

# 731B

## DC Reference Standard

Instruction Manual

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## Section 1

## Introduction &amp; Specifications

**1-1. INTRODUCTION**

1-2. The Model 731B DC Reference Standard is an ultra-stable dc power supply which, when standardized, is capable of providing a variety of precision output voltages with standard cell accuracy. The 731B will furnish basic dc voltage outputs of 10V, 1V,  $\Delta E$  (000 to 999  $\mu V$ ), 1.018 + $\Delta E$ , and 1.019 + $\Delta E$ .

1-3. The desired voltage mode is selected using a front panel function switch and the value of  $\Delta E$  is adjustable using a 10-turn linear potentiometer. The front panel  $\Delta E$  control includes a 3 digit turn counter to indicate the selected value of  $\Delta E$ , i.e., 000 to 999  $\mu V$ . The counter is equipped with a locking lever to prevent accidental changing of a selected  $\Delta E$  setting.

1-4. A front panel guard connection is provided for use in reducing errors caused by common mode voltages. The guarded internal circuitry is isolated from the chassis and earth ground.

1-5. Power to operate the 731B can be derived from either an internal battery pack for field or portable use, or from the ac power line for bench use. A front panel meter indicates the relative charge level of the internal battery pack during portable use. The AC line requirements are 115/230V ac, 50 to 400 Hz.

1-6. The 731B is supplied with non-marring feet for bench or field use. It may also be conveniently mounted in a standard 19" equipment rack using one of the rack mounting accessory kits shown in Table 1-1.

Table 1-1. ACCESSORY RACK MOUNTING KITS

MODEL NUMBER	MOUNTING CONFIGURATION
M03-201-601	One 731B, Offset mounting
M03-202-603	Two 731B's, Side-by-side
M03-206-604	Three 731B's, Side-by-side
M03-205-605	Four 731B's, Side-by-side

## 1-7. SPECIFICATIONS

## Output Voltage

Range	Output
10.0	10.0V dc
1.0	1.0V dc
1.018 + $\Delta E$	1.018 to 1.018999V dc
1.019 + $\Delta E$	1.019 to 1.019999V dc
$\Delta E$	0 to 999 $\mu V$ dc with 1 $\mu V$ resolution

**Output Accuracy:** Absolute accuracy at 23°C  $\pm 1^\circ C$   
after 30 minute warm-up

Range	Period		
	30 days	90 Days	1 Year
10V	$\pm 10$ PPM	$\pm 15$ PPM	$\pm 30$ PPM
1V	$\pm 10$ PPM	$\pm 15$ PPM	$\pm 30$ PPM
1.018+ $\Delta E$	$\pm 10$ PPM	$\pm 15$ PPM	$\pm 30$ PPM
$\Delta E$			$\pm 2$ $\mu V$

**Transfer Accuracy:** 4 Hr

Between standard cells on 1.018V +  $\Delta E$  or 1.019V +  $\Delta E$  ranges: 2 ppm

Between standard cell and 1V output: 3 ppm

Between 10V output and standard cell or 1V output: 5 ppm

**Temperature Coefficient:**

Less than 1 PPM/C°, 10°C to 45°C  
Less than 2 PPM/C°, 0°C to 10°C and 45°C to 55°C

**Output Current:**

## 10 Volt Range:

The 10 volt range is used in applications where some degree of loading is placed on the Reference Transfer Standard such as a Kelvin Varley Divider or other resistance networks.

## Loading Effect on the 10V Range:

Load R.	Output Change (PPM)
100 M $\Omega$	0
10 M $\Omega$	0.005 $\approx$ 0
1 M $\Omega$	.05
0.1 M $\Omega$	.5
10 K $\Omega$	5

1V, 1.018V, 1.019V Ranges:

The Reference Transfer Standard is designed to perform as a standard cell and therefore is intended to operate into a high impedance on the 1V, 1.018V and 1.019V ranges drawing minute currents. This impedance is usually infinity as in potentiometric circuits, or, in other applications should be at least 100 Megohms to prevent source loading.

**Source Resistance:**

10V Range	<0.07 $\Omega$
1V, 1.018V, 1.019V, $\Delta E$ Ranges:	< 1 k $\Omega$

**Output Protection:**

The output may be shorted indefinitely without damage to instrument.

**Line Regulation:**

Less than 1 PPM for  $\pm 10\%$  line variation.

**Ripple & Noise:**

Less than 1 PPM P-P dc to 1 Hz  
Less than 20  $\mu V$  RMS 1 Hz to 1 MHz  
Except <70  $\mu V$  RMS @ 10V output

**Common Mode Rejection:**

120 db at DC  
100 db at 60 Hz  
85 db at 400 Hz

**Isolation:**

Output may be floated up to 500 VDC between chassis ground and guard.

**Calibration Adjustment:**

Separate internal adjustments for the 5 output voltages. Front panel adjustment common to all voltages including the 10.000V output. Basic reference adjustments accessible from the front panel.

**Temperature/Humidity:**

+0°C to +55°C operating.  
-40°C to +60°C non-operating.  
Up to 70% RH for temperatures  $\leq 35^\circ C$

**Shock & Vibration:**

Meets requirements of MIL-T-21200L

**Terminals:**

Four five-way binding posts for positive, negative, ground and guard. Positive and negative are solid copper with gold flash.

**Input Power:**

115V or 230V  $\pm 10\%$  ac, 50 to 400 Hz single phase or internal battery operation.  
6 watts maximum, 120 Ma maximum

**Battery Operation:**

Rechargeable nickel-cadmium batteries provide at least 30 hours of continuous operation.

**Size:**

3½" high x 4¼" wide x 12" deep. (8.8 x 10.7 x 30.4  
(8.8 x 10.7 x 30.4 cm)

**Weight:**

5 lbs (2.26 kg)

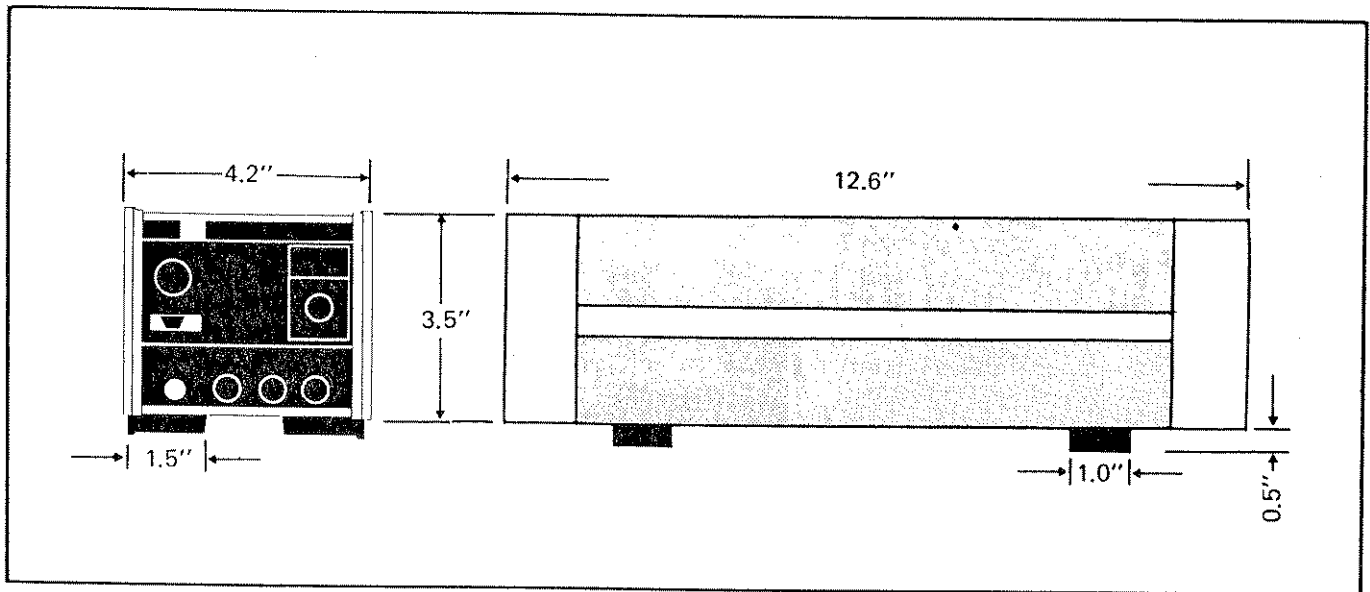


Figure 1-1. 731B OUTLINE DRAWING



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## Section 2

# Operating Instructions

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### 2-1. INTRODUCTION

2-2. This section of the manual contains information regarding installation and operation of the Model 731B DC Reference Standard. It is recommended that the contents of this section be read and understood before any attempt is made to operate the 731B. Should any difficulties arise during operation, please contact your nearest John Fluke Sales Representative or the John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043; telephone (206) 774-2211. A list of Sales Representatives is located in Section 7 of this manual.

### 2-3. SHIPPING INFORMATION

2-4. The 731B is packaged and shipped in a foam-

packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-5. If reshipment of the equipment is necessary, the original container should be used. If the original container is not available, a new container can be obtained from the John Fluke Mfg. Co., Inc. Please reference the equipment model number when requesting a new shipping container.

### 2-6. INPUT POWER

2-7. The 731B can be operated from a 115 or 230V ac, 50 to 400 Hz power line. Before connecting the instrument to the power line, check and, if necessary, set the instrument to operate at the local line voltage as follows:

- a. Remove the top cover from the 731B and locate the input power selection switch on the inside of the 731B.
- b. Set the slide switch to the desired operating voltage, 115 (white dot) or 230 (red dot).
- c. Install the proper fuse (i.e., AGC ½A for 115V ac and AGC ¼A for 230V ac) in the rear panel fuse holder.

2-8. The rear panel input power connector is a three prong, U-ground connector which permits the instrument to be connected, via the power cord, to the appropriate line power. The offset prong on this connector is connected to the 731B chassis and power supply, and should be connected, via the power cord, to a high quality earth ground.

## 2-9. RACK INSTALLATION

2-10. The 731B is designed for bench-top use or for installation in a standard 19-inch equipment rack, using one

of the optional accessory rack mounting kits. Information regarding rack installation procedures is given in Section 6 of this manual.

## 2-11. OPERATING FEATURES

2-12. The 731B controls, indicators and connectors are shown in Figure 2-1, and described in Table 2-1.

## 2-13. OPERATING NOTES

2-14. The following paragraphs describe various conditions which should be considered before operating the 731B.

## 2-15. Guarded Operation

2-16. The 731B is equipped with a guard that isolates its internal circuitry from the chassis and earth ground. A GUARD terminal is provided on the front panel, and when used, greatly reduces errors caused by common mode voltages. In general, guarded operation will be necessary under the following conditions:

- a. When a potential exists between equipment power line grounds.
- b. When long connecting leads are used to contact a high impedance load.

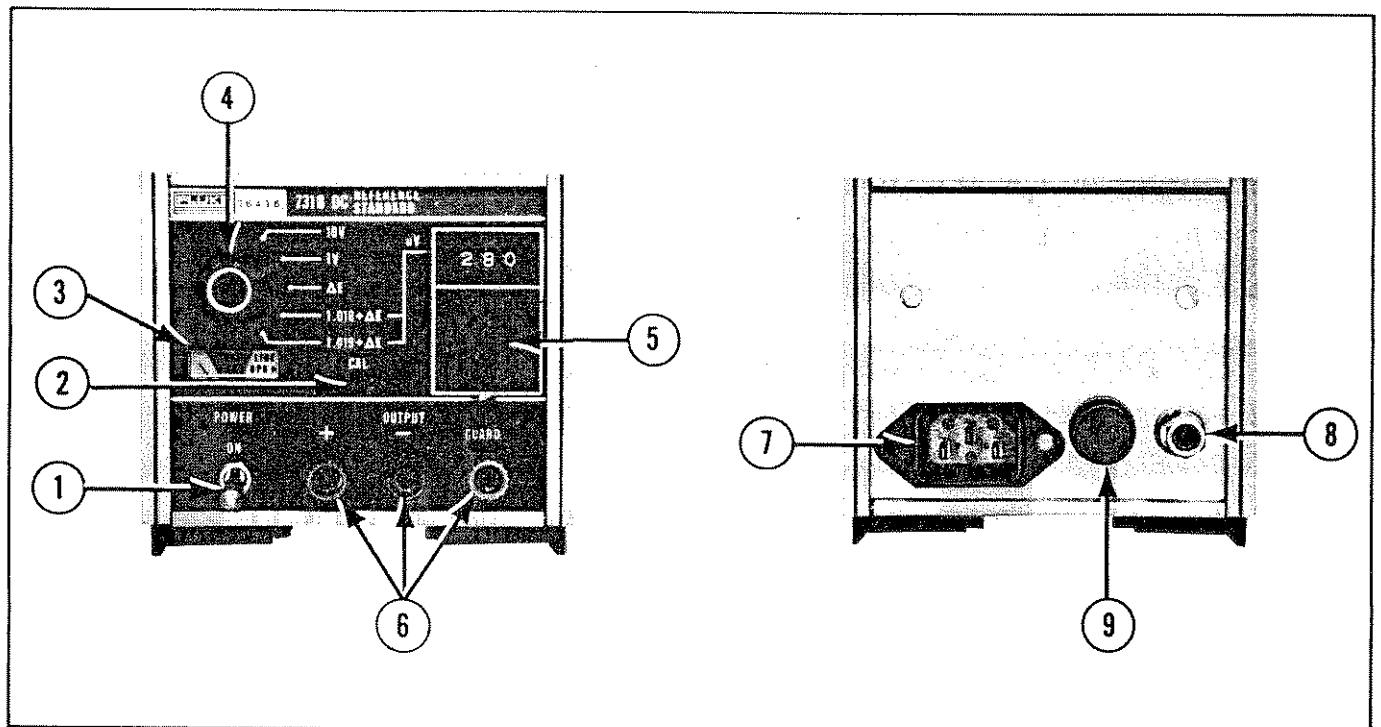


Figure 2-1. 731B CONTROLS, INDICATORS AND CONNECTORS

Table 2-1. 731B CONTROLS, INDICATORS AND CONNECTORS

REF. NO.	NAME	FUNCTION
1	POWER Switch	Switches the instrument on and off. When in the ON position, the Battery Charge Meter indicates line operation or battery charge level. Switch position can only be changed while activator is pulled out.
2	CAL Potentiometer	Provides the adjustment necessary to standardize the 731B (all modes) to an external standard cell.
3	Battery Charge Meter	Indicates power - on (LINE OPR) when the instrument is being operated from the power line. During battery operation, the meter indicates the relative charge level of the internal battery pack.
4	Mode Switch	<p>Selects the operating mode used to supply voltage to the + and - OUTPUT terminals:</p> <p>10V . . . . Provides a fixed 10V dc output.</p> <p>1V . . . . Provides a fixed 1V dc output.</p> <p><math>\Delta E</math> . . . . Provides an adjustable +000 to +999 <math>\mu V</math>dc output in 1 <math>\mu V</math> steps.</p> <p>1.018 + <math>\Delta E</math> . . Provides an adjustable +1.018000 to +1.018999 Vdc output. This mode is used to standardize to 731B to a standard cell whose voltage falls within the adjustable range.</p> <p>1.019 + <math>\Delta E</math> . . Provides an adjustable +1.019000 to +1.019999V dc output. This mode is used to standardize the 731B to a standard cell whose voltage falls within the adjustable range.</p>
5	$\Delta E$ vernier Control	A vernier control which provides the manual $\Delta E$ adjustment. The control is equipped with a three decade digital readout to permit exact settings from 000 to 999 $\mu V$ dc.
6	OUTPUT Terminals	<p>Provides front panel connection to the 731B output and guard circuits.</p> <p>+ and - . . . . . Voltage output terminals</p> <p>GUARD . . . . . Provides connection to the internal guard circuit and is used to reduce the effects of common mode voltages.</p>
7	Input Power Connector	Provides the means of connecting the instrument through the power cord to line power.
8	Ground Terminal	Provides a convenient ground point during battery operation.
9	Fuse	Protects the ac input section of the power supply.

- c. When operating the instrument in the presence of high level radiated noise, e. g., stay fields at the power line frequency.

2-17. One of the most common cases requiring guarding is that of differences in power line grounds. When the 731B is connected to another instrument, with both instruments grounded through their respective power cords, a potential difference may exist between the power line grounds of these two instruments. This potential difference can cause circulating ground currents which could cause errors in the output voltage. To prevent these errors from occurring, the 731B GUARD terminal should be connected to the load in such a manner as to provide a separate path for circulating ground currents. For proper connection, connect GUARD terminal directly to grounded side of load, at the load. Figure 2-2 illustrates correct GUARD terminal connection and the rerouted ground currents.

## 2-18. Battery Operation

2-19. The rechargeable nickel-cadmium battery provides at least 30 hours of continuous operation before recharging is required. Batteries are automatically trickle charged whenever the instrument is operating from the ac line. Recharging of completely discharged batteries requires approximately 12 hours.

### NOTE

*A ground terminal on the rear of the 731B provides a convenient method of grounding the instrument during battery operation.*

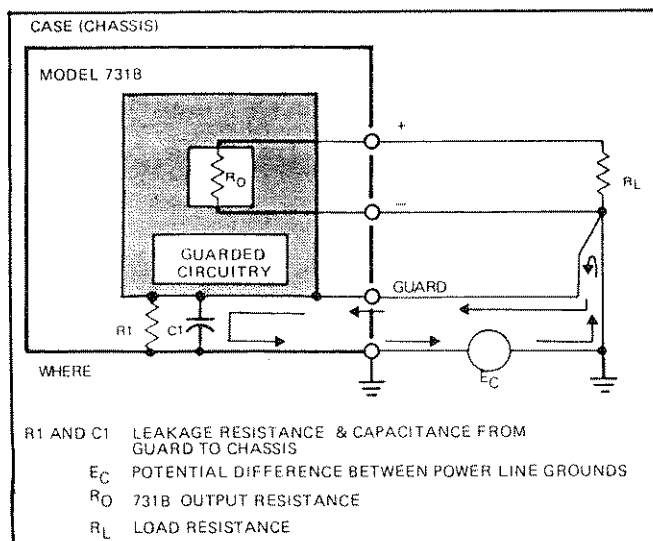


Figure 2-2. GUARD CONNECTION

## 2-20. OPERATION

### 2-21. Turn-On Procedure

2-22. Use of the following procedure is suggested for initial turn-on of the 731B:

- Connect the instrument to ac line power (See paragraph 2-6). This step is not necessary if battery operation is desired.
- Set the POWER switch to the ON position.

### NOTE

*The POWER switch actuator must be pulled out before the switch position can be changed.*

- Ensure that the instrument is energized by observing the indication shown on the battery charge meter. For line operation, the meter should indicate BAT OK. If the meter indication falls below BAT OK, the battery pack should be recharged.

### 2-23. Standard Cell Transfer

2-24. When standardized to an external standard cell, the selected 731B output will be within 2 ppm of the standard cell voltage. Stability is better than 10 ppm per month. Use the following procedure to standardize the 731B.

- Energize the 731B and allow a 30-minute warm-up period.
- Obtain a certified standard cell and note its voltage.
- Set the mode switch to  $(1.018 + \Delta E)$  or  $(1.019 + \Delta E)$  whichever includes the equivalent of the standard cell voltage.
- Connect the standard cell and a null detector (Fluke 845AB or equivalent) to the 731B as shown in Figure 2-3.
- Adjust the  $\Delta E$  control so that the mode switch setting plus the  $\Delta E$  setting is equal to the standard cell voltage.
- Adjust the front panel CAL potentiometer for an optimum null.

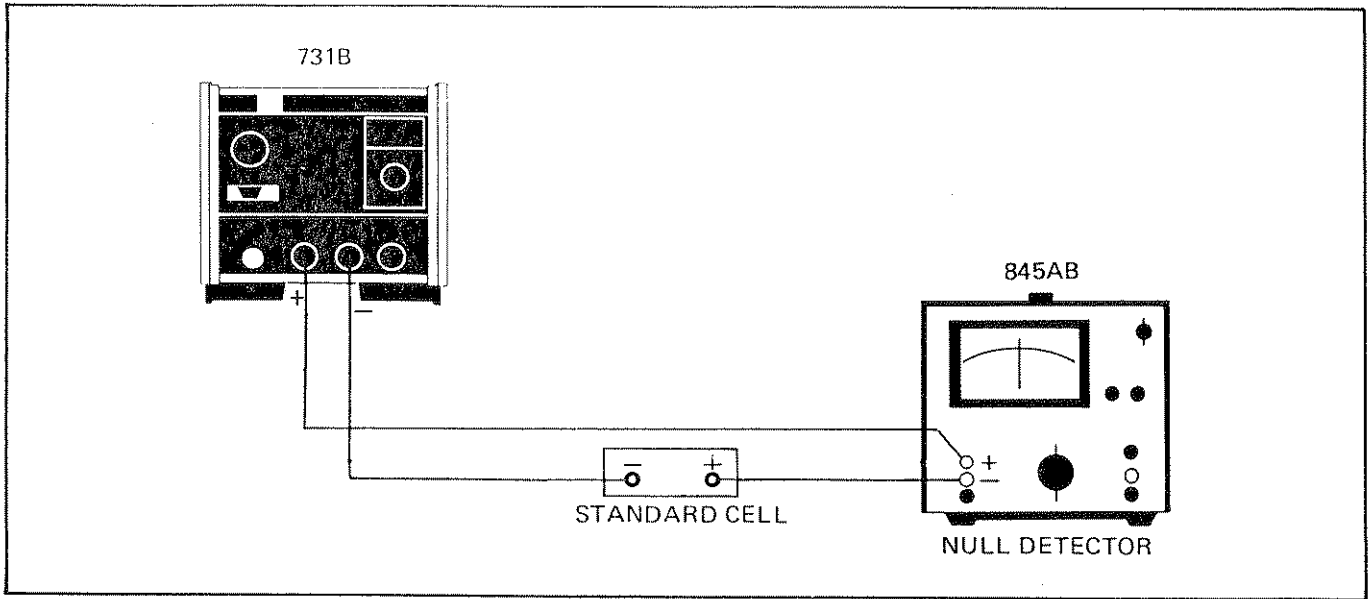


Figure 2-3. STANDARDIZING THE 731B.

- g. Disconnect the standard cell and the null detector from the 731B OUTPUT terminals.

**2-25. Reference Voltage Modes**

- 2-26. A standardized 731B can be used to provide either

a  $\Delta E$ , a 1 volt or a 10 volt output with standard cell transfer accuracies of 2 ppm, 3 ppm or 5 ppm, respectively. For example, standardizing the 731B to a standard cell having an absolute accuracy of 3 ppm would provide a 10 volt reference output which is accurate to 8 ppm (3 ppm standard cell accuracy + 5 ppm 731B transfer accuracy) or 0.0008%.

## Section 3

# Theory of Operation

### 3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description followed by a detailed block diagram analysis of the Model 731B DC Reference Standard. Simplified block diagrams and circuit diagrams are included as necessary, to supplement the text.

### 3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The 731B, is an ultra-stable dc power supply which, when standardized, is capable of providing either a standard 1 volt, 10 volt or 000 to 999 microvolt output. The desired output voltage is selected by the Mode switch, and in the  $\Delta E$  mode the output is adjustable using the  $\Delta E$  vernier control. The resistor networks in the Output Divider scale a

fixed precision dc voltage from the Reference Supply to provide the output voltage selected by the Mode switch setting. Operating voltage for the Reference Supply is derived from the Charging Circuit. Either ac line power or the battery pack can be used to provide the unregulated operating voltage to the Reference Supply. When using the ac line, the charging circuits also charge the battery pack.

### 3-5. BLOCK DIAGRAM ANALYSIS

#### 3-6. General

3-7. A block diagram analysis of the functional circuits of the 731B is given in the following paragraphs. The circuits described correspond to the functional blocks defined in Figure 3-1. Detailed schematics are included in Section 8 of this manual.

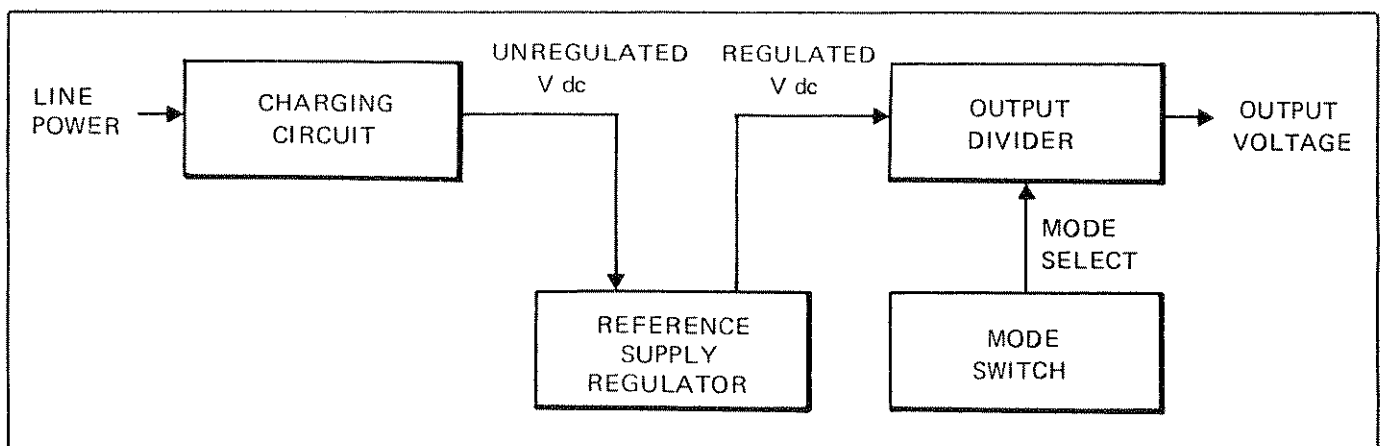


Figure 3-1. 731B SIMPLIFIED BLOCK DIAGRAM.

### 3-8. Charging Circuit

3-9. The Charging Circuit is included on the A3 Power Supply PCB and consists of a full wave rectifier CR12, series pass transistor Q3 and the associated components. The function of the charging circuit is two-fold, and depends on whether the 731B is being operated from the ac power line or the battery pack. In the line power configuration, the output of transformer A4T1 is rectified by CR12 before being used to supply the raw input voltage to the series-pass regulator Q3. Since the rectified output of CR12 exceeds the battery pack voltage, a trickle charge is delivered to the batteries, through CR5 and R30. When the 731B is disconnected from the ac power line, it is operated from the internal Ni-cad battery pack. In this configuration, the series regulator is by-passed and the battery output is delivered directly to the output of the charging circuit via diode CR8.

3-10. The meter circuit is calibrated to indicate the relative battery charge level during battery operation, and full scale during line operation. Resistors R31 and R32 are used to set the meter indication during battery operation. For line operation diode CR7 and R34 provide the extra drive necessary for a full scale indication.

### 3-11. Reference Supply

3-12. The Reference Supply (included on the Reference Regulator PCB) consists of a compensated zener reference amplifier U2, operational amplifier U1, transistors Q1 and Q2, and their associated circuitry. The function of the Reference Supply is to regulate the output voltage supplied by the charging circuit, and to provide a precisely regulated +10V dc output signal. Reference amplifier U2 functions as the primary element in the Reference Supply and is shown in Figure 3-2. It contains a silicon NPN transistor connected in series with a zener diode and both are mounted on a common substrate which is enclosed in a single envelope. The reference voltage,  $V_{ref}$ , is the sum of the zener voltage,  $V_z$ , and the transistor's base-to-emitter voltage  $V_{be}$ . Temperature variations affecting  $V_z$  are compensated for by corresponding changes in  $V_{be}$ .

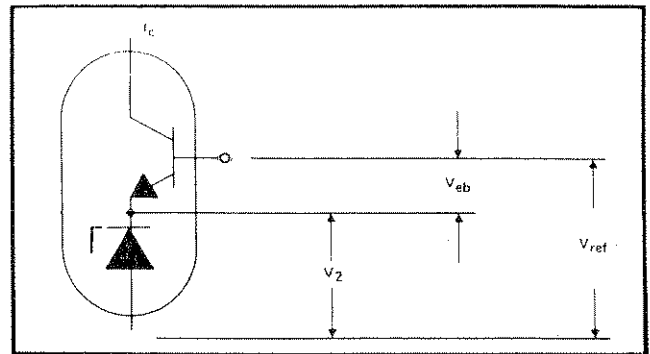


Figure 3-2. REFERENCE AMPLIFIER

3-13. In operation, the Reference Supply acts as a simple series pass regulator, with Q1 acting as the series pass element. Regulation is accomplished by the action of U2 which compares its internal reference voltage with the output voltage and adjusts the base drive of Q1, via amplifier U1, until both voltages are equal. Short circuit protection is provided by current sensing resistor R28 and transistor Q2. Potentiometer R11 is the front panel CAL adjust used to standardize the reference supply. The output of the supply, when standardized, is exactly +10V dc.

### 3-14. Output Divider

3-15. The 731A output voltage is selected by means of the front panel mode switch and a series of resistive dividers attached to the Reference Supply output. In the 10V mode the Reference Supply output is connected directly to the OUTPUT terminals. In all other modes the +10V reference voltage is reduced by a voltage divider before being made available at the OUTPUT terminals. Separate calibration potentiometers are provided for each of the selectable modes. The 1V output is adjusted by R19 and the 1.018 and 1.019 V outputs are adjusted by R17 and R15, respectively. The  $\Delta E$  output is calibrated by R24, and is adjustable from 000 to 999  $\mu V$  using the front panel  $\Delta E$  vernier control (A1R1). In the 1.018 + $\Delta E$  and 1.019 +  $\Delta E$  modes the  $\Delta E$  divider is operated in conjunction with the 1.018 and 1.019 dividers. In the  $\Delta E$  mode, the  $\Delta E$  divider operates independently.

## Section 4

# Maintenance

### 4-1. INTRODUCTION

4-2. This section of the manual contains maintenance information for the Model 731B DC Reference Standard. This includes service information, general maintenance, performance test, calibration and troubleshooting information. The performance test is recommended as a preventative maintenance tool, and should be executed every 90 days to verify proper instrument operation within the specifications given in Section 1. A calibration interval of 90 days is recommended to ensure that the instrument remains within these specifications. Table 4-1 lists the equipment required for the performance test and calibration.

### 4-3. SERVICE INFORMATION

4-4. Each instrument that is manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is given on the back of the title page located in the front of the manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these service centers is included with the

Table 4-1. REQUIRED TEST EQUIPMENT

EQUIPMENT NOMENCLATURE	RECOMMENDED EQUIPMENT
Null Detector	Fluke Model 845AB
DC Differential Voltmeter	Fluke Model 895A
True RMS Differential Voltmeter	Fluke Model 931B
DC Voltage Source	Fluke Model 341A DVM Calibrator
Standard Cell	Guildline Instruments Model 9152/P4
X1000 Amplifier	-----
Voltage Divider	Fluke Model 720A Kelvin-Varley Voltage Divider
Low-Thermal Switch	Leeds & Northrup Type 3702 Tapping Key
Autotransformer	General Radio W5MT3A or W10MT3A



WARRANTY. Shipping information is given in the operating instructions section of this manual. If requested, an estimate will be provided to the customer before work is begun on instruments that are beyond the warranty period.

#### 4-6. GENERAL MAINTENANCE

##### 4-7. Access Information

4-8. Use the following procedure to gain access to the interior of the instrument (See Figure 4-1):

- a. Remove the top dust cover.
- b. Remove the guard cover.
- c. Remove the bottom dust cover.

##### 4-9. Cleaning

4-10. Clean the instrument periodically to remove dust, grease and other contamination. Use the following procedure:

- a. Clean the surface of all PCB's using clean dry air at low pressure ( $\leq 120$  psi). If grease is encountered, spray with Freon T.F. Degreaser and remove grime with clean dry air at low pressure.
- b. Clean the front panel with a soft cloth dampened with a mild solution of detergent and water.

#### CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents on the front panel of the 731B.

##### 4-11. Fuse Replacement

4-12. The power fuse F1 is located on the rear panel of the Model 731B. If replacement is necessary, use the following rated fuses:

- a. 115 Volt operation – AGC  $\frac{1}{2}$  Ampere
- b. 230 Volt Operation – AGC  $\frac{1}{4}$  Ampere

##### 4-13. Service Tools

4-14. No special tools are required to maintain or repair the 731B.

#### 4-15. PERFORMANCE TEST

4-16. The performance test is designed to verify the overall operation of the 731B. This test can be used as an acceptance check and/or periodic maintenance check. Table 4-1 lists the equipment required to perform this test. If the unit fails any part of the performance test, corrective action is indicated. Tests should be conducted at an ambient temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  and a relative humidity of less than 70%. Allow a 30 minute warm-up period prior to conducting the performance test.

##### 4-17. Line Regulation

- a. Connect equipment as shown in Figure 4-2.
- b. Adjust the autotransformer for an output voltage of 115V ac.
- c. Zero the 845AB on the 1 microvolt range, then set it to the 10 microvolt range.
- d. With the test switch open, adjust 731B output to equal the standard cell voltage.
- e. Close the switch and adjust 731B output for null on the 845AB.
- f. Vary autotransformer output from 115 to 105V ac and from 115 to 125V ac. The 845AB indication should not change more than  $\pm 1$  microvolt.
- g. Set the variac output to 115V ac.

##### 4-18. Output Noise, DC to 1 Hz.

- a. Connect equipment as shown in Figure 4-2.
- b. Zero the 845AB on the 1 microvolt range, then set it to the 10 microvolt range.
- c. Adjust 731B output for null on 845AB.
- d. Observe the random voltage excursions indicated on the 845AB over a 10 second period. Excursions should be less than 1 microvolt peak to peak.

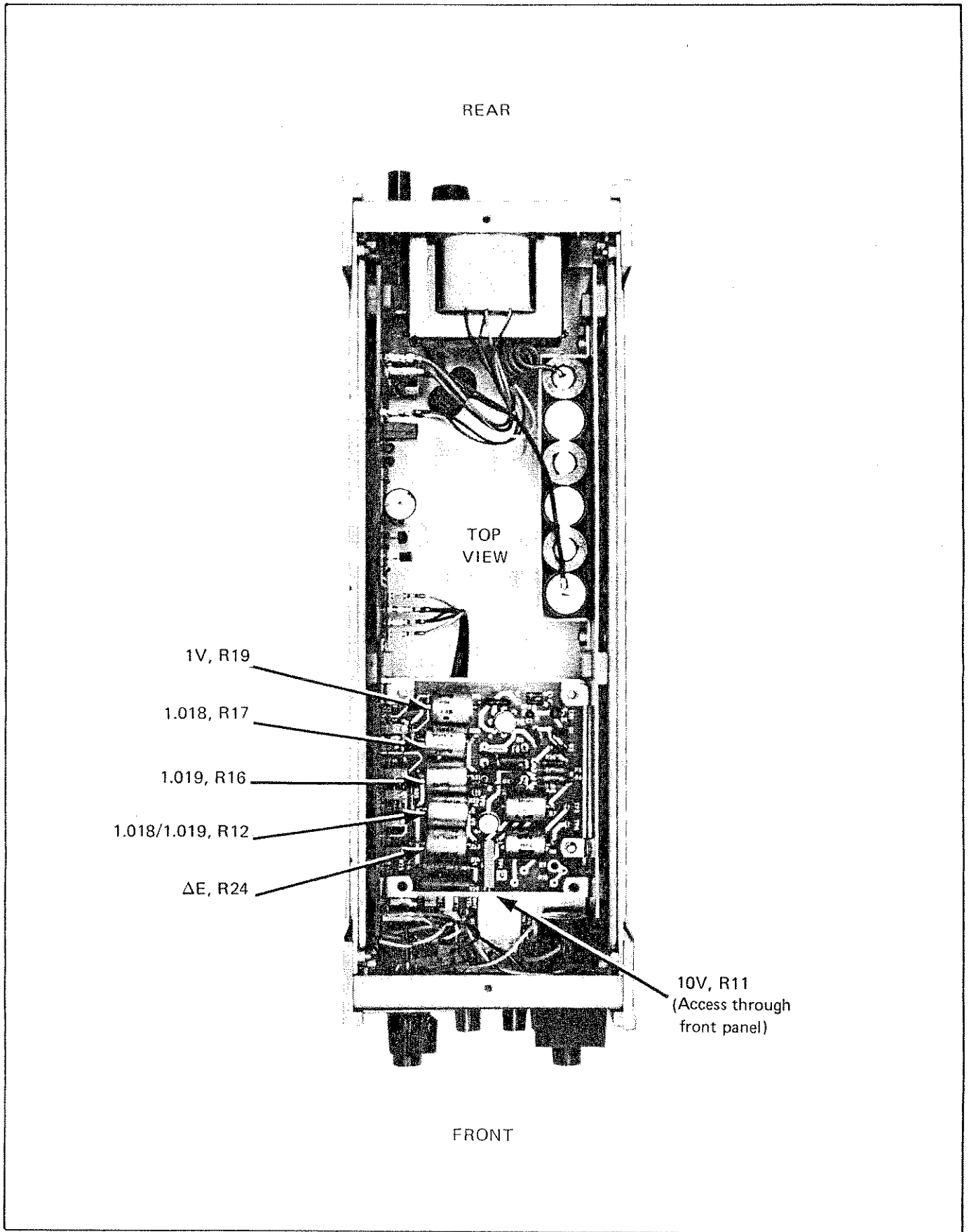


Figure 4-1. ADJUSTMENT LOCATIONS.

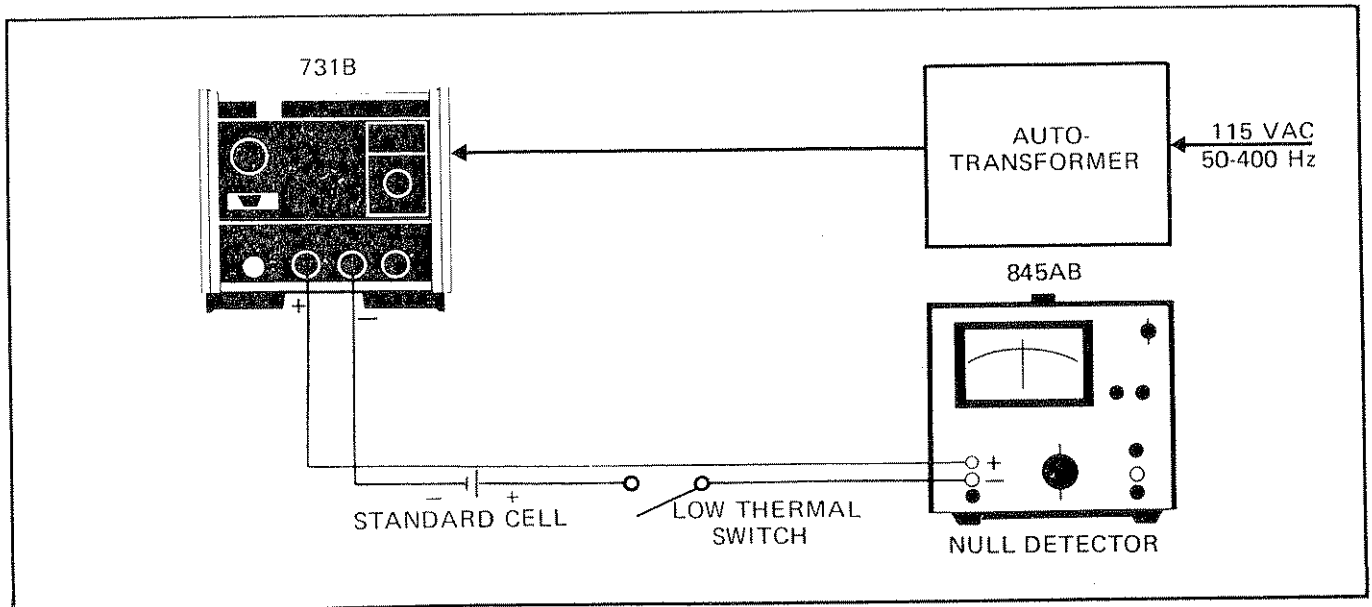


Figure 4-2. EQUIPMENT CONNECTIONS FOR LINE REGULATION, DC TO 1 Hz OUTPUT NOISE, AND TRANSFER ACCURACY TESTS.

#### 4-19. Output Noise, 1 Hz to 1 MHz

- a. Connect equipment as shown in Figure 4-3.
- b. Set 931B range to 100 millivolts, mode switch to TVM X1.
- c. Set 731B output to 1.018000 volts. The 931B should indicate less than 20 millivolts rms, which represents 20 microvolts output from the 731B.

#### 4-20. Common-Mode Rejection

- a. Connect equipment as shown in Figure 4-4.
- b. Set 341A for zero volts output.
- c. Set 731B output to 1.018000 volts.
- d. Set 895A range to 1 volt, null sensitivity to 100 microvolts, and readout dials for null indication.
- e. Set 341A output to 100 volts. The 895A meter indication should be zero  $\pm$  100 microvolts.

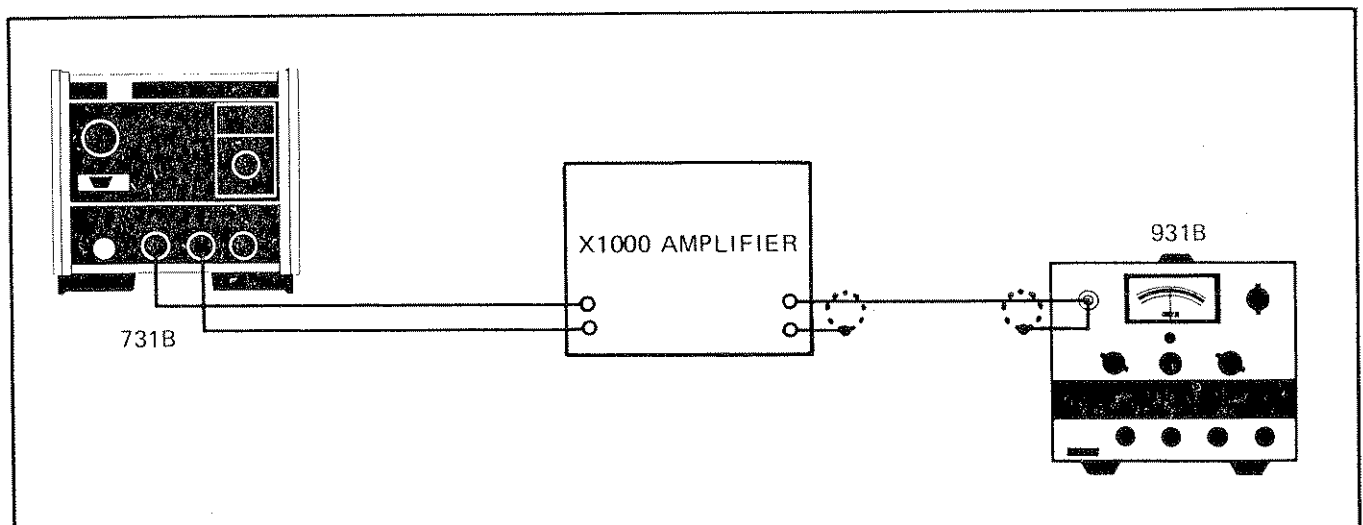


Figure 4-3. EQUIPMENT CONNECTIONS FOR 1 HZ TO 1 MHz OUTPUT NOISE TEST.

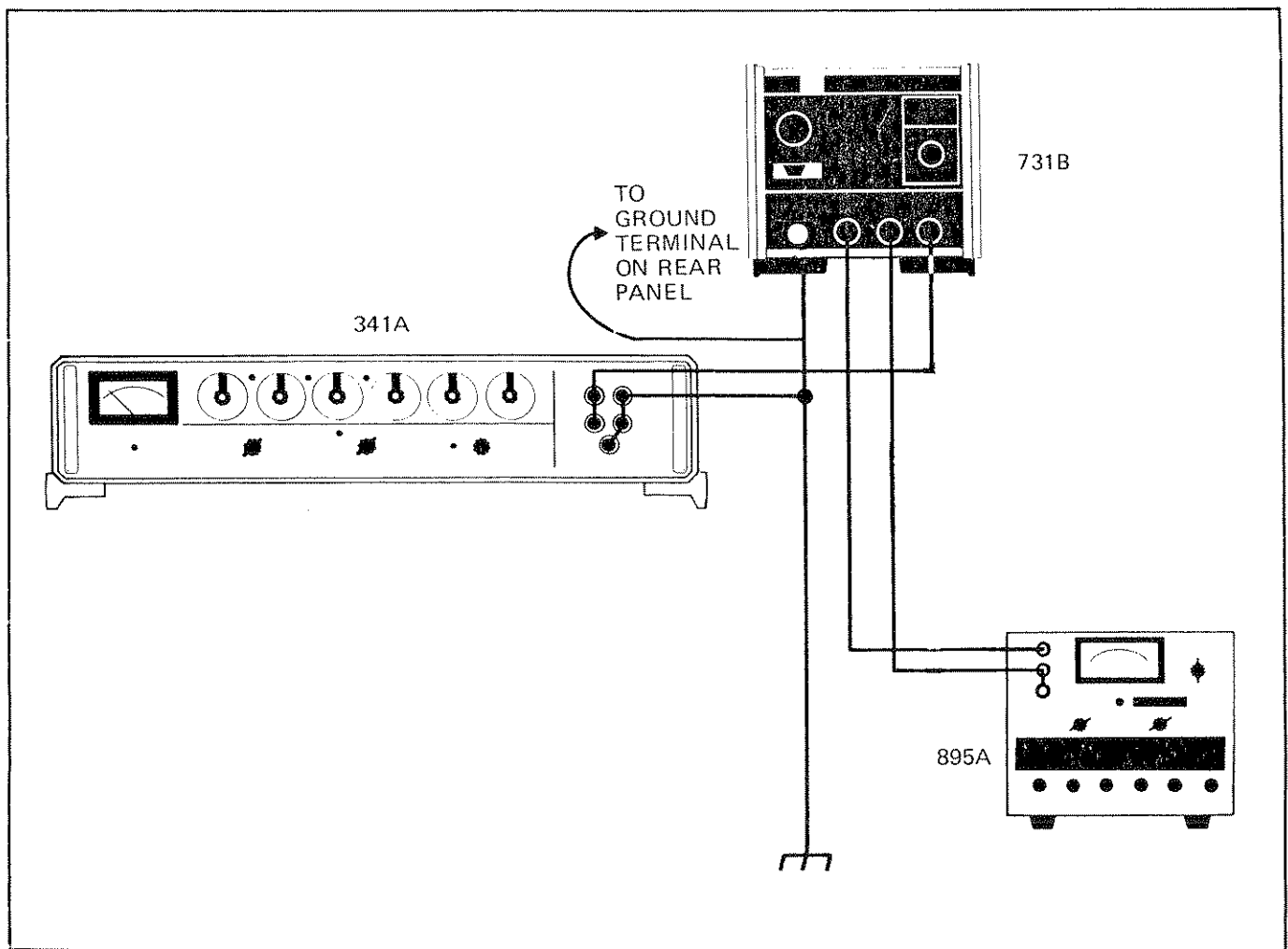


Figure 4-4. EQUIPMENT CONNECTIONS FOR COMMON-MODE REJECTION TEST.

#### 4-21. Isolation

- a. Turn off the 731B and disconnect it from the power line.
- b. Connect the negative output terminal of the 341A to the guard terminal of the 731B and the positive output terminal of the 341A to case (ground) of the 731B.
- c. Set 341A output to 500 volts. The 341A meter should indicate no discernable current flow.
- d. Repeat steps (b) and (c) for the positive output terminal of the 731B.
- e. Repeat steps (b) and (c) for the negative output terminal of the 731B.

#### 4-22. Transfer Accuracy

- a. Connect equipment as shown in Figure 4-2.
- b. Zero 845AB on the 1 microvolt range, then set it to the 10 microvolt range.
- c. With the switch open, adjust 731B output to equal standard cell voltage.
- d. Close the switch and adjust 731B output for null on the 845AB.
- e. Lock the  $\Delta E$  control on the 731B.
- f. Open the test switch, remove all test leads from the setup, and allow the 731B to operate for 20 minutes.
- g. Reconnect equipment and check 731B output for null against standard cell. The 845AB should indicate less than  $\pm 2$  microvolts deviation from null (zero).

Table 4-2. 731B CALIBRATION

STEP	EQUIPMENT CONNECTIONS	731B CONTROL SETTINGS		720A DIAL SETTINGS	845 AB RANGE	341A OUTPUT (VDC)	CALIBRATION INSTRUCTIONS
		FUNCTION	$\Delta E$				
1	Figure 4-5	10V	Any	1.0000000	10 $\mu$ V	11	Adjust 341A output for zero ( $\pm 10 \mu$ V) on the 845AB
2		1V		.1000000	1 $\mu$ V	As set in step (1).	Adjust the "1V Cal" control (R19) for zero ( $\pm 1 \mu$ V) on the 845AB.
3		1V		1.0000000	1 $\mu$ V	1.1	Adjust 341A output for zero ( $\pm 1 \mu$ V) on the 845AB
4		1.018 + $\Delta E$	000	1.0180000	1 $\mu$ V	As set in step (3)	Adjust the "1.018 Cal" control (R17) for zero ( $\pm 1 \mu$ V) on the 845AB.
5		1.019 + $\Delta E$		1.0190000	1 $\mu$ V	As set in step (3).	Adjust the "1.019 Cal" control (R15) for zero ( $\pm 1 \mu$ V) on the 845AB.
6		1.019 + $\Delta E$	999	1.0199999	1 $\mu$ V	As set in step (3).	Adjust the "1.018/1.019 + $\Delta E$ Cal" control (R12) for zero ( $\pm 1 \mu$ V) on the 845AB.
7		$\Delta E$		.000999	1 $\mu$ V	As set in step (3).	Adjust " $\Delta E$ Cal" control (R24) for zero ( $\pm 1 \mu$ V) on the 845AB.
8	Figure 4-6	Set to standard cell voltage.		-----	1 $\mu$ V	-----	Adjust front panel "CAL" control (R11) for zero ( $\pm 1 \mu$ V) on the 845AB.

4-23. CALIBRATION

4-24. The calibration procedure for the 731B is given in Table 4-2. A description of equipment required for calibration is given in Table 4-1.

Calibration should be performed with ambient temperature at  $+23^{\circ}\text{C} \pm 1^{\circ}\text{C}$  and relative humidity less than 70%. Adjustment locations are shown in Figure 4-1.

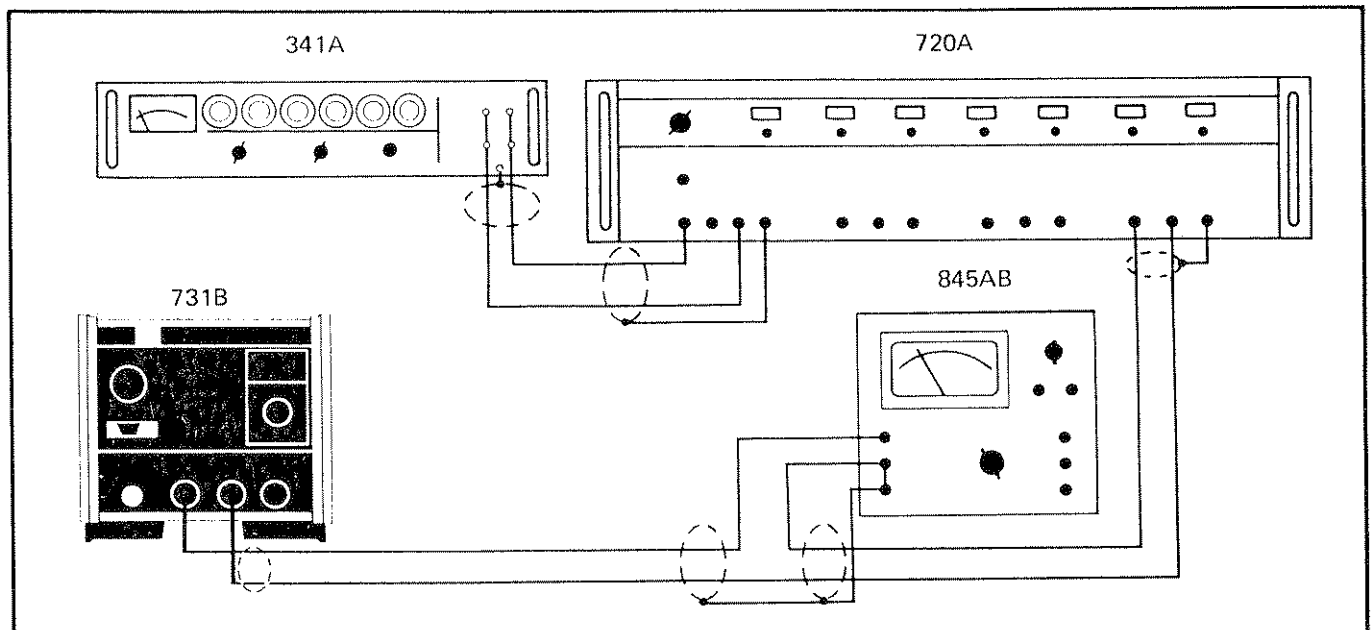


Figure 4-5. EQUIPMENT CONNECTIONS FOR DIVIDER ADJUSTMENT

## 4-25. TROUBLESHOOTING

4-26. Before attempting to troubleshoot the 731B, it should be verified that the trouble is actually in the instrument and is not caused by faulty external equipment or connections. Then the performance test should be executed to localize the problem.

4-27. Check output voltages at each position of the func-

tion switch. The 10V output must be correct or all voltages will be incorrect. If the 10V output is correct but one or more other outputs are incorrect, check calibration of the divider associated with the faulty output and check for proper resistance values in the divider.

4-28. The voltage at the collector of Q1 should be approximately 17V dc for line operation and 14V dc for battery operation. If these voltages are correct but the 10V output is incorrect, either U1 or U2 in the Reference Supply is defective.

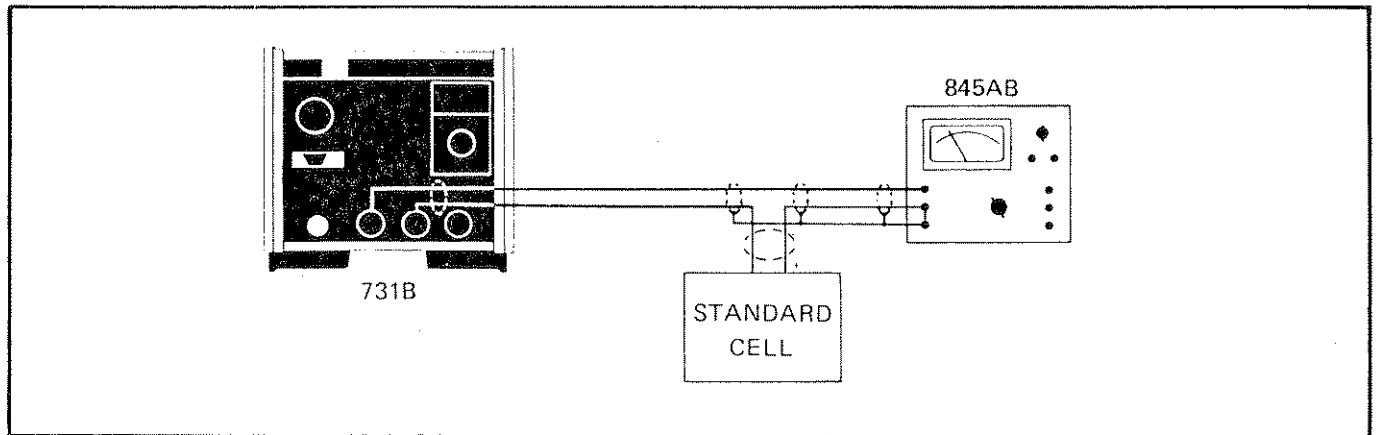


Figure 4-6. EQUIPMENT CONNECTIONS FOR ABSOLUTE VOLTAGE ADJUSTMENT

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Section 5

# Lists of Replaceable Parts

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TABLE OF CONTENTS

ASSEMBLY NAME	PART NO.	Page
Final Assembly, Model 731B		5 - 3
Reference Regulator PCB Assembly	390195	5 - 6
Power Supply and Adjustment PCB Assembly	390187	5 - 9

## 5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alpha-numerically by assembly. Electrical components are listed by reference designation and mechanical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

- a. Reference Designation or Item Number.
- b. Description of each part.
- c. Fluke Stock Number.
- d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)
- e. Manufacturer's part Number or Type.
- f. Total Quantity per assembly or component.
- g. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.
- h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

## 5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instruction, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information:

- a. Quantity
- b. FLUKE Stock Number
- c. Description
- d. Reference Designation or Item Number
- e. Printed Circuit Board Part Number
- f. Instrument model and serial number.

## 5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY
-------------	---------------------------



## FINAL ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	FINAL ASSEMBLY, Model 731B Figure 5-1						
A 2	Reference, Regulator Assembly	390195	89536	390195	1		
A3	Power Supply & Adjustment Assembly	390187	89536	390187	1		
BT1	Battery pack	306134	89536	306134	1		
F1	Fuse, ½ amp, fast acting	153858	71400	Type AGC	1		
J1	Binding post, red	380147	32767	820 - 55	1		
J2	Binding post, black	380154	32767	820 - 65	1		
J3	Binding post, blue	275578	32767	820 - 45	1		
M1	Meter, 0 - 1 mA	266494	32539	Type TS10	1		
R1	Res, var, ww, 5k ±5%, 2W	295626	80294	3509S9-502	1		
S1	Switch, rotary	284414	89536	284414	1		
S2	Switch, toggle	402537	83979	MSTL206N	1		
T1	Xfmr	390872	89536	390872	1		
XF1	Fuseholder	100107	71400	HKP	1		
J4	Binding post, grounding	155911	58474	GP30NC	1		
1	Corner	295972	89536	295972	4		
2	Cover, reference regulator	390351	89536	390351	1		
3	Decal, front	357970	89536	357970	1		
4	Dial, counting	295642	13511	1381	1		
5	Guard, right side	390344	89536	390344	1		
6	Knob	341453	89536	341453	1		
7	Panel, front	296814	89536	296814	1		
8	Panel, rear	390377	89536	390377	1		
9	Receptacle, conn.	267542	00779	367542	16		

## FINAL ASSEMBLY

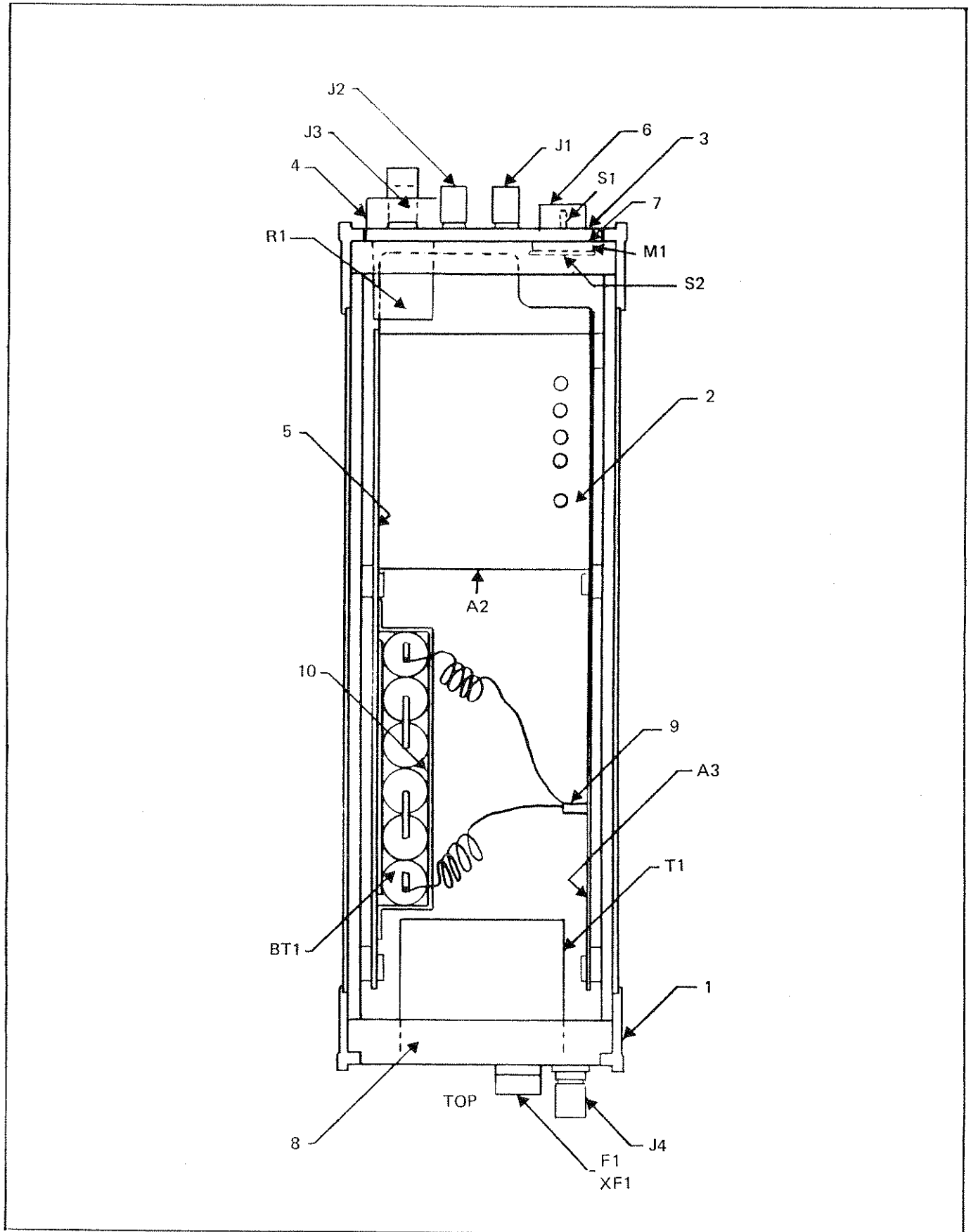


Figure 5-1 731B FINAL ASSEMBLY

FINAL ASSEMBLY

731B

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
10	Strap, battery	296822	89536	296822	1		
	Chassis, side	390385	89536	390385	2		
	Cover, bottom	301572	89536	301572	1		
	Cover, top	390385	89536	390385	2		
	Foot	292870	89536	292870	1		
	Retainer, meter	307322	89536	307322	1		

## REFERENCE-REGULATOR PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	REFERENCE-REGULATOR PCB ASSEMBLY (731B-4011) Figure 5 - 2	390195	89536	390195	REF		
C1	Cap, ta, 1 uF $\pm$ 20%, 35V	161919	56289	196D105X0035	1		
C2	Cap, mica, 100 pF $\pm$ 5%, 100V	148494	14655	CD15FD101J03	1		
C3	Cap, cer, 0.01 uF $\pm$ 20%, 100V	149153	56289	C023B101F103M	1		
C4	Cap, mylar, 0.01 uF $\pm$ 10%, 250V	161992	73445	C280AEA100K	1		
CR1	Diode, zener, 5.6V	277236	07910	1N752A	1		
CR2	Diode, FET, current regulator	348482	17856	E505	1		
Q1,Q2	Xstr, Si, PNP	218396	04713	2N3904	2		
R1	Res, comp, 100 $\pm$ 5%, $\frac{1}{4}$ W	147926	01121	CB1015	1		
R2	Res, ww, 4.22k $\pm$ 5%, $\frac{1}{2}$ W	311761	89536	311761	1		
R3	Res, ww, 10k $\pm$ 0.05%, $\frac{1}{2}$ W	195776	89536	195776	1		
R4	Res, ww, 1.27k $\pm$ 1%, $\frac{1}{2}$ W	341628	89536	341628	1		
R5, R6, U2	Ref Amplifier set	346270	89536	346270	1		
R7, R8	Ref Amplifier Divider set	346304	89536	346304	1		
R11	Res, var, 100 $\pm$ 20%, $\frac{1}{2}$ W	267823	71450	190PC101B	1		
R13	Res, ww, 412k $\pm$ 5%, $\frac{1}{2}$ W	311753	89536	311753	1		
R14	Res, met film, 845k $\pm$ 1%, 1/8W	221671	91637	MFF1-88453F	1		
R16	Res, met film, 31.6k $\pm$ 1%, 1/8W	312660	91637	MFF1-83162F	1		
R18, R26	Res, met film, 4.5M $\pm$ 1%, $\frac{1}{2}$ W	346981	91637	MFF1-24504F	2		
R20 thru R23	Res, divider set	391417	89536	391417	1		
R25	Res, met film, 845 $\pm$ 1%, 1/8W	320408	91637	MFF1-88450F	1		

REFERENCE - REGULATOR PCB ASSEMBLY

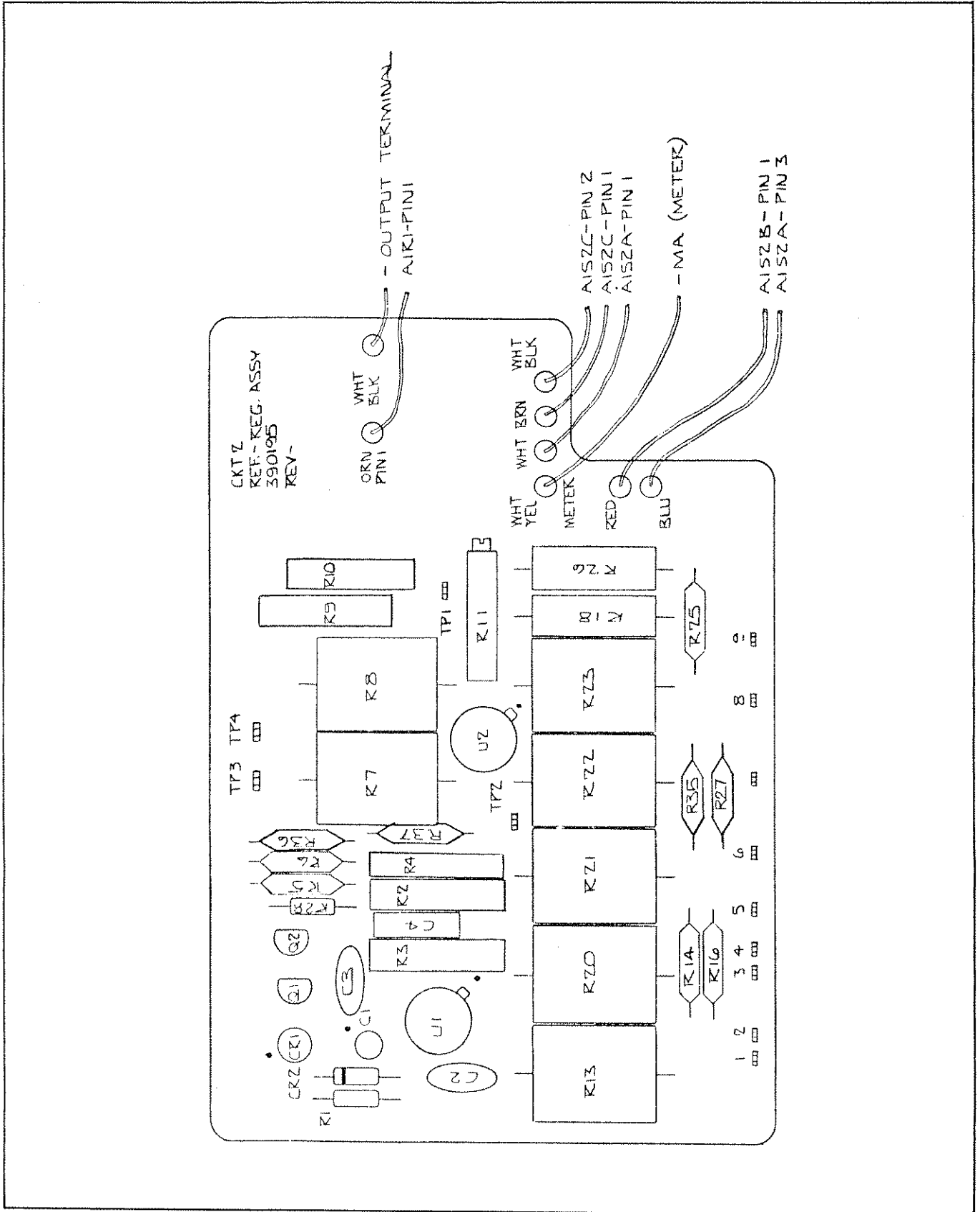


Figure 5-2. REFERENCE - REGULATOR PCB ASSEMBLY.

## REFERENCE-REGULATOR PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R27	Res, met film, 4.53k $\pm$ 1%, 1/8W	376921	91637	MFF1-84531F	1		
R28	Res, comp, 62 $\pm$ 5%, 1/4W	261842	01121	CB6205	1		
R35	Res, met film, 681k $\pm$ 1%, 1/8W	387043	01637	MFF1-86813F			
R36, R37	Res, met film, 10 $\pm$ 1%, 1/8W	268789	91637	MFF1-8100F	2		
UI	IC, Operational Amplifier	284760	12040	LM308	1		
	Connector, amp pins	267500	00779	86144-2	21		

## POWER SUPPLY AND ADJUSTMENT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	POWER SUPPLY AND ADJUSTMENT PCB ASSEMBLY (731B - 4012) Figure 5- 3	390187	89536	390187	REF		
C5	Cap, elect, 150 uF +50/-10%, 63V	170274	25403	ET151 X063A01	1		
CR5 thru CR9	Diode, Si hi-speed switch	203323	07910	TD8253	5		
CR10	Diode, FET, current regulator	348482	17856	E505	1		
CR11	Diode, zener, 18V	327973	07910	1N967B	1		
CR12	Rectifier, bridge	296509	51605	FB100	1		
Q3	Xstr, Si, NPN	218396	04713	2N3904	1		
R12	Res, var, cermet, 1k $\pm$ 20%, 1/2W	267856	71450	190PC102B	1		
R15, R17	Res, var, cermet, 10k $\pm$ 20%, 1/2W	267880	71450	190PC103B	2		
R19	Res, var, cermet, 200k $\pm$ 20%, 1/2W	381509	80031	ET34P204	1		
R24	Res, var, cermet, 100 $\pm$ 20%, 1/2W	267823	71450	190PC101B	1		
R30	Res, comp, 510 $\pm$ 5%, 1/2W	108951	01181	EB5115	1		
R31	Res, met film, 4.22k $\pm$ 1%, 1/8W	168245	91637	MFF1-84221F	1		
R32	Res, met film 16.9k $\pm$ 1%, 1/8W	267146	91637	MFF1-81692F	1		
R33	Res, comp, 180 $\pm$ 5%, 1/2W	108944	01121	CB1815	1		
R34	Res, comp, 8.2k $\pm$ 5%, 1/4W	160796	01121	CB8225	1		
S2	Switch, slide, DPDT	234278	82389	XW1649	1		
	Socket, Amp	267617	00779	85863-5	9		
	Pins, Amp	267500	00779	86144-2	24		

POWER SUPPLY AND ADJUSTMENT PCB ASSEMBLY

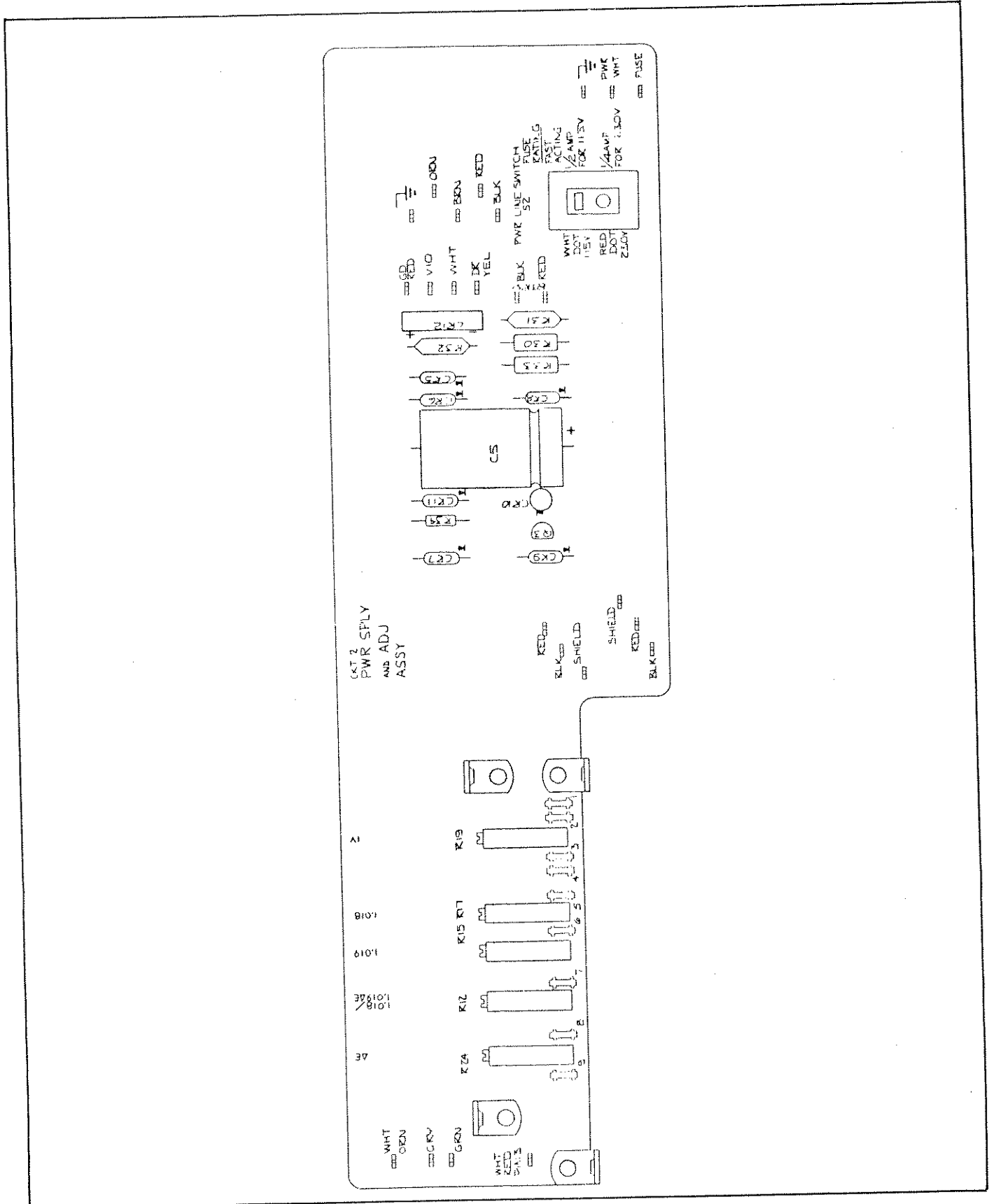


Figure 5-3. POWER SUPPLY AND ADJUSTMENT PCB ASSEMBLY.



## Section 6

# Option & Accessory Information

### 6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the options and accessories available for use with the 731B. Each option and/or accessory, if any, is described under separate major headings. The descriptions include the applicable operating instructions, maintenance instructions, and field installation procedures.

### 6-3. RACK MOUNTING KITS

6-4. Rack mounting kits for the 731B are available in four different configurations. Each of the configurations as shown in Figure 6-1, is designed for installation in a standard 19-inch equipment rack. The kits contain all of the hardware necessary for installation and each can be assembled to offset the 731B (s) to either the left or right side of the equipment rack.

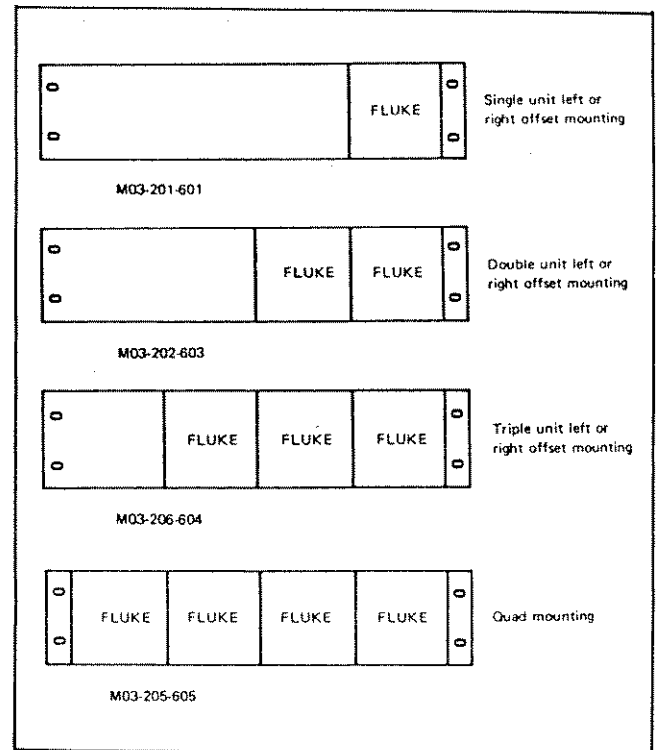


Figure 6-1. RACK MOUNTING CONFIGURATIONS.

6-5. Installation instructions for the 731B rack mounting kits are given in the following procedure. Use the same procedure for all configurations of the 731B rack mounting kits.

- a. Remove the four molded plastic feet and the bail from the bottom of the instrument (s).
- b. Peel off name plate decals from the corner of the instrument (s). See Figure 6-2.
- c. Refer to the kit shown in Figure 6-1 and select the instruments to which each of the rack ears will be attached.
- d. Remove the screws which match the rack ear patterns from the appropriate front corners of the selected instruments.
- e. Attach the rack ears using the pan head screws supplied with the kit.
- f. If the single-unit rack mounting kit (M03-201-601) is being installed, the unit can be mounted in the instrument rack at this point. Otherwise, proceed with steps g through k.
- g. Remove top and bottom covers from all 731B's.
- h. Remove the top and bottom corner screws from the front and rear of the instruments. Do not remove these screws on the rack ear side of the instruments.
- i. Assemble the instruments on a flat surface in the order in which they are to be installed.
- j. Insert the dual-rack-mounting fasteners through the front and rear corner nut locations which were vacated in step h. See Figure 6-3.
- k. Reinstall the top and bottom covers on all of the instruments.

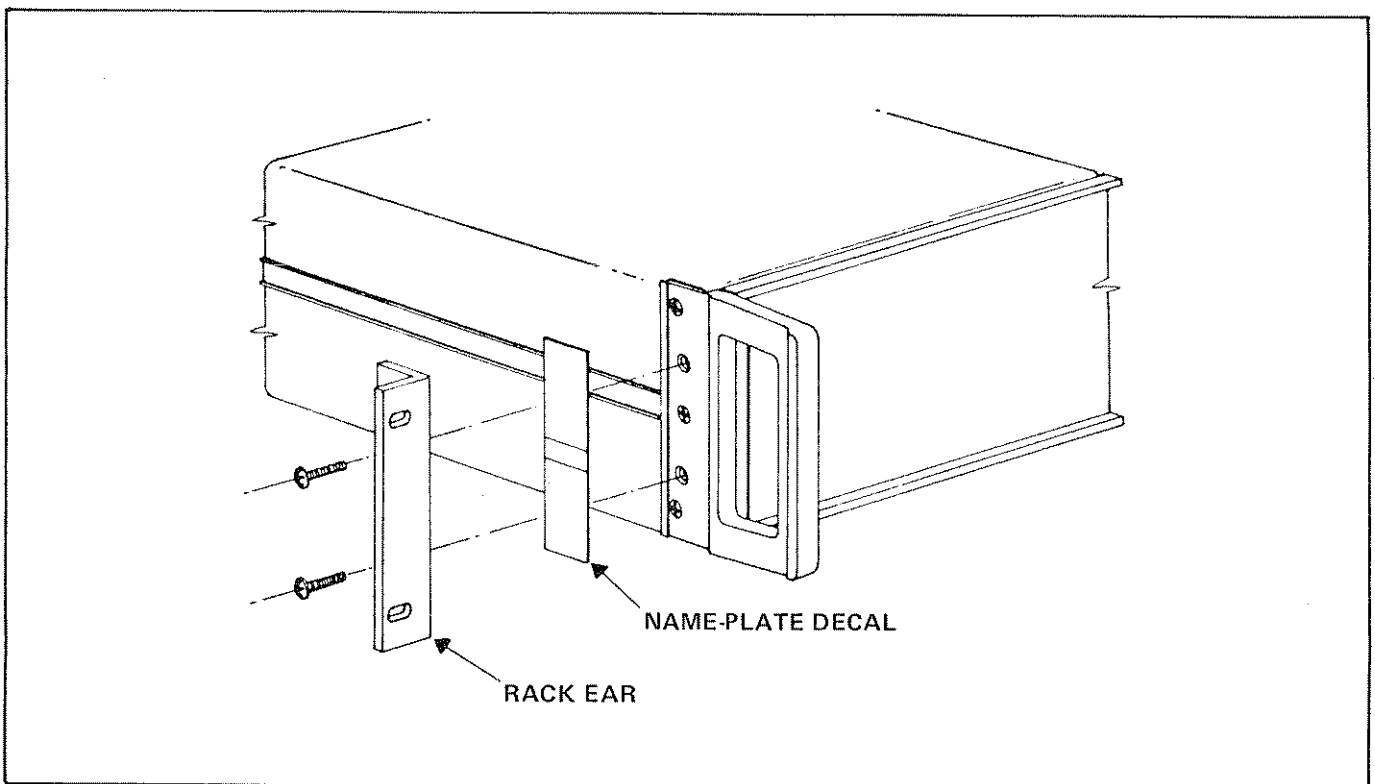


Figure 6-2. RACK EAR INSTALLATION.

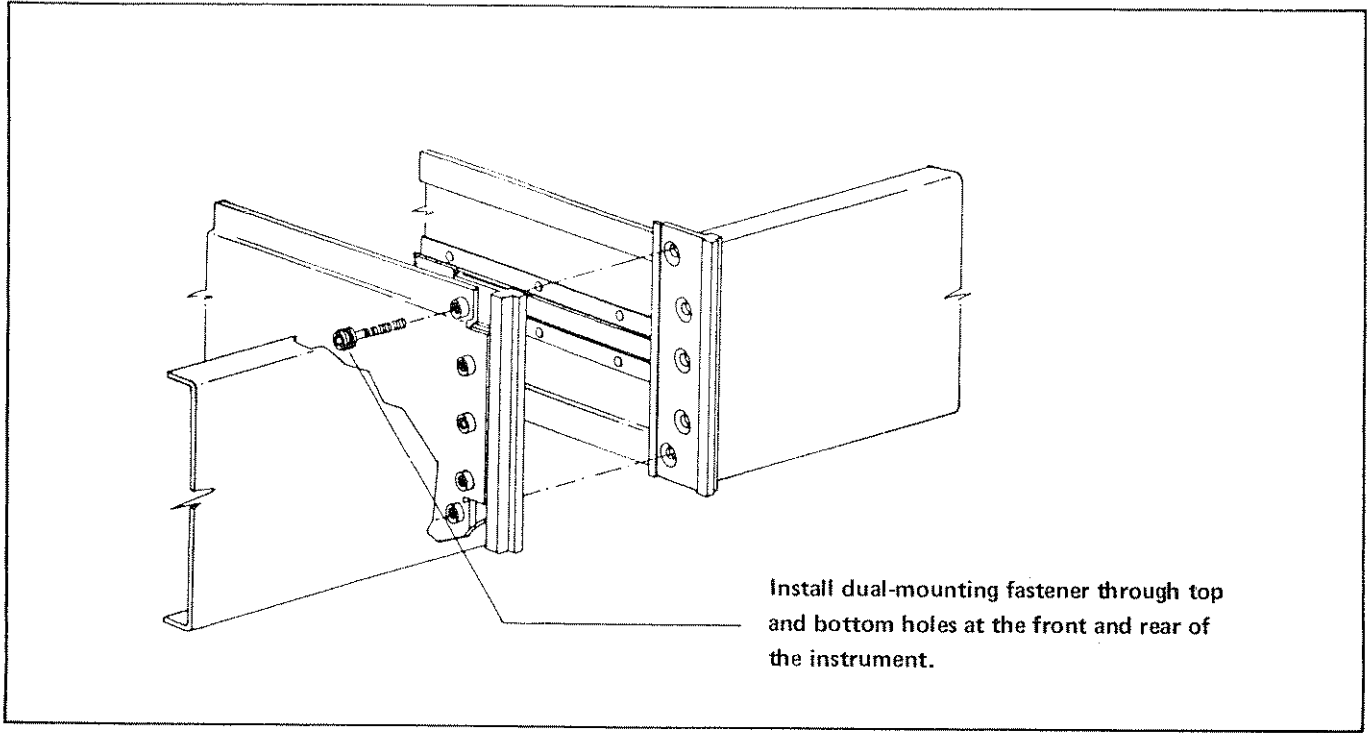


Figure 6-3. DUAL, TRIPLE, AND QUAD MOUNTING

## Section 7

# General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

## List of Abbreviations and Symbols

<b>A or amp</b>	ampere	<b>hf</b>	high frequency	<b>(+) or pos</b>	positive
<b>ac</b>	alternating current	<b>Hz</b>	hertz	<b>pot</b>	potentiometer
<b>af</b>	audio frequency	<b>IC</b>	integrated circuit	<b>p-p</b>	peak-to-peak
<b>a/d</b>	analog-to-digital	<b>if</b>	intermediate frequency	<b>ppm</b>	parts per million
<b>assy</b>	assembly	<b>in</b>	inch(es)	<b>PROM</b>	programmable read-only memory
<b>AWG</b>	american wire gauge	<b>intl</b>	internal	<b>psi</b>	pound-force per square inch
<b>B</b>	bel	<b>I/O</b>	input/output	<b>RAM</b>	random-access memory
<b>bcd</b>	binary coded decimal	<b>k</b>	kilo (10 <sup>3</sup> )	<b>rf</b>	radio frequency
<b>°C</b>	Celsius	<b>kHz</b>	kilohertz	<b>rms</b>	root mean square
<b>cap</b>	capacitor	<b>kΩ</b>	kilohm(s)	<b>ROM</b>	read-only memory
<b>ccw</b>	counterclockwise	<b>kV</b>	kilovolt(s)	<b>s or sec</b>	second (time)
<b>cer</b>	ceramic	<b>lf</b>	low frequency	<b>scope</b>	oscilloscope
<b>cermet</b>	ceramic to metal(seal)	<b>LED</b>	light-emitting diode	<b>SH</b>	shield
<b>ckt</b>	circuit	<b>LSB</b>	least significant bit	<b>Si</b>	silicon
<b>cm</b>	centimeter	<b>LSD</b>	least significant digit	<b>serno</b>	serial number
<b>cmrr</b>	common mode rejection ratio	<b>M</b>	mega (10 <sup>6</sup> )	<b>sr</b>	shift register
<b>comp</b>	composition	<b>m</b>	milli (10 <sup>-3</sup> )	<b>Ta</b>	tantalum
<b>cont</b>	continue	<b>mA</b>	milliampere(s)	<b>tb</b>	terminal board
<b>crt</b>	cathode-ray tube	<b>max</b>	maximum	<b>tc</b>	temperature coefficient or temperature compensating
<b>cw</b>	clockwise	<b>mf</b>	metal film	<b>tcxo</b>	temperature compensated crystal oscillator
<b>d/a</b>	digital-to-analog	<b>MHz</b>	megahertz	<b>tp</b>	test point
<b>dac</b>	digital-to-analog converter	<b>min</b>	minimum	<b>u or μ</b>	micro (10 <sup>-6</sup> )
<b>dB</b>	decibel	<b>mm</b>	millimeter	<b>uhf</b>	ultra high frequency
<b>dc</b>	direct current	<b>ms</b>	millisecond	<b>us or μs</b>	microsecond(s) (10 <sup>-6</sup> )
<b>dmm</b>	digital multimeter	<b>MSB</b>	most significant bit	<b>uut</b>	unit under test
<b>dvm</b>	digital voltmeter	<b>MSD</b>	most significant digit	<b>V</b>	volt
<b>elect</b>	electrolytic	<b>MTBF</b>	mean time between failures	<b>v</b>	voltage
<b>ext</b>	external	<b>MTTR</b>	mean time to repair	<b>var</b>	variable
<b>F</b>	farad	<b>mV</b>	millivolt(s)	<b>vco</b>	voltage controlled oscillator
<b>°F</b>	Fahrenheit	<b>mv</b>	multivibrator	<b>vhf</b>	very high frequency
<b>FET</b>	Field-effect transistor	<b>MΩ</b>	megohm(s)	<b>vlf</b>	very low frequency
<b>ff</b>	flip-flop	<b>n</b>	nano (10 <sup>-9</sup> )	<b>W</b>	watt(s)
<b>freq</b>	frequency	<b>na</b>	not applicable	<b>ww</b>	wire wound
<b>FSN</b>	federal stock number	<b>NC</b>	normally closed	<b>xfmr</b>	transformer
<b>g</b>	gram	<b>(-) or neg</b>	negative	<b>xstr</b>	transistor
<b>G</b>	giga (10 <sup>9</sup> )	<b>NO</b>	normally open	<b>xtal</b>	crystal
<b>gd</b>	guard	<b>ns</b>	nanosecond	<b>xtlo</b>	crystal oscillator
<b>Ge</b>	germanium	<b>opnl ampl</b>	operational amplifier	<b>Ω</b>	ohm(s)
<b>GHz</b>	gigahertz	<b>p</b>	pico (10 <sup>-12</sup> )	<b>μ</b>	micro (10 <sup>-6</sup> )
<b>gmV</b>	guaranteed minimum value	<b>para</b>	paragraph		
<b>gnd</b>	ground	<b>pcb</b>	printed circuit board		
<b>H</b>	henry	<b>pF</b>	picofarad		
<b>hd</b>	heavy duty	<b>pn</b>	part number		

## Federal Supply Codes for Manufacturers

D9816 Westemann Wilhelm Augusta-Anlage Mannheim-Nackarau Germany	02533 Leigh Instruments Ltd. Frequency Control Div. Don Mills, Ontario, Canada	04713 Motorola Inc. Semiconductor Group Phoenix, Arizona	06665 Precision Monolithics Sub of Bourns Inc. Santa Clara, California
00199 Marcon Electronics Corp Kearny, New Jersey	02606 Fenwal Labs Division of Travenel Labs Morton Grove, Illinois	05236 Jonathan Mfg. Co. Fullerton, California	06666 General Devices Co. Inc. Indianapolis, Indiana
00213 Nytronics Comp. Group Inc. Darrington, South Carolina	0266 Bunker Ramo-Eltra Corp. Amphenol NA Div. Broadview, Illinois	05245 Corcom Inc. Libertyville, Illinois	06739 Electron Corp. Littleton, Colorado
00327 Welwyn International Inc. Westlake, Ohio	02735 RCA-Solid State Div. Somerville, New Jersey	05276 ITT Pomona Electronics Div. Pomona, California	06743 Gould Inc. Foil Div. Eastlake, Ohio
00656 Aerovox Corp. New Bedford, Massachusetts	02799 Arco Electronics Inc. Passaic, New Jersey	05277 Westinghouse Elec. Corp. Semiconductor Div. Youngwood, Pennsylvania	06751 Components Inc. Sensor Div. Phoenix, Arizona
00686 Film Capacitors Inc. Passaic, New Jersey	03508 General Electric Co. Semiconductor Products & Batteries Auburn, New York	05397 Union Carbide Corp. Materials Systems Div. Cleveland, Ohio	06776 Robinson Nugent Inc. New Albany, Indiana
00779 AMP, Inc. Harrisburg, Pennsylvania	03797 Genisco Technology Corp. Electronics Div. Rancho Dominguez, Calif.	05571 Sprague Electric Co. (Now 56289)	06915 Richco Plastic Co. Chicago, Illinois
01121 Allen Bradley Co. Milwaukee, Wisconsin	03877 Gilbert Engineering Co. Inc Incon Sub of Transiron Electronic Corp. Glendale, Arizona	05574 Viking Connectors Inc Sub of Criton Corp. Chatsworth, Calif.	06961 Vernitron Corp. Piezo Electric Div. Bedford, Ohio
01281 TRW Electronics & Defense Sector Lawndale, California	03888 KDI Electronics Inc. Pyrofilm Div. Whippany, New Jersey	05820 EG & G Wakefield Engineering Wakefield, Massachusetts	06980 Varian Associates Inc. Eimac Div. San Carlos, California
01295 Texas Instruments Inc. Semiconductor Group Dallas, Texas	03911 Clairex Corp. Clairex Electronics Div. Mount Vernon, New York	05972 Loctite Corp. Newington, Connecticut	07047 Ross Milton Co., The Southampton, Penna.
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	03980 Muirhead Inc. Mountainside, New Jersey	06001 General Electric Co. Electric Capacitor Product Section Columbia, S. Carolina	07138 Westinghouse Electric Corp. Industrial & Government Tube Div. Horsesheds, New York
01686 RCL Electronics/Shallcross Inc. Electro Components Div. Manchester, New Hampshire	04009 Cooper Industries, Inc. Arrow Hart Div. Hartford, Connecticut	06141 Fairchild Weston Systems Inc. Data Systems Div. Sarasota, Florida	07233 Benchmark Technology Inc. City of Industry, Calif.
01884 Sprague Electric Co. (Now 56289)	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06192 La Deau Mfg. Co. Glendale, California	07239 Biddle Instruments Blue Bell, Penna.
01961 Varian Associates Inc. Pulse Engineering Div. Convoy, Connecticut	04221 Midland-Ross Corp. Midtex Div. N. Mankato, Minnesota	06229 Electrovert Inc. Elmsford, New York	07256 Silicon Transistor Corp. Sub of BBF Inc. Chelmsford, Massachusetts
02111 Spectrol Electronics Corp. City of Industry, California	04222 AVX Corp. AVX Ceramics Div. Myrtle Beach, S. Carolina	06383 Panduit Corp. Tinley Park, Illinois	07261 Avnet Corp. Culver City, California
02114 Amperex Electronic Corp. Ferrox Cube Div. Saugerties, New York	04223 Telonic Berkley Inc. Laguna Beach, California	06473 Bunker Ramo Corp. Amphenol NA Div. SAMS Operation Chatsworth, California	07263 Fairchild Camera & Instrument Semiconductor Div. Mountain View, California
02131 General Instrument Corp. Government Systems Div. Westwood, Massachusetts		06555 Beede Electrical Instrument Penacook, New Hampshire	07344 Bircher Co. Inc., The Rochester, New York
02395 Sonar Radio Corp. Hollywood, Florida			

## Federal Supply Codes for Manufacturers (cont)

07557 Campion Co. Inc. Philadelphia, Penna.	09423 Scientific Components Inc. Santa Barbara, California	11711 General Instrument Corp. Rectifier Div. Hicksville, New York	12954 Microsemi Corp. Components Group Scotsdale, Arizona
07597 Burdny Corp. Tape/Cable Div. Rochester, New York	09579 CTS of Canada, Ltd Streetsville, Ontario	11726 Qualidyne Corp. Santa Clara, California	12969 Unitrode Corp. Lexington, Massachusetts
07716 TRW Inc. (Can use 11502) IRC Fixed Resistors/ Burlington Burlington, Iowa	09922 Burdny Corp. Norwalk, Connecticut	12014 Chicago Rivet & Machine Co. Naperville, Illinois	13050 Potter Co. Wesson, Mississippi
07792 Lerma Engineering Corp. Northampton, Massachusetts	09969 Dale Electronics Inc. Yankton, South Dakota	12040 National Semiconductor Corp. Danbury, Connecticut	13103 Thermalloy Co., Inc. Dallas, Texas
07810 Bock Corp. Madison, Wisconsin	09975 Burroughs Corp. Electronics Components Detroit, Michigan	12060 Diodes Inc. Northridge, California	13327 Solitron Devices Inc. Tappan, New York
07933 Raytheon Co. Semiconductor Div. Mountain View, Calif.	10059 Barker Engineering Corp. Kenilworth, New Jersey	12136 PHC Industries Inc. Formerly Philadelphia Handle Co. Camden, New Jersey	13511 Bunker-Ramo Corp. Amphenol Cadre Div. Los Gatos, California
08235 Industro Transistor Corp. Long Island City, New York	10389 Illinois Tool Works Inc. Licon Div. Chicago, Illinois	12300 AMF Canada Ltd. Potter-Brumfield Guelph, Ontario, Canada	13606 Sprague Electric Co. (Use 56289)
08261 Spectra-Strip An Eltra Co. Garden Grove, Calif.	10582 CTS of Asheville Skyland, N. Carolina	12323 Practical Automation Inc. Shelton, Connecticut	13689 SPS Technologies Inc. Hatfield, Pennsylvania
08530 Reliance Mica Corp. Brooklyn, New York	11236 CTS Corp. Berne Div. Berne, Indiana	12327 Freeway Corp. Cleveland, Ohio	13919 Burr-Brown Research Corp. Tucson, Arizona
08718 ITT Cannon Electric Phoenix Div. Phoenix, Arizona	11237 CTS Corp of California Paso Robles Div. Paso Robles, California	12443 Budd Co.,The Plastics Products Div. Phoenixville, Pennsylvania	14099 Semtech Corp. Newbury Park, California
08806 General Electric Co. Miniature Lamp Products Cleveland, Ohio	11295 ECM Motor Co. Schaumburg, Illinois	12581 Hitachi Metals International Ltd. Hitachi Magna-Lock Div. Big Rapids, Missouri	14140 McGray-Edison Co. Commercial Development Div. Manchester, New Hampshire
08863 Nylomatic Fallsington, Penna.	11358 Columbia Broadcasting System CBS Electronic Div. Newburyport, Massachusetts	12615 US Terminals Inc. Cincinnati, Ohio	14193 Cal-R-Inc. Santa Monica, California
08988 Skottie Electronics Inc. Archbald, Pennsylvania	11403 Vacuum Can Co. Best Coffee Maker Div. Chicago, Illinois	12617 Hamlin Inc. Lake Mills, Wisconsin	14298 American Components Inc. an Insilco Co. RPC Div. Conshohocken, Pennsylvania
09021 Airco Inc. Airco Electronics Bradford, Penna.	11502 TRW Inc. TRW Resistive Products Div. Boone, North Carolina	12697 Clarostat Mfg. Co. Inc. Dover, New Hampshire	14298 ACIC Inc. Sub of Insilco Corp. Research Triangle Park, NC
09023 Cornell-Dublier Electronics Fuquay-Varina, N. Carolina	11503 Keystone Columbia Inc. Freemont, Indiana	12749 James Electronic Inc. Chicago, Illinois	14329 Wells Electronics Inc. South Bend, Indiana
09214 General Electric Co. Semiconductor Products Dept. Auburn, New York	11532 Teledyne Relays Teledyne Industries Inc. Hawthorne, California	12856 MicroMetals Inc. Anaheim, California	14482 Watkins-Johnson Co. Palo Alto, California
09353 C and K Components Inc. Newton, Massachusetts		12881 Metex Corp. Edison, New Jersey	14552 Microsemi Corp. Santa Ana, California
		12895 Cleveland Electric Motor Co. Cleveland, Ohio	14655 Cornell-Dublier Electronics Div. of Federal Pacific Electric Co. Govt Cont Dept. Newark, New Jersey

## Federal Supply Codes for Manufacturers (cont)

14704 Crydom Controls (Division of Int Rectifier) El Segundo, California	16733 Cablewave Systems Inc. North Haven, Connecticut	18927 GTE Products Corp. Precision Material Products Business Parts Div. Titusville, Pennsylvania	23936 William J. Purdy Co. Pamotor Div. Burlingame, California
14752 Electro Cube Inc. San Gabriel, California	16742 Paramount Plastics Fabricators Inc. Downey, California	19315 Bendix Corp., The Navigation & Control Group Terboro, New Jersey	24347 Penn Engineering Co. S. El Monte, California
14936 General Instrument Corp. Discrete Semi Conductor Div. Hicksville, New York	16758 General Motors Corp. Delco Electronics Div. Kokomo, Indiana	19451 Perine Machinery & Supply Co.. Kent, Washington	24355 Analog Devices Inc. Norwood, Massachusetts
14949 Trompeter Electronics Chatsworth, California	17069 Circuit Structures Lab Burbank, California	19613 Minnesota Mining & Mfg. Co. Textool Products Dept. Electronic Product Div. Irving, Texas	24444 General Semiconductor Industries, Inc. Tempe, Arizona
15412 Amtron Midlothian, Illinois	17117 Electronic Molding Corp. Woonsocket, Rhode Island	19647 Caddock Electronics Inc. Riverside, California	24655 Genrad Inc. Concord, Massachusetts
15542 Scientific Components Corp. Mini-Circuits Laboratory Div. Brooklyn, New York	17338 High Pressure Eng. Co. Inc. Oklahoma City, Oklahoma	19701 Mepco/Centralab Inc. A N. American Philips Co. Mineral Wells, Texas	24759 Lenox-Fugle Electronics Inc. South Plainfield, New Jersey
15636 Elec-Trol Inc. Saugus, California	17545 Atlantic Semiconductors Inc. Asbury Park, New Jersey	20584 Enochs Mfg. Inc. Indianapolis, Indiana	24796 AMF Inc. Potter & Brumfield Div. San Juan Capistrano, Calif.
15782 Bausch & Lomb Inc. Graphics & Control Div. Austin, Texas	17745 Angstrom Precision, Inc. Hagerstown, Maryland	20891 Cosar Corp. Dallas, Texas	24931 Specialty Connector Co. Greenwood, Indiana
15801 Fenwal Eletronics Inc. Div. of Kidde Inc. Framingham, Massachusetts	17856 Siliconix Inc. Santa Clara, California	21317 Electronics Applications Co. El Monte, California	25088 Siemen Corp. Isilen, New Jersey
15818 Teledyne Inc. Co. Teledyne Semiconductor Div. Mountain View, California	18178 E G & Gvactee Inc. St. Louis, Missouri	21604 Buckeye Stamping Co. Columbus, Ohio	25099 Cascade Gasket Kent, Washington
15849 Useco Inc. (Now 88245)	18324 Signetics Corp. Sacramento, California	21845 Solitron Devices Inc. Semiconductor Group Rivera Beach, Florida	25403 Amperex Electronic Corp. Semiconductor & Micro-Circuit Div. Slatersville, Rhode Island
15898 International Business Machines Corp. Essex Junction, Vermont	18520 Sharp Electronics Corp. Paramus, New Jersey	22526 DuPont, El DeNemours & Co. Inc. DuPont Connector Systems Advanced Products Div. New Cumberland, Pennsylvania	25706 Daburn Electronic & Cable Corp. Norwood, New Jersey
16245 Conap Inc. Olean, New York	18542 Wabash Inc. Wabash Relay & Electronics Div. Wabash, Indiana	22767 ITT Semiconductors Palo Alto, California	26629 Frequency Sources Inc. Sources Div. Chelmsford, Massachusetts
16258 Space-Lok Inc. Burbank, California	18612 Vishay Intertechnology Inc. Vishay Resistor Products Group Malvern, Pennsylvania	22784 Palmer Inc. Cleveland, Ohio	26806 American Zettler Inc. Irvine, California
16352 Codi Corp. Linden, New Jersey	18632 Norton-Chemplast Santa Monica, California	23050 Product Comp. Corp. Mount Vernon, New York	27014 National Semiconductor Corp. Santa Clara, California
16469 MCL Inc. LaGrange, Illinois	18677 Scanbe Mfg. Co. Div. of Zero Corp. El Monte, California	23732 Tracor Applied Sciences Inc. Rockville, Maryland	27167 Corning Glass Works Corning Electronics Wilmington, North Carolina
16473 Cambridge Scientific Industries Div. of Chemed Corp. Cambridge, Maryland	18736 Voltronics Corp. East Hanover, New Jersey	23880 Stanford Applied Engineering Santa Clara, California	27264 Molex Inc. Lisle, Illinois
			27440 Industrial Screw Products Los Angeles, California



## Federal Supply Codes for Manufacturers (cont)

27745 Associated Spring Barnes Group Inc. Syracuse, New York	30800 General Instrument Corp. Capacitor Div. Hicksville, New York	33297 NEC Electronics USA Inc. Electronic Arrays Inc. Div. Mountain View, California	49956 Raytheon Company Executive Offices Lexington, Massachusetts
27956 Relcom (Now 14482)	31019 Solid State Scientific Inc. Willow Grove, Pennsylvania	33919 Nortek Inc. Cranston, Rhode Island	50088 Thomson Components-Mostek Corp. Carrollton, Texas
28198 Positronic Industries Springfield, Missouri	31091 Alpha Industries Inc. Microelectronics Div. Hatfield, Pennsylvania	34333 Silicon General Inc. Garden Grove, California	50120 Eagle-Picher Industries Inc. Electronics Div. Colorado Springs, Colorado
28213 Minnesota Mining & Mfg. Co. Consumer Products Div. 3M Center Saint Paul, Minnesota	31323 Metro Supply Company Sacramento, California	34225 Advanced Micro Devices Sunnyvale, California	50157 Midwest Components Inc. Muskegon, Mississippi
28425 Serv-O-Link Eules, Texas	31448 Army Safeguard Logistics Command Huntsville, Alabama	34359 Minnesota Mining & Mfg. Co. Commercial Office Supply Div. Saint Paul, Minnesota	50541 Hypertronics Corp. Hudson, Massachusetts
28478 Deltrol Corporation Deltrol Controls Div. Milwaukee, Wisconsin	31746 Cannon Electric Woodbury, Tennessee	34371 Harris Corp. Harris Semiconductor Products Group Melbourne, Florida	50579 Litronix Inc. Cupertino, California
28480 Hewlett Packard Co. Corporate HQ Palo Alto, California	31827 Budwig Ramona, California	34649 Intel Corp. Santa Clara, California	51167 Aries Electronics Inc. Frenchtown, New Jersey
28484 Emerson Electric Co. Gearmaster Div. McHenry, Illinois	31918 ITT-Schadow Eden Prairie, Minnesota	34802 Electromotive Inc. Kenilworth, New Jersey	51372 Verbatim Corp. Sunnyvale, California
28520 Heyco Molded Products Kenilworth, New Jersey	32293 Intersil Cupertino, California	34848 Hartwell Special Products Placentia, California	51406 Murata Erie, No. America Inc. (Also see 72982) Marietta, Georgia
29083 Monsanto Co. Santa Clara, California	32539 Mura Corp. Westbury, Long Island, N.Y.	35009 Renfrew Electric Co. Ltd. IRC Div. Toronto, Ontario, Canada	51499 Amtron Corp. Boston, Massachusetts
29604 Stackpole Components Co. Raleigh, North Carolina	32559 Bivar Santa Ana, California	36665 Mitel Corp. Kanata, Ontario, Canada	51605 CODI Semiconductor Inc. Kenilworth, New Jersey
29907 Omega Engineering Inc. Stamford, Connecticut	32767 Griffith Plastics Corp. Burlingame, California	37942 Mallory Capacitor Corp. Sub of Emhart Industries Indianapolis, Indiana	51642 Centre Engineering Inc. State College, Pennsylvania
30035 Jolo Industries Inc. Garden Grove, California	32879 Advanced Mechanical Components Northridge, California	39003 Maxim Industries Middleboro, Massachusetts	51791 Stack Corp. Orange, California
30146 Symbex Corp. Painesville, Ohio	32897 Murata Erie North America Inc. Carlisle Operations Carlisle, Pennsylvania	40402 Roderstein Electronics Inc. Statesville, North Carolina	51984 NEC America Inc. Falls Church, Virginia
30148 AB Enterprise Inc. Ahoskie, North Carolina	32997 Boums Inc. Trimpot Div. Riverside, California	42498 National Radio Melrose, Massachusetts	52063 Exar Integrated Systems Sunnyvale, California
30161 Aavid Engineering Inc. Laconia, New Hampshire	33096 Colorado Crystal Corp. Loveland, Colorado	43543 Nytronics Inc.(Now 53342)	52072 Circuit Assembly Corp. Irvine, California
30315 Itron Corp. San Diego, California	33173 General Electric Co. Owensboro, Kentucky	44655 Ohmite Mfg. Co. Skokie, Illinois	52152 Minnesota Mining & Mfg. Saint Paul, Minnesota
30323 Illinois Tool Works Inc. Chicago, Illinois	33246 Epoxy Technology Inc. Billerica, Massachusetts	49671 RCA Corp. New York, New York	52333 API Electronics Hauppauge, Long Island, New York

## Federal Supply Codes for Manufacturers (cont)

52361 Communication Systems Piscataway, New Jersey	54590 RCA Corp. Electronic Components Div. Cherry Hill, New Jersey	58104 Simco Atlanta, Georgia	64155 Linear Technology Milpitas, California
52525 Space-Lok Inc. Lerco Div. Burbank, California	55026 American Gage & Machine Co. Simpson Electric Co. Div. Elgin, Illinois	58474 Superior Electric Co. Bristol, Connecticut	64834 West M G Co. San Francisco, Calif.
52531 Hitachi Magnetics Edmore, Missouri	55112 Plessey Capacitors Inc. (Now 60935)	59124 KOA-Speer Electronics Inc. Bradford, Pennsylvania	65092 Sangamo Weston Inc. Weston Instruments Div. Newark, New Jersey
52745 Timco Los Angeles, California	55261 LSI Computer Systems Inc. Melville, New York	59640 Supertex Inc. Sunnyvale, California	65940 Rohm Corp & Whatney Irvine, California
52763 Stettner-Electronics Inc. Chattanooga, Tennessee	55285 Bercquist Co. Minneapolis, Minnesota	59660 Tusonix Inc. Tucson, Arizona	65964 Evox Inc. Bannockburn, Illinois
52769 Sprague-Goodman Electronics Inc. Garden City Park, New York	55576 Synertek Santa Clara, California	59730 Thomas and Betts Corp. Iowa City, Iowa	66150 Entron Inc. Winslow Teltronics Div. Glendale, New York
52771 Monitern Corp. Amatrom Div. Santa Clara, California	55680 Michicon/America/Corp. Schaumburg, Illinois	59831 Semtronics Corp. Watchung, New Jersey	66608 Bering Industries Fremont, California
52840 Western Digital Corp. Costa Mesa, California	56282 Utek Systems Inc. Olathe, Kansas	60395 Xicor Inc. Milpitas, California	70290 Almetal Universal Joint Co. Cleveland, Ohio
53021 Sangamo Weston Inc. (See 06141)	56289 Sprague Electric Co. North Adams, Massachusetts	60399 Torin Engineered Blowers Div. of Clevepak Corp. Torrington, Connecticut	70485 Atlantic India Rubber Works Inc. Chicago, Illinois
53217 Technical Wire Products Inc. Santa Barbara, California	56365 Square D Co. Corporate Offices Palatine, Illinois	60705 Cera-Mite Corp. (formerly Sprague) Grafton, Wisconsin	70563 Amperite Company Union City, New Jersey
53342 Opt Industries Inc. Phillipsburg, New Jersey	56375 DAL Industries Inc. Wescorp Div. Mountain View, California	60935 Westlake Capacitor Inc. Tantalum Div. Greencastle, Indiana	70903 Belden Corp. Geneva, Illinois
53944 Glow-Lite Pauls Valley, Oklahoma	56481 Shugart Associates Sub of Xerox Corp. Sunnyvale, California	61804 M/A Com Inc. Burlington, Massachusetts	71002 Bimbach Co. Inc. Farmingdale, New York
54294 Shallcross Inc. Smithfield, North Carolina	56708 Zilog Inc. Campbell, California	61857 SAN-O Industrial Corp. Bohemia, Long Island, NY	71034 Bliley Electric Co. Eric, Pennsylvania
54453 Sullins Electronic Corp. San Marcos, California	56856 Vamistor Corp. of Tennessee Sevierville, Tennessee	61935 Schurter Inc. Petaluma, California	71183 Westinghouse Electric Corp. Bryant Div. Bridgeport, Connecticut
54473 Matsushita Electric Corp. (Panasonic) Secaucus, New Jersey	56880 Magnetics Inc. Baltimore, Maryland	62351 Apple Rubber Lancaster, New York	71400 Bussman Manufacturing Div. McGraw-Edison Co. St. Louis, Missouri
54583 TDK Garden City, New York	57026 Endicott Coil Co. Inc. Binghamton, New York	62793 Lear Siegler Inc. Energy Products Div. Santa Ana, California	71450 CTS Corp. Elkhart, Indiana
54869 Piher International Corp. Arlington Heights, Illinois	57053 Gates Energy Products Denver, Ohio	63743 Ward Leonard Electric Co. Inc. Mount Vernon, New York	71468 ITT Cannon Div. of IIT Fountain Valley, California
54937 DeYoung Mfg. Bellevue, Washington	58014 Hitachi Magnalock Corp. (Now 12581)	64154 Lamb Industries Portland, Oregon	71482 General Instrument Corp. Clare Div. Chicago, Illinois

## Federal Supply Codes for Manufacturers (cont)

71590 Mepco/Centralab A North American Philips Co. Fort Dodge, Iowa	73445 Amperex Electronic Corp. Hicksville, New York	75378 CTS Knights Inc. Sandwich, Illinois	79727 C - W Industries Southampton, Pennsylvania
71707 Coto Corp. Providence, Rhode Island	73559 Carlingswitch Inc. Hartford, Connecticut	75382 Kulka Electric Corp. (Now 83330) Mount Vernon, New York	79963 Zierick Mfg. Corp. Mount Kisco, New York
71744 General Instrument Corp. Lamp Div/Worldwide Chicago, Illinois	73586 Circle F Industries Trenton, New Jersey	75915 Tracor Littlefuse Des Plaines, Illinois	80009 Tektronix Beaverton, Oregon
71785 TRW Inc. Cinch Connector Div. Elk Grove Village, Illinois	73734 Federal Screw Products Inc. Chicago, Illinois	76854 Oak Switch Systems Inc. Crystal Lake, Illinois	80031 Mepco/Electra Inc. Morristown, New Jersey
71984 Dow Corning Corp. Midland, Michigan	73743 Fischer Special Mfg. Co. Cold Spring, Kentucky	77122 TRW Assemblies & Fasteners Group Fastener Div. Mountainside, New Jersey	80032 Ford Aerospace & Communications Corp. Western Development Laboratories Div. Palo Alto, California
72005 AMAX Specialty Metals Corp. Newark, New Jersey	73893 Microdot Mt. Clemens, Mississippi	77342 AMF Inc. Potter & Brumfield Div. Princeton, Indiana	80145 LFE Corp. Process Control Div. Clinton, Ohio
72136 Electro Motive Mfg. Corp. Florence, South Carolina	73899 JFD Electronic Components Div. of Murata Erie Oceanside, New York	77542 Ray-O-Vac Corp Madison, Wisconsin	80183 Sprague Products (Now 56289)
72228 AMCA International Corp. Continental Screw Div. New Bedford, Massachusetts	73905 FL Industries Inc. San Jose, California	77638 General Instrument Corp. Rectifier Div. Brooklyn, New York	80294 Boums Instruments Inc. Riverside, California
72259 Nytronics Inc. New York, New York	73949 Guardian Electric Mfg. Co. Chicago, Illinois	77900 Shakeproof Lock Washer Co. (Now 78189)	80583 Hammerlund Mfg. Co. Inc. Paramus, New Jersey
72619 Amperex Electronic Corp. Dialight Div. Brooklyn, New York	74199 Quam Nichols Co. Chicago, Illinois	77969 Rubbercraft Corp. of CA Ltd. Torrance, California	80640 Computer Products Inc. Stevens-Arnold Div. South Boston, Mass.
72653 G C Electronics Co. Div. of Hydrometals Inc. Rockford, Illinois	74217 Radio Switch Co. Marlboro, New Jersey	78189 Illinois Tool Works Inc. Shakeproof Div. Elgin, Illinois	81073 Grayhill Inc. La Grange, Illinois
72794 Dzus Fastner Co. Inc. West Islip, New York	74306 Piezo Crystal Co. Div. of PPA Industries Inc. Carlisle, Pennsylvania	78277 Sigma Instruments Inc. South Braintree, Mass.	81312 Litton Systems Inc. Winchester Electronics Div. Watertown, Connecticut
72928 Gulton Industries Inc. Gudeman Div. Chicago, Illinois	74542 Hoyt Elect.Instr. Works Inc. Penacook, New Hampshire	78290 Struthers Dunn Inc. Pitman, New Jersey	81439 Therm-O-Disc Inc. Mansfield, Ohio
72982 Murata Erie N. America Inc. Erie, Pennsylvania	74840 Illinois Capacitor Inc. Lincolnwood, Illinois	78553 Eaton Corp. Engineered Fastener Div. Cleveland, Ohio	81483 International Rectifier Corp. Los Angeles, California
73138 Beckman Industrial corp. Helipot Div. Fullerton, California	74970 Johnson EF Co. Waseca, Minnesota	78592 Stoeger Industries South Hackensack, New Jersey	81590 Korry Electronics Inc. Seattle, Washington
73168 Fenwal Inc. Ashland, Massachusetts	75042 TRW Inc. IRC Fixed Resistors Philadelphia, Pennsylvania	79136 Waldes Kohinoor Inc. Long Island City, New York	81741 Chicago Lock Co. Chicago, Illinois
73293 Hughes Aircraft Co. Electron Dynamics Div. Torrance, California	75297 Litton Systems Kester Solder Div. Chicago, Illinois	79497 Western Rubber Co. Goshen, Indiana	82227 Aipax Corp. Cheshire Div. Cheshire, Connecticut
	75376 Kurz-Kasch Inc. Dayton, Ohio		82240 Simmons Fastner Corp. Albany, New York

## Federal Supply Codes for Manufacturers (cont)

82305 Palmer Electronics Corp. South Gate, California	84171 Arco Electronics Commack, New York	89536 John Fluke Mfg. Co., Inc. Everett, Washington	91802 Industrial Devices Inc. Edgewater, New Jersey
82389 Switchcraft Inc. Sub of Raytheon Co. Chicago, Illinois	84411 American Shizuki TRW Capacitors Div. Ogallala, Nebraska	89597 Fredericks Co. Huntingdon Valley, Penna.	91833 Keystone Electronics Corp. New York, New York
82415 Airtax Corp Frederick Div. Frederick, Maryland	84613 FIC Corp. Rockville, Maryland	89709 Bunker Ramo-Eltra Corp. Amphenol Div. Broadview, Illinois	91836 King's Electronics Co. Inc. Tuckahoe, New York
82872 Roanwell Corp. New York, New York	84682 Essex Group Inc. Peabody, Massachusetts	89730 General Electric Lamp Div. Newark, New Jersey	91929 Honeywell Inc. Micro Switch Div. Freeport, Illinois
82877 Rotron Inc. Custom Div. Woodstock, New York	85367 Bearing Distributing Co. San Francisco, California	90201 Mallory Capacitor Co. Sub of Emhart Industries Inc. Indianapolis, Indiana	91934 Miller Electric Co. Woonsocket, Rhode Island
82879 ITT Royal Electric Div. Pawtucket, Rhode Island	85372 Bearing Sales Co. Los Angeles, California	90215 Best Stamp & Mfg. Co. Kansas City, Missouri	91984 Maida Development Co. Hampton, Virginia
83003 Varo Inc. Garland, Texas	85480 W. H. Brady Co. Industrial Product Milwaukee, Wisconsin	90303 Duracell Inc. Technical Sales & Marketing Bethel, Connecticut	91985 Norwalk Valve Co. S. Norwalk, Connecticut
83014 Hartwell Corp. Placentia, California	85932 Electro Film Inc. Valencia, California	91094 Essex Group Inc. Suflex/IWP Div. Newmarket, New Hampshire	92914 Alpha Wire Corp. Elizabeth, New Jersey
83055 Signalite Fuse Co. (Now 71744)	86577 Precision Metal Products Co. Peabody, Massachusetts	91247 Illinois Transformer Co. Chicago, Illinois	93332 Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts
83058 TRW Assemblies & Fasteners Group Fasteners Div. Cambridge, Massachusetts	86684 Radio Corp. of America (Now 54590)	91293 Johanson Mfg. Co. Boonton, New Jersey	94144 Raytheon Co. Microwave & Power Tube Div. Quincy, Massachusetts
83259 Parker-Hannifin Corp. O-Seal Div. Culver City, California	86928 Seastrom Mfg. Co. Inc. Glendale, California	91462 Alpha Industries Inc. Logansport, Indiana	94222 Southco Inc. Concordville, Pennsylvania
83298 Bendix Corp. Electric & Fluid Power Div. Eatonville, New Jersey	87034 Illuminated Products Inc. (Now 76854)	91502 Associated Machine Santa Clara, California	94988 Wagner Electric Corp. Sub of McGraw-Edison Co. Whippany, New Jersey
83315 Hubbell Corp. Mundelein, Illinois	88219 GNB Inc. Industrial Battery Div. Langhorne, Pennsylvania	91506 Augat Inc. Attleboro, Massachusetts	95146 Alco Electronic Products Inc. Switch Div. North Andover, Massachusetts
83330 Kulka Smith Inc. A North American Philips Co. Manasquan, New Jersey	88245 Winchester Electronics Liton Systems-Useco Div. Van Nuys, California	91507 Froeliger Machine Tool Co. Stockton, California	95263 Leecraft Mfg. Co. Long Island City, New York
83478 Rubbercraft Corp. of America West Haven, Connecticut	88486 Triangle PWC Inc. Jewitt City, Connecticut	91637 Dale Electronics Inc. Columbus, Nebraska	95275 Vitramon Inc. Bridgeport, Connecticut
83553 Associated Spring Barnes Group Gardena, California	88690 Essex Group Inc. Wire Assembly Div. Dearborn, Michigan	91662 Elco Corp. A Gulf Western Mfg. Co. Connector Div. Huntingdon, Pennsylvania	95303 RCA Corp. Receiving Tube Div. Cincinnati, Ohio
83740 Union Carbide Corp. Battery Products Div. Danbury, Connecticut	89020 Amerace Corp. Buchanan Crimpool Products Div. Union, New Jersey	91737 ITT Cannon/Greomar (Now 08718)	95348 Gordo's Corp. Bloomfield, New Jersey
	89265 Potter-Brumfield (See 77342)		95354 Methode Mfg. Corp. Rolling Meadows, Illinois

## Federal Supply Codes for Manufacturers (cont)

95573  
Campion Laboratories Inc.  
Detroit, Michigan

95712  
Bendix Corp.  
Electrical Comp. Div.  
Franklin, Indiana

95987  
Weckesser Co. Inc.  
(Now 85480)

96733  
SFE Technologies  
San Fernando, California

96853  
Gulton Industries Inc.  
Measurement & Controls Div.  
Manchester, New Hampshire

96881  
Thomson Industries Inc.  
Port Washington, New York

97525  
EECO Inc.  
Santa Ana, California

97540  
Whitchell Electronics Corp.  
Master Mobile Mounts Div.  
Fort Meyers, Florida

97913  
Industrial Electronic  
Hardware Corp.  
New York, New York

97945  
Pennwalt Corp.  
SS White Industrial Products  
Piscataway, New Jersey

97966  
CBS  
Electronic Div.  
Danvers, Massachusetts

98094  
Machlett Laboratories Inc.  
Santa Barbara, California

98159  
Rubber-Teck Inc.  
Gardena, California

98278  
Malco A Microdot Co.  
South Pasadena, California

98291  
Sealectro Corp.  
BICC Electronics  
Trumbull, Connecticut

98372  
Royal Industries Inc.(Now 62793)

98388  
Lear Siegler Inc.  
Accurate Products Div.  
San Deigo, California

99120  
Plastic Capacitors Inc.  
Chicago, Illinois

99217  
Bell Industries Inc.  
Elect. Distributor Div.  
Sunnyvale, California

99378  
ATLEE of Delaware Inc.  
N. Andover, Massachusetts

99392  
Mepco/Electra Inc.  
Roxboro Div.  
Roxboro, North Carolina

99515  
Electron Products Inc.  
Div. of American Capacitors  
Duarte, California

99779  
Bunker Ramo- Eltra Corp.  
Barnes Div.  
Lansdown, Pennsylvania

99800  
American Precision Industries  
Delevan Div.  
East Aurora, New York

99942  
Mepco/Centralab  
A North American Philips Co.  
Milwaukee, Wisconsin

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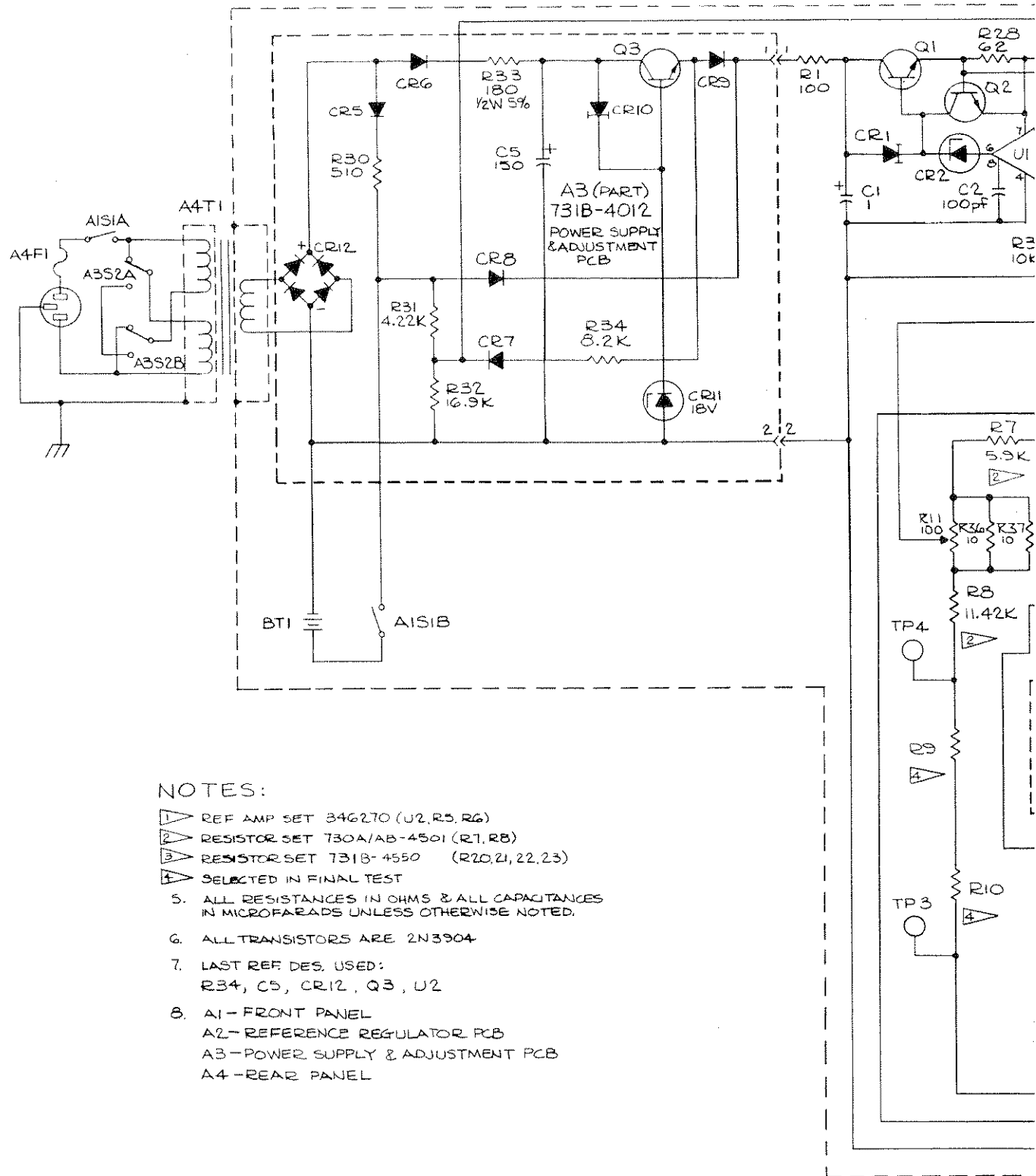
Section 8

# Schematic Diagrams

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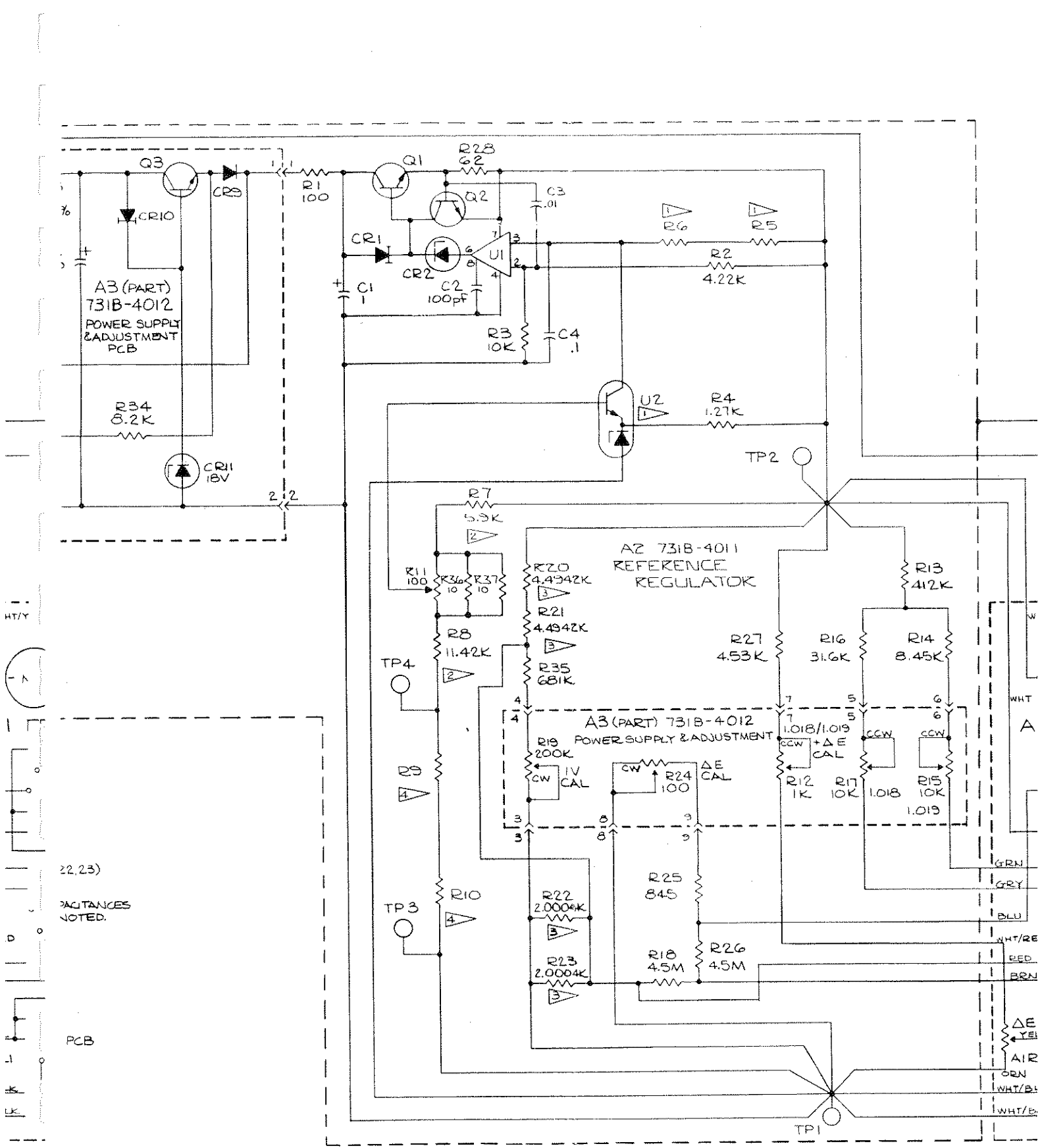
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FIGURE NO.	TITLE	DRAWING	PAGE
8-1	731B DC Reference Standard . . . . .	731B-1011	8-3



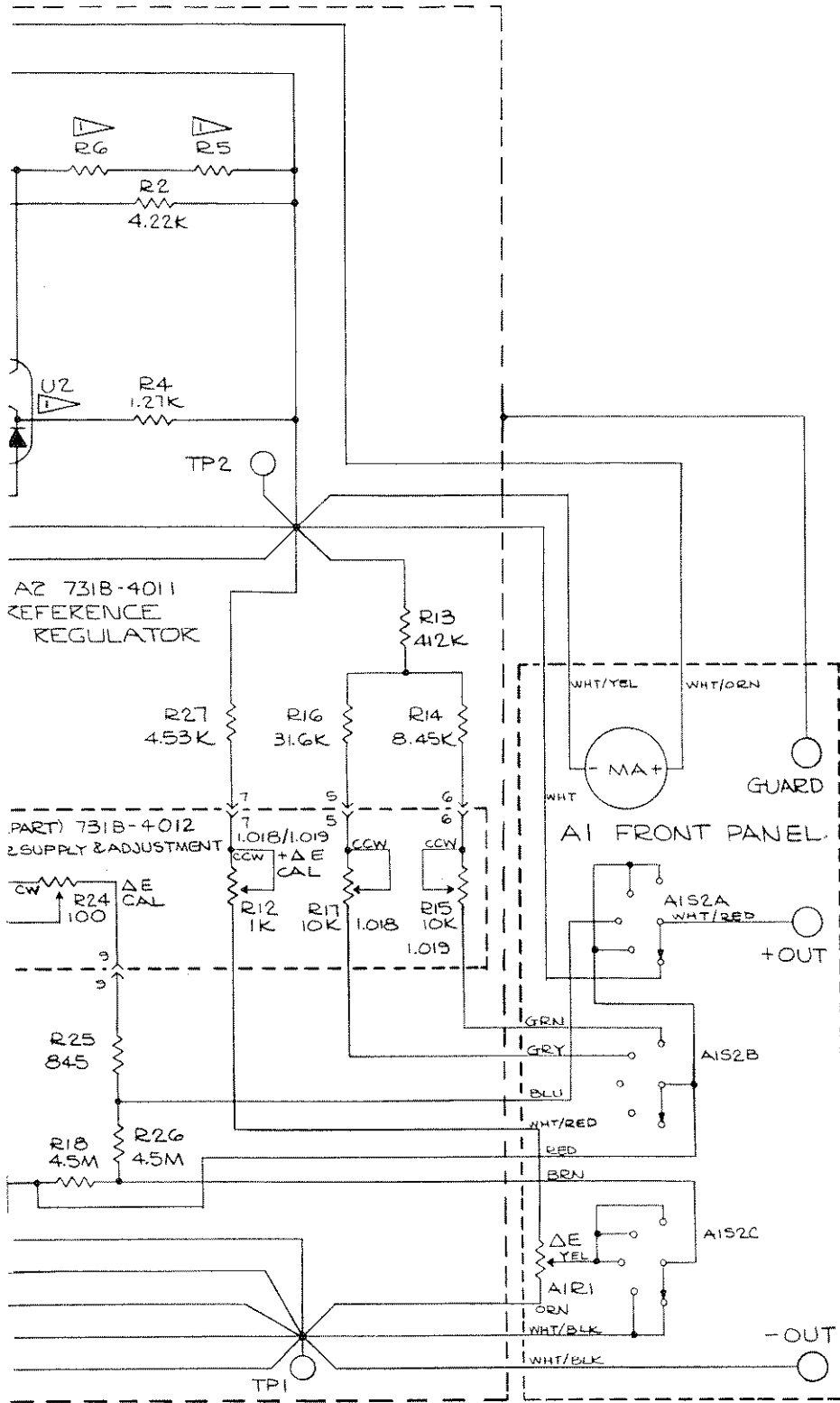
NOTES:

- 1 REF AMP SET 346270 (U2, R5, R6)
- 2 RESISTOR SET 730A/AB-4501 (R7, R8)
- 3 RESISTOR SET 731B-4550 (R20, 21, 22, 23)
- 4 SELECTED IN FINAL TEST
- 5. ALL RESISTANCES IN OHMS & ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE NOTED.
- 6. ALL TRANSISTORS ARE 2N3904
- 7. LAST REF DES. USED:  
R34, C5, CR12, Q3, U2
- 8. A1 - FRONT PANEL  
A2 - REFERENCE REGULATOR PCB  
A3 - POWER SUPPLY & ADJUSTMENT PCB  
A4 - REAR PANEL





A



-	REL. TO PRODUCTION	RD	10/10/84
B	DWG # WAS 731A-1011 REV WAS 731A-9512	MM	5/20/84
A	ADDED R5, R6 MOVED R11	TR	5/20/84
REV	CHANGE DESCRIPTION	DR	CHK APPR

FIGURE 8-1. 731B DC REFERENCE STANDARD (731B-1011)



## Change/Errata Information

Issue No: 5 6/79

This change/errata contains information necessary to ensure the accuracy of the following manual. Enter the corrections in the manual if either one of the following conditions exist:

1. The instrument's pcb revision letter is equal to or higher than that which is indicated at the beginning of the change.
2. No revision letter is indicated at the beginning of the change/errata.

### MANUAL

Title: MODEL 731B DC REFERENCE STANDARD  
Print Date: OCTOBER 1974  
Rev and Date: -----

### C/E PAGE EFFECTIVITY

Page No.	Print Date
1	6/79

## CHANGE #1 – 8434

On page 5-9, change the description, Fluke stock no, and mfg part no of R32

From: 16.9k, 267146, MFF1-81692F

To: 14k, 379057, MFF1-81402F.

On page 7-3/7-4, change the value of resistor R32 from 16.9k to 14k.

## CHANGE #2 – 10856

On page 5-3, change the description, mfg fed sply code and mfg part no of item #4:

From: 295642, 13511, 1381

To: 380808, 02111, 15-1-11.

## CHANGE #3 – 11193

On page 5-3, change the Fluke Stock no and mfg part no for item 1 (Corner) from 295972 to 394338.

## CHANGE #4 – 11194

On page 5-5, add the following new entry:

Decal, corner; 394379; 89536; 394379; 4

## CHANGE #5 – 11351

On Figure 7-1, change the value of R7 from 5.9k to 6.2k.

## CHANGE #6-11424

On page 1-2, Temperature Coefficient, change the 10°C temperature on both lines to 18°C.

## CHANGE #7 – 12054

On page 5-3, make the following changes:

FROM: 3/Decal, Front/375970/89536/375970/1

TO: 3/Decal, Front/507384/89536/507384/1

## ERRATA #1

On page 1-2, under SPECIFICATIONS, add the following information:

Protection Class . . . . . #1 (Relates solely to insulation or grounding properties further defined in IEC 348.)