

# **721A**

## **Lead Compensator**

Instruction Manual

P/N 294066  
October 1968



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## CHANGE/ERRATA INFORMATION

Issue No: 3    September 27, 1979

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

1. The revision letter given with each change is equal to or higher than that which is stamped on the indicated pcb assembly.
2. No revision letter is indicated at the beginning of the change/errata.

### MANUAL

Title:	721A LEAD COMPENSATOR
Print Date:	OCTOBER 1968
Rev and Date:	---

### C/E PAGE EFFECTIVITY

Page No.	Print Date
1	9/79

## ERRATA #1

On page 4-1, Figure 4-1:

Change the recommended DC Current Source FROM: Fluke Mode 351A  
TO: Fluke Modle 382A

On page 4-5, Change the table given in Figure 4-6 to agree with the following:

POSITION OF COARSE SWITCH	RANGE OF RESISTANCE	
1	0.152 to	0.168
2	0.390 to	0.431
3	0.770 to	0.851
4	1.370 to	1.510
5	2.320 to	2.560
6	3.84 to	4.24
7	6.21 to	6.87
8	10.01 to	11.07
9	16.00 to	17.80
10	25.00 to	28.18
11	40.70 to	45.00
12	64.45 to	71.23
13	102.45 to	113.23
14	162.30 to	179.50
15	257.30 to	284.40
16	409.30 to	452.40
17	646.80 to	714.88

## CHANGE #1 - 11890

On page 5-4:

FROM: 9~Panel, Front~1406-208447~89536~1406-208447~1  
TO: 9~Panel, Front~1406-496208~89536~1406-496208~1

FROM: 5~Knob, Coarse~2405-170050~89536~2404-170050~4  
TO: 5~Knob, Coarse~2405-341404~89536~2404-341404~4

FROM: 6~Knob, Fine~2405-170068~89536~2405-170068~2  
TO: 6~Knob, Fine~2405-341388~89536~2405-341388~2

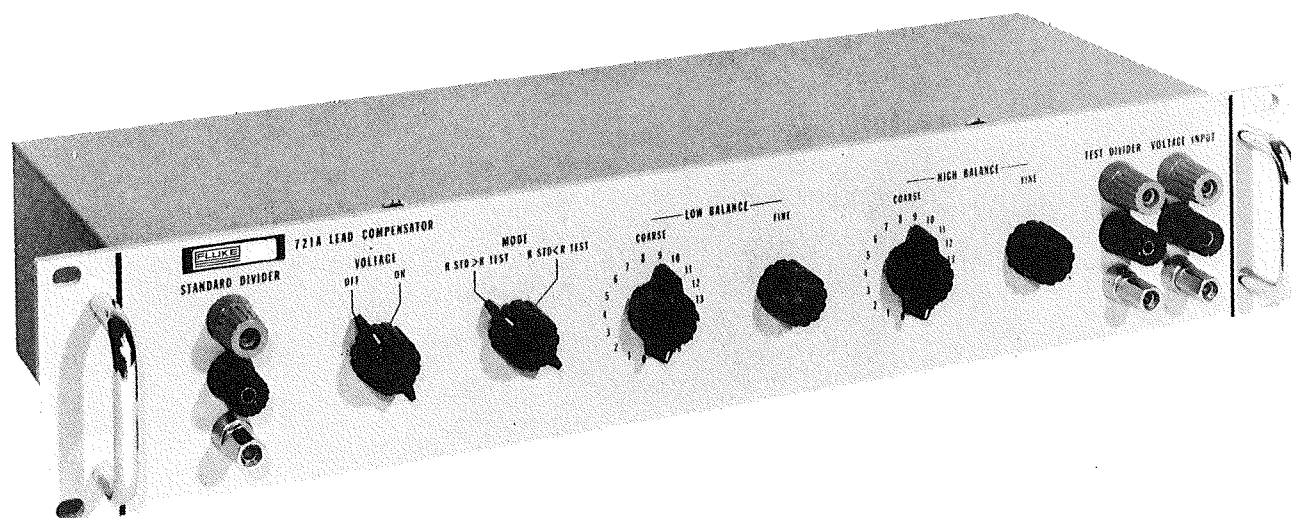
FROM: 17~Handle, Chrome-plated brass~2404-100412~05704~825~2  
TO: 17~Handle, Chrome-plated brass~2404-494955~89536~494955~2

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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.

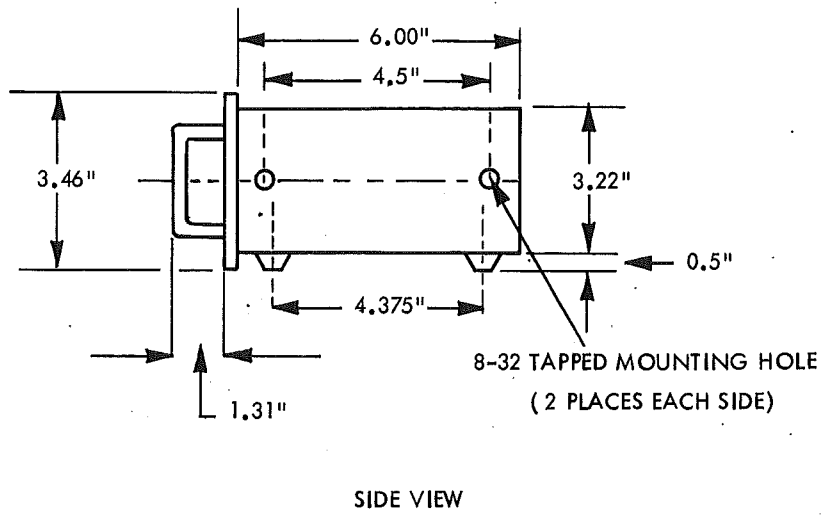
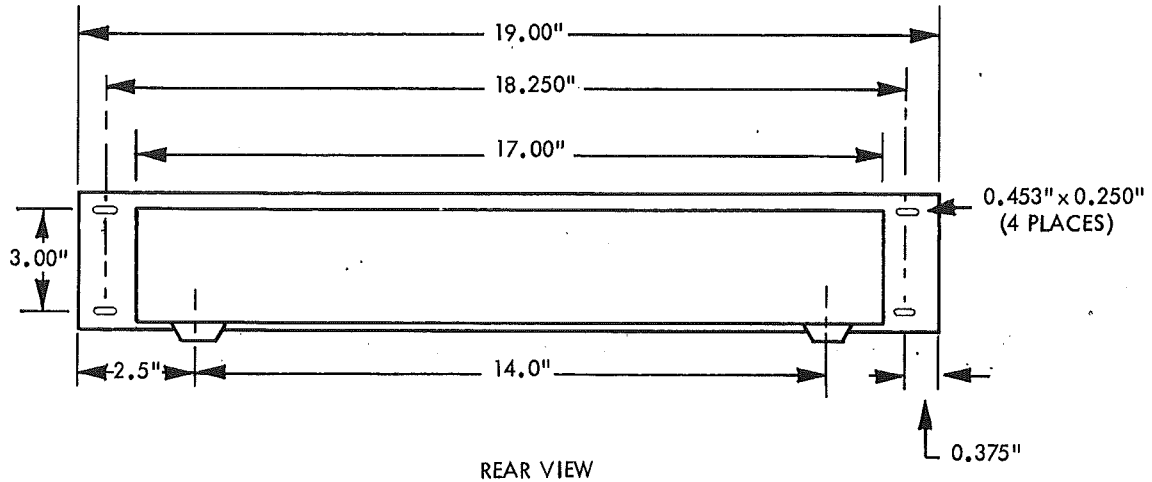


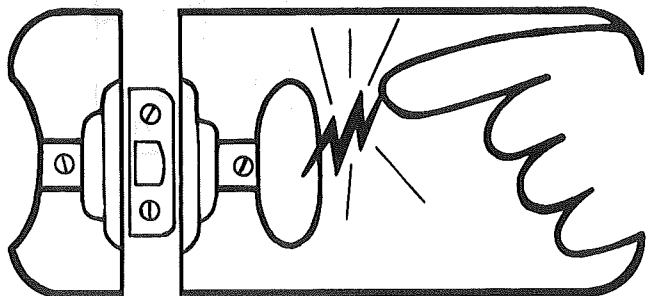
Figure 1-1. MODEL 721A OUTLINE DRAWING.



# static awareness



A Message From  
**John Fluke Mfg. Co., Inc.**

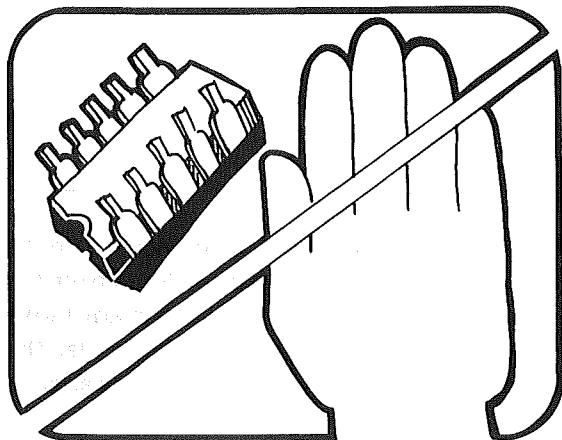


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

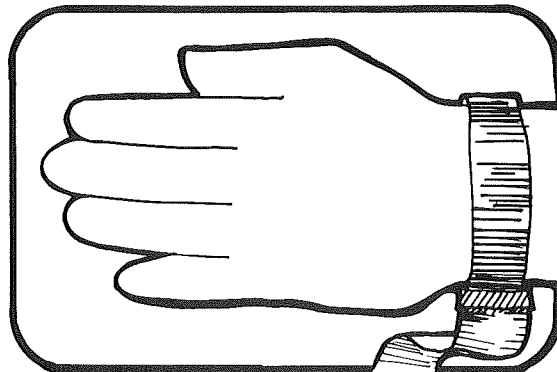
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

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

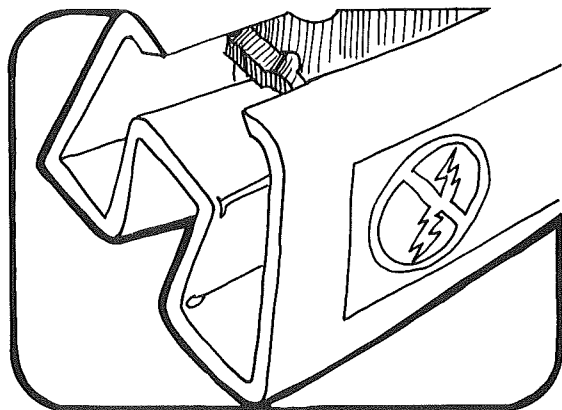
The following practices should be followed to minimize damage to S.S. devices.



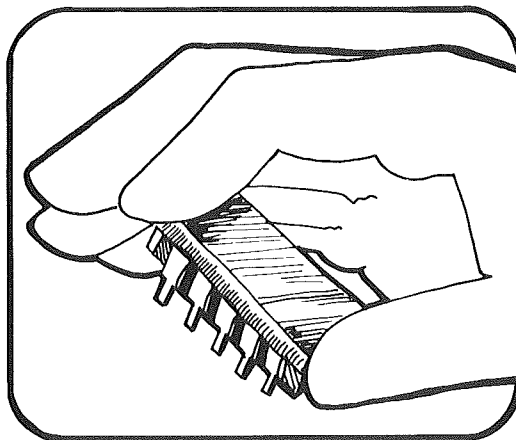
1. MINIMIZE HANDLING



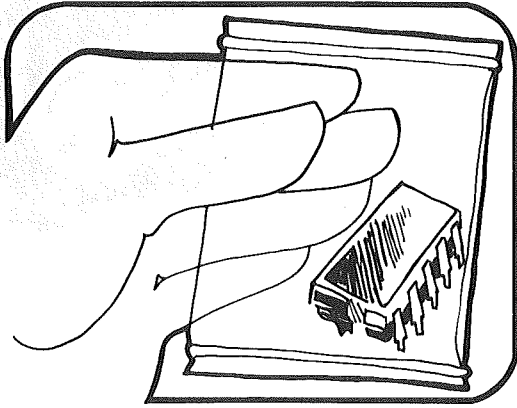
3. DISCHARGE PERSONAL STATIC  
BEFORE HANDLING DEVICES



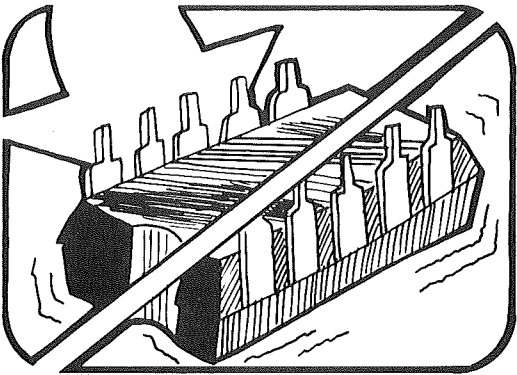
2. KEEP PARTS IN ORIGINAL CONTAINERS  
UNTIL READY FOR USE.



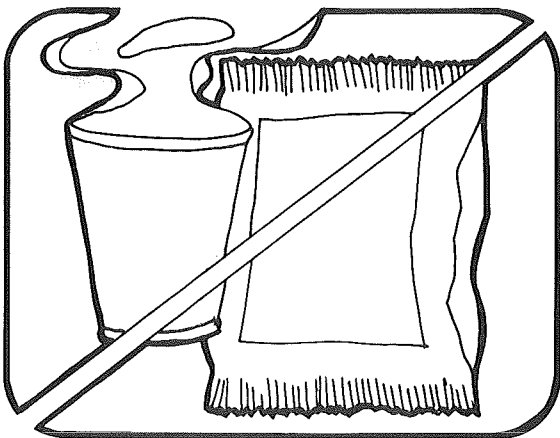
4. HANDLE S.S. DEVICES BY THE BODY



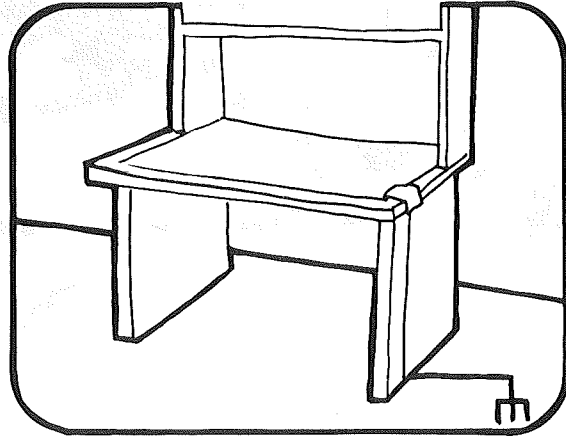
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



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"

## 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 di-

vider; 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.

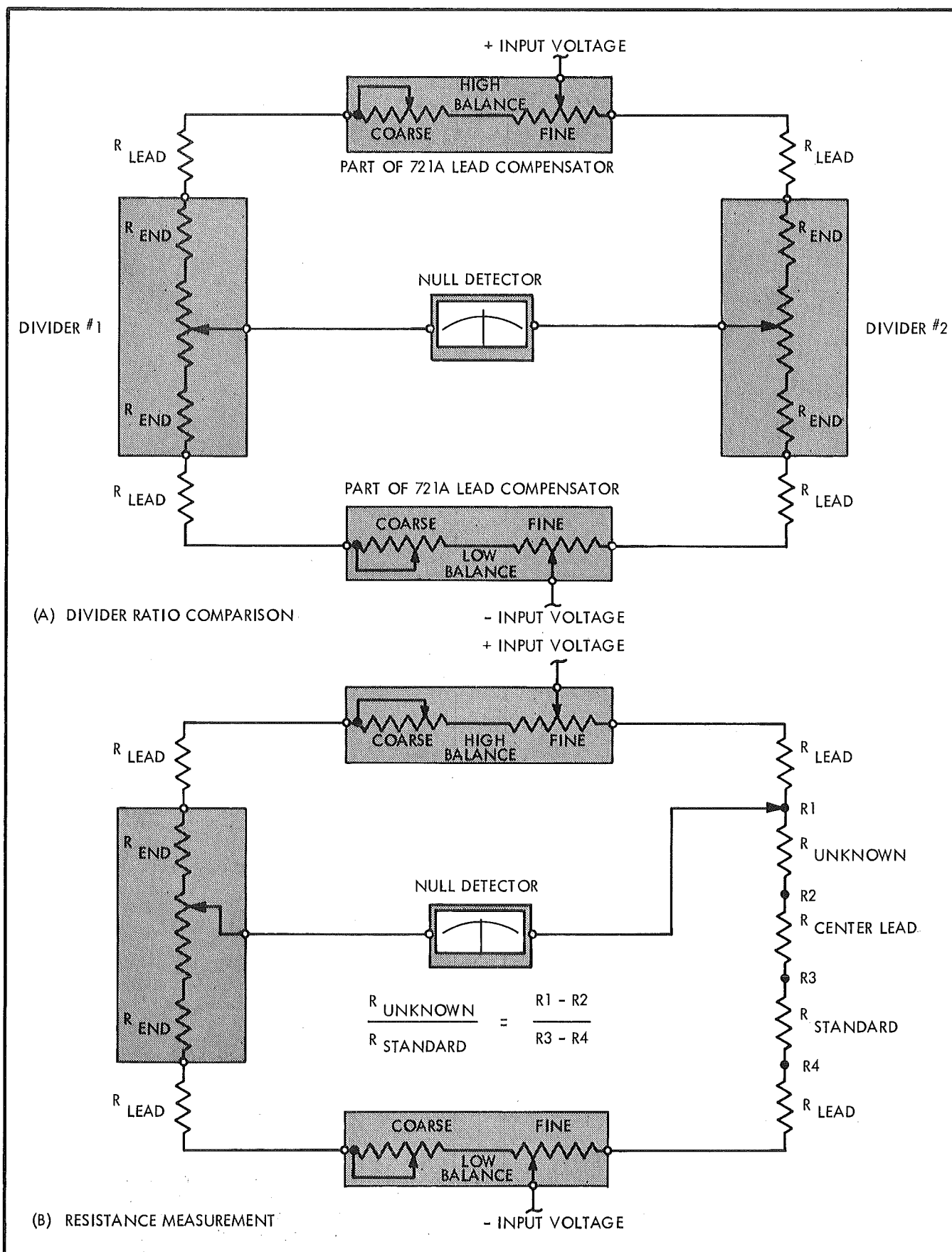


Figure 2-1. RATIO SYSTEM CONFIGURATION

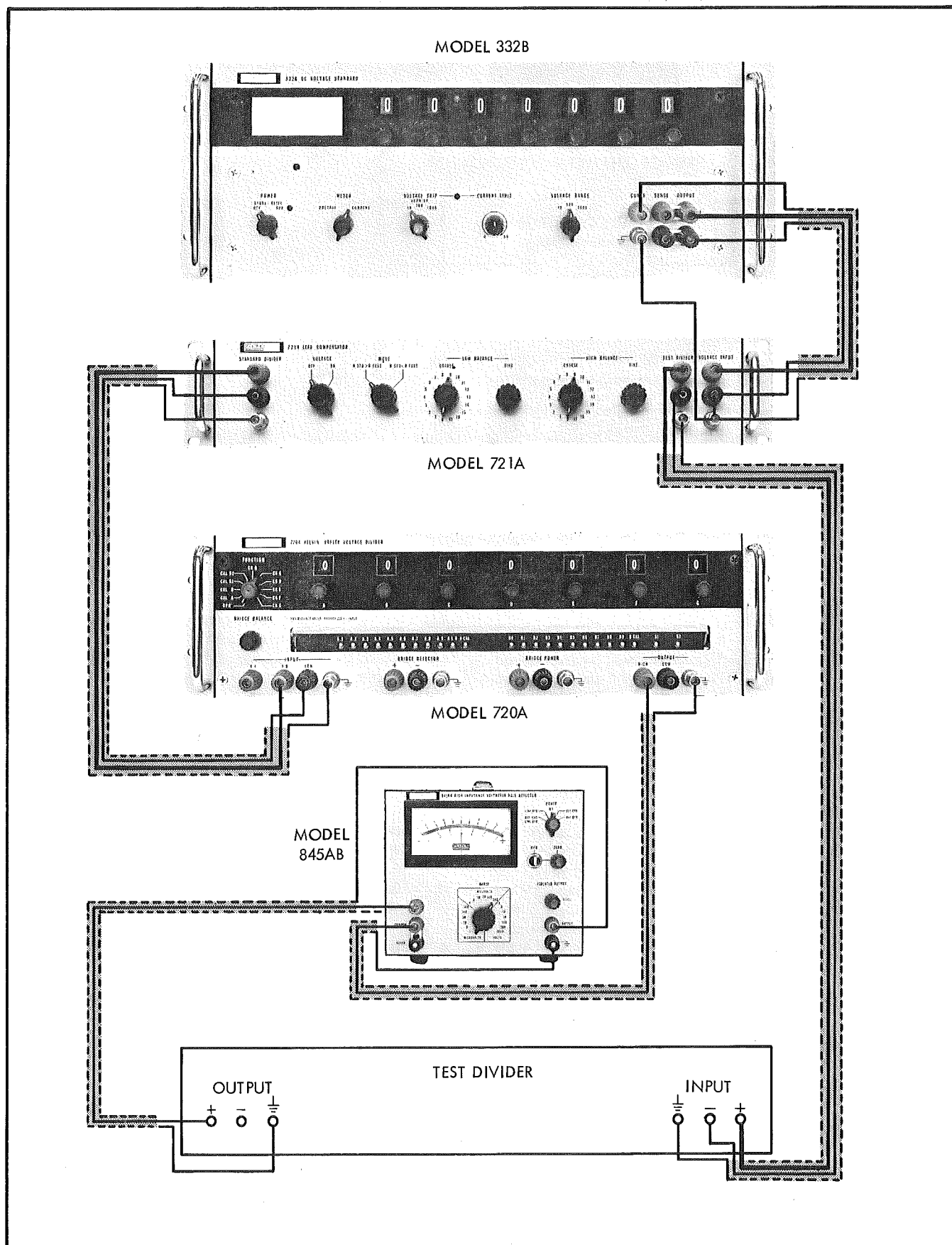


Figure 2-2. INTERCONNECTION OF UNITS FOR RATIO COMPARISON

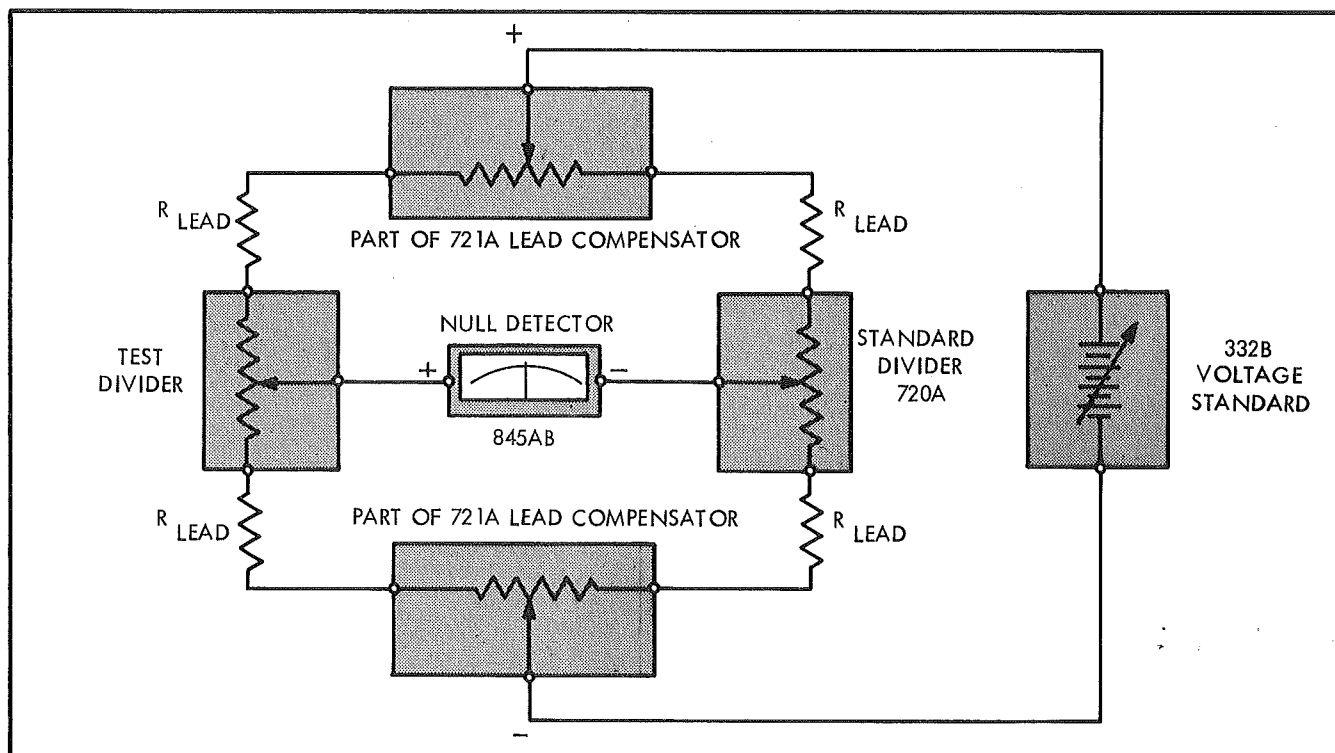


Figure 2-3. SCHEMATIC DIAGRAM OF EQUIPMENT CONNECTIONS

## 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:

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

## 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.

- Set the power supply to the desired output voltage.
- Set the MODE switch of the Model 721A to  $R_{\text{STD}} < R_{\text{TEST}}$  or  $R_{\text{STD}} > R_{\text{TEST}}$  as appropriate.
- Set both dividers to zero and turn the VOLTAGE switch of the Model 721A to OFF.
- Place the null detector in the zero mode of operation and adjust it for zero meter deflection.
- Return the null detector to the operating mode and set it to the desired sensitivity.
- 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.

- 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 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.

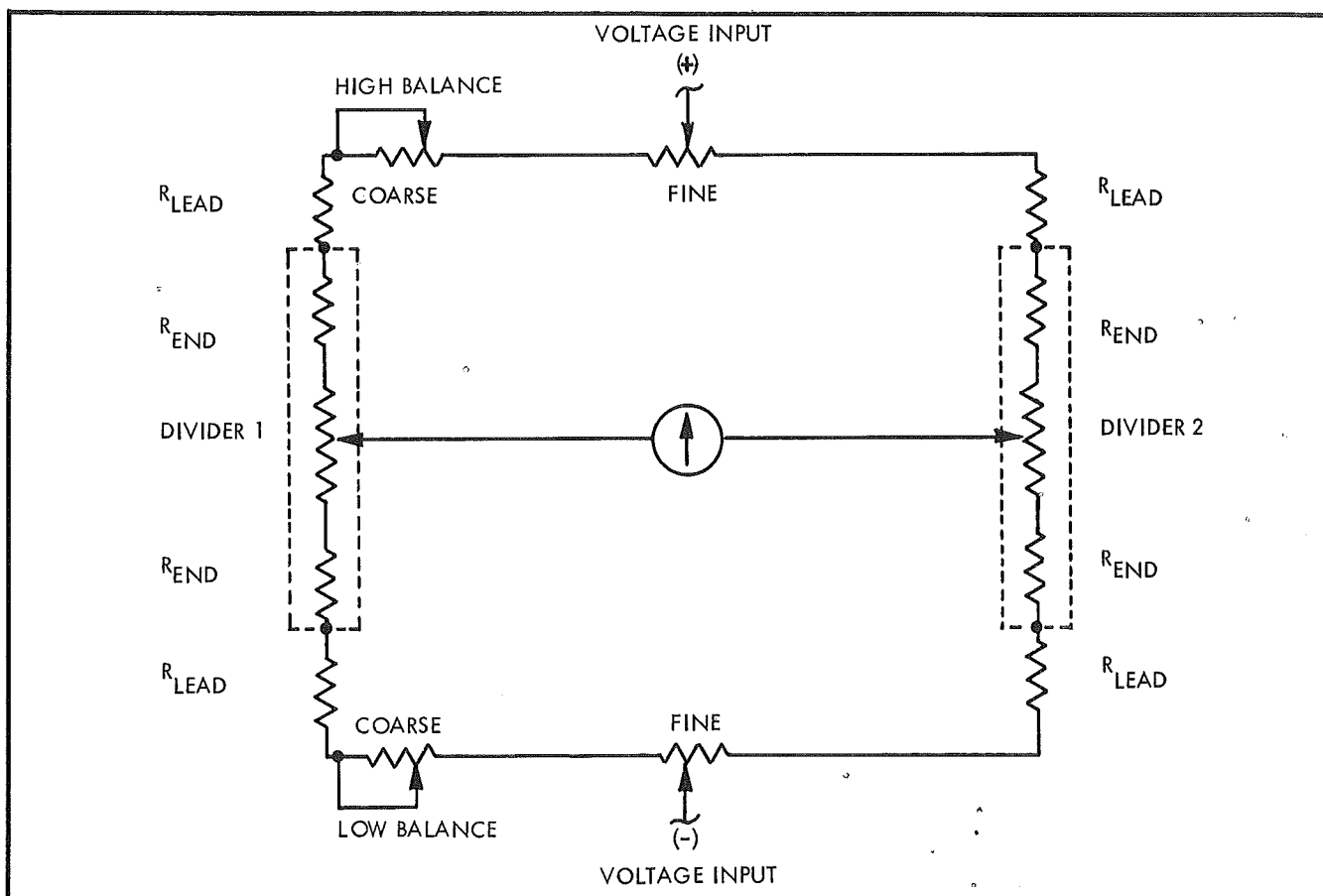


Figure 3-1. TYPICAL VOLTAGE DIVIDER CALIBRATION SETUP

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5

10.  $2^{10} \times 2^8 \times 2^6 \times 2^4 \times 2^2 \times 2^0 = 2^{30}$

1. The authors are grateful to the National Natural Science Foundation of China (Grant No. 81273055) for the financial support of this work.

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1. *Agave americana* L.

doi:10.1017/S0022292412001919

and  $\text{Fe}(\text{OH})_3$  precipitates.

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**Figure 1**

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## 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 occasional 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.

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

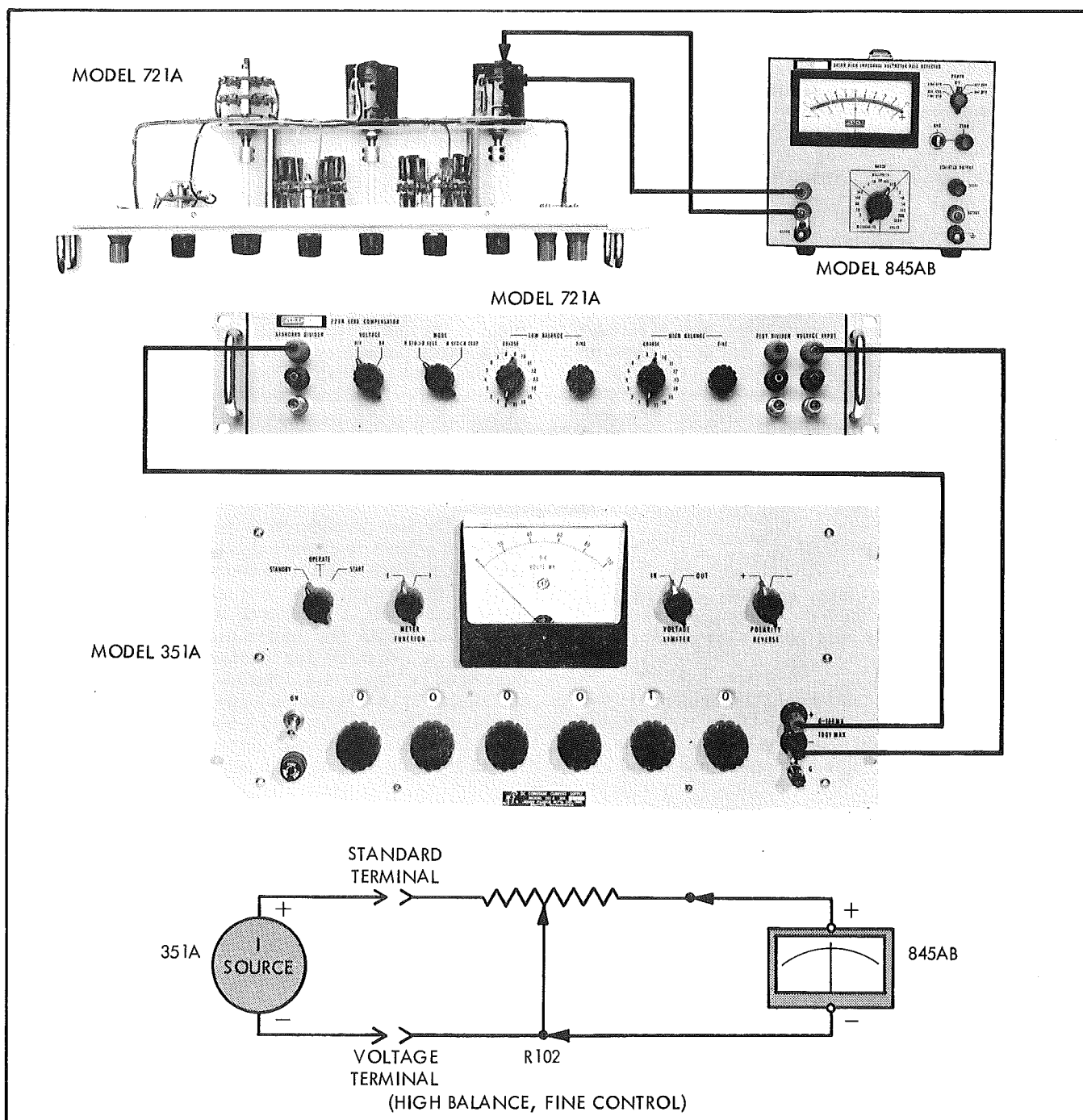


Figure 4-2. HIGH BALANCE CONTACT RESISTANCE

- 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.

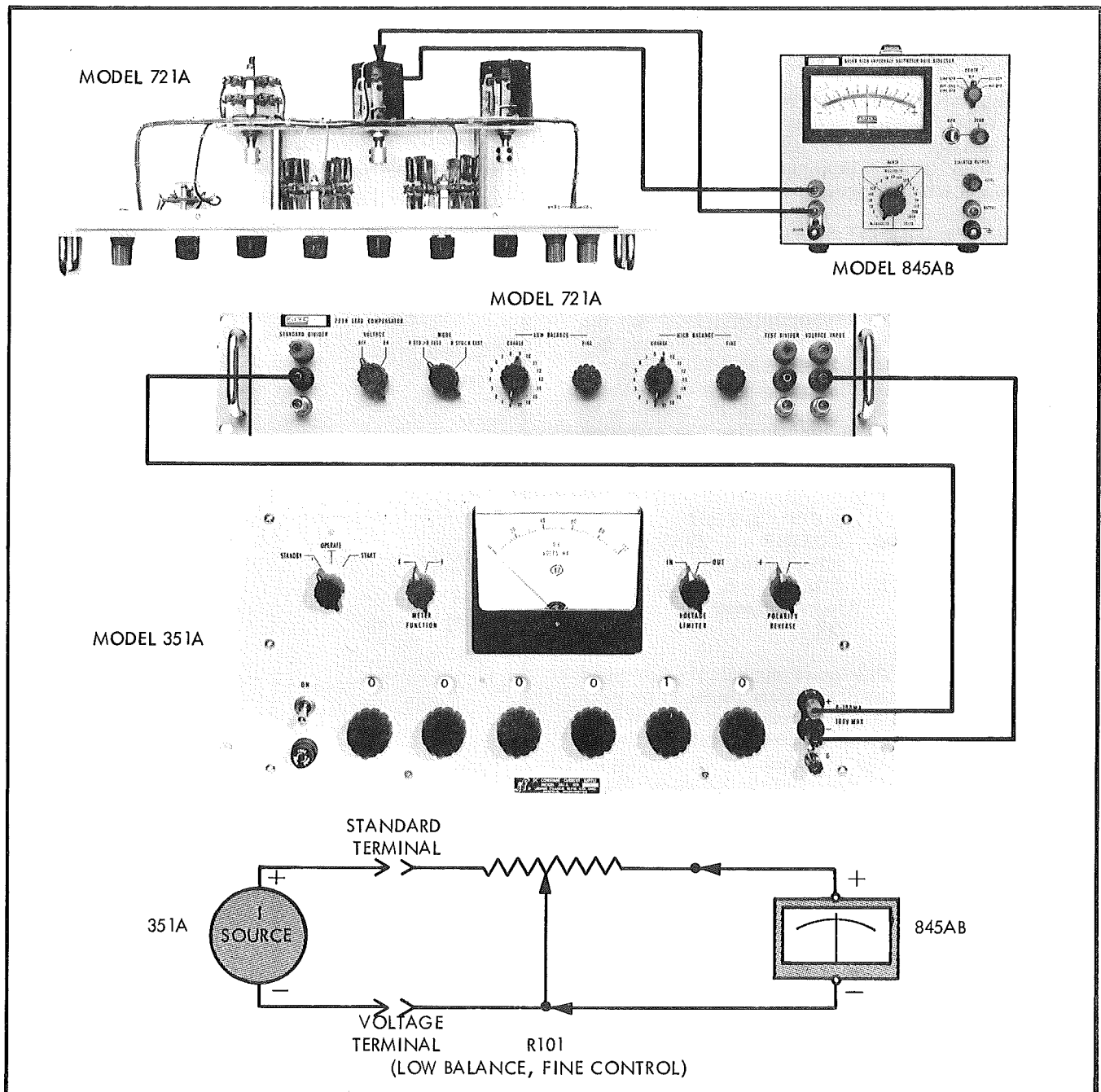


Figure 4-3. LOW BALANCE CONTACT RESISTANCE

## 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

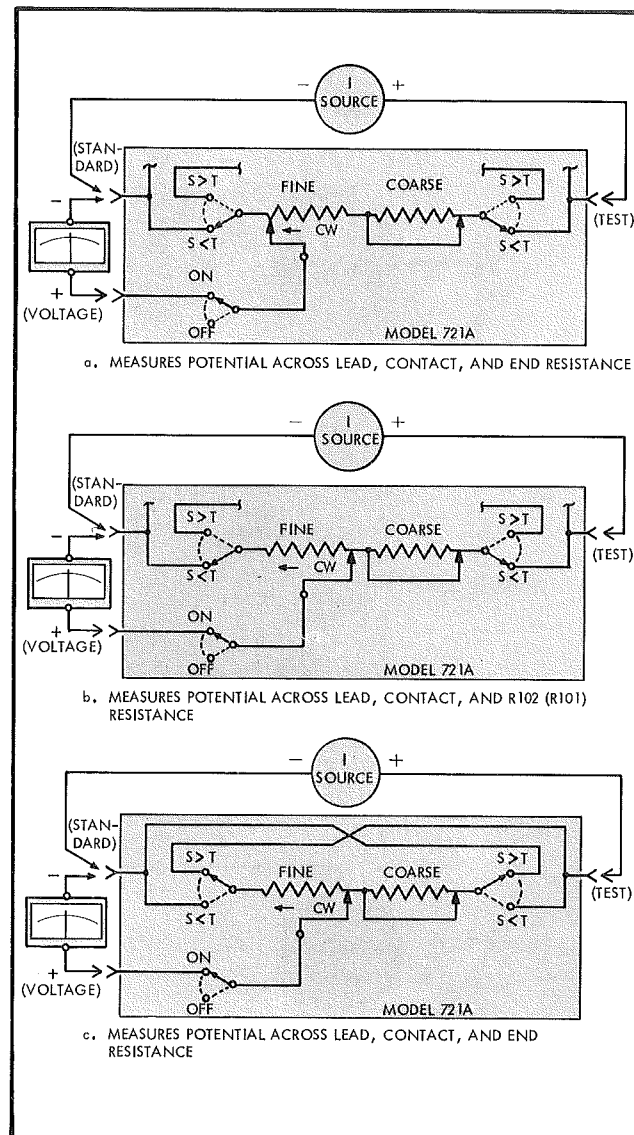


Figure 4-4. PRELIMINARY MEASUREMENTS



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.

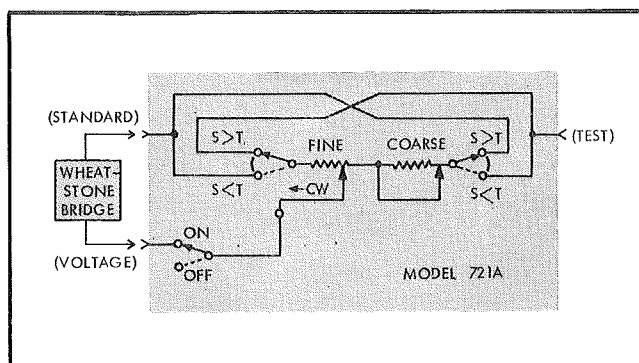


Figure 4-5. RANGE MEASUREMENTS

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:

- 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.
- 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

- Set the Model 845AB OPR-ZERO control to the OPR position. The Model 845AB should indicate less than 1 microvolt.
- 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.
- Set the MODE switch to the opposite position. The Model 845AB should indicate less than 1 microvolt.
- 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 throughout 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	mw	milliwatt
Al	Aluminum	na	nanoampere
amp	ampere	nsec	nanosecond
assy	assembly	nv	nanovolt
cap	capacitor	$\Omega$	ohm
car flm	carbon film	ppm	parts per million
C	centigrade	piv	peak inverse voltage
cer	ceramic	p-p	peak to peak
comp	composition	pf	picofarad
conn	connector	plstc	plastic
db	decibel	p	pole
dc	direct current	pos	position
dpdt	double-pole, double-throw	P/C	printed circuit
dpst	double-pole, single-throw	rf	radio frequency
elect	electrolytic	rfi	radio frequency interference
F	fahrenheit	res	resistor
Ge	germanium	rms	root mean square
gmV	guaranteed minimum value	rtry	rotary
h	henry	sec	second
Hz	hertz	sect	section
hf	high frequency	S/N	serial number
IC	integrated circuit	Si	silicon
if	intermediate frequency	scr	silicon controlled rectifier
k	kilohm	spdt	single-pole, double-throw
kHz	kilohertz	spst	single-pole, single-throw
kv	kilovolt	sw	switch
lf	low frequency	Ta	tantalum
MHz	megahertz	tstr	transistor
M	megohm	tvm	transistor voltmeter
met flm	metal film	uhf	ultrahigh frequency
ua	microampere	vtvm	vacuum tube voltmeter
uf	microfarad	var	variable
uh	microhenry	vhf	very high frequency
usec	microsecond	vlf	very low frequency
uv	microvolt	v	volt
ma	milliampere	va	voltampere
mh	millihenry	vac	volts, alternating current
m	milliohms	vdc	volts, direct current
msec	millisecond	w	watt
mv	millivolt	ww	wire wound

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

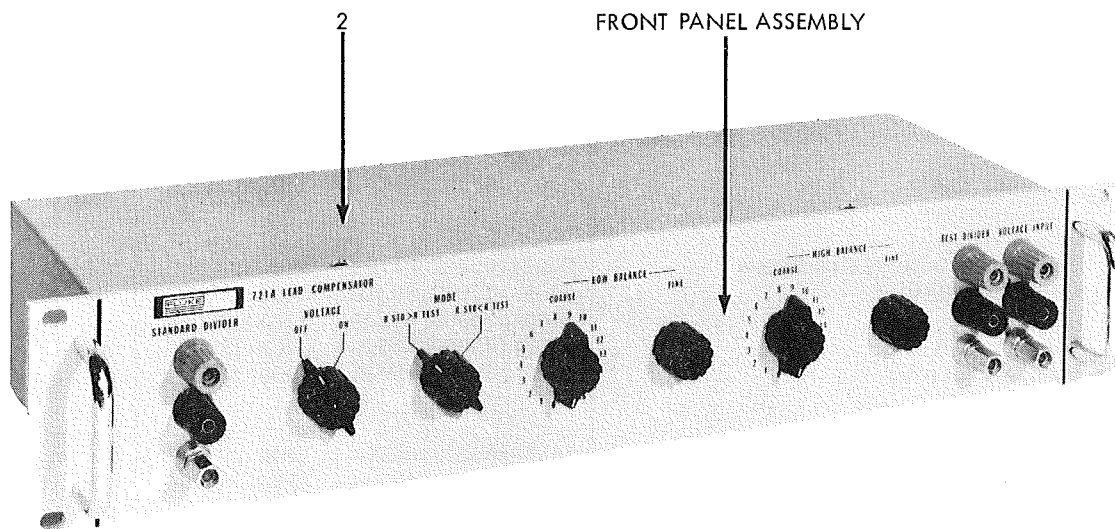


Figure 5-1. FINAL ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	<b>FRONT PANEL ASSEMBLY - Figure 5-2</b>						
	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, 0.15 $\Omega$ $\pm$ 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		

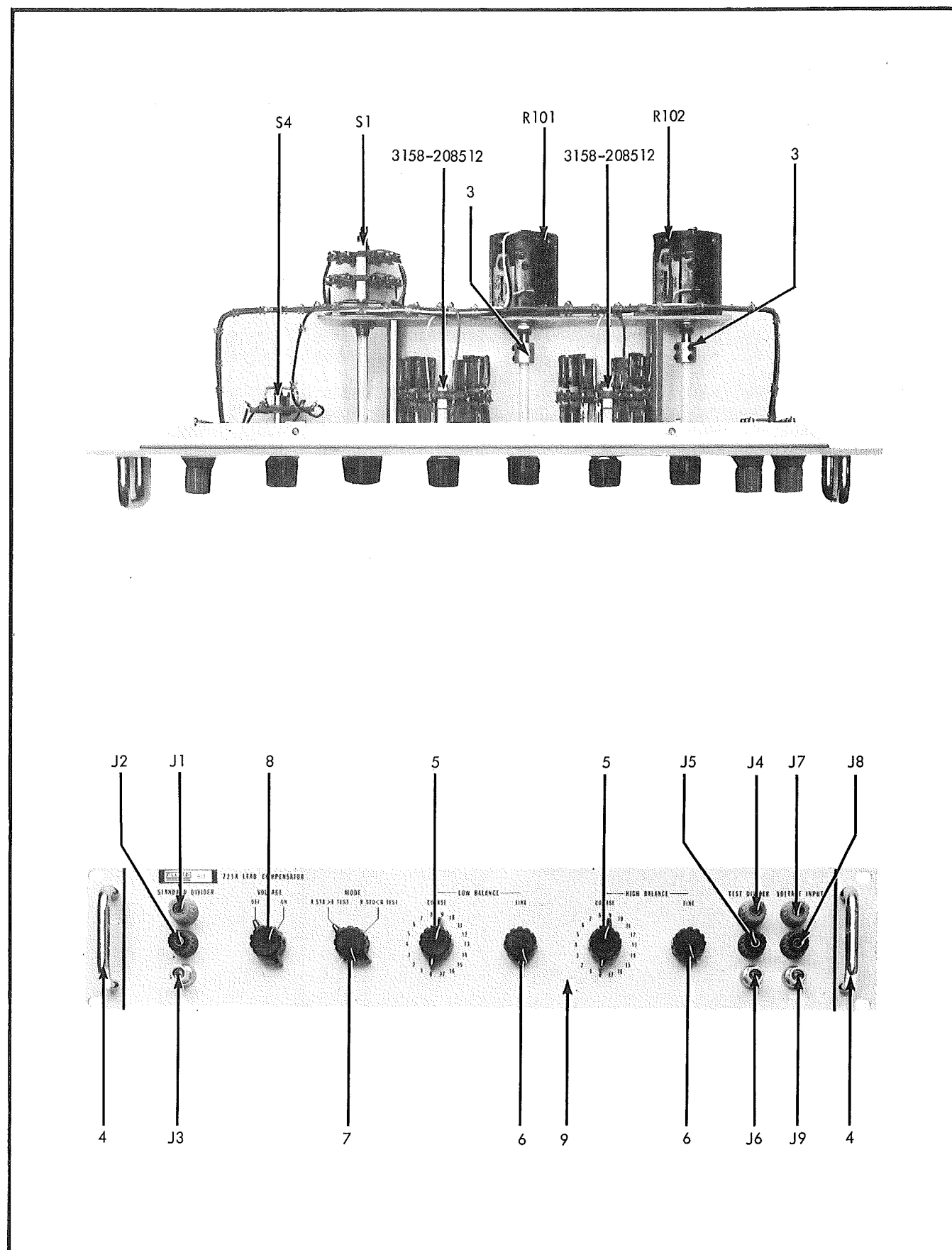


Figure 5-2. FRONT PANEL ASSEMBLY

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



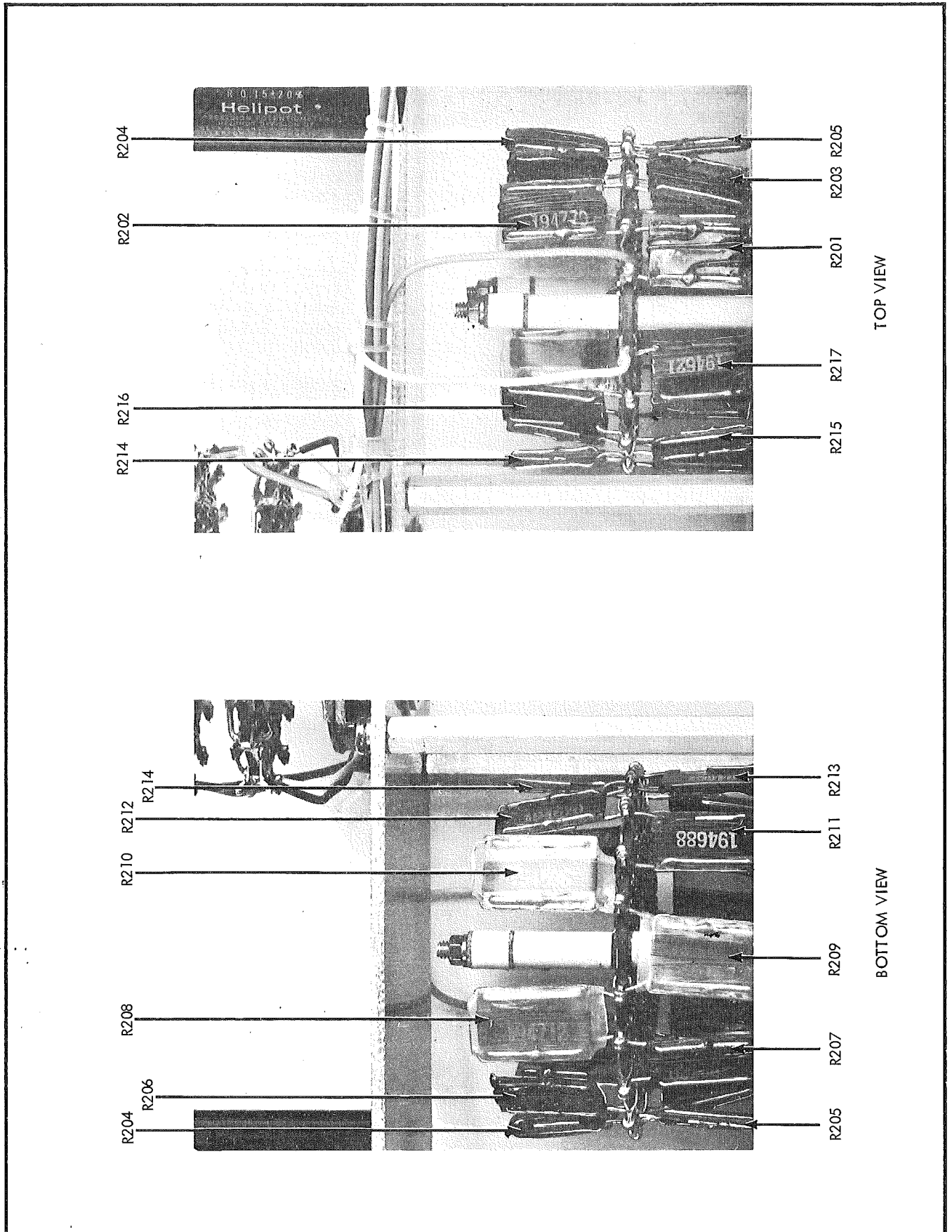


Figure 5-3. BALANCE SWITCH ASSEMBLY

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

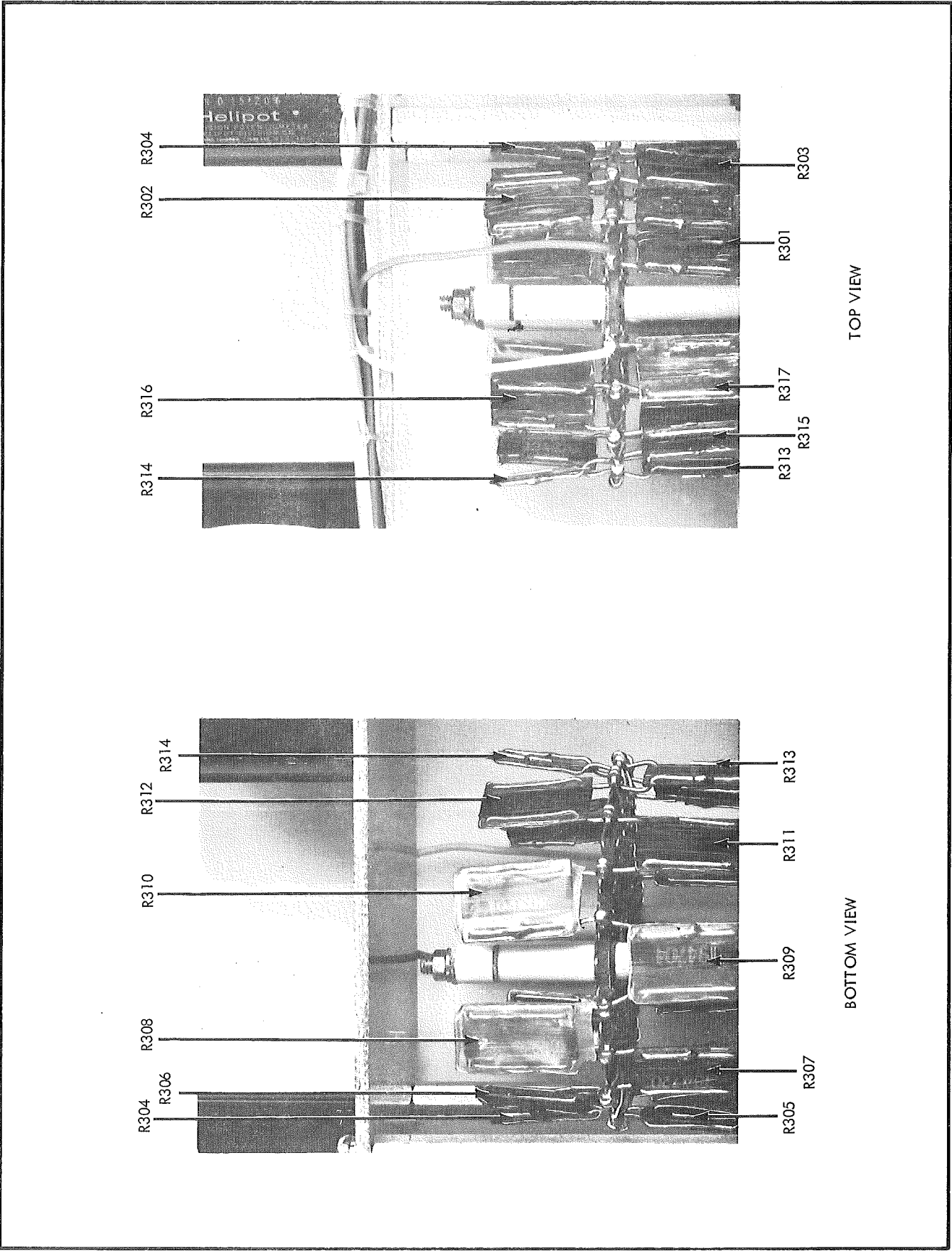


Figure 5-4. BALANCE SWITCH ASSEMBLY

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

# 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	18612 Vishay Resistor Products Div. Vishay Intertechnology Inc. Malvern, Pennsylvania	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	18736 Voltronics Corp. Hanover, New Jersey	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	18927 G T E Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania	28480 Hewlett Packard Co. Corporate H.Q. Palo Alto, California
12615 U.S. Terminals Inc. Cincinnati, Ohio	15818 Teledyne Semiconductors, formerly Amelco Semiconductor Mountain View, California	19451 Perine Machinery & Supply Co. Seattle, Washington	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	19701 Electro-Midland Corp. Mepco-Electra Inc. Mineral Wells, Texas	29083 Monsanto, Co., Inc. Santa Clara, California
12697 Clarostat Mfg. Co. Dover, New Hampshire	15898 International Business Machines Corp. Essex Junction, Vermont	20584 Enochs Mfg. Inc. Indianapolis, Indiana	29604 Stackpole Components Co. Raleigh, North Carolina
12749 James Electronics Chicago, Illinois	15909 Replaced by 14140	20891 Self-Organizing Systems, Inc. Dallas, Texas	30148 A B Enterprise Inc. Ahoskie, North Carolina
12856 Micrometals Sierra Madre, California	16258 Space-Lok Inc. Burbank, California	21604 Buckeye Stamping Co. Columbus, Ohio	30323 Illinois Tool Works, Inc. Chicago, Illinois
12954 Dickson Electronics Corp. Scottsdale, Arizona	16299 Corning Glass Electronic Components Div. Raleigh, North Carolina	21845 Solitron Devices Inc. Transistor Division Riveria Beach, Florida	31091 Optimax Inc. Colmar, Pennsylvania
12969 Unitrode Corp. Watertown, Massachusetts	16332 Replaced by 28478	22767 ITT Semiconductors Palo Alto, California	32539 Mura Corp. Great Neck, New York
13103 Thermalloy Co., Inc. Dallas, Texas	16473 Cambridge Scientific Ind. Div. of Chemed Corporation Cambridge, Maryland	23050 Product Comp. Corp. Mount Vernon, New York	32767 Griffith Plastic Corp. Burlingame, California
13327 Solitron Devices Inc. Tappan, New York	16742 Paramount Plastics Fabricators, Inc. Downey, California	23732 Tracor Inc. Rockville, Maryland	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	23880 Stanford Applied Engrng. Santa Clara, 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	23936 Pamotor Div., Wm. J. Purdy Co. Burlingame, California	32997 Bourns Inc. Trimpot Products Division Riverside, California
13839 Replaced by 23732		24248 Replaced by 94222	33173 General Electric Co. Products Dept. Owensboro, Kentucky
		24355 Analog Devices Inc. Norwood, Massachusetts	

# Federal Supply Codes for Manufacturers (Continued)

34333 Silicon General Westminster, 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	73445 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
49671 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. Carrollton, 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 Cutler-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			

# Federal Supply Codes for Manufacturers (Concluded)

82415 North American Phillips Controls Corp. Frederick, Maryland	88245 Litton Systems Inc. Unesco 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 Jewitt 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 Burroughs 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	Toyco 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. Anaheim, 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		



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