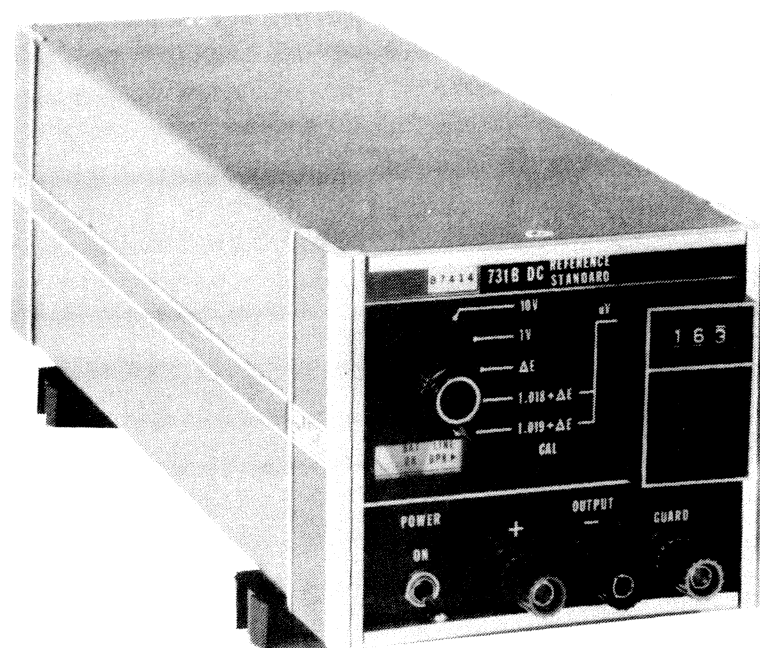

JOHN FLUKE MFG. CO., INC.

P. O. Box 43210
Mountlake Terrace, Washington 98043



MODEL
731B
DC REFERENCE STANDARD

P/N 405050
OCTOBER, 1974

WARRANTY

The JOHN FLUKE MFG. CO., INC.* warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operations, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken:

1. Notify the John Fluke Mfg. Co., Inc.,* giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.
2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate will be made before the work begins, provided the instrument is not covered by the Warranty.

"The foregoing warranty is in lieu of all other warranties, express or implied, including but not limited to, any implied warranty of merchantability, fitness or adequacy for any particular purpose or use. Fluke shall not be liable for any special, incident or consequential damages."

SHIPPING

All shipments of John Fluke Mfg. Co., Inc.* instruments should be made via United Parcel Service or "Best Way"*** prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc.* Upon receipt of this report, you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P.O. Box 43210, MOUNTLAKE TERRACE, WASHINGTON 98043*.

* For European customers: FLUKE (Nederland) B.V.
 Ledeboerstraat 27
 Tilburg, Netherlands

** For European customers, Air Freight prepaid.

CHANGE/ERRATA INFORMATION

MANUAL — [TITLE: MODEL 731B DC REFERENCE STANDARD
ISSUE: October 1974

Please make changes in this manual according to the following change and/or errata information:

Change 1

On page 5-9, change R32 from:

Res, met film 16.9k \pm 1%, 1/8w - 267146 - 91637 - MFF1-81692F - 1

to:

Res, met film 14k \pm 1%, 1/8w - 379057 - 91637 - MFF1-8143F - 1

On page 7-3, Figure 7-1, change R32 from 16.9k to 14k.

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Section 1

Introduction & 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, ΔE (000 to 999 μV), 1.018 + ΔE , and 1.019 + ΔE .

1-3. The desired voltage mode is selected using a front panel function switch and the value of ΔE is adjustable using a 10-turn linear potentiometer. The front panel ΔE control includes a 3 digit turn counter to indicate the selected value of ΔE , i.e., 000 to 999 μV . The counter is equipped with a locking lever to prevent accidental changing of a selected ΔE 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 +ΔE	1.018 to 1.018999V dc
1.019 +ΔE	1.019 to 1.019999V dc
ΔE	0 to 999 μV dc with 1 μV resolution

Output Accuracy: Absolute accuracy at 23°C ±1°C after 30 minute warm-up

Range	Period		
	30 days	90 Days	1 Year
10V	±10 PPM	±15 PPM	±30 PPM
1V	±10 PPM	±15 PPM	±30 PPM
1.018+ ΔE	±10 PPM	±15 PPM	±30 PPM
ΔE			±2 uV

Transfer Accuracy: 4 Hr

Between standard cells on 1.018V + ΔE or 1.019V + ΔE 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 MΩ	0
10 MΩ	0.005 ≈ 0
1 MΩ	.05
0.1 MΩ	.5
10 KΩ	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	<0.07Ω
1V, 1.018V, 1.019V, ΔE Ranges:	< 1 kΩ

Output Protection:

The output may be shorted indefinitely without damage to instrument.

Line Regulation:

Less than 1 PPM for ±10% line variation.

Ripple & Noise:

Less than 1 PPM P-P dc to 1 Hz
Less than 20 μV RMS 1 Hz to 1 MHz
Except <70 μV 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 ≤35°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 $\pm 10V$ 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)

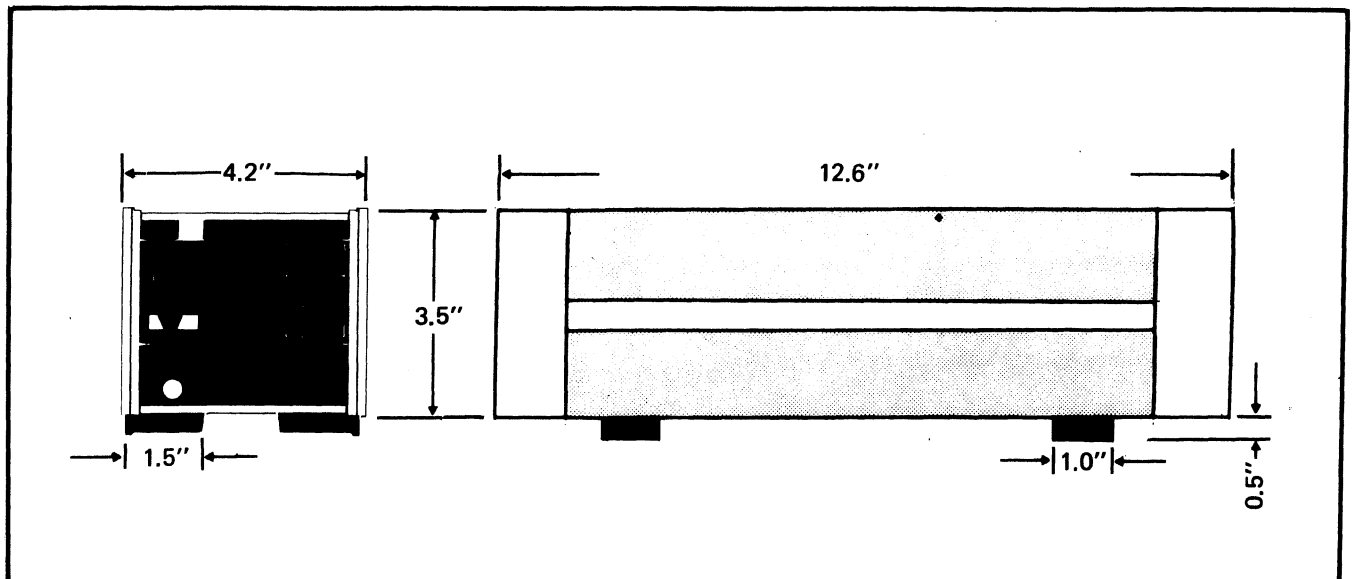


Figure 1-1. 731B OUTLINE DRAWING

Section 2

Operating Instructions

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:

731B

- 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.

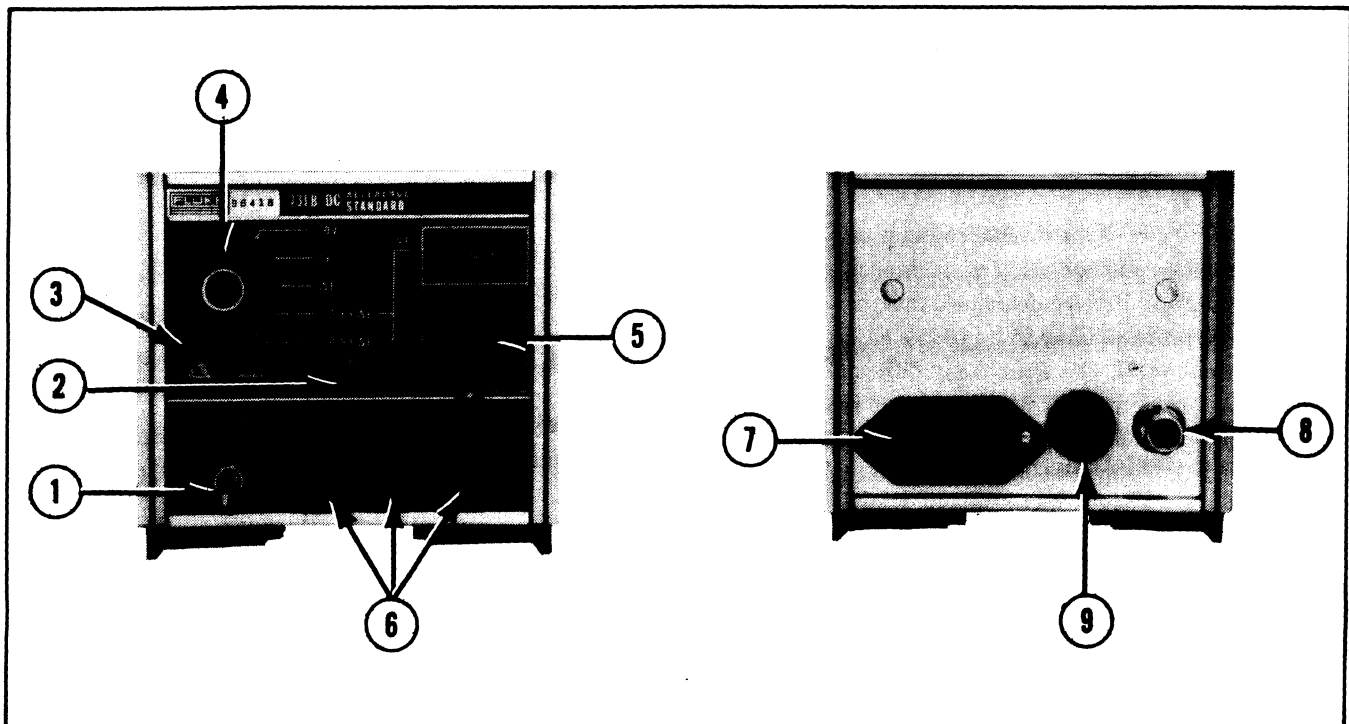


Figure 2-1. 731B CONTROLS, INDICATORS AND CONNECTORS

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>ΔE Provides an adjustable +000 to +999 μVdc output in 1 μV steps.</p> <p>1.018 + ΔE . . 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 + ΔE . . 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	ΔE vernier Control	A vernier control which provides the manual ΔE adjustment. The control is equipped with a three decade digital readout to permit exact settings from 000 to 999 μV 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.

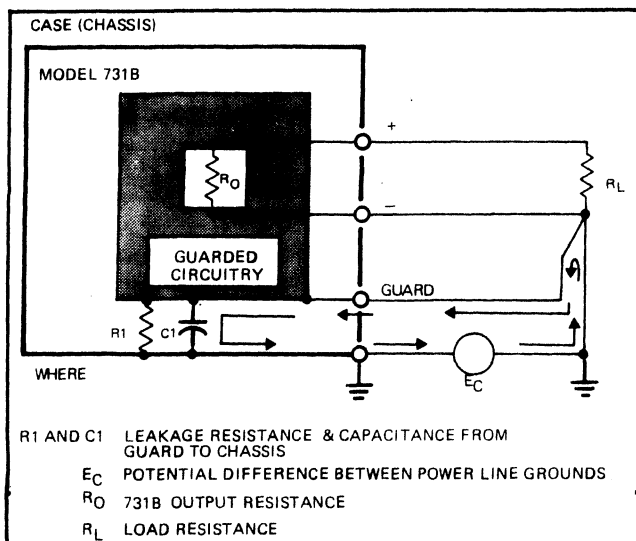


Figure 2-2. GUARD CONNECTION

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 ΔE control so that the mode switch setting plus the ΔE setting is equal to the standard cell voltage.
- Adjust the front panel CAL potentiometer for an optimum null.

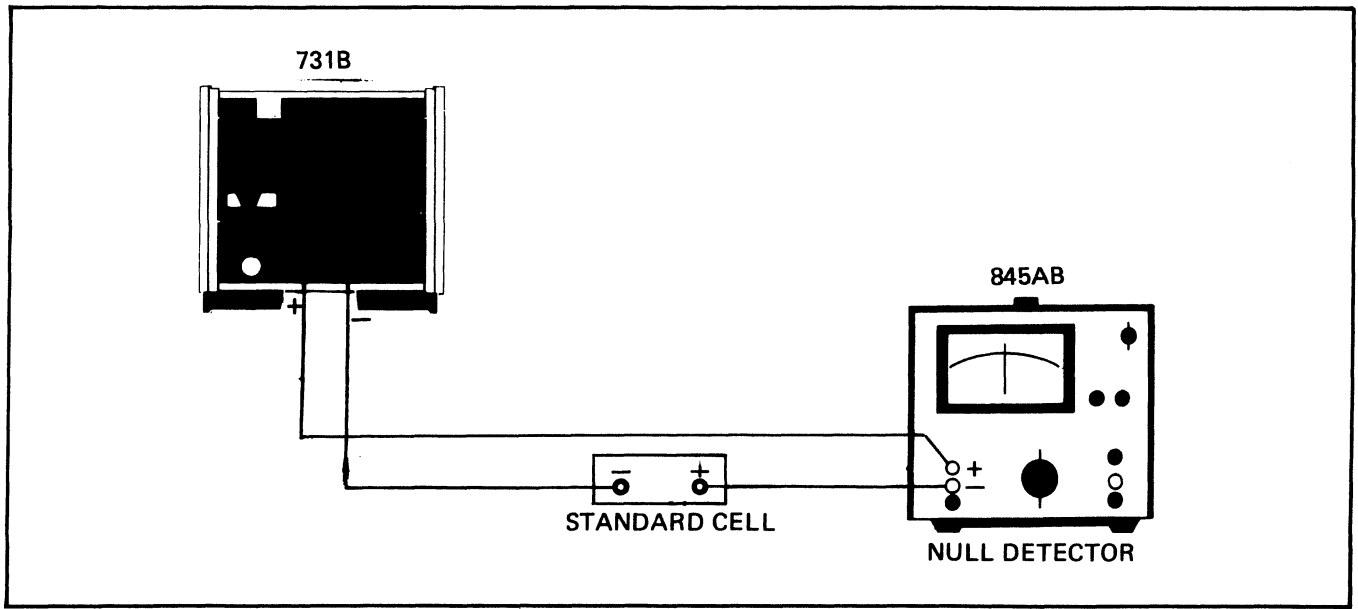


Figure 2-3. STANDARDIZING THE 731B.

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 ΔE , 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 ΔE mode the output is adjustable using the ΔE 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.

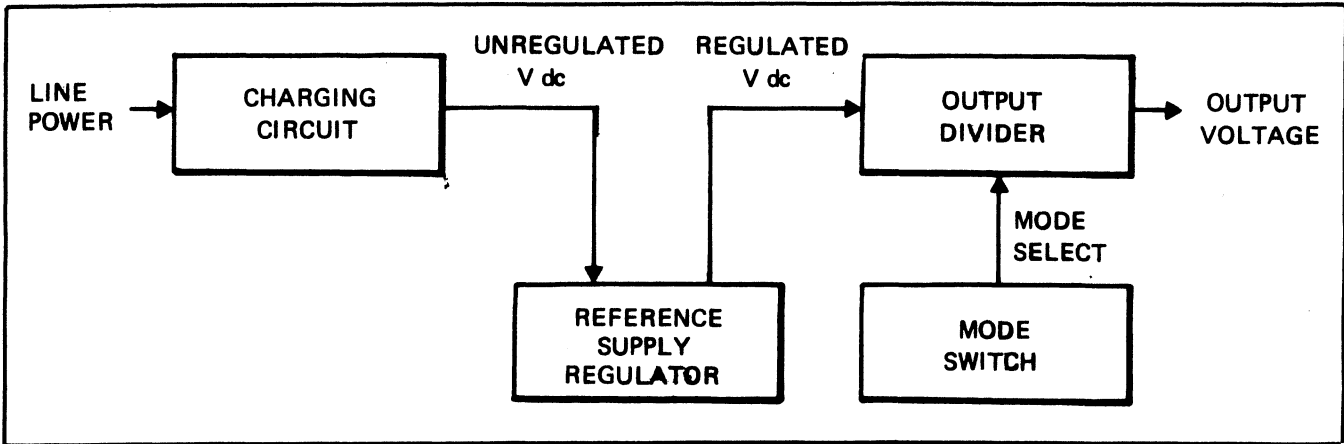


Figure 3-1. 731B SIMPLIFIED BLOCK DIAGRAM.

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} .

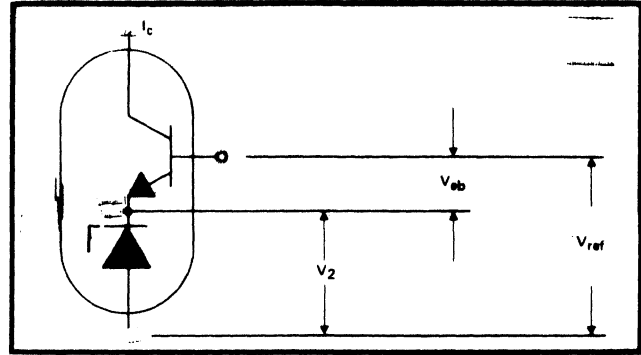


Figure 3-2. REFERENCE AMPLIFIER

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 ΔE output is calibrated by R24, and is adjustable from 000 to 999 μV using the front panel ΔE vernier control (A1R1). In the 1.018 + ΔE and 1.019 + ΔE modes the ΔE divider is operated in conjunction with the 1.018 and 1.019 dividers. In the ΔE mode, the ΔE 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 (≤ 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 ± 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.

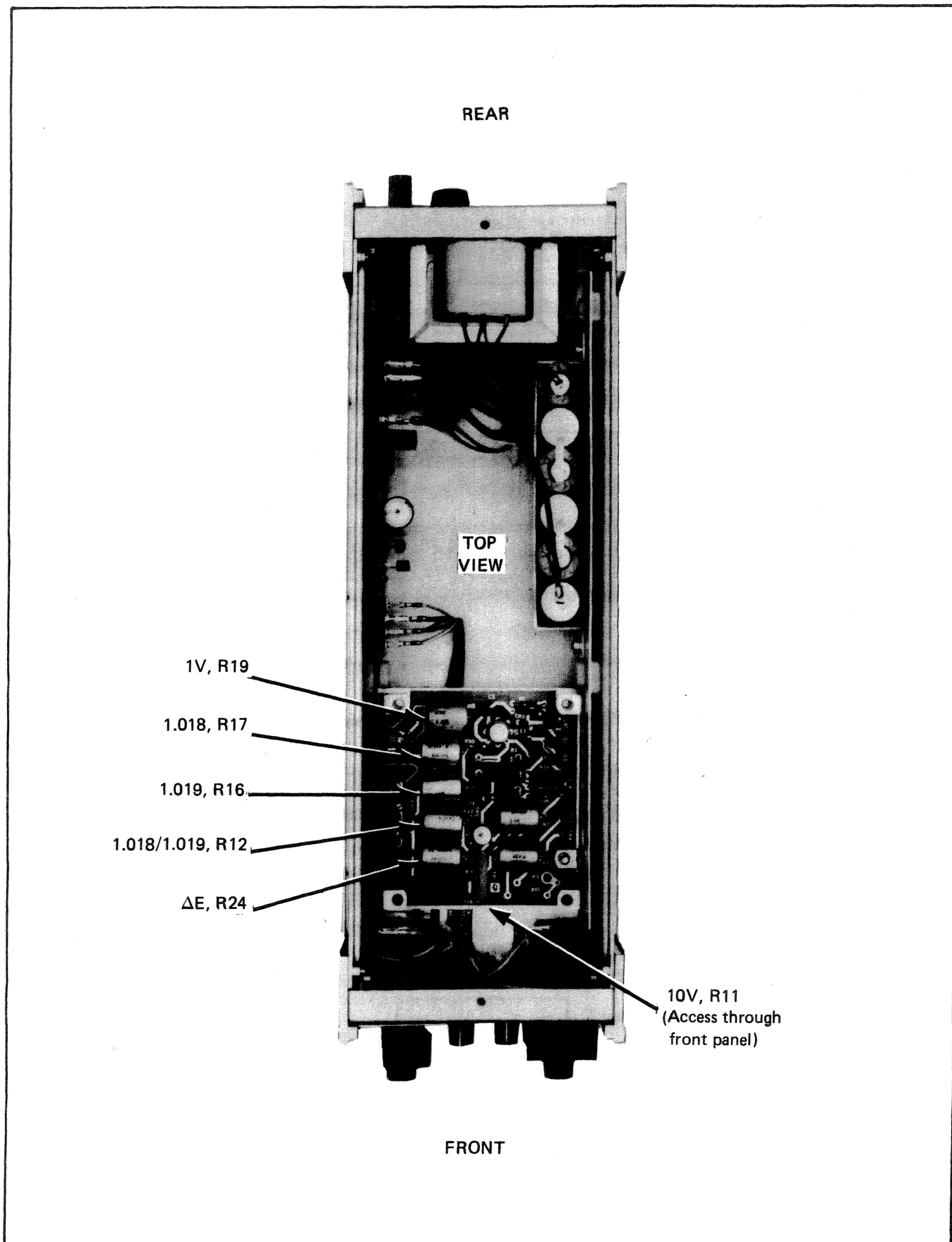


Figure 4-1. ADJUSTMENT LOCATIONS.

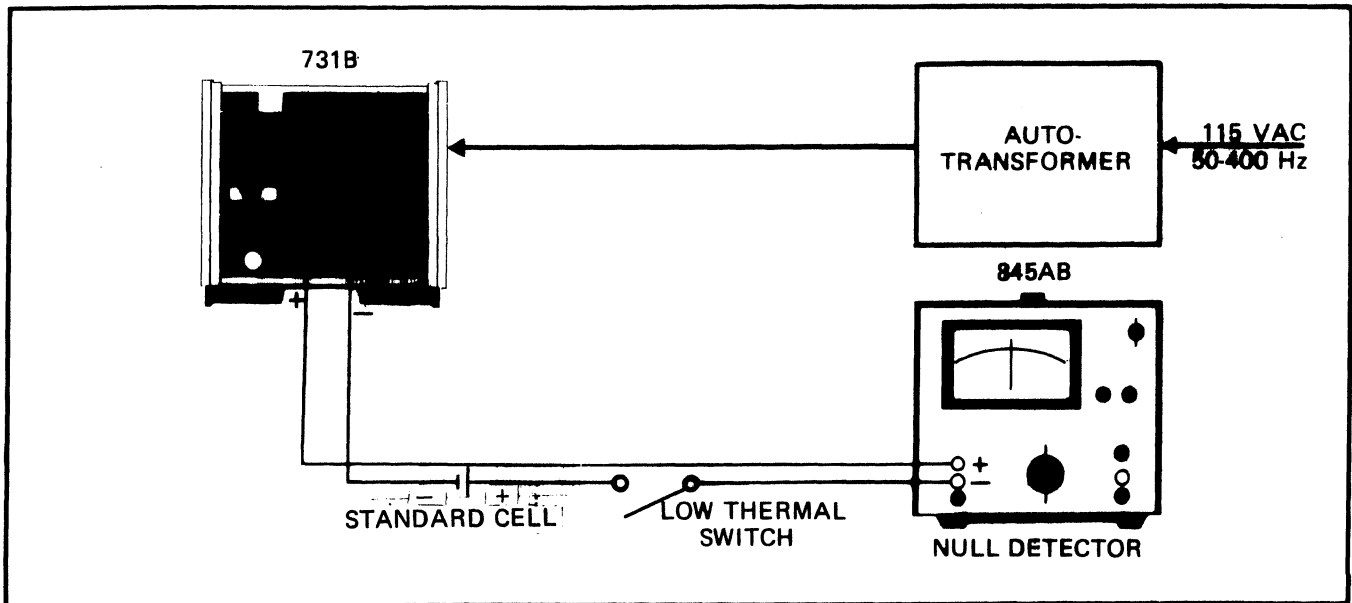


Figure 4-2. EQUIPMENT CONNECTIONS FOR LINE REGULATION, DC TO 1 Hz OUTPUT NOISE, AND TRANSFER ACCURACY TESTS.

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.

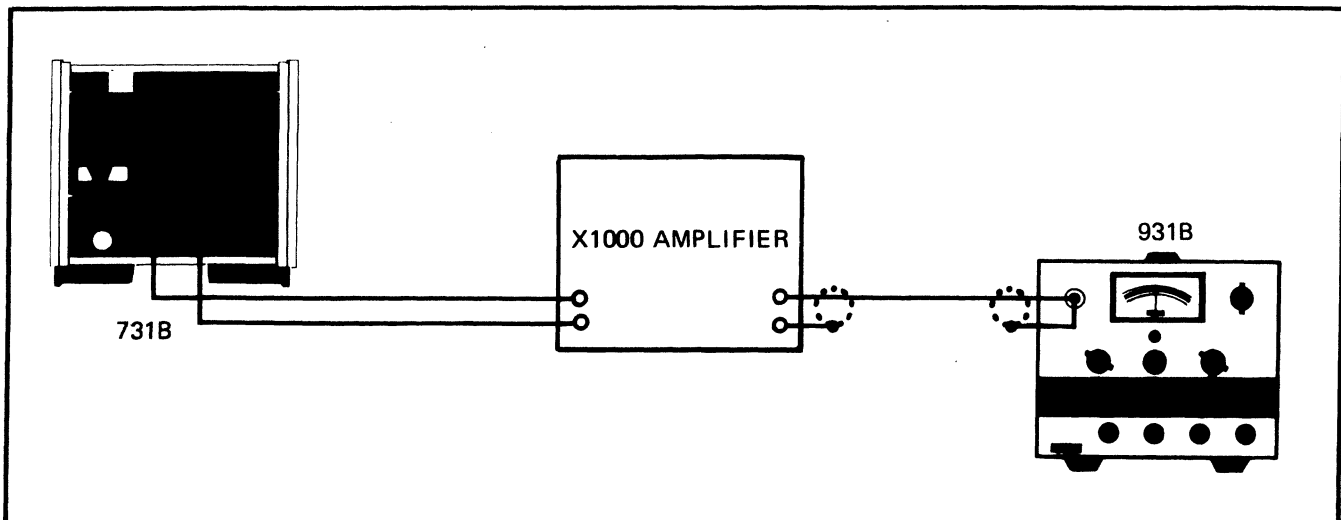


Figure 4-3. EQUIPMENT CONNECTIONS FOR 1 HZ TO 1 MHZ OUTPUT NOISE TEST.

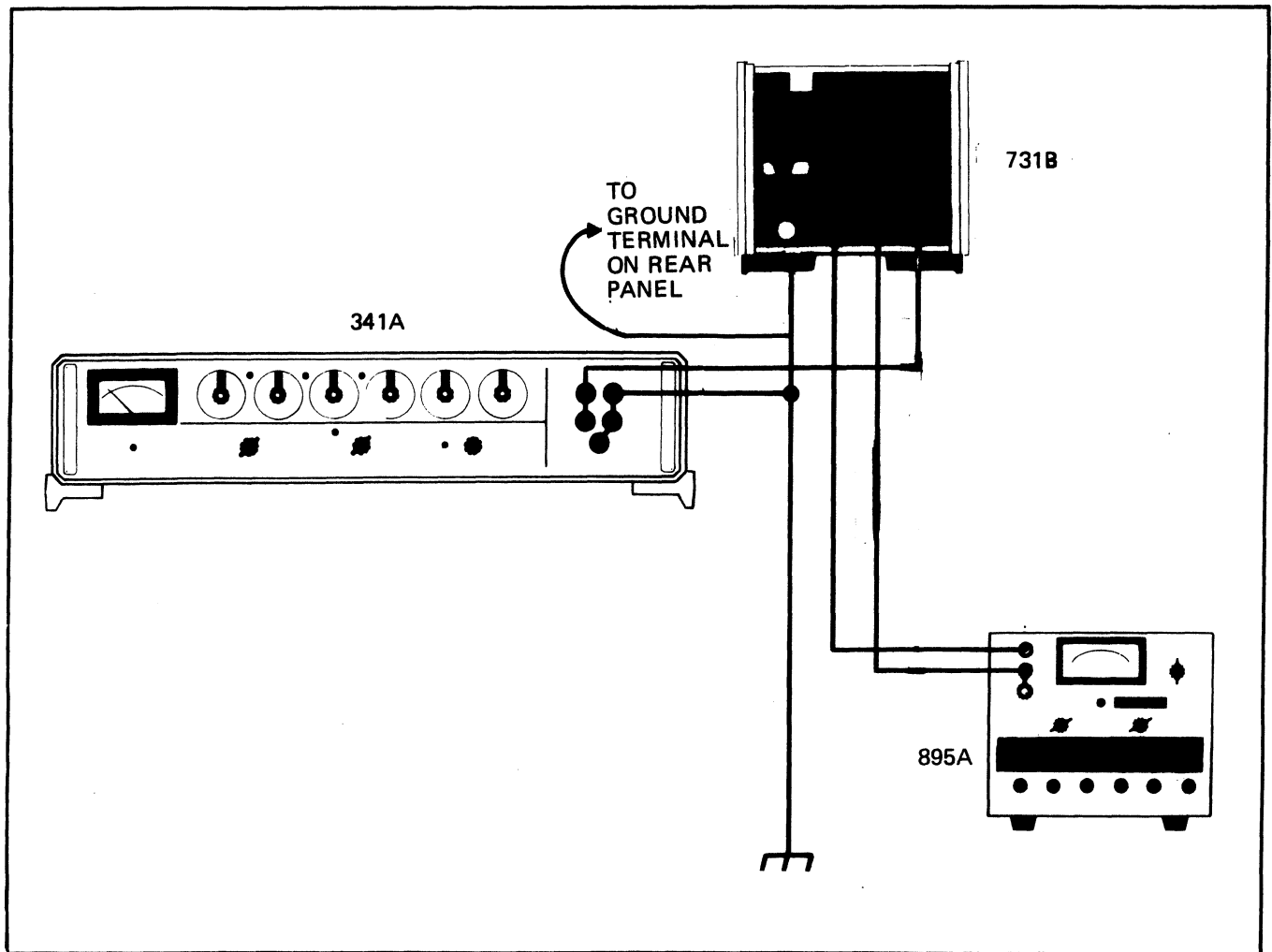


Figure 4-4. EQUIPMENT CONNECTIONS FOR COMMON-MODE REJECTION TEST.

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 ΔE 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 ± 2 microvolts deviation from null (zero).

1/2 hour warm up Required Table 4-2. 731B CALIBRATION

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

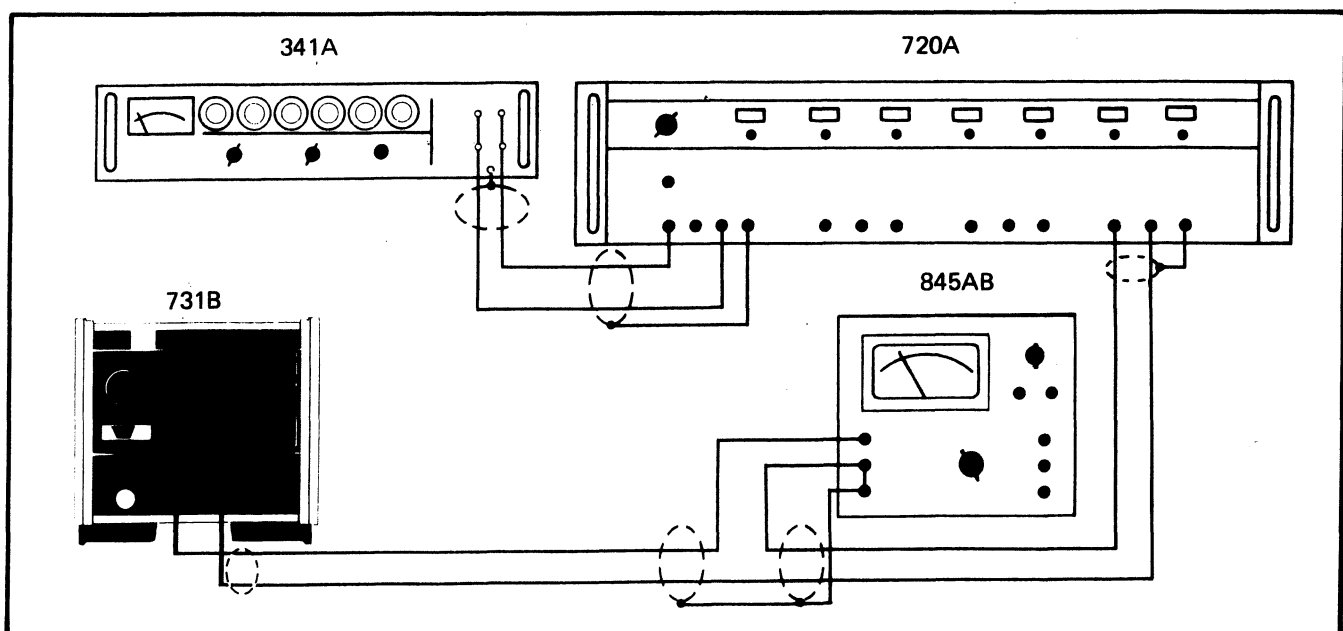


Figure 4-5. EQUIPMENT CONNECTIONS FOR DIVIDER ADJUSTMENT

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.

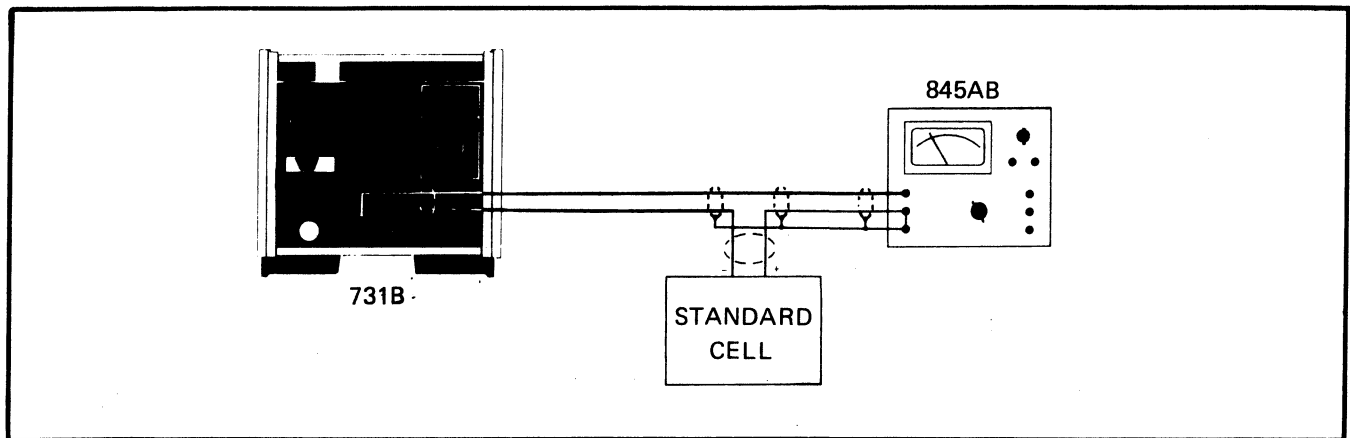


Figure 4-6. EQUIPMENT CONNECTIONS FOR ABSOLUTE VOLTAGE ADJUSTMENT

Section 5

Lists of Replaceable Parts

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 394338	89536	295972	4		
2	Cover, reference regulator	390351	89536	390351	1		
3	Decal, front	357970 507384	89536	357970	1		
4	Dial, counting	295642 380808	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		
	CORNER DECAL	394379					

FINAL ASSEMBLY

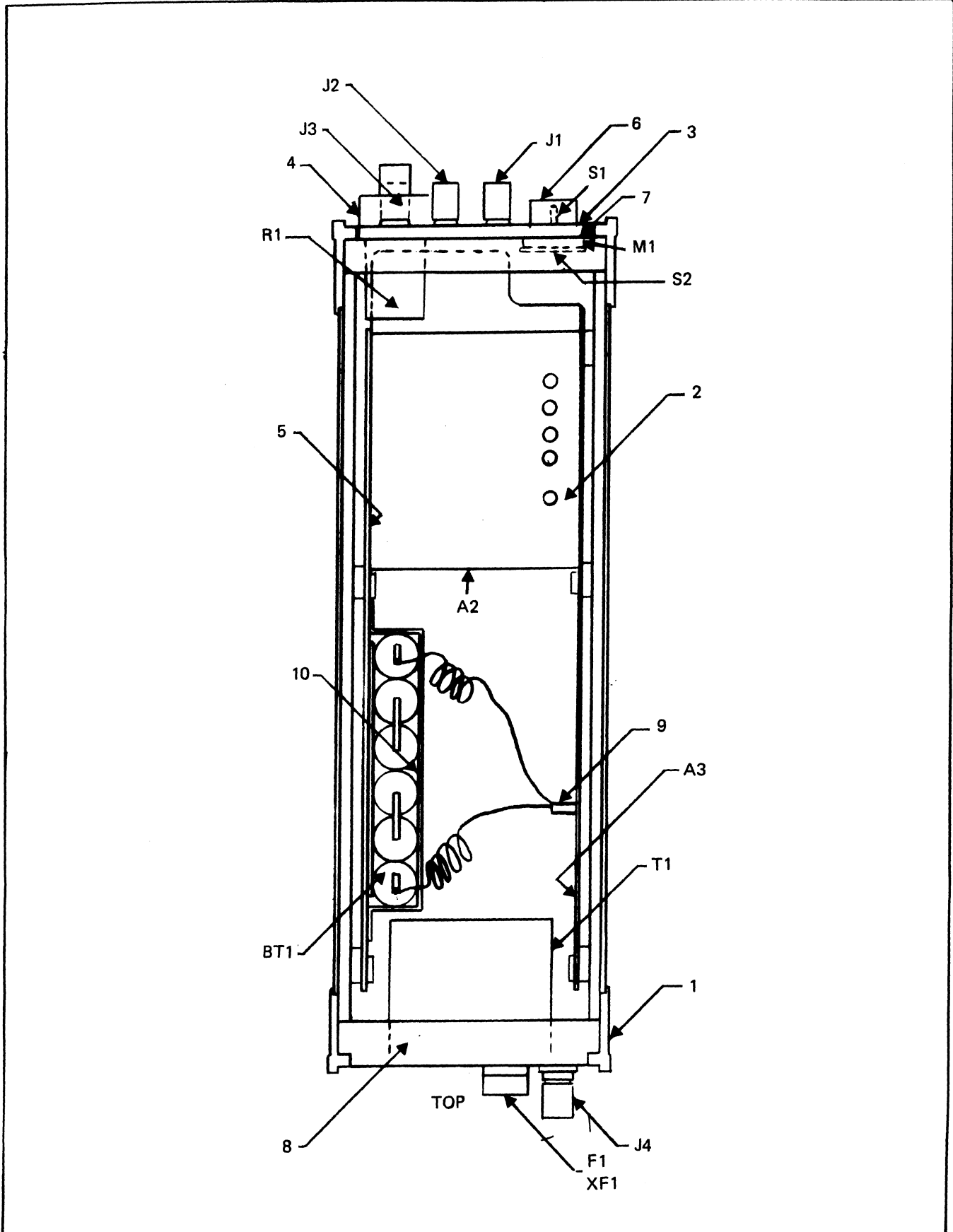


Figure 5-1 731B FINAL ASSEMBLY

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		
	DECAL CORNER	394379	89536	394379			

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 <i>1.000 Ma</i>	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%, $\frac{1}{4}$ 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

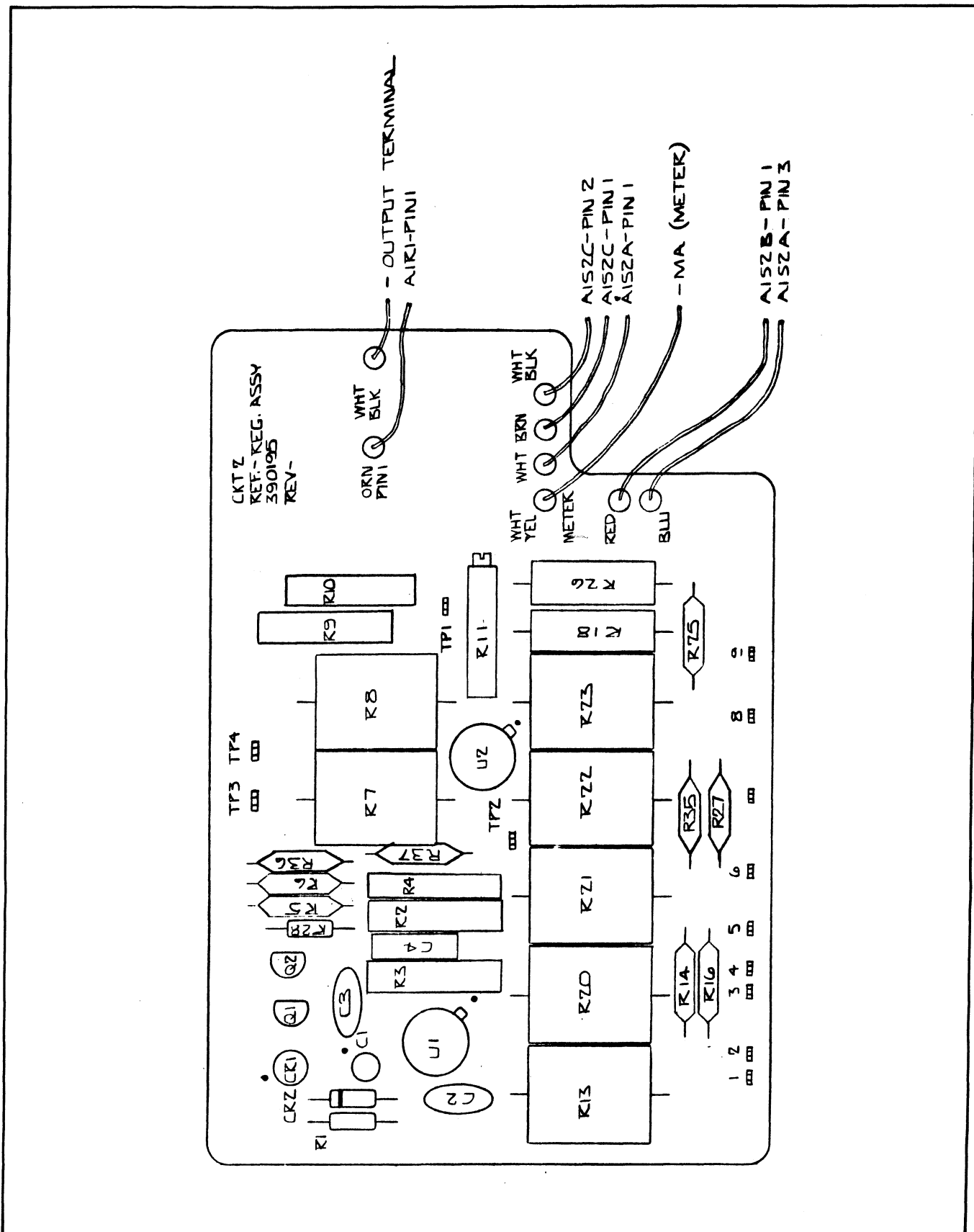


Figure 5-2. REFERENCE - REGULATOR PCB ASSEMBLY.

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		
U1	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	ET151X063A01	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 14K	267146 279057	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		

* ECO # 8434 changed R32 from 16.9K Ω TO 14K Ω from S/W 12500 AND ON

POWER SUPPLY AND ADJUSTMENT PCB ASSEMBLY

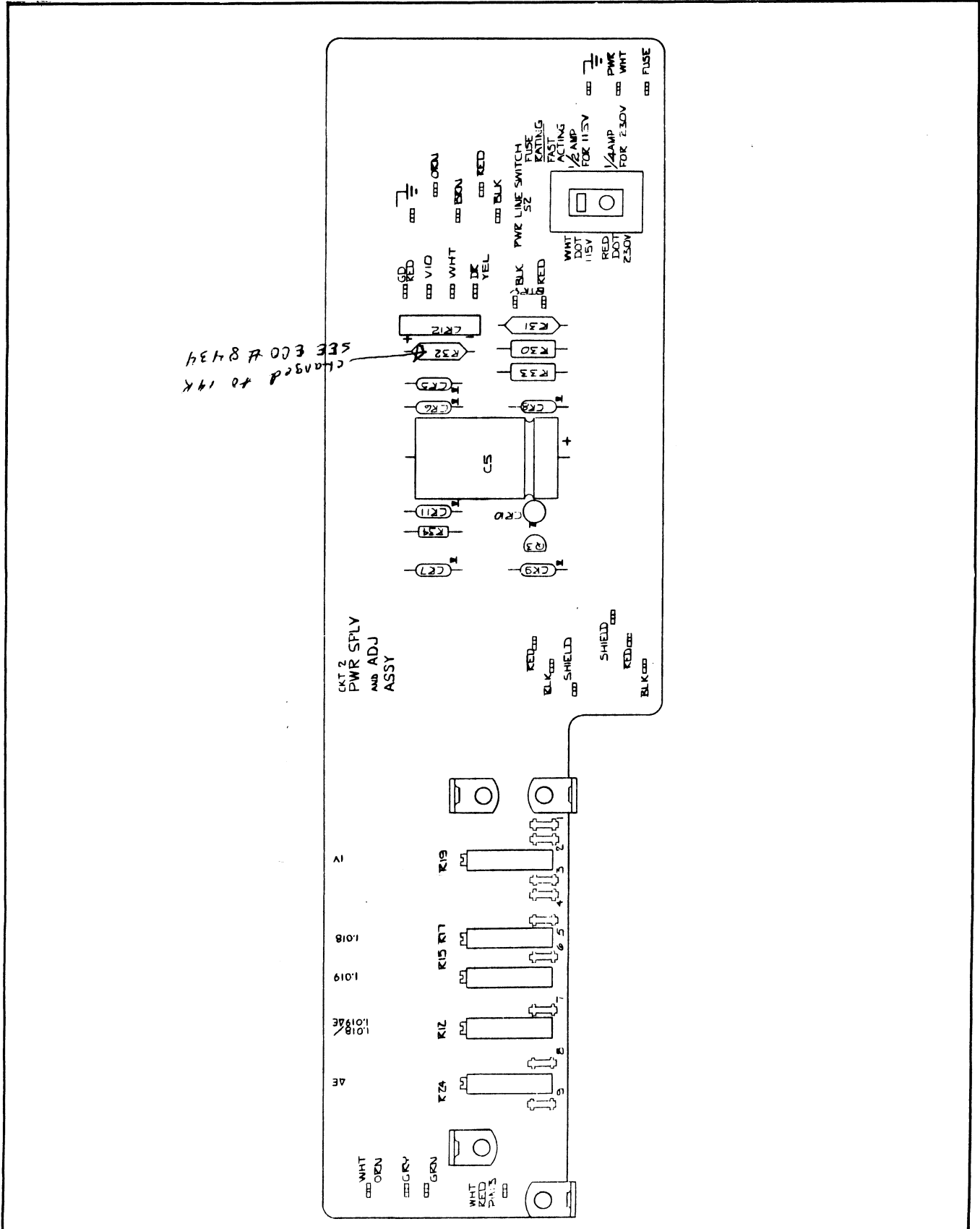


Figure 5-3. POWER SUPPLY AND ADJUSTMENT PCB ASSEMBLY.

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.

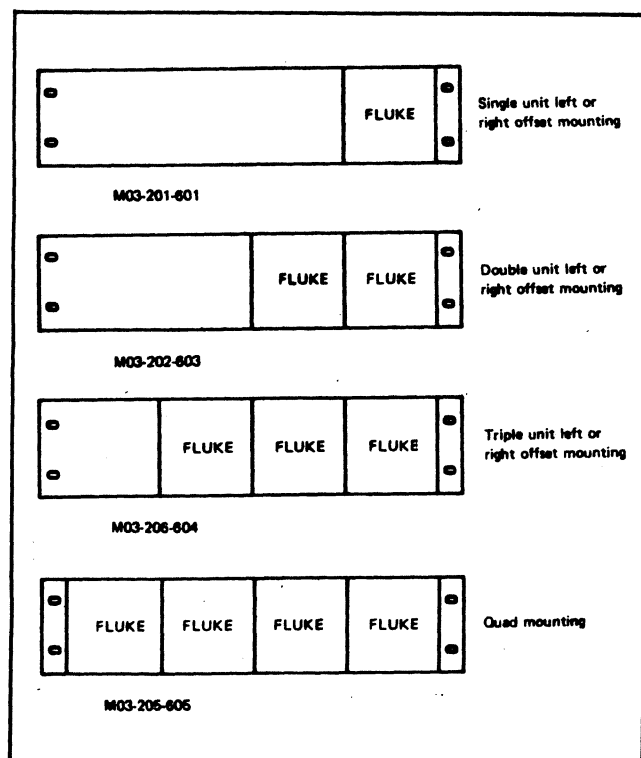


Figure 6-1. RACK MOUNTING CONFIGURATIONS.

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.

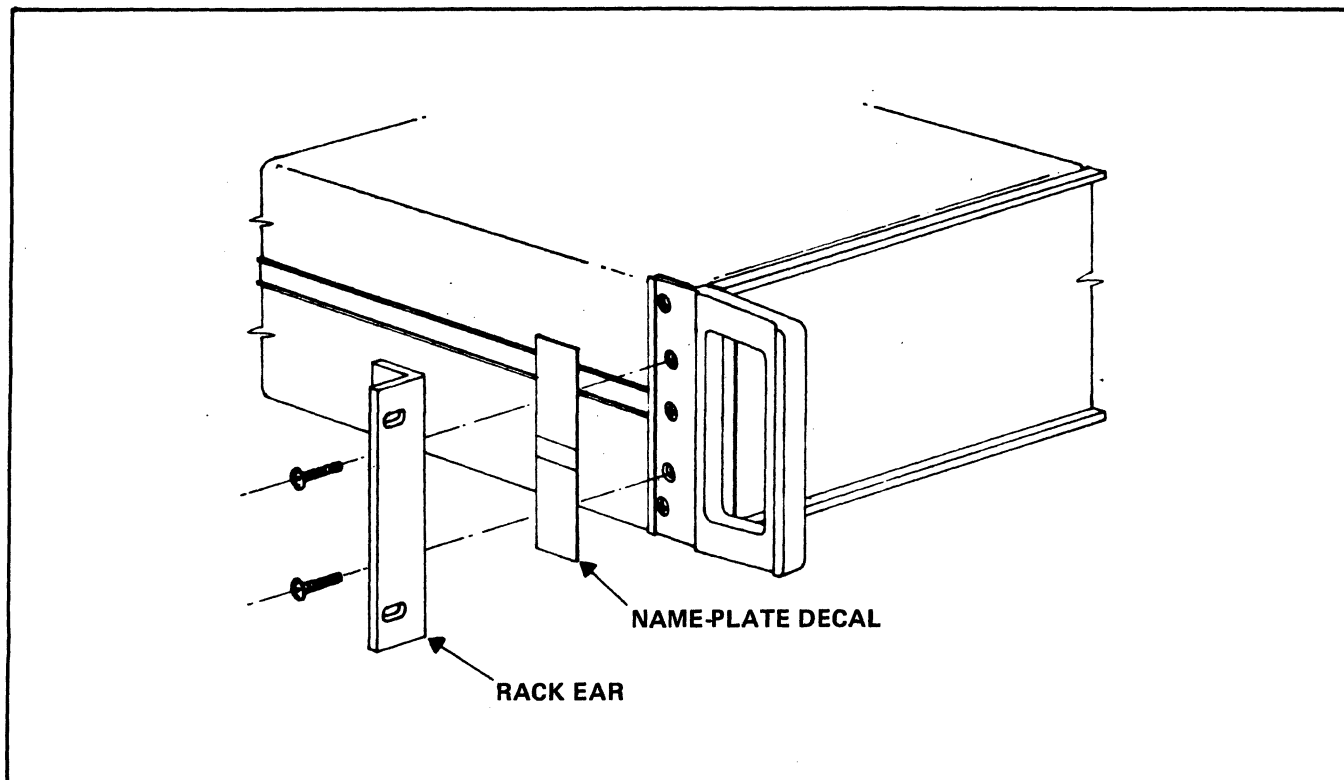


Figure 6-2. RACK EAR INSTALLATION.

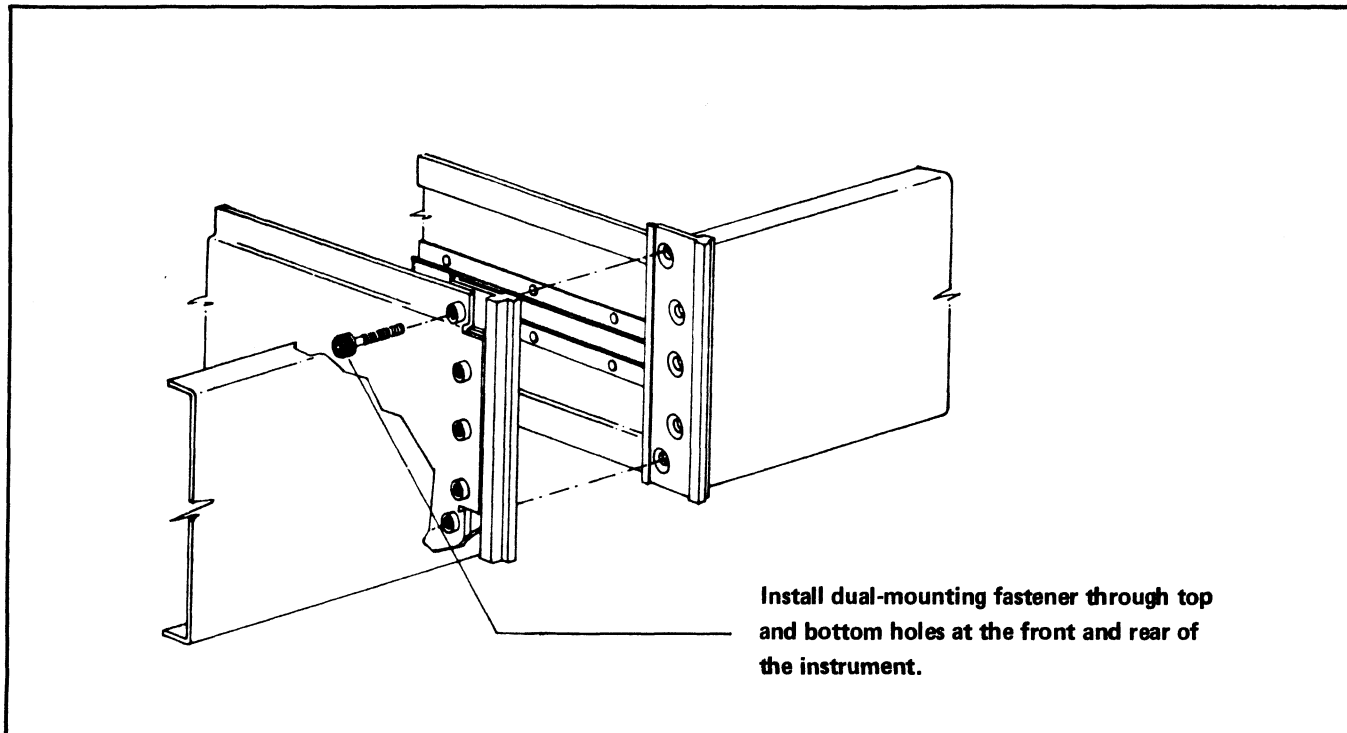


Figure 6-3. DUAL, TRIPLE, AND QUAD MOUNTING

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the

Lists of Replaceable parts contained in Section 5. The following information is presented in this section:

TABLE	TITLE	PAGE
7-1.	List of Abbreviations	7-2
7-2.	Federal Supply Codes for Manufacturers	7-3
7-3.	Fluke Technical Service Centers	7-7
7-4.	International Service Centers	7-7
7-5.	Sales Representatives-Domestic	7-8
7-6.	Sales Representatives-International	7-9

Table 7-1. LIST OF ABBREVIATIONS AND SYMBOLS

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

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS

00213 Nytronics Comp. Group Inc. Subsidiary of Nytronics Inc. Formerly Sage Electronics Rochester, New York	03797 Eidema Div. Genisco Technology Corp. Compton, California	05574 Viking Industries Chatsworth, California	07597 Burndy Corp. Tape/Cable Div. Rochester, New York
00327 Welwyn International, Inc. Westlake, Ohio	03877 Transistron Electronic Corp. Wakefield, Massachusetts	05704 Replaced by 16258	07792 Lerma Engineering Corp. Northampton, Massachusetts
00656 Aerovox Corp. New Bedford, Massachusetts	03888 KDI Pyrofilm Corp. Whippany, New Jersey	05820 Wakefield Engineering Inc. Wakefield, Massachusetts	07910 Teledyne Semiconductor Formerly Continental Device Hawthorne, California
00686 Film Capacitors, Inc. Passaic, New Jersey	03911 Clairex Electronics Div. Clairex Corp. Mt. Vernon, New York	06001 General Electric Co. Electronic Capacitor & Battery Products Dept. Columbia, South Carolina	07933 - use 49956 Raytheon Co. Semiconductor Div. HQ Mountain View, California
00779 AMP Inc. Harrisberg, Pennsylvania	03980 Muirhead Inc. Mountainside, New Jersey	06136 Replaced by 63743	08225 Industro Transistor Corp. Long Island City, New York
01121 Allen-Bradley Co. Milwaukee, Wisconsin	04009 Arrow Hart Inc. Hartford, Connecticut	06383 Panduit Corp. Tinley Park, Illinois	08261 Spectra Strip Corp. Garden Grove, California
01281 TRW Electronic Comp. Semiconductor Operations Lawndale, California	04062 Replaced by 72136	06473 Bunker Ramo Corp. Amphenol SAMS Div. Chatsworth, California	08530 Reliance Mica Corp. Brooklyn, New York
01295 Texas Instruments, Inc. Semiconductor Group Dallas, Texas	04202 Replaced by 81312	06555 Beede Electrical Instrument Co. Penacook, New Hampshire	08806 General Electric Co. Miniature Lamp Products Dept. Cleveland, Ohio
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06739 Electron Corp. Littleton, Colorado	08863 Nylomatic Corp. Norrisville, Pennsylvania
01686 RCL Electronics Inc. Manchester, New Hampshire	04221 Aemco, Div. of Midtex Inc. Mankato, Minnesota	06743 Clevite Corp. Cleveland, Ohio	08988 - use 53085 Skottie Electronics Inc. Archbald, Pennsylvania
01730 Replaced by 73586	04222 AVX Ceramics Div. AVX Corp. Myrtle Beach, Florida	06751 Components, Inc. Semcor Div. Phoenix, Arizona	09214 G.E. Co. Semi-Conductor Products Dept. Power Semi-Conductor Products OPN Sec. Auburn, New York
01884 - use 56289 Sprague Electric Co. Dearborn Electronic Div. Lockwood, Florida	04423 Telonic Industries Laguna Beach, California	06860 Gould Automotive Div. City of Industry, California	09353 C and K Components Watertown, Massachusetts
02114 Ferroxcube Corp. Saugerties, New York	04645 Replaced by 75376	06961 Vernitron Corp., Piezo Electric Div. Formerly Clevite Corp., Piezo Electric Div. Bedford, Ohio	09423 Scientific Components, Inc. Santa Barbara, California
02131 General Instrument Corp. Harris ASW Div. Westwood, Maine	04713 Motorola Inc. Semiconductor Products Phoenix, Arizona	06980 Eimac Div. Varian Associates San Carlos, California	09922 Burndy Corp. Norwalk, Connecticut
02395 Rason Mfg. Co. Brooklyn, New York	04946 Standard Wire & Cable Los Angeles, California	07047 Ross Milton, Co., The South Hampton, Pennsylvania	09969 Dale Electronics Inc. Yankton, S. Dakota
02533 Snelgrove, C.R. Co., Ltd. Don Mills, Ontario, Canada M3B 1M2	05082 Replaced by 94988	07115 Replaced by 14674	10059 Barker Engineering Corp. Formerly Amerace, Amerace ESNA Corp. Kenilworth, New Jersey
02606 Fenwal Labs Div. of Travenal Labs. Morton Grove, Illinois	05236 Jonathan Mfg. Co. Fullerton, California	07138 Westinghouse Electric Corp., Electronic Tube Division Horsehead, New York	11236 CTS of Berne Berne, Indiana
02660 Bunker Ramo Corp., Conn Div. Formerly Amphenol-Borg Electric Corp. Broadview, Illinois	05245 Components Corp. now Corcom, Inc. Chicago, Illinois	07233 TRW Electronic Components Cinch Graphic City of Industry, California	11237 CTS Keene Inc. Paso Robles, California
02799 Aero Capacitors, Inc. Chatsworth, California	05277 Westinghouse Electric Corp. Semiconductor Div. Youngwood, Pennsylvania	07256 Silicon Transistor Corp. Div. of BBF Group Inc. Chelmsford, MA	11358 CBS Electronic Div. Columbia Broadcasting System Newburyport, MN
03508 General Electric Co. Semiconductor Products Syracuse, New York	05278 Replaced by 43543	07261 Aumet Corp. Culver City, California	11403 Best Products Co. Chicago, Illinois
03614 Replaced by 71400	05279 Southwest Machine & Plastic Co. Glendora, California	07263 Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California	11503 Keystone Columbia Inc. Warren, Michigan
03651 Replaced by 44655	05397 Union Carbide Corp. Materials Systems Div. New York, New York	07344 Bircher Co., Inc. Rochester, New York	11532 Teledyne Relays Hawthorne, California

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS (Continued)

11711 General Instrument Corp Rectifier Division Hickville, New York	14099 Semtech Corp. Newbury Park, California	17069 Circuit Structures Lab. Burbank, California	24655 General Radio Concord, Massachusetts
11726 Qualidyne Corp. Santa Clara, California	14140 Edison Electronic Div. Mc Gray-Edison Co. Manchester, New Hampshire	17338 High Pressure Eng. Co., Inc. Oklahoma City, Oklahoma	24759 Lenox-Fugle Electronics Inc. South Plainfield, New Jersey
12014 Chicago Rivet & Machine Co. Bellwood, Illinois	14193 Cal-R-Inc. formerly California Resistor, Corp. Santa Monica, California	17545 Atlantic Semiconductors, Inc. Asbury Park, New Jersey	25088 Siemen Corp. Isilen, New Jersey
12040 National Semiconductor Corp. Danbury, Connecticut	14298 American Components, Inc. an Insilco Co. Conshohocken, Pennsylvania	17856 Siliconix, Inc. Santa Clara, California	25403 Amperex Electronic Corp. Semiconductor & Micro-Circuits Div. Slatersville, Rhode Island
12060 Diodes, Inc. Chatsworth, California	14655 Cornell-Dublier Electronics Division of Federal Pacific Electric Co. Govt. Control Dept. Newark, New Jersey	17870 Replaced by 14140	27014 National Semiconductor Corp. Santa Clara, California
12136 Philadelphia Handle Co. Camden, New Jersey	14752 Electro Cube Inc. San Gabriel, California	18178 Vactec Inc. Maryland Heights, Missouri	27264 Molex Products Downers Grove, Illinois
12300 Potter-Brumfield Division AMF Canada LTD. Guelph, Ontario, Canada	14869 Replaced by 96853	18324 Signetics Corp. Sunnyvale, California	28213 Minnesota Mining & Mfg. Co. Consumer Products Div. St. Paul, Minnesota
12323 Presin Co., Inc. Shelton, Connecticut	14936 General Instrument Corp. Semi Conductor Products Group Hicksville, New York	18736 Voltronics Corp. Hanover, New Jersey	28425 Serv./-Link formerly Bohannon Industries Fort Worth, Texas
12327 Freeway Corp. formerly Freeway Washer & Stamping Co. Cleveland, Ohio	15636 Elec-Trol Inc. Saugus, California	18927 G T E Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania	28478 Deltrol Controls Div. Deltrol Corporation Milwaukee, Wisconsin
12443 Budd Co. The, Polychem Products Plastic Products Div. Bridgeport, PA	15801 Fenwal Electronics Inc. Div. of Kidde Walter and Co., Inc. Framingham, Massachusetts	19451 Perine Machinery & Supply Co. Seattle, Washington	28480 Hewlett Packard Co. Corporate H.O. Palo Alto, California
12615 U.S. Terminals Inc. Cincinnati, Ohio	15818 Teledyne Semiconductors, formerly Amelco Semiconductor Mountain View, California	19701 Electro-Midland Corp. Mepco-Electra Inc. Mineral Wells, Texas	28520 Heyman Mfg. Co. Kenilworth, New Jersey
12617 Hamlin Inc. Lake Mills, Wisconsin	15849 Litton Systems Inc. Useco Div. formerly Useco Inc. Van Nuys, California	20584 Enochs Mfg. Inc. Indianapolis, Indiana	29083 Monsanto Co., Inc. Santa Clara, California
12697 Clarostat Mfg. Co. Dover, New Hampshire	15898 International Business Machines Corp. Essex Junction, Vermont	20891 Self-Organizing Systems, Inc. Dallas, Texas	29604 Stackpole Components Co. Raleigh, North Carolina
12749 James Electronics Chicago, Illinois	15909 Replaced by 14140	21604 Buckeye Stamping Co. Columbus, Ohio	30148 A B Enterprise Inc. Ahoskie, North Carolina
12856 Micrometals Sierra Madre, California	16258 Space-Lok Inc. Burbank, California	21845 Solitron Devices Inc. Transistor Division Riveria Beach, Florida	30323 Illinois Tool Works, Inc. Chicago, Illinois
12954 Dickson Electronics Corp. Scottsdale, Arizona	16299 Corning Glass Electronic Components Div. Raleigh, North Carolina	22767 ITT Semiconductors Palo Alto, California	31091 Optimax Inc. Colmar, Pennsylvania
12969 Unitrode Corp. Watertown, Massachusetts	16332 Replaced by 28478	23050 Product Comp. Corp. Mount Vernon, New York	32539 Mura Corp. Great Neck, New York
13103 Thermalloy Co., Inc. Dallas, Texas	16473 Cambridge Scientific Ind. Div. of Chemed Corporation Cambridge, Maryland	23732 Tracor Inc. Rockville, Maryland	32767 Griffith Plastic Corp. Burlingame, California
13327 Solitron Devices Inc. Tappan, New York	16742 Paramount Plastics Fabricators, Inc. Downey, California	23880 Stanford Applied Engrng. Santa Clara, California	32879 Advanced Mechanical Components Northridge, California
13511 Amphenol Cadre Div. Bunker-Ramo Corp. Los Gatos, California	16758 Delco Electronics Div. of General Motors Corp. Kokomo, Indiana	23936 Pamotor Div., Wm. J. Purdy Co. Burlingame, California	32897 Erie Technological Products, Inc. Frequency Control Div. Carlisle, Pennsylvania
13606 - use 56289 Sprague Electric Co. Transistor Div. Concord, New Hampshire	17001 Replaced by 71468	24248 Replaced by 94222	32997 Bourns Inc. Trimpot Products Division Riverside, California
13839 Replaced by 23732		24355 Analog Devices Inc. Norwood, Massachusetts	33173 General Electric Co. Products Dept. Owensboro, Kentucky

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS (Continued)

34333 Silicon General Westminister, California	70563 Amperite Company Union City, New Jersey	73293 Hughes Aircraft Co. Electron Dynamics Div. Torrence, California	77969 Rubbercraft Corp. of CA. LTD. Torrance, California
34335 Advanced Micro Devices Sunnyvale, California	70903 Belden Corp. Geneva, Illinois	7344 ^F Amperex Electronic Corp. Hicksville, LI, New York	78189 Shakeproof Div. of Illinois Tool Works Inc. Elgin, Illinois
34802 Electromotive Inc. Kenilworth, New Jersey	71002 Birnbach Radio Co., Inc. Freeport, LI New York	73559 Carling Electric Inc. West Hartford, Connecticut	78277 Sigma Instruments, Inc. South Braintree, Massachusetts
37942 Mallory, P.R. & Co., Inc. Indianapolis, Indiana	71400 Bussmann Mfg. Div. of McGraw-Edison Co. Saint Louis, Missouri	73586 Circle F Industries Trenton, New Jersey	78488 Stackpole Carbon Co. Saint Marys, Pennsylvania
42498 National Radio Melrose, Massachusetts	71450 CTS Corp. Elkhart, Indiana	73734 Federal Screw Products, Inc. Chicago, Illinois	78553 Eaton Corp. Engineered Fastener Div. Tinnerman Plant Cleveland, Ohio
43543 Nytronics Inc. Transformer Co. Div. Geneva, New York	71468 ITT Cannon Electric Inc. Santa Ana, California	73743 Fischer Special Mfg. Co. Cincinnati, Ohio	79136 Waldes Kohinoor Inc. Long Island City, New York
44655 Ohmite Mfg. Co. Skokie, Illinois	71482 Clare, C.P. & Co. Chicago, Illinois	73899 JFD Electronics Co. Components Corp Brooklyn, New York	79497 Western Rubber Company Goshen, Indiana
45-1 RCA Corp. New York, New York	71590 Centrelab Electronics Div. of Globe Union Inc. Milwaukee, Wisconsin	73949 Guardian Electric Mfg. Co. Chicago, Illinois	79963 Zierick Mfg. Corp. Mt. Kisko, New York
49956 Raytheon Company Lexington, Massachusetts	71707 Coto Coil Co., Inc. Providence, Rhode Island	74199 Quan Nichols Co. Chicago, Illinois	80031 Electro-Midland Corp., Mepco Div. A North American Phillips Co. Morristown, New Jersey
50088 Mostek Corp. Carrllton, Texas	71744 Chicago Miniature Lamp Works Chicago, Illinois	74217 Radio Switch Corp. Marlboro, New Jersey	80145 LFE Corp., Process Control Div. formerly API Instrument Co. Chesterland, Ohio
50579 Litronix Inc. Cupertino, California	71785 TRW Electronics Components Cinch Connector Operations Div. Elk Grove Village, Chicago, Illinois	74276 Signalite Div. General Instrument Corp. Neptune, New Jersey	80183 - use 56289 Sprague Products North Adams, Massachusetts
51605 Scientific Components Inc. Linden, New Jersey	72005 Driver, Wilber B., Co. Newark, New Jersey	74306 Piezo Crystal Co. Carlisle, Pennsylvania	80294 Bourns Inc., Instrument Div. Riverside, California
53021 Sangamo Electric Co. Springfield, Illinois	72092 Replaced by 06980	74542 Hoyt Elect. Instr. Works Penacook, New Hampshire	80583 Hammarlund Mfg. Co., Inc. Red Bank, New Jersey
54294 Cutter-Hammer Inc. formerly Shallcross, A Cutter-Hammer Co. Selma, North Carolina	72136 Electro Motive Mfg. Co. Williamantic, Connecticut	74970 Johnson E.F., Co. Waseca, Minnesota	80640 Stevens, Arnold Inc. South Boston, Massachusetts
55026 Simpson Electric Co. Div. of Am. Gage and Mach. Co. Elgin, Illinois	72259 Nytronics Inc. Pelham Manor, New Jersey	75042 TRW Electronics Components IRC Fixed Resistors Philadelphia, Pennsylvania	81073 Grayhill, Inc. La Grange, Illinois
56289 Sprague Electric Co. North Adams, Massachusetts	72619 Dialight Div. Amperex Electronic Corp. Brooklyn, New York	75376 Kurz-Kasch Inc. Dayton, Ohio	81312 Winchester Electronics Div. of Litton Industries Inc. Oakville, Connecticut
58474 Superior Electric Co. Bristol, Connecticut	72653 G.C. Electronics Div. of Hydrometals, Inc. Brooklyn, New York	75378 CTS Knights Inc. Sandwich, Illinois	81439 Therm-O-Disc Inc. Mansfield, Ohio
60399 Torin Corp, formerly Torrington Mfg. Co. Torrington, Connecticut	72665 Replaced by 90303	75382 Kulka Electric Corp. Mount Vernon, New York	81483 International Rectifier Corp. Los Angeles, California
63743 Ward Leonard Electric Co., Inc. Mount Vernon, New York	72794 Dzus Fastener Co., Inc. West Islip, New York	75915 Littlefuse Inc. Des Plaines, Illinois	81590 Korry Mfg. Co. Seattle, Washington
64834 West Mfg. Co. San Francisco, California	72928 Gulton Ind. Inc. Gudeman Div. Chicago, Illinois	76854 Oak Industries Inc. Switch Div. Crystal Lake, Illinois	81741 Chicago Lock Co. Chicago, Illinois
65092 Weston Instruments Inc. Newark, New Jersey	72982 Erie Tech. Products Inc. Erie, Pennsylvania	77342 AMF Inc. Potter & Brumfield Div. Princeton, Indiana	82305 Palmer Electronics Corp. South Gate, California
66150 Winslow Tele-Tronics Inc. Eaton Town, New Jersey	73138 Beckman Instruments Inc. Helipot Division Fullerton, California	77638 General Instrument Corp. Rectifier Division Brooklyn, New York	82389 Switchcraft Inc. Chicago, Illinois
70485 Atlantic India Rubber Works Chicago, Illinois			

Table 7-2. FEDERAL SUPPLY CODES FOR MANUFACTURERS (Continued)

82415 North American Phillips Controls Corp. Frederick, Maryland	88245 Litton Systems Inc. Useco Div. Van Nuys, California	91934 Miller Electric Co., Inc. Div of Aunet Woonsocket, Rhode Island	97966 Replaced by 11358
82872 Roanwell Corp. New York, New York	88419 Cornell-Dubilier Electronic Div. Federal Pacific Co. Fuquay-Varian, North Carolina	92194 Alpha Wire Corp. Elizabeth, New Jersey	98094 Replaced by 49956
82877 Rotron Inc. Woodstock, New York	88486 Plastic Wire & Cable Jewett City, Connecticut	93332 Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts	98159 Rubber-Teck, Inc. Gardena, California
82879 ITT Royal Electric Div. Pawtucket, Rhode Island	88690 Replaced by 04217	94145 Replaced by 49956	98278 Malco A Microdot Co., Inc. Connector & Cable Div. Pasadena, California
83003 Varo Inc. Garland, Texas	89536 Fluke, John Mfg. Co., Inc. Seattle, Washington	94154 - use 94988 Wagner Electric Corp. Tung-Sol Div. Newark, New Jersey	98291 Sealectro Corp. Mamaroneck, New York
83058 Carr Co., The United Can Div. of TRW Cambridge, Massachusetts	89730 G.E. Co., Newark Lamp Works Newark, New Jersey	94222 Southco Inc. formerly South Chester Corp. Lester, Pennsylvania	98388 Royal Industries Products Div. San Diego, California
83298 Bendix Corp Electric Power Division Eatontown, New Jersey	90201 Mallory Capacitor Co. Div of P.R. Mallory Co., Inc. Indianapolis, Indiana	95146 Alco Electronic Products Inc. Lawrence, Massachusetts	98743 Replaced by 12749
83330 Smith, Herman H., Inc. Brooklyn, New York	90211 - use 56365 Square D Co. Chicago, Illinois	95263 Leecraft Mfg. Co. Long Island City, New York	98925 Replaced by 14433
83478 Rubbercraft Corp. of America, Inc. West Haven, Connecticut	90215 Best Stamp & Mfg. Co. Kansas City, Missouri	95264 Replaced by 98278	99120 Plastic Capacitors, Inc. Chicago, Illinois
83594 Burrroughs Corp. Electronic Components Div. Plainfield, New Jersey	90303 Mallory Battery Co. Div. of Mallory Co., Inc. Tarrytown, New York	95275 Vitramon Inc. Bridgeport, Connecticut	99217 Bell Industries Elect. Comp. Div. formerly Southern Elect. Div. Burbank, California
83740 Union Carbide Corp. Battery Products Div. formerly Consumer Products Div. New York, New York	91094 Essex International Inc. Suglex/IWP Div. Newmarket, New Hampshire	95303 RCA Corp. Receiving Tube Div. Cincinnati, Ohio	99392 STM Oakland, California
84171 Arco Electronics Great Neck, New York	91293 Johanson Mfg. Co. Boonton, New Jersey	95348 Gordo's Corp. Bloomfield, New Jersey	99515 ITT Jennings Monrovia Plant Div. of ITT Jennings formerly Marshall Industries Capacitor Div. Monrovia, California
84411 TRW Electronic Components TRW Capacitors Ogallala, Nebraska	91407 Replaced by 58474	95354 Methode Mfg. Corp. Rolling Meadows, Illinois	99779 - use 29587 Bunker-Ramo Corp. Barnes Div. Landsdowne, Pennsylvania
84613 Fuse Indicator Corp. Rockville, Maryland	91502 Associated Machine Santa Clara, California	95712 Bendix Corp. Electrical Components Div. Microwave Devices Plant Franklin, Indiana	99800 American Precision Industries Inc. Delevan Division East Aurora, New York
84682 Essex International Inc. Industrial Wire Div. Peabody, Massachusetts	91506 Augat Inc. Attleboro, Massachusetts	95987 Weckesser Co. Inc. Chicago, Illinois	99942 Centrelab Semiconductor Centrelab Electronics Div. of Globe-Union Inc. El Monte, California
86577 Precision Metal Products, of Malden Inc. Stoneham, Massachusetts	91637 Dale Electronics Inc. Columbus, Nebraska	96733 San Fernando Electric Mfg. Co. San Fernando, California	Toy Electronics (R-Ohm Corp.) Irvine, California
86684 Radio Corp. of America Electronic Components Div. Harrison, New Jersey	91662 Elco Corp. Willow Grove, Pennsylvania	96853 Gulton Industries Inc. Measurement and Controls Div. formerly Rustrak Instruments Co. Manchester, New Hampshire	National Connector Minneapolis, Minnesota
86928 Seastrom Mfg. Co., Inc. Glendale, California	91737 - use 71468 Gremar Mfg. Co., Inc. ITT Cannon/Gremar Santa Ana, California	96881 Thomson Industries, Inc. Manhasset, New York	
87034 Illuminated Products Inc. Subsidiary of Oak Industries Inc. Anahiem, California	91802 Industrial Devices, Inc. Edgewater, New Jersey	97540 Master Mobile Mounts Div. of Whitehall Electronics Corp. Ft. Meyers, Florida	
88219 Gould Inc. Industrial Div. Trenton, New Jersey	91833 Keystone Electronics Corp. New York, New York	97913 Industrial Electronic Hdware Corp. New York, New York	
	91836 King's Electronics Co., Inc. Tuckahoe, New York	97945 Penwalt Corp. SS White Industrial Products Div. Piscataway, New Jersey	
	91929 Honeywell Inc. Micro Switch Div. Freeport, Illinois		

Table 7-3. FLUKE TECHNICAL SERVICE CENTERS

United States	ILLINOIS	NEW JERSEY	WASHINGTON
CALIFORNIA	Des Plaines Fluke Midwestern Technical Center Bruce Hunt, Service Manager 1287 N. Rand Road Zip: 60016 Tel. (312) 298-7470	Totowa Fluke Eastern Technical Center Al La Fleur, Service Manager 500 Union Blvd. Zip: 07012 Tel. (201) 742-3215	Mountlake Terrace John Fluke Mfg. Co., Inc. Bill Fetrow, Tech. Service Spvr. 7001 - 220th Ave. S.W. Zip: 98043 Tel. (206) 774-2206
Burbank Fluke Western Technical Center Mike Nagy, Service Manager 2020 N. Lincoln St. Zip: 91504 Tel. (213) 849-4641	MARYLAND	NEW YORK	Canada
Santa Clara Fluke Western Technical Center Tom Marshall, Service Manager 2359 De La Cruz Blvd. Zip: 95050 Tel. (408) 985-1200	Kensington Fluke Mideastern Technical Center John Hines, Service Manager 11501 Huff Court Zip: 20795 Tel. (301) 881-5300	Farmingdale, LI Fluke Eastern Technical Center Charles Vanek, Br. Manager 59 Central Ave. Unit 3 Zip: 11735 Tel. (516) 752-1078	ALBERTA
COLORADO	MASSACHUSETTS	Rochester Fluke Eastern Technical Center Wayne Roth, Br. Service Manager 4515 Culver Road Zip: 14622 Tel. (716) 342-6940	Calgary Fluke Canadian Technical Center Dave Racinsky, Service Manager 3829 - 12th St. N.E. Zip: T2E 6M5 Tel. (403) 261-0780
Denver Fluke Southwestern Technical Center Mel Suelzle, Service Manager 1980 S. Quebec St. Unit 4 Zip: 80231 Tel. (303) 750-1228	Lexington Fluke N.E. Technical Center Dick Zemba, Service Manager 109 Massachusetts Ave. Zip: 02173 Tel. (617) 861-8620	NORTH CAROLINA	ONTARIO
FLORIDA	MINNESOTA	Greensboro Fluke S.E. Technical Center Dwain Cox, Service Manager P.O. Box 9619 1310 Beaman Place Zip: 27408 Tel. (919) 273-1918	Mississauga Fluke Canadian Technical Center Herb Duval, Service Manager 6427 Northam Drive Zip: L4V 1J5 Tel. (416) 678-1500
Orlando Fluke S.E. Technical Center Jesse Morse, Service Manager P.O. Box 6578 40 N. Fern Creek Ave. Zip: 32803 Tel. (305) 896-2296	Minneapolis Fluke Midwestern Technical Center Robert Wayne, Br. Manager 10800 Lyndale Ave. So. Zip: 55420 Tel. (612) 884-4541		

Table 7-4. INTERNATIONAL SERVICE CENTERS

CENTRAL & SOUTH AMERICA	EUROPE	HONG KONG
ARGENTINA Coasin S.A. Miguel Volpe, Service Manager Virrey del Pino 4071 Buenos Aires , Argentina Tel: 523185	FRANCE M.B. Electronique S.A. Serge Pison, Service Manager 29, Rue Emile Duclaux 92150, Suresnes, France Tel: 7723111 (108)	Gilman & Co., Ltd. J.B. Tetlow P.O. Box 56 Hong Kong Tel: 227011 (14)
BRAZIL Ambriex S.A. Col. Josue Dantas Martins Filho Rua Ceara, 104 - 2° e 3° Andares ZC-29 Rio de Janeiro GB , Brazil Tel: 264-7406	NETHERLANDS C.N. Rood N.V. Sieb Hoekstra, Service Manager Cort van der Lindenstraat 11-13 P.O. Box 42 Rijswijk ZH 2100 Tel: 070-996360	INDIA Hinditron Services Pvt. Ltd. Chandu Vagal, Service Manager 69/A.L. Jagmohandas Marg Bombay —400 006, India Tel: 365344
Adolfo Toyomaro Ichiki , Service Manager Rua Tupi, 535 01233 Sao Paulo SP , Brazil Tel: 52-7806 & 0912	Fluke (Nederland) B.V. Henk Lit, Service Manager P.O. Box 5053 Zevenheuvelenweg 53 Tilburg , Netherlands Tel: (13) 673973	IRAN Berkeh Company Ltd. Tom Payne 20 Salm Road, Roosevelt Ave. Tehran , Iran Tel: 828294 831564
ECUADOR Proteco Coasin CIA, Ltda. Ing Jaime Jaramillo Apartado 228A Quito , Ecuador Tel: 526759	NORWAY Morgenstjerne & Co. A/S Finn Schjervan Konghellegate 3 P.O. Box 6688, Rodelokka Oslo 5, Norway Tel: 472 356110	ISRAEL R.D.T. Electronics Engineering Ltd. Shamai Ram-nof, Service Manager 46, Sokolov Street Ramat Hasharon 47235 Israel Tel: 483211
MEXICO Mexitek, S.A. Enrique Batista Mangas, Service Manager Eugenia 408 Department 1 Mexico 12, D.F. Mexico Tel: 5360910 - 5239751	UNITED KINGDOM Fluke International Corporation Ed Cutter, Service Manager Garnet Close Watford , WD2 4TT England Tel: 0923-33066	JAPAN Toyo Trading Company Ltd. Mr. Adachi, Service Manager P.O. Box 5014 International Tokyo Tokyo 100-31, Japan Tel: (03) 279-0771
VENEZUELA Coasin C.A. Leslie Dunia, Service Manager Apdo. Postal 50939 Sabana Grande No. 1 Caracas 105, Venezuela Tel: 722311 - 728662	AFRICA, ASIA & AUSTRALIA	SOUTH AFRICA Fluke (Pty) Ltd. P.O. Box 13091 Benoni 1511 Transvaal Republic of South Africa Tel: 011-849-6811
	AUSTRALIA Elmeasco Instruments Pty. Ltd. Andrew McKean, Service Manager P.O. Box 30 Concord , N.S.W. Australia 2137 Tel: (02) 736-2888	For areas not listed, contact the Fluke Technical Center nearest you or contact Fluke directly at Mountlake Terrace, WA.

Table 7-5. SALES REPRESENTATIVES – DOMESTIC

John Fluke Mfg. Co., Inc.

P.O. Box 43210, Mountlake Terrace, WA 98043

Tel: (206) 774-2211 Toll Free: (800) 426-0361 TWX: 910-449-2850 Telex: 32-0013 Cable: Fluke

United States

ALABAMA

Huntsville
BCS Associates, Inc.
P.O. Box 1273
3322 S. Memorial Parkway
Zip: 35807
Tel. (205) 881-6220

ALASKA

Anchorage
Harry Lang & Associates
1406 W. 47th Ave.
Zip: 99503
Tel. (907) 279-5741

ARIZONA

Phoenix
Barnhill Associates, Inc.
7319 E. Stetson Drive
Scottsdale, AZ 85251
Tel. (602) 947-7841

CALIFORNIA

Los Angeles
Instrument Specialists
Sales Group
John Fluke Mfg. Co., Inc.
2020 North Lincoln Street
Burbank, CA 91504
Tel. (213) 849-7181
Santa Clara
Instrument Specialists
Sales Group
John Fluke Mfg. Co., Inc.
2359 De La Cruz Blvd.
Zip: 95050
Tel. (408) 244-1505

COLORADO

Denver
Barnhill Associates, Inc.
1980 S. Quebec Street, Unit 4
Zip: 80231
Tel. (303) 750-1222

CONNECTICUT

Hartford
IRI Sales Group
John Fluke Mfg. Co., Inc.
P.O. Box 518
Glastonbury, CT 06033
Tel. (203) 633-0777

FLORIDA

Orlando
BCS Associates, Inc.
P.O. Box 6578
940 N. Fern Creek Ave.
Zip: 32803
Tel. (305) 896-4881

GEORGIA

Decatur
BCS Associates, Inc.
2522 Tanglewood Road
Zip: 30033
Tel. (404) 321-0980

HAWAII

Honolulu
Industrial Electronics, Inc.
P.O. Box 135
646 Queen Street
Zip: 96817
Tel. (808) 533-6095

ILLINOIS

Chicago
Cozzens & Cudahy Sales Group
John Fluke Mfg. Co., Inc.
1301 North Rand Road
Des Plaines, IL 60016
Tel. (312) 298-3600

INDIANA

Indianapolis
Cozzens & Cudahy Sales Group
John Fluke Mfg. Co., Inc.
Port O'Call Executive Center
21 Beachway Drive
Zip: 46224
Tel. (317) 244-2456

KANSAS

Kansas City, MO
Cozzens & Cudahy Sales Group
John Fluke Mfg. Co., Inc.
4406 Chouteau Traffic Way
Zip: 64117
Tel. (816) 454-5836

KENTUCKY

Louisville
BCS Associates, Inc.
4506 Freda Way
Valley Station, KY 40272
Tel. (502) 935-9634

MARYLAND

Baltimore
John Fluke Mfg. Co., Inc.
11501 Huff Court
Kensington, MD 20795
Tel. (301) 881-3370

MASSACHUSETTS

Boston
Instrument Representatives
Sales Group
John Fluke Mfg. Co., Inc.
109 Massachusetts Ave.
Lexington, MA 02173
Tel. (617) 861-8620

MICHIGAN

Detroit
WKM Associates, Inc.
345 Girard
Madison Heights, MI 48071
Tel. (313) 588-2300

MINNESOTA

Minneapolis
Cozzens & Cudahy
Sales Group
John Fluke Mfg. Co., Inc.
10800 Lyndale Ave. S.
Zip: 55420
Tel. (612) 884-4336

MISSOURI

Kansas City
Cozzens & Cudahy
Sales Group
John Fluke Mfg. Co., Inc.
4406 Chouteau Traffic Way
Zip: 64117
Tel. (816) 454-5836

St. Louis

Cozzens & Cudahy
Sales Group
John Fluke Mfg. Co., Inc.
P.O. Box 10013
Zip: 63145
Tel. (314) 423-1234

NEW JERSEY

Newark
SBM Representatives
Sales Group
John Fluke Mfg. Co., Inc.
1519A Stuyvesant Ave.
Union, NJ 07083
Tel. (201) 687-8737

NEW MEXICO

Albuquerque
Barnhill Associates, Inc.
1410-D Wyoming N.E.
Zip: 87112
Tel. (505) 299-7658

NEW YORK

New York
SBM Representatives
Sales Group
John Fluke Mfg. Co., Inc.
28 Hobby Street
Pleasantville, NY 10570
Tel. (914) 769-1811

Rochester

SBM Representatives
Sales Group
John Fluke Mfg. Co., Inc.
4515 Culver Road
Zip: 14622
Tel. (716) 266-1400

NORTH CAROLINA

Greensboro
BCS Associates, Inc.
P.O. Box 9619
1310 Beaman Place
Zip: 27408
Tel. (919) 273-1918

OHIO

Cleveland
WKM Associates, Inc.
16141 Puritas Ave.
Zip: 44135
Tel. (216) 267-0445
Dayton
WKM Associates, Inc.
7913 S. Suburban Road
Zip: 45459
Tel. (513) 434-7500

OREGON

Beaverton
Showalter Instruments Inc.
3800 S.W. Cedar Hills Blvd.
Suite 160
Zip: 97005
Tel. (503) 646-5196

PENNSYLVANIA

Philadelphia
John Fluke Mfg. Co., Inc.
Suite H
1010 West 8th Avenue
King of Prussia, PA 19406
Tel. (215) 265-4040

Pittsburgh

WKM Associates, Inc.
90 Clairton Blvd.
Zip: 15236
Tel. (412) 892-2953

TEXAS

Austin
Barnhill Associates, Inc.
1200 Barton Hill, No. 197
Zip: 78704
Tel. (512) 444-2377

Dallas

Barnhill Associates, Inc.
908 Business Parkway
Richardson, TX 75080
Tel. (214) 231-2573

Houston

Barnhill Associates, Inc.
10606 Hempstead Highway
Suite 132
Zip: 77092
Tel. (713) 688-9971

VIRGINIA

Williamsburg
BCS Associates, Inc.
107 Rich Neck Road
Zip: 23185
Tel. (804) 877-4053

WASHINGTON

Benton City
Showalter Instruments, Inc.
P.O. Box 828
Zip: 99320
Tel. (509) 588-3472

Seattle

Showalter Instruments, Inc.
1521 - 130th N.E.
Bellevue, WA 98005
Tel. (206) 455-4922

WASHINGTON, D.C.

Baltimore
John Fluke Mfg. Co., Inc.
11501 Huff Court
Kensington, MD 20795
Tel. (301) 881-3370

For U.S. areas not listed, contact the regional office nearest you or John Fluke Mfg. Co., Inc., Mountlake Terrace, WA.

Canada

ALBERTA

Calgary
Allan Crawford Assoc., Ltd.
3829 - 12th Street N.E.
Zip: T2E 6M5
Tel. (403) 276-9658

BRITISH COLUMBIA

North Vancouver
Allan Crawford Assoc., Ltd.
116 E. Third St., Suite 203
Zip: V7L 1E6
Tel. (604) 980-4831

NOVA SCOTIA

Halifax
Allan Crawford Assoc., Ltd.
Suite 201, Townsend Pl.
800 Windmill Rd.
Burnside Industrial Park
Dartmouth, NS
Zip: B3B 1L1
Tel. (902) 469-7865

ONTARIO

Toronto
Allan Crawford Assoc., Ltd.
6427 Northam Drive
Mississauga, Ont L4V 1J5
Tel. (416) 678-1500

Ottawa

Allan Crawford Assoc., Ltd.
1299 Richmond Road
Zip: K2B 7Y4
Tel. (613) 829-9651

QUEBEC

Montreal
Allan Crawford Assoc., Ltd.
1330 Marie Victorious Blvd. E.
Longueuil, P.Q. J4G 1A2
Tel. (514) 670-1212

For Canadian areas not listed, contact the regional office nearest you or Allan Crawford Assoc., Ltd., Mississauga, Ontario.

All of the above Fluke Sales Offices carry local stocks of low-cost Digital Multimeters (Models 8000A, 8030A, 8040A), Counters (Model 1900A), Digital Thermometers (Models

2160A, 2170A, 2165A, 2175A) and the Universal Temperature Probe (Model 80T-150). These same products are available from the following distributors:

Brownell Electronics
Atlanta, GA (404) 762-5181
Charlotte, NC (704) 394-4341
Memphis, TN (901) 323-8554
Nashville, TN (615) 889-8230
Orlando, FL (305) 843-6770
Mobile, AL (205) 479-5405

The Mancib Company
Boston, MA (617) 272-9450
Middletown, CT (203) 346-6646
Elmar Electronics
San Francisco, CA (415) 961-3611
Denver, CO (303) 287-9611

Pioneer-Standard
Cleveland, OH (216) 587-3600
Dayton, OH (513) 236-9900
Indianapolis, IN (317) 849-7300
Pittsburgh, PA (412) 782-2300
Detroit, MI (313) 525-1800

Liberty Electronics
El Segundo, CA (213) 322-8100
San Diego, CA (714) 565-9171
Phoenix, AZ (602) 257-1272
Seattle, WA (206) 763-8200
Albuquerque, NM (505) 299-8293
Beaverton, OR (503) 644-4783

Table 7-6. SALES REPRESENTATIVES – INTERNATIONAL

Supplied and supported by Fluke (Nederland) B.V.,
P.O. Box 5053, Zevenheuvelenweg 53, Tilburg, Netherlands.

AUSTRIA

Kontron GmbH & Co. KG
Ameisgasse 43
1140 Vienna, Austria
Tel: 222-945646

BELGIUM

C.N. Rood S/A
37 Place de Jamblinne de Meux
B-1040 Brussels, Belgium
Tel: 02-27352135

CYPRUS

Chris Radiovision Ltd.
P.O. Box 1989
Nicosia, Cyprus
Tel: 66121

DENMARK

Tage Olsen A/S
Teglvaerksgade 37
DK-2100 Copenhagen Ø, Denmark
Tel: 01-294800

FINLAND

Oy Findip AB
Teollisuustie 7
02700 Kauniainen, Finland
Tel: 080-502255

FRANCE

M.B. Electronique S.A.
Rue Fournay
ZAC de BUC
B.P. N° 31
78530 BUC, France
Tel: 9563130

GERMAN FEDERAL

REPUBLIC
Fluke (Deutschland) GmbH
4-Dusseldorf
Meineckestrasse 53
West Germany
Tel: 211-450831

Fluke (Deutschland) GmbH
8000 Munich 80
Mutschellestrasse 1
West Germany
Tel: 089-433021

GREECE

Hellenic Scientific
Representations Ltd.
10, Nympheou Street
Athens 615, Greece
Tel: 021-7792320/705960

ISRAEL

R.D.T. Electronics
Engineering Ltd.
46, Sokolov Street
Ramat Hasharon 47235, Israel
Tel: 483211

ITALY

Sistrel S.p.A.
Via Giuseppe Armellini No. 37
00143 Rome, Italy
Tel: 5915551

Sistrel S.p.A.
Via Timavo 66
20099 Sesto S. Giovanni (Milan)
Italy
Tel: 02-2485233

NETHERLANDS

C.N. Rood, B.V.
Cort van der Lindenstraat 11-13
Rijswijk (Z.H.) 2100
Netherlands
Tel: 070-996360
Fluke (Nederland) B.V.
P.O. Box 5053
Zevenheuvelenweg 53
Tilburg, Netherlands
Tel: (13) 673973

NORWAY

Morgenstjerne & Co. A/S
Konghellegate 3
P.O. Box 6688, Rodeløkka
Oslo 5, Norway
Tel: 02-356110

PORTUGAL

Equipamentos
De Laboratorio Ltda.
P.O. Box 1100
Lisbon 1, Portugal
Tel: 019-976551

SPAIN

Ataio Ingenieros S.A.
Enrique Larreta 10-12
Madrid 16, Spain
Tel: 01-7330562

SWEDEN

Teleinstrument AB
P.O. Box 490
S-162 Vallingby-4
Sweden
Tel: 08-380370

TURKEY

M. Süheyl Erkman
Necatibey Cad 92/2
Karaköy/Istanbul
Turkey
Tel: 441546, 447651

UNITED KINGDOM

Fluke International Corp.
Garnet Close
Watford, WD2 4TT, England
Tel: 0923-33066

Customers in the following countries:

Bulgaria, Czechoslovakia, Hungary, Poland, Romania,
U.S.S.R. and Yugoslavia

Contact: Amtest Associates Ltd., P.O. Box 55, Addlestone,
Surrey, KT 15 1DU, England. Tel: 0932-52121.

Table 7-6. SALES REPRESENTATIVES – INTERNATIONAL (Continued)

Supplied and supported by Fluke International Corporation,
P.O. Box 43210, Mountlake Terrace, WA 98043.

ARGENTINA

Coasin S.A.
Virrey del Pino 4071
Buenos Aires, Argentina
Tel: 523185

AUSTRALIA

Elmeasco Instruments Pty Ltd
P.O. Box 30
Concord, N.S.W.
Australia 2137
Tel: (02) 736-2888
Elmeasco Instruments Pty Ltd
P.O. Box 107
Mt. Waverly, VIC. 3149
Australia
Tel: 236 4044

BOLIVIA

Coasin Bolivia S.R.L.
Casilla 7295
La Paz, Bolivia
Tel: 40962

BRAZIL

Ambriex S.A.
Rua Ceara, 104-2º e 3º Andares
ZC-29
Rio de Janeiro GB, Brazil
Tel: 264-7406
Ambriex S.A.
Rua Tupi, 535
101233
São Paulo SP, Brazil
Tel: 66-0912, 66-5947

CARIBBEAN

& CENTRAL AMERICA

West Indies Sales Co.
7360 Northwest 66th Street
Miami, FL 33166
Tel: (305) 592-8188

CHILE

Coasin Chile Ltd.
Casilla 14588—Correo 15
Santiago, Chile
Tel: 396713

CHINA,

PEOPLE'S REPUBLIC OF
May Lee Industries, Ca. Inc.
11 Broadway, Suite 1612
New York, New York 10004
Tel: (212) 425-4347

COLOMBIA

Assistec Limitada
Apartado Aereo 12322
Bogota 1, Colombia
Tel: 419331

ECUADOR

Proteco Coasin CIA, Ltda.
Apartado 228A
Quito, Ecuador
Tel: 526759

EGYPT

Lotus Engineering Organisation
P.O. Box 1252
Cairo, Egypt
Tel: 71617

HONG KONG

Gilman & Co., Ltd.
P.O. Box 56
Hong Kong
Tel: 794266

INDIA

Hinditron Services Pvt. Ltd.
69/A L. Jagmohandas Marg
Bombay 400 006, India
Tel: 365344, 381615

Hinditron Services Pvt. Ltd./
Hinditron Computers Pvt. Ltd.
"Hinditron House"
412 Rajmahal Vilas Extension
Bangalore 560 006, India
Tel: 32852

INDONESIA

P.T. United Dico-Citas Co., Ltd.
JLN Penjaringan 39A
Jakarta, Indonesia
Tel: 21380

IRAN

Berkeh Company Ltd.
20 Salm Road, Roosevelt Avenue
Tehran, Iran
Tel: 828294, 831564

JAPAN

Toyo Trading Company Ltd.
P.O. Box 5014
Tokyo International
Tokyo 100-31, Japan
Tel: (03) 279-0771

Toyo Trading Company, Ltd.
Suzuki Building
2-38 Junkeicho-dori
Minami-ku, Osaka, Japan
Tel: (06) 262-3471

JORDAN

Trading & Agricultural
Development Co.
P.O. Box 567
Amman, Jordan
Tel: 23052

KENYA

Advanced Communications Ltd.
City House, Wabera Street
P.O. Box 30635
Nairobi, Kenya
Tel: 31955

KOREA

Asia Science & Co.
International P.O. Box 1250
Seoul, Korea
Tel: 76-2761

KUWAIT

Tareq Company
P.O. Box Safat 20506
Kuwait, Arabian Gulf
Tel: 436100, 436045

LEBANON

General Marketing Trading &
Contracting Company
Anis Nsouli Street
Nsouli Building
P.O. Box 155.655
Beirut, Lebanon
Tel: 319383, 312061

MALAYSIA

O'Connor's (Pte) Ltd.
P.O. Box 1197
Kota Kinabalu, Sabah
East Malaysia
Tel: 54082
O'Connor's (Pte) Ltd.
P.O. Box 91
Petaling Jaya, Selangor
West Malaysia
Tel: 51563

MEXICO

Mexitek, S.A.
Eugenia 408
Department 1
Mexico 12, D.F., Mexico
Tel: 5360910

MOROCCO

S.I.E.E.M.
Residence Moulay Ismail
Bat. C.
Boulevard Moulay Slimane
Rabat, Morocco
Tel: 276-64

NEW ZEALAND

Elmeasco Instruments Pty. Ltd.
P.O. Box 4069
Wellington, New Zealand
Tel: 721318

NIGERIA

Mofat Engineering Co., Ltd.
P.O. Box 6369
Lagos, Nigeria

PAKISTAN

Pak International Operations
595 Muhammadi House-
McLeod Road
P.O. Box 5323
Karachi, Pakistan

PERU

Importaciones
y Representaciones
Electronicas S.A.
Avda. Franklin D. Roosevelt 105
Lima 1, Peru
Tel: 288650

SAUDI ARABIA

Electronic Equipment
Marketing Establishment
P.O. Box 3750
Riyadh, Saudi Arabia
Tel: 32700

SINGAPORE

O'Connor's (Pte) Ltd.
98 Pasir Panjang Road
Singapore 5, Singapore
Tel: 637944

SOUTH AFRICA

Fluke (Pty.) Ltd.
P.O. Box 13091
Benoni 1511, Transvaal
Republic of South Africa
Tel: 011-849-6811

Fluke (Pty.) Ltd.
24 Fountain Shopping Ctr.
Main Road
Rondebosche 7700
Cape Town
Republic of South Africa
Tel: 651881

TAIWAN

Tatung Company
22 Chungshan North Road
3rd Sec.
Taipei, Taiwan
Rep. of China
Tel: 5215252

THAILAND

Dynamic Supply
Engineering R.O.P.
No. 56 Ekamai, Sukhumvit 63
Bankok-11, Thailand
Tel: 914434, 928532

URUGUAY

Coasin Uruguay S.R.L.
Cerrito 617-4º Piso
Montevideo, Uruguay
Tel: 917978

VENEZUELA

Coasin C.A.
APDO Postal 50939
Sabana Grande No. 1
Caracas 105, Venezuela
Tel: 722311

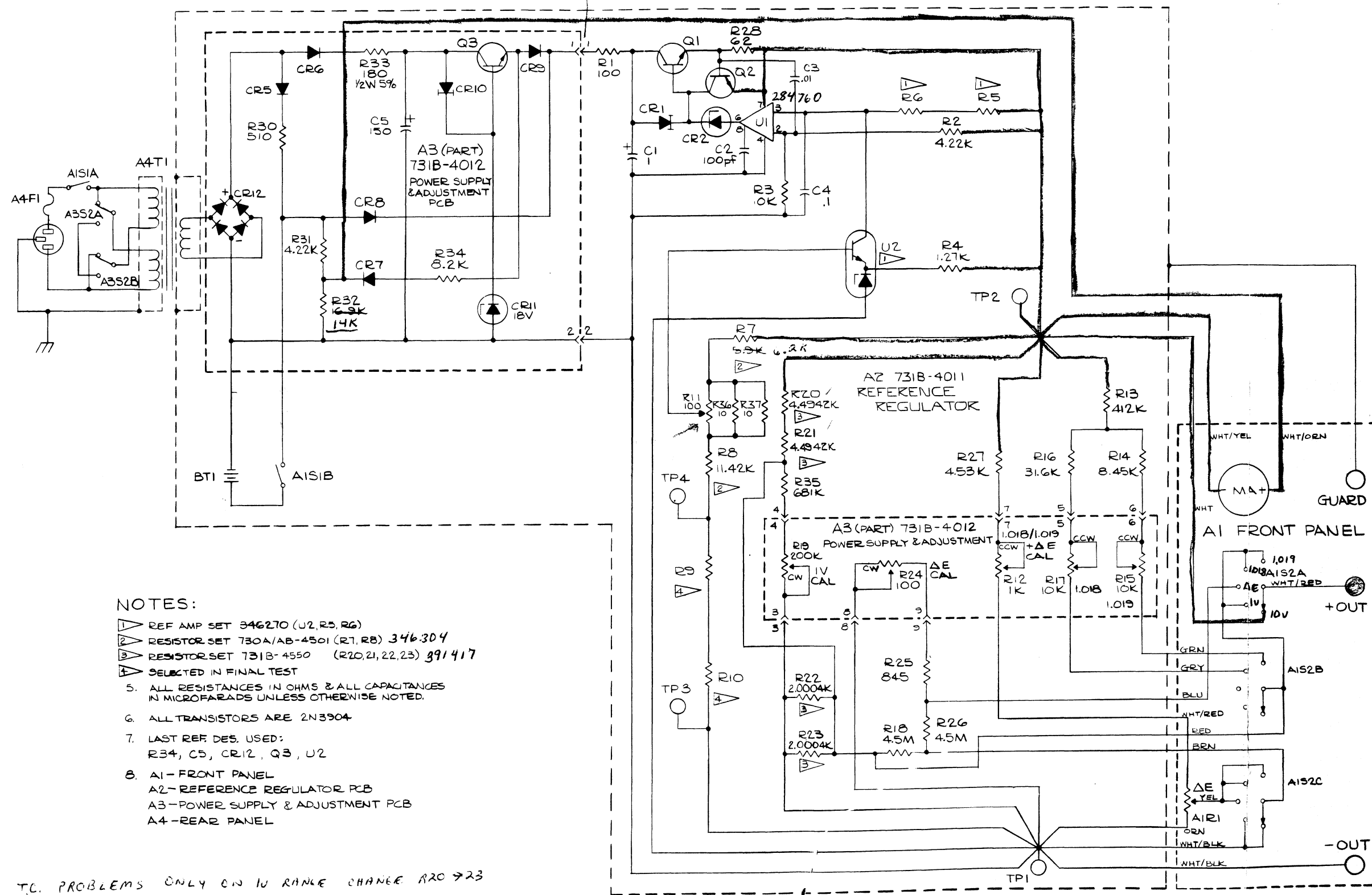
Section 8

Schematic Diagrams

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8-1	731B DC Reference Standard	731B-1011	8-3

The VOLTAGE at A1 MUST BE EXACTLY THE SAME on Batt or line IF 1.3 VOLT Diff. Then an A 10 MICRO VOLT Diff occurs



NOTES:

- 1 REF AMP SET 346270 (U2, R5, R6)
- 2 RESISTOR SET 730A/AB-4501 (R7, R8) 346.304
- 3 RESISTOR SET 731B-4550 (R20, 21, 22, 23) 391.417
- 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

T.C. PROBLEMS ONLY ON 10 RANGE CHANGE R20 → R23

R7 CHANGE FROM 5.9K TO 6.2K E.C.C #11204

REV	CHANGE DESCRIPTION	DR	CHK	APPN
-	REL. TO PRODUCTION			
B	DWG # WAS 731A-1011 R2 WAS 731A-9512			
A	ADDED R34, R37 MOVED R11			

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