FLUKE®

Instruction Manual

Model

721A

Lead Compensator

P/N 294066

OCTOBER 1968

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within one year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

> 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. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or the nearest Service facility, 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, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

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 and of adequate size. 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 TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. 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 is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC. will be happy to answer all application or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, ATTEN: Sales Dept. For European Customers: Fluke (Nederland) B.V., Zevenheuvelenweg 53, Tilburg, The Netherlands.

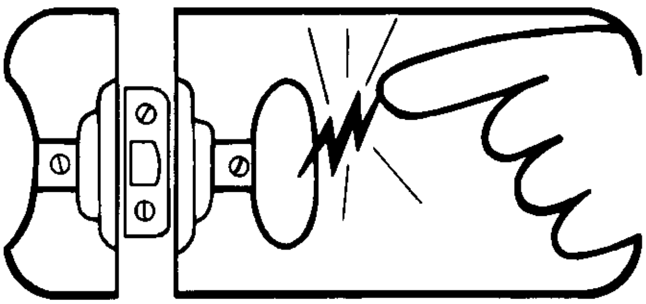
* For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., • P.O. Box 43210 • Mountlake Terrace, Washington 98043

static awareness

A Message From

John Fluke Mfg. Co., Inc.

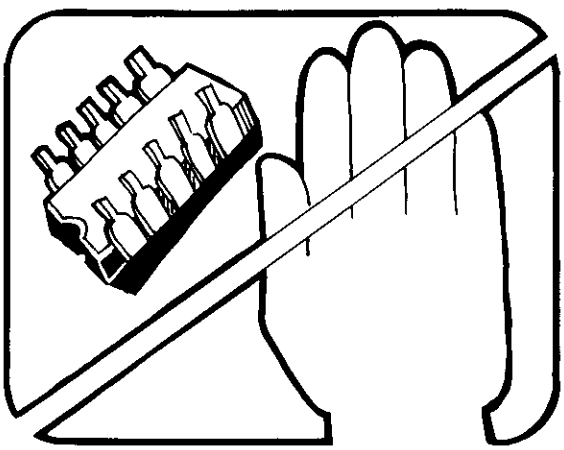


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

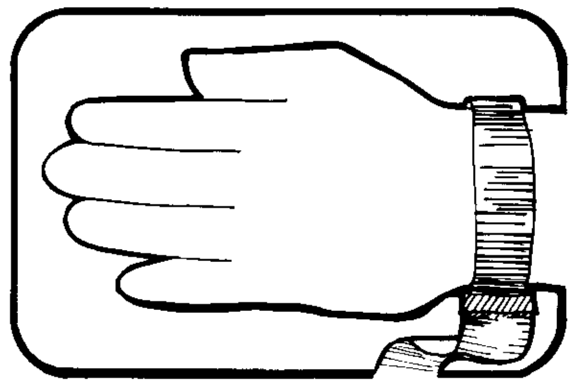
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗".

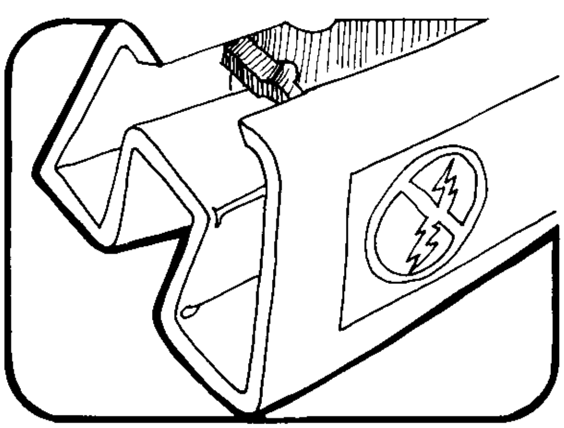
The following practices should be followed to minimize damage to S.S. devices.



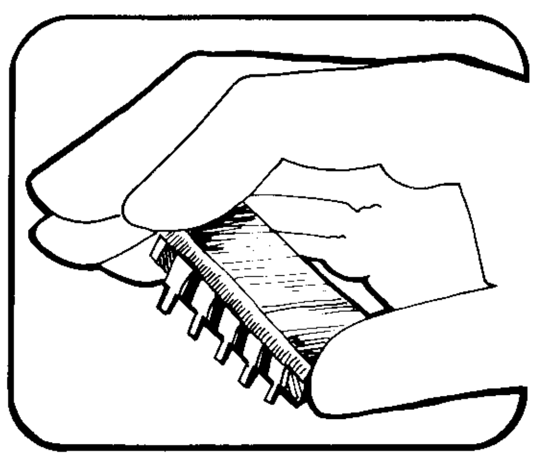
1. MINIMIZE HANDLING



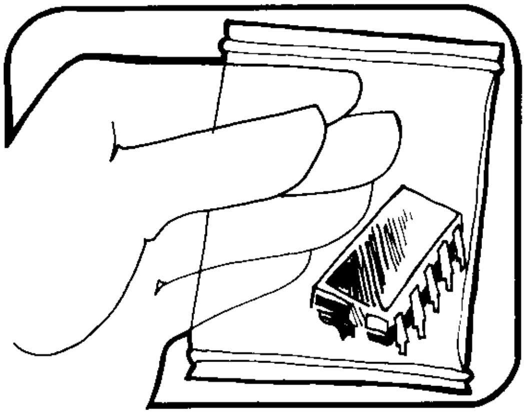
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



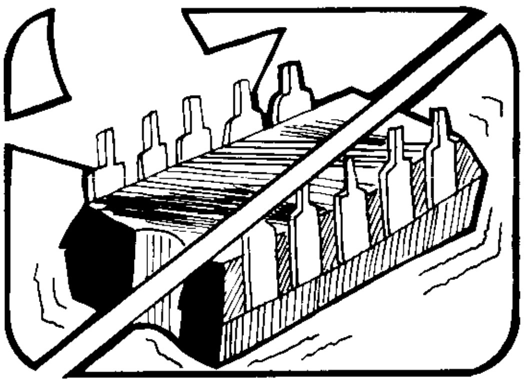
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



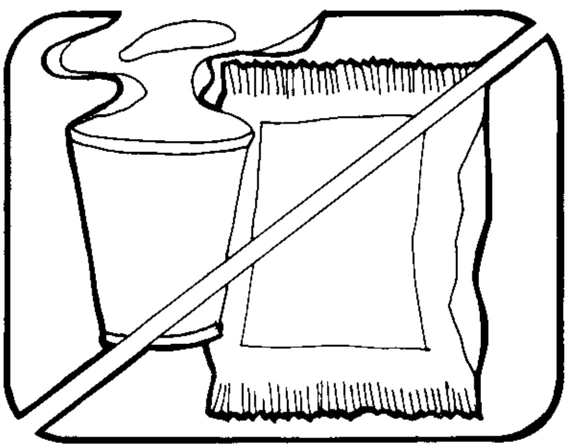
4. HANDLE S.S. DEVICES BY THE BODY



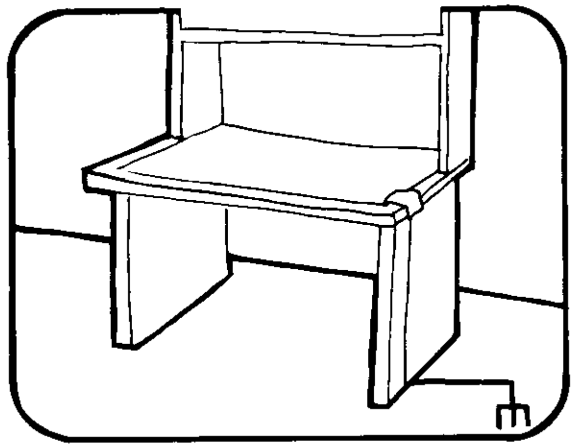
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREA



8. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

9. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

10. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Bag Size
453522	6" x 8"
453530	8" x 12"
453548	16" x 24"
454025	12" x 15"

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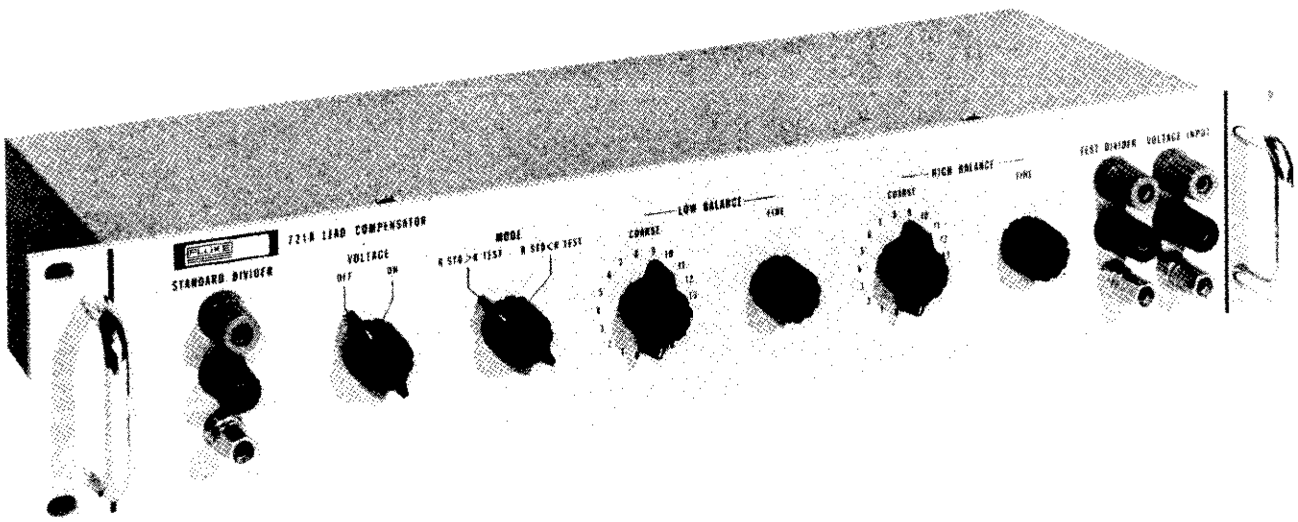


MODEL 721A LEAD COMPENSATOR

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. The Model 721A Lead Compensator is a device designed to compensate for the effects of lead and contact resistance in voltage-divider measurement circuits. It is particularly useful in those situations demanding the utmost in accuracy. It is a useful operational accessory for such high-accuracy voltage dividers as the John Fluke Model 720A and Model 725A.

1-3. SPECIFICATIONS

1-4. ELECTRICAL

RESOLUTION OF RESISTANCE COMPENSATION
0.1 milliohm.

MAXIMUM RATIO BETWEEN DIVIDER RESISTANCES
4000 to 1.

MAXIMUM ALLOWABLE LEAD RESISTANCE
150 milliohms.

MAXIMUM DIVIDER VOLTAGE
1500 volts, dc or peak ac.

1-5. MECHANICAL

FINE CONTROL
10-turn, 150-milliohm, slide-wire potentiometer.

COARSE CONTROL
18-position rotary switch.

BINDING POSTS
Gold plated copper.

VOLTAGE SWITCH
Grounds input voltage terminals to permit compensation for thermal voltages.

DIMENSIONS
3-1/2 high x 19" wide x 6" deep.

1-6. OUTLINE DRAWING

1-7. Figure 1-1 is an outline drawing of the Model 721A presenting the information necessary for installation.

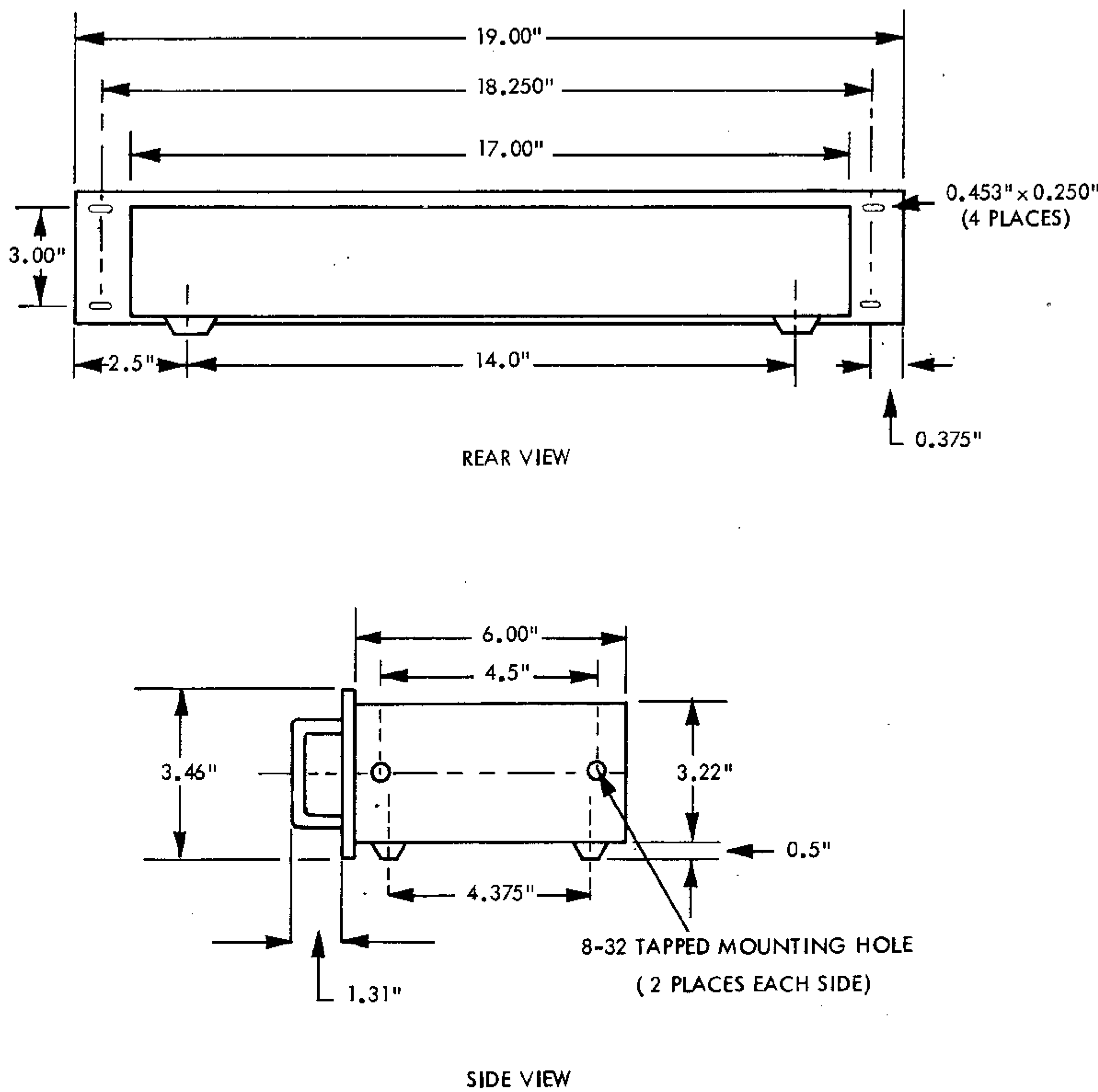


Figure 1-1. MODEL 721A OUTLINE DRAWING

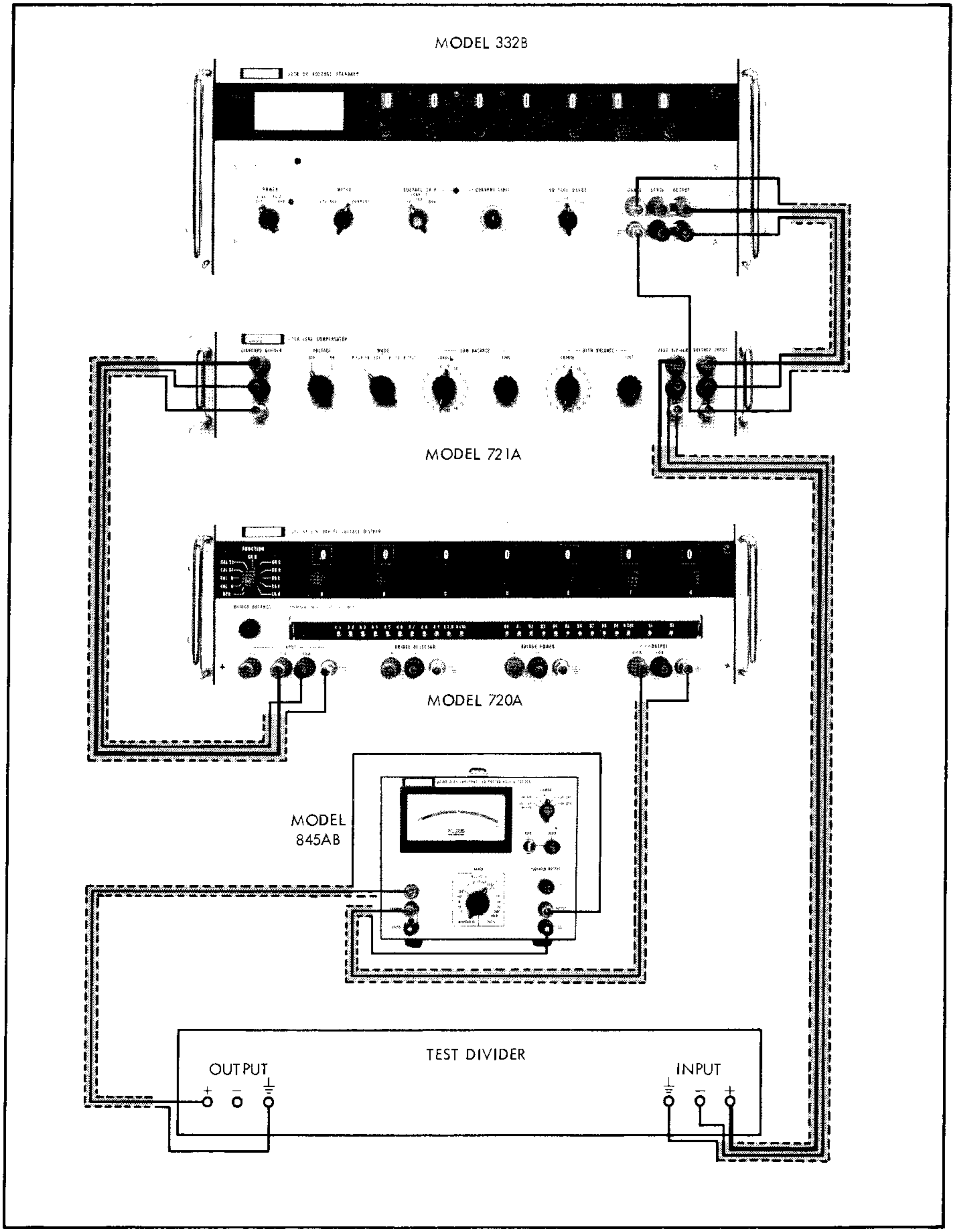


Figure 2-2. INTERCONNECTION OF UNITS FOR RATIO COMPARISON

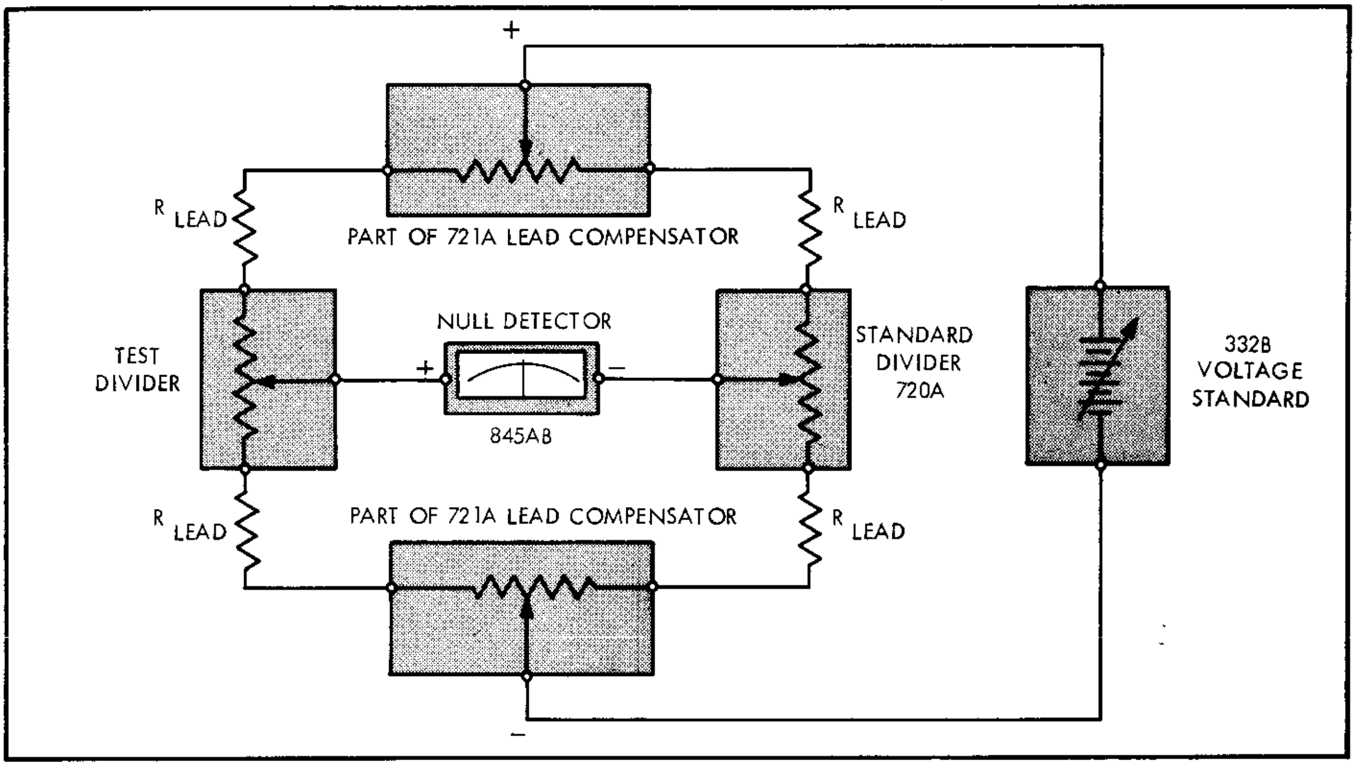


Figure 2-3. SCHEMATIC DIAGRAM OF EQUIPMENT CONNECTIONS

2-18. APPLICATIONS

2-19. The Model 721A Lead Compensator was designed to compensate for lead resistance and end resistance in a high-accuracy ratio system. Figure 2-1 shows the two basic configurations of such a system. Lead compensation is essential to accuracy of measurement in both. In Figure 2-1 (A), the ratios of two resistive dividers are compared. This is the typical setup used for divider calibration. The coarse compensation is added in series with the standard divider indicating that it has a higher input resistance than the test divider. If the input resistance of the test divider were higher, the coarse compensation would be switched to the other side. In Figure 2-1 (B), an unknown resistance is measured by using a standard divider to compare it to a standard resistor. Notice that the standard resistance and the unknown resistance form a voltage divider. For this type of measurement, the lead compensator is used to set point R_4 equal to zero setting on the standard divider and to set point R_1 equal to 1.0 setting on the standard divider. The standard divider settings at points R_2 and R_3 at null are then determined and used to compute the unknown resistance from the formula:

$$\frac{R_{unknown}}{R_{standard}} = \frac{1 - R_2}{R_3}$$

2-20. LEAD RESISTANCE COMPENSATION

2-21. To use the Model 721A for lead compensation, it must be connected into the ratio comparison system as shown in Figure 2-2. Figure 2-3 illustrates a schematic diagram of the equipment connections. The equipment should be turned on and allowed to warm up for 30 minutes before the lead compensating adjustments are made. After warm-up perform the following steps to compensate for lead resistance.

a. Set the power supply to the desired output voltage.

b. Set the MODE switch of the Model 721A to R STD< R TEST or R STD> R TEST as appropriate.

c. Set both dividers to zero and turn the VOLTAGE switch of the Model 721A to OFF.

d. Place the null detector in the zero mode of operation and adjust it for zero meter deflection.

e. Return the null detector to the operating mode and set it to the desired sensitivity.

*f. Note the meter deflection. It is caused by the thermal voltages in the circuit.

Note!

To avoid overloading the null detector amplifier during initial balance steps it is advisable to reduce sensitivity before turning the VOLTAGE switch to ON.

g. Turn the VOLTAGE switch to ON and adjust the LOW BALANCE controls while increasing sensitivity until the deflection noted in step f is obtained at the desired sensitivity.

h. Set the HIGH BALANCE COARSE control to the same setting as the LOW BALANCE COARSE control. If the meter deflection changes, readjust the LOW BALANCE FINE control to obtain the meter deflection noted in step f.

i. Turn the VOLTAGE switch to OFF, reverse power supply polarity, and turn the VOLTAGE switch to ON.

j. Observe the meter. If meter deflection changes, repeat steps d through j until the null detector reading remains constant for both polarities of applied voltage.

k. Turn the VOLTAGE switch to OFF and set both dividers to full scale.

l. Place the null detector in the zero mode of operation and adjust it for zero meter deflection.

m. Return the null detector to the operating mode and set it to the desired sensitivity.

n. Note the meter deflection caused by the thermal voltages in the circuit.

Note!

The thermal voltages, and meter deflection, may be different at different points in the circuit.

o. Turn the VOLTAGE switch to ON and adjust the HIGH BALANCE FINE control to obtain the meter deflection noted in step n.

p. Turn the VOLTAGE switch to OFF, reverse power supply polarity, and turn the VOLTAGE switch to ON.

q. Observe the meter. If meter deflection changes, readjust the HIGH BALANCE FINE control to find a setting which will cause the same deflection for either supply polarity. The Model 721A now compensates for the lead resistances at the high and low ends of the circuit.

2-22. COMPENSATION FOR THERMAL VOLTAGES AT CALIBRATION POINTS

2-23. The technique used for measurement at calibration points must compensate for thermal voltages if optimum accuracy is to be obtained. Adjustment of the Model 721A compensates only for voltage drops at the high and low ends of the circuit caused by end and lead resistance; it can not compensate for thermal voltages at calibration points because they may vary from one calibration point to the next. To make thermal compensated measurements at calibration points, proceed as follows:

a. Turn the VOLTAGE switch to OFF and set both dividers to the desired calibration point.

b. Place the null detector in the zero mode of operation and adjust it for zero meter deflection.

c. Return the null detector to the operating mode.

d. Turn the VOLTAGE switch to ON and note the meter deflection.

e. Turn the VOLTAGE switch to OFF, reverse power supply polarity, turn the VOLTAGE switch to ON, and observe meter deflection.

Note!

The object of this procedure is to obtain the same meter deflection with normal and reversed power supply polarity.

f. Adjust the setting of the standard divider to bring the meter needle one half the distance toward the deflection noted in step d and note the deflection.

g. Turn the VOLTAGE switch to OFF, return power supply polarity to normal, turn the VOLTAGE switch to ON, and note meter deflection. If it is the same as the deflection noted in step f, the measurement is complete.

h. Continue reversing power supply polarity and adjusting the standard divider setting until the meter deflection is unchanged when polarity is reversed. The setting of the standard divider is now the true ratio of the test divider.

SECTION II

OPERATING INSTRUCTIONS

2-1. INTRODUCTION

2-2. In most resistance measurement setups, the resistance of test leads, switch contacts, etc. is difficult if not impossible to determine with high accuracy. In high-accuracy ratio measurements, these resistances can contribute a significant portion of the total error. A resistance measurement setup is a proportional bridge circuit in which the ratio of one divider is compared to the ratio of another divider. The undesired resistance of test leads and contacts causes an unbalance in the bridge circuit which may be seen easily when making both the low end and the high end comparisons with a null detector. The Model 721A is designed to compensate for this unbalance at both ends permitting linear comparison of the divider ratios. With the Model 721A used correctly to balance the circuit, the accuracy of ratio measurement is limited primarily by the accuracy of the standard voltage divider.

2-3. CONTROLS AND TERMINALS

2-4. STANDARD DIVIDER TERMINALS

2-5. The three STANDARD DIVIDER terminals are used for making the connections to the standard resistive divider. The bottom terminal is a ground terminal. It is electrically connected to the similar terminals for the TEST DIVIDER and the VOLTAGE INPUT.

2-6. VOLTAGE SWITCH

2-7. When the VOLTAGE switch is in the ON position, voltage is applied to the test circuit. When it is in the OFF position, the voltage is removed from the test circuit and the wipers of the fine adjust potentiometers are grounded to permit monitoring the circuit for thermal voltages.

2-8. MODE SWITCH

2-9. The MODE switch controls the placement in the circuit of the coarse balance resistance. With the switch in the R STD $<$ R TEST position, the coarse balance resistance is placed in series with the test divider; with the switch in the R STD $>$ R TEST position, the coarse balance resistance is placed in series with the standard divider.

2-10. LOW BALANCE CONTROLS

2-11. The COARSE control, an 18-position switch, controls application of the relatively large amounts of resistance in series with the low (black) terminal for either the standard divider or the test divider, required to compensate for differences in divider input resistance. The FINE control potentiometer provides high-resolution balance (centering) adjustment over a narrow range.

2-12. HIGH BALANCE CONTROLS

2-13. The COARSE control, an 18-position switch, controls application of the relatively large amounts of resistance in series with the high (red) terminal for either the standard divider or the test divider, required to compensate for differences in divider input resistance. The FINE control potentiometer provides high-resolution balance (centering) adjustment over a narrow range.

2-14. TEST DIVIDER TERMINALS

2-15. The three TEST DIVIDER terminals are used for making the connections to the test divider. The bottom terminal is a ground terminal. It is electrically connected to the similar terminals for the STANDARD DIVIDER and the VOLTAGE INPUT.

2-16. VOLTAGE INPUT TERMINALS

2-17. The three VOLTAGE INPUT terminals are used for connecting the voltage source to the test circuit. The upper (red) terminal is normally connected to the positive (+) terminal of the power supply and the middle (black) terminal is normally connected to the negative (-) terminal of the power supply. The bottom terminal is used for grounding the circuit. It is electrically connected to the similar terminals for the STANDARD DIVIDER and the TEST DIVIDER.

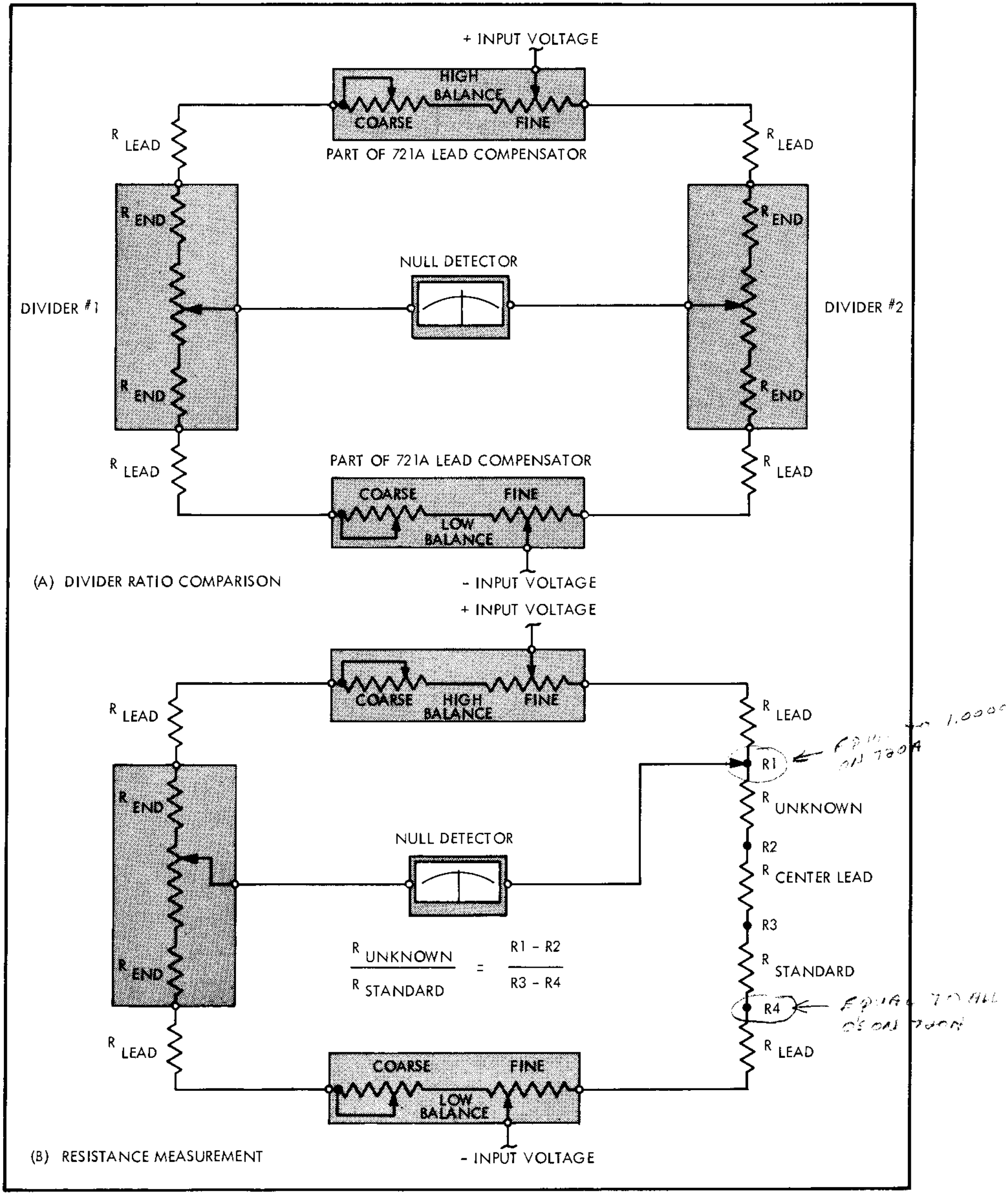


Figure 2-1. RATIO SYSTEM CONFIGURATION

SECTION III

THEORY OF OPERATION

3-1. PURPOSE OF THE LEAD COMPENSATOR

3-2. A lead compensator is a device designed primarily to provide a convenient means of balancing the voltage drops resulting from lead resistance when two dividers are connected in parallel for ratio comparison. It may also be used when a divider and a standard resistor are used to measure an unknown resistance.

3-3. FUNCTIONING

3-4. To balance out the voltage drops caused by end resistance and lead resistance, it is necessary to add series resistance into the circuit. Figure 3-1 is a simplified diagram of a typical voltage divider calibration setup. Notice that the voltage input is at the wipers of the FINE balance controls. The adjustment range of the FINE balance controls is sufficient to compensate for end resistance and lead resistance if the resistances of the dividers are equal unless lead resistance is exceptionally high. The COARSE balance controls are 18-position switches arranged to add progressively greater amounts of series resistance into the circuit to balance the bridge when the divider resistances are unequal. For the sake of simplicity, the MODE switch has not been shown in Figure 3-1. This switch provides a convenient means of interchanging divider connections in the lead compensator. The VOLTAGE switch which also is not shown in Figure 3-1 is used to ground the wipers of the FINE controls so the operator may determine the magnitude of thermal voltages in the circuit.

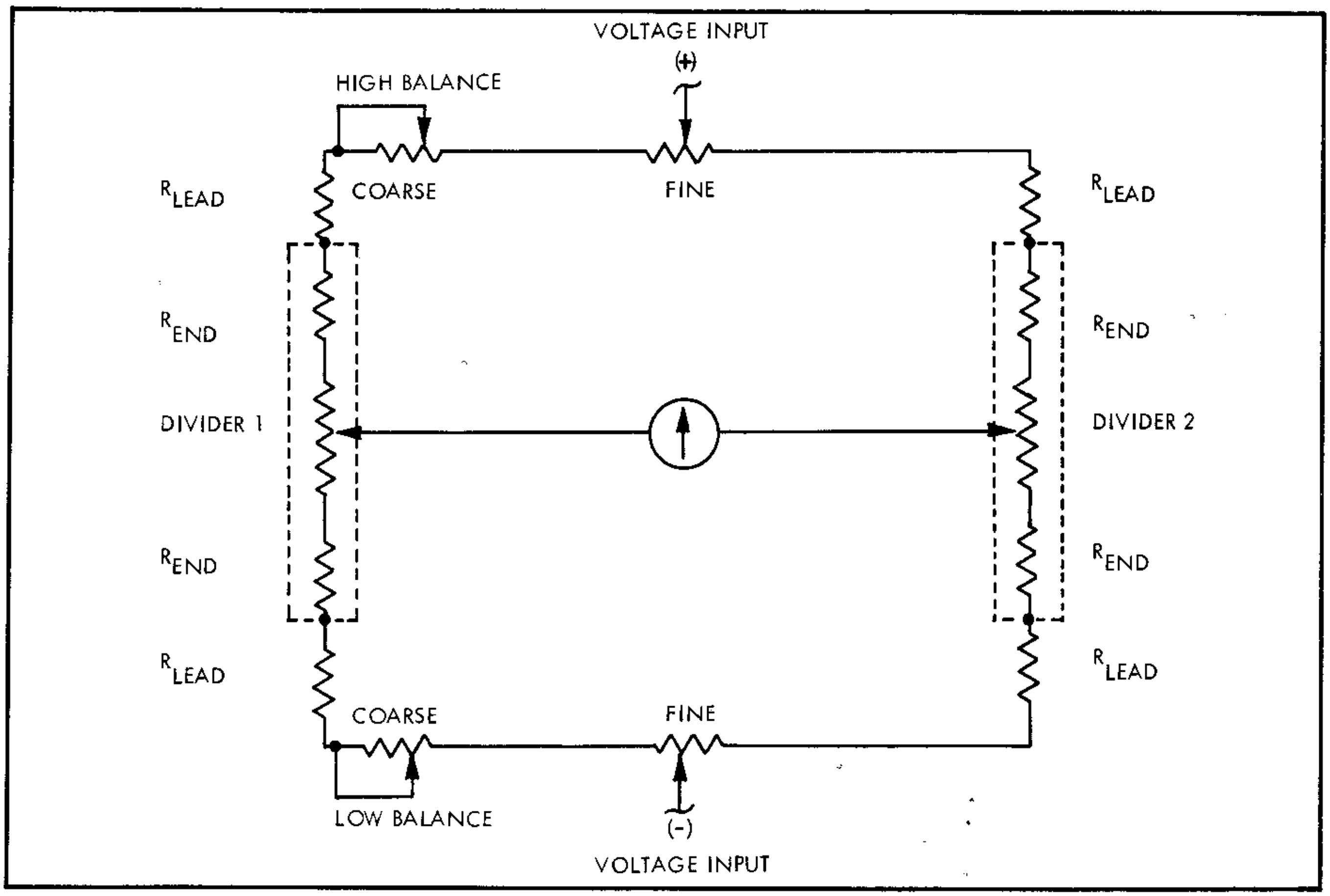


Figure 3-1. TYPICAL VOLTAGE DIVIDER CALIBRATION SETUP

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. Since the Model 721A is a passive device, little routine maintenance will be necessary. Usually, maintenance will consist of occational cleaning and periodic checks of the accuracy of the internal components. Information about recommended cleaning procedures is discussed in paragraph 4-3, GENERAL MAINTENANCE. Test procedures for checking the internal components of the Model 721A are provided in paragraph 4-6, TESTING.

4-3. GENERAL MAINTENANCE

4-4. General maintenance of the Model 721A will generally be limited to cleaning the instrument. The binding posts, and the area around them, should be kept free from contamination. A soft, lint free, cloth or cotton swab moistened in anhydrous ethyl alcohol is recommended for cleaning this area as well as the entire front panel. Since the internal circuitry of the Model 721A is completely enclosed, this area will rarely need cleaning. However, should dust contamination accumulate, remove the contamination with low-pressure clean dry air.

CAUTION!

Do not use Metriclene, acetone, lacquer thinner, or any ketone for cleaning purposes. These chemicals may react with plastic parts.

4-5. Switch cleaning should only be performed after determining that the contact resistance is excessive and/or erratic. Cleaning should be limited only to the suspected switch (es). Use a pressurized spray can of MS-180 "FREON" TF Degreaser (Miller Stephenson Chemical Company, Inc.) for cleaning the switch (es). After cleaning, lubricate the switch rotor blades by applying a very small drop of Cramolin Blue Special (Craig Laboratories, Inc.). Rotate the switch rotor several times to distribute the lubricant among the switch contacts.

4-6. TESTING

4-7. INTRODUCTION

4-8. The purpose of the following test procedures is to provide information for determining if critical resistances within the Model 721A have changed. These tests should be performed at regular intervals. The duration of the intervals will depend upon the operating environment of the instrument. If the instrument is operated in a standards laboratory environment, these tests can be performed at intervals extending to one year. By recording the indications observed during these periodic inspections, a historical record may be prepared. In addition to periodic inspections, these tests may also be used for incoming inspection. Valuable troubleshooting data may also be obtained by performing these tests.

4-9. The test procedures in the following paragraphs include a contact resistance check of the LOW and HIGH BALANCE FINE potentiometers (paragraph 4-10), a check of the resistance value of all the passive elements (paragraph 4-12), and a check of the thermal voltages generated within the instrument (paragraph 4-22). Equipment required for performing these tests is described in Figure 4-1. Before performing the tests, the Model 721A should be allowed to stabilize in the testing environment for 2 to 4 hours. This should reduce the effect of thermal voltages within the instruments from interfering with any measurements.

EQUPIMENT REQUIRED	SPECIFICATIONS REQUIRED	USE
DC Null Detector, Fluke Model 845AB or equivalent	1 microvolt sensitivity Accuracy of ±3% full scale	Contact Resistance Resistance, and Thermal Voltage Tests
DC Current Source, Fluke Model 351A or equivalent	10 milliampere constant current. Accuracy ±0.05%	Contact Resistance and Resistance Tests
Wheatstone Bridge, ESI 231C or equivalent	DC Resistance range of 0.1 to 715 ohms. Accuracy of at least ±0.5%	Resistance Tests

Figure 4-1. TEST EQUIPMENT REQUIRED

4-10. CONTACT RESISTANCE TESTS

4-11. The purpose of this test is to determine if the contact resistances of the HIGH and LOW BALANCE potentiometers (FINE controls) are within optimum limits. The simplified schematic diagram of Figure 4-2 illustrates how this is accomplished. Remove the dust cover from the Model 721A and perform the following steps:

a. Set the controls of the Model 721A as follows:

MODE	R STD<R TEST
HIGH BALANCE	COARSE - 0, FINE - full clockwise
LOW BALANCE	COARSE - 0, FINE - full clockwise
VOLTAGE	ON

b. Adjust the Model 351A for a constant current output of 10 milliamperes. Connect the Model 351A Constant Current Source and the Model 845AB High Impedance Voltmeter to the Model 721A as illustrated in Figure 4-2.

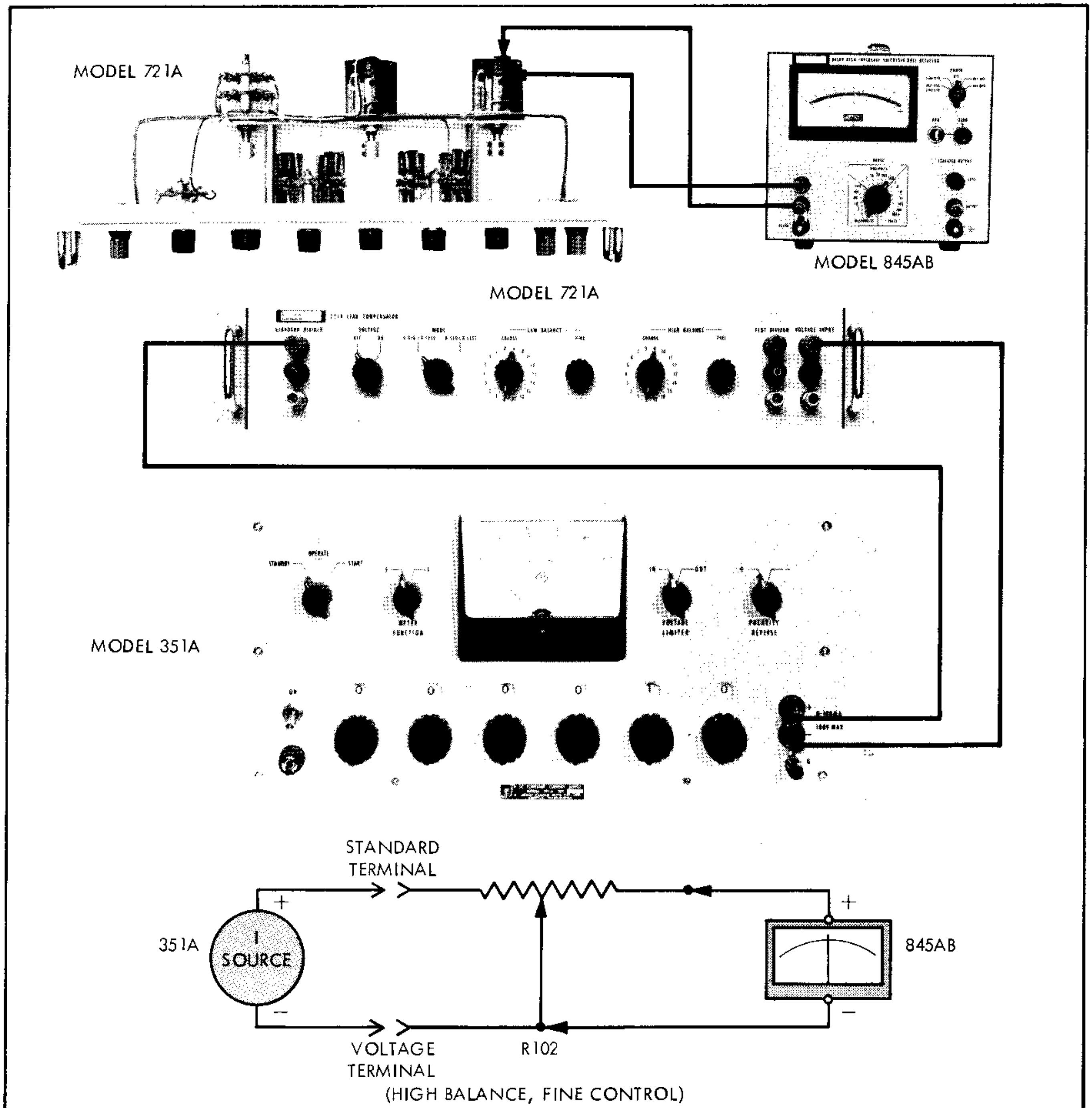


Figure 4-2. HIGH BALANCE CONTACT RESISTANCE

c. Set the Model 845AB RANGE switch to the 1 millivolt position. Apply 10 milliamperes to the Model 721A from the Model 351A.

d. The Model 845AB should indicate less than 350 microvolts (35 milliohms) as the wiper of the HIGH BALANCE potentiometer (R102) is moved from one extremity to the other.

e. Place the OPERATE switch of the Model 351A to STANDBY. Connect the equipment as illustrated in Figure 4-3.

f. Apply 10 milliamperes from the Model 351A to the Model 721A. The Model 845AB should indicate less than 350 microvolts (35 milliohms) as the wiper of the LOW BALANCE potentiometer (R101) is moved from one extremity to the other.

Note!

Should either of the potentiometers exceed the contact resistance limit, rotate the potentiometer through its entire range several times in an attempt to wear through any contamination. Retest the potentiometer. If the potentiometer is still out of limits, it should be replaced.

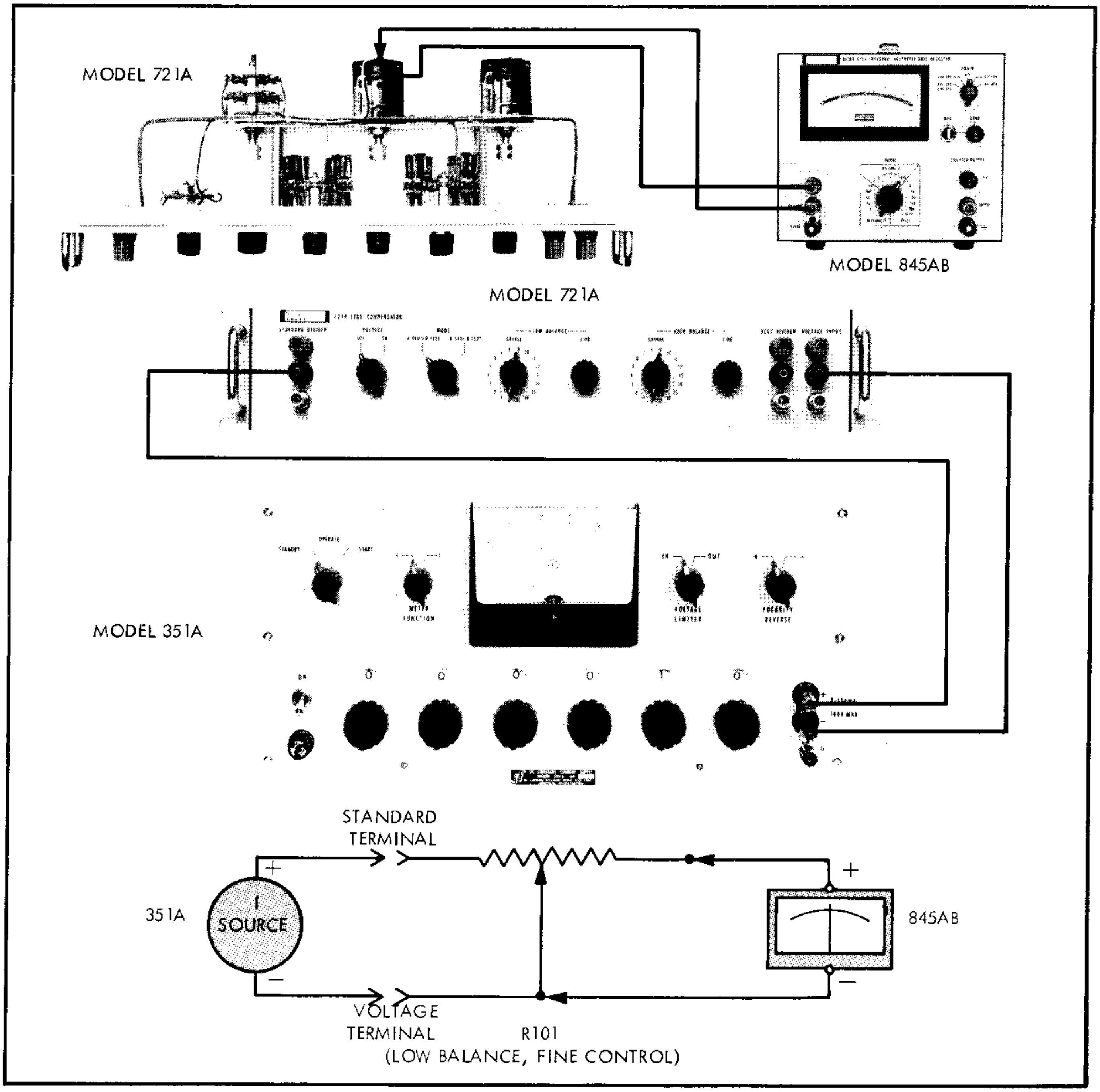


Figure 4-3. LOW BALANCE CONTACT RESISTANCE

4-12. RESISTANCE TEST

4-13. GENERAL. In this test, the resistance of the compensating resistors is measured to determine if they are within tolerable limits. This is accomplished in two ways. Paragraph 4-15 (PRELIMINARY MEASUREMENTS) provides a method of determining if the lead resistance, MODE switch contact resistance, FINE potentiometer end resistance, and the FINE potentiometer resistance range are within acceptable limits. To perform this test, a constant current source and voltmeter will be needed. The recommended equipment is listed in Figure 4-1. In the second part of the test, paragraph 4-21 (RANGE MEASUREMENTS), a method is provided to determine if the range resistors of the COARSE switch are within acceptable limits. The only piece of test equipment necessary for this portion of the test will be a Wheatstone bridge. Figure 4-1 lists the specifications required of the Wheatstone bridge.

4-14. PRELIMINARY MEASUREMENTS. The following procedure is written for testing the HIGH BALANCE circuit of the Model 721A. Use the same procedure for testing the LOW BALANCE circuit by performing the connections and control settings enclosed in parenthesis.

4-15. With the OPERATE switch in the STANDBY position, adjust the Model 351A for a 10 milliampere output. Connect the positive lead to the red (black) TEST DIVIDER terminal and the negative lead to the red (black) STANDARD DIVIDER terminal. Set the Model 845AB to the 1 millivolt range. Connect the INPUT lead to the red (black) VOLTAGE INPUT terminal and the COMMON lead to the red (black) STANDARD DIVIDER terminal. Connect the GUARD terminal to the COMMON terminal with the shorting link provided on the Model 845AB. Set the controls of the Model 721A as follows:

MODE	R STD < R TEST
HIGH BALANCE	COARSE - 0, FINE - full clockwise
LOW BALANCE	COARSE - 0, FINE - full clockwise
VOLTAGE	ON

Refer to Figure 4-4. This figure summarizes the types of preliminary resistance measurements to be performed on the Model 721A. Part a, of Figure 4-4, illustrates schematically the electrical configuration of the Model 721A with the controls set as previously described. Apply 10 milliamperes from the Model 351A. The Model 845AB should indicate less than 0.5 millivolts. Record the exact value indicated.

4-16. Set the Model 845AB to the 3 millivolt range. Rotate the FINE, HIGH (LOW) BALANCE, potentiometer to the full counter-clockwise position. Figure 4-4, part b, illustrates this electrical configuration. Record the voltage indication and subtract the value recorded in paragraph 4-17. The resulting value should be between 0.7 and 1.6 millivolts.

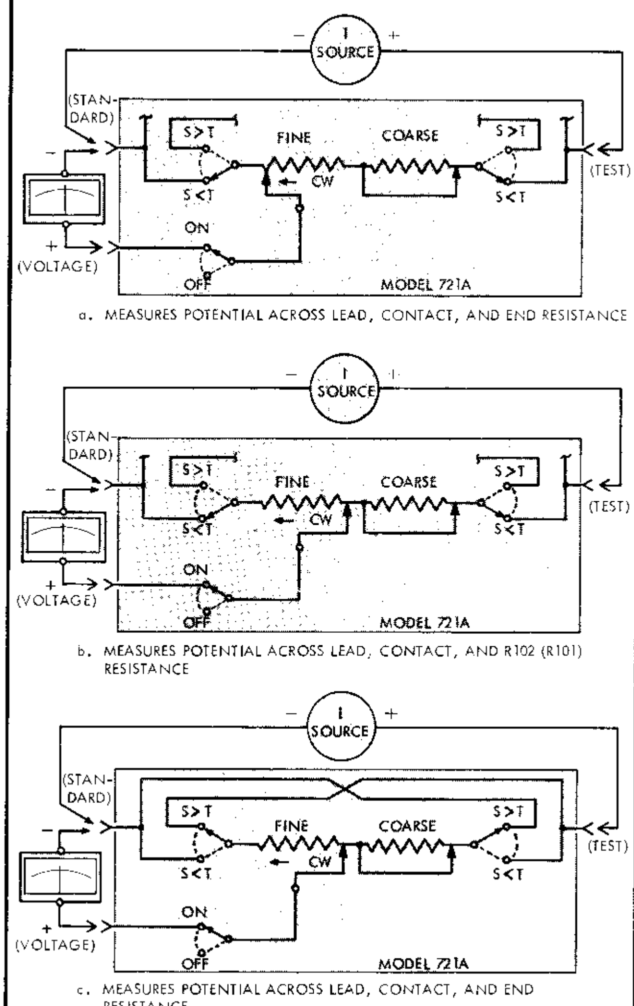
4-17. Set the MODE switch of the Model 721A to the R STD > R TEST. Figure 4-4, part c, illustrates this electrical configuration. The Model 845AB should indicate less than 0.5 millivolts.

4-18. After testing both the HIGH and LOW BALANCE circuits, disconnect the Model 845AB and Model 351A from the Model 721A.

4-19. RANGE MEASUREMENTS. The following procedure is written for testing the HIGH BALANCE circuit of the Model 721A. Use the same procedure for testing the LOW BALANCE circuit by performing the connections and control settings enclosed in parenthesis.

4-20. Connect the Wheatstone bridge between the red (black) STANDARD DIVIDER terminal and the red (black) VOLTAGE INPUT terminal. Set the controls of the Model 721A as follows:

MODE	R STD > R TEST
HIGH BALANCE	COARSE - 0, FINE - full clockwise
LOW BALANCE	COARSE - 0, FINE - full clockwise
VOLTAGE	ON



a. MEASURES POTENTIAL ACROSS LEAD, CONTACT, AND END RESISTANCE

b. MEASURES POTENTIAL ACROSS LEAD, CONTACT, AND R102 (R101) RESISTANCE

c. MEASURES POTENTIAL ACROSS LEAD, CONTACT, AND END RESISTANCE

Figure 4-4. PRELIMINARY MEASUREMENTS

Figure 4-5 illustrates the electrical configuration of the Model 721A with the controls set as previously described. Measure the resistance with the Wheatstone bridge and record the value of the indication.

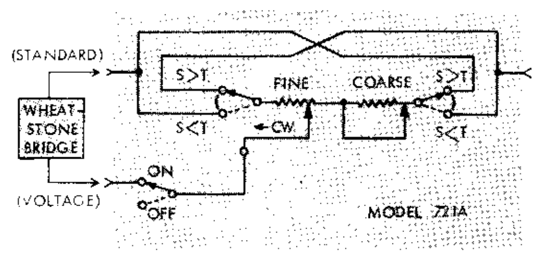


Figure 4-5. RANGE MEASUREMENTS

4-21. Set the COARSE, HIGH (LOW) BALANCE, switch to "1". Measure this resistance. Subtract the value recorded in paragraph 4-20 from this value. Compare the resulting value to those values considered tolerable for COARSE switch position "1", in Figure 4-6. Repeat this process for the remaining positions of the COARSE switch.

4-22. THERMAL VOLTAGE TEST

4-23. The following procedure need only be accomplished if corrective maintenance, involving soldering, has been performed. The purpose of the test is to determine if excessive thermal voltage is being generated, as a result of a cold solder joint or poor connection after soldering. Before performing the test, the instrument should be completely assembled and allowed to temperature stabilize for at least 30 minutes. The following procedure is written for testing the HIGH BALANCE circuit of the Model 721A. The same procedure may be used to test the LOW BALANCE circuit by performing the control settings enclosed in parenthesis. Proceed as follows:

a. Using low-thermal copper leads, connect the Model 845AB between the red (black) STANDARD DIVIDER terminal and the red (black) TEST DIVIDER terminal of the Model 721A.

b. Set the OPR-ZERO control of the Model 845AB to ZERO and adjust the control for a null in the 3 microvolt range.

POSITION OF COARSE SWITCH	RANGE OF RESISTANCE VALUE IN OHMS
1	0.152 to 0.168
2	0.408 to 0.482
3	0.788 to 0.902
4	1.386 to 1.564
5	2.337 to 2.613
6	3.86 to 4.29
7	6.25 to 6.90
8	10.05 to 11.10
9	16.03 to 17.72
10	25.53 to 28.22
11	40.73 to 45.02
12	64.48 to 71.27
13	102.5 to 113.4
14	162.3 to 179.5
15	257.3 to 284.5
16	409.3 to 452.5
17	646.8 to 714.9

Figure 4-6. RESISTANCE RANGE

c. Set the Model 845AB OPR-ZERO control to the OPR position. The Model 845AB should indicate less than 1 microvolt.

d. Slowly rotate the Model 721A COARSE, HIGH (LOW) BALANCE, switch through all positions. The Model 845AB should indicate less than 1 microvolt in each position.

e. Set the MODE switch to the opposite position. The Model 845AB should indicate less than 1 microvolt.

f. After testing both the HIGH and LOW BALANCE circuits, disconnect the Model 845AB from the Model 721A.

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section contains complete descriptions of those parts one might normally expect to replace during the life of the instrument. The first listing is a breakdown of all of the major assemblies in the instrument. Subsequent listings itemize the components in each assembly. Every listing is accompanied by an illustration identifying each component in the listing. Assemblies and subassemblies are identified by name in the parts list and by a ten digit stock number in the illustrations. Components are identified by the schematic diagram reference designation (e.g. R1, C107 DS1). Parts not appearing on the schematic diagram are numbered consecutively throughtout the parts list with a whole number.

5-3. COLUMNAR INFORMATION

a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.

b. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, see the following page.

c. The ten-digit part number by which the item is identified at the John Fluke Mfg. Co. is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

d. The Federal Supply Code for the item manufacturer is listed in the MFR column. An abbreviated list of Federal Supply Codes is included in the Appendix.

e. The part number which uniquely identifies the item to the original manufacturer is listed in the MFR PART NO column. If a component must be ordered by description, the type number is listed.

f. The TOT QTY column lists the total quantity of the item used in the instrument. Second and subsequent listing of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, the TOT QTY column lists the total quantity of the item in that particular assembly.

g. Entries in the REC QTY column indicate 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 every part in the instrument be stocked.

h. The USE CODE column identifies certain parts which have been added, deleted or modified during the 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 Serial Number Effectivity List at the end of the parts list. As Use Codes are added to the list, the TOT QTY column listings are changed to reflect the most current information. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-4. HOW TO OBTAIN PARTS

5-5. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representative by using the Fluke part 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, if necessary.

5-6. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co. if you include the following information:

a. Instrument model and serial number.

b. Component description.

c. Component reference designation.

d. John Fluke Mfg. Co. part number.

If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part showing its location to other parts of the instrument is usually most helpful.

5-7. LIST OF ABBREVIATIONS

ac	alternating current
Al	Aluminum
amp	ampere
assy	assembly
cap	capacitor
car flm	carbon film
C	centigrade
cer	ceramic
comp	composition
conn	connector
db	decibel
dc	direct current
dpdt	double-pole, double-throw
dpst	double-pole, single-throw
elect	electrolytic
F	fahrenheit
Ge	germanium
gmv	guaranteed minimum value
h	henry
Hz	hertz
hf	high frequency
IC	integrated circuit
if	intermediate frequency
k	kilohm
kHz	kilohertz
kv	kilovolt
lf	low frequency
MHz	megahertz
M	megohm
met flm	metal film
ua	microampere
uf	microfarad
uh	microhenry
usec	microsecond
uv	microvolt
ma	milliampere
mh	millihenry
m	milliohms
msec	millisecond
mv	millivolt
mw	milliwatt
na	nanoampere
nsec	nanosecond
nv	nanovolt
Ω	ohm
ppm	parts per million
piv	peak inverse voltage
p-p	peak to peak
pf	picofarad
plstc	plastic
p	pole
pos	position
P/C	printed circuit
rf	radio frequency
rfi	radio frequency interference
res	resistor
rms	root mean square
rtry	rotary
sec	second
sect	section
S/N	serial number
Si	silicon
scr	silicon controlled rectifier
spdt	single-pole, double-throw
spst	single-pole, single-throw
sw	switch
Ta	tantalum
tstr	transistor
tvm	transistor voltmeter
uhf	ultrahigh frequency
vtvm	vacuum tube voltmeter
var	variable
vhf	very high frequency
vlf	very low frequency
v	volt
va	voltampere
vac	volts, alternating current
vdc	volts, direct current
w	watt
ww	wire wound

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	FINAL ASSEMBLY - Figure 5-1	721A					
	Front Panel Assembly (See Figure 5-2)						
1	Cover, bottom (not illustrated)	3156-208470	89536	3156-208470	1		
2	Cover, top	3156-208462	89536	3156-208462	1		

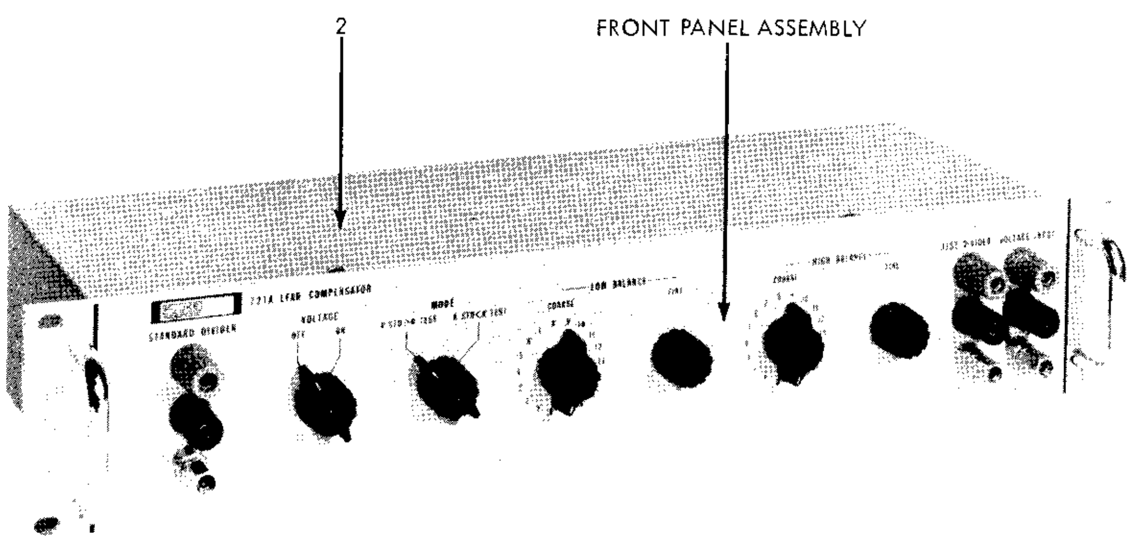


Figure 5-1. FINAL ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	FRONT PANEL ASSEMBLY - Figure 5-2						
	Balance Switch Assembly (See Figure 5-3)	3158-208512	89536	3158-208512	2		
	Balance Switch Assembly (See Figure 5-3)	3158-208512	89536	3158-208512	REF		
J1	Binding post, red	2811-149856	58474	BHB-10208-G22	2		
J2	Binding post, black	2811-149864	58474	BHB-10208-G21	2		
J3	Binding post, ground	2811-155911	58474	GP-30NC	3		
J4	Binding post, red	2811-149856	58474	BHB-1-208-G22	REF		
J5	Binding post, black	2811-149864	58474	BHB-10208-G21	REF		
J6	Binding post, ground	2811-155911	58474	GP-30NC	REF		
J7	Binding post, red	2811-142976	58474	DF31RC	1		
J8	Binding post, black	2811-142984	58474	DF31BC	1		
J9	Binding post, ground	2811-155911	58474	GP-30NC	REF		
R101, R102	Res, var, ww, 0.15Ω ±20%, 5w	4702-203539	73138	SA5734	2		
S1	Switch, MODE, rotary, 4p, 2 pos, 2 sect	5105-208934	89536	5105-208934	1		
S4	Switch, VOLTAGE, rotary, 2p, 2 pos 1 sect	5105-208942	89536	5105-208942	1		
3	Coupler, 1/4"	2402-104505	89536	2402-104505	2		
4	Handle, chrome-plated brass	2404-100412	05704	825	2		
5	Knob, COARSE	2405-170050	89536	2404-170050	4		
6	Knob, FINE	2405-170068	89536	2405-170068	2		
7	Knob, MODE	2405-170050	89536	2405-170050	REF		
8	Knob, VOLTAGE	2405-170050	89536	2405-170050	REF		
9	Panel, front	1406-208447	89536	1406-208447	1		
10	Shaft, pot	3155-208496	89536	3155-208496	2		

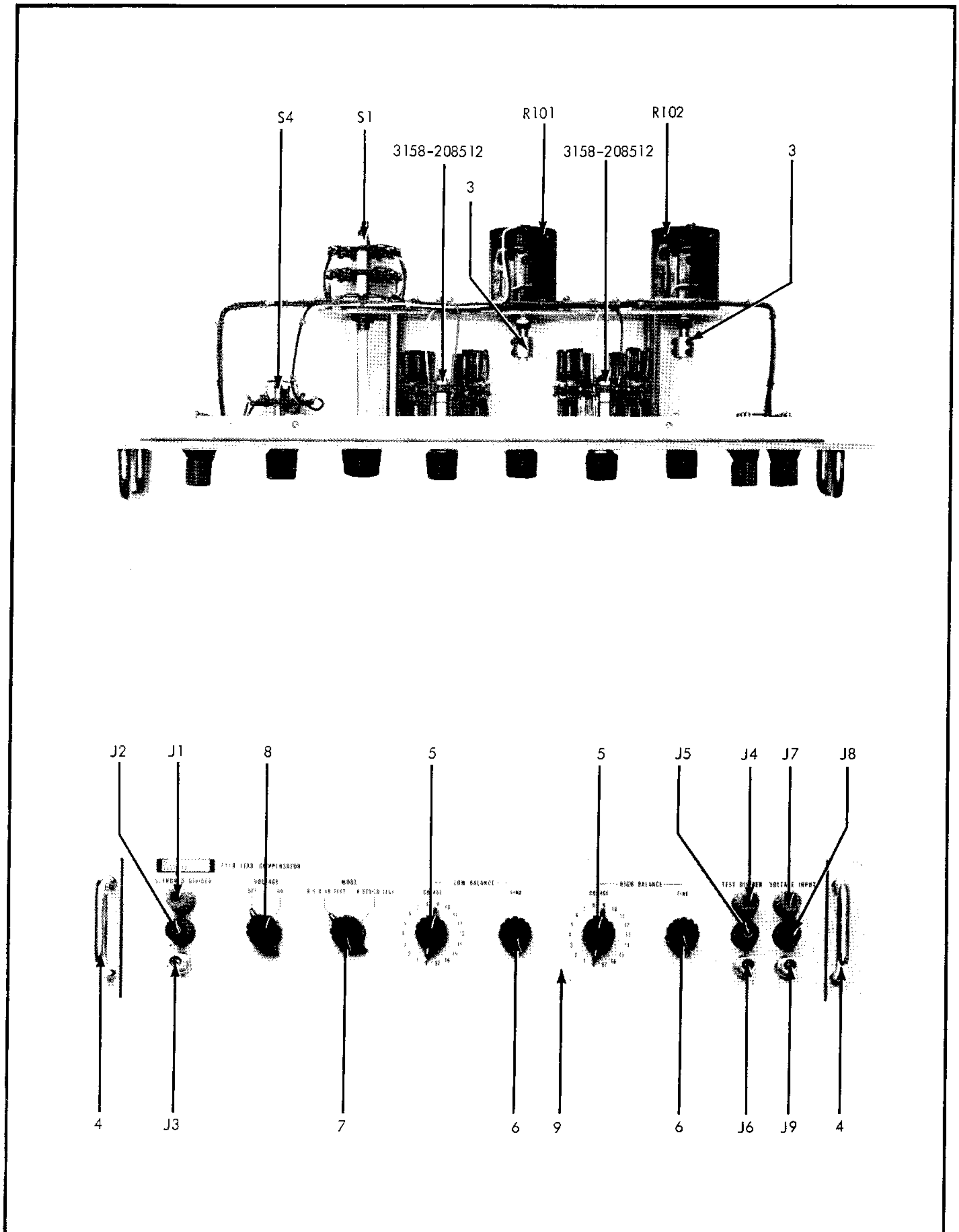


Figure 5-2. FRONT PANEL ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	BALANCE SWITCH ASSEMBLY Figure 5-3	3158-208512 (721A-4001)	89536	3158-208512	REF		
R201	Res, ww, 0.16Ω 3%, 1/4w	4707-194787	89536	4707-194787	2		
R202	Res, ww, 0.25Ω ±3%, 1/4w	4707-194779	89536	4707-194779	2		
R203	Res, ww, 0.4Ω ±3%, 1/4w	4707-194761	89536	4707-194761	2		
R204	Res, ww, 0.63Ω ±3%, 1/4w	4707-194753	89536	4707-194753	2		
R205	Res, ww, 1Ω ±3%, 1/4w	4707-194746	89536	4707-194746	2		
R206	Res, ww, 1.6Ω ±3%, 1/4w	4707-194738	89536	4707-194738	2		
R207	Res, ww, 2.5Ω ±3%, 1/4w	4707-194720	89536	4707-194720	2		
R208	Res, ww, 4Ω ±3%, 1/4w	4707-194712	89536	4707-194712	2		
R209	Res, ww, 6.3Ω ±3%, 1/4w	4707-194704	89536	4707-194704	2		
R210	Res, ww, 10Ω ±3%, 1/4w	4707-194696	89536	4707-194696	2		
R211	Res, ww, 16Ω ±3%, 1/4w	4707-194688	89536	4707-194688	2		
R212	Res, ww, 25Ω ±3%, 1/4w	4707-194670	89536	4707-194670	2		
R213	Res, ww, 40Ω ±3%, 1/4w	4707-194662	89536	4707-194662	2		
R214	Res, ww, 63Ω ±3%, 1/4w	4707-194654	89536	4707-194654	2		
R215	Res, ww, 100Ω ±3%, 1/4w	4707-194647	89536	4707-194647	2		
R216	Res, ww, 160Ω ±3%, 1/4w	4707-194639	89536	4707-194639	2		
R217	Res, ww, 250Ω ±3%, 1/4w	4707-194621	89536	4707-194621	2		
S2	Switch, BALANCE, rotary, 1p, 18 pos, 1 sect	5105-208926	89536	4707-208926	2		

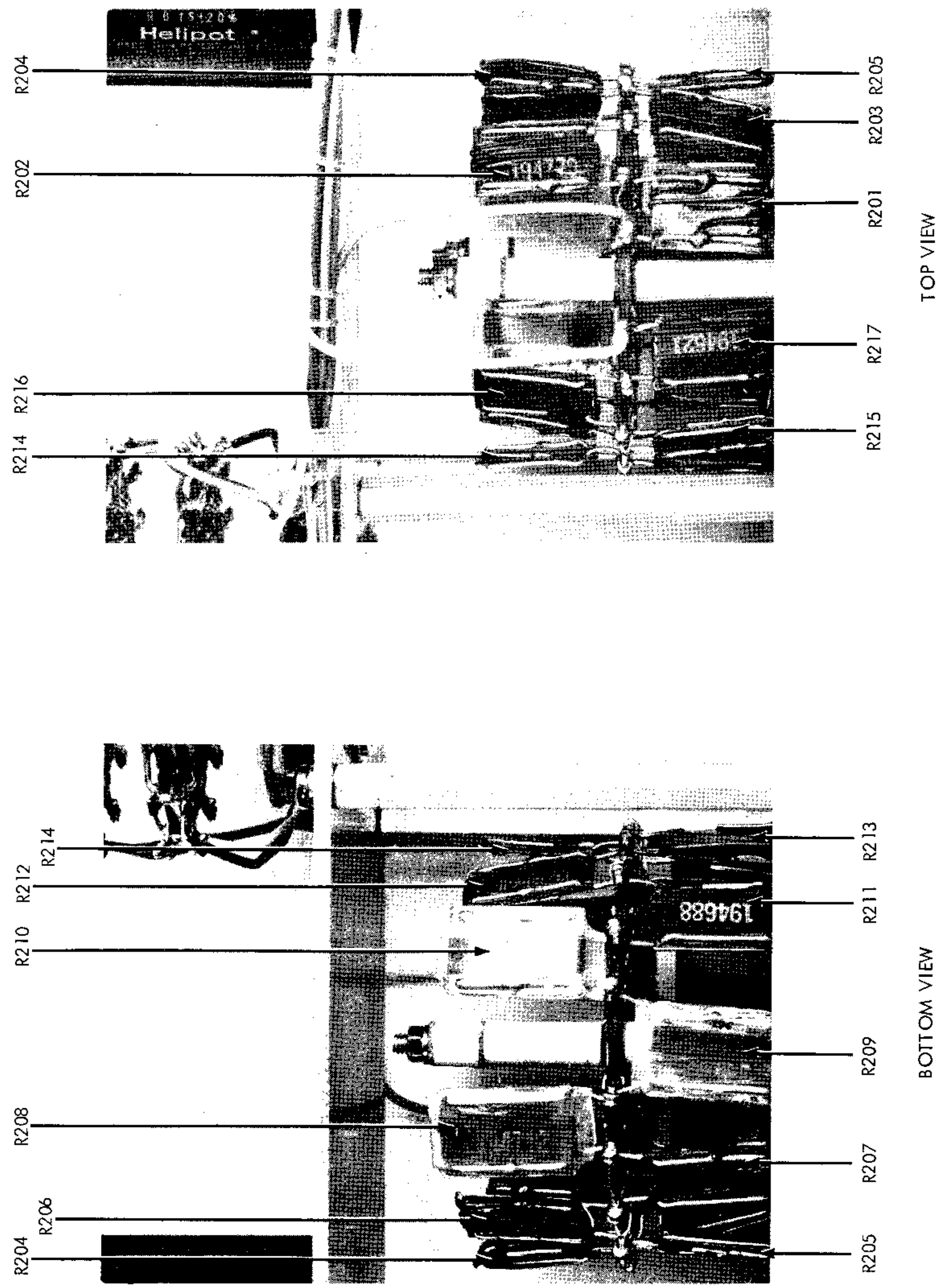


Figure 5-3. BALANCE SWITCH ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	BALANCE SWITCH ASSEMBLY Figure 5-4	3158-208512 (721A-4001)	89536	3158-208512	REF		
R301	Res, ww, 0.16Ω ±3%, 1/4w	4707-194787	89536	4707-194787	REF		
R302	Res, ww, 0.25Ω ±3%, 1/4w	4707-194779	89536	4707-194779	REF		
R303	Res, ww, 0.4Ω ±3%, 1/4w	4707-194761	89536	4707-194761	REF		
R304	Res, ww, 0.63Ω ±3%, 1/4w	4707-194753	89536	4707-194753	REF		
R305	Res, ww, 1Ω ±3%, 1/4w	4707-194746	89536	4707-194746	REF		
R306	Res, ww, 1.6Ω ±3%, 1/4w	4707-194738	89536	4707-194738	REF		
R307	Res, ww, 2.5Ω ±3%, 1/4w	4707-194720	89536	4707-194720	REF		
R308	Res, ww, 4Ω ±3%, 1/4w	4707-194712	89536	4707-194712	REF		
R309	Res, ww, 6.3Ω ±3%, 1/4w	4707-194704	89536	4707-194704	REF		
R310	Res, ww, 10Ω ±3%, 1/4w	4707-194696	89536	4707-194696	REF		
R311	Res, ww, 16Ω ±3%, 1/4w	4707-194688	89536	4707-194688	REF		
R312	Res, ww, 25Ω ±3%, 1/4w	4707-194670	89536	4707-194670	REF		
R313	Res, ww, 40Ω ±3%, 1/4w	4707-194662	89536	4707-194662	REF		
R314	Res, ww, 63Ω ±3%, 1/4w	4707-194654	89536	4707-194654	REF		
R315	Res, ww, 100Ω ±3%, 1/4w	4707-194647	89536	4707-194647	REF		
R316	Res, ww, 160Ω ±3%, 1/4w	4707-194639	89536	4707-194639	REF		
R317	Res, ww, 250Ω ±3%, 1/4w	4707-194621	89536	4707-194621	REF		
S3	Switch, BALANCE, rotary, 1p, 18 pos, 1 sect	5105-208926	89536	5105-208926	REF		

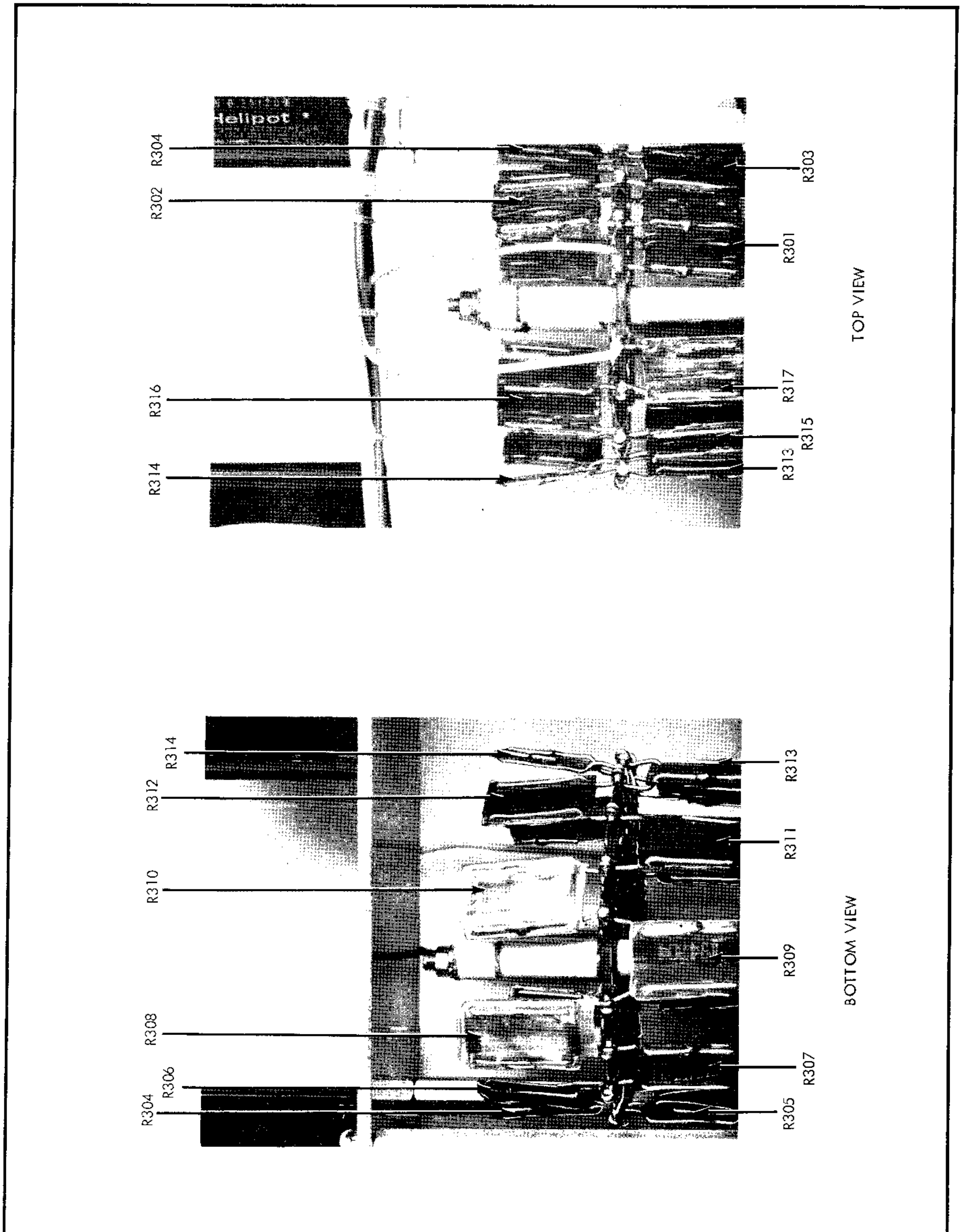


Figure 5-4. BALANCE SWITCH ASSEMBLY

5-8 SERIAL NUMBER EFFECTIVITY

5-9. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 721A. 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 List below. All parts with no code are used on all instruments with serial numbers above 123. New codes will be added as required by instrument changes.

USE CODE	EFFECTIVITY
No Code	Model 721A serial number 123 and on

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. The following information is presented in this section:

List of Abbreviations
Federal Supply Codes for Manufacturers
Fluke Technical Service Centers — U.S. and Canada
Sales and Service Locations — International
Sales Representatives — U.S. and Canada

List of Abbreviations and Symbols

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

Federal Supply Codes for Manufacturers (Continued)

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisberg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884 - use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571 - use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
Ross Milton, Co., The
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Division
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, MA

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933 - use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept.
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988 - use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, MN

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

Federal Supply Codes for Manufacturers (Continued)

11711
General Instrument Corp
Rectifier Division
Hickville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Division
AMF Canada LTD.
Guelph, Onatrio, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
Budd Co. The, Polychem Products
Plastic Products Div.
Bridgeport, PA

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606 - use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors, formerly
Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
G T E Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Buckeye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co. Corporate H.Q.
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
A B Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
Mallory, P.R. & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp, formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, Californai

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnbach Radio Co., Inc.
Freeport, LI New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village, Chicago, Illinois

72005
Driver, Wilber B., Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrence, California

73445
Amperex Electronic Corp.
Hicksville, LI, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp., Mepco Div.
A North American Phillips Co.
Morristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183 - use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Stevens, Arnold Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81439
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

Federal Supply Codes for Manufacturers (Concluded)

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
Carr Co., The United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Division
Eatontown, New Jersey

83330
Smith, Herman H., Inc.
Brooklyn, New York

83478
Rubbercraft Corp. of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products,
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co. Div of
P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211 - use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737 - use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154 - use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic Hdware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect. Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779 - use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

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Fluke Technical Center
1980 S. Quebec St.
Unit 4
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Tel. (312) 398-5800

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460 Colfax Ave.
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NORTH CAROLINA
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Fluke Technical Center
1310 Beaman Place
Zip: 27408
Tel. (919) 273-1918

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Fluke Technical Center
14400 Midway Road
Zip: 75240
Tel. (214) 233-9945

WASHINGTON
Mountlake Terrace
John Fluke Mfg. Co., Inc.
21707 66th Ave. W. Suite 1
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Tel. (206) 774-2206

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Fluke Technical Center
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6503 Northam Drive
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Tel. (416) 678-1500

QUEBEC
Longueuil
Allan Crawford Assoc. Ltd.
Fluke Technical Center
1330 Marie Victorin Blvd. E.
Zip: J4G 1A2
Tel. (514) 670-1212

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Liechtensteinstrasse 97/6
A-1090 Vienna, Austria
Tel. (222) 347646-0

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*C. N. Rood S/A
37 Place de Jamblinne de Meux
B-1040 Brussels, Belgium
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P.O. Box 1989
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Tel. 66121

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*Tage Olsen A/S
Ballerup Byveg 222
DK-2750 Ballerup
Tel. (01) 2-65 81 11

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*Oy Findip AB
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02700 Kauniainen
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78530 BUC, France
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00143 Rome, Italy
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*Equipamentos
De Laboratorio Ltda.
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Lisbon 1, Portugal
Tel. (019) 976551

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*Hispano Electronica S.A.
Poligono Industrial Urtinsa
Apartado de Correos 48
Alcorcon (Madrid), Spain
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*Teleinstrument AB
P.O. Box 490
S-162 Vallingby-4
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SWITZERLAND
*Traco Electronic AG
Jenatschstrasse 1
8002 Zurich, Switzerland
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*Erkman Electronik Aletler
Necatibey Cad 92/2
Karakoy/Istanbul
Turkey
Tel. 441546

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*Fluke International Corp.
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Lotus Engineering Organisation
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Cairo, Egypt
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*Irantronics Company Ltd.
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ISRAEL
*R.D.T. Electronics
Engineering Ltd.
46, Sokolov Street
Ramat Hasharon 47235, Israel
Tel. 482311

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

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P.O. Box Safat 20506
Kuwait, Arabian Gulf
Tel. 436100

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P.O. Box 11-3823
Beirut, Lebanon
Tel. 252631

MOROCCO
Mainvest
Residence Moulay Ismail
Bat.C Boulevard
Moulay Slimane, Rabat, Morocco
Tel. 276-64

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Marketing Est.
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Tel. 32700

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