BERKELEY INSTRUMENTS INC.

Effective April 19, 1973, Beckman Instruments, Inc. sold the Digital product line to

BERKELEY INSTRUMENTS, INC.
1701 Reynolds Street
Santa Ana, California 92705

All inquiries and communications regarding the product line should be directed to the Customer Service Department of Berkeley Instruments at the above address.

1701 Reynolds Street • Santa Ana, California 92705 • (714) 556-0623

BII No. 015-436114

MODEL 998

Linear IC Tester

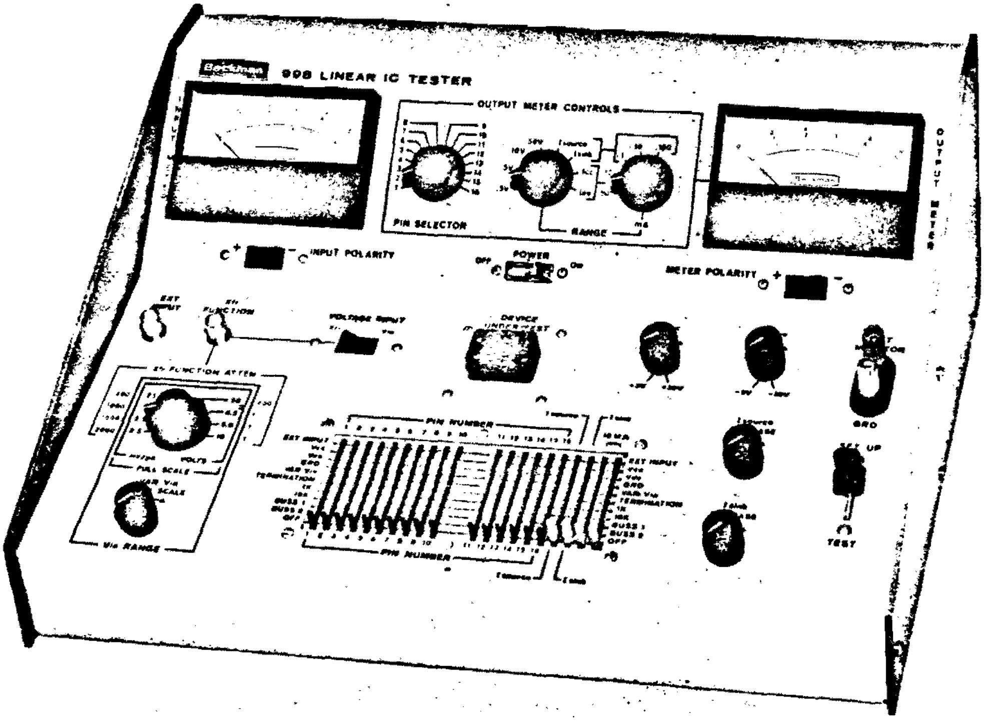
(PREFIX 501)

LOT 4

SERIAL NO. ________

Electronic Instruments Division
3300 River Road
Schiller Park, Illinois 60176
Tel: (312) 671-3300

AUGUST 1968
(REV. 3-70)



Model 998 Linear IC Tester

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continued. . .

ILLUSTRATIONS

TABLES

SECTION 1
INTRODUCTION

1.1 GENERAL

The Beckman Model 998 Linear IC Tester provides the user with the most important considerations sought in testing of linear integrated circuits. It tests all important dc parameters including input offset voltage, input offset current, input bias current, input voltage range, open loop gain, supply current levels, and power dissipation. In addition, device output voltage limits, output current capabilities, equivalent input noise voltage and output resistance may be measured. With peripheral equipment, supply voltage sensitivity and transfer functions may be examined.

Operator controls have been functionally positioned to facilitate a continuous visual indication of input and output voltage of the device under test. Expensive and lengthy programming is not required with the Model 998. This instrument is used by laboratories, quality assurance, manufacturing, and educational facilities. Anyone knowledgeable of linear ICs can quickly set up and operate the IC Tester; anyone studying linear ICs can use the tester for practical demonstrations of integrated circuit theory, and for learning and checking the characteristics of linear ICs.

1.2 SPECIFICATIONS

Specifications for the Model 998 are given in Table 1-1.

Table 1-1. Specifications

Vcc (Device Supply)	Continuously variable from +3 to +30V.
Vee (Device Supply)	Continuously variable from -3 to -30V.
Current Source (Output Capability)	50 μa to 100 ma (±5% of full scale), adjustable in 3 ranges.
Current Sink (Output Capability)	50 μa to 100 ma (±5% of full scale), adjustable in 3 ranges.
Input Voltage (Input Offset Voltage, Input Voltage Range)	±2.5 mV, ±5 mV, ±10 mV, ±25 mV, ±50 mV, ±0.5V, ±5V, ±10V; All ranges zero to full scale (±5% of full scale).
Input Current (I input, I offset)	±2.5 μa, ±5 μa, ±10 μa, ±25 μa, ±50 μa; All ranges zero to full scale (±5% of full scale); ±50 ma full scale on inverting inputs.

. . . continued

Table 1-1. Specifications (continued)

Output Current (Device Supply Requirement)	±10 ma, ±50 ma; (±5% of full scale).
Meters - INPUT METER:	Monitors input voltage and current. Polarity of readout is determined by INPUT POLARITY selector switch. Ranges are called out under Input Current and Voltages specifications. INPUT METER system accuracy ±5% of full scale.
OUTPUT METER:	Any pin of the IC socket may be monitored. Voltage measurements are referenced to ground. Voltage ranges available are ±0.5V, ±5V, ±10V, and ±50V. The meter measures current source and current sink tests with full scale ranges of 1, 10, 100ma. Vcc and Vee supply current are measured on 10 and 50 ma Iee, Icc ranges. OUTPUT METER system accuracy ±5% of full scale.
Transfer Function (Xfr FUNCTION)	A switched input to allow input of an external waveform for XY display of device characteristics. The input waveform is controlled by an attenuator on the Input Voltage Range (Vin RANGE) switch. Offset voltages can be applied during transfer function operation for comparison of typical parameters. The transfer function input may be used to apply an external dc voltage for increased resolution in gain measurement.
External Monitor (EXT MONITOR)	An oscilloscope or digital voltmeter may be used to monitor any pin of the IC.
TEST/SETUP Switch	In SETUP, all power is removed from the IC.
Short Circuit Protection	All voltages supplied are protected against short circuits.
Power Required	115/230V ac (switch selected) 50 to 400 Hz.
Input Power	15 watts.

. . . . continued

Table 1-1. Specifications (continued)

Types of IC Packages Accepted	14-pin, dual-in-line (Option C-1) 16-pin, dual-in-line (Option C-2) 8-pin, TO-99 (Option C-3) 10-pin, TO-99 (Option C-4) 12-pin, TO-99 (Option C-5) 14-pin, TO-99 (Option C-6) 14-pin, 1/4" x 1/4" flat-pack (Option C-7) 14-pin, 1/8" x 1/4" flat-pack (Option C-8) Optional adapters C-1 through C-8 available. Modified C-1 through C-8 options available with a universal PC board for access terminations to the device. Convenient for adding compensation elements.
Operating Temperature	+15° to +45° C.
Dimensions	16-1/2 inches wide, 7 inches high, 12-1/4 inches deep.
Weight	10 pounds.

SECTION 2
INSTALLATION & OPERATION

2.1 UNPACKING AND HANDLING

The Model 998 is thoroughly tested and inspected before shipment, then carefully packed. The unit should be unpacked with the care due any precision instrument. If the package shows it has been dropped or handled roughly, return it to the carrier unopened.

Remove the packing carton and the braces, being careful not to scar or damage the unit. Make a complete visual inspection of the equipment, checking for damage or missing components. Check that all switches and controls operate mechanically. Report any damage immediately to Beckman Instruments, Inc., Electronic Instruments Division.

2.2 RESHIPPING

Should it become necessary to return the unit to the factory for any reason, follow these packing instructions:

1) Wrap the unit in polyethylene sheeting, sealing all sides.
2) Punch small air holes in the sheeting.
3) Wrap the unit in rubberized hair and pack in a carton.
4) Seal the carton and mark it clearly: "FRAGILE -- HANDLE WITH CARE".

2.3 INSTALLATION

No special installation requirements are necessary. Simply determine whether 115 volt or 230 volt ac power is available, and set the rear-panel switch accordingly. Then plug the power connector into power source.

2.4 OPERATING CONTROLS & CONNECTORS

Operating controls and connectors of the Model 998 Linear IC Tester are shown in Figure 2-1 and described in the following paragraphs. In the text, all controls and connectors are called out as they appear on the equipment. For example, set the POWER switch to the ON position.

2.4.1 Meter Panel

Located in the top portion of the front panel, this section is used for monitoring input and output voltages and currents. The meter panel includes two 100 microampere meters (OUTPUT METER and INPUT METER), one 16-position PIN SELECTOR rotary switch, two RANGE selector switches, and three rocker switches (METER POLARITY, INPUT POLARITY, and POWER). These are described in Table 2-1. The circled numbers in the table refer to callouts in Figure 2-1.

2.4.2 Control Panel

The control section is located in the lower portion of the front panel, and consists of a programming matrix, an IC adapter socket (DEVICE UNDER TEST), and various controls for setting up test parameters. The IC under test plugs into an adapter, and the adapter plugs into the DEVICE UNDER TEST socket. Adapters are optionally provided with the instrument to accommodate all IC packages currently on the market.

The programming matrix is described in Table 2-2, and a simplified schematic diagram of the matrix is shown in Figure 2-2.

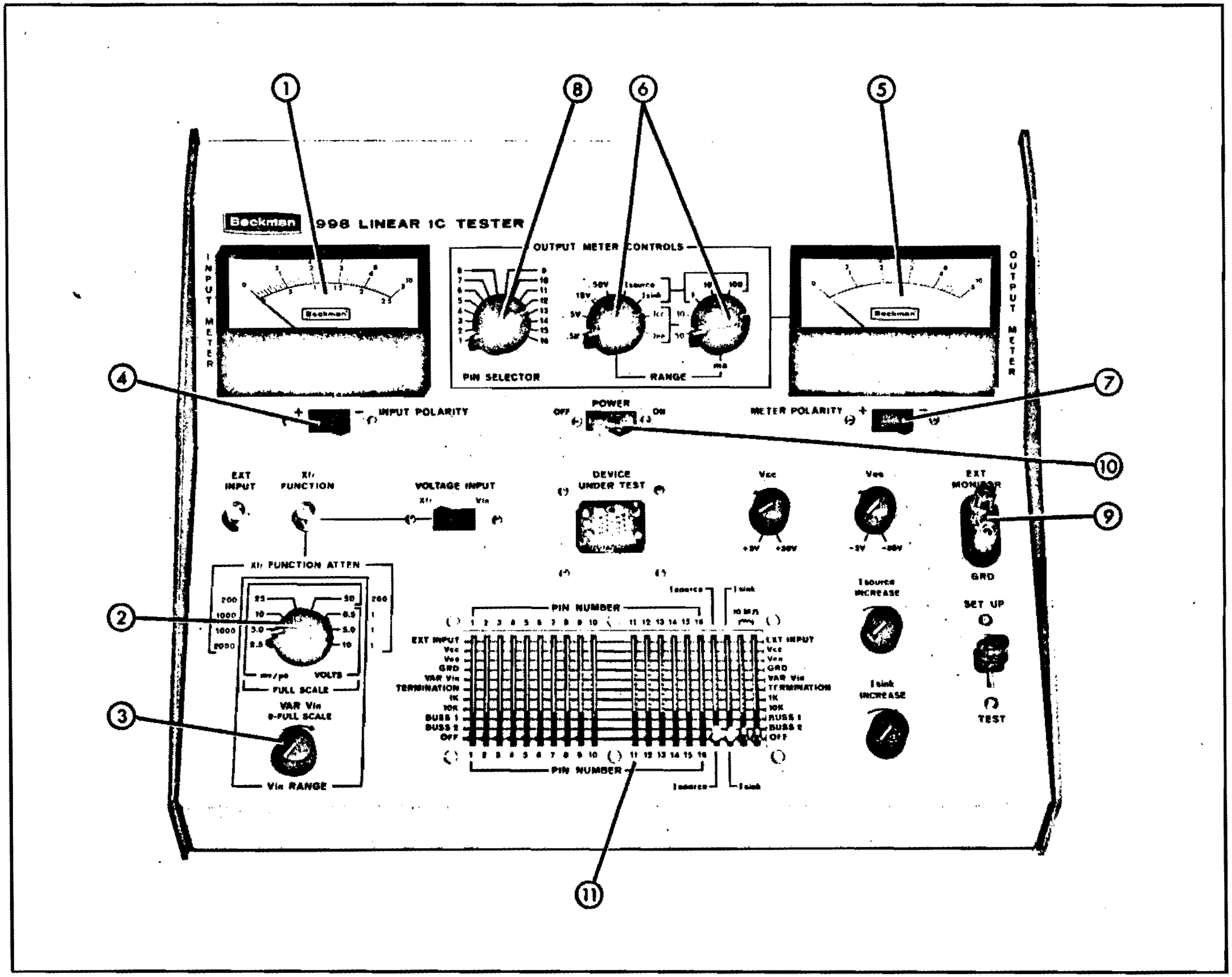


FIG. 2-1. Operating Controls.

Table 2-1. Meter Panel Controls

CONTROL	FUNCTION
INPUT METER (1)	Indicates voltage or current, depending upon the particular test being made. It monitors the voltage controlled by the Vin RANGE switch (2) and VAR Vin ten-turn potentiometer (3) (lower left section of front panel). The polarity of the INPUT METER is determined by the INPUT POLARITY switch (4), and all meter ranges are controlled by the Vin RANGE.
OUTPUT METER (5)	Indicates voltage or current, depending upon the settings of the RANGE switches (6). In the first four positions (middle switch), the meter indicates 0.5V, 5V, 10V, or 50V full scale. The polarity of the voltage to be read is positive if the METER POLARITY switch (7) is set positive; the 16-position PIN SELECTOR switch (8) is used to select the output. The right side of the OUTPUT METER is referenced to ground for voltage measurements. In the I source position, the OUTPUT METER indicates the amount of current drawn by the IC (integrated circuit) under test from a variable constant current source. The current may be 1 ma, 10 ma, or 100 ma full scale depending upon the setting of the 3-position RANGE (right-hand) switch. In the I sink position, the meter measures the current flowing out of the IC under test into a current sink. The current may be 1 ma, 10 ma, or 100 ma, again depending upon the setting of the RANGE switch. The amount of current flowing out of, or into, the IC under test will not exceed the range selected. The last two positions of the left-hand RANGE switch (middle in Output Meter Controls series) are not related to the I source and I sink controls. The 10 ma and 50 ma positions are convenient for measurement of supply current requirements to the ICs.
PIN SELECTOR (8)	To measure voltage and current at any pin of the IC under test. The PIN SELECTOR rotary switch provides access to each pin of the IC under test. The arm of the switch directs the pin selected directly to the voltage measurement positions of the RANGE selector switches. The signal selected by the PIN SELECTOR switch appears on the EXT MONITOR terminal posts (9). Therefore, every pin of the IC under test can be brought out of the tester for further analysis by an external digital voltmeter, oscilloscope, etc.
POWER Switch (10)	Illuminated rocker switch which controls the input power to the instrument.

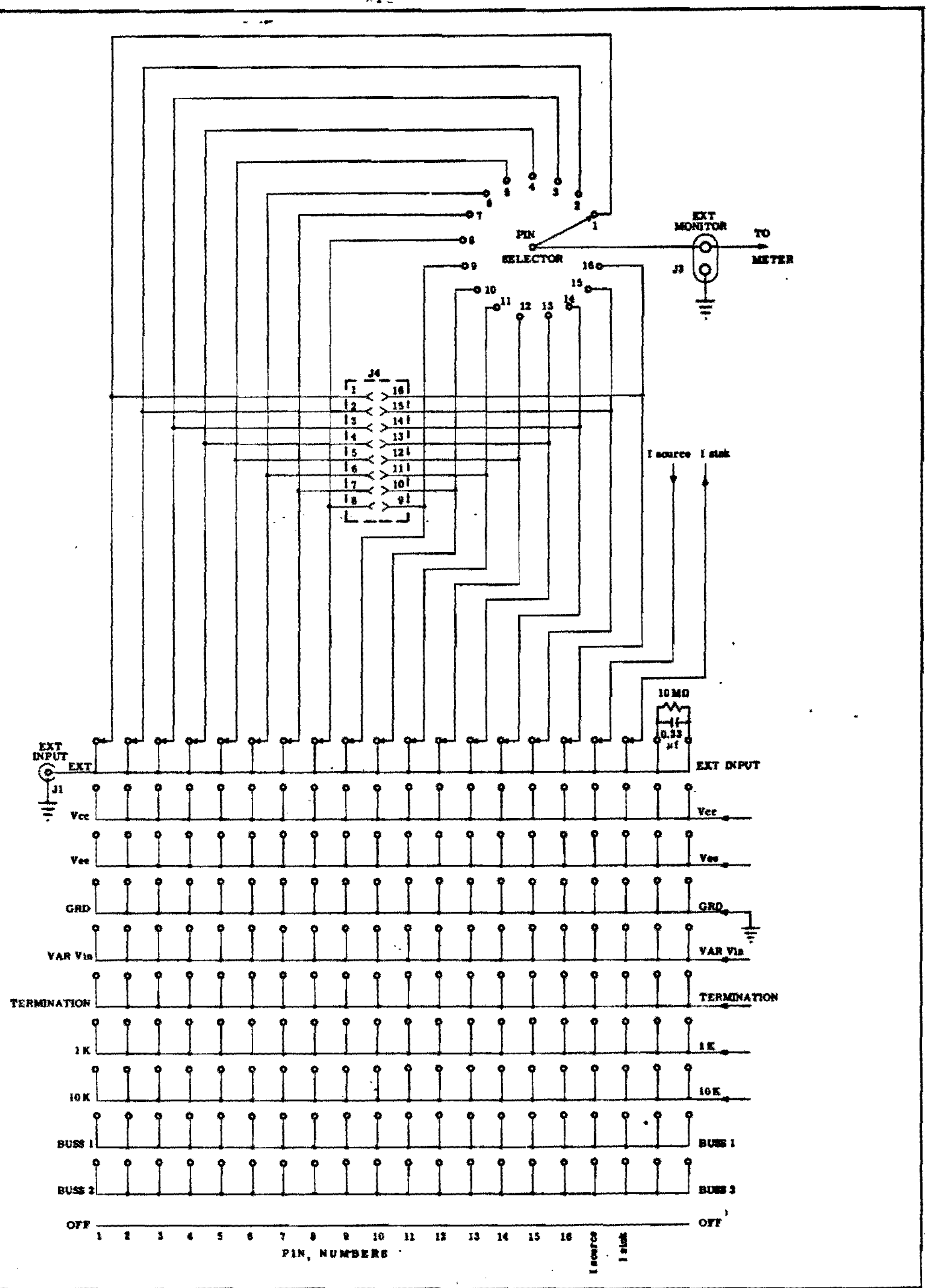


FIG. 2-2. Programming Matrix and Pin Selection Simplified Schematic Diagram.

Table 2-2. Programming Matrix

Programming Matrix (11)	Made up of 20 separate 11-position slider switches. The positions of the switches are indicated by horizontal lines; at either end of the horizontal lines the function or signal associated with that position of the switch is indicated. See Figure 2-3. The vertical lines through the programming matrix represent the arms of the switches. Associated with the first sixteen (16) switches are the pins of the IC adapter socket. The remaining four switches are for a current source and a current sink. DC signals are applied to the various pins of the IC under test by sliding the corresponding switches to the signal or function positions. Thus, to apply Vee to pin 5 of the IC under test, simply slide the PIN NUMBER 5 switch to the Vee position. The various signals and interconnections that are present at the programming matrix are described in the following paragraphs in the order that they appear on the program matrix.

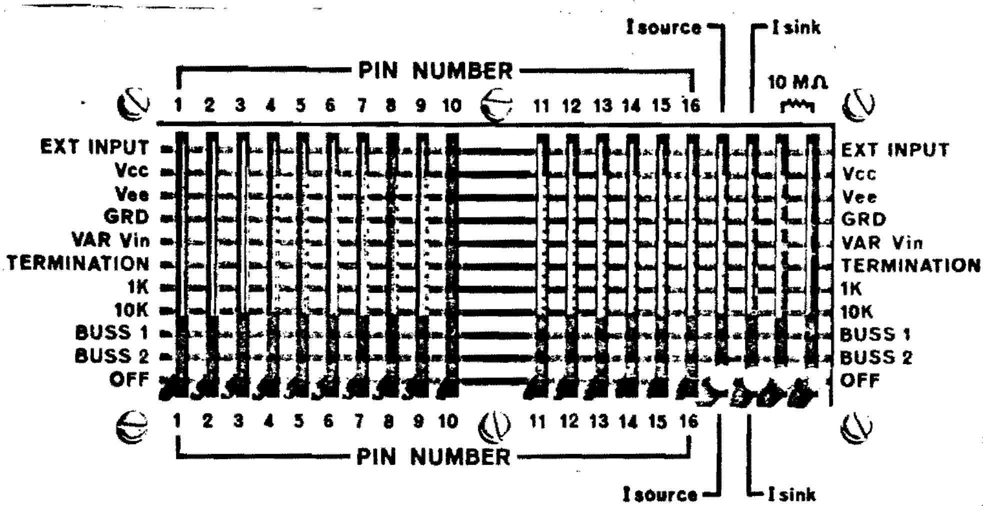
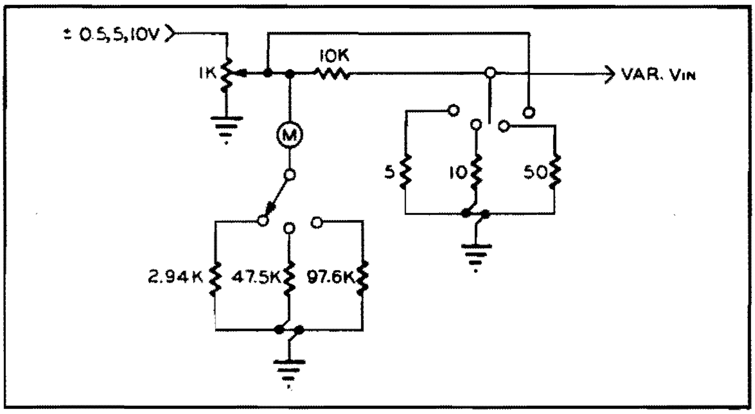


FIG. 2-3. Programming Matrix.

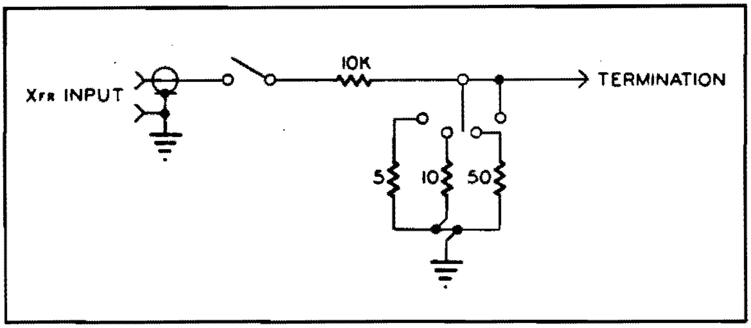
. . . continued

Table 2-2. Programming Matrix (continued)

SWITCH POSITION	FUNCTION
EXT INPUT	a direct line to the EXT INPUT BNC connector (center-left on panel). This position is available for introducing a signal into the instrument that is not supplied by the IC tester. It can also be used to interconnect pins or to connect an external load, which can then be connected to any pin.
Vcc	supplies a variable voltage to the programming matrix, from +3 to +30 volts dc, with a current capability of up to 100 ma. The amplitude of this voltage is controlled by the variable Vcc control (located right of the matrix). No voltage is applied until the TEST/SETUP lever switch (right side of panel) is in the TEST position. The supply is short circuit protected.
Vee	identical to the Vcc supply except for polarity. This position supplies -3 to -30 volts dc and is current limited. The amplitude is adjusted by means of the variable Vee control. Again, no voltage is applied until the TEST/SETUP lever switch is in the TEST position.
GRD	ground is the reference for all voltages of the IC tester.
VAR Vin	supplies a controlled dc voltage for applications to device input terminals. The polarity and magnitude of the voltage are selected by the input controls. The polarity is selected by the INPUT POLARITY switch; the magnitude is controlled by the Vin RANGE selector and potentiometer. The voltage is also monitored on the INPUT METER as shown in Figure 2-4. The source resistance for the voltage supply is a function of the Vin RANGE selector position. From the 2.5 mV to the 50 mV range the maximum source resistance is 50 ohms. The 0.5, 5, and 10V positions are meant to be used for maximum common mode and differential voltage measurements.  FIG. 2-4. VAR Vin: Simplified Schematic.

. . . . continued

Table 2-2. Programming Matrix (continued)

SWITCH POSITION	FUNCTION
TERMINATION	allows the second input of a differential input amplifier to be equally terminated with the voltage source VAR Vin. Also the transfer function input is applied to the TERMINATION input terminal. As shown in Figure 2-5, the voltage is applied to a BNC connector, attenuated by a selected factor, and then applied to the TERMINATION input terminal. This particular technique allows the application of a dc signal to the VAR Vin terminals to offset transfer functions while they are being displayed.  FIG. 2-5. TERMINATION Simplified Schematic.
1K Position	a 1K ohm, 1% resistor to ground bypassed by a $1 \mu f$ capacitor. This position is used as the termination point during input current measurements.
10K Position	a 10K ohm, 5% resistor to ground, used as a load for device output.
BUSS 1 and BUSS 2	serve as interconnecting lines between pins of the IC under test, or they can provide a current source or a current sink. When used as interconnecting lines, the switches corresponding to pin numbers being interconnected are positioned on the same BUSS line. For other applications, the switch that provides the function is first set to either BUSS line. The PIN NUMBER switches are then moved to the BUSS line as required. <u>EXAMPLE</u>: Assume that a current source must be directed to pin number 14. The setup is made as follows: a) The I source switch to BUSS 1. b) The PIN NUMBER 14 switch to BUSS 1. With the switches in these positions, it is then possible to monitor voltage or current levels depending on the specific measurement requirements.

. . . . continued

Table 2-2. Programming Matrix (continued)

<table>
<tr><th>SWITCH POSITION</th><th>FUNCTION</th></tr>
<tr><td>I source</td><td>a constant current source. This switch is usually positioned on the EXT INPUT, BUSS 1, or BUSS 2 line. The line on which it is placed then becomes the current source for any of the IC pins under test.

Figure 2-6 is a simplified schematic diagram of the current source (I source) circuit. The amount of current supplied by the circuit is adjusted by the I source control (located to the right of the matrix). The +33 volt supply to the current source circuit is applied only when the TEST/SETUP lever switch is in the TEST position.

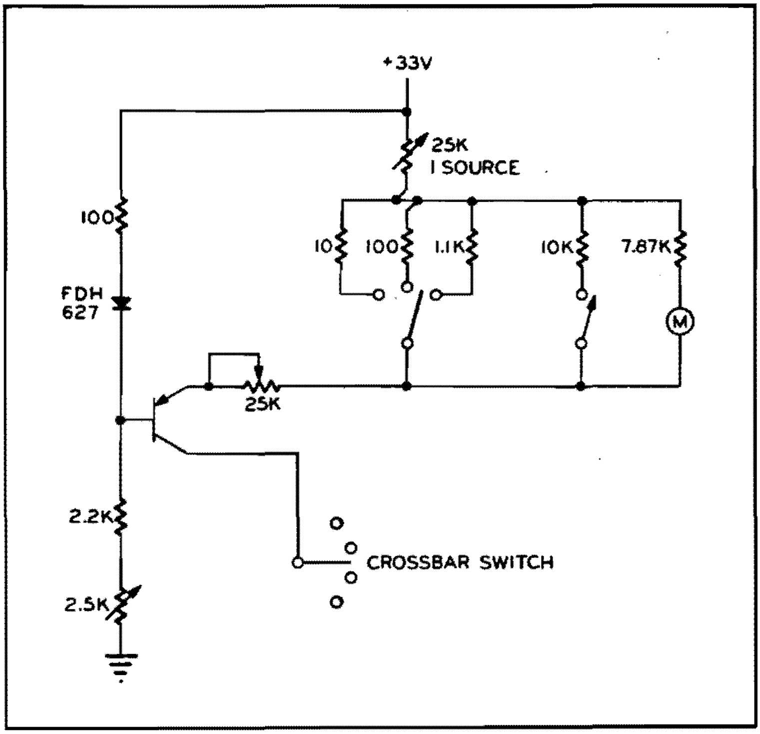


FIG. 2-6. I source Simplified Schematic.</td></tr>
<tr><td>I sink</td><td>switch is generally positioned on the EXT INPUT, BUSS 1, or BUSS 2 line. The line at which it is placed then becomes the current sink for any of the IC pins under test. A simplified schematic of the current sink (I sink) circuit is given in Figure 2-7.</td></tr>
</table>

. . . continued

Table 2-2. Programming Matrix (continued)

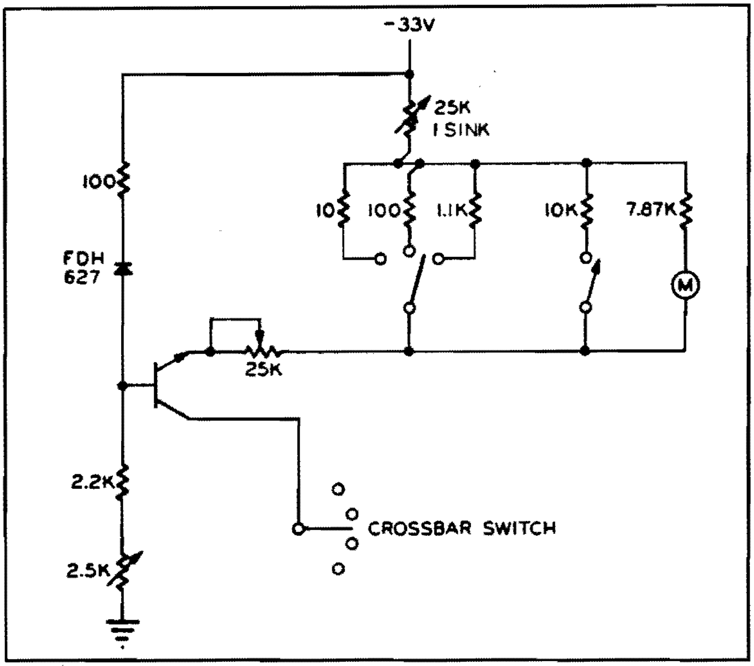
<table>
<tr><th>SWITCH POSITION</th><th>FUNCTION</th></tr>
<tr><td></td><td>


FIG. 2-7. I sink Simplified Schematic.
</td></tr>
<tr><td>10 MΩ</td><td>
conveniently used for measuring bias current in some applications. It is most easily used in a differential-input, single-ended output amplifier as shown in Figure 2-8.

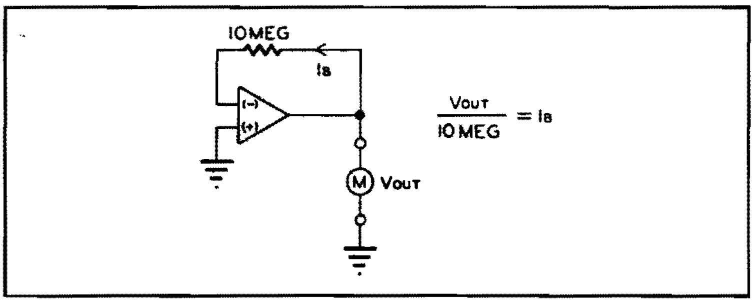


FIG. 2-8. 10 MΩ Connection for Bias Current Measurement.

The feedback is returned to the inverting input to keep the system stable. Minimum current resolution is measured on the OUTPUT METER 0.5V scale (10 ma/division).
</td></tr>
</table>

2.5 OPERATING PROCEDURES

2.5.1 General

A complete procedure for testing a typical operational amplifier IC is given in the following paragraphs. This is broken down into the various measurements, such as Input Offset Voltage, etc., which are described in Section 3. A thorough understanding of these measurement techniques is advisable before proceeding with the testing.

The IC chosen to be tested is the Fairchild 709 Operational Amplifier. Before testing begins, set up the power supply and crossbar switches in the following manner with the device to be tested out of the socket:

2.5.2 Crossbar Switches and Power Supply Setup (Fairchild μA709)

1) Set all programming matrix switches to OFF position.

2) Set the appropriate PIN NUMBER switches.

TO-99 Package	Dual In-Line Package
1. OFF	1. OFF
2. VAR Vin	2. OFF
3. TERMINATION	3. OFF
4. Vee	4. VAR Vin
5. OFF	5. TERMINATION
6. 10K (load)	6. Vee
7. Vcc	7. OFF
8. OFF	8. OFF
	9. OFF
	10. 10K (load)
	11. Vcc
	12. OFF
	13. OFF
	14. OFF

3) Set power supply controls fully counterclockwise.

------- NOTE -------

Pin numbers in text will refer to TO-99 setup.

----

4) PIN SELECTOR to PIN 7.

5) METER POLARITY to (+).

6) OUTPUT METER RANGE to 50V.

7) Pull TEST/SETUP switch to TEST and set Vcc to +15 on the OUTPUT METER 50V scale.

8) Release TEST/SETUP switch and set PIN SELECTOR to PIN 4.

9) Set METER POLARITY to (-) and pull TEST/SETUP switch to TEST.

10) Set Vee for -15V on the 50 volt scale.

11) Release TEST switch and set PIN SELECTOR to PIN 6 to monitor the load voltage.

2.5.3 Input Offset Voltage

1) With device out of the socket, set VAR Vin range to 5.0 mV range and vernier pot fully counterclockwise.

2) Set INPUT POLARITY to (+) and insert the device.

3) Set the OUTPUT METER range to 10V and (-) polarity.

4) Pull the TEST/SETUP switch to TEST and observe the output. If a slow oscillation is present, increase the input VAR Vin pot slowly and observe oscillation. If the oscillation stops, you have brought the device into its active region. (The oscillations observed are a characteristic peculiar to the Model 709 and appear only at the extreme positive and negative output levels.) If oscillations have not stopped upon reaching the +5 mV level, move the INPUT POLARITY control to the (-) position. The device output will probably go to the opposite voltage extreme. Switch the METER POLARITY to (+). Decrease the VAR Vin pot until the output voltage follows the VAR Vin pot variations linearly. Once the output follows the input, the output is adjusted for zero volts while the OUTPUT METER range is reduced to the 0.5 volt scale for increased

sensitivity. With output zeroed, observe the INPUT METER reading for the magnitude of the Input Offset Voltage.

In general, this measurement was made with the amplifier connected in an inverting configuration. The OUTPUT METER moved opposite to the INPUT METER. The input was varied over a (+) and (-) 5 mV range to put the output in an active region. Once the active region was reached, it was adjusted to zero volts. The input voltage magnitude and polarity required to do this is the input offset voltage. The offset voltage could also be measured in the non-inverting mode by reversing the VAR Vin and TERMINATION connections. The offset voltage in this setup will be opposite in polarity and approximately equal in magnitude. VAR Vin and the TERMINATION terminals are identically terminated to GRD.

2.5.4 Input Offset and Bias Currents

1) Set up the device for Input Offset Voltage measurement.

2) Zero the output as in paragraph 2.5.3, number 4.

3) Observe the magnitude and polarity in terms of microamperes.

4) Move the TERMINATION switch to the 1K position.

5) Rezero the output voltage and observe the magnitude and polarity of the INPUT METER. The difference between the initial and final reading on INPUT METER will be the current in the leg terminated at the 1K position.

6) Set the 1K position switch to VAR Vin and the switch on VAR Vin to TERMINATION. Rezero the output with VAR Vin controls and observe magnitude and polarity on the INPUT METER in terms of μa.

7) Move the TERMINATION terminal switch to the 1K position and rezero the output with the VAR Vin controls.

8) Observe the input magnitude and polarity. Take the difference of the initial and final readings. The result will yield the current in the terminal at the 1K position.

9) Calculate the Input Bias Current and magnitude

$$I_{bias} = \frac{I_1 + I_2}{2} \; ; \; I_1 - I_2 = I_{offset}.$$

2.5.5 Open Loop Voltage Gain

1) Set up the device with a zeroed output as in the Input Offset Voltage measurement. Move PIN 6 to OFF position.

2) Set the OUTPUT METER to the +10V scale and vary the input for a full-scale reading at the output. Record the magnitude and polarity of the input voltage reading.

3) Adjust VAR Vin for a -10V full-scale reading at the output.

4) Record the magnitude and polarity of the INPUT METER.

5) Calculate the difference in the two input voltages and divide this into 20 volts for the dc open loop gain.

$$Gain_{open\ loop} = \frac{20\,V}{X\ mV}.$$

6) The output load consisted of the OUTPUT METER circuit and equalled 100K ohm on the 10V scale.

7) A quicker gain measurement may be made by adjusting the VAR Vin control a convenient known amount and multiplying the output by a convenient factor; i.e., after V Offset measurement (zero output), vary the input 1 mV and multiply by 1000. Vary input 0.5 mV and multiply output by 2000.

2.5.6 Output Voltage Swing

1) Place OUTPUT under desired load. (Use the external input to PIN 6.)

2) Vary VAR Vin and observe the limits of output voltage in (+) and (-) levels. (For the Model 709, the levels just prior to oscillation are valid.)

2.5.7 Supply Current and Power Consumption

1) Set up the device for V Offset with the output zeroed.

2) For Vcc current, place the OUTPUT METER controls into the Icc position on the 10 ma scale. Place the METER POLARITY to (+) and pull the TEST/SETUP switch to TEST. Read the current level for the Vcc supplied on the OUTPUT METER.

   (+) power supplied = Vcc x $I_{(+)}$.

3) Negative current is measured as above except:

   Switch the OUTPUT METER controls to Iee, and METER POLARITY to (-). Pull the TEST/SETUP switch to TEST and read the Vee current supplied on the OUTPUT METER.

   (-) power supplied = Vee x $I_{(-)}$.

4) Calculate total power dissipation by adding the two supply requirements together.

   Total power = $P_{(+)}$ + $P_{(-)}$.

2.5.8 Supply Voltage Rejection Ratio : SVRR

1) Set up same as for Voltage Offset measurement with the output zeroed.

2) Vary Vcc or Vee a known amount and remeasure V offset.

3) Calculate SVRR:

$$SVRR = \frac{V_{offset\ 1} - V_{offset\ 2}}{V_{supply\ 1} - V_{supply\ 2}} = \frac{\Delta V_{offset}}{\Delta V_{supply}}$$

$$SVRR\ (dB) = 20 \log_{10} \frac{V_{offset}}{V_{supply}}$$

2.5.9 Transfer Function (General Setup)

1) Set up the device for an Input Offset Voltage measurement with the VAR Vin pot fully counterclockwise.

2) Test circuit is shown in Figure 2-9.

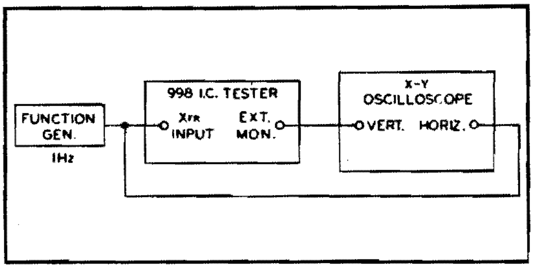


FIG. 2-9. Test Setup for Transfer Function.

3) Plug generator output into scope vertical amplifier. Use a sine or triangular function. Adjust the generator for an output of 10V peak-to-peak with zero offset from the generator.

4) Disconnect the scope Vertical Input so a dot appears on the screen. Center the dot with Horizontal and Vertical position controls.

5) Connect the function generator output that was just calibrated to the horizontal input. Adjust the horizontal deflection amplifier for full graticule deflection.

6) With a "T" connector, run the function generator input to the Xfr FUNCTION input of the Model 998, as well as to the scope horizontal input. Place the VOLTAGE INPUT switch to the Xfr position and the Xfr FUNCTION ATTEN to the 2000 position.

7) Connect the EXT MONITOR to the scope vertical input on the 5V/div scale. Insure PIN SELECTOR is on device output terminal.

8) Place the device into the DEVICE UNDER TEST socket and pull the TEST/SETUP switch down. Transfer functions should appear on the scope. An example of the Transfer Function is given in Figure 2-10.

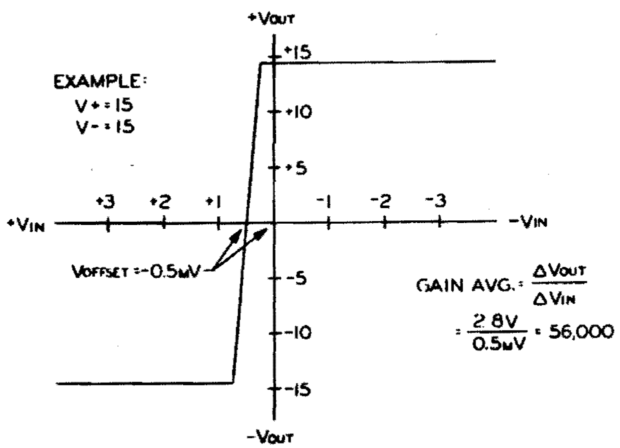


FIG. 2-10. Example of Transfer Function.

9) Explanation of displayed waveform.

- Function generator waveform is attenuated by a factor of 2000 before being applied to the device input;

  i.e., $\frac{10V\ p\text{-}p}{2000}$ = 5 mV p-p into device.

- Waveform to scope horizontal input is set for maximum graticule divisions and represents device input;

  i.e., $\frac{5\ mV\ p\text{-}p}{10\ \text{graticule divs.}}$ = 0.5 mV/div. to device horizontal.

- Waveform to scope vertical input is the device output, interpreted as the vertical amplifier's attenuated setting;

  i.e., 5V/div.

SECTION 3
MEASUREMENT TECHNIQUES

3.1 GENERAL

To understand the measurement techniques used in the Model 998, a knowledge of the test configurations is required. This is a versatile instrument and therefore most of the measurements must be set up individually. In this section, an outline of each measurement will be given; a full procedure for testing a typical linear IC is given in Section 2.5.

3.2 INPUT OFFSET VOLTAGE MEASUREMENT

Definition: That voltage which must be applied between the input terminals to obtain zero output voltage.

Vcc and Vee are applied and the output is monitored on the OUTPUT METER. The input voltage is monitored and divided down. Input voltage to the device is the voltage indicated on the INPUT METER. See Figure 3-1.

With the Vin RANGE potentiometer set to zero, the OUTPUT METER will indicate a voltage. With the Vin RANGE controls, a voltage is applied at the inverting terminal. Assuming the output was at the positive extreme, a positive input voltage will decrease the output towards zero volts. When the output voltage has been zeroed with Vin RANGE controls, the Input Offset Voltage may be read on the INPUT METER. The Input Offset Voltage will be $E_1 - E_2$, with Vout at zero volts.

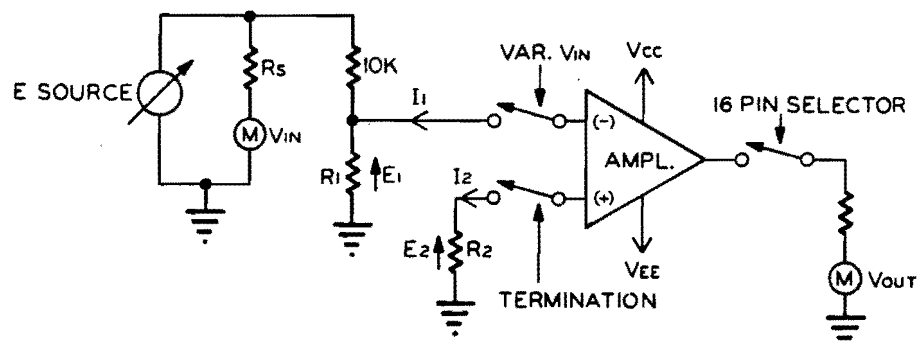


FIG. 3-1. Input Offset: Test Circuit.

3. 3 INPUT BIAS CURRENT AND INPUT OFFSET CURRENT

Definition: Input Bias Current - The average of the two input currents, I_1 and I_2.

$$I\,bias = \frac{I_1 + I_2}{2}$$

Input Offset Current - The difference in the currents at the two input terminals with the output at zero volts.

$$I\,offset = |I_1| - |I_2| \quad I_1 > I_2$$

$$= |I_2| - |I_1| \quad I_2 > I_1$$

When testing these two parameters, the current level in each leg has to be determined individually.

Initially, the circuit under test is adjusted for zero volts on the OUTPUT METER. (Refer to Figure 3-2.) This is done using the VAR Vin and TERMINATION terminals. S1 is then shifted to the 1K position (on crossbar). VAR Vin is readjusted for zero output volts. This procedure has allowed measurement of the offset voltage initially ($E_1 - E_2$). After 1K is placed in the circuit and the output readjusted to zero, the voltage ($E_1 - E_2$) is still known. Since ($E_1 - E_2$) is the same as in the original test condition, the difference in the reading of VAR Vin now appears across 1K. The resistor is a 1K ohm 1% resistor, and when the value of ΔVAR Vin is known, the current in that leg may be calculated by $\frac{\Delta \text{VAR Vin}}{1K}$. The current at the other leg may be measured in the same manner provided the inputs to the device are interchanged.

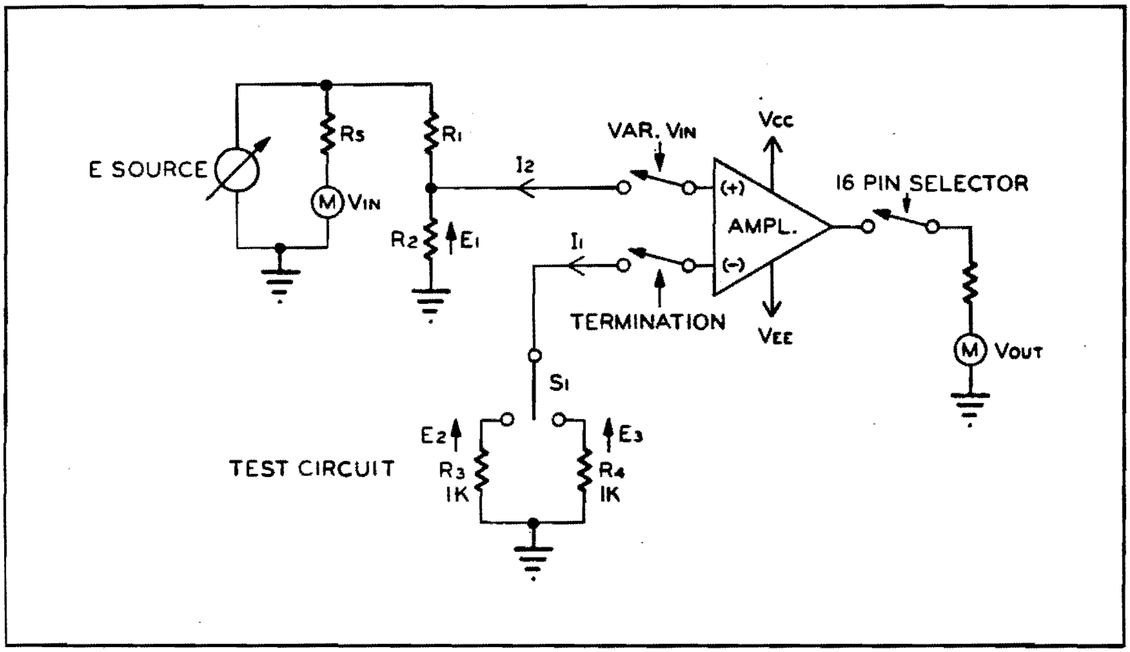


FIG. 3-2. Input Bias and Input Offset Current: Test Circuit.

Calculation of the voltage current relationship is eliminated by reading the INPUT METER directly as shown on the microampere range switch. This is done by subtracting the initial current reading from the final current reading during the two steps of the test. Once the two current levels have been determined (I_1 and I_2), the Bias and Offset Currents may be calculated.

3. 4 INPUT VOLTAGE RANGE

Definition: The range of voltage which, if exceeded on either input terminal, could cause the amplifier to cease functioning properly.

The test is made on a catastrophic basis that, if the device is still operating with the same offset voltage after exposure to these potentials, it is considered as passing. Each input terminal is exposed to the plus and minus limit as shown in Figure 3-3. Then the inputs are tied together and exposed in a common mode configuration to the specified potential, the device is set up for measurement of the Offset Voltage, and checked for any irregular operation.

3. 5 OPEN LOOP VOLTAGE GAIN

Definition: The ratio of the output voltage swing with load to the change in input voltage required to drive the output from zero to this voltage.

To test the Open Loop Voltage Gain, the Offset Voltage measurement setup is used. (See Figure 3-1.) The most common way of doing this test is to check the output voltage limits and then set the input for an output in the middle of the minimum and maximum levels. The input can be varied a convenient amount (1 mV) and the output variation observed. The ratio of the output to input variation will be Open Loop Voltage Gain. When the input is varied 1 mV, the output voltage swing may be multiplied by 1000 for the voltage gain (provided device output is in the active region).

3. 6 SUPPLY VOLTAGE REJECTION RATIO

Definition: The ratio of the change in input offset voltage to the change in supply voltage producing it.

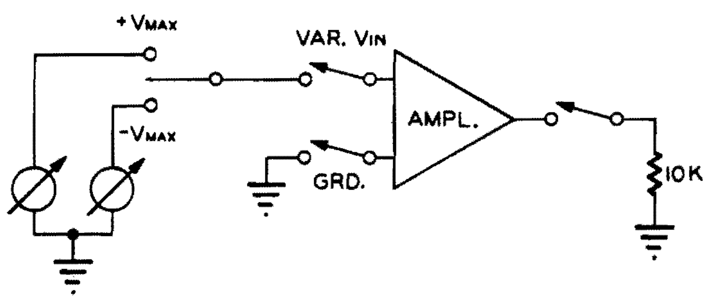


FIG. 3-3. Input Voltage Range: Test Circuit.

Initially, the Offset Voltage is measured as in paragraph 3.2. Vcc or Vee is varied a known amount, perhaps two to five volts. The Offset Voltage is then remeasured. The difference in Offset Voltage is noted and the calculation made with the obtained data. Only one supply voltage should be varied during a test. The test circuit is shown in Figure 3-4.

3.7 EQUIVALENT INPUT NOISE VOLTAGE

Definition: The true rms output noise voltage as referred to the device input by Open Loop Gain.

The Open Loop Gain of the amplifier must first be determined; the equivalent input noise may then be measured. After Open Loop Gain has been measured, the amplifier output is zeroed as in making Offset Voltage measurements. The output noise is measured on a true rms voltmeter. The Equivalent Input Noise is then calculated as follows.

$$\text{V NOISE} = \frac{\text{V out rms}}{\text{A V OPEN LOOP}} .$$

Refer to Figure 3-5.

3.8 POWER SUPPLY REQUIREMENTS AND POWER CONSUMPTION

The amplifier is set up with a no-load condition and V Offset set for approximately zero output volts. The OUTPUT METER is set on an Icc or Iee current range and placed in series with the supply voltage to be monitored. See Figure 3-6.

The same procedure is used to monitor the positive supply voltage. Once the positive and

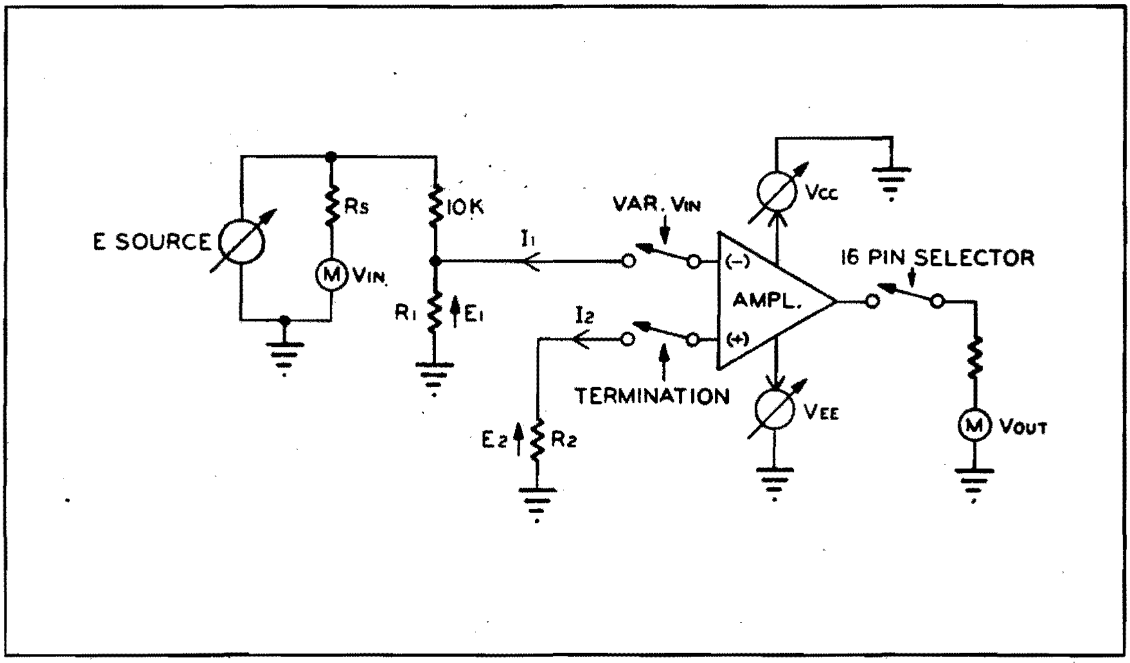


FIG. 3-4. Supply Voltage Rejection Ratio: Test Circuit.

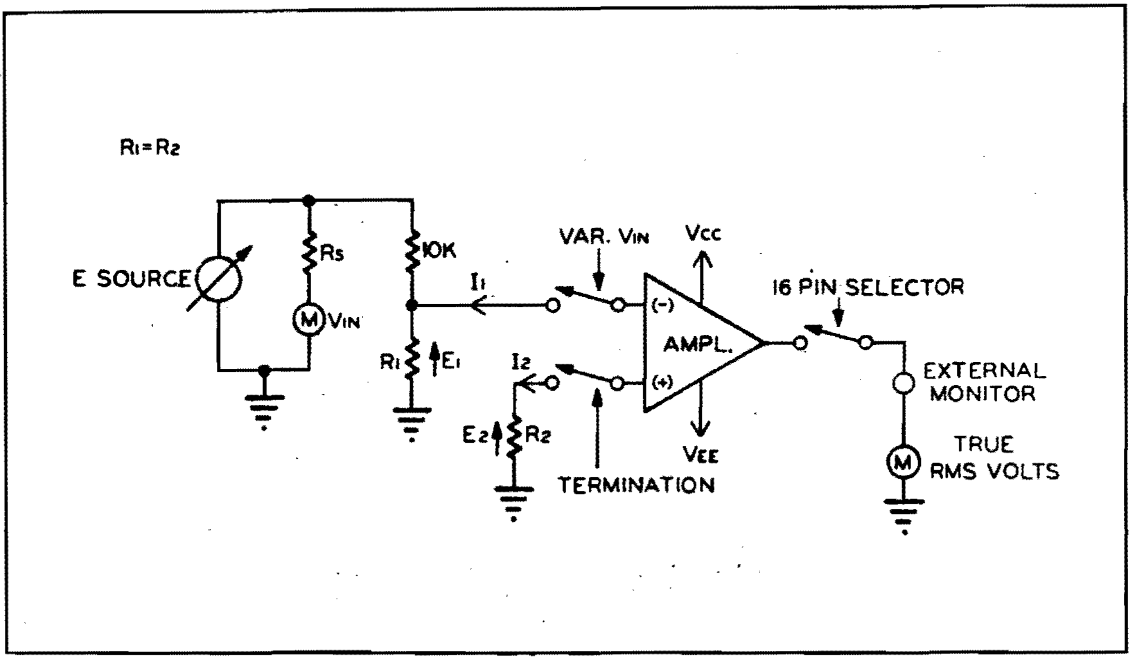


FIG. 3-5. Input Noise Voltage: Test Circuit.

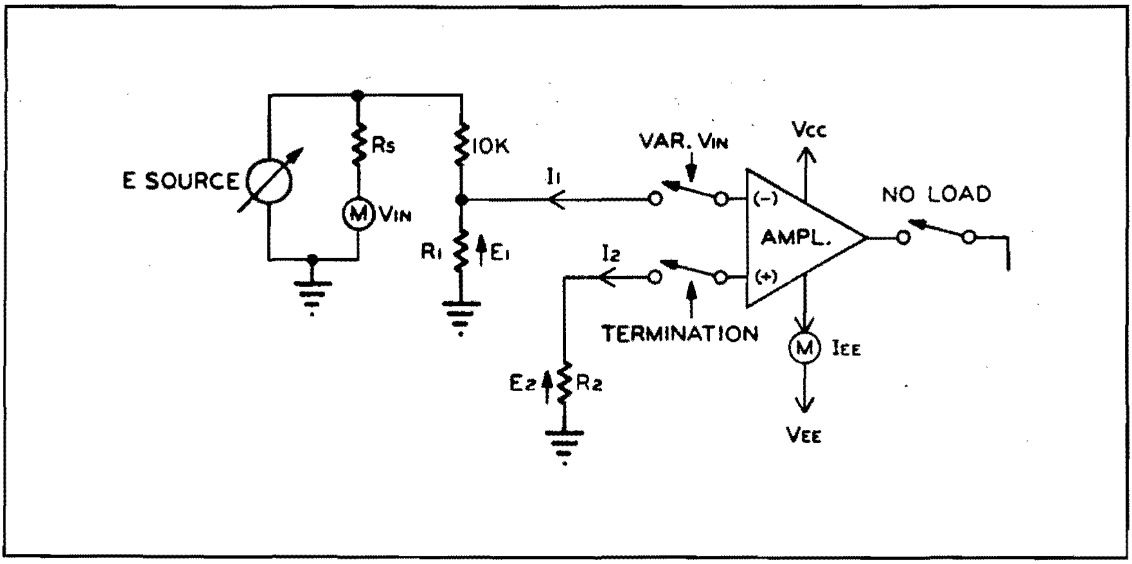


FIG. 3-6. Power Consumption: Test Circuit.

negative supply current requirements are known, the power consumption can be calculated.

$$(I\,pos)\ (V\,pos) = \text{Power } (+)$$

$$(I\,neg)\ (V\,neg) = \text{Power } (-)$$

$$\text{Total Power} = \text{Power } (+) + \text{Power } (-)$$

3.9 TRANSFER FUNCTIONS

The Model 998 has input and output terminations for conveniently displaying device transfer functions.

The function generator's output waveform may be a sine or triangular waveform of approximately 1 Hz or less. The output is applied to the test device input after attenuation by a known factor as selected on the front panel (Xfr FUNCTION ATTEN). The output is also fed to the oscilloscope horizontal input. The test device output is monitored by the oscilloscope vertical input as shown in Figure 3-7.

Oscilloscope calibration can be performed as described in the following procedure:

1) Monitor the function generator output on the oscilloscope vertical input. Calibrate the generator output for zero offset and a known peak-to-peak amplitude.

2) Connect the generator output to the oscilloscope horizontal input and the Model 998 Xfr FUNCTION jack.

3) Set the Xfr FUNCTION ATTEN for the desired factor.

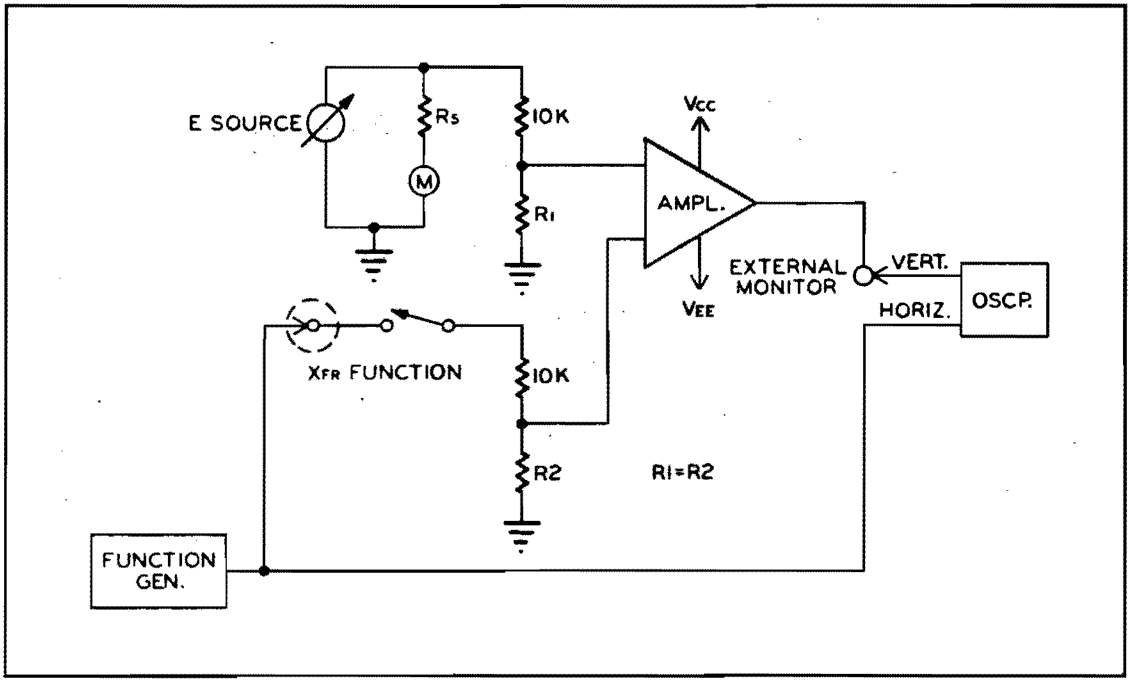


FIG. 3-7. Transfer Functions: Test Circuit.

4) Set the oscilloscope horizontal control for a full graticule horizontal sweep.

5) Calculate the horizontal displayed sensitivity.

EXAMPLE

Function Generator Output = 10V p-p

Attenuation = 2000

Device Input Voltage $= \frac{10V\ p\text{-}p}{2000} = 5\ mV\ p\text{-}p$

Horizontal Graticule Divisions = 10

Horizontal Sensitivity $= \frac{5\ mV\ p\text{-}p}{10} = 0.5\ mV/div.$

6) The device output at the EXT MONITOR may be applied to the oscilloscope vertical input and the vertical sensitivity set accordingly.

7) The oscilloscope zeroing controls should be set to display the waveform uniformly on the cathode ray tube.

8) The device offset voltage may be nulled out on the presentation with the VAR Vin control. This allows testing of devices for variation from typical values.

9) The Xfr FUNCTION input may be used in a slightly different application. The Xfr FUNCTION ATTEN may be used to apply external dc voltages to null offset voltage while the VAR Vin control is zeroed. This leaves the VAR Vin control available to make a sensitive gain measurement on the most sensitive scale (2.5 mV). The attenuation on this scale is 2000 to 1.

EXAMPLE

Analysis of the Transfer Function

For the following discussion, refer to Figure 3-8.

1) The level at point A is the positive transition limit (+4V).

2) The level at point B is the negative transition limit (-3V).

3) The horizontal value at point C shows the Input Offset Voltage for a zero output voltage (-1 mV).

4) The slope from D to E indicates the device gain

$$\text{Gain} = \frac{\Delta Vout}{\Delta Vin} = \frac{(+4) - (-3)}{(+1) - (-3)} = \frac{7}{4}$$

$$= 1.75 \times 10^3 = 1,750.$$

5) Relative straightness of line DE gives an indication of device linearity.

3.10 TESTING OTHER CONFIGURATIONS

All test setups have been for differential input amplifiers. Other configurations including single-ended inputs and differential outputs are easily adapted to testing on the Model 998. The TERMINATION position is left out on single-ended measurements.

It should be noted that the transfer input waveform is applied through the TERMINATION terminal for single-ended transfer functions. Differential outputs can be monitored individually by the OUTPUT METER.

Other test configurations can be set up with an accessory adapter which allows external components to be wired to the device under test. Such applications would arise in setting gain of dc feedback systems or checking parameters under various loads.

Offset nulling networks may be tested and designed on the accessory adapter, also. Finally, complete systems may be dc checked provided the user connects the appropriate terminals to the test head.

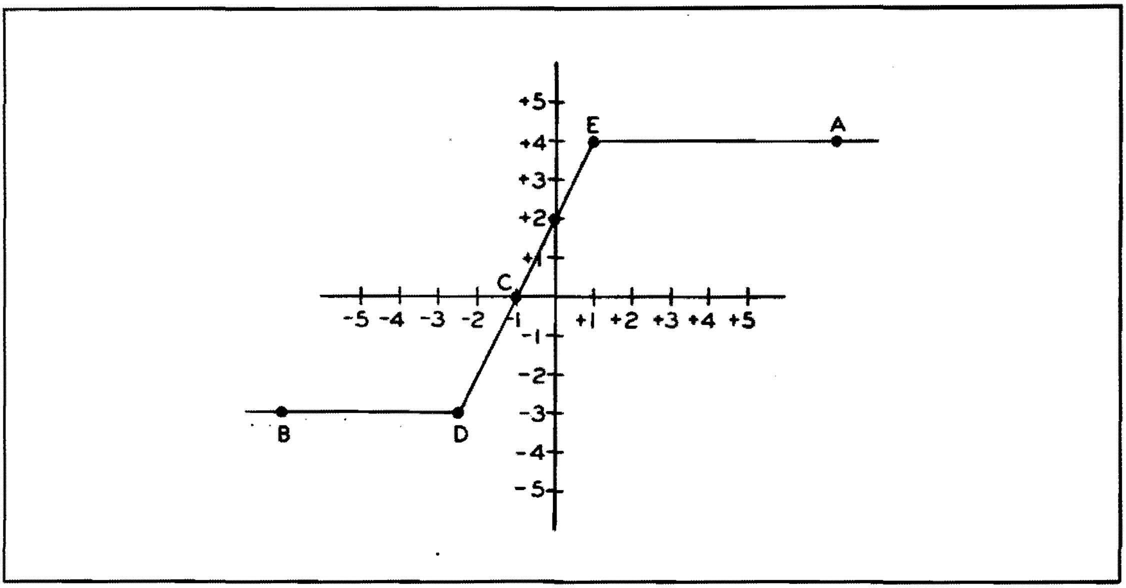


FIG. 3-8. Transfer Function Analysis.

SECTION 4
MAINTENANCE

4.1 GENERAL

Periodic maintenance of the Model 998 Linear IC Testèr is normally not required. The overall stability and reliability of the instrument is such that, if used properly, it will provide years of uninterrupted service. The power supply voltages, current source circuit, and current sink circuit may require adjustment after prolonged usage because of component ageing. Also, meter circuit calibrations may need checking and adjustment. Procedures are given in the following paragraphs; associated controls are shown in Figure 4-1.

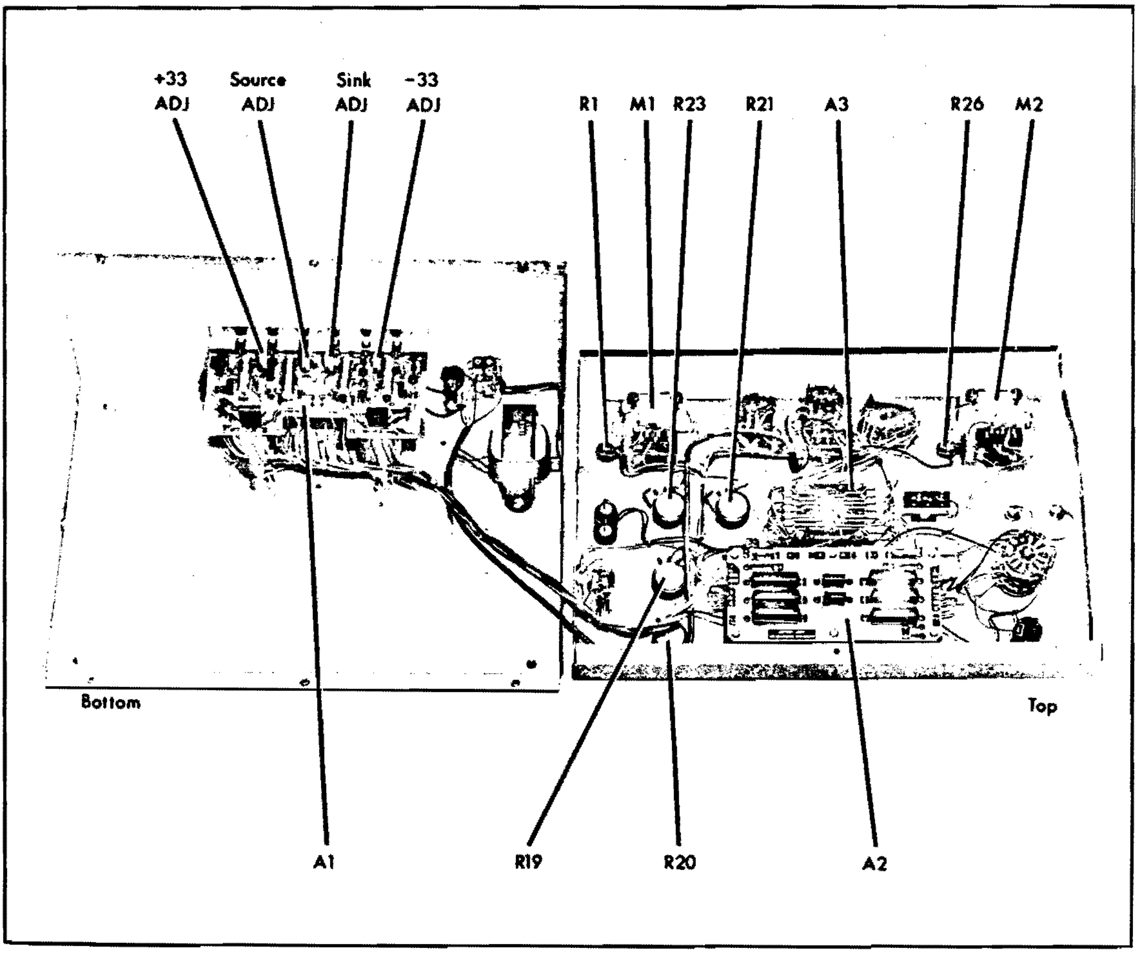


FIG. 4-1. Adjustments

4.2 COVER REMOVAL

To expose the necessary test points and components used in servicing the Tester, the following disassembling procedure should be used:

1) Remove side plates by removing the five screws on each side.

2) Remove the three screws holding the front panel to the bottom and the three screws holding the panel to the back of the bottom frame.

3) Bring the front panel forward slightly to clear the components in the instrument; then rock the panel up and forward to remove.

4) Lay the panel on its side or face and proceed with adjustments and/or troubleshooting.

The Tester is assembled in the reverse order.

4.3 ADJUSTMENTS

4.3.1 Power Supply Adjustments

1) Monitor the voltage at TP1 (+33 V).

2) Adjust potentiometer R7 to obtain +33 (±1%) volts.

3) Monitor the voltage at TP2 (-33 V).

4) Adjust potentiometer R24 to obtain -33 (±1%) volts.

4.3.2 Current Source Adjustment

1) Set all PIN NUMBER switches to OFF position.

2) Place a short between the two EXTERNAL MONITOR TERMINALS.

3) Place the I source switch in the BUSS 1 position.

4) Place the PIN 1 switch in BUSS 1 position.

5) Set the RANGE switches to I source and 100 ma, and the METER POLARITY to (+).

6) Set the I source control fully clockwise.

7) Hold the TEST/SETUP lever switch in the TEST position and adjust potentiometer R17 for full scale indication on the OUTPUT METER.

4.3.3 Current Sink Adjustment

1) Set all PIN NUMBER switches to the OFF position.

2) Place a short between the two EXTERNAL MONITOR TERMINALS.

3) Place the I sink switch in the BUSS 1 position.

4) Place the PIN 1 switch in the BUSS 1 position.

5) Set the RANGE switches to I sink and 100 ma, METER POLARITY to (+).

6) Set the I sink control fully clockwise.

7) Hold the TEST/SETUP lever switch in the TEST position and adjust potentiometer R34 for full scale indication on the output meter.

4.3.4 Meter Resistor Adjustments

1) Set all PIN NUMBER switches to the OFF position.

2) Set the PIN 1 switch to the VAR Vin position.

3) Set the PIN SELECTOR to Pin 1 and the RANGE switch to the 0.5 Volt range.

4) Set the INPUT POLARITY switch to +.

5) Set the METER POLARITY switch to +.

6) Monitor the output voltage at the EXTERNAL MONITOR with a VTVM and set VAR Vin for 0.50 Volts.

7) Adjust R1 and R26 for full scale deflection on the INPUT and OUTPUT METERS.

4.4 PREVENTIVE MAINTENANCE

Preventive maintenance is work performed on the equipment, usually when the equipment is not in use, to keep it in good working order so breakdowns and needless interruptions will be kept to a minimum.

4.4.1 Cleaning

Proper cleaning of the equipment will aid in minimizing breakdowns or malfunctions. The following cleaning methods may be used as applicable.

1) A clean, dry, lint-free cloth; a dry brush; or a vacuum cleaner may be used to remove loose dust, dirt, and lint.

2) If available, dry compressed air at a line pressure not exceeding 30 psi may be used to remove dust from inaccessible places, provided that care is exercised to prevent transfer of dirt to nearby parts. Care must also be exercised to ensure that damage to components does not result from the air blast.

3) Corrosion should be removed with fine crocus cloth (No. 000). Emery paper or steel wool must never be used to clean near electrical equipment; the particles that come from such material are conductive and can create short circuits.

   All dust and metallic particles should be removed by compressed air or vacuum cleaning. If compressed air is used, prevent the scattering of particles to magnetic parts.

4) After corrosion is removed, the affected surface should be treated with paint and/or moisture-and-fungus resistant crylan.

5) Pure ethyl alcohol may be used to clean connector contacts and to remove excess rosin flux; it must not be used, however, to clean insulating varnish.

4.5 SERVICING INTEGRATED CIRCUITS

CAUTION

Extreme care should be exercised in phases of servicing instruments containing semiconductors, especially when integrated circuits are involved. In general, for IC replacement, return the instrument to Beckman's Service Department. If this is impractical, carefully read paragraphs 4.5.1 through 4.5.4 before attempting any troubleshooting or repair work.

In removing defective integrated circuits, be very careful not to cause damage to the circuit board. The cost of the IC is small in comparison, and no attempt should be made to remove the part intact when it may result in damage to the parent board.

When installing the replacement component, make sure the part is correctly oriented and all leads are inserted into the proper holes of the circuit board before soldering.

4.5.1 Special Troubleshooting Procedures

The following special troubleshooting procedures are recommended for instruments using integrated circuits.

1) Be sure that all line-operated test equipment have their ground terminals or chasses solidly and securely connected to instrument ground.

2) Use small pin-tipped test probes on meters and oscilloscopes to reduce the chance of shorting IC leads together.

3) Use the greatest care to avoid even a momentary short of any point in a circuit to ground or to other circuit points.

4) Do not allow "dangling" oscilloscope probe ground leads, or other stray leads, to touch circuitry in the instrument.

4.5.2 Visual Inspection

After cleaning the equipment, inspect carefully before restoring it into operation. The inspection should include the following:

1) Check the fuse, either visually or with an ohmmeter.

2) Check all components for damaged leads and loose connections.

3) Check that switches have not been inadvertently placed to the wrong settings.

4) Examine the printed circuit boards and the components for signs of overheating.

5) Ensure that there is adequate air circulation for the equipment.

6) Unplug the line cord before removing, replacing or soldering components.

4.5.3 Removing Integrated Circuit Modules

A recommended method for removing integrated circuit modules is given below.

1) Note position of the IC indexing point.

2) Carefully cut the leads from the IC with small, diagonal cutting pliers.

3) Use a low-temperature soldering iron (no more than 40W) to remove each IC lead from the circuit board. Use just enough heat to melt the solder, and remove each IC lead with small, long-nose pliers or tweezers. If necessary, use a SOLDA-PULLT® desoldering tool to clear the holes of excess solder.

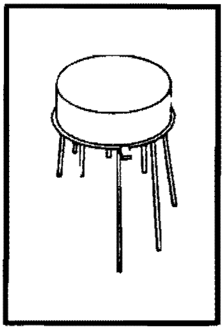
4.5.4 Installing Integrated Circuit Modules

To install the integrated circuit modules, follow these recommended procedures:

1) Replace with correct type.

2) Make sure the indexing point of the new IC is in the same position as the previous one.

3) With the TO-99 cased IC, cut leads in a stair-step fashion starting at the tab, as shown. Insert leads into the board one at a time.



4) With the in-line cased IC, insert the leads on one side part way into the board first, and then insert the other side.

5) Make sure that all the leads are in the correct holes of the board, and not bent under the case.

6) Carefully solder each lead, using a low-temperature soldering iron.

7) If necessary, trim excess leads on the wire side of the board.

8) If the instrument has integrated circuits mounted in sockets, care must be used when replacing the IC in the socket. Make sure that each lead is properly started into the correct socket receptacle before pushing the IC into place. This prevents damage to either the IC or socket.

4.6 TROUBLESHOOTING

4.6.1 Basic Troubleshooting Procedures

In troubleshooting electronic equipment, sources of problems can be divided into two categories: improper operating procedures, and equipment malfunctions. The first category, since it deals with human error, is a more prevalent source of equipment problems than most people care to admit. Therefore, this category should always be investigated and eliminated before it is assumed that a valid equipment malfunction exists. After eliminating all possibility of human error, an equipment malfunction can, with assurance, by systematically attacked. It is vitally important to define the problem before attempting to solve it. The basic procedure consists of the following steps:

1) Examine the evidence of trouble.

2) Look for obvious solutions first.

3) Isolate the problem to a major functional area.

4) Analyze the reduced problem area for final solution.

5) Correct the difficulty.

6) Restore conditions for normal operation.

4.6.1.1 Examine Evidence of Trouble

Take time to study the problem thoroughly. For example, if the display indicates erroneous information, note whether the trouble is general or whether the error applies to one or two decades only. Examine the data reaching the display; it should be in agreement with the data on the storage register. Gather clues from all accessible check points.

In evaluating indications from the various checkpoints, determine particularly whether a disagreement exists between various related functions.

4.6.1.2 Look for Obvious Solutions First

Question the coincidence of failure with other recent events, such as cleaning or servicing. Human errors sometimes result in accidentally displaced control settings. Consider also the possibility of miscellaneous simple failures, such as the plug-in modules not fully inserted. Quite often the solution to a difficulty will become self-evident through thoughtful analysis of immediate indications.

4.6.1.3 Isolate Problem to a Major Functional Area

As the troubleshooter develops a working knowledge of the overall equipment, he will experience little difficulty with this isolation step. Isolating the disorder to an individual functional circuit can be accomplished either by a method of direct association or through a process of elimination.

4.6.1.4 Analyze Reduced Problem Area for Final Solution

Once the investigation has been narrowed down to a restricted circuit area, the rest of the unit can be temporarily ignored.

4.6.1.5 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 as required. Some remedies, however, may call for performing a repair on one of the relatively few assemblies that is not designed for instant removal and replacement. Typical of these items is a break in the circuit board etching.

4.6.1.6 Restore Conditions for Normal Operation

When all remedies have been completed, make sure that the unit is returned to normal operating condition. If controls have been changed to facilitate troubleshooting, reset them. Note particularly that all circuit board components are in and secured, and all switches are set properly.

4.7 REPAIR

Once a trouble is traced to a defective individual part, replacement should be made with identical parts, if practical. Refer to the drawings in Section 5 for correct values, tolerances, etc. When substitutions are necessary, use components that duplicate the originals in every possible respect. Avoid applying excessive heat to the printed circuit board by using a small iron and working quickly.

SECTION 5
PARTS LISTS & DIAGRAMS

5.1 GENERAL

The parts list for each individual assembly is located with its associated assembly drawing and schematic diagram. This facilitates the location and ordering of information for defective parts. Some miscellaneous chassis and hardware parts are listed with the Final Assembly diagram.

Table 5-1. Parts Lists and Diagrams

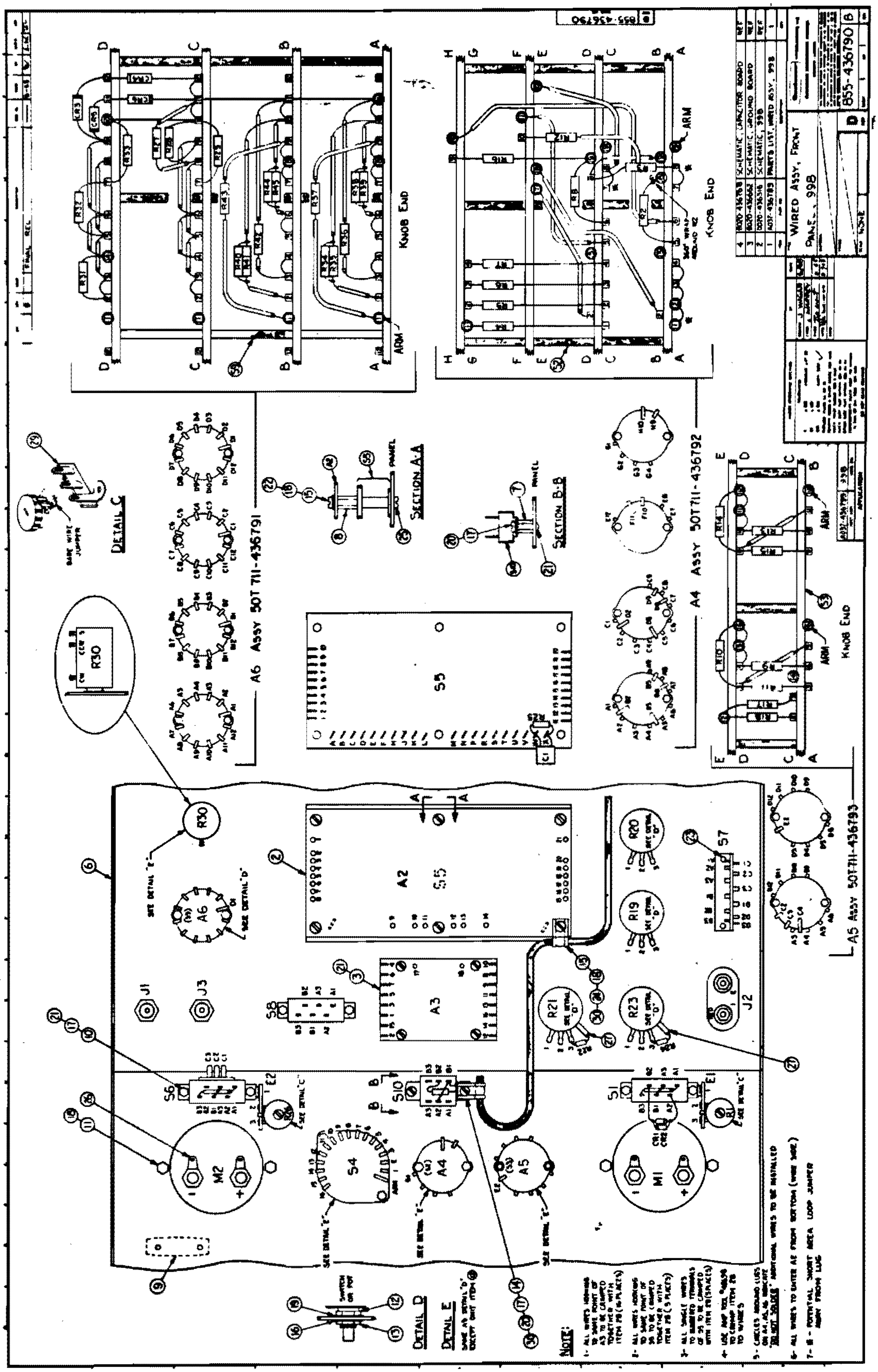
FRONT PANEL WIRED ASSEMBLY PARTS LIST

Detail No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./Assy.
	855-436790-B	Front Panel Wired Assembly	Beckman	
A4:	711-436792	Switch Assembly, Volt Range	Beckman	1
C1	633-815873	Capacitor, 0.33μf, 25V	Sprague 5C10A	1
R2, 8	607-855099	Resistor, F., Film, 7.87K, 1/4W, 1%	IRC CEB-TO	2
R3, 4	607-822600	Resistor, F., Film, 2.94K, 1/4W, 1%	IRC CEB-TO	2
R5	607-844550	Resistor, F., Film, 47.5K, 1/4W, 1%	IRC CEB-TO	1
R6	607-844549	Resistor, F., Film, 97.6K, 1/4W, 1%	IRC CEB-TO	1
R7	607-863083	Resistor, F., Film, 499K, 1/4W, 1%	IRC CEB-TO	1
R12, 16	607-822883	Resistor, F., Film, 10K, 1/4W, 1%	IRC CEB-TO	2
S2	711-436786	Switch, Rotary	Beckman	1
A5:	711-436793	Switch Assembly, mA Range	Beckman	
R9, 13	607-825879	Resistor, F., Film, 100Ω, 1/4W, 1%	IRC CEB-TO	2
R10, 14, 18	607-825873	Resistor, F., Film, 10Ω, 1/4W, 1%	IRC CEB-TO	3
R11, 15	607-828892	Resistor, F., Film, 1.1K, 1/4W, 1%	IRC CEB-TO	2
R17	607-833727	Resistor, F., Film, 49.9Ω, 1/4W, 1%	IRC CEB-TO	1
S3	711-436785	Switch, Rotary	Beckman	1
A6:	711-436791	Switch Assembly Vin Range & Atten.	Beckman	
CR3, 5	755-834285	Diode, Zener, 1N962A	Motorola	2
CR4, 6	755-845049	Diode, FDH627	Fairchild	2
R27	607-844550	Resistor, F., Film, 47.5K, 1/4W, 1%	IRC CEB-TO	1
R28	607-844549	Resistor, F., Film, 97.6K, 1/4W, 1%	IRC CEB-TO	1
R29	607-822600	Resistor, F., Film, 2.94K, 1/4W, 1%	IRC CEB-TO	1
R31, 32	607-827077	Resistor, F., Film, 90.9Ω, 1/2W, 1%	IRC CEB-TO	2
R33, 34, 35, 36, 40, 41, 42	607-825873	Resistor, F., Film, 10Ω, 1/4W, 1%	IRC CEB-TO	7
R37, 43	607-822883	Resistor, F., Film, 10K, 1/4W, 1%	IRC CEB-TO	2
R38, 39, 44, 45	607-825879	Resistor, F., Film, 100Ω, 1/4W, 1%	IRC CEB-TO	4
S9	711-436652	Switch, Rotary	Beckman	1
C1	633-815873	Capacitor, 0.33μf, 25V, -20+80%	Sprague 5C10A	1
CR1, 2	755-845049	Diode, FDH627	Fairchild	2
J1, 3	670-854373	Connector, BNC	Kings KC79-35	2
J2	695-857335	Binding Post, Metal	General Radio 938A	1
M1	813-436344	Meter, Output	Beckman	1
M2	813-436343	Meter, Input	Beckman	1
R1, 26	614-857320	Resistor, V., Comp., 500Ω, 1/8W, 30%	Centralab 9-T-500Ω	2
R19, 20	614-857379	Resistor, V., Comp., 25K, 2W, 10%	Allen Bradley J94340	2

continued. . .

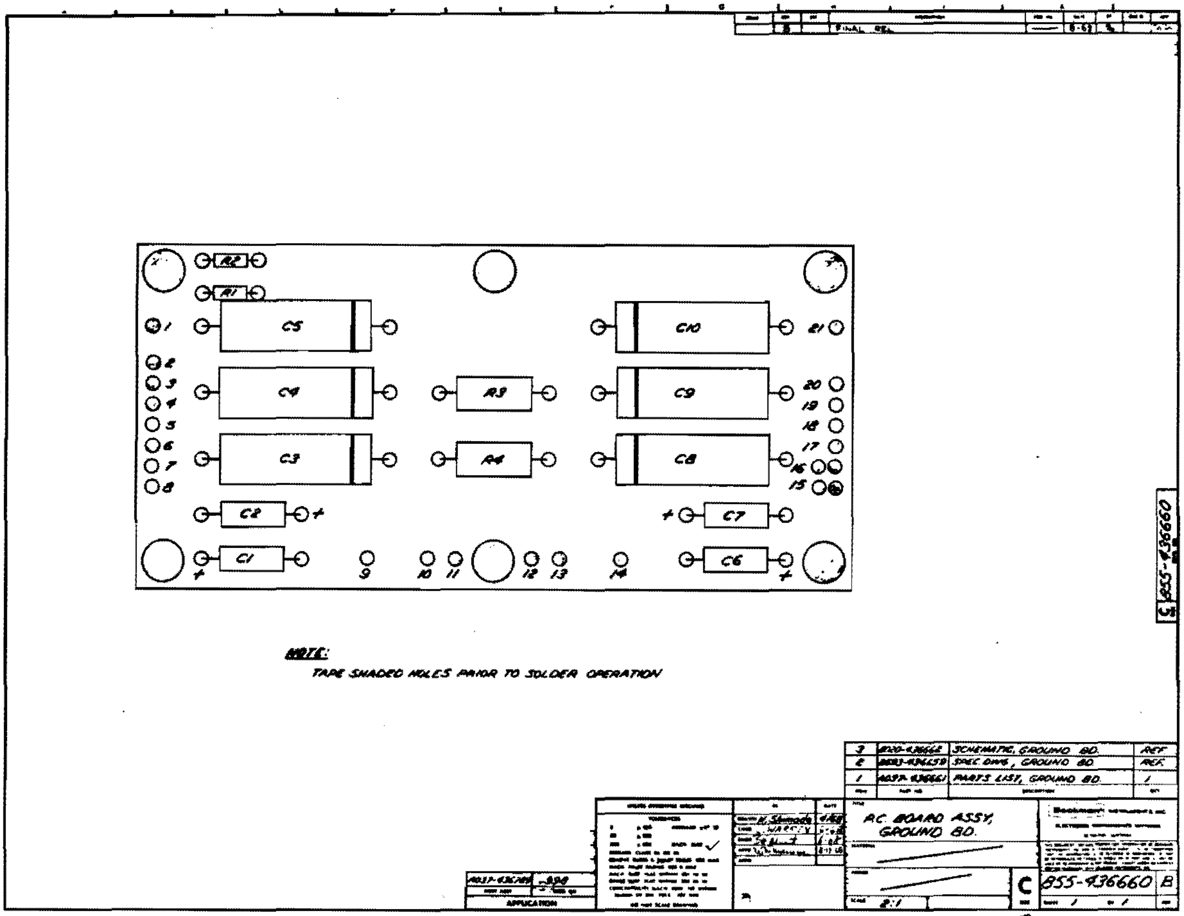
FRONT PANEL WIRED ASSEMBLY PARTS LIST - continued

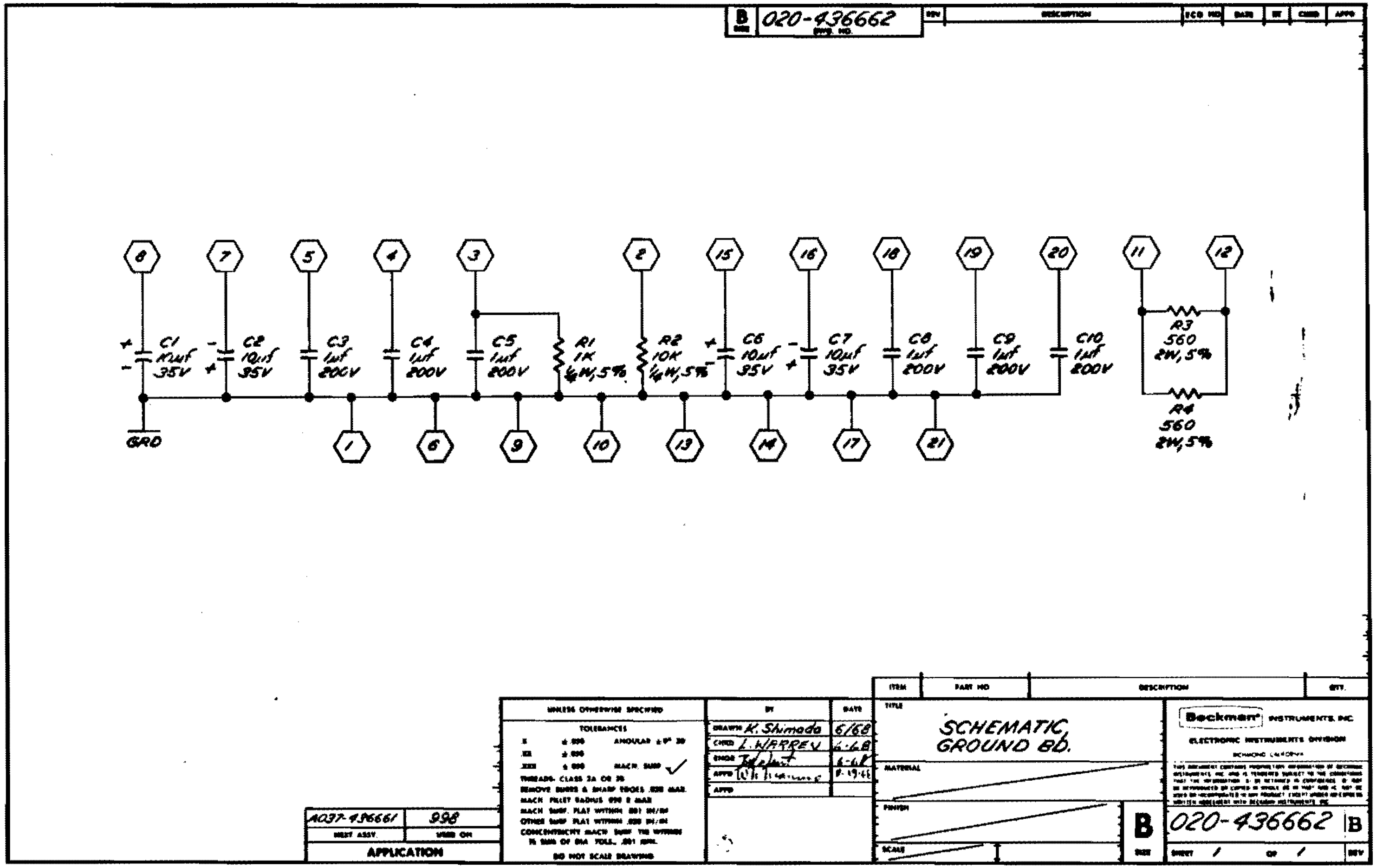
Detail No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./ Assy.
R21, 23	614-815828	Resistor, V., Comp., 10K, 2W, 10%	Allen Bradley JA1N-048S-10302	2
R22, 24	601-823396	Resistor, F., Comp., 560Ω, 1/4W, 5%	Allen Bradley CB5615	2
R25	601-008154	Resistor, F., Comp., 1/2W, 5%	Allen Bradley EB1055	1
R30	611-839197	Resistor, V., W.W., 1K, 2W, 5%	Helipot 7246 R1K L.25	1
S1, 8	716-857447	Switch, Rocker, DPDT	Stackpole RS-33	2
S4	711-435799	Switch, Rotary, 1 Pole, 16 Pos.	Beckman	1
S5	726-857343	Switch Assy., Slide	Cherry Elec. C10-42A	1
S6	716-857446	Switch, Rocker, 3 PDT	Stackpole RS-34	1
S7	701-857346	Switch, Lever	Centralab 1457	1
S10	706-857431	Switch, Rocker, Lighted, DPDT	U.I.D. Electronics LRSW-322N	1
A2	855-436660	Ground P.C. Board Assembly	Beckman	1
A3	855-436770	Capacitor P.C. Board Assembly	Beckman	1
	687-807180	Meter, Lug, No. 10	Shakeproof 2101-10-00	4
	687-807233	Lug, Terminal	Centralab B16352	2
	691-817890	Terminal Strip	Cinch Jones 332-14-03-013	2
	338-003343	Cable Clamp	Weckesser Co. 3/16-3	2


WIRED ASSY, FRONT PANEL, 998
855-436790
A6 ASSY 50T711-436791
A4 ASSY 50T711-436792
A5 ASSY 50T711-436793
SECTION A-A
SECTION B-B
DETAIL C
DETAIL D
DETAIL E
KNOB END
ARM
NOTE:

GROUND P.C. BOARD ASSEMBLY (A2) PARTS LIST

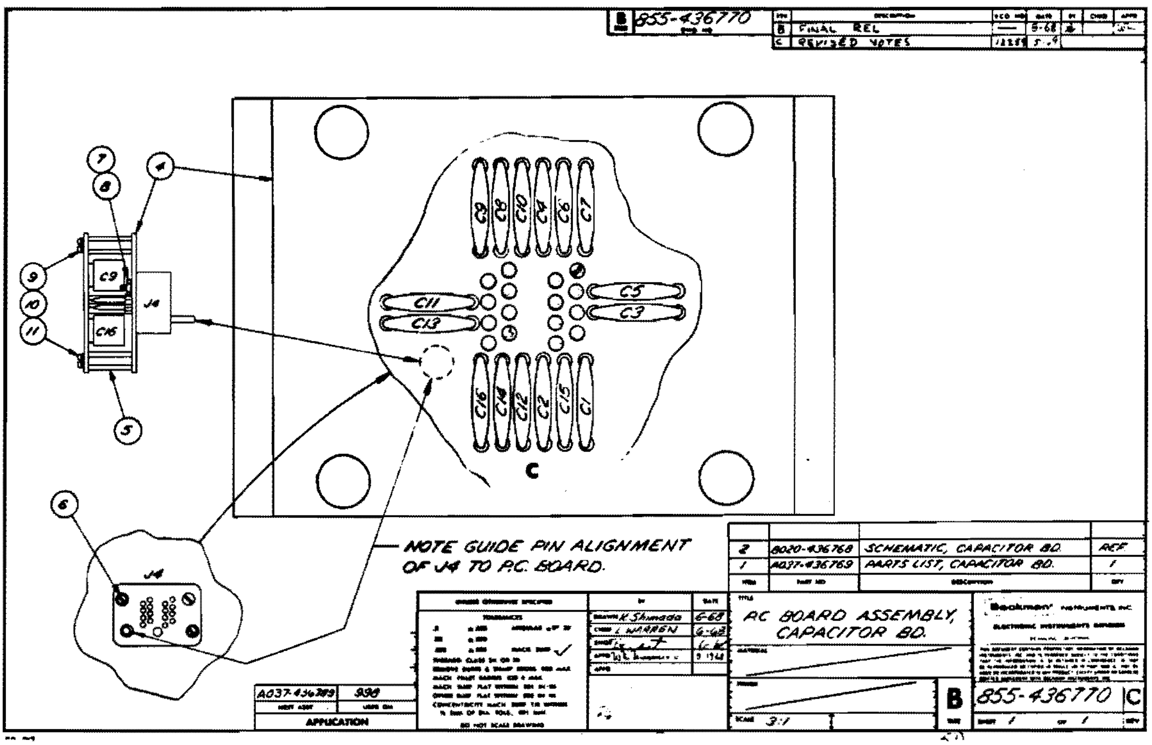
Detail No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./ Assy.
	855-436660-B	Ground P.C. Board Assembly	Beckman	1
C1, 2, 6, 7	631-835668	Capacitor, F., Tant., 10µf, 35V	Sprague 150D106X-9035R2	4
C3, 4, 5, 8, 9, 10	639-857587	Capacitor, F., Paper, 1µf, 200V	Elpac ZD-2X-105	6
R1	607-825321	Resistor, F., Film, 1K, 1/4W, 1%	IRC CEB-TO	1
R2	601-822324	Resistor, F., Comp., 10K, 1/4W, 5%	Allen Bradley CB1035	1
R3, 4	601-800131	Resistor, F., Comp., 560Ω, 2W, 5%	Allen Bradley HB5615	2

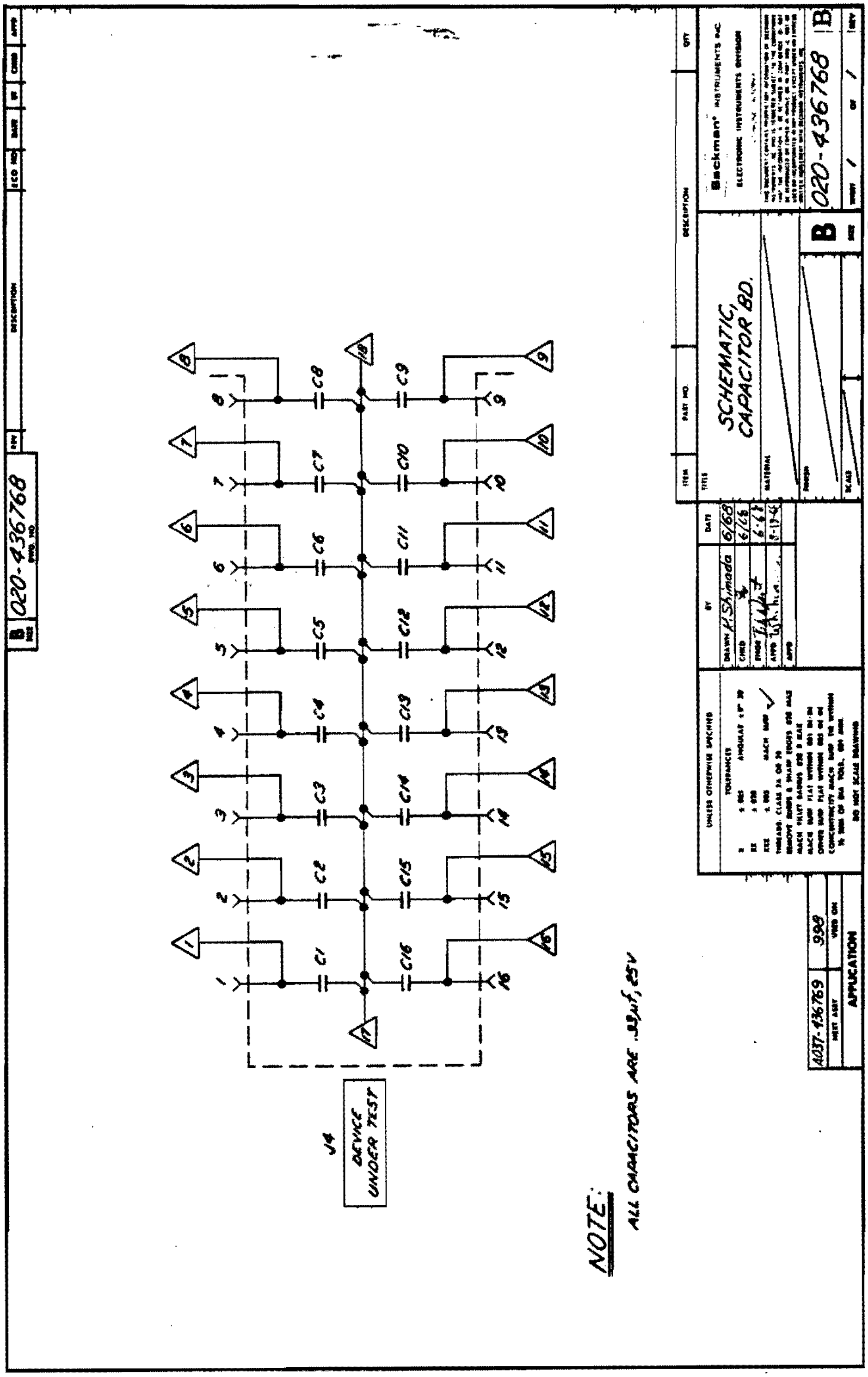



020-436662
DWG. NO.
C1 10µf 35V
C2 10µf 35V
C3 1µf 200V
C4 1µf 200V
C5 1µf 200V
R1 1K 1/4W, 5%
R2 10K 1/4W, 5%
C6 10µf 35V
C7 10µf 35V
C8 1µf 200V
C9 1µf 200V
C10 1µf 200V
R3 560 2W, 5%
R4 560 2W, 5%
GRD
UNLESS OTHERWISE SPECIFIED
TOLERANCES
DO NOT SCALE DRAWING
DRAWN K. Shimoda 6/68
CHKD L. WARREN
A037-436661
998
NEXT ASSY
USED ON
APPLICATION
SCHEMATIC GROUND BD.
Beckman INSTRUMENTS, INC.
ELECTRONIC INSTRUMENTS DIVISION
B
020-436662
SHEET 1 OF 1

CAPACITOR P.C. BOARD ASSEMBLY (A3) PARTS LIST

Detail No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./ Assy.
	855-436770-C	Capacitor P.C. Board Assembly	Beckman	1
C1 thru C16	633-815873	Capacitor, F., Cerm., 0.33μf, 25V -20 +80%	Sprague 5C10A	16
J4	860-857340	Socket, Adapter	Barnes RD86x4	1

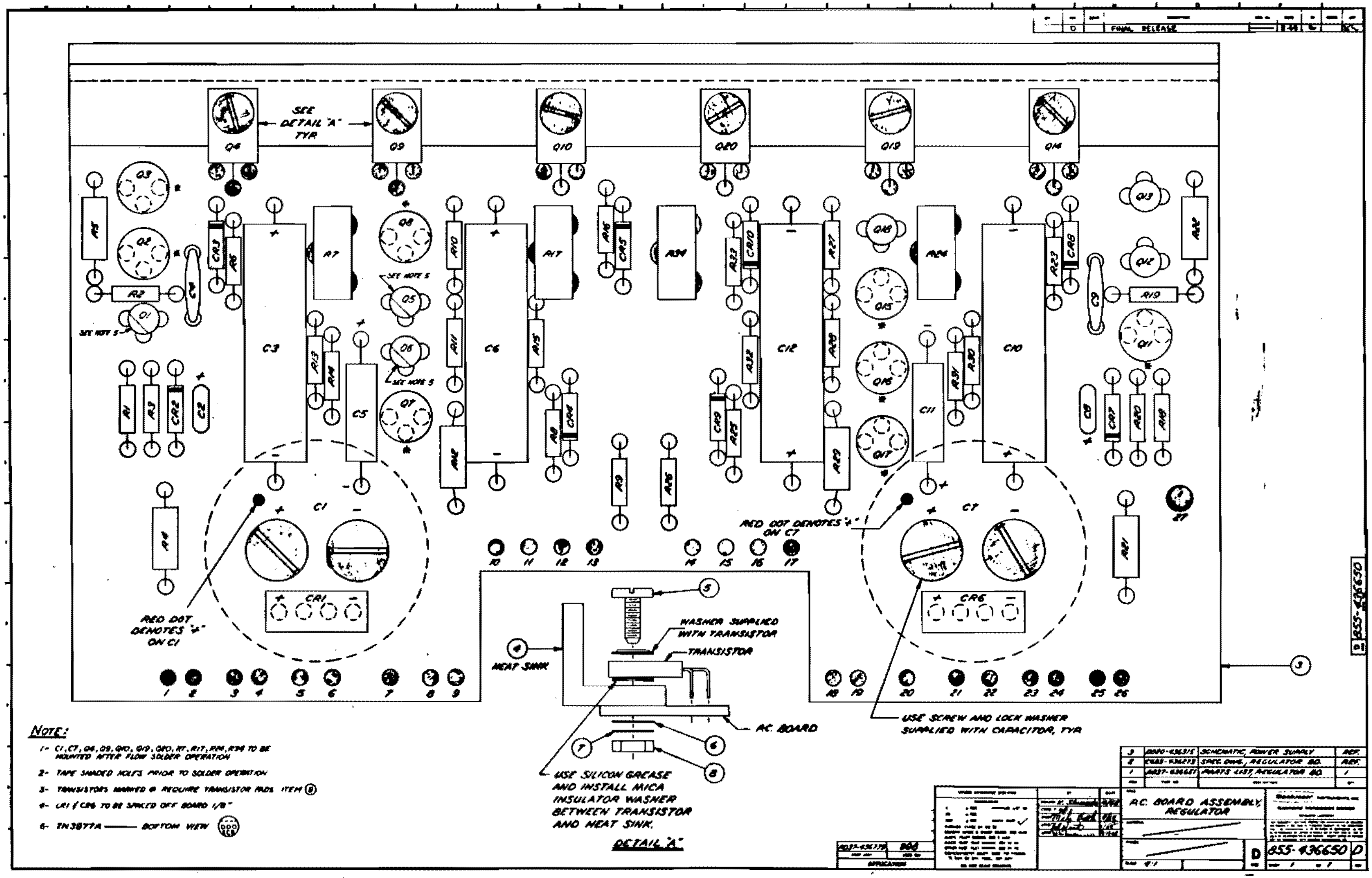



B 020-436768
SCHEMATIC, CAPACITOR BD.
Beckman® INSTRUMENTS INC
ELECTRONIC INSTRUMENTS DIVISION
DRAWN H. Shimada 6/68
B 020-436768
SHEET 1 OF 1
A037-436769
998
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
TOLERANCES
DO NOT SCALE DRAWING
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
J4
DEVICE UNDER TEST
NOTE:
ALL CAPACITORS ARE .33μf, 25V

REGULATOR P.C. BOARD ASSEMBLY PARTS LIST

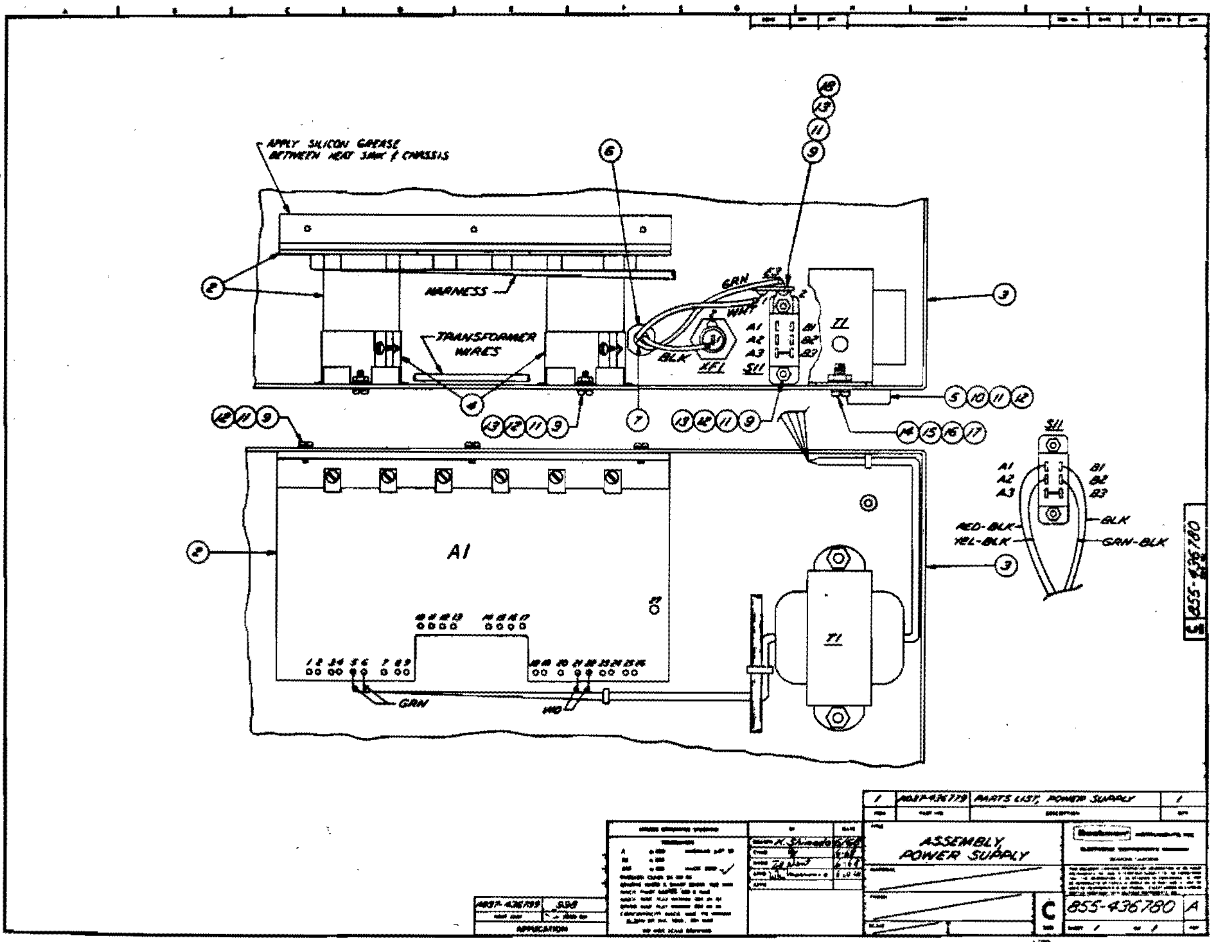
Detail No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./ Assy.
	855-436650-D	Regulator P.C. Board Assembly	Beckman	
C1, 7	631-857443	Capacitor, F., Elect., 600µf, 75V	Mallory CG62U75A1	2
C2, 8	631-841450	Capacitor, F., Elect., 10µf, 25V	Kemet K10P25	2
C3, 6, 10, 12	631-862008	Capacitor, F., Elect., 100µf, 50V	Sprague 30D107G050-DH2	4
C4, 9	633-815873	Capacitor, F., Cerm., 0.33µf, 25V	Sprague 5C10A	2
C5, 11	631-823421	Capacitor, F., Elect., 1µf, 50V	Cornell-Dubilier NLW-1-50	2
CR1, 6	774-857280	Rectifier, Bridge, 1.5A, 100V	Motorola MDA942A-3	2
CR2, 7	755-832774	Diode, Zener, 1N756A	Texas Instruments	2
CR3, 8	755-839930	Diode, Zener, 1N968B	Motorola	2
CR4, 9	755-858143	Diode, Zener, 1N967B	Texas Instruments	2
CR5, 10	755-845049	Diode, FDH627	Fairchild	2
Q1, 5, 6	755-846287	Transistor, 2N3877A	Sprague	3
Q2, 3, 8, 11, 15, 16, 17	755-857278	Transistor, 2N4356	Fairchild	7
Q4, 9, 10	755-857401	Transistor, 2N4919	Motorola	3
Q7	755-817964	Transistor, 2N1420	Pacific Semiconductor	1
Q12, 13, 18	755-857274	Transistor, 2N4275	Fairchild	3
Q14, 19, 20	755-857436	Transistor, 2N4922	Motorola	3
R1, 18	601-822299	Resistor, F., Comp., 6.8K, 1/4W, 5%	*A. B. CB6825	2
R2, 10, 19, 27	601-822308	Resistor, F., Comp., 1K, 1/4W, 5%	A. B. CB1025	4
R3, 20	601-822324	Resistor, F., Comp., 10K, 1/4W, 5%	A. B. CB1035	2
R4, 21	601-010942	Resistor, F., Comp., 6.8K, 1/2W, 5%	A. B. EB6825	2
R5, 22	601-857373	Resistor, F., Comp., 2.2Ω, 1/2W, 5%	A. B. EB22G5	2
R6, 15, 23, 32	601-817735	Resistor, F., Comp., 100Ω, 1/4W, 5%	A. B. CB1015	4
R7, 17, 24, 34	614-857321	Resistor, Var., 2.5K, 1/5W, 20%	Centralab 9-T-2-5K	4
R8, 16, 25, 33	601-822328	Resistor, F., Comp., 2.2K, 1/4W, 5%	A. B. CB2225	4
R9, 26	601-822335	Resistor, F., Comp., 27K, 1/4W, 5%	A. B. CB2735	2
R11, 28	601-822301	Resistor, F., Comp., 15K, 1/4W, 5%	A. B. CB1535	2
R12, 29	601-015047	Resistor, F., Comp., 3.9K, 1/2W, 5%	A. B. EB3925	2
R13, 14, 30, 31	601-822326	Resistor, F., Comp., 1.2K, 1/4W, 5%	A. B. CB1225	4
	776-436274	Heat Sink	Beckman	1
	864-806358	Transistor Pad	Milton Ross 10028	8

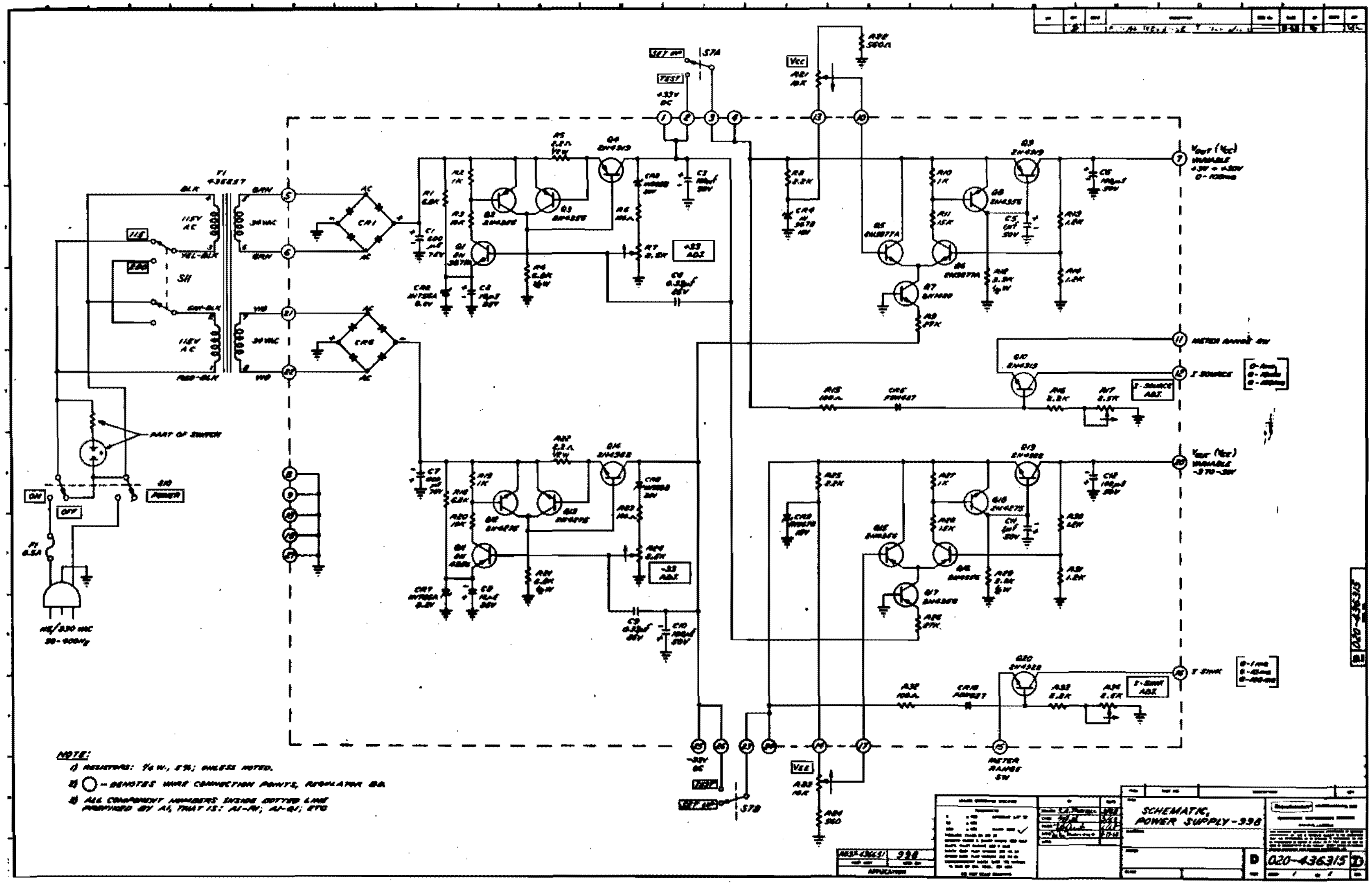
* "A. B." refers to Allen Bradley.


SEE DETAIL "A" TYP
RED DOT DENOTES "+" ON C1
RED DOT DENOTES "+" ON C7
HEAT SINK
WASHER SUPPLIED WITH TRANSISTOR
TRANSISTOR
AC BOARD
USE SCREW AND LOCK WASHER SUPPLIED WITH CAPACITOR, TYP
USE SILICON GREASE AND INSTALL MICA INSULATOR WASHER BETWEEN TRANSISTOR AND HEAT SINK.
DETAIL "A"
NOTE:
1- C1, C7, Q4, Q9, Q10, Q19, Q20, R7, R17, R24, R34 TO BE MOUNTED AFTER FLOW SOLDER OPERATION
2- TAPE SHADED HOLES PRIOR TO SOLDER OPERATION
3- TRANSISTORS MARKED * REQUIRE TRANSISTOR PADS ITEM 8
4- CR1 & CR6 TO BE SPACED OFF BOARD 1/8"
5- 2N3877A —— BOTTOM VIEW
FINAL RELEASE
SCHEMATIC, POWER SUPPLY
SPEC DWG, REGULATOR BD.
PARTS LIST, REGULATOR BD.
AC BOARD ASSEMBLY, REGULATOR
855-436650

POWER SUPPLY ASSEMBLY PARTS LIST

Detail No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./ Assy.
	855-436780-A	Power Supply Assembly	Beckman	
S11	716-857276	Switch, Slide, 115/230, 3A/125VAC	Switchcraft 4625 6LF	1
T1	792-436257	Transformer, Power	Beckman	1
XF1	735-007268	Fuse Holder	Bussman HKP	1
	691-000502	Terminal Strip	Cinch Jones 332-14-02-001	1
	664-812450	Line Cord	Belden Mfg. Co.	1

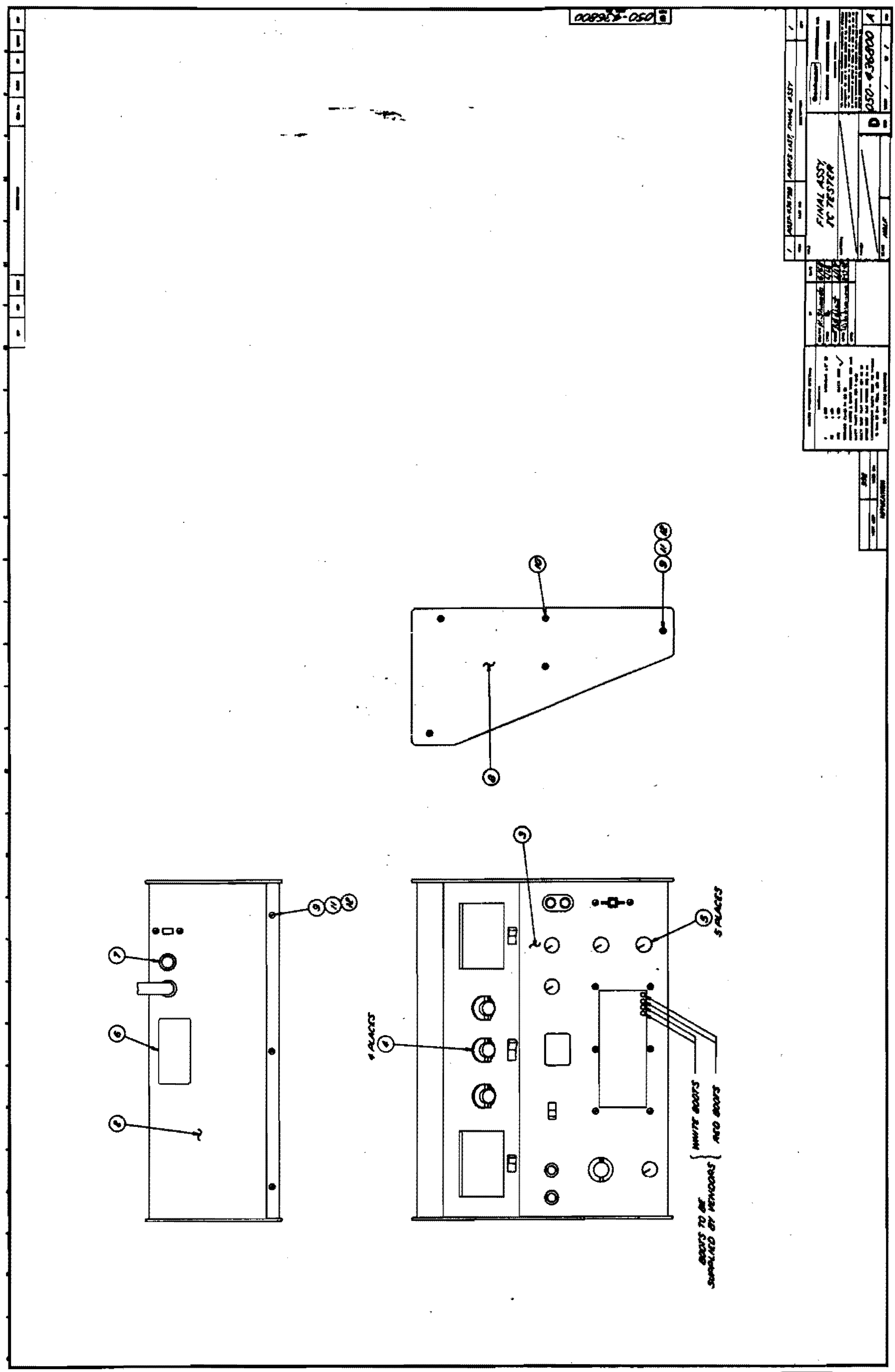


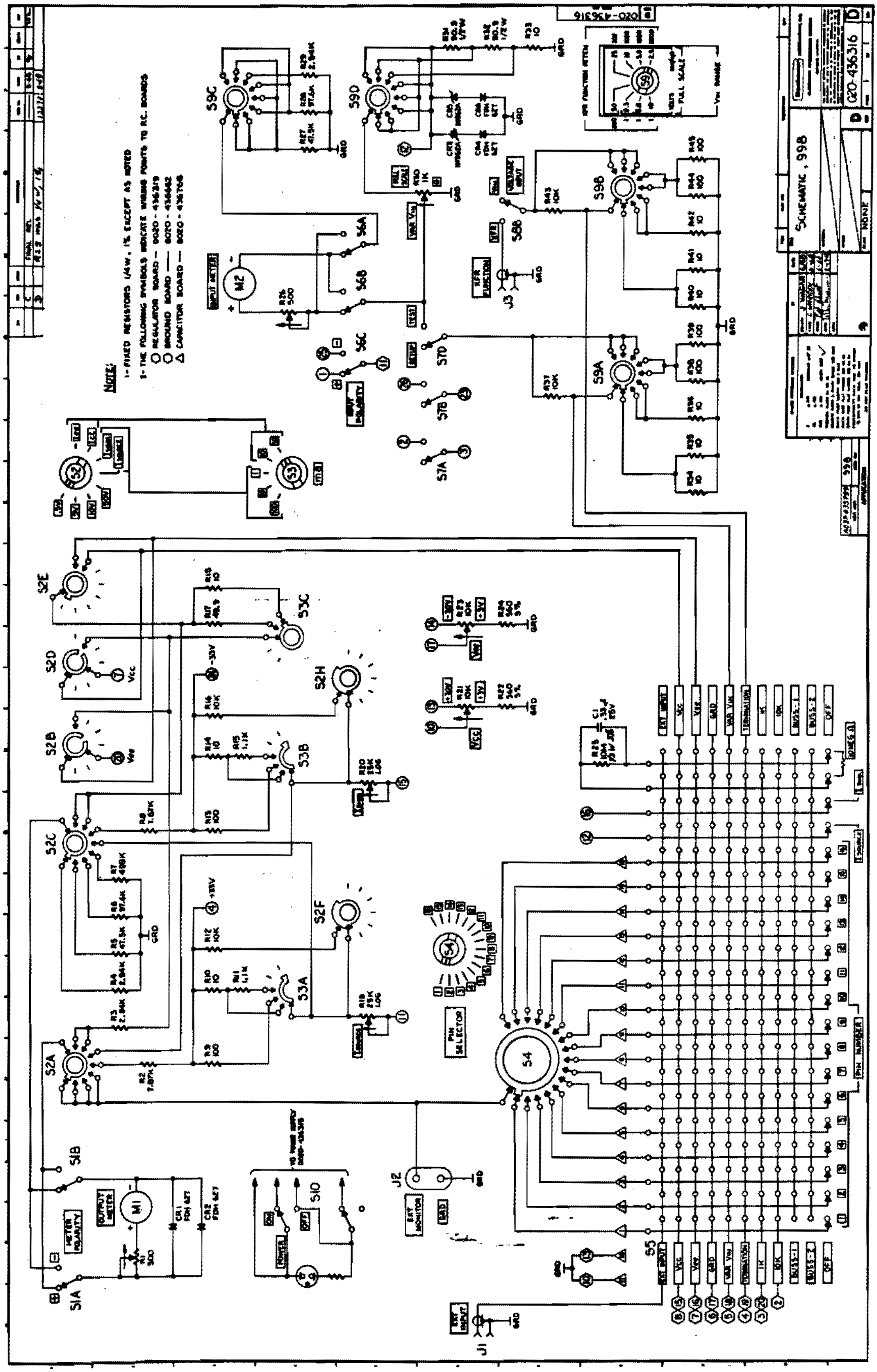

SCHEMATIC, POWER SUPPLY-398
020-436315
NOTE:
1) RESISTORS: 1/4 W., 5%; UNLESS NOTED.
2) ◯ - DENOTES WIRE CONNECTION POINTS, REGULATOR BD.
3) ALL COMPONENT NUMBERS INSIDE DOTTED LINE PREFIXED BY A1, THAT IS: A1-R1; A1-Q1; ETC
115/230 VAC 50-400Hz
PART OF SWITCH

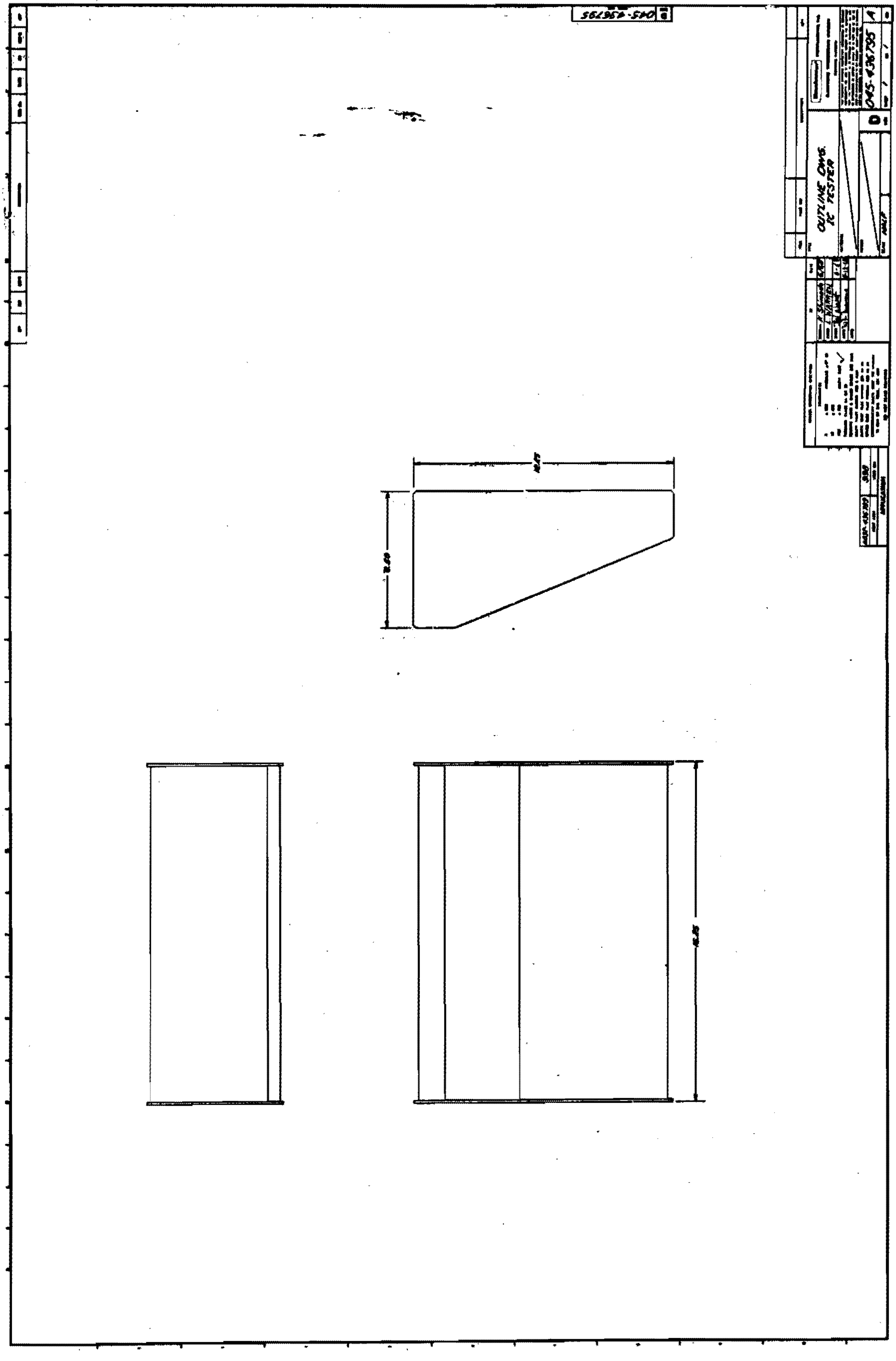
FINAL ASSEMBLY PARTS LIST

NOTE: Item numbers omitted are hardware or fabricated parts.

Item No.	Beckman Part No.	Description	Typical Manufacturer & No.	Qty./Assy.
	050-436800-A	Model 998 Final Assembly	Beckman	
4	325-413171	Knob, Bar, Skirted	Beckman	4
5	325-415351	Knob, Round	Beckman	5
6	030-436796	Nameplate	Beckman	1
7	731-099403	Fuse, 1/2 A	Bussman	1
8	433-435715	Panel, Side	Beckman	2


050-436800
FINAL ASSY
IC TESTER
5 PLACES
4 PLACES
WHITE BOOTS
RED BOOTS
BOOTS TO BE
SUPPLIED BY VENDORS


SCHEMATIC, 998
020-436316
NONE
NOTE:
1- FIXED RESISTORS 1/4W, 1% EXCEPT AS NOTED
PIN SELECTOR
PIN NUMBER
EXT INPUT
VCC
VAR VIN
GRD
TERMINATION
1K
10K
BUSS-1
BUSS-2
OFF


OUTLINE DWG.
IC TESTER
045-436795