FLUKE 7100 SERIES
SYSTEM MANUAL

LIST OF ILLUSTRATIONS

(continued on page iv)

LIST OF ILLUSTRATIONS, *continued*

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. This manual provides operating and servicing instructions for the Model 7100B, 7101B, 7103A, 7104A, and the 7105A DC Voltage and Ratio Calibration Systems. Electrical and physical characteristics are contained here in Section I, and installation and operating instructions are contained in Section II. Section III contains the system theory of operation and unique calibration procedures. Section IV contains the individual Instruction Manuals for each instrument comprising the various systems.

1-3. SYSTEM DESCRIPTIONS

1-4. The Model 7100 DC Calibration Systems are designed to supply and measure dc voltages and compare dc voltages and resistance ratios with measurements traceable to the National Bureau of Standards. Generation and measurement of voltages from 0 to 1100 volts dc is available with the Model 7100B and the 7103A. The sam capability, in addition to measurement of voltage an resistance ratios and calibration of voltage dividers, is a vailable with the Model 7101B, 7104A, and the 7105A The Model 7101B, 7104A, and 7105A are also "self calibrating" systems in that their ratio accuracy can b maintained without the use of any external equipment o standards.

1-5. SPECIFICATIONS

1-6. The makeup and capability of each Model 710 System is listed in Figure 1-1. Stated accuracies are a standard reference conditions of 23°C ±1°, at up to 70 relative humidity with a constant line voltage. Specification for each instrument contained in the systems are availabl in the Instruction Manuals located in Section IV. Charac teristics of the two null detectors contained in the Mode 7105A System are listed in Figure 1-2.

MODEL 7100B		
VOLTAGE STANDARD 332B	REFERENCE DIVIDER 750A	NULL DETECTOR 845AR

APPLICATION	ACCURACY [1]
Voltmeter Calibrator	10 ppm/year
Power Supply Calibrator	10 ppm/year
Differential Voltmeter	20 ppm

MODEL 7103A		
VOLTAGE STANDARD 335A	REFERENCE DIVIDER 750A	NULL DETECTOR 335A

APPLICATION	ACCURACY [1]
Voltmeter Calibrator	10 ppm/year
Power Supply Calibrator	10 ppm/year
Differential Voltmeter	20 ppm

MODEL 7101B				
VOLTAGE STANDARD	REFERENCE DIVIDER	NULL DETECTOR	LEAD COMPENSATOR	KELVIN-VARLEY DIVIDER
332B	750A	845AR	721A	720A

APPLICATION	ACCURACY [1]
Voltmeter Calibrator	5 ppm to 100v, 8 ppm to 1100v
Power Supply Calibrator	5 ppm to 100v, 8 ppm to 1100v
Differential Voltmeter	10 ppm to 100v, 20 ppm to 1100v
Ratio Calibrator	0.1 ppm of input

MODEL 7104A				
VOLTAGE STANDARD	REFERENCE DIVIDER	NULL DETECTOR	LEAD COMPENSATOR	KELVIN-VARLEY DIVIDER
335A	750A	335A	721A	720A

APPLICATION	ACCURACY [1]
Voltmeter Calibrator	5 ppm to 100v, 8 ppm to 1100v
Power Supply Calibrator	5 ppm to 100v, 8 ppm to 1100v
Differential Voltmeter	10 ppm to 100v, 20 ppm to 1100v
Ratio Calibrator	0.1 ppm of input

MODEL 7105A				
VOLTAGE STANDARD	REFERENCE DIVIDER	NULL DETECTOR	LEAD COMPENSATOR	KELVIN-VARLEY DIVIDER
335A	750A	335A and 845AR	721A	720A

APPLICATION	ACCURACY [1]
Voltmeter Calibrator	5 ppm to 100v, 8 ppm to 1100v
Power Supply Calibrator	5 ppm to 100v, 8 ppm to 1100v
Differential Voltmeter	5 ppm to 100v, 20 ppm to 1100v
Ratio Calibrator	0.1 ppm of input

[1] Standard Cell uncertainty not included

Figure 1-1. SYSTEM SPECIFICATIONS

	MODEL 845AR	MODEL 335A
RANGES	1 uv to 1000v in X1 and X3 progression	10 uv to 1000v in X10 progression
Input Resistance	10M 1 mv to 100 mv 100M 300 mv to 1000v	1M 10 uv to 1 mv 10M 10 mv to 100 mv 100M 1v to 1000v
Resolution	0.2 uv, maximum	0.5 uv, maximum
Isolation	10^{12} ohms for each model. Either terminal of the input may be floated up to 1100 volts from ground.	
Recorder Output	Each model provides an isolated output, 0 to 1.0v.	

Figure 1-2. NULL DETECTOR CHARACTERISTICS

1-7. MECHANICAL DESCRIPTION

1-8. Each system is mounted in a controlled heat-rise cabinet having heat insulators between each instrument, a cooling fan, and a dust filter. The cabinet is fitted with an ac input power receptacle, resilient feet, and fold-out carrying handles. A complete set of test leads and a storage drawer are also provided with each system. Cabinet dimensions are 29 inches high by 20 inches wide by 29 inches deep. An outline drawing of a system is illustrated in Figure 1-3. Blank panels are provided for systems having fewer instruments than the one illustrated in Figure 1-3. System weights are as follows:

SYSTEM	WEIGHT (LBS)
7100B	105
7103A	95
7101B	130
7104A	120
7105A	130

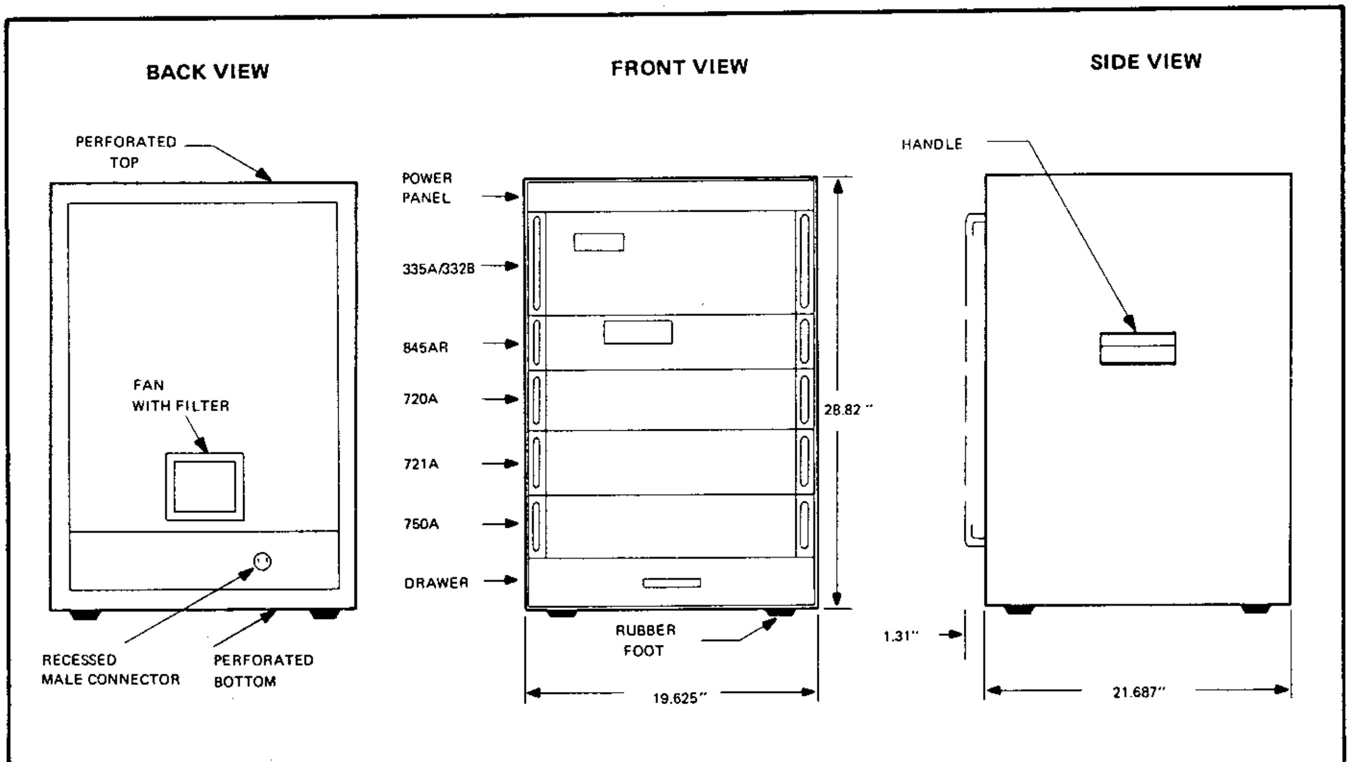

Figure 1-3. SYSTEM OUTLINE DRAWING.

SECTION II

OPERATING INSTRUCTIONS

2-1. INTRODUCTION

2-2. This section of the manual contains information essential for the correct operation and performance of the Model 7100 Systems. It is recommended that the contents of this section be thoroughly read and understood before attempting to operate any of these systems.

2-3. Should any difficulties be encountered during the operation of a system, please feel free to contact the nearest John Fluke Sales Representative or write the John Fluke Mfg. Co., Inc., Box 7428, Seattle, Washington 98133, with a statement of the problem. A complete list of Sale Representatives is located at the rear of this manua

2-4. SYSTEM INSTALLATION PROCEDURE

2-5. The instruments and cabinet comprising eac system are shipped in separate containers and must b assembled in a prescribed manner to provide the desire operating temperatures throughout the cabinet. Correc location of each instrument is illustrated in Figure 2-1 Attaching hardware for each instrument is included wit the cabinet. The resilient feet on the bottom of th instruments must be removed before installation in th cabinet.

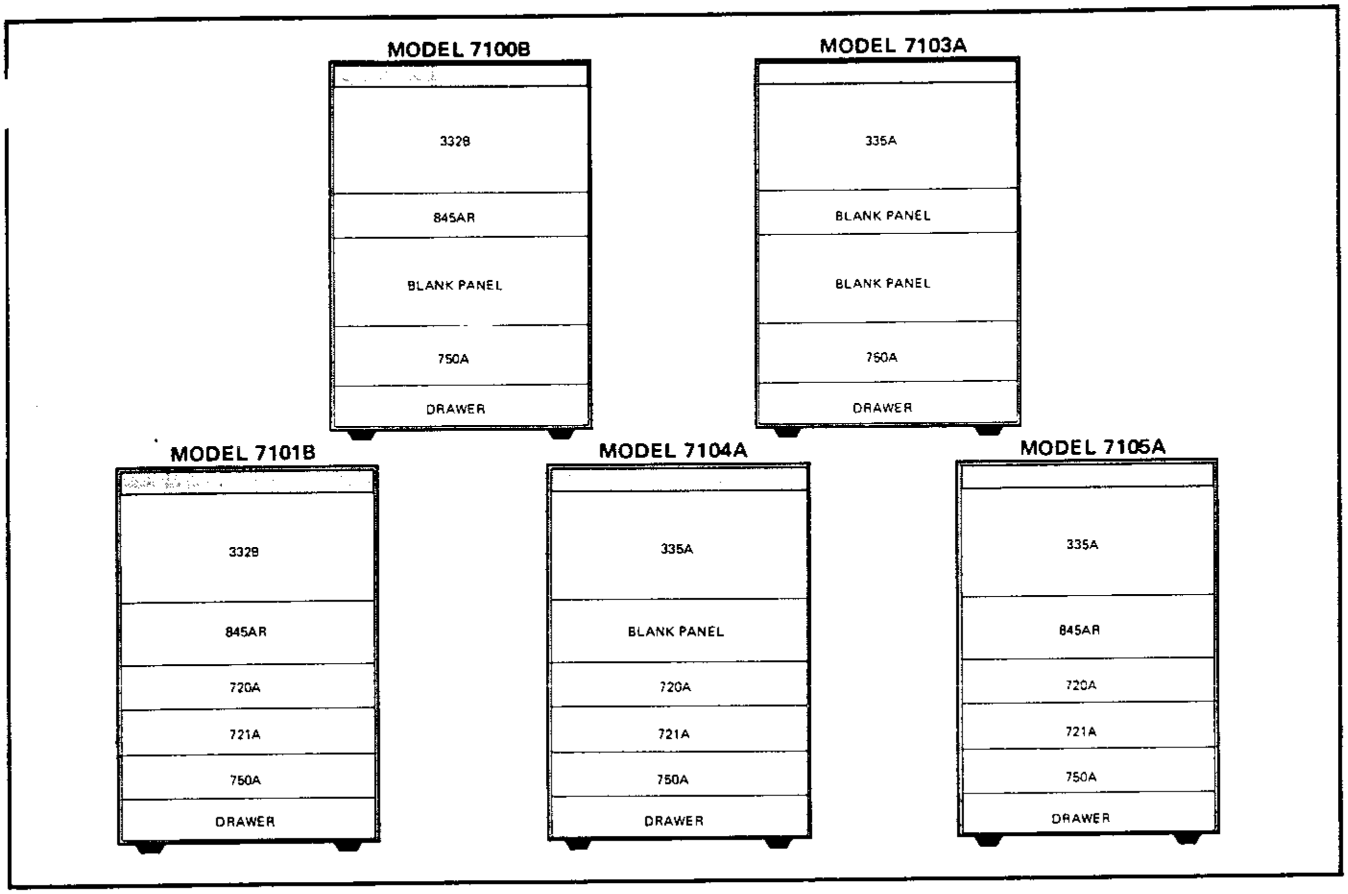

Figure 2-1. SYSTEM PANEL LAYOUT

2-6. INPUT POWER

2-7. Each system is shipped wired for operation from either a 115 or 230 volt ac power source. Power requirements are approximately 135 volt-amperes. To apply ac power to the system, perform the following steps:

a. Open the door on the rear of the cabinet and connect the instrument power cords to the receptacles on the power box.

b. Connect the system power cord to the ac line source.

c. Set the cabinet front panel toggle switch to ON. The front panel pilot lamp should illuminate and an air flow should be felt through the rear panel dust filter.

d. Set the Model 332B or 335A POWER switch to STDBY/RESET.

e. Set the Model 845AR, if installed in the system, POWER switch to ON.

CAUTION!

Ensure that the round pin on the three-prong power cord plug is connected to a high-quality earth ground.

Note!

The pilot lamps associated with the POWER switches on the Model 332B, 335A, and 845AR should be illuminated when their respective power switches are set to OPR or ON.

2-8. INITIAL SYSTEM VERIFICATION TESTS

2-9. Correct operation of each instrument in the system can be verified using applicable maintenance instructions contained in the Instruction Manuals located in Section IV. Test equipment necessary to perform these tests are listed in the respective Instruction Manuals.

2-10. APPLICATIONS

2-11. Introduction

2-12. The following paragraphs describe various applications of the Model 7100 Systems. Capabilities of each

APPLICATION	SYSTEM
POWER SUPPLY CALIBRATOR	ALL
VOLTMETER CALIBRATOR:	
Loading or Non-Loading Voltmeter at Model 750A Output Settings.	ALL
Loading Voltmeter at Points Other Than Model 750A Output Settings.	Model 7101B, 7104A, 7105A
DIFFERENTIAL VOLTMETER:	
20 ppm Accuracy	ALL
5–10 ppm Accuracy	Model 7101B, 7104A, 7105A
RATIO CALIBRATOR:	
Voltage Divider Calibrator	Model 7101B, 7104A, 7105A
Resistance Measurements	Model 7102B, 7104A, 7105A
STABILITY MEASUREMENTS	ALL

Figure 2-2. SYSTEM APPLICATION CAPABILITIES.

system are listed in Figure 2-2. Operating procedures and obtainable accuracies are described in the associated application paragraphs.

2-13. Application Notes

2-14. INITIAL OPERATION. Before attempting any measurements, the system should be energized using the procedures contained in paragraph 2-6 and allowed to operate for one hour at the ambient room temperature. Standard reference conditions of 23°C ±1°, at up to 70% relative humidity should be maintained to achieve the specified system accuracies.

2-15. TEMPERATURE COEFFICIENT. If the operating temperature is more than ±1°C from the standard reference condition of 23°C, appropriate derating factors must be applied to the accuracy specifications of each instrument in the system or they must be recalibrated at the new operating temperature. Refer to the Instruction Manuals located in Section IV for the derating factors and calibration procedures.

2-16. STANDARD CELLS. The accuracy of a system measurement is no better than the uncertainty and stability of the standard cell used with the Model 750A. This standard cell has a basic uncertainty of no greater than ±1 ppm when certified by the National Bureau of Standards, but by the time it reaches the user's facility, the uncertainty is greater than ±1 ppm. As time passes the basic uncertainty will increase even further unless periodic monitoring and evaluation of the cell's emf in a controlled environment is undertaken. A laboratory with several banks of cells in enclosures at different internal temperatures can reduce the uncertainty to ±2 ppm. However, a laboratory with only one bank of four cells mounted in a single enclosure will probably only reduce the uncertainty to ±4 ppm.

2-17. THERMALS. The heating at a junction of dissimilar metals in a circuit connection can cause a thermocouple effect known as thermal emfs. These voltages will contribute an error to measurements using nulling techniques. A suggested means of minimizing these effects is given below.

a. Perform the nulling measurement.

b. Remove the test voltage from the circuit and record the null detector indication.

c. Apply the test voltage and adjust the standard divider for the null detector indication observed in step b.

2-18. Power Supply Calibrator

2-19. Power supplies can be calibrated using any of the Model 7100 Systems. Obtainable system accuracies are given in Figure 2-3. To operate the system as a Power Supply Calibrator, perform the following steps:

SYSTEM TEST VOLTAGE	SYSTEM ACCURACIES (ppm)	
	MODEL 7101B, 7104A,7105A	MODEL 7100B, AND 7103A
1100	7	10
1000	7	10
500	7	10
100	5	10
50	4	10
10	4	10
5	4	10
1.1	4	10

Figure 2-3. POWER SUPPLY CALIBRATOR ACCURACIES

a. Set the Model 750A controls to the following positions:

STD CELL CIRCUIT	OPEN
STANDARD CELL VOLTAGE Dials	Standard Cell Voltage
INPUT VOLTAGE Switch	RESET
OUTPUT VOLTAGE Switch	Desired Test Power Supply Output Voltage

Note!

Setting the INPUT VOLTAGE switch to RESET disconnects the Model 750A over-voltage protection circuit to ensure calibration accuracy.

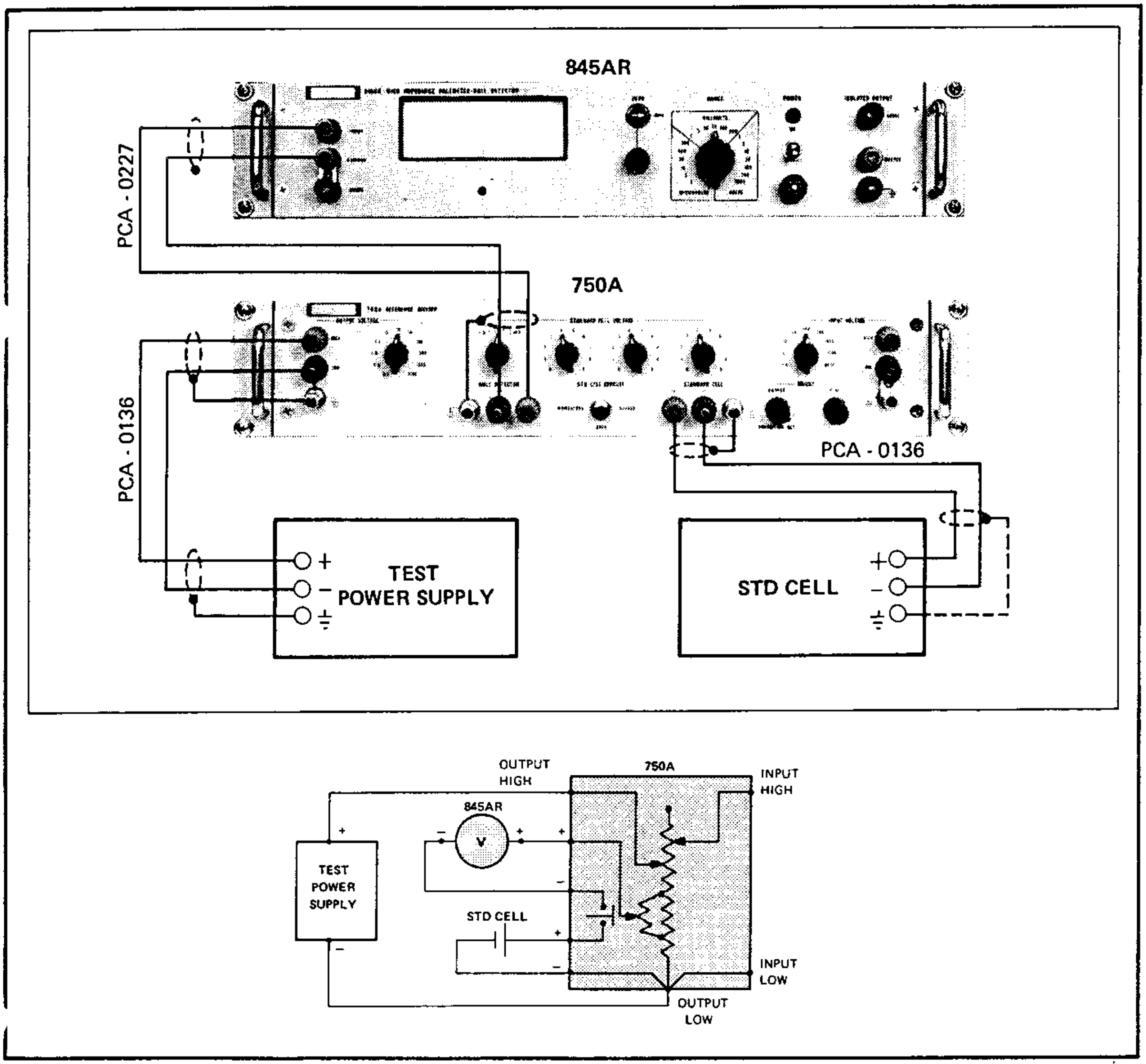

Figure 2-4. POWER SUPPLY CALIBRATION CONNECTIONS

b. Set the Model 335A or Model 845AR null detector controls to the following positions:

ZERO/OPR	OPR
RANGE	Desired sensitivity

c. Make the equipment connections illustrated in Figure 2-4.

d. Energize the test power supply and allow the instrument to reach equilibrium temperature.

e. Hold the Model 750A STD CELL CIRCUIT switch to MOMENTARY and adjust the test power supply calibration control to obtain a null on the null detector.

f. Increase the null detector sensitivity by selecting a lower range and repeat step e.

g. Repeat steps e and f until a null indication is obtained on the 10 microvolt range of the null detector. The test power supply is now calibrated to the voltage selected with the Model 750A OUTPUT VOLTAGE switch.

CAUTION!

If the power supply is to be tested at other lower output voltages, always decrease its output before decreasing the Model 750A OUTPUT VOLTAGE Switch setting.

2-20. Voltmeter Calibrator

2-21. LOADING AND NON-LOADING VOLTMETERS AT MODEL 750A OUTPUT SETTINGS. Loading and non-loading voltmeters can be calibrated using any of the Model 7100 Systems. System calibration accuracies for non-loading voltmeters are given in Figure 2-5. The input impedance of loading voltmeters will contribute additional errors at 0.1 to 1.0 volt dc calibration points. Figure 2-6 contains typical examples of these errors. To operate a system as a voltmeter calibrator, perform the following steps:

a. Set the Model 750A controls to the following positions:

STD CELL CIRCUIT	OPEN
STANDARD CELL VOLTAGE Dials	Standard Cell Voltage

SYSTEM TEST VOLTAGE	SYSTEM ACCURACIES (ppm)	
	MODEL 7101B, 7104A, 7105A	MODEL 7100B AND 7103A
1100	8	10
1000	8	10
500	6	10
100	5	10
50	5	10
10	5	10
5	5	10
1.1	5	10
1.0	5	10
0.5	6	10
0.1	8	10

Figure 2-5. NON-LOADING VOLTMETER CALIBRATION ACCURACIES

VOLTMETER INPUT IMPEDANCE (Megohms)	MODEL 750A OUTPUT ERROR	
	0.1, 1.0 Volts	0.5 Volts
1	−0.9%	−2.4%
10	−0.09%	−0.25%
100	−0.009%	−0.025%
1000	−0.0009%	−0.0025%
10000	−0.9 ppm	−2.5 ppm

Figure 2-6. LOADING VOLTMETER ERRORS

INPUT VOLTAGE Switch	Desired Input Voltage
INPUT VOLTAGE COARSE	Midrange
OUTPUT VOLTAGE Switch	Desired Test Voltage

b. Set the Model 335A or Model 845A null detector controls to the following positions:

ZERO/OPR	OPR
RANGE	Desired Sensitivity

c. Make the equipment connections illustrated in Figure 2-7 or 2-8.

d. Set the Model 332B or 335A voltage dials to the Model 750A INPUT VOLTAGE selected in step a and then select the OPR mode.

e. Hold the Model 750A STD CELL CIRCUIT switch to momentary and adjust the voltage dials on the Model 332B or 335A until a null is obtained on the null detector.

f. Increase the null detector sensitivity by selected successively lower ranges and repeating step e.

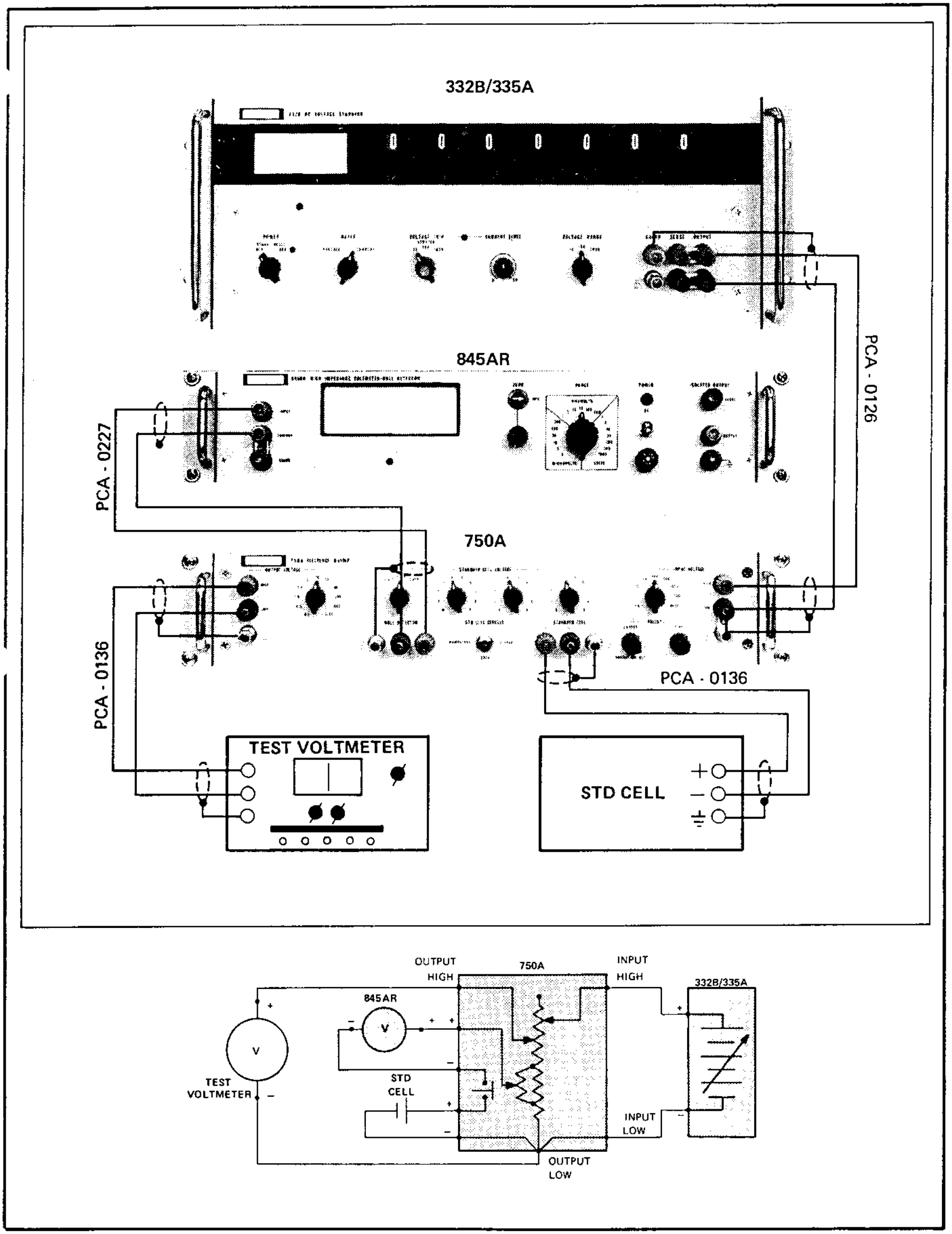

Figure 2-7. CONNECTIONS FOR VOLTMETER CALIBRATION AT 750A OUTPUT SETTINGS, SYSTEMS 7100B, 7101B AND 7105A.

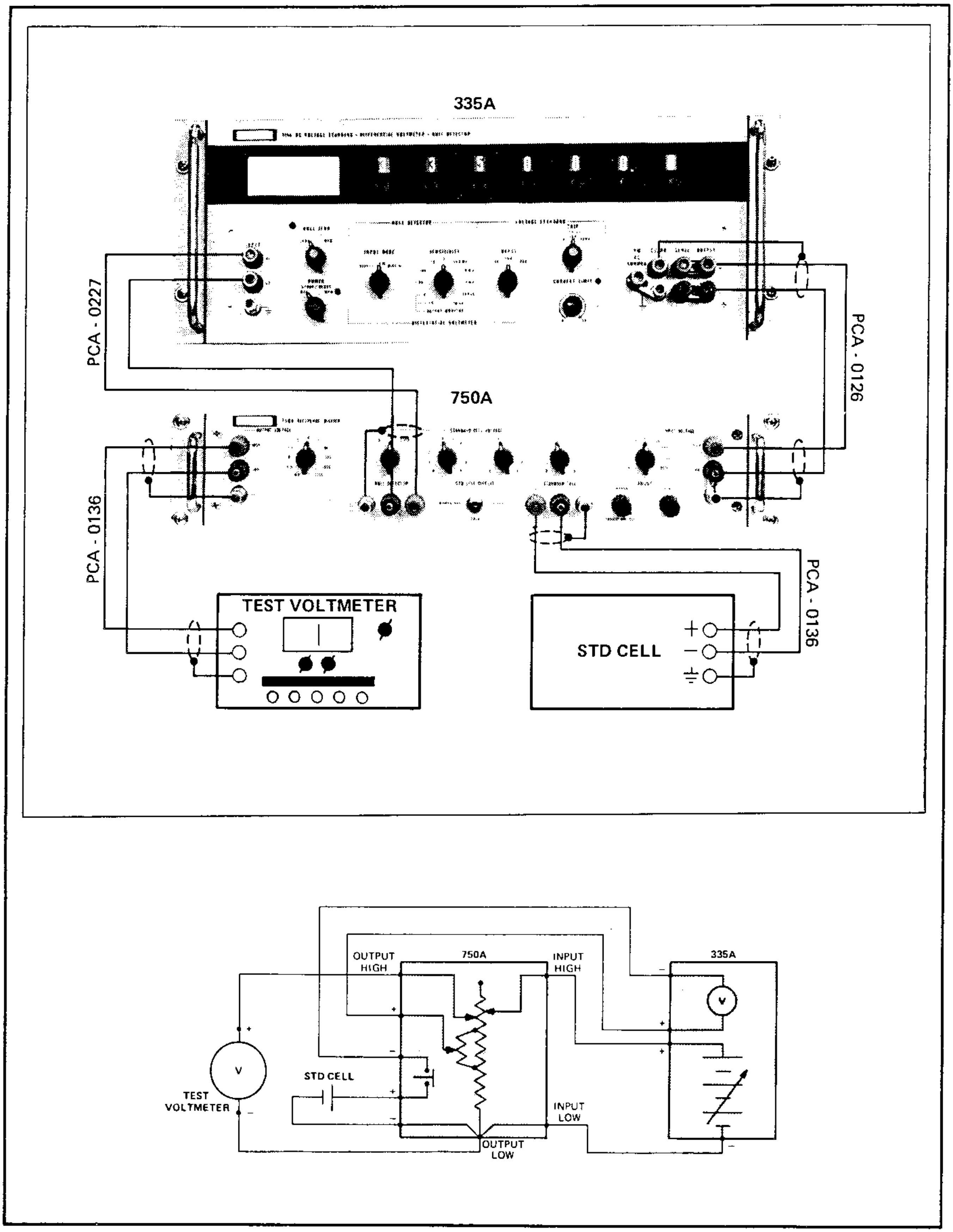

Figure 2-8. CONNECTIONS FOR VOLTMETER CALIBRATION AT 750A OUTPUT SETTINGS, SYSTEMS 7103A AND 7104A

g. Repeat steps e and f until a null indication (0 ±0.5 uv) is obtained on the 10 microvolt range of the null detector.

h. The desired voltmeter calibration voltage is now available at the OUTPUT VOLTAGE terminals of the Model 750A.

Note!

The setting of the Model 750A OUTPUT VOLTAGE switch must not exceed the INPUT VOLTAGE switch setting.

2-22. LOADING VOLTMETERS AT POINTS OTHER THAN MODEL 750A OUTPUT SETTINGS. The Model 7101B, 7104 or 7105A system, when used with a decade divider having adequate resolution capabilities, can be employed to calibrate loading voltmeters at points other than the Model 750A output settings. In this application, two null detectors are used to provide a continuous monitor of the standard divider calibration and the decade divider output voltage applied to the test voltmeter. A simplified schematic diagram of the test equipment is illustrated in Figure 2-9. Obtainable accuracies are given in Figure 2-10. An additional error consisting of the reading resolution of the test voltmeter and the short-term instability of the voltage standard must be added to the values given in Figure 2-10 to determine the actual system accuracy.

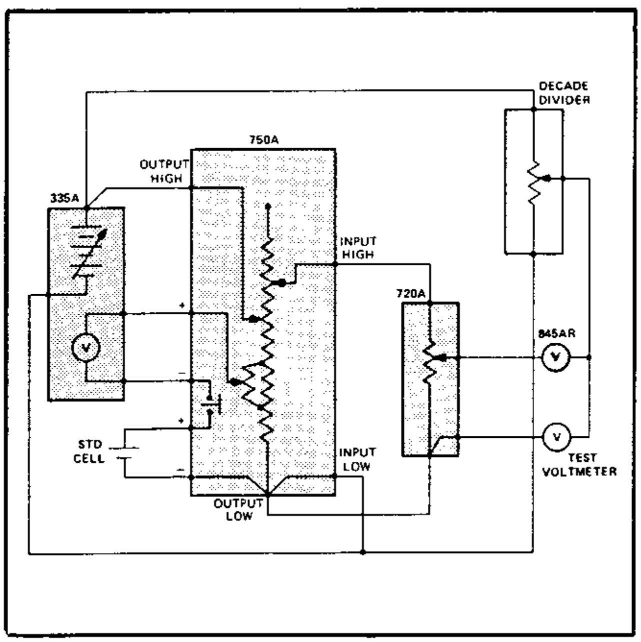

Figure 2-9. SCHEMATIC DIAGRAM OF LOADING VOLTMETER CALIBRATION, SYSTEM 7105A

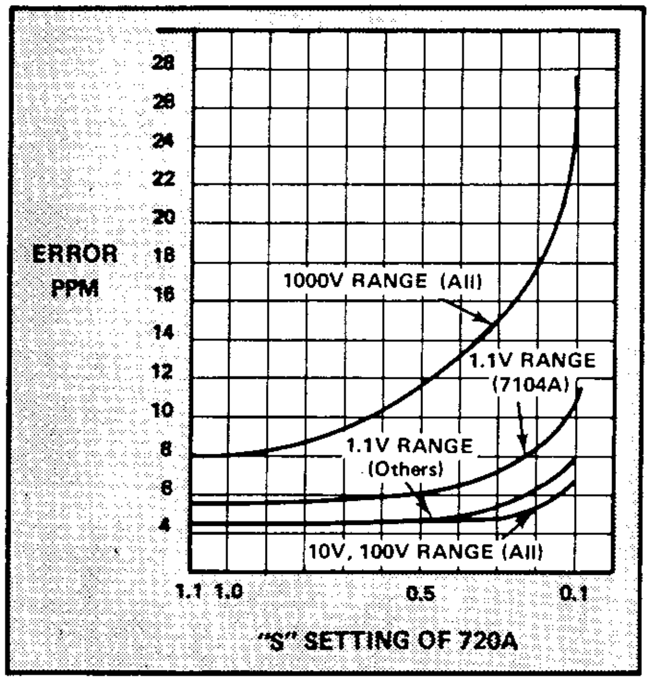

Figure 2-10. ERROR LIMIT CURVES

2-23. To operate a system as a loading voltmeter calibrator, perform the following steps:

a. Set the Model 750A controls to the following positions:

STD CELL CIRCUIT	OPEN
STANDARD CELL VOLTAGE Dials	Standard Cell Voltage
INPUT VOLTAGE Switch	Desired Decade Divider Input Voltage
INPUT VOLTAGE COARSE	Midrange
OUTPUT VOLTAGE Switch	Desired Model 720A Input Voltage

b. Make the equipment connections illustrated in Figure 2-11. If the system has only one null detector, connect this instrument to the Model 750A NULL DETECTOR terminals. If the system has two null detectors, set the Model 845AR ZERO/OPR control to ZERO.

c. Set the Model 332B or 335A voltage dials to the Model 750A INPUT VOLTAGE selected in step a and then select the OPR mode.

d. Hold the Model 750A STD CELL CIRCUIT switch to MOMENTARY and adjust the voltage dials on the Model 332B or 335A for a null

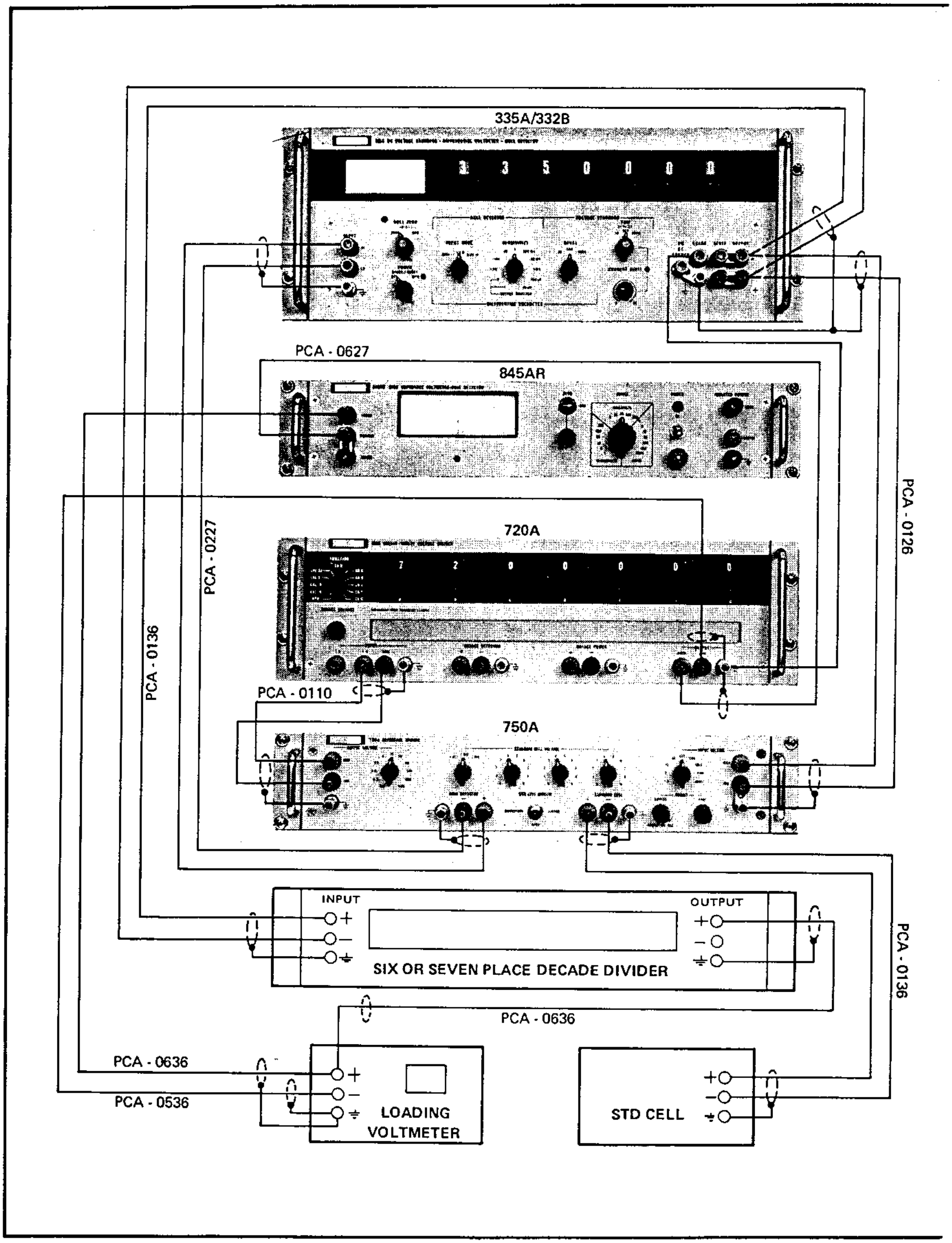

Figure 2-11. CONNECTIONS FOR LOADING VOLTMETER CALIBRATION AT POINTS OTHER THAN 750A OUTPUT SETTINGS, SYSTEM 7105A

indication on the null detector connected to the Model 750A.

e. Increase the null detector sensitivity by selecting successively lower ranges and repeating step d.

f. Connect a null detector between the decade divider and the Model 720A OUTPUT. If the system has two null detectors, set the Model 845AR ZERO/OPR switch to OPR.

g. Set the Model 720A dials to the desired calibration voltage. For example, if the voltmeter calibration voltmeter is to be 9.9999 volts and the Model 750A OUTPUT VOLTAGE is 10 volts, set the Model 720A dials to .9999900.

h. Adjust the decade divider controls for a null indication on the null detector connected between the decade divider and the Model 720A.

i. Increase the null detector sensitivity by selecting successively lower ranges and then repeat step h.

j. The desired voltmeter calibration voltage is now available at the decade divider output.

2-24. Differential Voltmeter

2-25. 20 PPM ACCURACY. Each of the Model 7100 Systems can be used as a differential voltmeter having a 20 ppm accuracy. Systems having the Model 332B and the Model 845AR can be operated as a differential voltmeter using applicable operating instructions contained in the Model 332B Instruction Manual. Differential voltmeter operating instructions for systems having the Model 335A are contained in the Model 335A Instruction Manual.

2-26. 5-10 PPM ACCURACY. Differential voltage measurements of 100 volts dc or less can be made with up to a +5 ppm accuracy using the Model 7105A System and to ±10 ppm with the Model 7101B or 7104A System. Measurements on the 1000 volt range can be accomplished with the reduced accuracies specified in Figure 2-10. To operate a system as a differential voltmeter, perform the following steps:

a. Set the Model 750A controls to the following positions:

STD CELL CIRCUIT	OPEN
STANDARD CELL VOLTAGE Dials	Standard Cell Voltage
INPUT and OUTPUT VOLTAGE Switches	Approximate value of measured voltage.
INPUT VOLTAGE COARSE	Midrange

b. Make the equipment connections illustrated in Figure 2-12. If the system has only one null detector, connect the instrument to the Model 750A NULL DETECTOR terminals. If the system has two null detectors, set the Model 845AR ZERO/OPR switch to ZERO.

c. Set the Model 332B or 335A voltage dials to the Model 750A INPUT VOLTAGE selected in step a and then select the OPR mode.

d. Hold the Model 750A STD CELL CIRCUIT switch to MOMENTARY and adjust the Model 332B or 335A voltage dials for a null indication on the null detector connected to the Model 750A.

e. Increase the null detector sensitivity by selecting successively a lower range and then repeat step d.

f. Perform steps g through k if a 1.1 or 10 volt range is selected on the Model 750A.

g. Set the Model 720A dials to the value of a second standard cell.

h. Connect the system to the second standard cell in the same manner as a measurement is performed. If the system has two null detectors, set the Model 845AR ZERO/OPR switch to OPR.

i. Adjust the Model 332B or 335A voltage dials for a null indication on the Model 845AR. Final null indication must be obtained using the lowest possible range of the Model 845AR.

j. Adjust the Model 750A STANDARD CELL VOLTAGE Dials to obtain a null indication on the null detector connected to the Model 750A.

k. Disconnect the second standard cell from the system.

l. Connect the system to the voltage to be measured. If the system has two null detectors set the Model 845AR ZERO/OPR control to OPR.

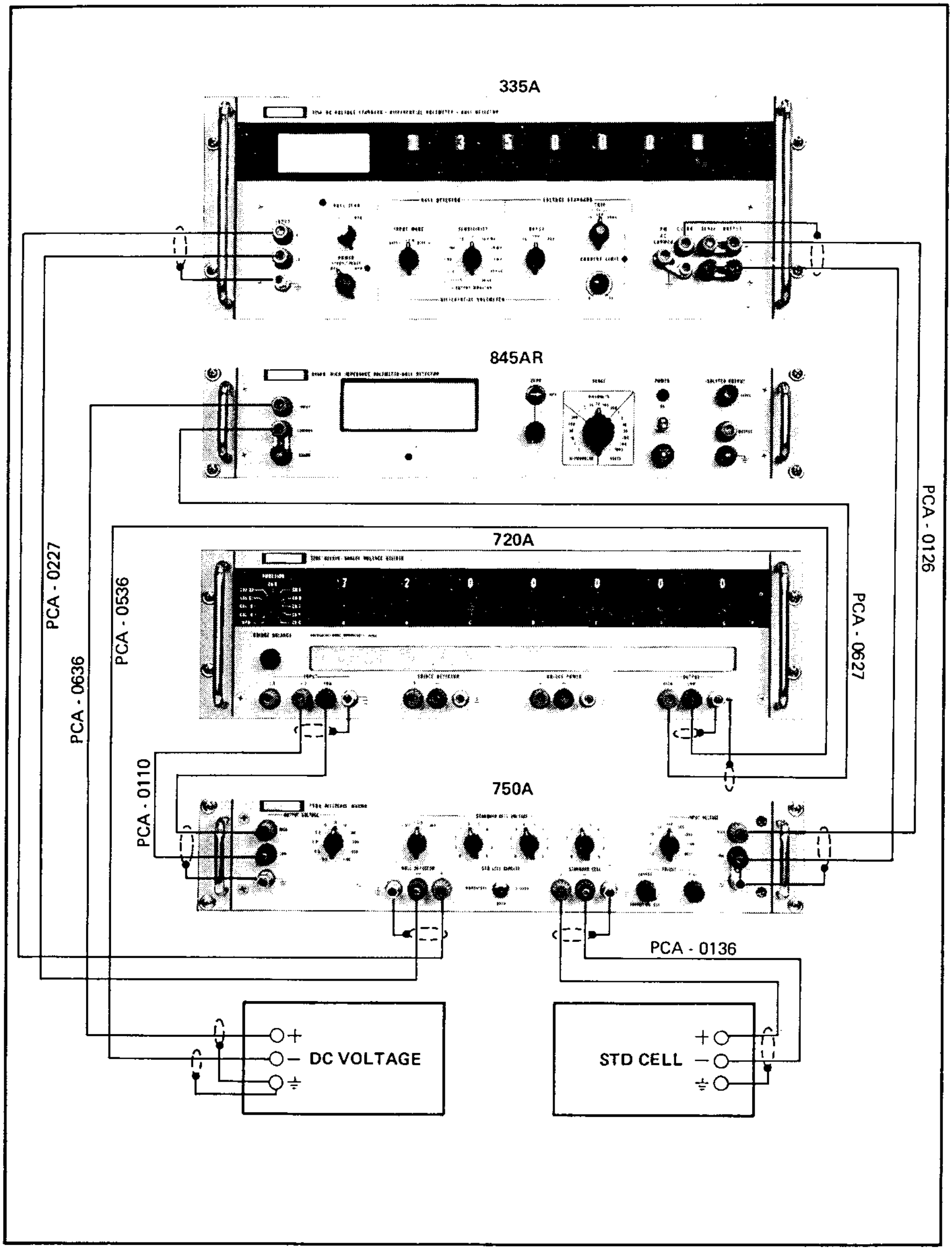

Figure 2-12. CONNECTIONS FOR 5 PPM DIFFERENTIAL VOLTMETER, SYSTEM 7105A. (Sheet 1 of 2)

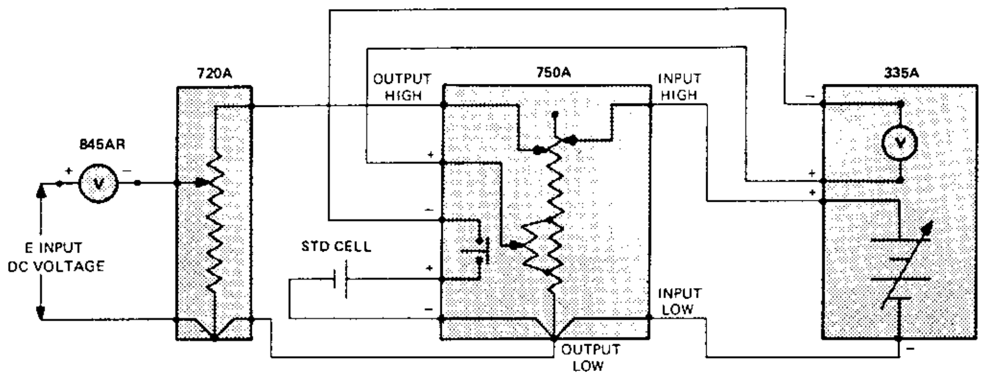

Figure 2-12. SCHEMATIC DIAGRAM OF 5 PPM DIFFERENTIAL VOLTMETER, SYSTEM 7105A. (Sheet 2 of 2)

m. Adjust the Model 720A dials to obtain a null indication on the Model 845AR. Final null indication must be obtained using the lowest possible range of the Model 845AR.

n. Calculate the unknown voltage by multiplying the Model 750A OUTPUT VOLTAGE setting by the Model 720A dial settings. For example, if the Model 750A OUTPUT setting is 100 and the Model 720A dial setting is .9876543, the measured dc voltage is 98.76543 volts dc.

2-27. Ratio Calibrator

2-28. VOLTAGE DIVIDER CALIBRATION. The Model 7101B, 7104A, and 7105A can be used to calibrate voltage dividers to an accuracy of 0.1 ppm of input. To operate the system as a voltage divider calibrator, perform the following steps:

a. Make the equipment connections illustrated in Figure 2-13. If the test divider has a 1.1 input tap, use the 1.1 INPUT terminal on the Model 720A.

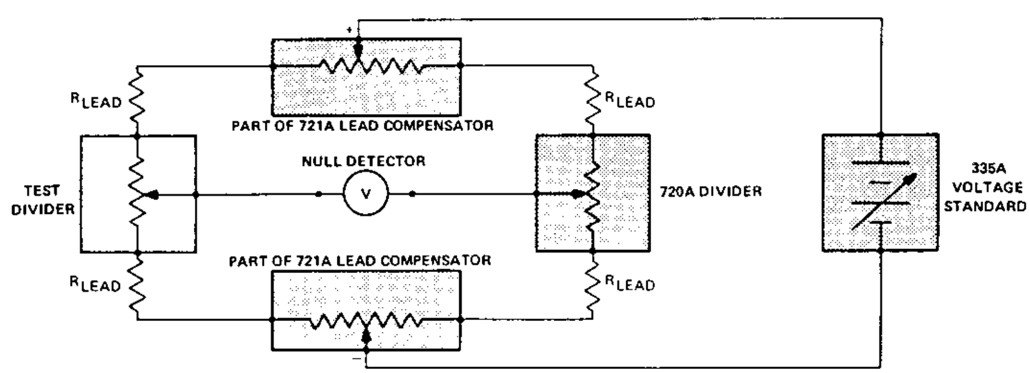

Figure 2-13. VOLTAGE DIVIDER CALIBRATION, SCHEMATIC DIAGRAM. (Sheet 1 of 2)

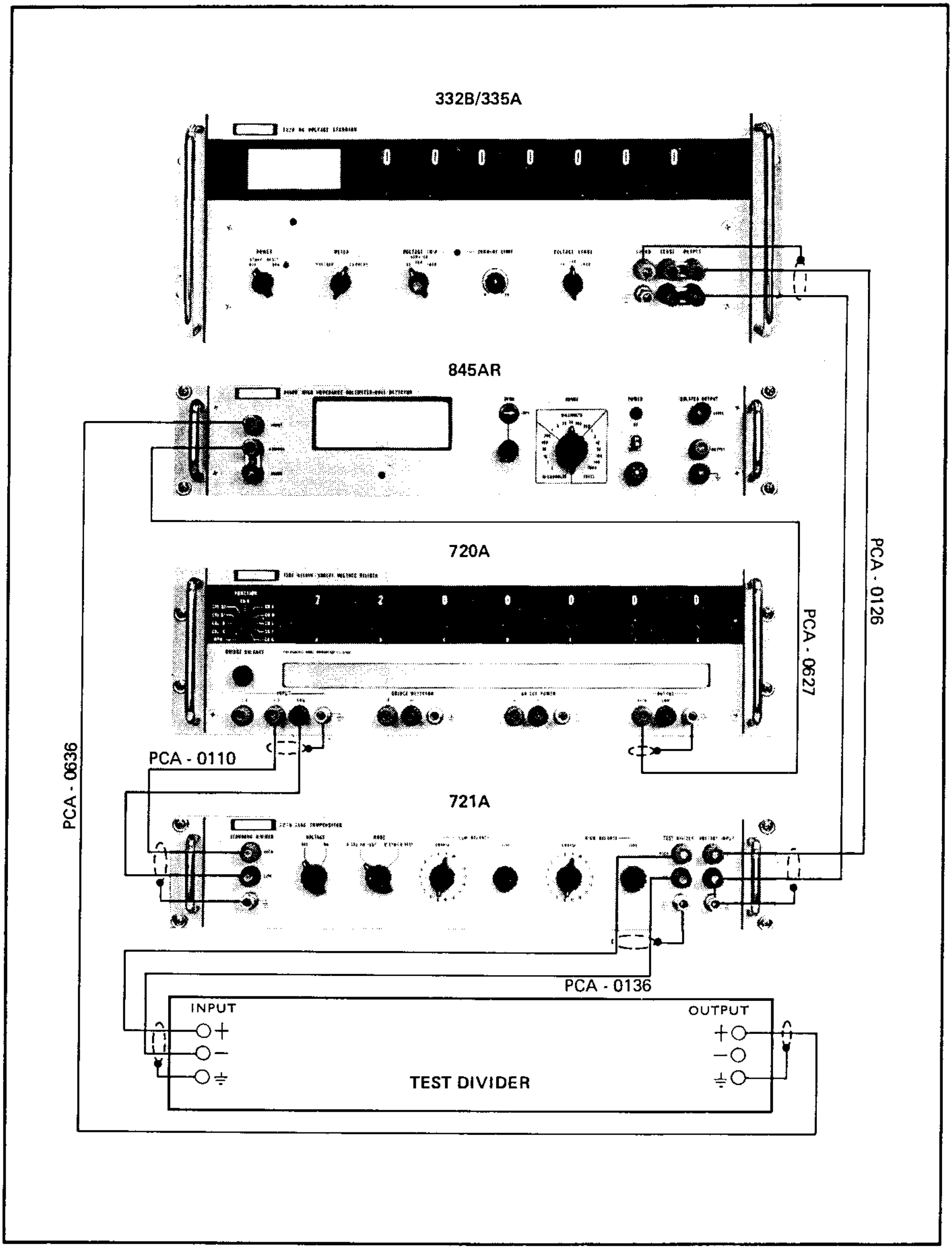

Figure 2-13. CONNECTIONS FOR VOLTAGE DIVIDER CALIBRATION. (Sheet 2 of 2)

b. Set the Model 720A and the test divider dials to 0.

c. Set the Model 721 MODE switch to $R_{STD} > R_{STD}$ or $R_{STD} < R_{STD}$, depending on which divider has the largest input resistance, and set the VOLTAGE switch to OFF.

d. Set the Model 845AR ZERO/OPR switch to ZERO and then zero the instrument.

e. Set the Model 845AR ZERO/OPR switch to OPR and select the 10 microvolt RANGE. Record the meter deflection.

Note!

The Model 845AR meter deflection is due to thermal voltages.

f. Set the Model 332B or 335A readout dials to the desired test voltage and select the OPR mode.

CAUTION!

The input voltage to the Model 720A should not exceed 1000 volts dc at the 1.0 INPUT terminal or 1100 volts dc at the 1.1 INPUT terminal.

g. Set the Model 721A VOLTAGE switch to ON and adjust the LOW BALANCE controls for the null detector indication recorded in step e.

h. Set the Model 721A HIGH BALANCE control to the same setting as the LOW BALANCE COARSE. If the null detector indication changes, readjust the LOW BALANCE FINE control.

i. Set the Model 721A VOLTAGE switch to OFF.

j. Set the Model 720A dials to .999999X if the 1.0 INPUT terminal is used or 1.099999X if the 1.1 INPUT terminal is used.

Note!

Always set the Model 845AR ZERO/OPR control to ZERO when changing divider settings.

k. Set the test divider dials to full-scale and record the null detector indication.

l. Set Model 721A VOLTAGE switch to ON and adjust the HIGH BALANCE controls for the null detector indication observed in step k.

m. Set the Model 845AR ZERO/OPR control to ZERO and then repeat steps b, e, and g.

n. Set the Model 720A and test divider dials to the initial calibration settings. Record the null detector indication.

o. Set the Model 721A VOLTAGE switch to ON and adjust the Model 720A dials for the null detector indication recorded in step n. The difference between the Model 720A settings and the settings established in step n divided by the input (1.0 or 1.1) is the test divider error expressed as a decimal fraction of the input.

p. Repeat steps n and o for each calibration point of the test divider.

2-29. RESISTANCE MEASUREMENT. The Model 7101B, 7104A, or 7105A Systems, when used with a standard resistor, can be used to measure the value of resistors with a high degree of accuracy. The value of the standard resistor, however, must be on the same order of magnitude as the unknown resistor to obtain the highest accuracy. To measure resistance values with a system, perform the following steps:

a. Make the equipment connections illustrated in Figure 2-14.

b. Set the Model 332B or 335A voltage dials for the desired test voltage and select the OPR mode.

CAUTION!

The selected test voltage should not exceed the power rating of the standard resistor or the voltage rating of the Model 720A.

c. Set the Model 720A readout dials to zero.

d. Connect the null detector input to test point P1.

e. Adjust the Model 720A readout dials for a null indication on the Model 845A. Record the Model 720A readout dial settings.

f. Connect the null detector input to test point P2 and repeat step e.

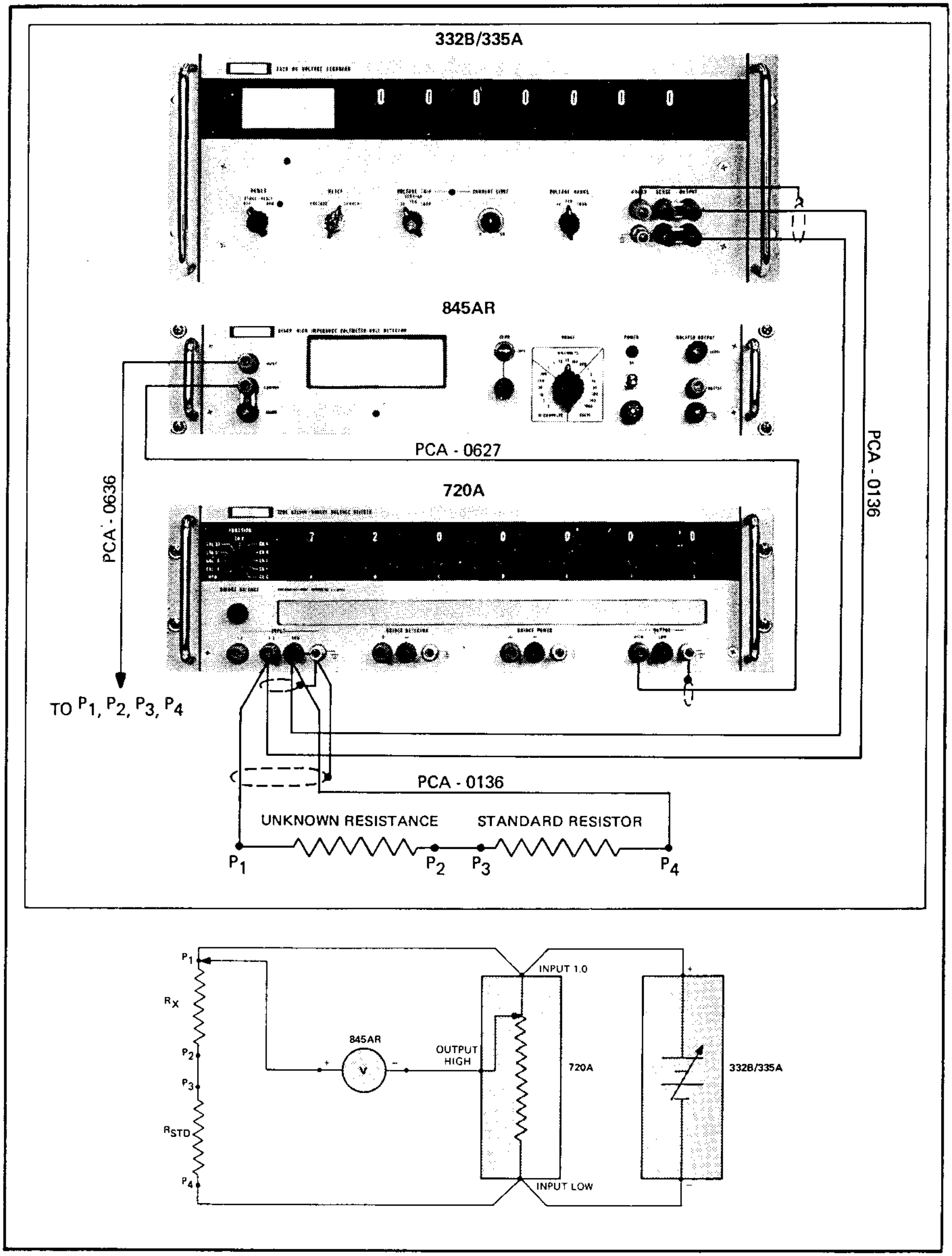

Figure 2-14. CONNECTIONS FOR RESISTANCE MEASUREMENT

g. Connect the null detector input to test point P3 and repeat step e.

h. Connect the null detector input to test point P4 and repeat step e.

i. Calculate the unknown resistance value using the following equation:

$$\frac{R_X}{R_{STD}} = \frac{P1 - P2}{P3 - P4}$$

P1 through P4 are decimal values obtained from the Model 720A readout.

Note!

If $R_X + R_{STD}$ is greater than 100 ohms, the use of the Model 721A will greatly simplify the calculation. P1 can be made equal to 1.000000 and P4 can be made equal to zero. If the lead resistance between resistors is made insignificant, then P2 = P3 and the equation of step i can be further simplified to be:

$$\frac{R_X}{R_{STD}} = \frac{1}{P} - 1$$

Where P = decimal readout of the Model 720A.

2-30. DC Voltage Stability Measurements

2-31. The Model 7100 Systems can be used to make dc voltage stability measurements which can be recorded by an external recorder connected to the Model 845AR or Model 335A RECORDER OUTPUT terminals. To perform dc voltage stability measurements with a system, perform the following steps:

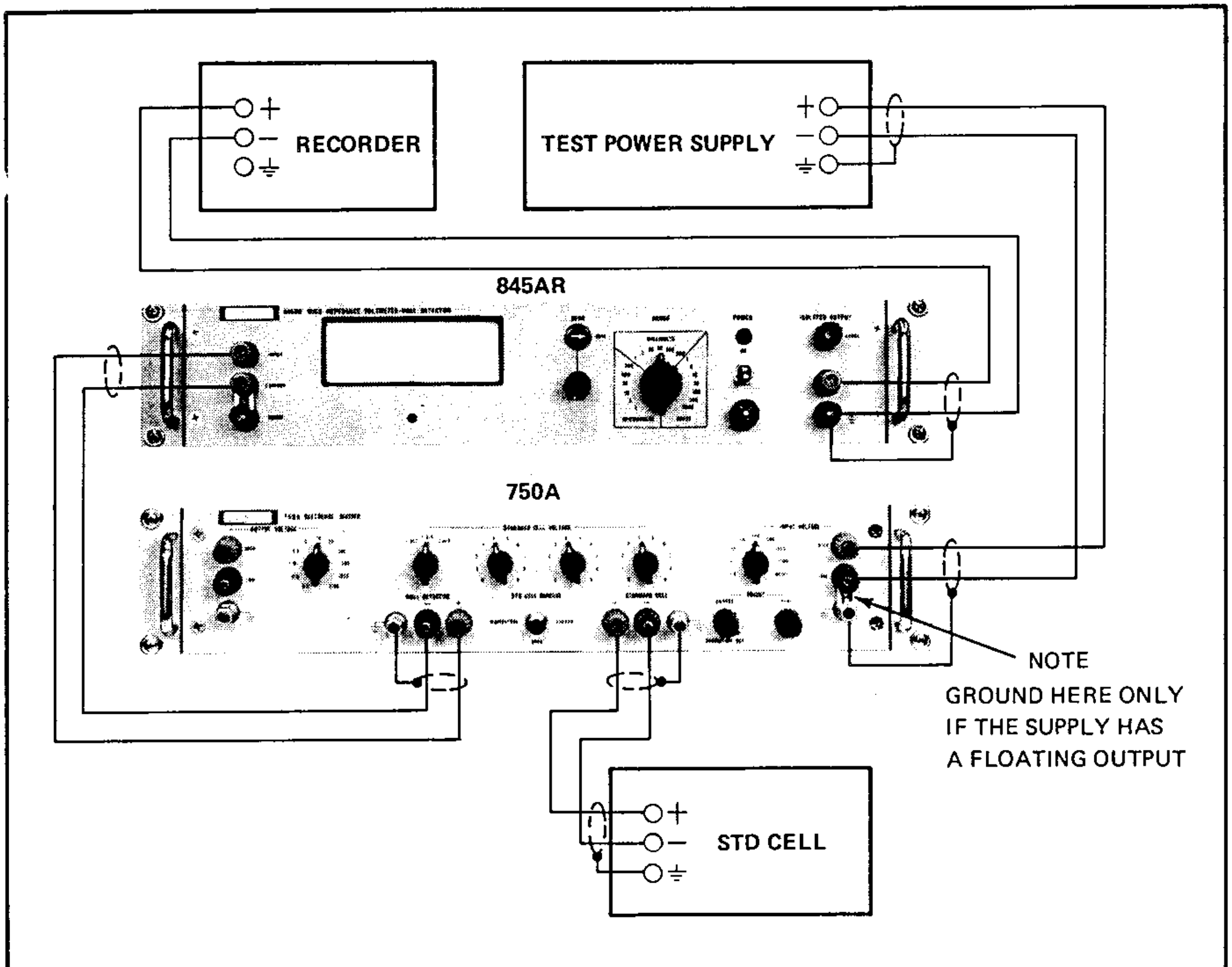

Figure 2-15. CONNECTIONS FOR STABILITY MEASUREMENTS, SYSTEMS 7100B, 7101B AND 7105A

a. Make the appropriate equipment connection illustrated in Figures 2-15 or 2-16. Ensure that the Model 750A STD CELL CIRCUIT switch is set to the OPEN position.

Note!

The more rugged and less expensive unsaturated standard cell can be used for this measurement.

b. Set the Model 750A INPUT VOLTAGE switch and the test power supply output to the same value.

c. Set the Model 750A STANDARD CELL VOLTAGE dials to the value of the standard cell.

d. Hold the Model 750A STD CELL CIRCUIT switch to MOMENTARY and adjust the test power supply output for a null indication on the null detector.

e. Select the desired null detector sensitivity and adjust the null detector recorder output controls to obtain the desired full-scale display on the external recorder.

f. The external recorder will now chart a recording of the test power supply output variations.

Note!

For best results, the ambient room temperature should be constant. If the test is conducted in an environment where temperature variations follow an established cycle, the test results will follow the temperature cycles.

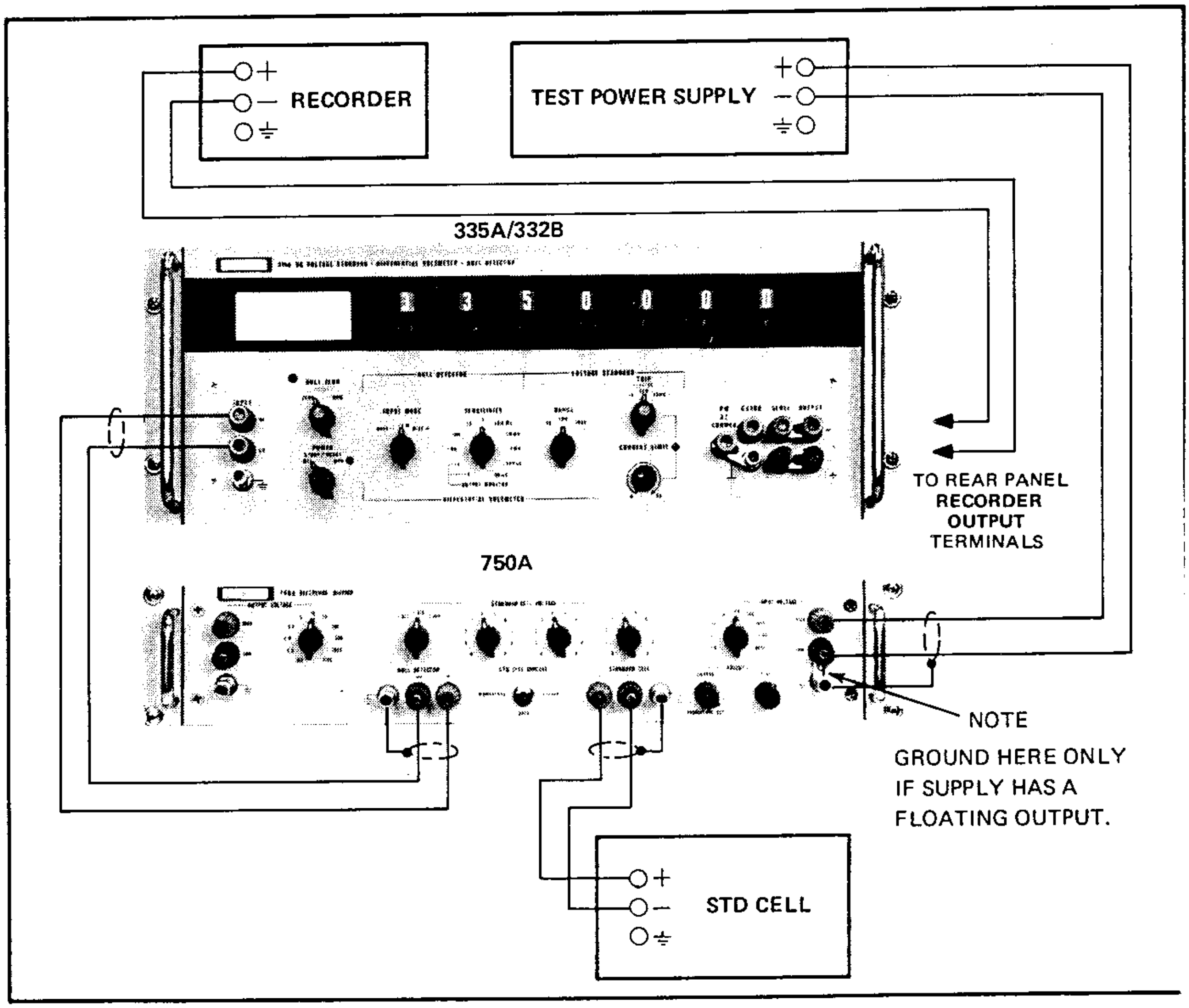

Figure 2-16. CONNECTIONS FOR STABILITY MEASUREMENTS, SYSTEMS 7103A AND 7104A

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. This section of the manual contains information that will allow complete maintenance of the FLUKE Model 7100 Series Calibration Systems. The information is arranged under headings of "THEORY OF OPERATION, TRACEABILITY TO NBS, SERVICE INFORMATION, MAINTENANCE PROCEDURES, and REPLACEMENT PARTS LIST"

3-3. THEORY OF OPERATION

3-4. System Description

3-5. The Model 7100 Calibration Systems are comprised of a group of instruments interconnected to form a dc measurement and generation system which has accuracies traceable to the National Bureau of Standards. The instruments forming the basic system consist of a stable dc voltage source, two voltage ratio devices, a lead compensator, a standard cell, and a null detector. A block diagram of such a system is illustrated in Figure 3-1.

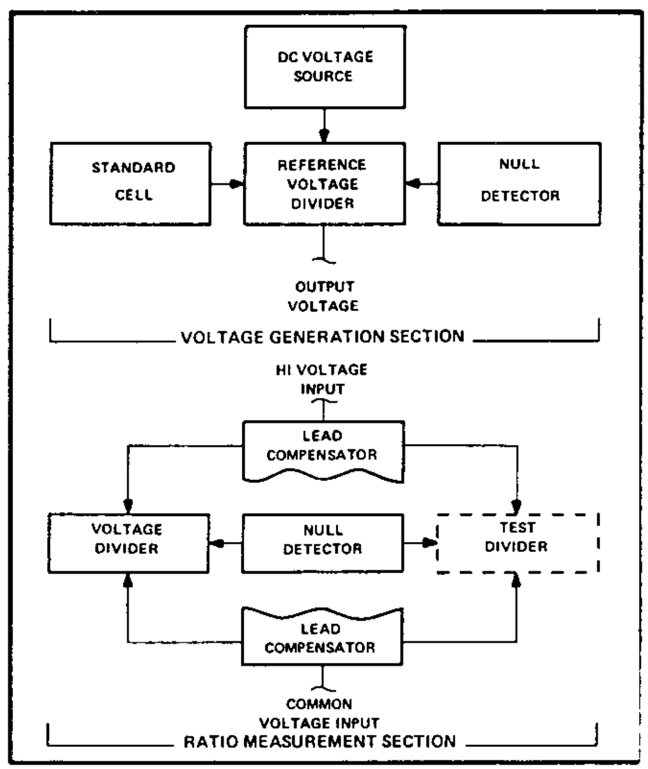

Figure 3-1. SYSTEM BLOCK DIAGRAM

3-6. DC Voltage Measurement and Generation Section

3-7. The basic system to measure and generate dc voltage consists of a stable voltage source, a voltage ratio device, a standard cell, and a null detector. A block diagram of this system is illustrated in Figure 3-2.

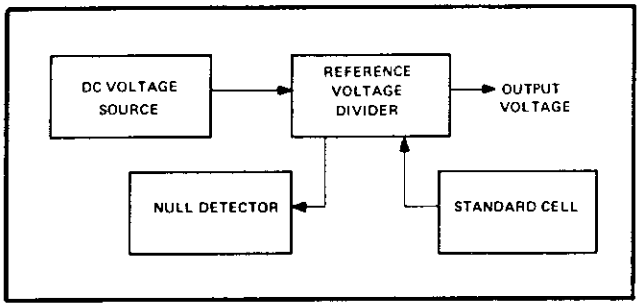

Figure 3-2. DC VOLTAGE CALIBRATION SYSTEM, BLOCK DIAGRAM

3-8. DC VOLTAGE SOURCE. The dc voltage source of the system, either a Model 332B or 335A Voltage Standard, is designed to supply stable, precision voltages to loads drawing current. The output voltage characteristics of the two instruments are identical. Each instrument will deliver up to 1111 volts with an accuracy of 20 ppm at load currents up to 50 milliamperes. The output resolution is 0.1 ppm. Stability is 10 ppm per month, and combined noise and ripple is less than 40 microvolts at maximum output. Overvoltage and overcurrent limit circuits provide protection in the event of component failure or operator error. The Model 335A combines the dc voltage generation capability with a null detector to function as a self-contained differential voltmeter. The output of the voltage standard is compared against the unknown voltage via the null detector, and the value of the unknown is read from the voltage dials.

3-10. REFERENCE VOLTAGE DIVIDER. The Model 750A Reference Divider is the voltage ratio device of the system. A simplified schematic of the Model 750A is shown in Figure 3-3. The Model 750A provides a means of providing specific output voltages from 0.1 to 1100 volts referenced to the known potential of a standard cell. It may also be used as a standardizing link or for direct comparison of a power supply output to a standard cell voltage.

3-11. The Model 750A consists of a main divider, a modified Kelvin-Varley divider, and an overvoltage protection circuit. It includes terminals for connecting a standard cell and a null detector. The total effective resistance of the main divider is 1.1 megohms. The input resistance is 1000 ohms per volt of rated input, resulting in a nominal current of one milliampere. The STANDARD CELL VOLTAGE controls shunt the lower end of the main divider from common to the 1.1 volt tap. These controls from the modified Kelvin-Varley circuit spanning the range from 1.017000 to 1.019999 volts. The controls are used to obtain from the divider a voltage exactly equal to the standard cell voltage when the input is at nominal value. This voltage is compared to the standard cell voltage by the null detector, and the input to the divider is adjusted to obtain a null.

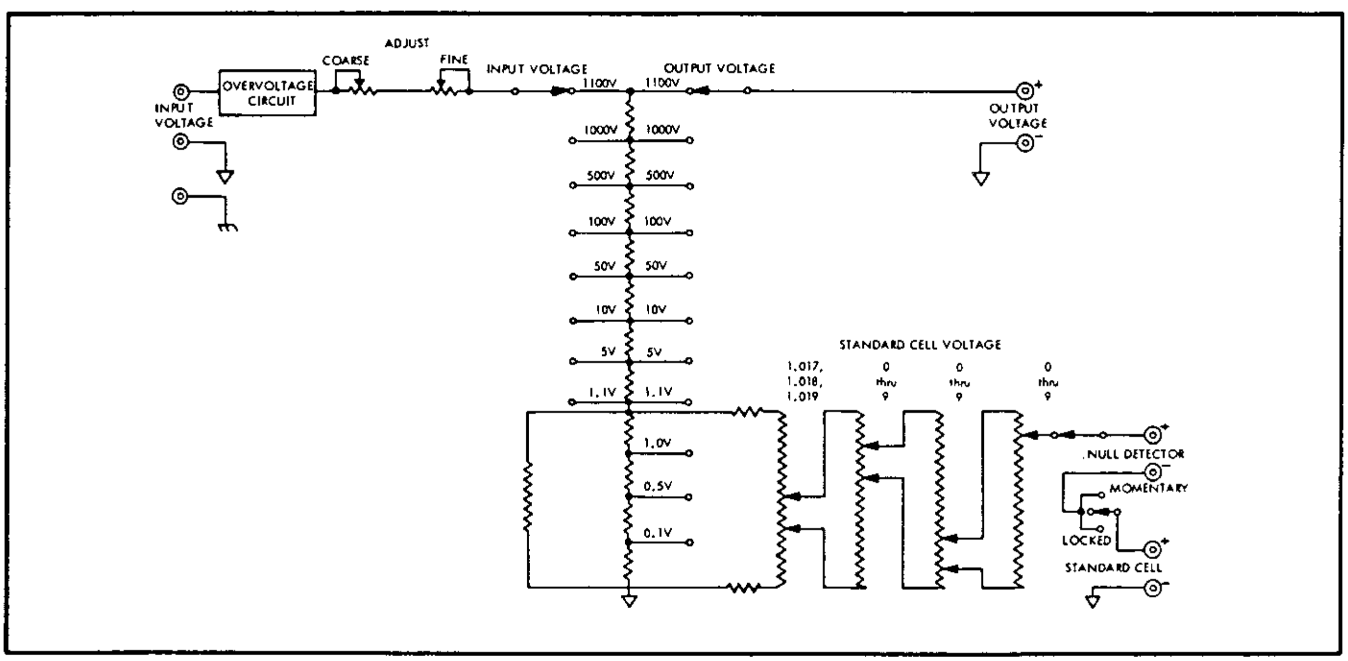

Figure 3-3. SIMPLIFIED SCHEMATIC, MODEL 750A

3-12. The input voltage may be adjusted by rheostats located on the front panel. The span of adjustment of 10 millivolts and resolution of better than one microvolt permit the operator to achieve an exact null. An adjustment in each step of the main divider, 1.1 volt to 1100 volts, is used to compensate for drift during periodic maintenance calibration. The overvoltage protection circuit removes the input voltage from the divider when it exceeds approximately 1.4 times the setting of the input voltage switch.

3-13. The accuracy of the Model 750A depends on maintaining rated current in the divider. If current is required at a particular output voltage, the INPUT VOLTAGE switch should match the OUTPUT VOLTAGE switch setting to prevent drawing excessive current through the resistors above the output tap of the divider. When calibrating precision power supplies, the test voltage must be applied to the OUTPUT VOLTAGE terminals and the INPUT VOLTAGE switch placed to the RESET position. With this configuration the overvoltage protection circuit is inoperative and care must be taken to avoid exceeding the rated voltage. The Model 332B and 335A have over current limit protection circuitry which can be set for a current slightly above one milliampere, thus preventing harm from occuring to the Model 750A

3-14. NULL DETECTOR. The null detector in the system is either a Model 845AR or the null detector in the Model 335A. The Model 845AR provides full scale measurement ranges of one microvolt to 1000 volts. The 335A null detector provides ranges of 10 microvolts to 1000 volts. Important characteristics of each model are listed in Section I, Figure 1-2.

3-15. Ratio Measurement Section

3-16. Voltage ratio techniques provide a means of measuring voltage, current and resistance. Voltage ratios are usually obtained in a voltage divider. Resistive divider ratios may be established to high accuracy without knowing the ohmic value of the resistors. It is not necessary to have traceability of ratio measurements to any national standard because ratios are dimensionless quantities. The principle is illustrated in the following example: If ten resistors of exactly the same value were connected in series, a perfect divider with outputs of 0.1 through 0.9 would result. To establish such a divider, all that is required is that one resistor be selected as the standard and the other nine be adjusted to be the same value as the standard. The adjustment is accomplished using bridge techniques without reference to absolute standards.

3-17. The operation of Ohms and Kirchoffs laws convert resistance ratios to voltage ratios when ratio calibrated resistors are connected as voltage dividers. Accordingly, it can be seen that voltage ratios can be established to high accuracy independent of national standards. Relative values are converted to absolute values in conjunction with a known quantity. For example, when the voltage output of a ratio calibrated divider is made equal to the emf of a certified standard cell, all other voltages existing on that divider became known in terms of absolute voltage with an accuracy limited only by the attainable ratio accuracy and the uncertainty of the cell voltage.

3-18. KELVIN-VARLEY VOLTAGE DIVIDER. The primary device of a 7100 ratio system is the Model 720A Kelvin-Varley Voltage Divider. A Kelvin-Varley divider is basically a cascoded arrangement of resistors which subdivides voltages. The principle is shown in Figure 3-4. Assume that each bank of resistors shown in Figure 3-4 comprises ten equal resistors and also assume that there is no shunting effect between resistor banks. If 100 volts is applied to the first divider, it will divide the input by ten volts to the second divider for another division by ten. The second divider will deliver one volt to the third divider, with each suceeding divider dividing the input by ten. In reality, however, there is shunting effect between dividers, and the actual voltage division is accomplished as described in paragraphs 3-19 through 3-21.

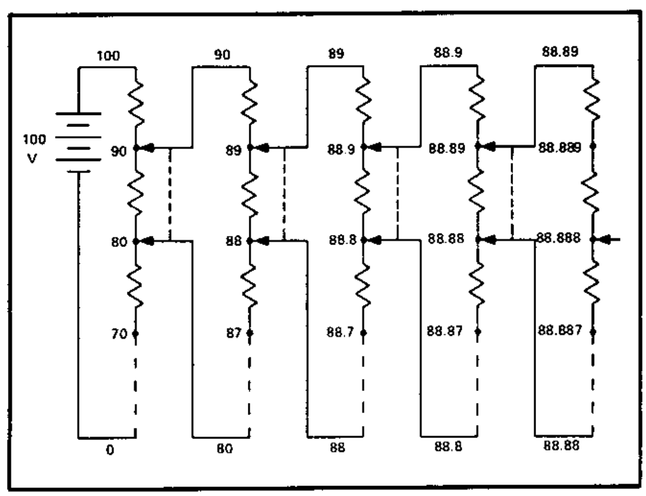

Figure 3-4. PRINCIPLE OF KELVIN-VARLEY DIVIDER

3-19. Figure 3-5 is a simplified schematic of the Model 720A Kelvin-Varley Voltage Divider. Normally, the first decade of a Kelvin-Varley divider comprises eleven resistors of equal value. The Model 720A, however, contains 12 resistors in the first decade to provide a 10% over-ranging capability in conjunction with the 1.1 input terminal.

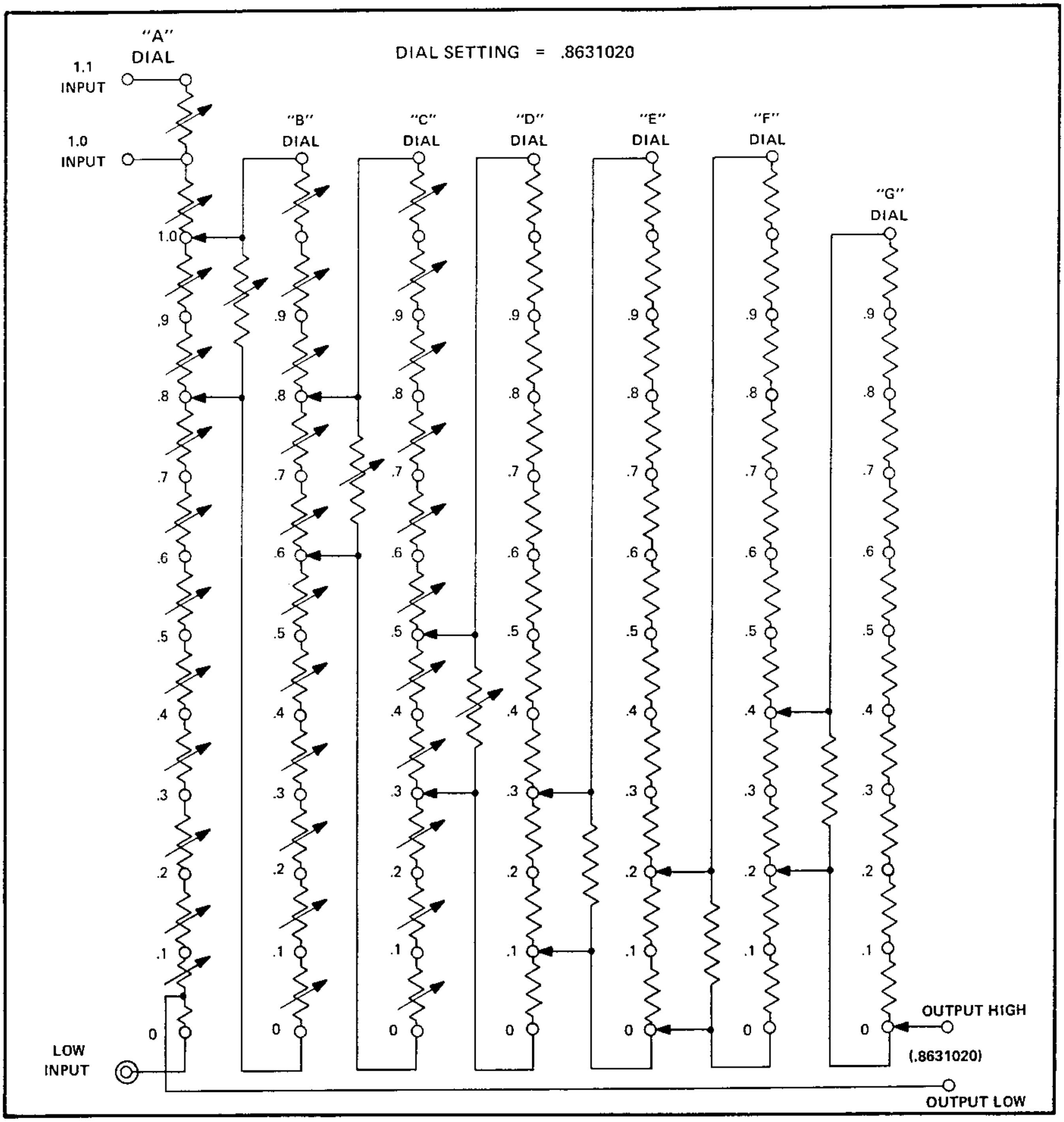

Figure 3-5. SIMPLIFIED SCHEMATIC, MODEL 720A

Voltage division is accomplished as follows: At any setting of the first decade switch, two resistors are shunted by a total resistance equal to the resistance of the two shunted resistors. Since the resistors of the first decade are all equal (10K), the result is that the resistance of the two shunted resistors is made equal to one unshunted resistor. The end-to-end resistance of the first decade will then be ten resistors rather than eleven (for the 1.0 input) and a ten-to-one voltage division will be accomplished at each step.

3-20. The second decade and following decades are Kelvin-Varley elements which cover one step of the preceding decade in steps of one tenth to nine tenths. The last decade is an exception in that it may be set to values of zero to 10. It is only through the use of the eleventh setting (dial reads X) of the last decade that the divider can be set to full scale (.999999X or 1.099999X). To permit the use of resistors of high ohmic value in the latter decades, the second decade through last have shunt resistors connected across them. The combined value of the shunt and the following decades is then equal to the two shunted resistors of the preceding decade.

3-21. The resistors of the first, second and third decades and the shunts across the second, third and fourth decades are adjustable. The resistors of the first and second decade and the shunts across the second and third decades are adjusted during the self-calibration procedure in conjunction with a built-in Wheatstone bridge. The resistors of the third decade and the fourth decade shunt may be adjusted during maintenance in conjunction with the second built-in Wheatstone bridge.

3-22. LEAD COMPENSATOR. The Model 721A Lead Compensator is a device designed primarily to provide a convenient means of balancing voltage drop due to lead resistance when two dividers are connected in parallel for comparison. When lead resistance and divider end resistance is properly compensated for, a direct comparison of the absolute linearity of the two dividers can be made. Absolute linearity may be defined as the linearity or uniformity between minimum and maximum ratio settings of a divider.

3-23. Figure 3-6 shows a divider comparison setup First, both dividers are set to zero and the Model 721A low balance controls are adjusted to obtain a null. Then the dividers are set to full scale and the high balance controls are adjusted for a null. These adjustments ensure that the voltages at the end measurement points of each divider are equal. The adjustment range of the Model 721A will compensate for differences in divider resistances as great as 4000:1.

3-24. TRACEABILITY TO NBS

3-25. General

3-26. The lines of traceability from the National Bureau of Standards to the standards of a standards laboratory enabling that laboratory to measure and generate dc voltage and current and to measure dc resistance are shown in Figure 3-7. As indicated by Figure 3-7, three references are required to establish the accuracy of these measurements to the legal standards maintained by NBS; (1) Saturated standard cells, (2) Standard resistors, (3) Standard

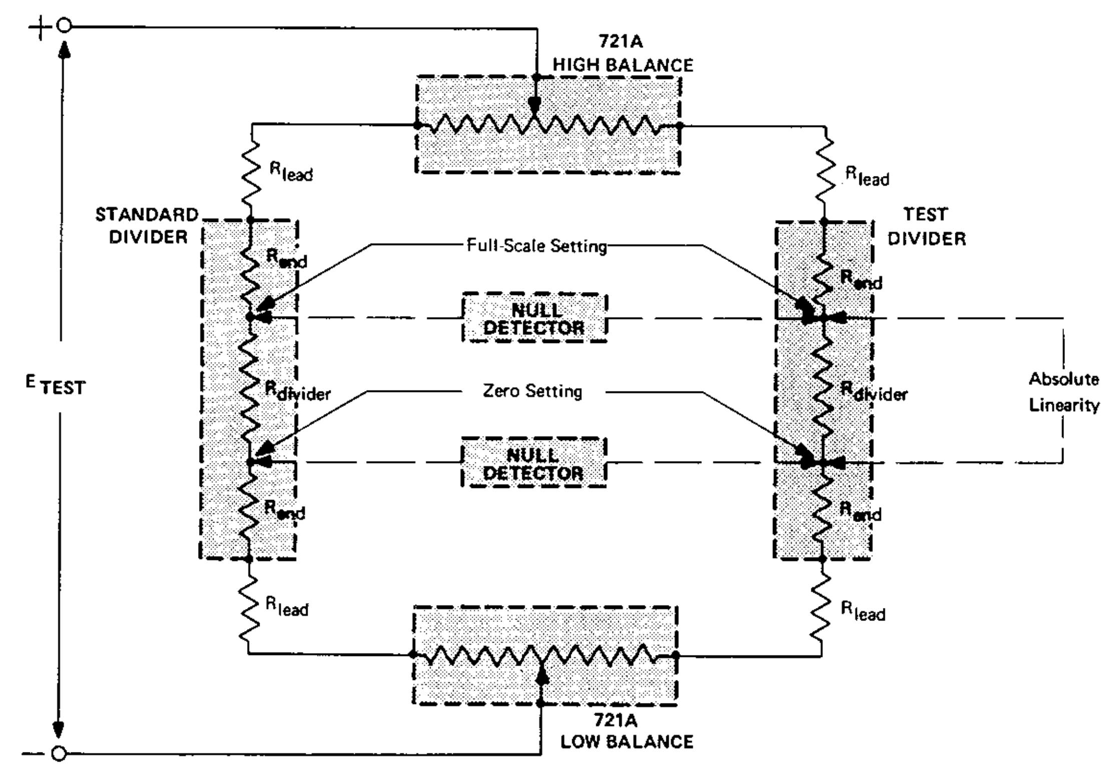

Figure 3-6. DIVIDER CALIBRATION, END CORRECTIONS

thermometer. The value of a standard cell and a standard resistor changes with time and temperature. In order to maintain standard measurement conditions and achieve accuracies in parts per million, the standard thermometer as well as the standard cell and standard resistor must be certified periodically by NBS. At least three standard cells and three standard resistors must be maintained by a laboratory. This permits inter-comparison of standards in order to detect a variation in one unit.

3-27. A Model 7100 system permits a laboratory to calibrate dc instruments to high accuracy in relation to national standards with a minimum of transportable references. Measurements that can be performed by the Model 7100 System equipped with a Model 720A and Model 721A are represented by the shaded blocks of Figure 3-7.

3-28. Traceability of 7100 System

3-29. Traceability of the 7100 system to NBS is shown in Figure 3-8. The system relates its absolute accuracy to NBS through the standard cell used with the Model 750A Reference Divider. The Model 750A contains a modified Kelvin-Varley divider which may be set to any ratio between 1.01700 and 1.01999. The Kelvin-Varley output at these settings is compared to a standard cell via a null detector. When the input voltage to the 750A is adjusted to obtain a null indication on the null detector, the output taps are calibrated in absolute voltages.

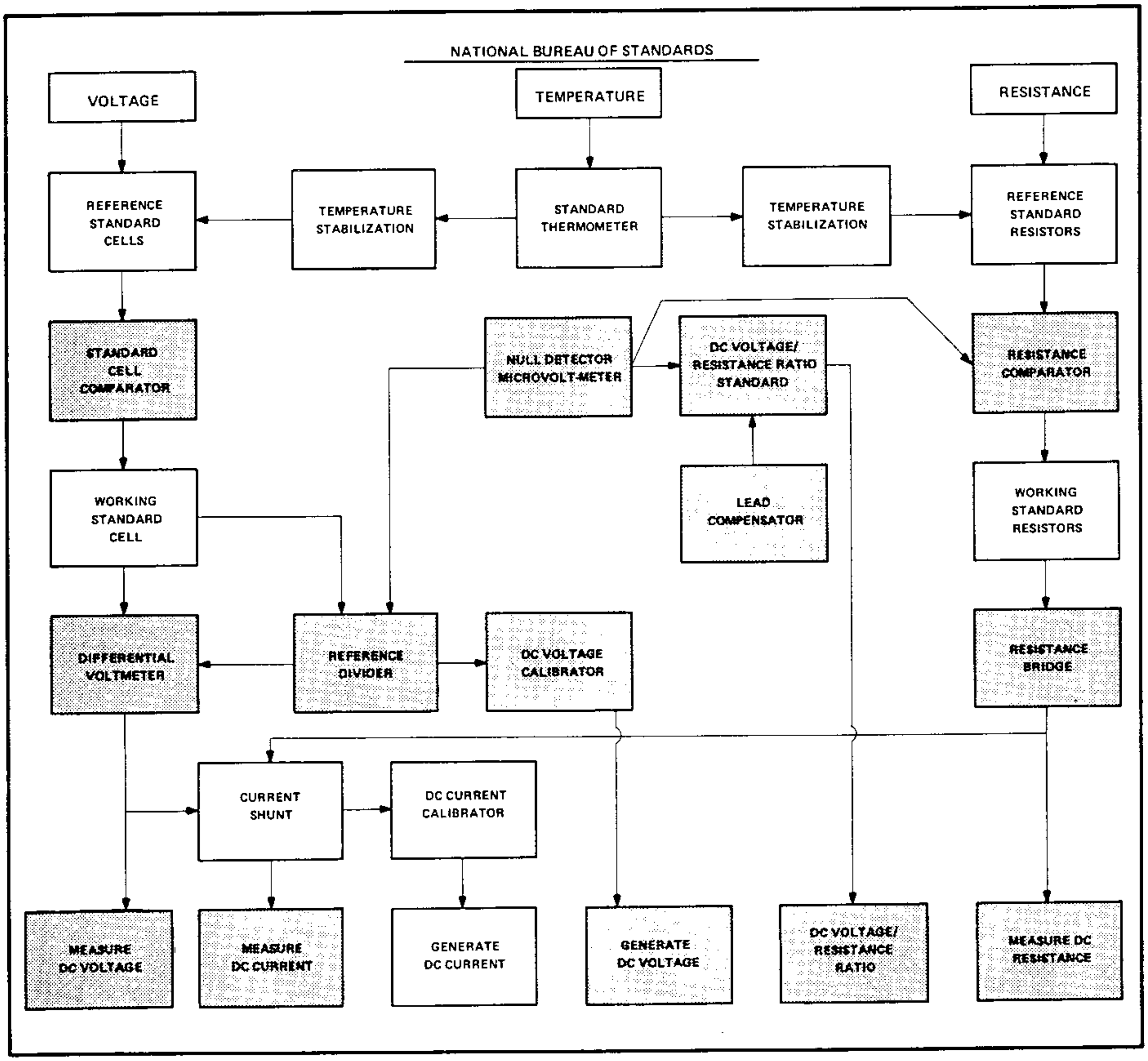

Figure 3-7. DC VOLTAGE,CURRENT AND RESISTANCE TRACEABILITY TO NBS

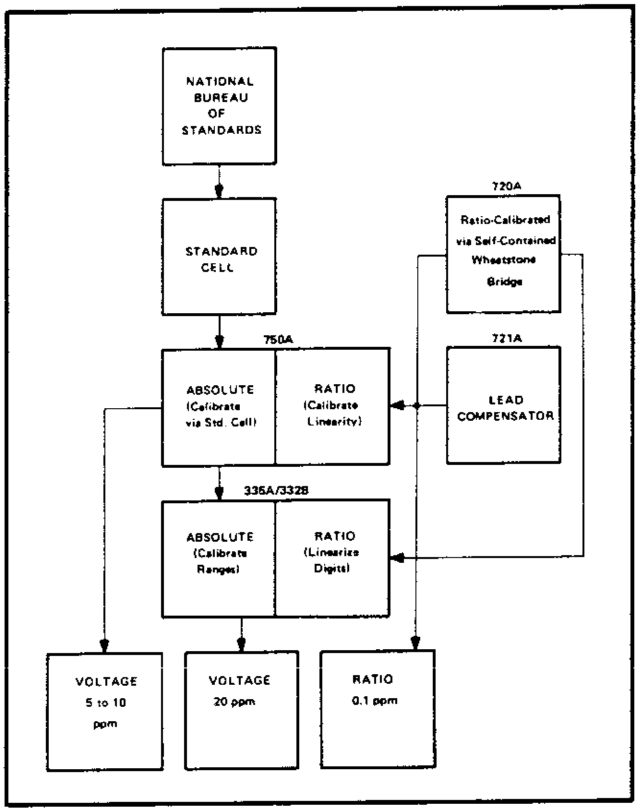

Figure 3-8. SYSTEM TRACEABILITY VIA STANDARD CELL AND RATIO CALIBRATION

3-30. SERVICE INFORMATION

3-31. Each instrument manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. Complete warranty information is contained in the Warranty page located at the rear of this manual.

3-32. Factory authorized calibration and repair service all Fluke instruments are available at various world wide locations. A complete list of factory authorized service centers is located at the rear of this manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments beyond the warranty period.

3-33. MAINTENANCE PROCEDURES

3-34. General Maintenance

3-35. CLEANING. If the system is operated in a controlled environment cleaning will seldom be required. However, if cleaning of the system exterior becomes necessary, a cloth moistened with anhydrous ethyl alcohol or Freon TF Degreaser can be used to remove any dirt or grease. If any of the cleaning agents are not readil available, soap and water applied sparingly to a cloth can b used to clean the system exterior.

3-36. The fan screen on the back of the cabinet shoul be periodically inspected and washed with a solution o water and detergent to remove any dirt or grease.

3-37. FUSES, LAMPS AND BATTERIES. A list o fuses, lamps, and batteries in the system is contained i Figure 3-9. Refer to the appropriate Instruction Manual located in Section IV for replacement procedures. Figur 3-10 is a diagram of system ac power.

FUSES	
Fan motor	1/4 amp, slow blow
Model 335A and 332B	
Line	3 amp, slow blow
High Voltage	1/4 amp, slow blow
Model 845AR	1/16 amp, slow blow
LAMPS	
Model 335A and 332B	28v; General Electric, 757
Model 845AR	115 vac, neon; Sloan Co., 858-R-A1C-68K
System ac power	115 vac., neon; Sloan Co. 858-R-A1C-68K
BATTERIES	
Model 750A	6.75v, mercury, two required; Mallory TR-135R

Figure 3-9. FUSES, LAMPS, AND BATTERIES.

3-38. Model 332B or 335A Linearization

3-39. The following procedure can be used in place o the Model 332B or 335A Instruction Manual linearizatio method when a second stable reference source such as th Model 332B or 335A is not available. The stable referenc source in this procedure is a standard cell. To lineariz either the Model 332B or 335A, perform the followin steps:

a. Self-calibrate the Model 750A using the procedu contained in its Instruction Manual.

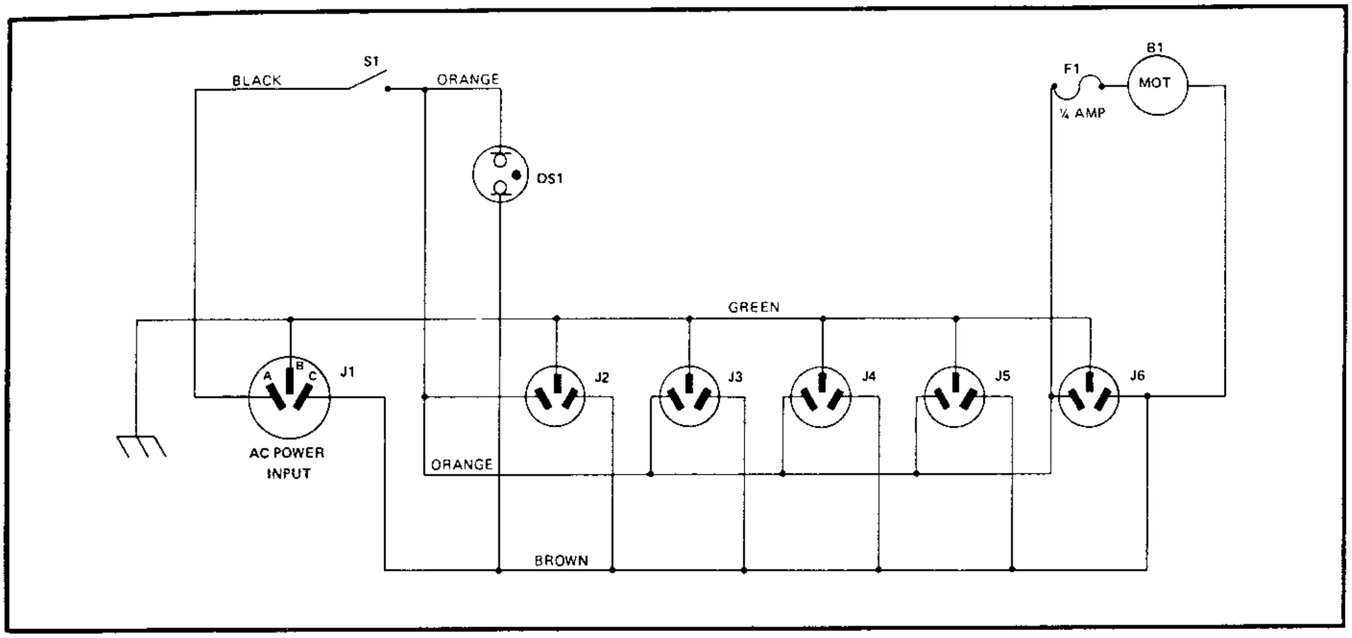

Figure 3-10. SYSTEM 115V AC POWER WIRING

b. Make the equipment connections illustrated in Figure 3-11.

c. Slide the Model 332B or 335A out of its case just far enough to gain access to the SAMPLE STIRNG ADJUST (DECK A AND B) access holes. Maintenance access instructions are contained in the respective Instruction Manuals.

d. Set the Model 332B or 335A controls to the following positions:

Meter Controls	Voltage Monitor
VOLTAGE TRIP	100
VERNIER	Midrange
CURRENT LIMIT	Midrange
RANGE	1000
Voltage Dials	00X.0000
POWER	OPR

e. Set the Model 720A dials to 1/10 the value of the standard cell.

f. Set the Model 845AR ZERO/OPR control to OPR, and adjust the Model 720A dials for a null indication on the Model 845AR 10 microvolt range. Record the exact null detector indication.

CAUTION!

To prevent abusing the standard cell, set the Model 845AR ZERO/OPR control to ZERO when changing the Model 720A dial settings. Nulling adjustments should be performed initially at reduced null detector sensitivity. Increase the null detector sensitivity as the final null is approached.

g. Set the Model 845AR ZERO/OPR control to ZERO and the Model 332B or 335A voltage dials to 010.0000.

h. Set the Model 845AR ZERO/OPR control to OPR and adjust the Model 332B or 335A DECK B adjustment 1 for the null detector indication recorded in step f.

i. Perform the DECK B adjustments of Figure 3-12 steps c through l. Flagnotes 1 and 2 set limits for decades six and seven.

j. Set the Model 332B or 335A RANGE switch to 100 and perform the DECK A adjustments of Figure 3-13.

3-41. REPLACEMENT PARTS LIST

3-41. Introduction

3-42. The following list describes the replaceable parts for the system. The listing is divided into two groups: The first group lists the complement of instruments by system model number. The second group lists the replaceable parts used on all models of the 7100 system. Parts common

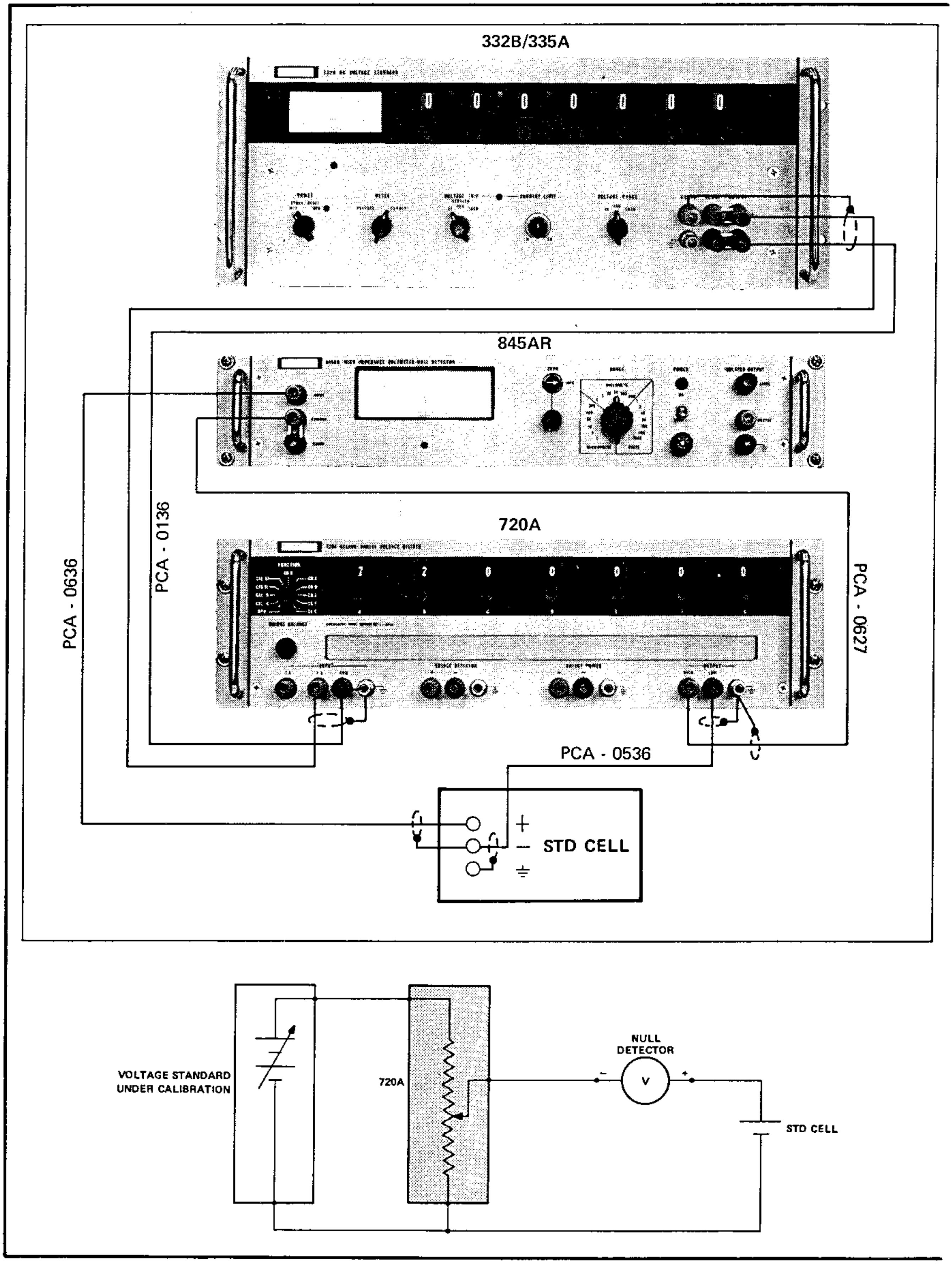

Figure 3-11. CONNECTIONS FOR SAMPLE STRING LINEARIZATION USING STANDARD CELL

STEP	VOLTAGE STANDARD DIAL SETTING	INITIALLY SET 720A TO STD CELL EMF DIVIDED BY	INSTRUCTIONS
a	00X.0000	10	Adjust 720A for an 845AR null within ±1 microvolt.
b	010.0000	- - -	Rotate adjustment 1 for an 845AR null within ±1 microvolt of step a.
c	01X.0000 [1]	20	Adjust 720A for an 845AR null within ±2 microvolt.
d	020.0000	- - -	Rotate adjustment 2 for an 845AR null within ±1 microvolt of step c.
e	03X.0000 [1]	40	Adjust 720A for an 845AR null within ±4 microvolt.
f	040.0000	- - -	Rotate adjustment 4 for an 845AR null within 0.5 microvolt of step e.
g	05X.0000 [1]	60	Adjust 720A for an 845AR null within ±6 microvolt.
h	060.0000	- - -	Rotate adjustment 6 for an 845AR null within ±0.3 microvolt of step g.
i	07X.0000 [2]	80	Adjust 720A for an 845AR null within ±8 microvolt.
j	080.0000	- - -	Rotate adjustment 8 for an 845AR null within ±0.2 microvolt of step i.
k	09X.0000 [2]	100	Adjust 720A for an 845AR null within ±10 microvolt.
l	0X.0000	- - -	Rotate adjustment X for an 845AR indication within ±0.2 microvolt of step k.

[1] The setting of the seventh dial may be any position 0 through X.

[2] The setting of the sixth dial may be 0 or 1. The setting of the seventh dial may be any position 0 through X.

Figure 3-12. DECK B LINEARIZATION USING STANDARD CELL

STEP	VOLTAGE STANDARD DIAL SETTING	INITIALLY SET 720A TO STD CELL EMF DIVIDED BY	INSTRUCTIONS
a	0X.00000	10	Adjust 720A for an 845A null within ±1 microvolt.
b	10.00000	- - -	Rotate adjustment 1 for an 845AR indication within ±1 microvolt of step a.
c	1X.00000	20	Adjust 720A for an 845AR null within ±2 microvolt.
d	20.00000	- - -	Rotate adjustment 2 for an 845AR null within ±1 microvolt of step c.
e	3X.00000 [1]	40	Adjust 720A for an 845AR null within ±4 microvolt.
f	40.00000	- - -	Rotate adjustment 4 for an 845AR null within ±0.5 microvolt of step e.
g	5X.00000 [1]	60	Adjust 720A for an 845AR null within ±6 microvolt.
h	60.00000	- - -	Rotate adjustment 6 for an 845AR null within ±0.3 microvolt of step g.
i	7X.00000 [2]	80	Adjust 720A for an 845AR null within ±8 microvolt.
j	80.00000	- - -	Rotate adjustment 8 for an 845AR null within ±0.2 microvolt of step i.
k	9X.00000 [2]	100	Adjust 720A for an 845AR null within ±10 microvolt.
l	100.00000	- - -	Rotate adjustment 10 for an 845AR null within ±0.1 microvolt of step k.

[1] The setting of the sixth dial may be 0 or 1. The setting of the seventh dial may be any position 0 through X.

[2] The setting of the fifth and sixth dial may be 0 or 1. The setting of the seventh dial may be any position 0 through X.

Figure 3-13. DECK A LINEARIZATION USING STANDARD CELL to all models are those associated with ac power distribution and the cooling fan. A detailed breakdown of replacement parts for each instrument is given in the individual Instruction Manuals contained in Section IV of this manual.

3-43. Columnar Information

a. The REF DESIG column indexes the item description to the parts shown on the ac power wiring diagram, Figure 3-10.

b. The DESCRIPTION column describes the important characteristics of the component. Indentation of the description indicates the relationship to an assembly. For abbreviations used in this column, see the List of Abbreviations following paragraph 3-47.

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. For a list of Federal Supply Codes, see any instrument instruction manual (Section IV).

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 QUT 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. 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.

3-44. How To Obtain Parts

3-45. 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 instructions, if necessary.

3-46. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co., if you include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description.

d. Reference Designation.

e. Instrument model and serial number.

Example: 2 each, 4805-177105; Transistors, 2N3565, Q107-108 for 845AR S/N 168.

3-47. 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.

3-48. List of Abbreviations

ac	alternating current
Al	Aluminum
amp	ampere
assy	assembly
cap	capacitor
car flm	carbon film
C	centrigrade
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 rectifi(
spdt	single-pole, double-throv
spst	single-pole, single-throw
sw	switch
Ta	tantalum
tstr	transistor
tvm	transistor voltmeter
uhf	ultra high 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

3-49. SERIAL NUMBER EFFECTIVITY

USE CODE	SERIAL NUMBER EFFECTIVITY
NONE	Model 7100 Systems serial number 123 and on.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DC CALIBRATION SYSTEM	7100B					
		DC Voltage Standard	332B					
		High-Impedance Votlmeter/Null Detector	845AR					
		Reference Driver	750A					
		DC CALIBRATION SYSTEM	7101B					
		DC Voltage Standard	332B					
		High-Impedance Voltmeter/null Detector	845AR					
		Kelvin-Varley Voltage Divider	720A					
		Lead Compensator	721A					
		Reference Divider	750A					
		DC CALIBRATION SYSTEM	7103A					
		DC Voltage Standard-Differential Voltmeter - Null Detector	335A					
		Reference Divider						
		DC CALIBRATION SYSTEM	7104A					
		DC Voltage Standard - Differential Voltmeter - Null Detector	335A					
		Kelvin-Varley Voltage Divider	720A					
		Lead Compensator	721A					
		Reference Divider	750A					
		DC CALIBRATION SYSTEM	7105A					
		DC Voltage Standard - Differential Voltmeter - Null Detector	335A					
		High Impedance Voltmeter/Null Detector	845AR					
		Kelvin-Varley Voltage Divider	720A					
		Lead Compensator	721A					
		Reference Divider	750A					
B1		Far Assembly	255562	82877	Whisper Venturi	1		
DS1		Lamp, Neon	193524	08717	858-R-A1C-68K	1		
F1,F2		Fuse, ¼A, SLO-BLO	166306	71400	Type MDL	2		
J1		Connector, Power (Male)	157685	74545	5278	1		
J2-J6		Connector, Power (Female)	247015	73586	M-1538GS	5		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		Accessory Kit - Leads						
		PCA-0110	278887	89536	278887	2		
		PCA-0116	278895	89536	278895	1		
		PCA-0126	279893	89536	279893	1		
		PCA-0136	278903	89536	278903	1		
		PCA-0227	278911	89536	278911	1		
		PCA-0536	278929	89536	278929	1		
		PCA-0627	278937	89536	278937	1		
		PCA-0636	278945	89536	278945	1		
		Fuse Holder	160846	75915	342004	2		
		Line Cord	161638	91934	Type SVT, 019-1, 107-1	1		
		Switch, toggle, Power	114850	04009	20994LH	1		