH 310	TECH 330
±200μA	100nA	±(1.0% reading + 1 digit)	±0.75% reading + 1 digit)	±(0.35% reading + 1 digit)
±2mA	1μA			
±20mA	10μA			
±200mA	100μA			
±2A	1mA			
±10A* (TECH 310 only)	10mA		±(1.5% reading + 1 digit)	±(1.0% reading + 1 digit)

*Continuous measurements up to 10 amperes, 30 seconds maximum from 10 to 19.99 amperes.

Table 1-1. Multimeter Specifications (continued)

DC CURRENT MEASUREMENT SPECIFICATIONS (cont.)

Series 3000

RANGE	RESOLUTION	ACCURACY (1 YEAR, 20°C to 30°C) MODEL 3010	ACCURACY (1 YEAR, 20°C to 30°C) MODEL 3020 AND RMS 3030
±200µA ±2mA ±20mA ±200mA ±2A	100nA 1µA 10µA 100µA 1mA	±(0.75% reading + 1 digit)	±(0.35% reading + 1 digit)
±10A*	10mA	±(1.5% reading + 1 digit)	±(1.0% reading + 1 digit)

RESPONSE TIME
Less than 1 second

VOLTAGE BURDEN
200µA to 200mA ranges: 250mV maximum at fullscale
2A and 10A ranges: 700mV maximum at fullscale

OVERCURRENT PROTECTION — A INPUT
2 amperes, 250V (fused)

OVERCURRENT PROTECTION — 10A INPUT (not included on TECH 300). Up to 20 amperes for 30 seconds (unfused).

*Continuous measurements up to 10 amperes, 30 seconds maximum from 10 to 19.99 amperes.

AC CURRENT MEASUREMENT SPECIFICATIONS

		ACCURACY (1 YEAR, 20°C to 30°C)				
		45Hz to 400Hz		400Hz to 2kHz		2kHz to 5kHz
RANGE	RESOLUTION	TECH 300	TECH 310	TECH 300	TECH 310	TECH 330
200µA 2mA 20mA 200mA 2A	100nA 1µA 10µA 100µA 1mA	±(2.0% reading + 4 digits)	±(1.5% reading + 3 digits)	±(2.0% reading + 3 digits)	±(1.5% reading + 3 digits)	±(1.5% reading + 3 digits)
10A* (TECH 310 only)	10mA		±(2.0% reading + 3 digits)			

		ACCURACY (1 YEAR, 20°C to 30°C)				
		45Hz to 400Hz		400Hz to 2kHz		2kHz to 5kHz
RANGE	RESOLUTION	Model 3010	Model 3020 and RMS 3030	Model 3010	Model 3020 and RMS 3030	Model RMS 3030
200µA 2mA 20mA 200mA 2A	100nA 1µA 10µA 100µA 1mA	±(1.5% reading + 3 digits)	±(0.9% reading + 3 digits)	±(1.5% reading + 3 digits)	±(0.9% reading +3 digits)	±(1.5% reading + 3 digits)
10A	10mA	±(2.0% reading + 3 digits)	±(1.5% reading + 3 digits)			

CREST FACTOR (RMS 3030)
1.0 to 5.0

CONVERSION TECHNIQUE
Models 3010 and 3020: Average sensing calibrated to display rms value of sine wave

RMS 3030 and TECH 330
True rms responding (ac + dc)

RESPONSE TIME
Less than 2 seconds (on RMS 3030 and TECH 330, above 10% of fullscale)

*Continuous measurements up to 10 amperes, 30 seconds maximum from 10 to 19.99 amperes.

AC CURRENT MEASUREMENT SPECIFICATIONS (cont.)

VOLTAGE BURDEN
200µA to 200mA ranges: 250mV maximum at fullscale
2A and 10A ranges: 700mV maximum at fullscale

OVERCURRENT PROTECTION — A INPUT
2 amperes 250V (fused)

OVERCURRENT PROTECTION — 10A INPUT (not included on TECH 300) Up to 20 amperes for 30 seconds (unfused)

RESISTANCE MEASUREMENT SPECIFICATIONS

Series 300

			ACCURACY (20°C to 30°C)		
RANGE	RESOLUTION	MAX. TEST CURRENT	TECH 300	TECH 310	TECH 330
200Ω 2kΩ 20kΩ 200kΩ 2MΩ	0.1Ω 1Ω 10Ω 100Ω 1000Ω	2.5mA 250µA 25µA 2.5µA 250nA	±(0.75% reading +1 digit)	±(0.5% reading + 1 digit)	±(0.2% reading + 1 digit)
20MΩ	10kΩ	25nA	±(1.5% reading + 1 digit)		±(1.0% reading + 1 digit)

Series 3000

			ACCURACY (20°C to 30°C)	
RANGE	RESOLUTION	MAX. TEST CURRENT	Model 3010	Model 3020, RMS 3030
200Ω 2kΩ 20kΩ 200kΩ 2MΩ	0.1Ω 1Ω 10Ω 100Ω 1000Ω	2.5mA 250µA 25µA 2.5µA 250nA	±(0.5% reading + 1 digit)	±(0.2% reading + 1 digit)
20MΩ	10kΩ	25nA	±(1.5% reading + 1 digit)	±(1.0% reading + 1 digit)

MAXIMUM OPEN CIRCUIT VOLTAGE
0.5V, all ranges

MAXIMUM IN-RANGE VOLTAGE (Low-Power Ohms)
250mV, all ranges

RESPONSE TIME
Less than 1 second — except on 20 megohm range less than 4 seconds

OVERLOAD PROTECTION
300Vdc or rms ac any range

Table 1-1. Multimeter Specifications (continued)

DIODE TEST MEASUREMENT SPECIFICATIONS

RANGE
0 to 2V

RESOLUTION
1 mV

TEST CURRENT
5 mA, ±10%

RESPONSE TIME
Less than 1 second

OVERLOAD PROTECTION
300Vdc or rms ac

Insta-Ohms™ QUICK CONTINUITY INDICATOR* MEASUREMENT SPECIFICATIONS

RESPONSE TIME
Less than 100 milliseconds

*Not available on TECH 300

SECTION TWO
DETAILED FUNCTIONAL DESCRIPTION

2.1 GENERAL

The main functioning component of the Beckman Series 3000 Digital Multimeter is the custom-designed CMOS LSI Multiprocessor Chip U4. The multiprocessor chip contains an active input filter, an averaging ac-to-dc converter, the Insta-Ohms detection, resistance measurement circuits, an analog-to-digital converter with ±200mVdc fullscale ratiometric inputs, and all necessary digital and LCD display drive circuits.

Additional peripheral components are used with the multiprocessor chip to perform a range of voltage, current, resistance, and semiconductor measurements, and to provide overall instrument protection.

Included in these peripheral components are the Function/Range Switch, three resistor networks, a voltage reference diode, several circuit protection components, the battery, and the display. The RMS 3030 also contains an additional integrated circuit which permits true rms conversion of the ac signals.

2.2 GENERAL DESCRIPTION OF MULTIMETER OPERATING FEATURES AND CHARACTERISTICS

A simplified block diagram of the Multimeter is shown in Figure 2-1.

The Function/Range Switch routes an input signal to an input conditioning circuit. Here the signal is converted to a dc voltage between −200mV and +200mV. The signal is then processed by the multiprocessor chip. After being passed through an active filter for normal-mode rejection of interfering power-line and audio frequency signals, the signal is converted to digital form by an analog-to-digital converter on the multiprocessor chip. The output from the ADC is presented as display segment driving signals, resulting in a display of the applied input signal.

Decimal point positions on the display are determined automatically by the multiprocessor chip based upon Function/Range Switch settings.

2.3 FUNCTIONAL ANALYSIS OF THE MULTIPROCESSOR CHIP

The multiprocessor chip contains the averaging ac converter, an active input filter, the Insta-Ohms detector, the analog-to-digital converter, circuits for controlling voltage polarity signs, overload indicator, low battery indicator, and all display drivers.

2.3.1 ANALOG-TO-DIGITAL CONVERTER

The analog-to-digital converter performs a true ratio voltage conversion between two input ports. One input to the analog-to-digital converter is the unknown input voltage. For all voltage and current measurements, the reference or second port is connected to a precision voltage reference generated by a band gap diode VR1 and a voltage divider network U2. The reference voltage is set by an adjustment of trimmer R5. In the TECH 300, TECH 310, Model 3010, and Model 3020, this one trimmer comprises the only adjustment required for calibration.

When the unknown input voltage exactly equals the reference voltage, a fullscale reading results from the analog-to-digital converter. As the ratio of the unknown input voltage to the reference voltage declines, proportionally lower readings result from the main converter.

In the resistance ranges, the reference input is supplied by the voltage drop across a reference resistor connected in series with the unknown resistance.

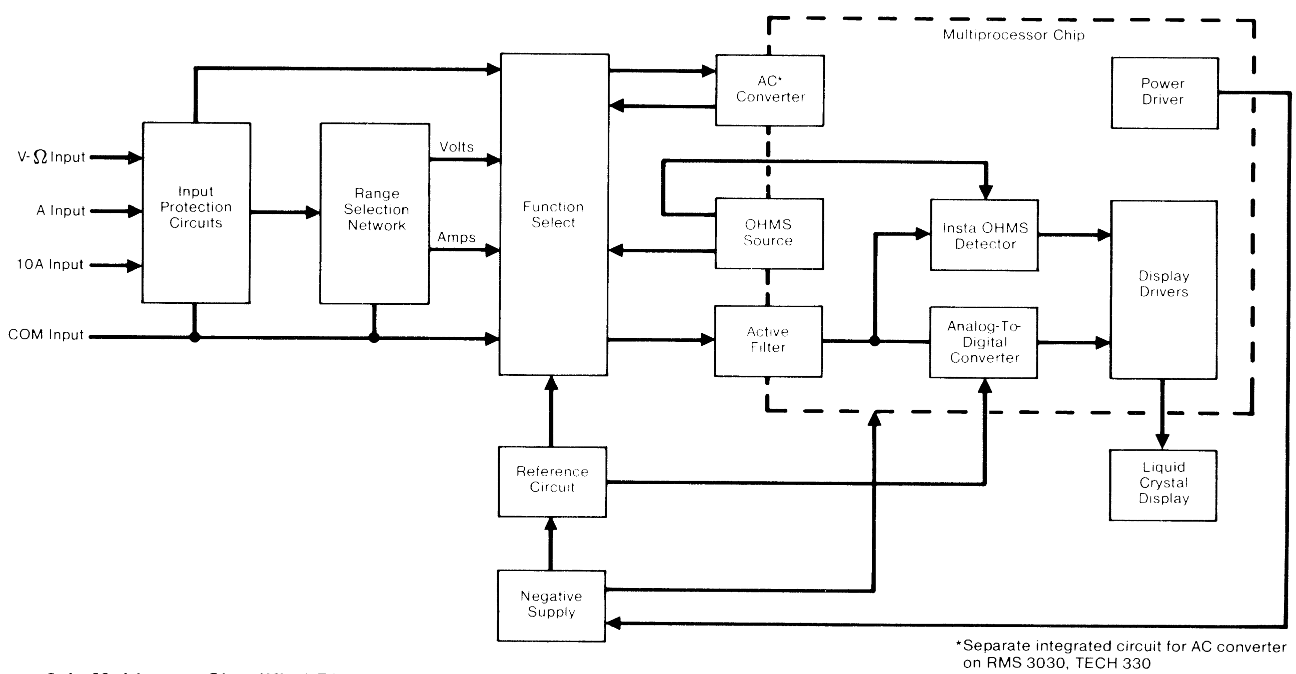


Figure 2-1. Multimeter Simplified Block Diagram

2.3.2 ACTIVE FILTER

A second-order Bessel filter insures broadband normal-mode rejection of interfering powerline and audio frequencies. This, combined with the usual 6dB per octave rejection of the integrating converter, provides more than 60dB rejection at powerline frequencies.

2.3.3 Insta-Ohms QUICK CONTINUITY INDICATOR

The Insta-Ohms Quick Continuity Indicator allows a very quick determination of circuit continuity. The Insta-Ohms detector consists of a single-bit analog-to-digital converter triggered by a resistance less than double the maximum resistance measurable on a selected range. For example, on the 200Ω range, the symbol appears when less than 400Ω is detected by the Multimeter.

2.4 FUNCTIONAL ANALYSIS OF INSTRUMENT MULTIPROCESSOR CHIP PERIPHERAL CIRCUITS

2.4.1 INPUT PROTECTION

Input protection circuits isolate the instrument from normally encountered overloads and range selection errors.

In the dc voltage range, primary overvoltage protection is provided by a two-megohm series resistor (part of the active filter) working into voltage limiters included in the converter chip. Secondary protection from high voltages is provided by a 2-kilovolt spark gap SG1 and a 2-kΩ resistor. Continuous overloads of 1500Vdc and energy-limited transients of much higher voltage can be accepted.

On all resistance ranges and the diode test function, a positive temperature coefficient resistor R10, and zener diodes VR2, VR3, provide isolation from the application of external voltages.

In the current mode, protection is provided by a combination of a diode limiter bridge BR1 and a 2-ampere 250-volt fuse F1. The diodes divert overloads from the current measurement resistors and the fuse will blow for long-term overloads.

Although not fuse-protected, the 10-ampere current input connects directly into a current shunt resistor that can withstand 10 amperes continuously and up to 20 amperes for a moderate duration.

2.4.2 INPUT SIGNAL CONDITIONING

The analog-to-digital converter on the multiprocessor chip converts an unknown voltage within the range of −200mVdc to +200mVDC to a digital equivalent for display. If the measured signal is not a dc voltage in the ±200mV range, it must be scaled down and converted to a dc voltage before being presented to the analog-to-digital converter.

A. AC and DC Voltage Precision-Divider Network.

If the ±200mVdc range is selected, the input signal feeds directly into the multiprocessor chip through the active filter network. On all other high dc voltage ranges, a precise power-of-ten voltage is selected from the voltage divider as the multiprocessor input.

A precision-ratio resistor network is used as the voltage divider for both ac and dc voltage ranges. The voltage divider is part of a Beckman thin-film resistor network U1.

If an ac voltage range is selected, voltage divider output is coupled to an ac converter which in turn provides a proportional output for the active filter input to the multiprocessor chip. On the TECH 330 and RMS 3030 C19 forms part of a parallel capacitive divider to balance the resistance divider at higher frequency. This allows full advantage to be taken of the greater accuracy inherent in the true RMS converter.

B. AC Measurements in the 3010 and 3020 Multimeters.

The ac converter used in the Models 3010 and 3020 is "average-responding." An rms value is determined by first rectifying and filtering the signal to obtain an average value. The average value is then scaled upward by a factor of 1.11 to obtain the displayed value. The scaling factor of 1.11 is accurate in the rms measurement of pure sine wave signals.

In measuring non-sinusoidal waveforms, however, significant errors can be introduced because of different scaling factors relating averages to rms values. Rough correction factors can sometimes be calculated for standard waveforms which are free from significant noise and distortion, but accurate measurements of complex waveforms are sometimes difficult to achieve.

C. AC Measurements in the RMS 3030 and TECH 330 Multimeters.

RMS values for non-sinusoidal ac signals are measured directly and more accurately with the RMS 3030 and TECH 330 which feature a "true-rms responding" ac converter. True rms ac response is particularly useful in measuring complex or noisy signals for which even rough correction factors are not easily computed.

AC converters of all types are limited by their frequency response and input dynamic range. Bandwidth defines the range of frequencies in which the conversion accuracy is within 3dB. The bandwidth of the RMS 3030 and TECH 330 is 100kHz.

Crest factor is a measure of the input dynamic range of a true-rms responding ac converter. It expresses the ability of the ac converter to handle a signal that has large peak values compared to its rms value without saturating the converter circuit and degrading the specified accuracy.

For the RMS 330 and TECH 330, crest factor is defined as the ratio of the peak voltage to the total rms (ac ± dc) voltage.

$$\text{Crest Factor} = \frac{\text{Vpeak}}{\text{Vrms}}$$

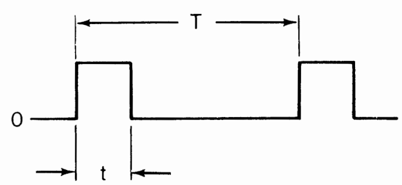
Crest factor for the RMS 3030 and TECH 330 Multimeters range from 1.0 to 5.0 on each voltage scale depending on the rms value of the signal being measured. At fullscale (1999 counts), signals with crest factors between 1.0 to 1.5 can be measured. Signals with crest factors of 1.0 include a square wave or pure dc (peak voltage equals rms voltage). An undistorted sine wave signal (crest factor = 1.414) as well as a sine wave with considerable harmonic distortion can both be accurately measured at fullscale.

At half scale (1000 counts), signals with crest factor between 1.0 and 3.0 can be measured without performance degradation. At 600 counts and below, signals with crest factors up to 5.0 can be measured. If the crest factor of a waveform is not known, it can be determined by measuring the peak voltage with an oscilloscope and dividing by the rms voltage measured by the Multimeter. The crest factor of some typical waveforms are shown in Figure 2-2.

Crest factor for a pulse train is also related to duty cycle (D) as follows:

$$\text{Crest Factor} = \sqrt{\frac{I}{D}}$$

$$\text{where } D = \frac{t}{T}$$



Waveform	Crest Factor
Sine Wave	1.414
Sawtooth	1.732
Half-Wave Rectified Sine Wave	2.0
SCR Output 100% to 10%	1.414 to 3.0
Rectangular Pulse 50% · D · 10%	1.414 to 3.16

Figure 2-2. Typical Waveform Creast Factors

D. Current Range.
Current is converted to a dc voltage by passing the current through a selected shunt resistor, resulting in a (IR) voltage drop within the ±200mV range required by the multiprocessor chip. This process assures that the maximum voltage burden or voltage dropped through the current sense resistor is less than 0.25V.

The resistors that are switched in series to make current shunt values from 0.1Ω to 1kΩ are part of the thin-film network U1 and wirewound resistors R3, R4, and R5. The 0.01-Ω shunt for the 10-ampere current range is a separate resistance component switched in automatically when a test lead is fully inserted into the 10A input.

The voltage drop from a dc current measurement is routed directly to the multiprocessor chip. In ac current ranges, the shunt voltage drop is routed to the same ac converter used in the conversion of ac voltages.

2.4.3 RESISTANCE MEASUREMENTS

Resistance measurements are made using a ratio technique where the unknown resistance is compared against an internal standard. The unknown resistance is connected in series with a selected reference resistor to a bias voltage (approximately 400mV) generated by the multiprocessor chip, Figure 2-3.

The reference resistor is selected from the input attenuator network to be equal to the fullscale range of the unknown resistor being measured. For example, if the 20kΩ range is selected, a precision 20kΩ resistor is switched across the reference input. Reference resistors are selected from the same thin-film resistor network (U1) used as the voltage divider for voltage measurements. Because of negligible loading at the sensing terminals by the multiprocessor chip, the ratio of the two resistors is equal to the ratio of their respective voltage drops.

$$\frac{V_x}{R_x} = \frac{V_{ref}}{R_{ref}}$$

The analog-to-digital converter on the multiprocessor chip uses a ratiometric conversion technique which relies solely on the ratio of the unknown voltage, V_x, to a reference voltage, V_{ref}. Choosing a low bias voltage assures that the voltage developed across the unknown resistance is 0.25-volt maximum. This allows low voltage testing of resistors in circuits where the presence of semiconductor junctions could otherwise affect measurement accuracy.

2.4.4 DIODE MEASUREMENTS (Figure 2-3)

This operating mode provides a repeatable and easily understandable means to check semiconductor junctions. In this mode, the Multimeter operates with a ±2 volt fullscale dc measurement range. The Ohms Bias Voltage circuit converts to a current source clamped at 5mA by R6 and Q1. The constant-current source so formed forces 5 mA of current via the volt/ohm terminal into the semiconductor junction under test. This results in a voltage drop, scaled to within ±200mV by the voltage divider and converted in the multiprocessor chip for display. This current level permits measurement of in-circuit semiconductor junctions with as little as 200 ohms in parallel with the transistor or diode, while minimizing the possibility of damage to low-power semiconductor junctions. Reverse connection of the test leads (for checking diode blocking) will normally display OL.

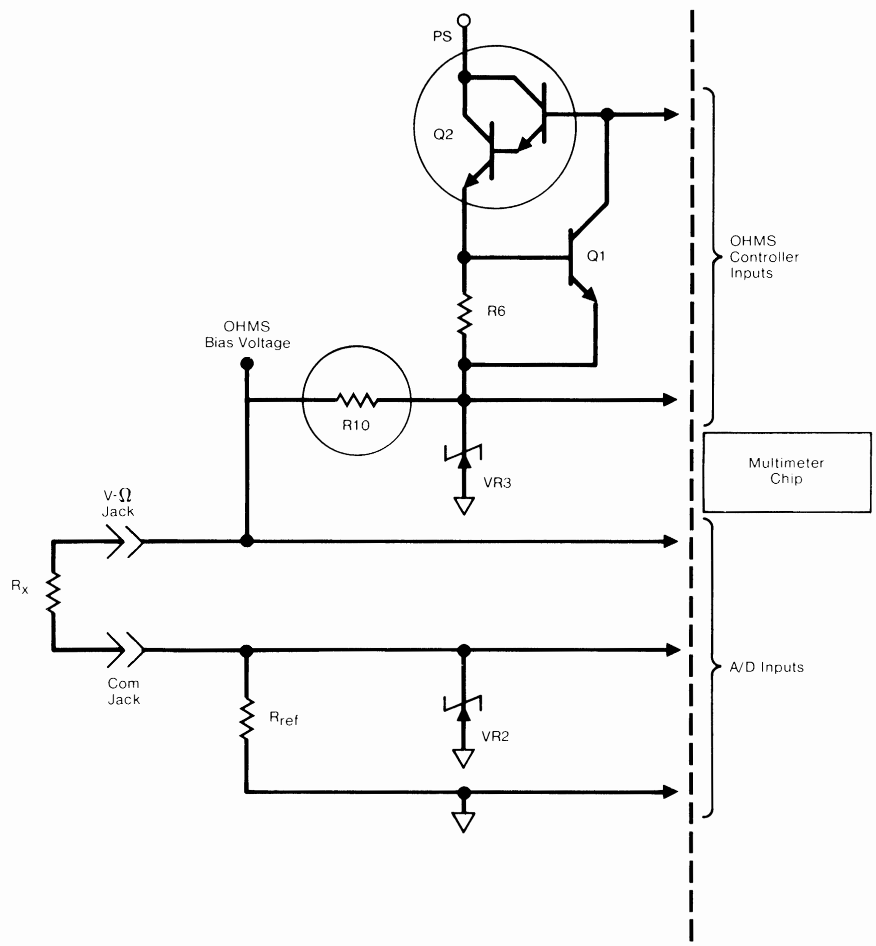


Figure 2-3. Circuit for Resistance Measurements

SECTION THREE
MAINTENANCE AND SERVICING

3.1 GENERAL

This section contains procedures for calibration, maintenance and repair of the Series 300 and Series 3000 Multimeters. Also included are procedures for Multimeter disassembly, component replacement, and Function/Range Switch disassembly and check procedures. If you are uncertain about what maintenance and service to perform refer to Section Four, Troubleshooting.

3.2 SERVICING POLICY

3.2.1 ONE-YEAR LIMITED WARRANTY POLICY ON NEW INSTRUMENTS

The Beckman Digital Multimeter is warranted entirely against any defects of material or workmanship which develop for any reason whatsoever, except abuse, within a period of one (1) year following the date of purchase of the Multimeter by the original purchaser. This warranty is extended by Beckman Instruments, Inc. (Beckman), only to the original purchaser or original user of the Multimeter, who must, as a CONDITION PRECEDENT TO WARRANTY COVERAGE AND PERFORMANCE THEREUNDER BY BECKMAN, complete and return the Warranty Registration Card, received on purchase of the Multimeter.

In the event a defect develops during the warranty period, Beckman will, at Beckman's election, repair or replace the Multimeter with a new or reconditioned model of equivalent quality. To obtain performance of any obligation of Beckman under the warranty, the original purchaser or original user must return the defective Multimeter, postage prepaid, along with a handling charge of $3.00,* to:

Beckman Instruments, Inc.
2550 Harbor Boulevard, Box 3100
Fullerton, CA 92634
Attention: Customer Service

or to any other authorized Beckman Service Center.

In the event of replacement with a new or reconditioned model, the replacement unit will continue the warranty period of the original Multimeter. Replacement units will be returned by air, typically with only one (1) working day turn-around at the Service Center.

ANY IMPLIED WARRANTIES ARISING OUT OF THE SALE OF THE MULTIMETER, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE LIMITED IN DURATION TO THE ABOVE-STATED ONE (1) YEAR PERIOD. BECKMAN SHALL NOT BE LIABLE FOR LOSS OF USE OF THE MULTIMETER OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, OR ECONOMIC LOSS OR FOR ANY CLAIM OR CLAIMS FOR SUCH DAMAGE, EXPENSES OR ECONOMIC LOSS.

Some states do not allow limitations on how long implied warranties last or the exclusion or limitations of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

3.2.2 AFTER-WARRANTY REPAIR OR EXCHANGE SERVICE

After-warranty service is provided by Beckman in two ways. You may elect to have your instrument repaired at an authorized Beckman repair facility, or you can exchange your defective out-of-warranty instrument for a reconditioned instrument at a flat rate contained on Beckman's current price list. The replacement unit carries a three (3) month warranty. Contact any authorized Beckman distributor or Beckman Instruments, Inc., for the current non-warranty replacement rates and instructions for shipping the instrument.

3.2.3 CALIBRATION SERVICE

Each Beckman Multimeter should be recalibrated at least once a year or after it is repaired. A procedure to accomplish this is contained in Paragraph 3.4. If you do not have the necessary equipment specified to accomplish calibration, this service can be performed at the Beckman Service Center for $15.00 in the continental U.S.A. and $25.00 elsewhere. (These prices are subject to change.) Multimeter calibrations performed by Beckman are traceable to the National Bureau of Standards (NBS). If you wish to take advantage of this service, contact any authorized Beckman distributor, repair facility, or Beckman Instruments, Inc., for current calibration rates and instructions for shipping the instrument.

3.3 SERVICING PROCEDURES

3.3.1 MULTIMETER DISASSEMBLY PROCEDURE

Before performing any of the Multimeter servicing, inspection, or repair procedures, it is necessary to disassemble the instrument according to the directions given in Figure 3-1.

After performing the servicing or inspection, or repair procedures, reassemble the instrument according to Figure 3-1.

CAUTION

Be sure to follow the directions for instrument reassembly closely as improper reassembly can damage the foil shield, resulting in possible improper operation of the Multimeter.

*Prices subject to change.

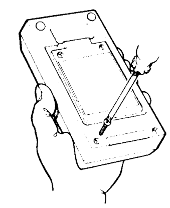
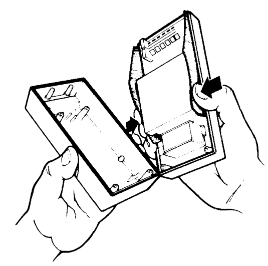
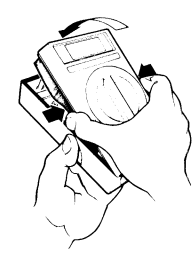
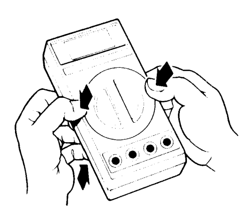
CAUTION: Always turn instrument off and disconnect test leads before disassembly.	
DISASSEMBLY 1. Remove four screws and carefully lift off back cover. This exposes Multimeter for basic servicing and for further disassembly, inspection, and repair.	
REASSEMBLY 2. Hold Multimeter back cover in your left hand and front cover in your right hand. Press foil shield inward between fingers of your right hand as shown.	
3. Hinge front bottom to rear bottom of Multimeter. Then carefully mate the front and rear of Multimeter as shown, being careful to hold foil so that it goes inside housing without getting bent or crushed.	
4. Press Multimeter front and rear together. Reinstall and carefully tighten four screws in back cover.	

Figure 3-1. Multimeter Disassembly and Reassembly Procedure

3.3.2 BATTERY REPLACEMENT

CAUTION

To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing back cover.

1. After disconnecting test leads and turning off Multimeter, remove back cover by removing four screws, Figure 3-1, then lift off back cover.

CAUTION

Failure to turn off instrument before installing battery could result in damage to battery if it is connected incorrectly to terminals.

2. Disconnect battery from instrument and replace with a standard 9-volt transistor battery,Figure 3-2.
3. Replace back cover and secure with four screws according to procedure in Figure 3-1.

CAUTION

Do not operate Multimeter with back cover removed (except during calibration).

3.3.3 FUSE REPLACEMENT

CAUTION

To prevent electrical shock hazard, turn off Multimeter and disconnect test leads before removing back cover.

1. After disconnecting test leads and turning off Multimeter, remove back cover by removing four screws, Figure 3-1, and then lift off cover.
2. The fuse is located in the upper half of the instrument, Figure 3-2.
3. Remove old fuse and replace with good fuse. If spare fuse is missing from inside the back cover, replace it also.

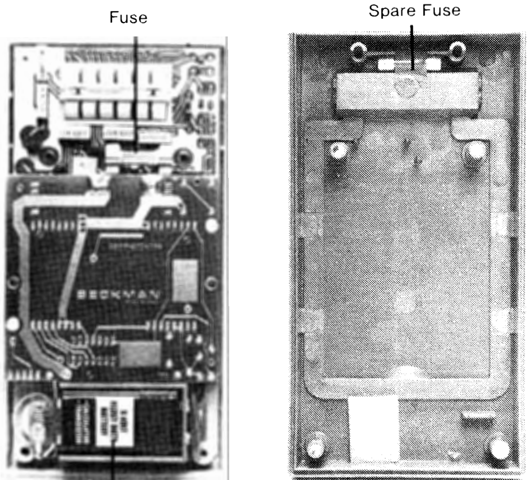


Figure 3-2. Multimeter, Internal View

CAUTION

To prevent fire, use Type AGX 2A/250V fuse only.

4. Replace back cover and secure with four screws according to directions in Figure 3-1.

CAUTION

Do not operate Multimeter with back cover removed (except during calibration).

3.3.4 MULTIPROCESSOR CHIP AND LIQUID CRYSTAL DISPLAY REPLACEMENT

If you have determined that either the multiprocessor chip or the display needs to be replaced, this can be accomplished by following the procedure in Figure 3-3.

3.3.5 ELASTOMER STRIPS CLEANING AND REPLACEMENT PROCEDURE

If display segments do not function or if a corrective action step in the troubleshooting guide instructs you to inspect or replace an elastomer strip, access to these connectors can be gained by performing the procedure in Figure 3-3. Strips can be cleaned by dusting with a short bristle camel's hair brush. If grease or fingerprint contamination is suspected, the strip may be washed in clean alcohol and air-dried. Do not wipe off with fibrous material as excessive lint can cause poor connections.

3.3.6 SMALL CIRCUIT BOARD INSPECTION AND REPLACEMENT PROCEDURE

Inspecting the small circuit board to determine if the Function/ Range Switch is working properly or replacement of the small circuit board because of faulty operation requires following the procedure in Figure 3-4.

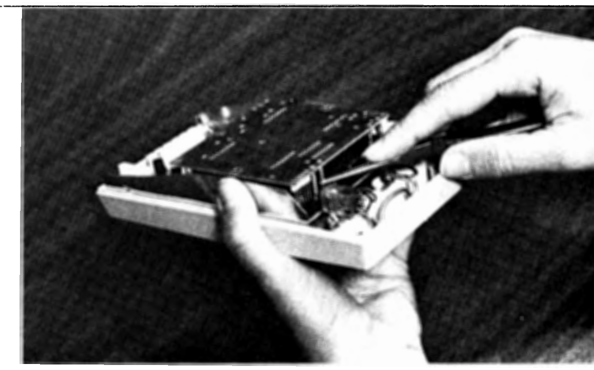
NOTE

After removing back cover of Multimeter as shown in Figure 3-1, further disassembly for replacement of display and multiprocessor chip is described in the following steps.

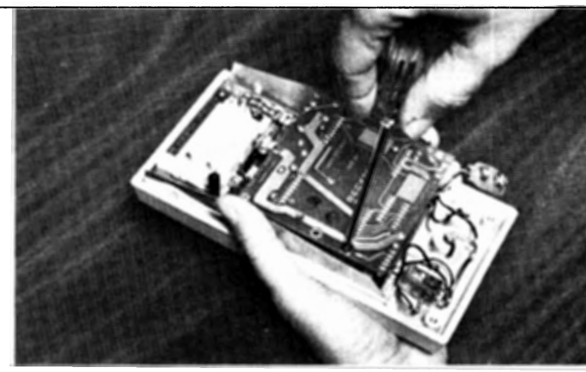
1. Remove battery and battery case, then disconnect four female connectors with needle nose pliers.

NOTE

Pull straight down on connectors to avoid bending pins.



2. Remove two No. 6 screws.



3. Lift switch and circuit board assembly from front cover using light pressure.

CAUTION

Avoid touching face of circuit boards by holding assembly as shown.

4. With assembly facing downward, squeeze prongs holding LCD retainer bar. Apply light pressure downward to free chip retainer from prongs. Repeat this for second set of prongs.

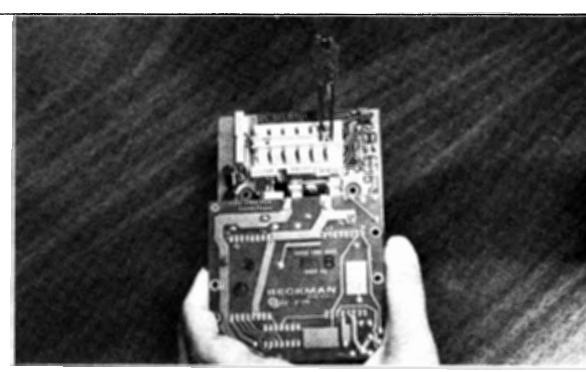


Figure 3-3. Disassembly and Replacement Procedure — Liquid Crystal Display and Multiprocessor Chip.

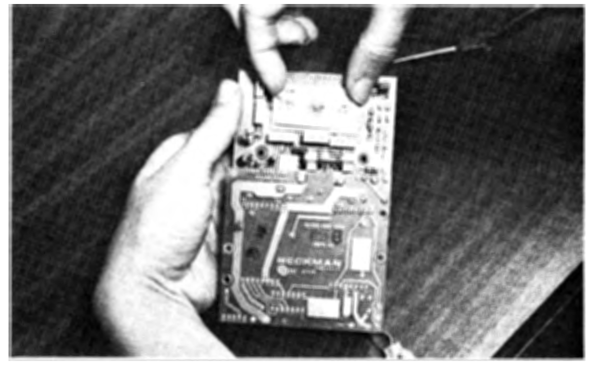
5. Again squeeze prongs if necessary and carefully remove multiprocessor chip.

CAUTION

As multiprocessor chip is a statically sensitive MOS device, handle chip only according to approved procedures.

NOTE

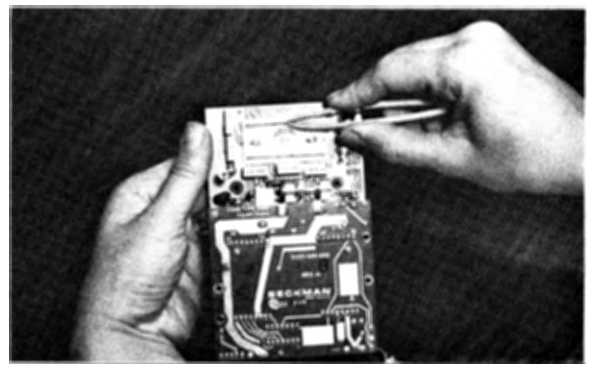
If you are replacing multiprocessor chip only, proceed to Step 16 for reassembly of Multimeter. To replace the display, proceed with Step 6.



6. Remove elastomer (zebra) strips from board.

CAUTION

DO NOT pinch zebra strips. A crushed strip cannot be satisfactorily reused. Avoid touching strip with your fingers.



7. Squeeze prongs together and remove display face and chip retainer from large circuit board.

8. Carefully remove zebra strip from top of display retaining assembly.

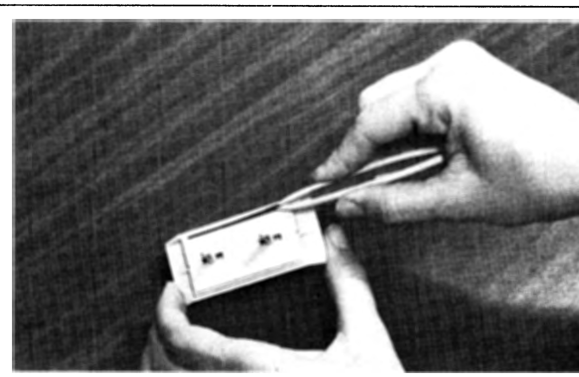
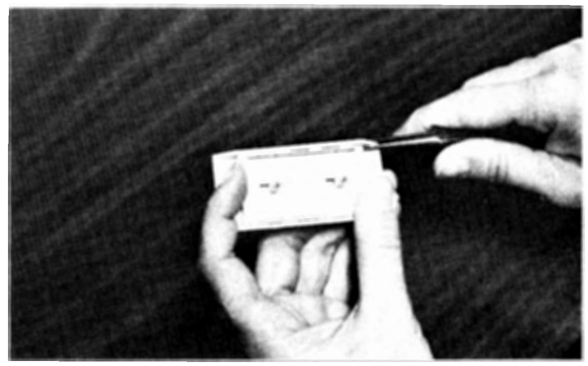


Figure 3-3. Disassembly and Replacement Procedure — Liquid Crystal Display and Multiprocessor Chip (continued)

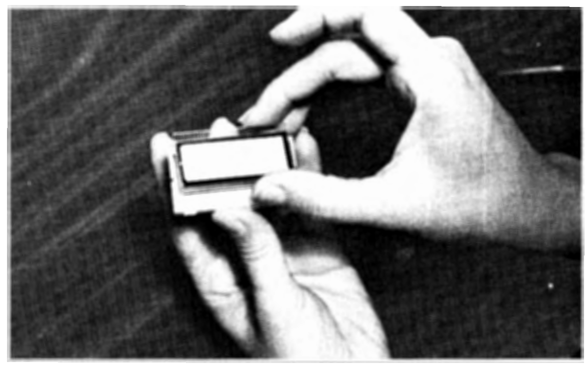
9. To remove display, insert small flat blade screwdriver between retainer and connector. Pry gently along edge to unlatch all tabs. Gently work with screwdriver or needle nose pliers until retainer is loose. Then remove retainer.



10. Remove LCD display. Be careful to touch display only by edges of glass.

NOTE

The display can now be replaced with a new display assembly.



11. Place new display right-side up in display connector and snap retainer over rear of display. Make sure that all "ears" are fully engaged.

NOTE

Mount display correctly by matching connector on glass (stripped edge) with zebra strip.

12. Replace zebra strip in slot provided.

13. Insert Digital Display into two holes in large circuit board by pinching tabs together.

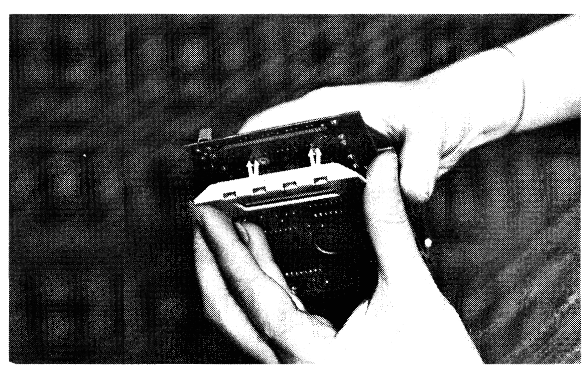
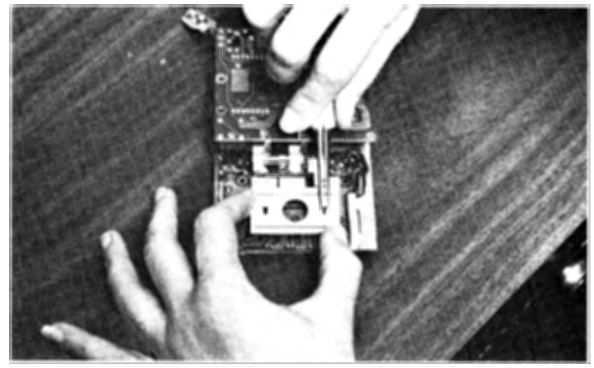


Figure 3-3. Disassembly and Replacement Procedure — Liquid Crystal Display and Multiprocessor Chip (continued)

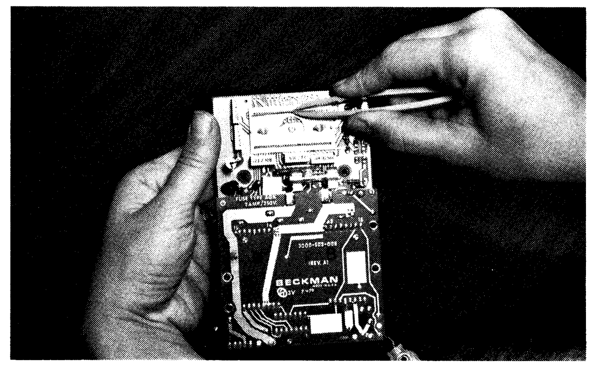
14. Place multiprocessor chip holder onto tabs. Make sure that dimple on right-hand underside of holder is inserted into hole in large circuit board.



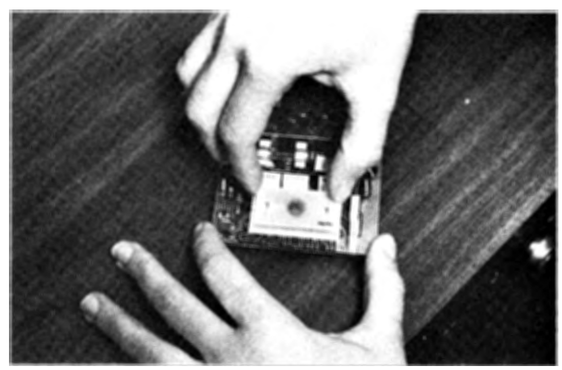
15. Insert two cleaned zebra strips (Paragraph 3.3.5) or new zebra strips into chip retainer.

CAUTION

Do not touch strips with your fingers and avoid pinching with tweezers.



16. Carefully place multiprocessor chip onto holder, gold side towards board. Align notch in chip carrier with index in holder.



17. Press chip retainer over chip until tabs are spread outward holding chip and retainer in place.

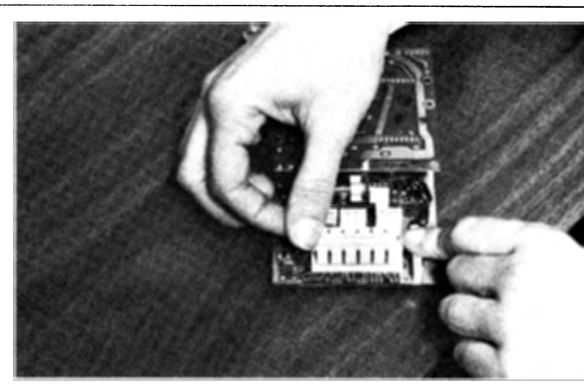
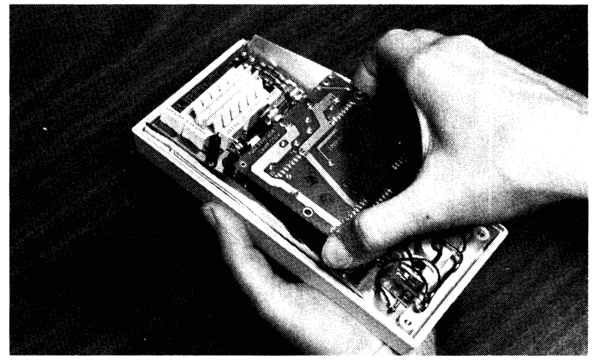


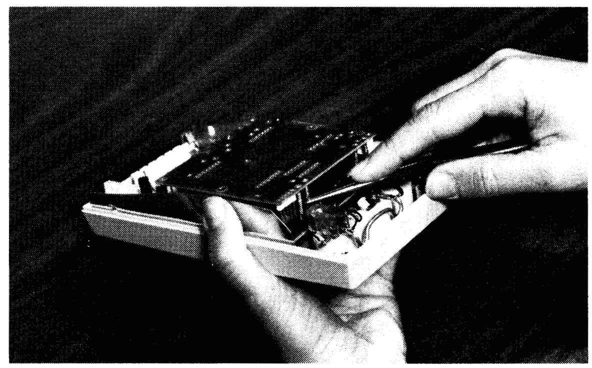
Figure 3-3. Disassembly and Replacement Procedure — Liquid Crystal Display and Multiprocessor Chip (continued)

18. Insert switch and circuit board assembly into front cover. Align front cover knob and shaft so that it aligns with opening in center of cam.

19. Insert two screws into back of Electronics Assembly and tighten.



20. Insert female connectors onto pins protruding from small circuit board. Be sure that these connectors fit snugly. Press leads so that they will not be pinched by the battery pack or between the housings.



21. Reinstall battery into battery pack and connect plug. Place battery pack onto mounting slots provided. Route leads so that they cannot be pinched or contact the input terminals.

22. Reassemble Multimeter according to procedure in Figure 3-1.

Figure 3-3. Disassembly and Replacement Procedure — Liquid Crystal Display and Multiprocessor Chip (continued)

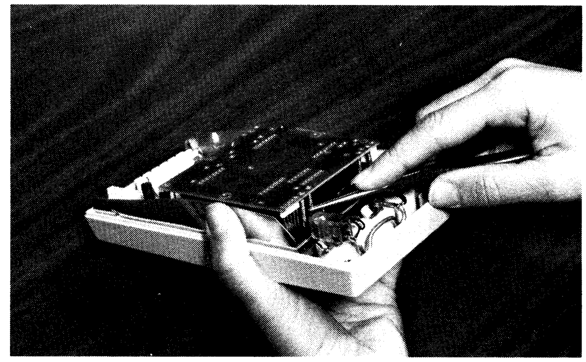
NOTE

After removing back cover of Multimeter as shown in Figure 3-1, further disassembly for inspection and repair of the circuit boards and switch is given in the following steps.

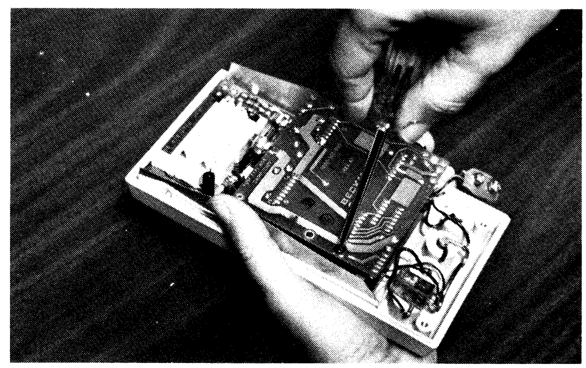
1. Remove battery and battery case, then disconnect four female connectors with needle nose pliers.

   NOTE

   Pull straight down on connectors to avoid bending pins.



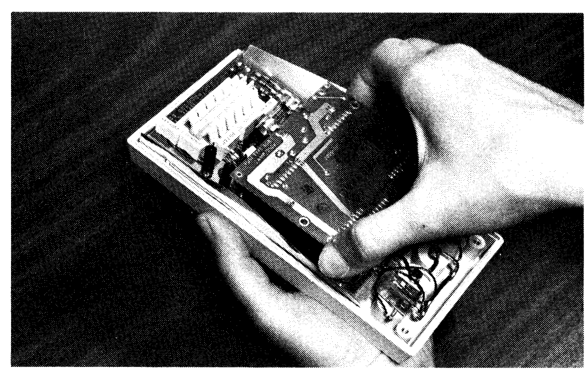
2. Remove two No. 6 screws.



3. Lift switch and circuit board assembly from front cover.

   CAUTION

   Avoid touching face of circuit boards by holding assembly as shown.



4. Place switch and circuit board assembly on a table with display facing upward. Remove two screws.

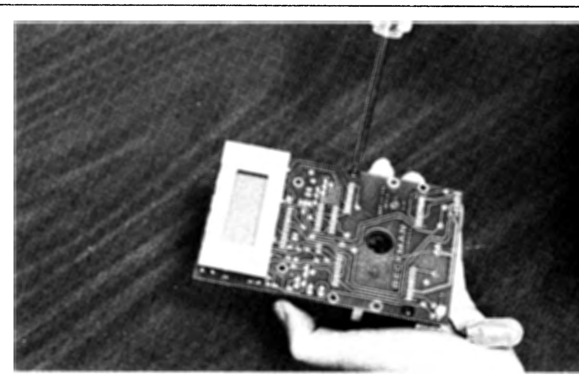
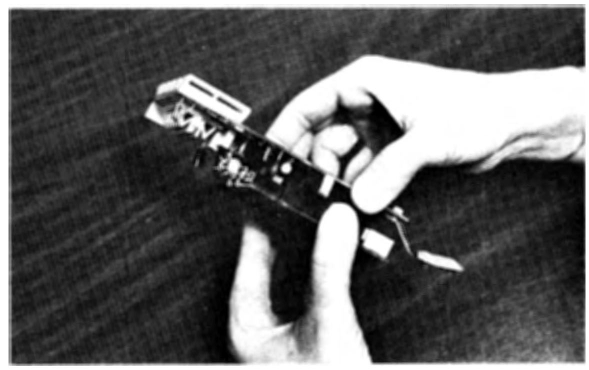


Figure 3-4. Removal/Replacement and Inspection Procedure — Electronics Assembly

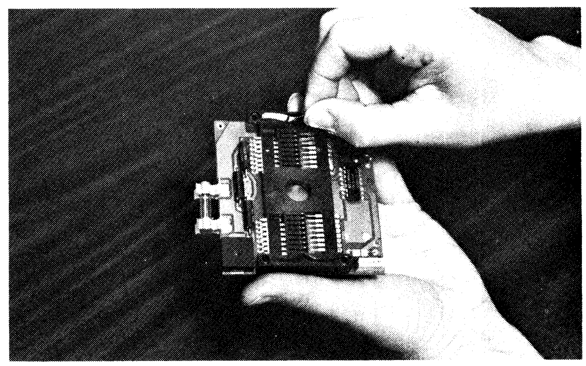
5. Grasping outer edge of large circuit board in one hand and outside edge of small circuit board in other hand, gently pull two boards apart.

CAUTION

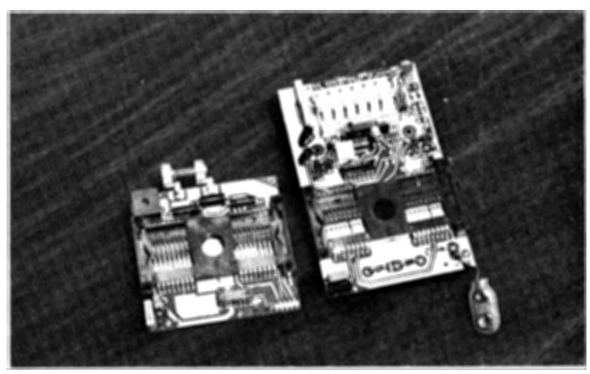
Damage to Function/Range Switch may result if circuit boards are not pulled straight apart as shown.



6. Carefully remove switch cam from circuit board and remove detent spring from switch block.



7. Disassembly is now complete and Multimeter is exposed for inspection, repair or replacement of parts. After these are completed proceed to Step 8 for reassembly.



8. Carefully engage cam onto large circuit board "T" slot. Hub of cam should be placed downward into hole.

CAUTION

Do not engage cam at an angle as damage to delicate switch contacts will result.

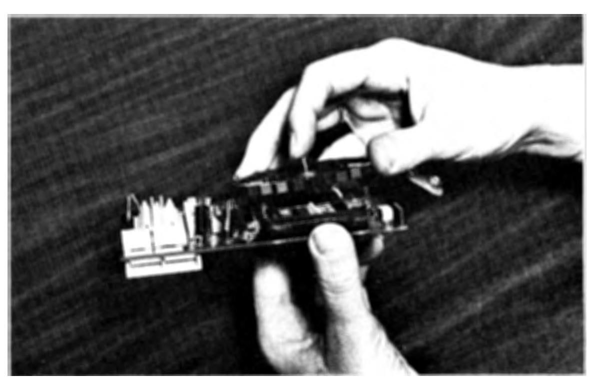
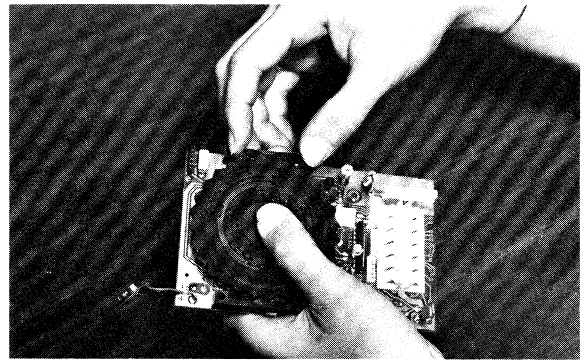
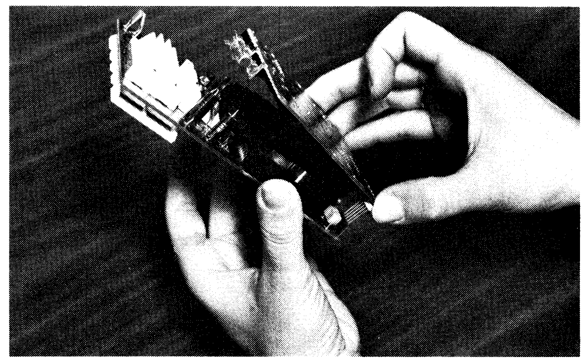


Figure 3-4. Removal/Replacement and Inspection Procedure — Electronics Assembly (continued)

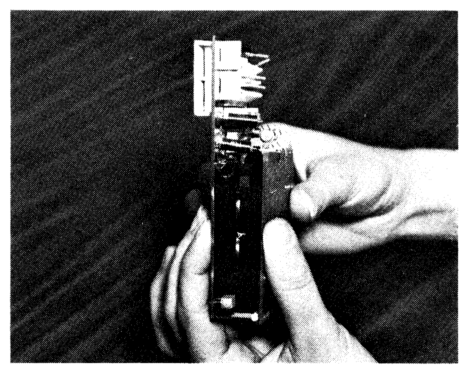
9. Insert detent spring into slot beside cam. Detent spring can be mounted on either side.



10. Engage connector on bottom edge of circuit boards as shown.



11. When connector is engaged, gently press two circuit boards together. Make sure that hub of cam fits into place on small circuit board, and two mounting dimples protrude into holes as indicated.



12. When two circuit boards are fully engaged, carefully turn assembly over and insert two screws and tighten.

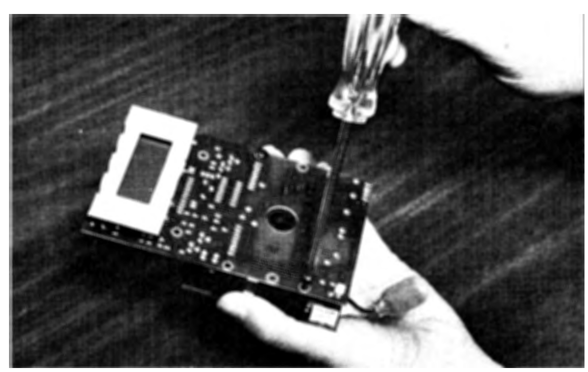
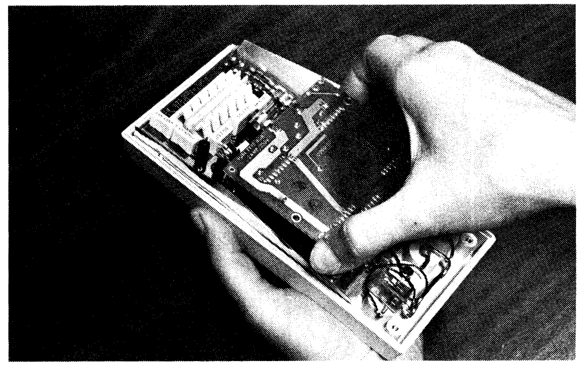
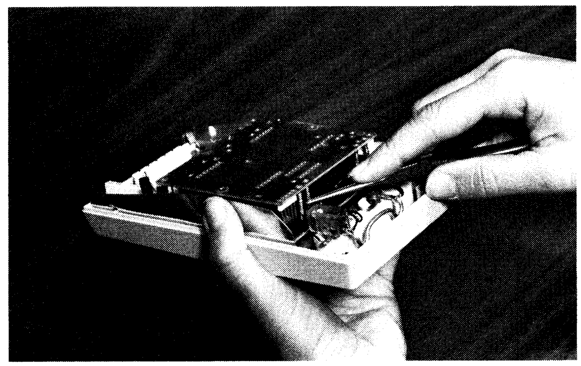


Figure 3-4. Removal/Replacement and Inspection Procedure — Electronics Assembly (continued)

13. Insert switch and circuit board assembly into front cover. Align front cover knob and shaft so that it aligns with opening in center of cam.
14. Insert two screws into back of Electronics Assembly and tighten.



15. Insert female connectors onto pins protruding from small circuit board. Be sure that these connectors fit snugly. Press leads so that they will not be pinched by the battery pack or between the housings.



16. Reinstall battery into battery pack and connect plug. Place battery pack back onto mounting slots provided. Route leads so that they cannot be pinched or contact the input terminals.
17. Reassemble Multimeter according to procedure in Figure 3-1.

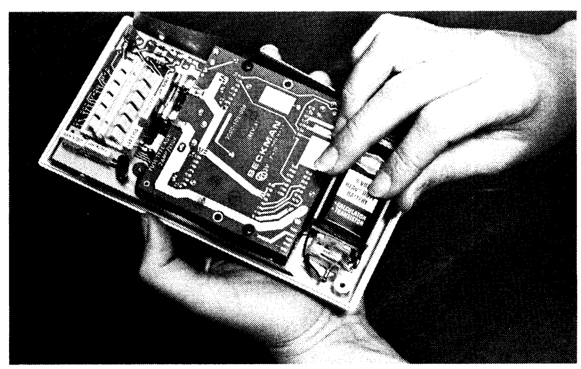


Figure 3-4. Removal/Replacement and Inspection Procedure — Electronics Assembly (continued)

3.4 CALIBRATION

To maintain the accuracy specification of the Multimeter, it is important that the Multimeter be calibrated at least once a year and every time that it is repaired. The test equipment necessary to accomplish this procedure is described in Table 3-1.

Table 3-1. Equipment Required for Calibration

Instrument	Characteristics	Recommended Models
DC Calibrator	Voltage Range: 0 to 1000Vdc Accuracy: ±0.025%	Rotek 600 or equivalent
AC Calibrator	Voltage Range: 0 to 110Vac Frequency Range: 400Hz to 20kHz Accuracy: 0.05% at 400Hz 0.5% at 20kHz	Rotek 600, 745A or equivalent

3.4.1 DC CALIBRATION

1. Perform calibration at ambient temperature of 25 ±2°C and relative humidity of 80% or less.

NOTE

Allow instrument to stabilize at this temperature for at least thirty minutes before proceeding with calibration.

2. Remove back cover from instrument by removing four screws and then lifting off cover. (Use procedure in Figure 3-1.)
3. Adjust output of dc calibrator for 190mV ±0.02% and connect to volt/ohm and COM input connectors on Multimeter.

4. Turn Function/Range Switch on Multimeter to 200mV DCV position.
5. Using small flat-tipped screwdriver, adjust potentiometer R5 as identified in Figure 3-5, until Multimeter Digital Display reads +190.0 or +190.1.
6. Disconnect dc calibrator from Multimeter.
7. Replace back cover and secure with four screws. (Refer to procedure in Figure 3-1.)

3.4.2 CALIBRATION OF RMS 3030 AND TECH 330 MULTIMETERS

1. Perform dc calibration, Steps 1 through 6 of Paragraph 3.4.1.
2. Short input Multimeter terminals.
3. Turn Function/Range Switch on Multimeter to 1000V ACV position.
4. Adjust potentiometer R14, (AC Zero Adj.) as identified in Figure 3-5, until Digital Display reads 000 or 001. Make this adjustment very slowly to allow instrument to stabilize.
5. Turn Function/Range Switch on Multimeter to 200mV ACV position.
6. Set output of dc calibrator to 190mV. Connect dc calibrator to V/Ohm and COM Input Connectors on Multimeter (polarity is not important).
7. Adjust potentiometer R13, (AC F.S. Adj.) Figure 3-5 until Digital Display reads 190.0 ±1 digit.
8. Disconnect dc calibrator from Multimeter.
9. Place Function/Range Switch on Multimeter in 2V ACV position and set ac calibrator for output of 1.900V, 20kHz.
10. Temporarily reinstall back cover of Multimeter.
11. Connect ac calibrator to V/Ohm and COM input connectors, and note reading. Insure that COM or "low" side terminal of ac calibrator is matched with Multimeter COM terminal.
12. Remove Multimeter back cover and again note Digital Display reading. The difference between first and second readings is *error voltage.*

NOTE

At 20kHz, (calibration frequency) 2 Vac Multimeter readings tend to be higher with back cover shield removed than with cover attached. Adjust Multimeter to read higher than calibration standard voltage so that with cover attached, desired output is achieved.

13. Adjust trimming capacitor C19, (H.F. Adj.) as identified in Figure 3-6, until Digital Display reads number equal to 1.900 plus the error voltage.
14. Reinstall Multimeter back cover and secure with four screws, refer to Figure 3-1.
15. Verify that Digital Display reads 1.900 ±20 digits.
16. Disconnect ac calibrator from Multimeter.
17. Replace back cover and secure with four screws, refer to procedure in Figure 3-1.

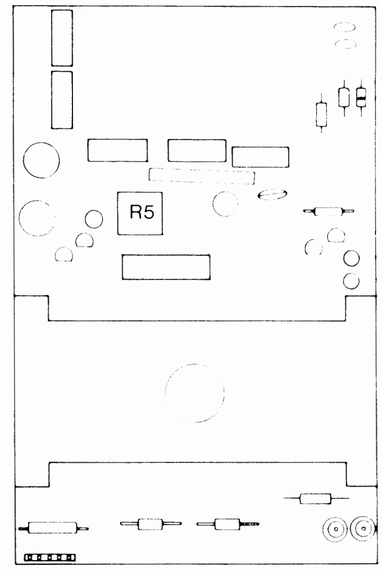


Figure 3-5A. Large Circuit Board Assembly (3010, 3020, TECH 300, TECH 310)

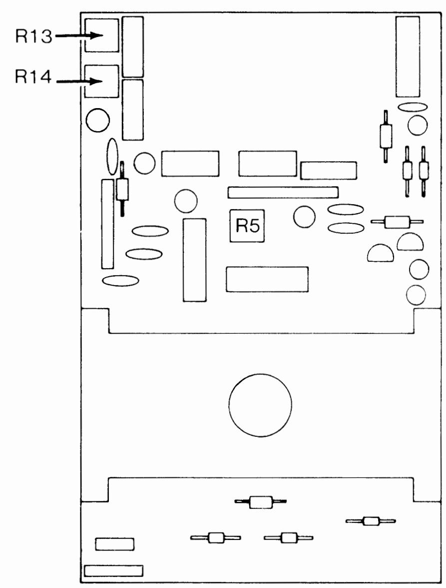


Figure 3-5B. Large Circuit Board Assembly (RMS 3030)

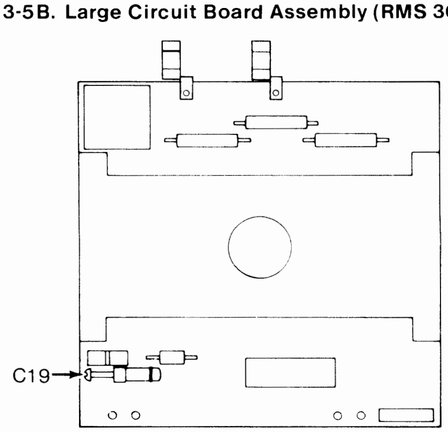


Figure 3-6. Small Circuit Board Assembly (RMS 3030)

SECTION FOUR
TROUBLESHOOTING

4.1 GENERAL

This section contains information for restoring the operating performance of the Beckman Series 300 and 3000 Multimeters. These troubleshooting procedures, together with the specific tests and recommendations for identifying possible causes of faults, provide the technician with the aids to quickly diagnose and correct malfunctions. To be effective in troubleshooting, the technician should understand the information contained in this manual.

4.2 BASIC TROUBLESHOOTING

Although this is a complex electronic instrument, much of the complexity has been simplified for troubleshooting and servicing by the use of a central multiprocessor integrated circuit (chip) and other passive and active integrated circuits (chips). Understanding the function of the multiprocessor chip and peripheral circuits is necessary before beginning to diagnose problems. A description of the operation of these circuits is provided in Section Two.

With an understanding of the Multimeter circuits, a technician should be able to make reasonable assumptions as to the general source of trouble based on the symptoms. Frequently a systematic approach to the troubleshooting problem may be more rewarding than a haphazard check of voltages and components. The following instructions are presented as an aid in formulating the systemation approach.

Sources of problems are divided into two categories: 1) Improper operating procedures, and 2) instrument malfunctions. The first category, with human error, is a more prevalent source of problems than most people care to admit. Always investigate and eliminate these problems before assuming a valid instrument malfunction exists. After eliminating sources of human error, the instrument malfunction can with assurance be systematically approached with the following procedure.

1. **Examine evidence of trouble.** Study the problem thoroughly. For example, if a Multimeter function is erroneous, operate the instrument using all functions. Many times finding more than one faulty function is a clue to the possible source of trouble.
2. **Look for obvious solutions first.** Question the coincidence of failure with other recent events such as servicing.
3. **Isolate problem to a major functional area.** If many of the Multimeter functions are not operating correctly, it is likely that the multiprocessor chip needs to be replaced. On the other hand, if only one function is not working properly, some peripheral circuit may be suspected.
4. **Analyze reduced problem area for final solution.** When investigations have narrowed down to a restricted area, the remainder of the Multimeter can be temporarily ignored.
5. **Correct the difficulty.** When the final solution has been reached and the defective or faulty part has been pinpointed, remedy the fault by replacing the component, such as the multiprocessor chip or display chip.
6. **Restore conditions for normal operation.** Careful reassembly of the Multimeter is necessary. For example, careless reassembly of the Function/Range Switch or damage to zebra strips will cause additional problems.

4.3 INITIAL DIAGNOSTIC INSTRUMENT TEST

Before attempting to diagnose Multimeter problems, perform the following instrument checkout procedure. Results of this test may reveal additional problems. Many times when these secondary problems are corrected the original problem is also corrected.

1. Be certain that battery and fuse are installed properly.
2. Connect red test lead to V-Ω Input Connector and black test lead to COM Input Connector.
3. Place Function/Range Switch in 1500 DCV position.
4. Touch red test lead and black test lead together. Digital Display should read 000 ±1.
5. Turn Function/Range Switch counterclockwise to each DCV position while observing Digital Display. With test lead tips in contact, Digital Display should read zero plus or minus one digit and decimal point positioned as follows:

POSITION	READING
200V	00.0
20V	0.00
2V	.000
200mV	00.0

6. Turn Function/Range Switch to 20MΩ position. With two test lead tips separated, Digital Display should read OL.
7. Touch test lead tips together and observe Digital Display; it should read 0.00 or 0.01.
8. Turn Function/Range Switch to each ohm position while observing Digital Display. With test lead tips in contact, Digital Display should read zero in each position. In 200Ω position, Digital Display may read 000.1 or 000.2 because of test lead resistance. Decimal point should be positioned as follows:

POSITION	READING
20MΩ	0.00
2MΩ	.000
200kΩ	00.0
20kΩ	0.00
2kΩ	.000
200Ω	00.0

9. Turn Function/Range Switch to 1000 ACV postion.

WARNING

The next step requires measurement of local ac line (mains) voltage. Be careful not to touch test lead tips with fingers and do not allow tips to contact each other.

10. Measure local line (mains) voltage at ac power outlet. Digital Display should show appropriate voltage with resolution of one volt.

NOTE

When using the 10A Input Connector for current measurements, test lead jack must be fully depressed into input connector. This engages microswitch which enables 10-ampere current shunt.

4.4 MULTIMETER OPERATING CONTROLS AND INPUT CONNECTORS

The locations of Multimeter operating controls, input connectors are shown in Figure 4-1. An explanation of each control and connector is summarized below the photograph.

4.5 TROUBLESHOOTING GUIDE

A number of malfunctions are traceable to a faulty multiprocessor chip display, faulty zebra strips connections, or dirty and damaged contacts on the Function/Range Switch.

If good parts are available, the ease of replacement of the multiprocessor chip, display, and zebra strip connector makes test by substitution the most effective technique. Unless experience indicates that these items cannot be involved, the best first step is replacement to eliminate them from further consideration. After the actual trouble is corrected, the original parts may be reinstalled.

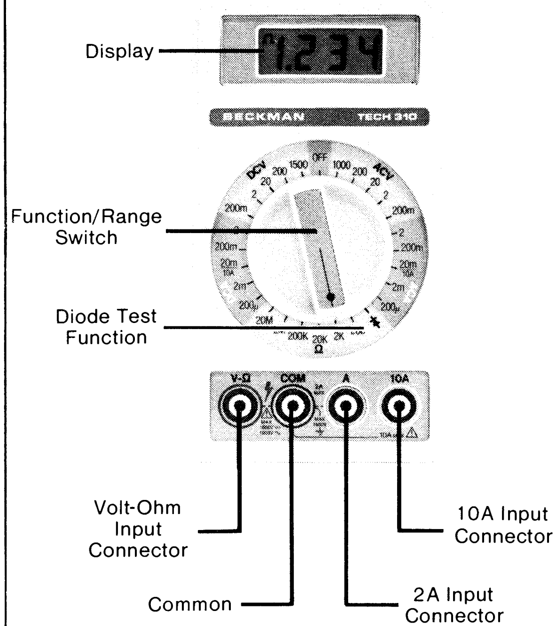
Some of the symptoms or faults encountered with the Multimeter are listed in TABLE 4-1. Also listed in this table are probable causes and corrective actions necessary to restore the Multimeter to proper operating condition. If technician is still unable to obtain proper performance from the Multimeter after reading this manual and applying all the troubleshooting information contained in this section, return the Multimeter to the factory for repair or exchange with a new or reconditioned model. Contact an authorized Beckman Service Center or Beckman Instruments, Inc., for instructions.

4.6 RANGE/FUNCTION SWITCH

Figure 4-2 contains a matrix describing the position of all contacts in all positions of the Multimeter Function/Range Switch. This diagram is valuable for tracing various circuits to determine proper operation of Multimeter.

4.7 MULTIMETER CIRCUIT DIAGRAM

Figure 4-3 is a functional Schematic Diagram of the Multimeter. Figure 4-3B refers to the models featuring RMS AC measurements, Figure 4-3A covers all other models. Refer to Section 5, Replacement Parts and Supplies, for the physical location of components.



DIGITAL DISPLAY
A 3½-digit LCD readout (maximum reading 1999) indicating measured input value in volts, amperes, or ohms as selected by Function/Range Switch.

FUNCTION/RANGE SWITCH
This switch turns instrument off or on and selects function and range. Six functions are: (DCV, ACV, DCA, ACA, Ω, Diode Test).

- **DCV function** provides 5 ranges from 200mVdc to 1500Vdc
- **ACV function** provides 5 ranges from 200mVac to 1000Vac rms ac.
- **DCA and ACA functions** each provide five ranges of current measurements, from 200μA to 2A fullscale. $\frac{20m}{10A}$ positions in the DCA and ACA functions serves two purposes on those models with the 10-Ampere Shunt Feature. When using the A input jack, the $\frac{20m}{10A}$ position serves as the 20mA range. When using the 10A input jack, the $\frac{20m}{10A}$ position, serves as the 10A range.
- **OHM (Ω) function** provides six ranges of resistance measurements from 200Ω to 20MΩ.
- **DIODE TEST function**
  This position of switch used for checking diodes and other semiconductor junctions.

10A INPUT CONNECTOR (not available on all models)
Used for continuous current measurements from 0A to 10A. Measurements between 10 amperes and 20 amperes may also be made for a duration of thirty seconds maximum. *Inputs beyond 20 amperes may cause damage to instrument.*

2A INPUT CONNECTOR
Used for current measurements up to 2 amperes. Instrument protected by fuse against inputs over 2 amperes.

COM INPUT CONNECTOR (BLACK)
Used as common or low input for all measurements.

V-Ω INPUT CONNECTOR
Used as high input for all voltage and resistance measurements.

Figure 4-1. Operating Controls and Input Connectors

Table 4-1. Troubleshooting — Diagnostic Guide

Symptom	Probable Cause	Corrective Action
1. Decimal point blinks	A. Battery voltage low B. Multiprocessor chip faulty	A. Replace with good battery B. Replace, Figure 3-3
2. Display blank	A. No power B. Display connector is disconnected or loose C. Display faulty D. Multiprocessor chip faulty	A. Check battery and connecting wires. Replace battery if defective. Check Function/Range Switch, Figure 3-4 B. Check connector, Figure 3-3 C. Replace, Figure 3-3 D. Replace, Figure 3-3
3. Display segment missing, always on, blurry or faint	A. Poor connection between multiprocessor chip and display B. Display faulty C. Multiprocessor chip faulty	A. Disassemble, inspect, and clean instrument, Figure 3-4 B. Replace, Figure 3-3 C. Replace, Figure 3-3
4. Ohms indicator fails to come on	A. Poor connection between multiprocessor chip and display B. Display faulty C. Multiprocessor chip faulty D. Resistor network (U4) faulty or open	A. Disassemble, inspect, and clean, Figure 3-3 B. Replace, Figure 3-3 C. Replace, Figure 3-3 D. Replace U4
5. Does not measure dc volts, all ranges	A. Multiprocessor chip faulty B. Function/Range Switch faulty C. Input protection network faulty D. Input filter network faulty E. Faulty zebra strips connections from multiprocessor chip to Digital Display	A. Replace, Figure 3-3 B. Disassemble and check, Figure 3-4 C. Refer to Figure 4-3 D. Refer to Figure 4-3 E. Refer to Figure 3-4
6. Instrument will not calibrate	A. Improper reference voltage B. Calibration network faulty C. Multiprocessor chip faulty	A. Measure dc voltage at TP-1. Should be approximately 1.2Vdc. B. Refer to Figure 4-3 C. Replace, Figure 3-3
7. Instrument calibrates, but one or more dc voltage ranges do not function	A. Input attentuator faulty B. Function/Range Switch faulty	A. Replace, Figure 4-3 B. Disassemble and check, Figure 3-4
8. Does not measure dc amperes, all ranges. Zero reading on scale. Records full scale (OL)	A. Fuse blown B. Function/Range Switch faulty C. Input protection diodes faulty A. Function/Range Switch faulty B. 0.1-ohm input resistor faulty	A. Replace B. Disassemble and check, Figure 3-4 C. Replace A. Disassemble and check, Figure 3-4 B. Replace
9. Does not measure ohms, all ranges	A. Ohms bias power source defective B. Function/Range Switch faulty C. Circuit board interface converter dirty or faulty	A. Refer to Figure 4-3 for further troubleshooting B. Disassemble and check, Figure 3-4 C. Disassemble, check, clean or repair, Figure 3-4
10. Resistance measurements are out of calibration or do not read correctly.	A. Input attenuator faulty B. Function/Range Switch faulty C. Protection zeners, VR1, VR2 damaged	A. Replace B. Disassemble and check, Figure 3-4 C. Replace
11. Diode test does not function	A. Ohms bias source does not function B. Function/Range Switch faulty	A. Refer to Figure 4-3 B. Disassemble and check, Figure 3-4
12. Does not measure ac volts and ac amperes	A. Faulty ac input protection network B. Faulty ac calibration resistors, U3 C. Function/Range Switch faulty D. Multiprocessor chip faulty	A. Refer to Figure 4-3 B. Replace U3 C. Disassemble and check, Figure 3-4 D. Replace, Figure 3-3
13. Does not measure ac volts but does measure ac amperes	A. Small circuit board faulty B. Function/Range Switch faulty	A. Check B. Check Function/Range Switch, Figure 3-4
14. Does not measure ac amperes but does measure ac volts	A. Function/Range Switch faulty	A. Disassemble and check Figure 3-4
15. Inaccurate measurements — ac voltage and amperes	A. Faulty ac input buffer network B. Faulty ac output filter network	A. Refer to Figure 4-3 B. Refer to Figure 4-3
16. Inaccurate measurements — ac voltage	A. C1 defective B. Function/Range Switch faulty	A. Replace B. Disassemble and check, Figure 3-4
17. Inaccurate measurements — ac amperes	A. Function/Range Switch faulty B. Excessive dc component in ac amperes	A. Disassemble and check, Figure 3-4 B. Be sure input is within range of instrument
18. All readings non-linear	A. Multiprocessor chip faulty B. Replacement of multiprocessor chip does not cure problem	A. Replace, Figure 3-3 B. Return instrument to Beckman for repair.

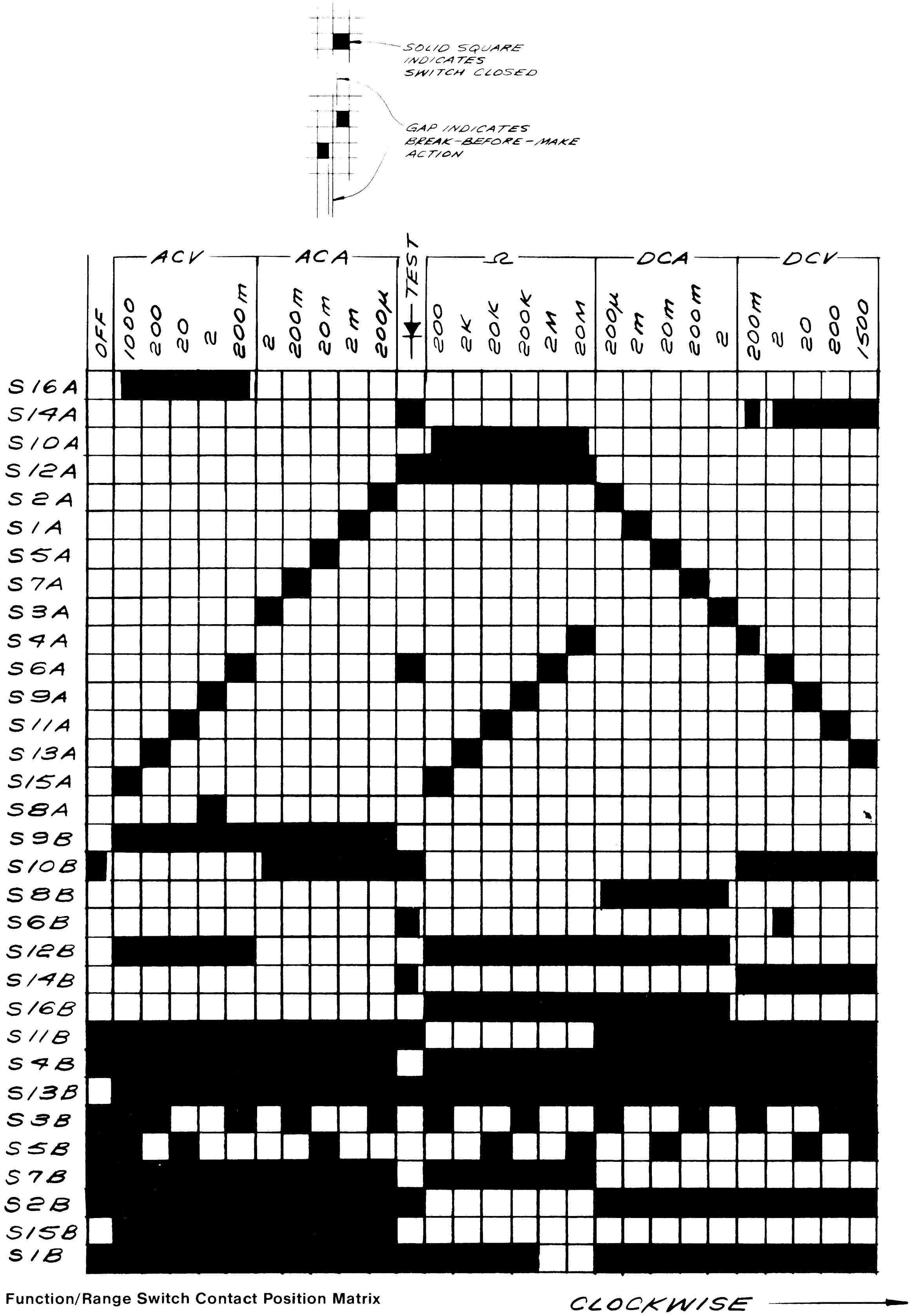


Figure 4-2. Function/Range Switch Contact Position Matrix

SECTION FIVE
REPLACEMENT PARTS AND SUPPLIES

The replacement parts and supplies listed in this section may be ordered from Beckman. To determine the Beckman Part Number and description for the part which must be replaced, first find the part located on an illustration, (Figures 5-1 through 5-9). Then note illustration figure number and part index number. Locate the identical figure number on the parts list and the part index number. In the third column, find the corresponding part number. Parts indexed with a letter are available only as part of the main assembly kit. Note that Series 3000 covers Models 3010, 3020, and RMS 3030; and Series 300 covers TECH 300 and TECH 310.

The Spare Parts Quantity column indicates the recommended number of parts necessary to support one to ten instruments for two years. This list omits those common parts that are typically available from local parts suppliers.

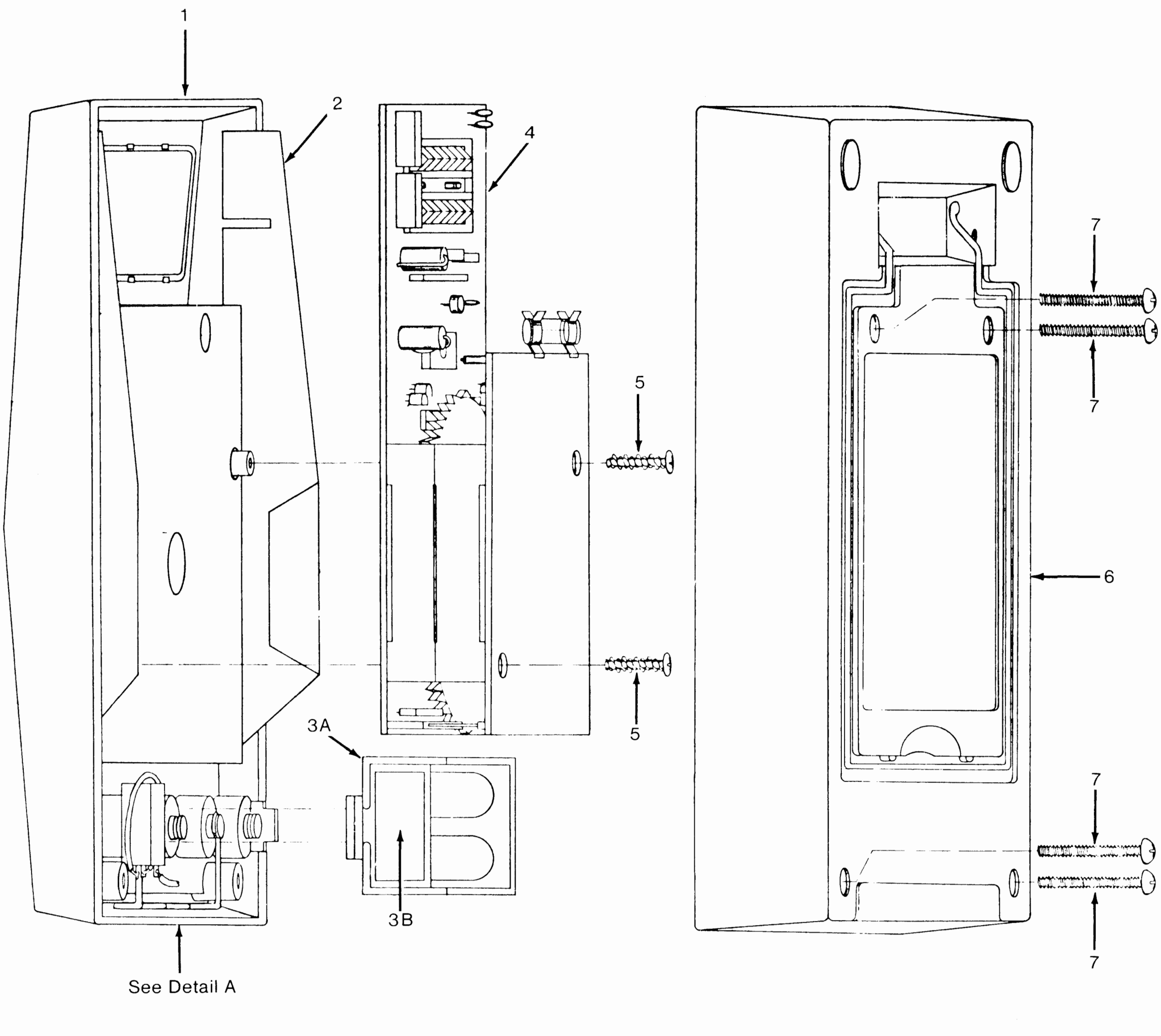
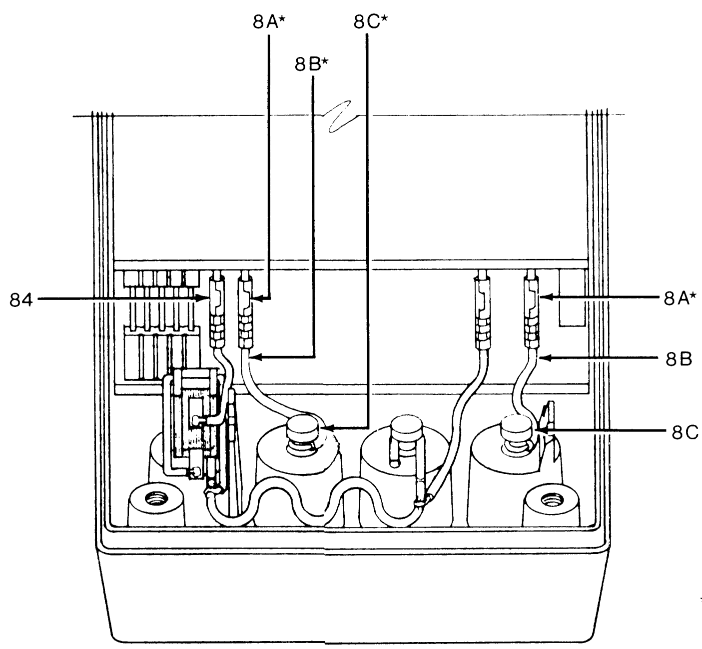


Figure 5-1. Multimeter Assembly

MULTIMETER ASSEMBLY **Parts List for Figure 5-1**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1			Housing Assembly, Front	1	
2		FG3000-450-116	Shield, Upper	1	
3		FG3000-410-116	Battery Cover Assembly	1	
3A		FG3000-420-109	Cover, Battery	1	
3B		FG3000-450-112	Pad, Non-Skid	1	
4			Electronic Assemblies	1	
5		FG3000-450-102	Screw, No. 4, Thread Forming, 1¼-inch	2	
6			Housing Assembly, Rear	1	
7		FG3000-450-104	Screw, 4-40 Block Oxide, 1¼-inch	4	
8		FG3000-543-21	Jack Assembly	2 or 3	
8A		FG3000-370-111	Terminal PC Crimp Female	1	
8B		FG3000-372-116	Wire, 1-7/16 inch long	1	
8C		FG3000-370-106	Receptical, Measuring Probe Input	1	



*Do not unsolder these connections

Detail A

Figure 5-1. Multimeter Assembly (continued)

REAR HOUSING ASSEMBLY

Parts List for Figure 5-2

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1		FG3000-410-108	Series 3000 Case Bottom Assembly	1	
1A		FG3000-421-104	Case Bottom, Series 3000	1	
1B		FG3000-450-108	Pad, Bottom	1	
1C		FG3000-450-107	Foot, Top	2	
1D		FG3000-400-101	Fuse, 2-Amperes	1	
1E		FG3000-451-100	Bail	1	
1		FG3000-410-109	Series 300 Case Bottom Assembly	1	
1A		FG3000-420-104	Case Bottom, Series 300	1	
1B		FG3000-450-108	Pad, Bottom	1	
1C		FG3000-450-107	Foot, Top	2	
1D		FG3000-450-101	Fuse, 2-Amperes	1	
1E		FG3000-451-100	Bail, Multimeter Tilt	1	
2		FG3000-410-115	Shield, Lower with Reassembly Instruction and Foam Pad	1	
2A		FG3000-450-111	Pad	1	
2B		FG3000-450-117	Shield	1	
2C		FG3000-970-201	Label	1	
3		FG3000-920-500	Overlay, Instructions, Series 300	1	
3		FG3000-920-501	Overlay, Instructions, Series 3000	1	
3		FG3000-920-502	Overlay, Instructions, Series 3000, Japanese	1	
3		FG3000-920-503	Overlay, Instructions, Series 3000, French	1	
3		FG3000-920-504	Overlay, Instructions, Series 3000, German	1	
3		FG3000-920-506	Overlay, Instructions, Series 3000, Italian	1	
3		FG3000-920-507	Overlay, Instructions, Series 3000, Spanish	1	
4		FG3000-451-100	Bail, Multimeter Tilt	1	

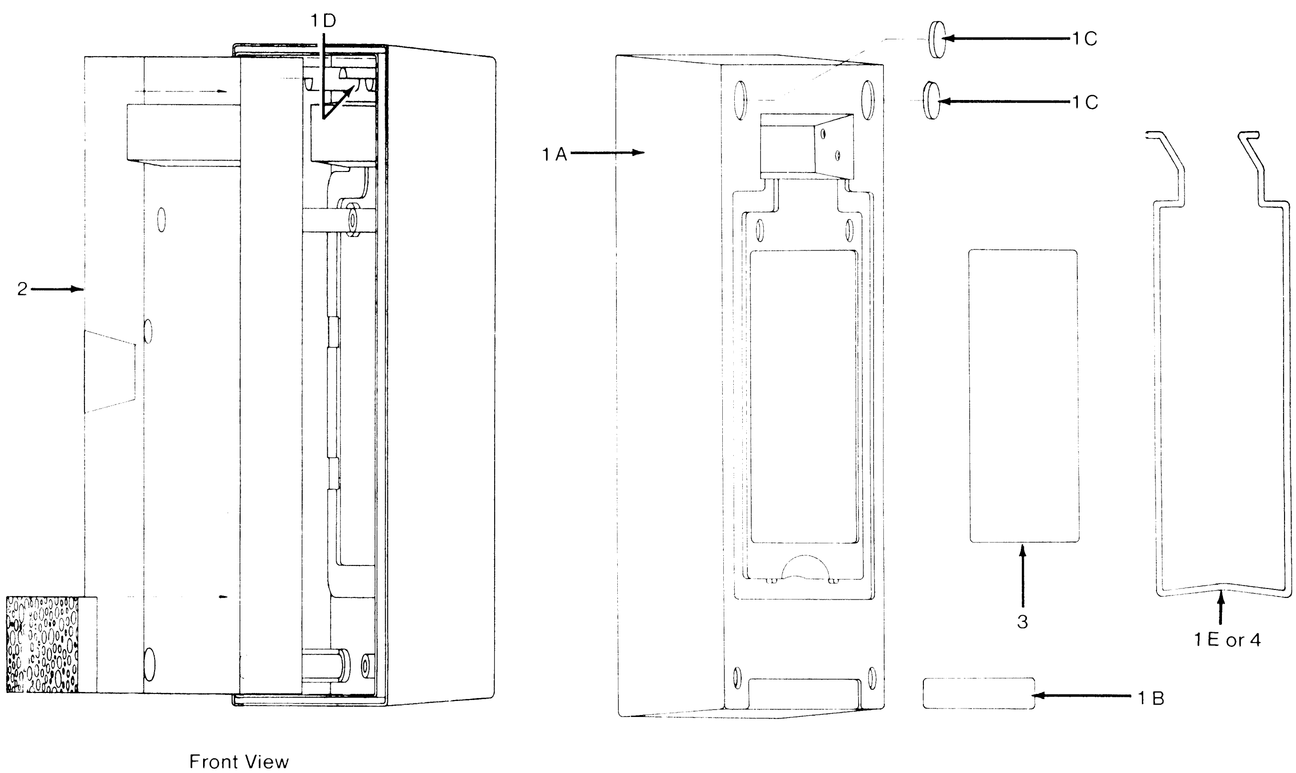


Figure 5-2. Rear Housing Assembly

FRONT HOUSING ASSEMBLY **Parts List for Figure 5-3**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1		FG3000-410-110	Series 3000 Case Top Assembly	1	
1		FG3000-410-111	TECH 300 Case Top Assembly	1	
1		FG3000-410-112	TECH 310/330 Case Top Assembly	1	
1A		FG3000-920-400	Overlay, Knob Insert, Series 3000	1	
1A		FG3000-920-401	Overlay, Knob Insert, Series 300	1	
1B		FG3000-420-105	Knob, Function/Range Switch	1	
1C		FG3000-450-105	O-Ring, Knob Sealing	1	
1D		FG3000-920-100	Overlay, Switch, TECH 300	1	
1D		FG3000-920-101	Overlay, Switch, TECH 310, 330	1	
1D		FG3000-920-102	Overlay, Switch, Series 3000	1	
1E		FG3000-420-103	Case, Top Series 300	1	
1E		FG3000-421-103	Case, Top Series 3000	1	
1F		FG3000-420-102	Shaft, Function Range	1	
1G		FG3000-450-109	Seal, Display Window	1	
1H		FG3000-420-106	Window, Display	1	
2		FG3000-920-300	Overlay, Logo, TECH 300	1	
2		FG3000-920-301	Overlay, Logo, TECH 310	1	
2		FG3000-920-302	Overlay, Logo, TECH 330	1	
2		FG3000-920-310	Overlay, Logo, 3010	1	
2		FG3000-920-320	Overlay, Logo, 3020	1	
2		FG3000-920-330	Overlay, Logo, 3030	1	
3		FG3000-920-201	Overlay, Input Jacks, TECH 300	1	
3		FG3000-920-202	Overlay, Input Jacks, TECH 320, 330	1	
3		FG3000-920-203	Overlay, Input Jacks, Series 3000	1	
4		FG3000-526-21	10-Ampere Shunt Assembly	1	

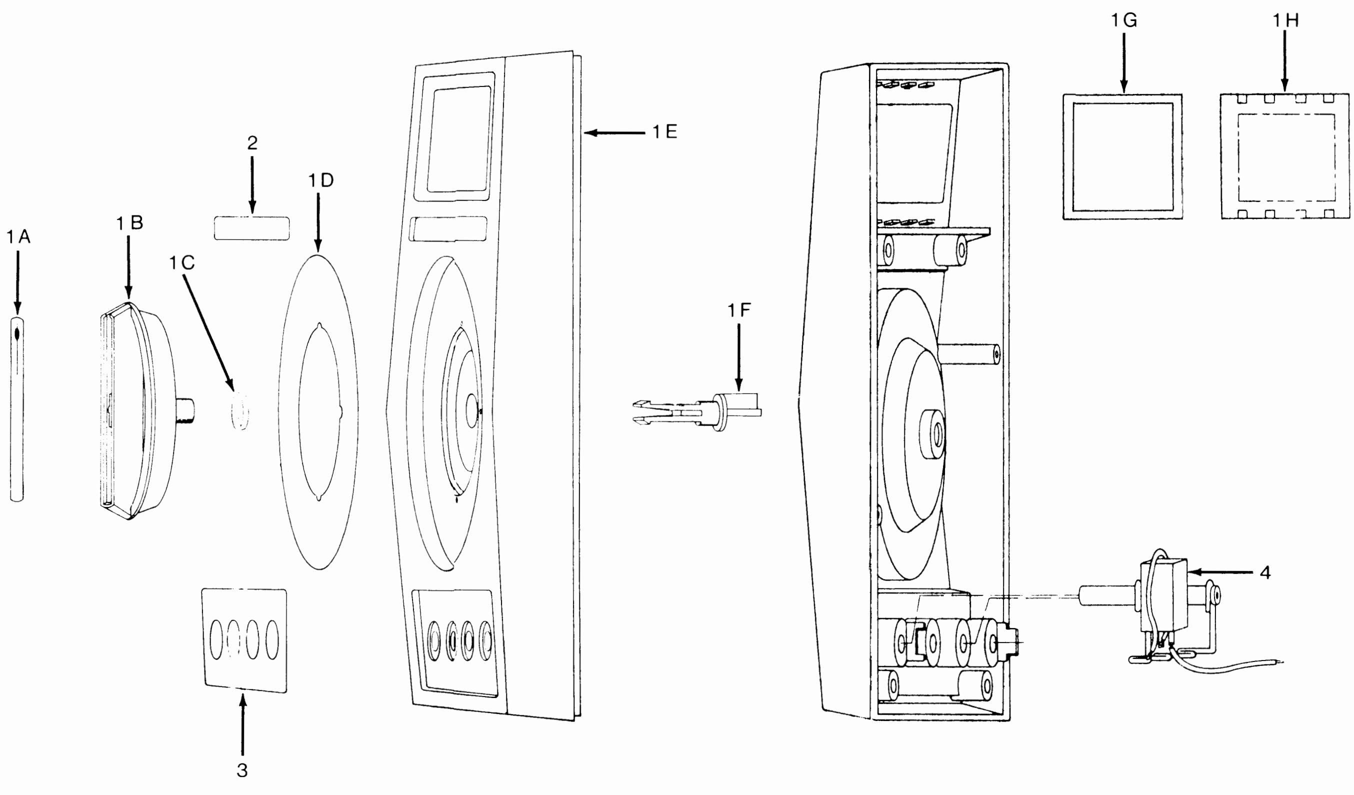


Figure 5-3. Front Housing Assembly

ELECTRONICS ASSEMBLY **Parts List for Figure 5-4**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1			Circuit Board Assembly, Small	1	1
2	F1	FG3000-400-101	Fuse, 2-Ampere	1	5
3			Circuit Board and Display Assembly	1	
4		FG3000-450-102	Screw, No. 6, Thread Forming, ¾-inch	2	
5		FG3000-450-110	Spring Detent	1	
6		FG3000-420-101	Cam, Function/Range Switch	1	
7		FG3000-370-115	Spring Contact, DSN Aquadag	1	1

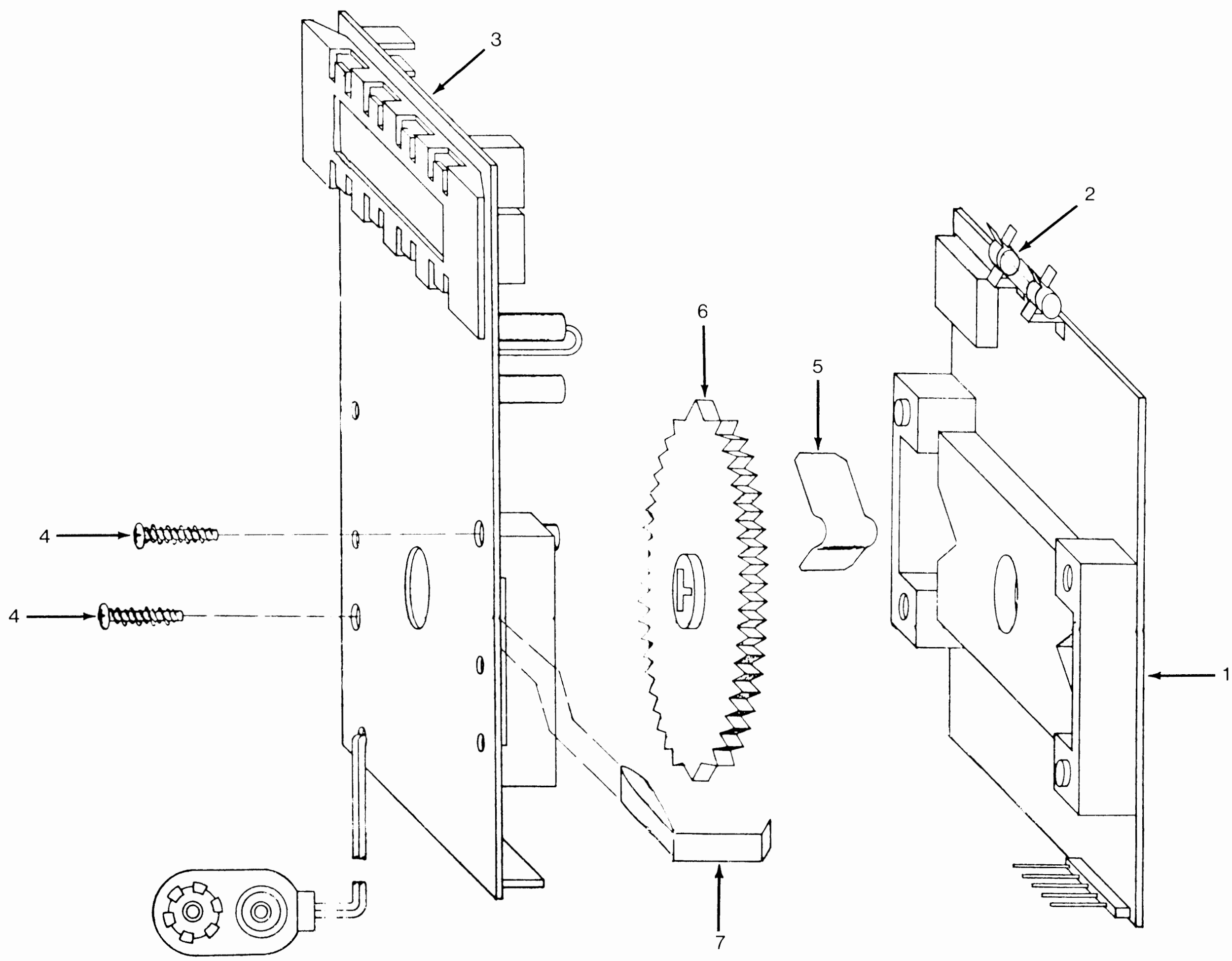


Figure 5-4. Electronics Assembly

SMALL CIRCUIT BOARD ASSEMBLY (3010, 3020, TECH 300, TECH 310) **Parts List for Figure 5-5**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1	BR1	FG3000-211-100	Bridge, 2-Ampere, Low Leakage	1	
2		FG3000-370-100	Connector, Male, 5-Pin	1	
3	R1	FG3000-1-202	Resistor, 2k Ohm +5%, ¼%WW	1	
4	R2	FG3000-51-106	Resistor, 9 Ohms, 3W, ¼%WW	1	
5	R3	FG3000-71-101	Resistor, 0.9 Ohm, 3W, ¼%WW	1	
6	R4	FG3000-71-100	Resistor, 0.1 Ohm, 3W, ¼%WW	1	
7	U1	FG3000-313-101	Resistor Network, Attenuator (TECH 330, RMS 3030, Model 3020)	1	
7	U1	FG3000-312-101	Resistor Network, Attenuator (TECH 310, Model 3010)	1	
7	U1	FG3000-410-118	Resistor Network, Attenuator (TECH 300)	1	
8	SG1	FG3000-401-100	Spark Gap, 2kV	1	
9		FG3000-420-100	Switch Block	1	
10		FG3000-370-110	Terminal Pin, Male	4	2
11	C1	FG3000-130-100	Capacitor, Metallized Polyester, 0.047μf .250V	1	
12		FG3000-370-107	Fuse Clip	2	2
13		FG3000-521-21	Small Circuit Board (assembled) TECH 310 Model 3010	1	
13		FG3000-522-21	Small Circuit Board (assembled) Model 3020	1	
13		FG3000-410-117	Small Circuit Board (assembled) TECH 300	1	

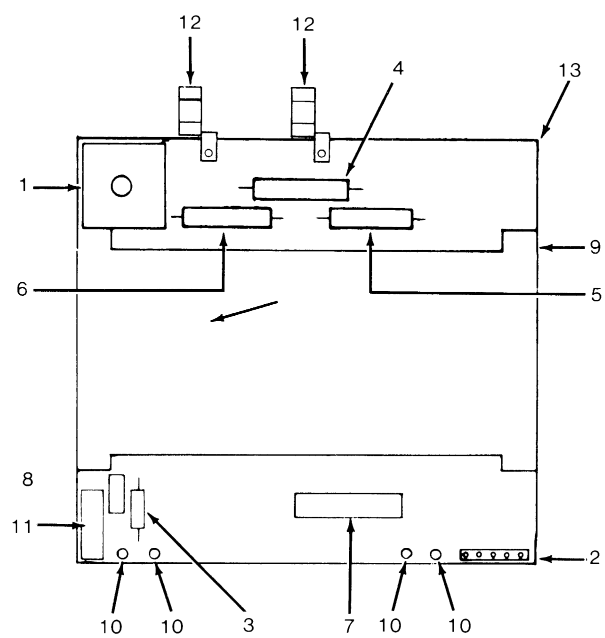


Figure 5-5. Small Circuit Board Assembly (3010, 3020, TECH 300, and TECH 310) for Part Location

SMALL CIRCUIT BOARD ASSEMBLY (RMS 3030 AND TECH 330) **Parts List for Figure 5-6**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1	BR1	FG3000-211-100	Bridge, 2-Ampere, Low Leakage	1	
2		FG3000-370-100	Connector, Male, 5-Pin	1	
3	R1	FG3000-1-202	Resistor, 2k Ohm +5%, ¼%W	1	
4	R2	FG3000-51-106	Resistor, 9 Ohms, 3W, ¼%WW	1	
5	R3	FG3000-71-101	Resistor, 0.9 Ohm, 3W, ¼%WW	1	
6	R4	FG3000-71-100	Resistor, 0.1 Ohm, 3W, ¼%WW	1	
7	U1	FG3000-313-101	Resistor Network, Attenuator, Thin Film	1	1
8	SG1	FG3000-401-100	Spark Gap, 2kV	1	
9		FG3000-420-100	Switch, Block	1	
10		FG3000-370-110	Terminal Pin, Male	4	2
11	C19	FG3000-191-100	Capacitor, Trimmer	1	1
12		FG3000-370-107	Fuse Clip	2	2
13		FG3000-504-21	Complete Board Assembly	1	1

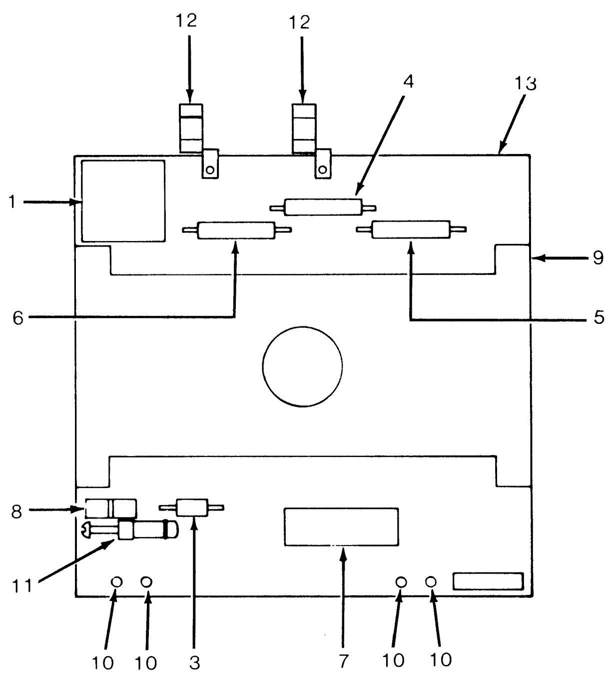


Figure 5-6. Small Circuit Board Assembly (RMS 3030 and TECH 330) for Part Location

CIRCUIT BOARD AND DISPLAY ASSEMBLY **Parts List for Figure 5-7**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1			Circuit Board Assembly Large	1	
2		FG3000-410-114	Series 300 LCD Retainer Assembly	1	
2		FG3000-410-113	Series 3000 LCD Retainer Assembly	1	
2A		FG3000-920-600	Mask Window, Series 300	1	
2A		FG3000-920-601	Mask Window, Series 3000	1	
2B		FG3000-420-107	Retainer, Liquid Crystal Display	1	
3		FG3000-390-100	Liquid Crystal Display (3½ Digits)	1	1
4		FG3000-370-102	Elastomeric Connector, Carbon-Filled	1	2
5		FG3000-420-111	Connector, Liquid Crystal Display	1	2
6		FG3000-420-110	Connector, Multiprocessor Chip	1	
7		FG3000-370-103	Connector, Elastomeric Silver Filled	2	2
8	U4	FG3000-270-100	Integrated Circuit, Multiprocessor	1	1
9		FG3000-420-108	Chip Retainer	1	

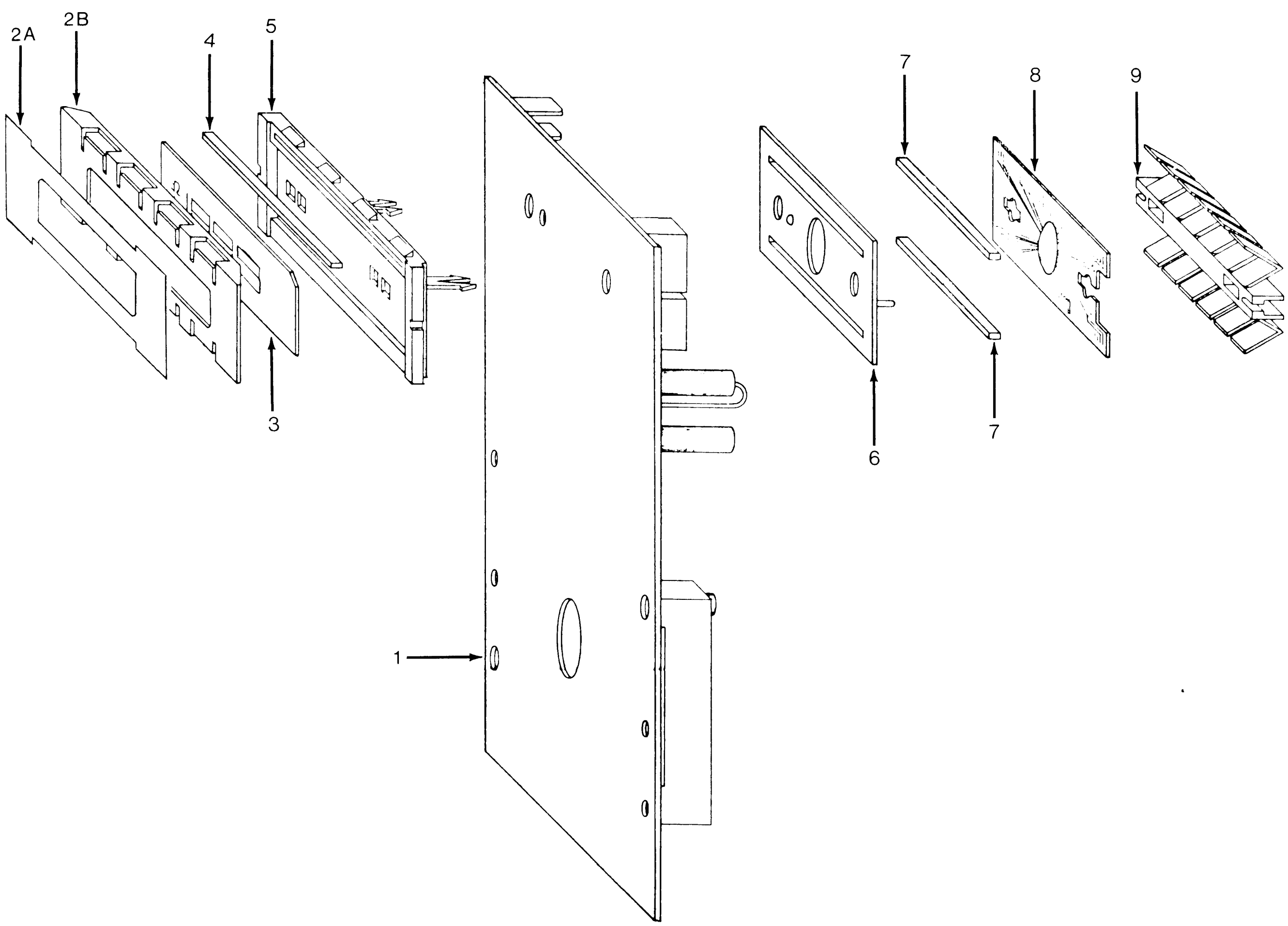


Figure 5-7. Circuit Board and Display Assembly

LARGE CIRCUIT BOARD ASSEMBLY (3010, 3020, TECH 300, TECH 310) **Parts List for Figure 5-8**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1	C2,5	FG3000-111-100	Capacitor, 0.22 μf/25V, Min., Ceramic	2	
2	C10	FG3000-101-100	Capacitor, 470 pf, Disc Ceramic	1	
3	C8,9	FG3000-130-102	Capacitor, 0.22 μf, 100V, Min., Metallized Polyester	2	
4	C6	FG3000-130-101	Capacitor, 0.022 μf, 250V, Metallized Polyester	1	
5	C4,7	FG3000-130-100	Capacitor, 0.047 μf, 250V, Metallized Polyester	2	
6	C3,11	FG3000-151-101	Capacitor, 10 μf/10V, Min., Tantalum	2	
7	C12	FG3000-151-100	Capacitor, 3.3 μf/20V, Min., Tantalum	1	
8	CR1,2,3	FG3000-201-100	Diode, Small Signal	3	
9	VR1	FG3000-231-102	Diode, Reference, 1.2V	1	
10	VR2,3	FG3000-231-101	Diode, Zener, Low Leakage	2	
11	R7	FG3000-1-474	Resistor, 470k Ohm +5%, ¼W	1	
12	R6	FG3000-1-101	Resistor, 100 Ohm +5%, ⅓W	1	
13	R8	FG3000-51-102	Resistor, 2M Ohm +5%, 3W	1	
14	R9	FG3000-51-101	Resistor, 200k Ohm +5%, 3W	1	
15	U3	FG3000-300-100	Resistor Network, 10-Pin Sip	1	
16	R10	FG3000-81-100	Resistor, Positive T.C.	1	
17	U2	FG3000-310-100	Reference Divider, Thin Film	1	
18	R5	FG3000-90-101	Variable Resistor, 10k +10%	1	
19	Q2	FG3000-251-102	Transistor, NPN, Darlington MPS A12	1	
20	Q1	FG3000-251-101	Transistor, NPN, General Purpose, 2N 5088	1	
21	Q3,4	FG3000-251-100	Transistor, PNP, General Purpose, 2N 4126	2	
22		FG3000-371-105	Connector, Battery Snap Terminals	1	2
23		FG3000-370-101	Connector, Female, 5-Pin	1	
24		FG3000-420-100	Switch Block	1	
25		FG3000-501-21	Large Circuit Board Assembly	1	1

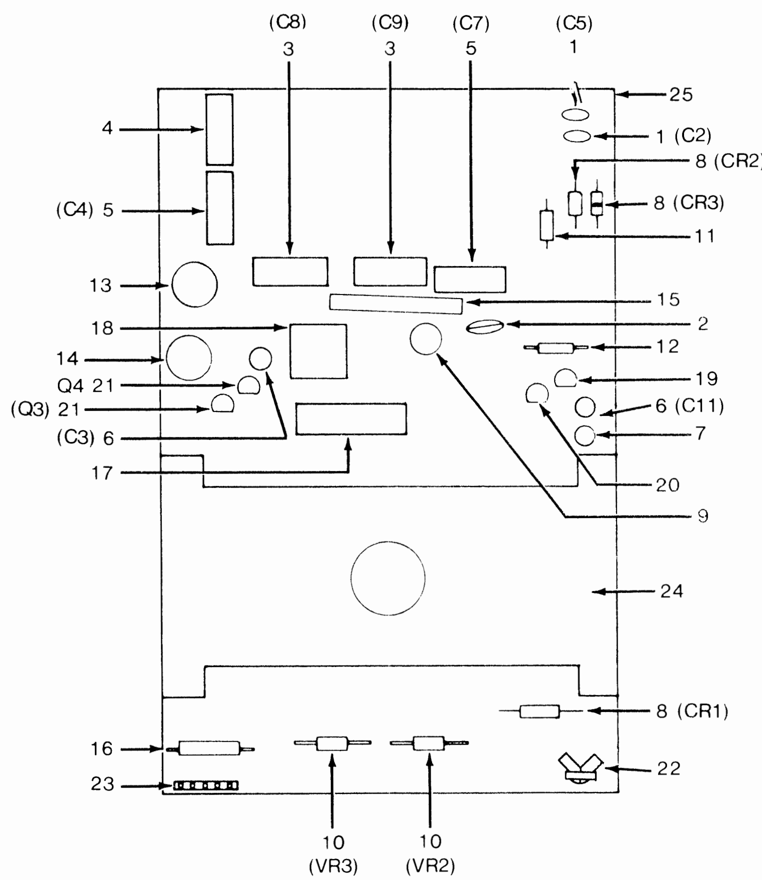


Figure 5-8. Large Circuit Board Assembly (3010, 3020, TECH 300, TECH 310) for Part Location

LARGE CIRCUIT BOARD ASSEMBLY (RMS 3030 AND TECH 330) **Parts List for Figure 5-9**

Index No.	Ref Des	Beckman Part No.	Description	Qty Per Assembly	Spare Parts Qty
1	C5	FG3000-111-100	Capacitor, 0.22 μf, 25V, Min., Ceramic	1	
2	C14,15	FG3000-101-101	Capacitor, 33 pf, Disc Ceramic	2	
3	C10,13,16	FG3000-101-100	Capacitor, 470 pf, Disc Ceramic	3	
4	C18	FG3000-101-102	Capacitor, 4.7 pf, Disc Ceramic	1	
5	C4,7	FG3000-130-100	Capacitor, 0.047 μf, 250V Min., Metallized Polyester	2	
6	C8,9	FG3000-130-102	Capacitor, 0.22 μf, 100Vdc, Min. Metallized Polyester	2	
7	C6	FG3000-130-101	Capacitor, 0.022 μf, 250Vdc, Min., Metallized Polyester	1	
8	C17	FG3000-151-102	Capacitor, 47 μf/6V, Min., Tantalum	1	
9	C11,C2	FG3000-151-101	Capacitor, 10μf/10V Min. Tantalum	2	
10	C12	FG3000-151-100	Capacitor, 3.3 μf/20V Min., Tantalum	1	
11	CR1	FG3000-231-102	Diode, Reference, 1.2V	1	
12	VR2,3	FG3000-231-101	Diode, Zener, Low Leakage	2	
13	CR1,2,3	FG3000-201-100	Diode, Small Signal	3	
14	U6	FG3000-270-102	Integrated Circuit, Hex Inverter 4069	1	1
15	U7	FG3000-270-101	Integrated Circuit, RMS Converter	1	1
16	R5, U2	FG3000-90-101	Resistor, Variable, 10k +10%	1	
17	R12	FG3000-1-120	Resistor, 12 Ohm +5%, ¼W	1	
18	R7	FG3000-1-474	Resistor, 470k Ohm +5%, ¼W	1	
19	R6	FG3000-1-101	Resistor, 100 Ohm +5%, ¼W	1	
20	R11	FG3000-1-165	Resistor, 1.6 Megohm +5%, ¼W	1	
21	R8	FG3000-51-102	Resistor, 2M Ohm +5%, Metal Film, 3W	1	
22	R9	FG3000-51-101	Resistor, 200k Ohm +5%, Metal Film, 3W	1	
23	U5	FG3000-300-102	Resistor, Network, 8-Pin Sip	1	
24	U3	FG3000-300-100	Resistor, Network, 10-Pin Sip	1	
25	R10	FG3000-81-100	Resistor, Positive, T.C.	1	
26	R14	FG3000-90-102	Resistor, Variable, 500 Ohm +10%	1	
27	R13	FG3000-90-103	Resistor, Variable, 5M Ohm +20%	1	
28	U2	FG3000-310-100	Reference Divider, Thin Film	1	
29	Q2	FG3000-251-102	Transistor, NPN Darlington, MPS A12	1	
30	Q1	FG3000-251-101	Transistor, NPN, General Purpose, 2N5088	1	
31		FG3000-371-105	Connector, Battery Snap Terminals	1	
32		FG3000-370-101	Connector, Female, 5-Pin	1	
33		FG3000-420-100	Switch Block	1	
34		FG3000-503-21	Large Circuit Board (assembly)	1	1

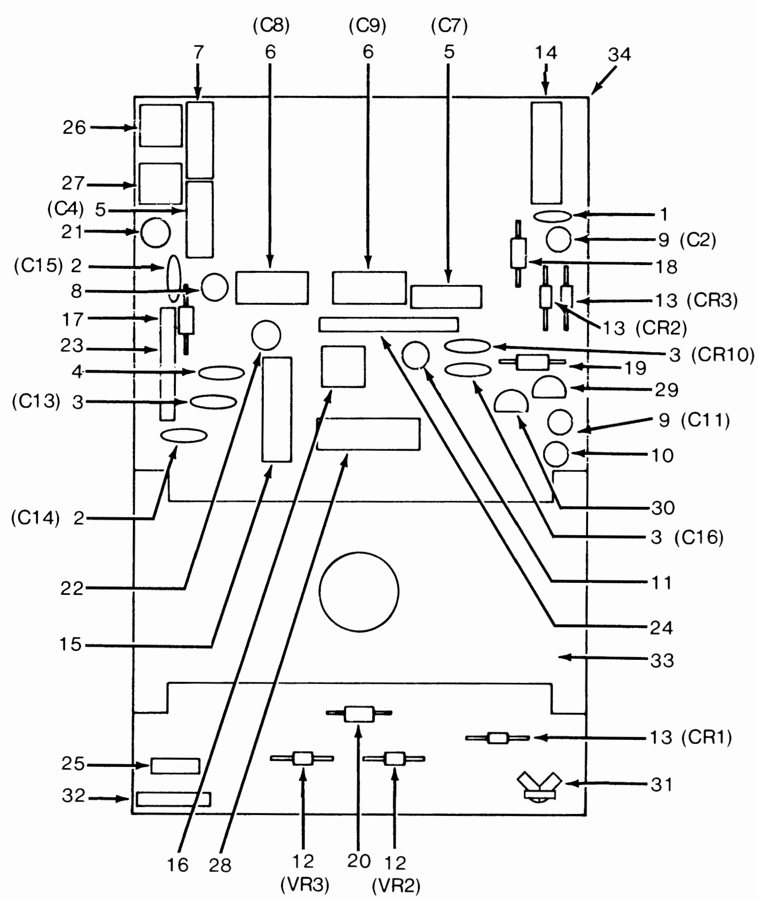


Figure 5-9. Large Circuit Board Assembly (RMS 3030 and TECH 330) for Part Location

Beckman Instruments, Inc.
Fullerton, CA 92634

January 1981 802802 3000-940-110 Printed in U.S.A.

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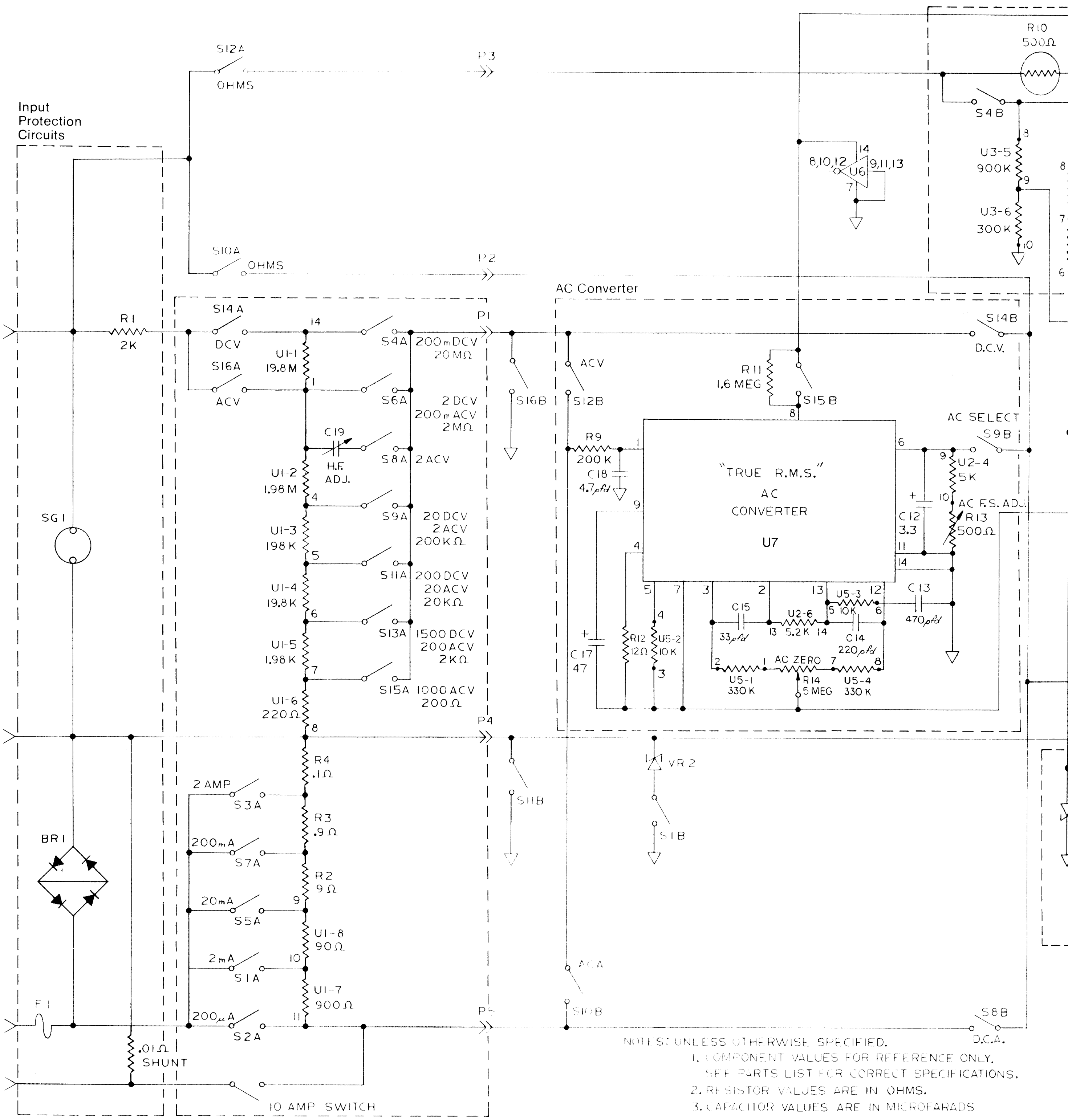
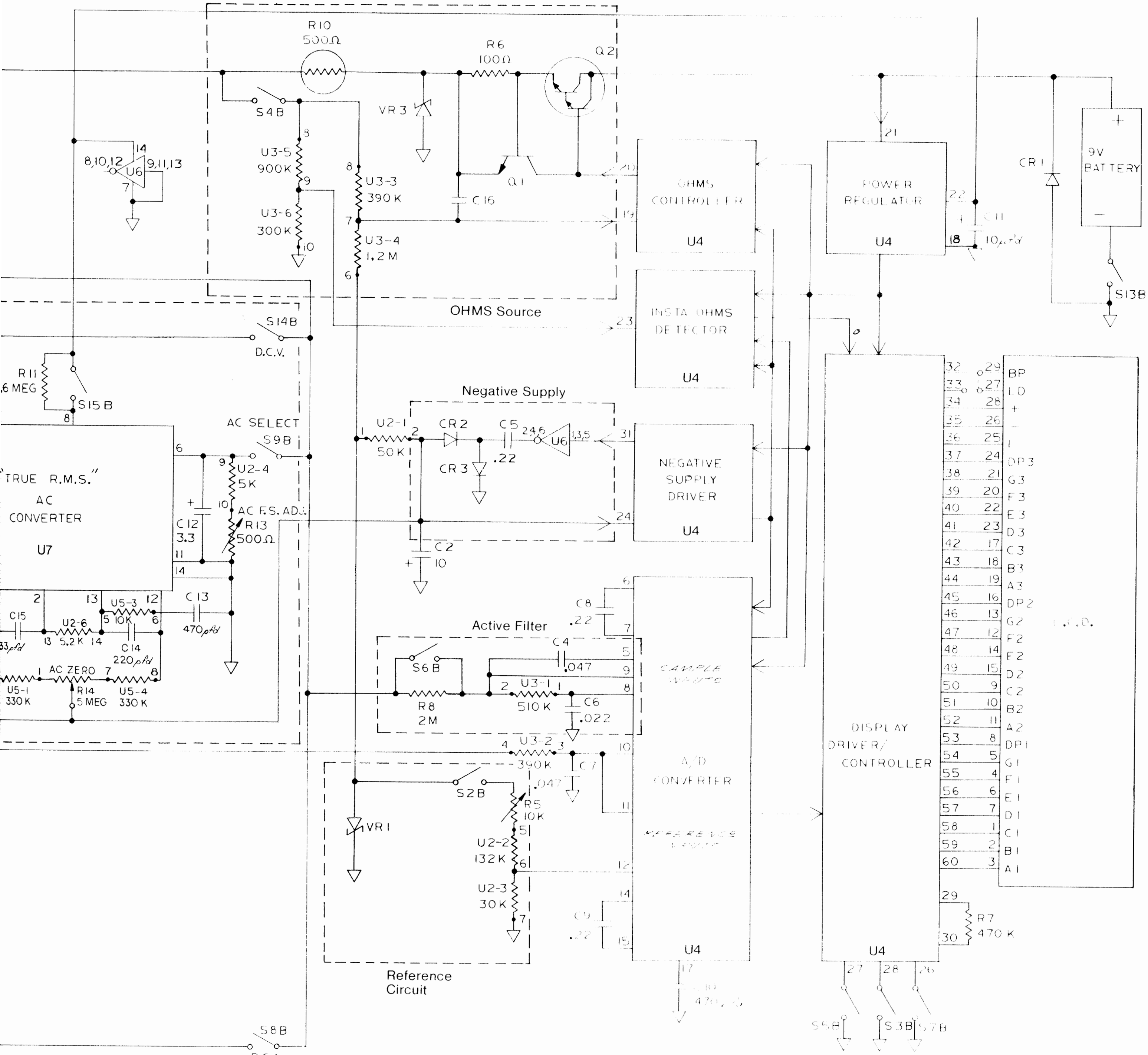


Figure 4-3B. Multimeter Schematic Diagram (RMS 3030, TECH 330)



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PACITOR VALUES ARE IN MICROFARADS

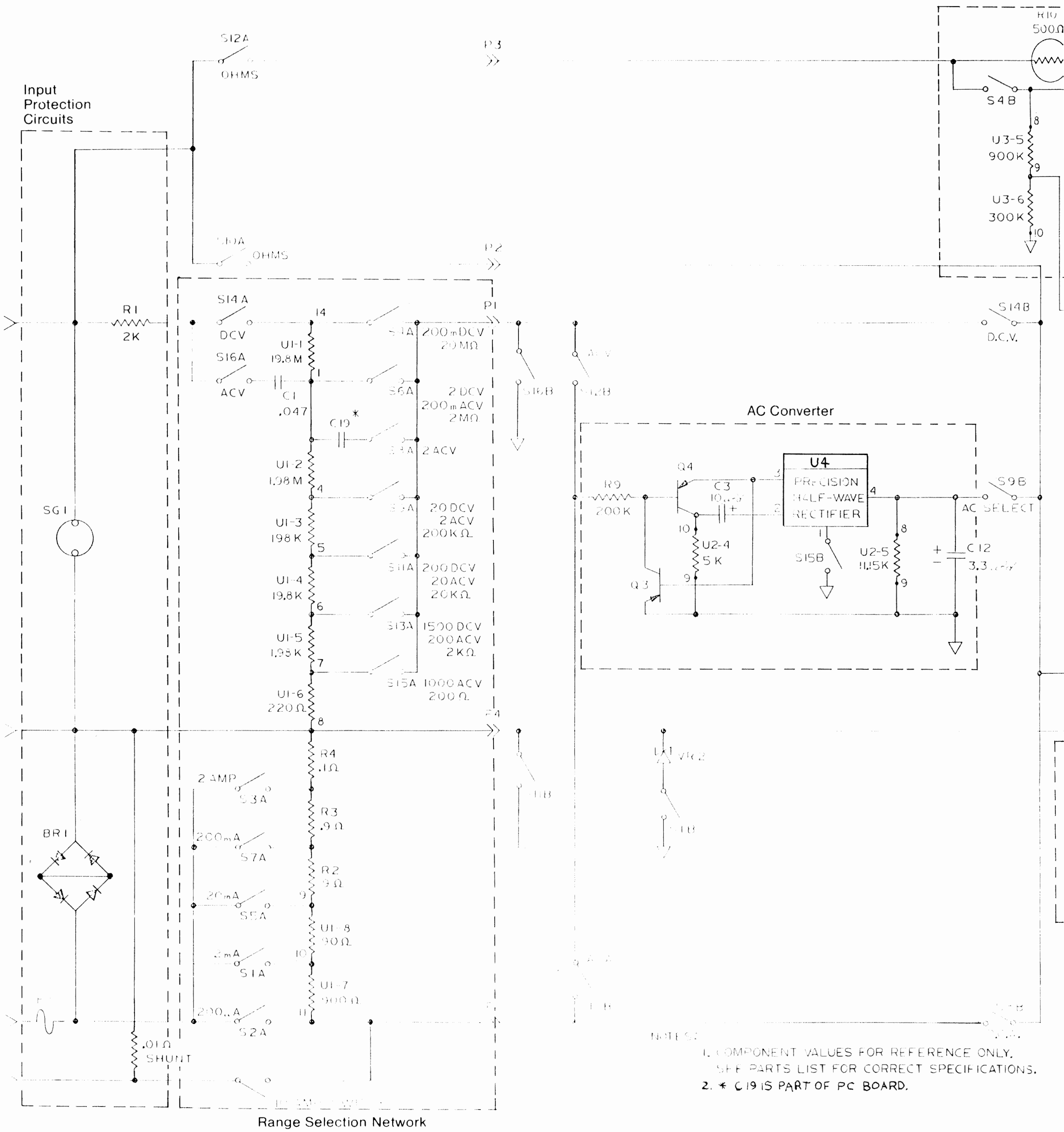
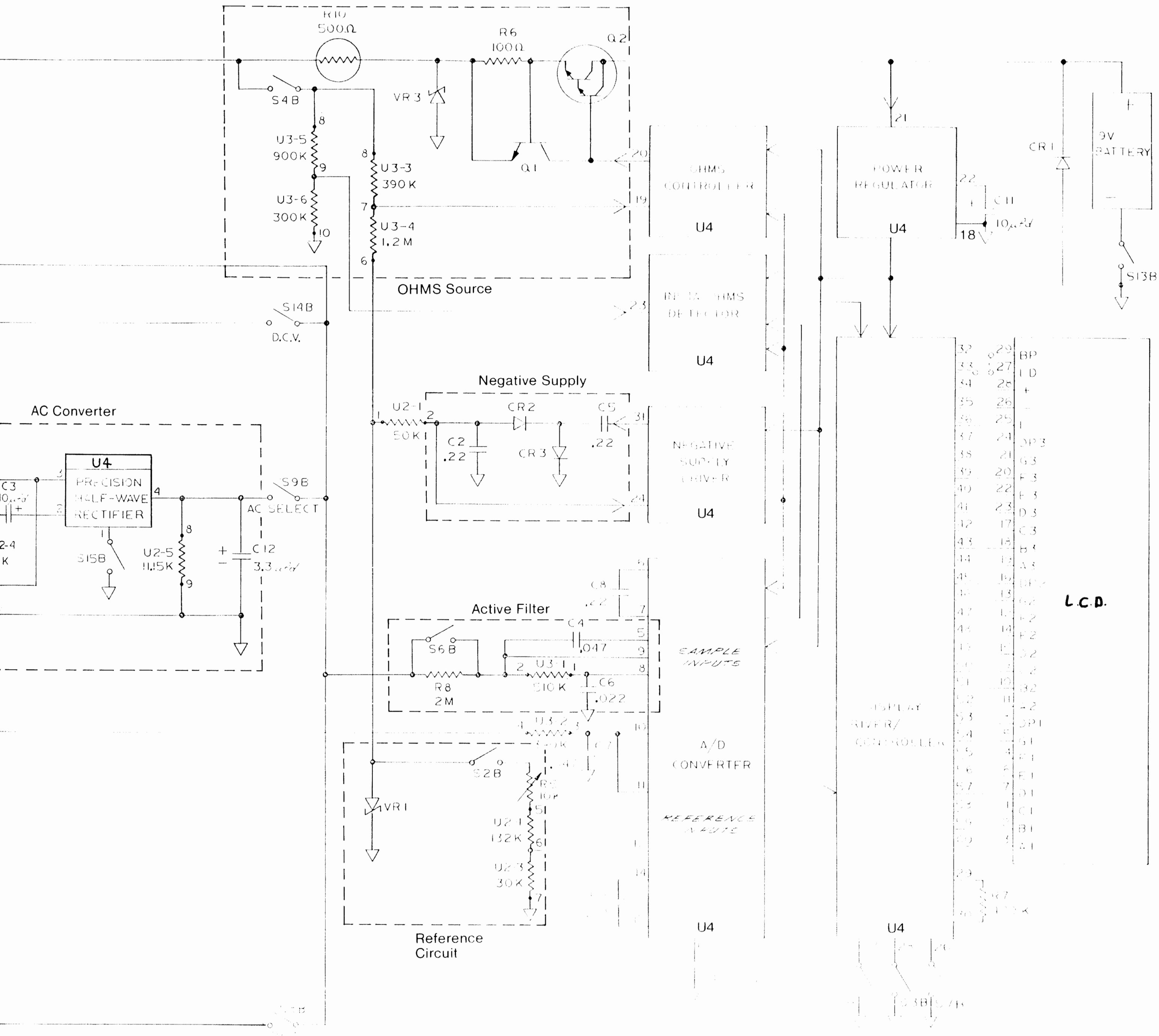


Figure 4-3A. Multimeter Schematic Diagram (TECH 300, TECH 310, 3010, 3020)



COMPONENT VALUES FOR REFERENCE ONLY.
SEE PARTS LIST FOR CORRECT SPECIFICATIONS.
* C19 IS PART OF PC BOARD.