JOHN FLUKE MFG. CO., INC.
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September 30, 1966

MODELS 885A & 885AB

DC DIFFERENTIAL VOLTMETER

885A & 885AB serial no. _______ and above.

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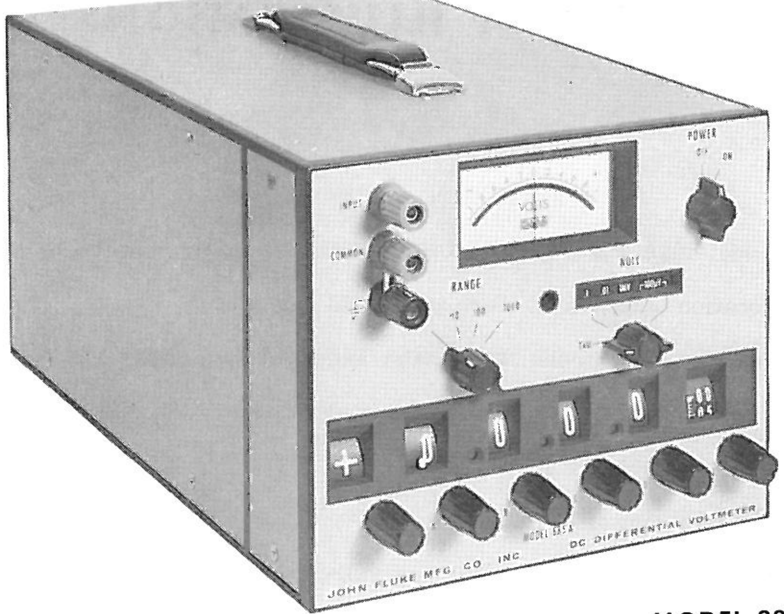
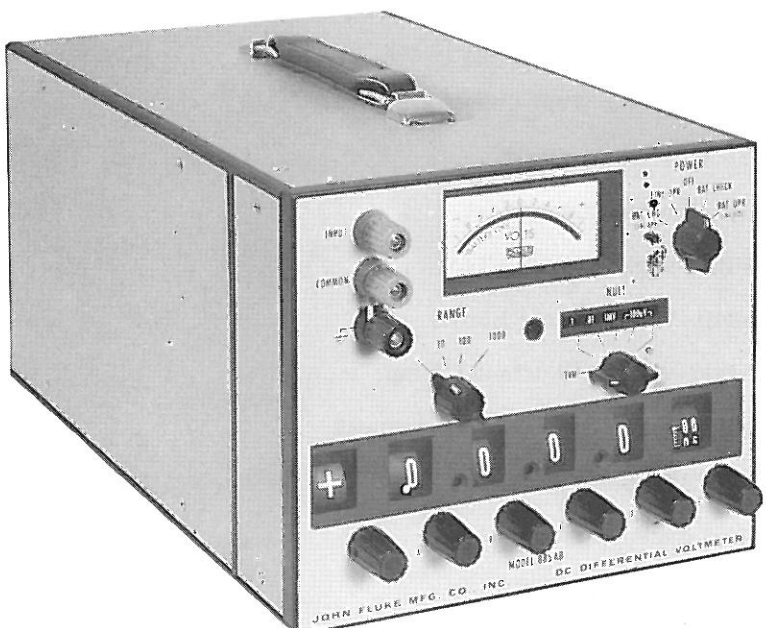


MODEL 885A



MODEL 885AB

SOLID STATE DC DIFFERENTIAL VOLTMETERS

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. This instruction manual is for use with the 885A series Differential DC Voltmeters. This instrument is available as either a line-powered instrument (Model 885A), or as a combination line-powered/battery-powered instrument (Model 885AB). Both instruments are half-rack size and are equipped with resilient feet and tilt-up bail for field or bench use. A single instrument may be mounted in a standard 19 inch rack with metal handle-rack adapter kit 881A-102. A single instrument may be mounted side-by-side with another Fluke half-rack size instrument by using metal handle-rack adapter kit 881A-103.

1-3. The 885A series instruments can be used as: (a) Conventional voltmeters for rapid determination of dc voltages from 0 to 1100 volts dc to within ±3% of range setting. (b) Differential voltmeters for precise measurement of dc voltages from 0 to 1100 volts to an accuracy of ±(0.0025% of input + 0.0001% of range + 5 uv), and (c) As megohmmeters for measurement of resistance from 10 megohms to 111,000 megohms with a typical accuracy of 5%. The instrument can also be used to measure voltage excursions about a nominal value. One feature which should be emphasized is that no current is drawn from the unknown, when the voltmeter is at null, at up to 11 volts. Thus the determination of the unknown potential is independent of its source resistance. Above 11 volts, the input resistance is 10 megohms.

1-4. To minimize errors due to common mode voltages, the 885A series is provided with exceptionally high leakage resistance to ground, typically several hundred thousand megohms. Where ground loop current may be present, complete isolation from the power line through battery operation of the 885AB entirely eliminates this source of error. The 885A series contains a polarity switch for equal convenience in measuring positive or negative voltages and an adjustable recorder output which makes the instrument particularly useful for monitoring the stability of dc voltages.

1-5. When used as a differential voltmeter, the 885A and 885AB operates on the potentiometric principle. An unknown voltage is measured by comparing it to a known adjustable voltage with the aid of a null detector. An accurate standard for measurement is obtained from an 11 volt reference supply derived from a pair of temperature-compensated zener diodes. The known adjustable reference voltage is provided by a Kelvin-Varley voltage divider with four decades of Fluke precision wirewound resistors and a high-resolution interpolaring vernier that are set accurately by five voltage readout dials to give a six digit readout. The unknown voltage is indicated by the voltage readout dials. For voltages between 11 and 110 volts, an input attenuator divides the unknown voltage by 10 before it is measured potentiometrically; between 110 and 1100 volts, the input attenuator divides the unknown voltage by 100.

1-6. INPUT POWER

1-7. The instrument is usually supplied with the primary windings of the power transformer connected in parallel for operation from 115 volts ac. Upon request, the instrument is supplied with the primary windings connected in series for operation from 230 volts. If it becomes desirable to convert from one operating voltage to the other, refer to the instruction decal on the power transformer, and to the schematic diagram.

1-8. RECEIVING INSPECTION

1-9. This instrument has been thoroughly tested and inspected before being shipped from the factory. Immediately after receiving the instrument, carefully inspect for damage which may have occurred in shipment. If any damage is noted, follow the instructions outlined in the warranty page at the back of this manual.

1-10. SPECIFICATIONS

DIFFERENTIAL VOLTMETER

ACCURACY: ±(0.0025% of input voltage + 0.0001% of range + 5 uv) from 0 to 1100 volts dc at the nominal calibration temperature of 23 (±1)° C, and less than 70% relative humidity. Calibration cycle of 30 days. ±(0.005% of input + 5 uv) from 0 to 1100 volts dc within 16° C to 32° C (60° F to 90° F), less than 70% relative humidity.

INPUT RESISTANCE: Infinite at null on the 1 volt and 10 volt ranges: 10 megohms on the 100 volt and 1000 volt ranges.

INPUT AND NULL RANGES:

Input Range (volts)	Null Range (volts)
1	.1, .01, .001, .0001
10	1, .1, .01, .001, .0001
100	10, 1, .1, .01, .001
1000	100, 10, 1, .1, .01
NOTE: Each input range and each null range has 10% overvoltage capability.	

VOLTAGE DIAL RESOLUTION:

Input Range (volts)	Resolution	
	ppm of range	voltage
1	1	1 uv
10	1	10 uv
100	1	100 uv
1000	1	1 mv

METER RESOLUTION:

Null Range (volts)	Resolution
.0001	1 uv
.001	10 uv
.01	100 uv
.1	1 mv
1	10 mv
10	100 mv
100	1 v

CONVENTIONAL VOLTMETER

ACCURACY: 3% of input range.

RANGES:

Input Range (volts)	Input Resistance (megohms)
1000-0-1000	10
100-0-100	10
10-0-10	10
1-0-1	10
*.1-0-.1	10
*.01-0-.01	10
*.001-0-.001	1
*.0001-0-.0001	1

NOTE: 10% overranging on each range

*These ranges are obtained by using null ranges with the readout dials set to zero.

GENERAL

ELECTRICAL DESIGN: Completely solid-state.

INPUT RESISTANCE OF NULL DETECTOR: 10 megohms on the three least sensitive null ranges, all input ranges: 1 megohm on the two most sensitive null ranges, all input ranges.

REFERENCE ELEMENT: Temperature-compensated zener diodes with a temperature coefficient less than 1 ppm/°C from 16°C to 32°C.

REGULATION OF REFERENCE SUPPLY: 0.0002% for a 10% line voltage change.

STABILITY OF REFERENCE SUPPLY:
0.0005% peak-to-peak per hour
0.001% peak-to-peak per 24 hours
0.0015% peak-to-peak per sixty days

ACCURACY OF OFF-NULL DEFLECTION: ±5% of null range (±3% of null range with voltage dials set to zero).

KELVIN-VARLEY DIVIDER ACCURACY: ±0.0012% of setting from 1/10 full scale to full scale. ±0.00012% terminal linearity below 1/10 full scale.

RECORDER/ISOLATION AMPLIFIER OUTPUT: Adjustable from 0 to 0.5 volt minimum for end-scale meter deflection. Source resistance 5K to 8K, linearity better than ±0.5% of end-scale. Gain as an isolation amplifier is (0.5 volt divided by the null range sensitivity).

POLARITY: Reversible via front-panel switch.

WARMUP TIME: 30 seconds.

DC COMMON MODE REJECTION: 140 db, or 0.1 uv/volt of common mode voltage.

AC COMMON MODE REJECTION:
140 db at 50, 60, and 120 Hz
120 db at 400 Hz

OPERATING TEMPERATURE RANGE: Within accuracy specifications from 16°C to 32°C (60°F to 90°F), derated at 0.00035%/°C outside these temperatures to 0°C and 50°C (32°F and 122°F).

STORAGE TEMPERATURE RANGE:
Model 885A -40°C to 70°C (-40°F to 158°F)
Model 885AB -40°C to 60°C (-40°F to 140°F)

SHOCK:
Meets requirements of MIL-T-945A and MIL-S-901B.

VIBRATION: Meets requirements of MIL-T-945A.

HUMIDITY: Within specifications up to 70% relative humidity.

INPUT POWER:
Model 885A 115/230 volts ac ±10%, 50 to 440 Hz.
Model 885AB 115/230 volts ac ±10%, 50 to 440 Hz and rechargeable battery operation. Minimum of 24 hours operation on full charge.

SIZE: 7" high x 8-1/2" wide x 14-3/4" deep.

WEIGHT:
Model 885A - approximately 14 lbs.
Model 885AB - approximately 15 lbs.

SECTION II

OPERATING INSTRUCTIONS

2-1. FUNCTION OF CONTROLS, TERMINALS AND INDICATORS

2-2. The location, reference designation, and a functional description of the external controls, terminals, and indicators on the 885A and 885AB DC Differential Voltmeters is given in Figures 2-1 and 2-2.

2-3. PRELIMINARY OPERATION OF 885A

a. Mechanically zero the meter with the adjustment screw on the front panel. If the instrument has been operating, it must be shut off for at least three minutes prior to this adjustment.

b. Connect the power plug to a 115 volt ac power source, or to 230 volts ac if the instrument is so wired.

WARNING!

The round pin on the polarized three-prong plug connects the instrument case to power system ground. Use a three-to-two pin adapter when connecting to a two-contact outlet. For personnel safety, connect the short lead from the adapter to a high-quality ground.

c. Set the switches on the 885A as follows:

RANGE	1000
NULL	TVM
Polarity	+
Voltage readout dials	000000
POWER	ON

2-4. PRELIMINARY OPERATION OF 885AB

a. Mechanically zero the meter with the adjustment screw on the front panel. If the instrument has been operating, it must be shut off for at least three minutes prior to this adjustment.

b. For line operation, connect the power plug to a 115 volt ac power outlet, or to 230 volts ac if the instrument is so wired.

WARNING!

The round pin on the polarized three-prong plug connects the instrument case to power system ground. Use a three-to-two pin adapter when connecting to a two-contact outlet. For personnel safety, connect the short lead from the adapter to a high-quality ground.

c. For line operation, set the POWER switch to LINE OPR.

d. For battery operation, set the POWER switch to BAT CHECK. Meter needle should deflect to the BATTERY OK region. If the meter needle does not stay within the BATTERY OK region for 10 seconds, charge the batteries as outlined in paragraph 2-5. If the batteries are adequately charged, set the POWER switch to BAT OPR-LINE ISOL.

e. Set the remaining switches on the 885AB as follows:

RANGE	1000
NULL	TVM
Polarity	+
Voltage readout dials	000000

2-5. BATTERY CHARGING OF 885AB

a. Connect the power plug to a 115 volt ac source, or to 230 volts ac if the instrument is so wired.

b. Set the POWER switch to BAT CHG-LINE OPR. After 16 hours, the batteries will be fully charged and capable of operating the instrument for at least 24 hours. The instrument may be operated while the batteries are being charged.

CAUTION!

Since overcharging decreases battery life, it is recommended that the batteries be charged for less than 48 hours, and never more than 1 week. When used properly, the batteries will provide more than 200 charge-discharge cycles.

2-6. OPERATION AS A DIFFERENTIAL VOLTMETER

a. Perform preliminary operation according to paragraph 2-3 or 2-4.

b. Connect the unknown voltage between the INPUT and COMMON posts. If one side is grounded, always connect it to the COMMON post.

c. Set the RANGE switch to the lowest range that will permit on-scale meter deflection, and note the approximate value of the unknown voltage.

d. If the meter deflects to the left, the polarity of the unknown voltage is negative. Set the polarity switch to the negative position. The meter will deflect to the right.

e. Noting the position of the decimal point, set the five voltage readout dials to the approximate voltage determined in step c. For example, if the approximate voltage is 35 volts, the decimal point will be between the B and C readout dials. Therefore, set dial A to 3, and set dial B to 5.

f. Set the NULL switch from TVM to the first null position for the range being used, and adjust the readout dials for zero meter deflection.

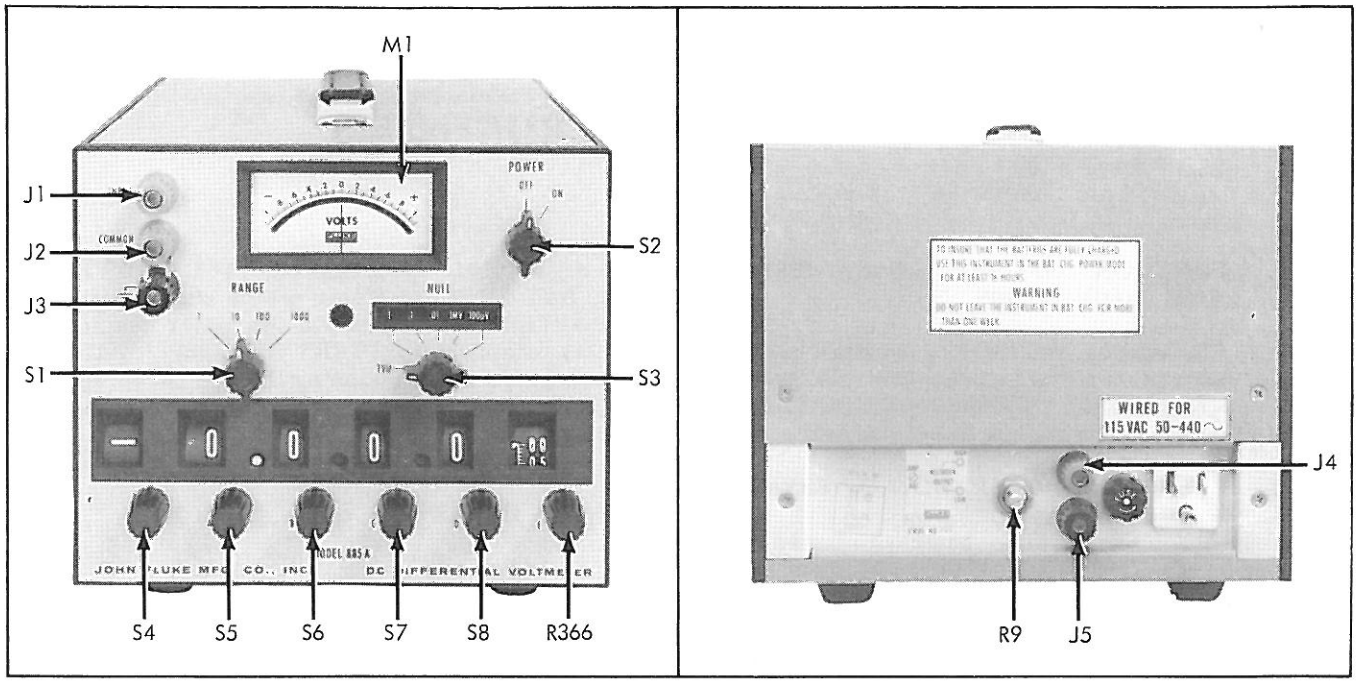


Figure 2-1. LOCATION OF CONTROLS, TERMINALS, AND INDICATORS

CONTROLS TERMINALS AND INDICATORS	REFERENCE DESIGNATION	FUNCTIONAL DESCRIPTION
INPUT and COMMON terminals	J1, J2	Provided for connecting the dc voltage to be measured.
Chassis ground terminal	J3	Provided for grounding purposes. A 0.047 uf capacitor is connected from the COMMON binding post to the chassis ground post. The INPUT post should never be connected to chassis ground. Since the instrument is equipped with a three-wire line cord with the third wire connected to the chassis, the circuit should be checked for conflicts in grounding before connecting the COMMON post to the chassis ground post.
POWER switch	S2	In the Model 885A, the POWER switch applies ac line voltage to the primary circuit of the power transformer when set from OFF to ON. In the Model 885AB, positions are available for OFF, BAT CHECK, and three modes of operation (BAT CHG-LINE OPR, LINE OPR, and BAT OPR-LINE ISOL). When set to LINE OPR, ac line voltage is applied to the primary circuit of transformer T1. When set to BAT CHG-LINE OPR, ac line voltage is applied to the primary of T1 and the batteries are charged at the same time. When set to BAT OPR-LINE ISOL, battery power is applied to the instrument and both sides of the primary of T1 are open. When set to BAT CHECK, battery power is applied to the instrument, both sides of the primary circuit are open, and the meter is connected in series with a resistor to measure the difference between the battery voltage and the reference power supply voltage, which indicates the state of battery charge.
RANGE switch	S1	Selects desired voltage range, changes null ranges appearing in NULL window, and positions decimal point of voltage readout dials.

Figure 2-2. FUNCTION OF CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 2)

CONTROLS TERMINALS AND INDICATORS	REFERENCE DESIGNATION	FUNCTIONAL DESCRIPTION
NULL switch	S3	Sets the instrument for either conventional voltmeter operation, or differential voltmeter operation. The null ranges represent the difference between the unknown voltage and the internal reference voltage set by the voltage readout dials.
Voltage readout dials A, B, C, D, and E	S5, S6, S7, S8, & R366	Provide an in-line readout of the amount of internal reference voltage necessary to equal the unknown voltage.
Polarity switch	S4	Changes polarity of 885A to match the polarity of the unknown voltage. The + position indicates that the INPUT post is positive with respect to the COMMON post.
Mechanical zero	none	Sets meter to zero mechanically. This adjustment should be used only after the instrument has been off for at least three minutes, or if the internal meter terminals are shorted.
Meter	M1	Indicates the unknown voltage when the instrument is in the tvm mode, and indicates the difference between the unknown and the internal reference voltage when the instrument is in the null mode.
RECORDER OUTPUT	J4, J5	Provided for connecting a recorder to monitor meter deflection. Also used as the output terminals when the instrument is used as an isolation amplifier.
AMP ADJ control	R9	Varies the output voltage at the RECORDER OUTPUT posts from 0 to at least 0.5 volt for full-scale meter deflection.

Figure 2-2. FUNCTION OF CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 2)

g. Adjust the readout dials for zero meter deflection in successively more sensitive null ranges. When the meter needle deflects to the right, the magnitude of the voltage under measurement is greater than the voltage set on the readout dials. When deflection is to the left, the voltage under measurement is less than the voltage set on the readout dials.

h. When the meter is at null on the most sensitive null range, the unknown voltage equals the value set on the five readout dials.

2-7. OPERATION AS A CONVENTIONAL VOLTMETER

2-8. The instrument can also be used as a conventional 3% voltmeter (TVM). Additional ranges can be made available for measuring low-level voltages by converting the null ranges to conventional voltmeter ranges, by setting the voltage readout dials to zero. Proceed as follows:

a. Perform preliminary operation according to paragraph 2-3 or 2-4.

b. Refer to Figure 2-3 and select the full-scale voltage range desired. If the approximate value of the voltage being measured is unknown, select the 1000 volt range initially.

c. Set the RANGE switch, NULL switch, and voltage readout dials according to Figure 2-3 for the range selected.

d. Connect the voltage to be measured between the INPUT and COMMON posts. If one side is grounded, always connect it to the COMMON post.

e. Voltage is indicated by the meter deflection. Deflection to the right when the polarity switch is set to positive indicates that the unknown voltage is of positive polarity.

2-9. MEASUREMENT OF VOLTAGE EXCURSIONS ABOUT A NOMINAL VALUE

a. Perform preliminary operation according to paragraph 2-3 or 2-4.

b. Connect the voltage to be measured between the INPUT and COMMON posts. If one side is grounded, always connect it to the COMMON post. Deflection to the left indicates that the voltage is of negative polarity; set the polarity switch to negative. The meter will deflect to the right.

FULL-SCALE DEFLECTION	RANGE SWITCH	NULL SWITCH	VOLTAGE DIALS
1000-0-1000	1000	TVM	No effect
100-0-100	100	TVM	No effect
10-0-10	10	TVM	No effect
1-0-1	1	TVM	No effect
0.1-0-0.1	1	0.1	All zero
0.01-0-0.01	1	0.01	All zero
0.001-0-0.001	1	0.001	All zero
0.0001-0-0.0001	1	0.0001	All zero

Figure 2-3. TVM RANGES

c. Set the RANGE switch to the lowest range that will permit on-scale meter deflection, and note the nominal value of the voltage indicated.

d. Set the five voltage readout dials to the nominal voltage.

e. Set the NULL switch from TVM to the highest null sensitivity possible, while retaining voltage excursions on scale.

f. Voltage excursions are indicated by the meter. Note that full-scale right and left meter deflection is equal to the null range being used (disregarding 10% overranging). Meter deflection to the right indicates that the voltage being measured has increased above the nominal value set on the readout dials. Deflection to the left indicates that the voltage has, of course, decreased below the nominal value.

2-10. USE WITH A RECORDER

2-11. A recorder may be used with the 885A series instruments to record deflection of the panel meter. Since the low side of the RECORDER OUTPUT is grounded to the chassis, the input isolation characteristics of the recorder is of no consequence. Proceed as follows:

a. Connect the RECORDER OUTPUT terminals to the input terminals of the recorder.

b. Perform the preliminary operation according to paragraph 2-3 or 2-4.

c. Short the INPUT and COMMON posts, and set the front-panel switches on the 885A as follows:

RANGE	10
NULL	1
Polarity	+
Voltage readout dials	1.000000

d. The meter will indicate full scale (-1.0). This provides up to 0.5 volts dc at the RECORDER OUTPUT terminals, depending on the setting of the AMP ADJ control.

e. Adjust the AMP ADJ control until recorder deflection is as desired for full-scale meter deflection.

f. Remove the short between the INPUT and COMMON posts, and connect the voltage to be monitored. The voltmeter and recorder are ready for use. Proceed according to paragraph 2-9.

2-12. MEASUREMENT OF HIGH RESISTANCE

2-13. One of the features of the 885A series voltmeters is the ability to be used as a megohmmeter for rapid measurements of high resistance from 10 megohms to 110,000 megohms with a typical accuracy of 5%. The following equation derived from Figure 2-4 may be used to compute the resistance in megohms of an unknown connected to the input binding posts when the RANGE switch is set to 10.

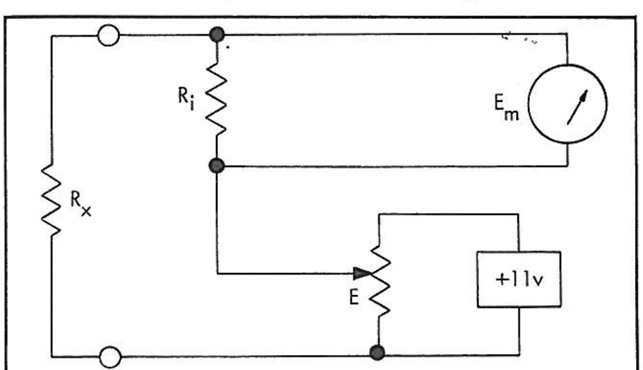


Figure 2-4. MEASUREMENT OF RESISTANCE

$$R_x = R_i\left(\frac{E}{E_m} - 1\right) \text{ megohms}$$

where:

R_x = the unknown resistance in megohms

E = the voltage indicated by the voltage readout dials

E_m = the voltage indicated by the meter

R_i = the input resistance of the tvm circuit in megohms, which is 10 for the 1, 0.1, and 0.01 null ranges, and 1 for the 0.001 and 0.0001 null ranges, on the 10 volt range.

2-14. A convenient way of measuring leakage resistance between 10 megohms and 110,000 megohms is to adjust the voltage readout dials so that the meter indicates full scale (-1.0). The unknown resistance is then easily calculated from the readout dial setting. Proceed as follows:

a. Perform preliminary operation according to paragraph 2-3 or 2-4.

b. Set RANGE switch to 10.

c. Set NULL switch to 1.

d. Connect the unknown resistance between INPUT and COMMON posts. Use short isolated leads to prevent measuring the leakage resistance between leads.

e. Adjust voltage readout dials for full-scale meter deflection (-1.0). If full scale deflection cannot be obtained with the NULL switch set to 1, increase the null sensitivity as necessary.

f. Determine the value of the unknown resistance according to Figure 2-5.

2-15. NOTES ON OPERATION OF 885A AND 885AB

2-16. Ground loop currents should be avoided to assure measurement accuracy. A potential difference often exists between different points on power system grounds. Consequently, current may flow from the power system ground through the voltmeter and the equipment being measured and back to the power system ground. To prevent ground loop currents when the system being measured is grounded, do not connect the COMMON post to the chassis ground post.

2-17. USE OF SHORTING LINK

2-18. A 0.047 uf capacitor (C1) is connected from the COMMON binding post to the chassis ground binding post, which reduces the effect of circulating ac currents from the transformer. In some cases, it is possible for C1 to acquire a charge. For example, C1 will become charged when making measurements in the presence of dc common mode voltages. This charge may cause an error on subsequent low-level measurements (under 5 volts) due to C1 discharging through the Kelvin-Varley divider and leakage resistance to ground. Connecting the shorting link from the COMMON post to the chassis ground post for a few seconds will discharge C1 and thus prevent an incorrect indication.

RANGE OF UNKNOWN RESISTANCE	NULL SWITCH POSITION	UNKNOWN RESISTANCE IN MEGOHMS AT FULL-SCALE (-1.0) METER DEFLECTION
10 megohms to 100 megohms	1	Multiply amount set on voltage readout dials by 10, and subtract 10.
90 megohms to 1090 megohms	.1	Multiply amount set on voltage readout dials by 100, and subtract 10.
990 megohms to 11,000 megohms	.01	Multiply amount set on voltage readout dials by 1000, and subtract 10.
10,000 megohms to 110,000 megohms	100 UV	Multiply amount set on voltage readout dials by 10000.

Figure 2-5. RESISTANCE MEASUREMENTS USING FULL-SCALE DEFLECTION

2-19. EFFECT OF AC COMPONENTS

2-20. Occasionally an ac component may be present on the dc being measured. A double-section, low-pass filter, R202, C202, R203, and C203, at the input of the null detector attenuates any ac component by 50 db, or about 300 to 1. At lower frequencies, this low-pass filter is less effective, and the ac component may be significant. The only ac component that will reduce measurement accuracy is one that either starts to satu- the null detector, or one that is very close to a multiple or submultiple of the chopper frequency of 84 Hertz. The null detector is more sensitive to the latter. However, if harmonics of the chopper frequency are affecting the null detector the meter will oscillate at the difference frequency. For all pratical purposes, no trouble should be encountered above a hundred Hertz. If ac components that affect accuracy are ever encountered, additional filtering at the input of the instrument will be necessary. For alternating current of a single frequency, a twin-T filter is effective, and has low total series resistance. For an alternating current of various frequencies, an ordinary low-pass filter can be used. In either case, the filter should be constructed of high-quality capacitors having high leakage resistance.

2-21. EFFECT OF DC COMMON MODE VOLTAGE

2-22. DC common mode errors are caused partly by leakage currents passing through ground loops. Care has been taken in the design and construction of the instrument to isolate the circuitry from chassis ground. Accurate dc measurements can be made with the 885A and 885AB in the presence of common mode voltages of up to 1000 volts dc. The dc common mode rejection is at least 140 db (10,000,000 to 1), or 0.1 uv of error per common-mode-volt, up to 70% relative humidity. Since the leakage resistance varies inversely with humidity, the dc common mode error is typically much less at lower relative humidity. If the common mode voltage is greater than 50 volts, the measurement should be made several minutes after hookup for best accuracy. This is due to the time required to charge stray capacitance through the extremely high leakage resistance to ground.

2-23. CHECKING BATTERIES OF 885AB

2-24. If the 885AB is turned off with the batteries completely discharged, the battery voltage may recover with time. It is possible for the batteries to recover sufficiently for the meter to indicate that they are charged, when the power switch is first set to battery check. However, after a few seconds, the battery voltage will fall, and the meter will indicate that the batteries need to be charged. It should be noted that the discharge characteristic of nickel-cadmium batteries is nearly flat, except near full charge and complete discharge. Therefore, when the batteries are checked, the meter indication is not proportional to the remaining ampere-hour capacity of the batteries. Just after the batteries are charged, the meter will indicate near full scale. However, most of the time the meter will indicate near half scale. A few hours before the batteries need recharging, the meter needle will indicate just within the BATTERY OK region.

2-25. MEASUREMENT OF NEGATIVE VOLTAGES

2-26. Because of the polarity switch, voltage which is negative with respect to common, as well as positive voltage, may be measured with equal facility. If the INPUT binding post is connected to ground, either at the front panel or at the source being measured, the accuracy of the voltmeter may be reduced. If the unknown voltage is grounded, always connect the grounded side to the COMMON post, and use the polarity switch to obtain the proper result.

2-27. OFF-NULL INPUT RESISTANCE

2-28. The input resistance of the 885A and the 885AB is infinite at null on the 1 volt and 10 volt input ranges, since no current flows from the source being measured. However, a small current does flow from the unknown when the meter is deflected from null. For example, when the meter is deflected 10% of full-scale on the 10 volt input range and 1 mv null range, the input resistance of the instrument is 10^{10} ohms per volt of input, or 100,000 megohms total. Figure 2-6 is a graph of the apparent dc input resistance when the meter is off null.

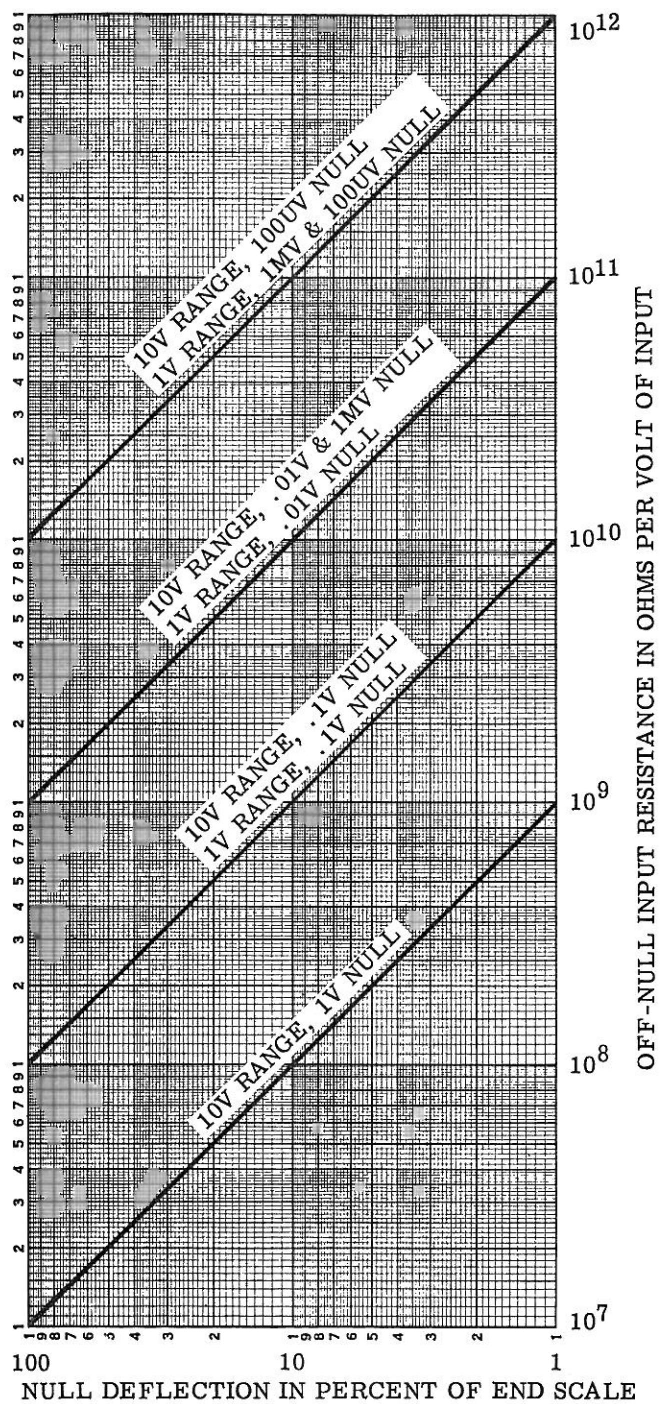


Figure 2-6. 885A OFF-NULL INPUT RESISTANCE

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. GENERAL

3-3. A block diagram for the 885A/885AB DC Differential Voltmeter is given in Figure 3-1. Additional detail is contained in the functional schematic in the back of this manual. The schematic is intended to aid in understanding circuit theory and in troubleshooting. The signal flow is from left to right and the components are arranged functionally.

3-4. The overall operation of the instrument may be summarized as follows. For direct measurement of an unknown voltage between 0 and 11 volts, it is connected directly to the input attenuator of the transistorized voltmeter (tvm). Since full-scale sensitivity of the meter amplifier is 1 millivolt, the tvm attenuator reduces the input voltage before it is applied to the meter circuit. The value of the unknown is indicated by deflection of the panel meter. For null measurement of the unknown voltage, an internal reference voltage of 0 to 11 volts is connected in opposition to the unknown, and the meter circuit indicates the difference between the two voltages. The reference voltage is then adjusted with the Kelvin-Varley voltage dials until the internal voltage equals the unknown, as indicated by zero deflection of the null detector. The unknown is then indicated by the setting of the Kelvin-Varley dials. For voltages between 11 and 1100 volts, an input attenuator reduces the input voltage to the level of the 10 volt range. The reduced voltage is then measured as described above, either in the TVM mode or in the null mode.

3-5. INPUT RESISTANCE OF INSTRUMENT

3-6. For the tvm, low sensitivity, and medium low sensitivity null ranges, the input resistance of the tvm attenuator is 10 megohms (R1 through R6). For the

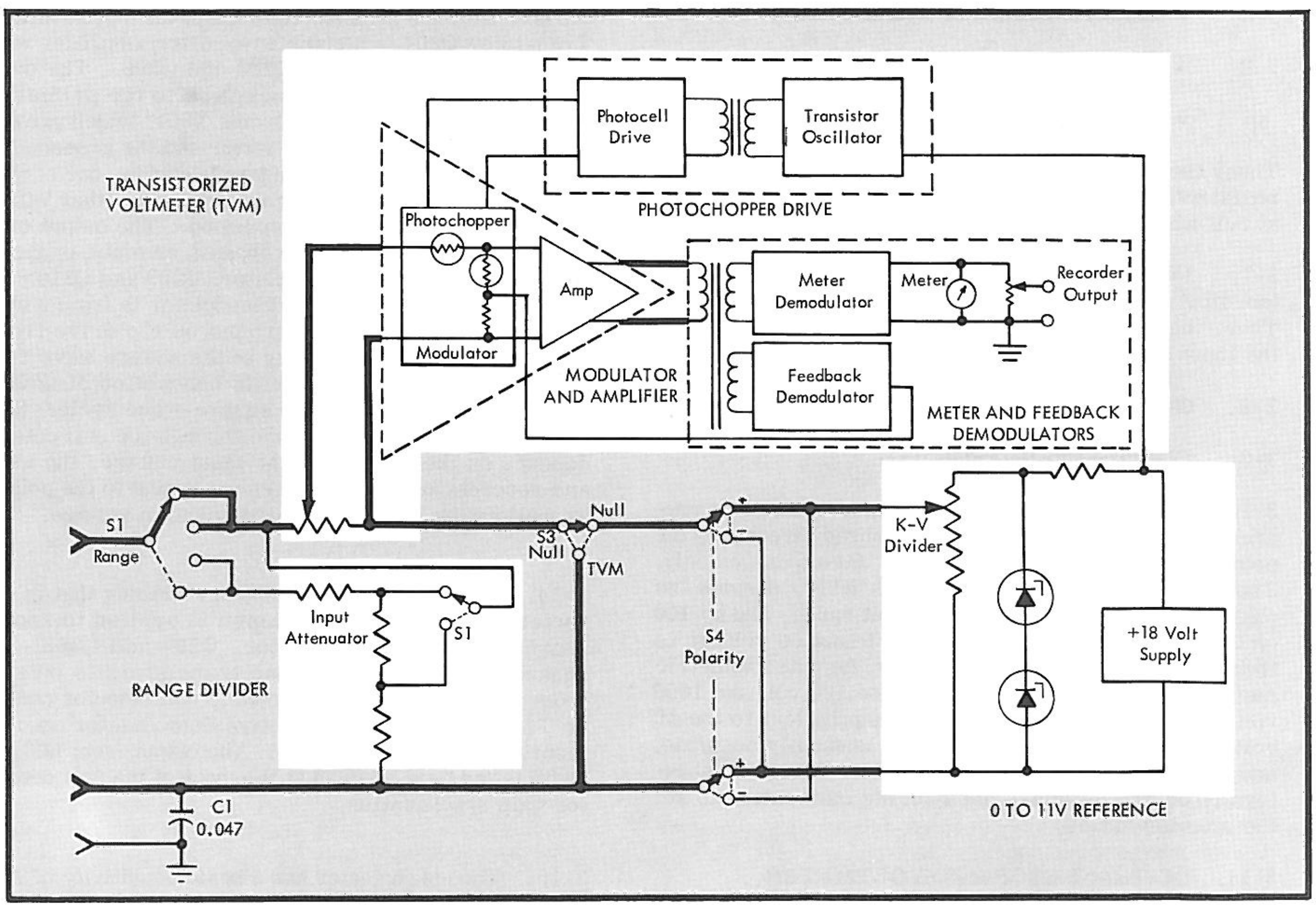


Figure 3-1. MODEL 885A BLOCK DIAGRAM

medium high and high sensitivity null ranges, the input resistance of the tvm attenuator is 1 megohm (R1 through R6). However, this is not the input resistance of the instrument when making a null measurement. For the 1 and 10 volt ranges, the input resistance is determined by dividing the unknown terminal voltage by the current drawn from the unknown. The current drawn from the unknown is equal to the difference between the unknown terminal voltage and the internally known voltage, divided by the resistance of the tvm attenuator. The equation for input resistance can therefore be written as:

$$R_{in} = \frac{E_u}{I_u} = \frac{E_u R_a}{|E_u - E|} = \frac{E_s (R_a + R_s)}{|E_s - E|} - R_s$$

where:

R_{in} = input resistance of voltmeter

I_u = current drawn from unknown

E_u = source voltage of unknown

R_s = source resistance of unknown

E_u = $E_s - I_u R_s$ = terminal voltage of unknown

R_a = input resistance of tvm attenuator

E = voltage indicated by voltage readout dials

$| \; |$ = absolute value (magnitude only)

Thus, the input resistance is essentially infinite (leakage resistance across the input is approximately 10^{12} ohms) at null when E is equal to E_u and E_s.

3-7. For the 100 and 1000 volt ranges, the input attenuator is always connected across the input terminals. Thus, the input resistance is equal to the resistance of the input attenuator, which is 10 megohms.

3-8. CIRCUIT DESCRIPTIONS

3-9. INPUT ATTENUATOR

3-10. Since the instrument contains a 0 to 11 volt reference, the unknown voltage is measured directly by the potentiometric method on the 1 and 10 volt ranges only. The input attenuator, R101 through R110, divides the unknown voltage by 10 on the 100 volt range, and by 100 on the 1000 volt range, and this attenuated voltage is then measured by either the tvm or the potentiometric method. Thus, after attenuation, the 100 volt and 1000 volt ranges provide an input level equivalent to the 10 volt range. The input attenuator is unusually accurate, and has excellent long-term stability. Variable resistors R106 and R109 are used during calibration to set the division ratios.

3-11. DC TRANSISTORIZED VOLTMETER

3-12. INTRODUCTION. The dc transistorized voltmeter (tvm) is composed of a tvm attenuator and a null detector. The primary part of the tvm is the null detector, in which the dc signal is modulated by a photochopper, amplified by a five-stage amplifier, rectified by a phase-sensitive demodulator, and filtered to produce a dc output. Transformer coupling is used to isolate the dc meter/recorder drive from the remainder of the instrument circuitry. High negative feedback makes the null detector relatively insensitive to gain variations of individual transistors. Meter M1 has tautband suspension, which eliminates the stickiness associated with pivot and jewel meters.

3-13. NULL DETECTOR. The null detector is a current feedback amplifier that drives a meter. The feedback voltage is the voltage drop across R208 caused by a portion of the output current. At the input to the 885A null detector, R202, C202, R203, and C203 form a double section low-pass filter that reduces any ac component present on the dc voltage being measured. The difference between the voltage appearing at the output of the filter and the voltage across feedback resistor R208 is converted to a square wave by PC201 and PC202, an 84 Hz photo-chopper. The effect of a negative input voltage is to shift the phase of the square wave by 180°. Thus, by using a phase-sensitive demodulator, the polarity of the input voltage is reconstructed in the meter drive circuit. The alternating voltage created by PC201 and PC202 is amplified by a five-stage amplifier. Transistors Q201, Q202, and Q203 are common-emitter amplifiers having a resistor common to all three emitters. Transistor Q204 is a common-emitter amplifier which drives the push-pull pair Q205 and Q206. The output from the push-pull pair is applied to the primary of transformer T201. Transformer T201, which provides isolation between the null detector and the grounded recorder output, has two secondary windings, one of which is connected to null detector common, the other winding being connected to chassis common. The output of the winding that is connected to chassis common is applied to a phase-sensitive demodulator, Q209 and Q210. The square-wave drive for this demodulator is from a winding connected to chassis ground on the drive transformer, T101. The polarity of the square wave out of the drive transformer permits conduction of Q209 or Q210 during only 1/2 of the square-wave cycle. Since the phasing of the square wave through the null detector depends on the polarity of the input voltage, the meter and recorder output are driven according to the polarity as well as the magnitude of the unknown voltage.

3-14. The output of the secondary winding that is connected to null detector common is applied to another phase-sensitive demodulator, Q207 and Q208. The square-wave drive for these transistors is obtained from a winding that is connected to null detector common on T101. This phase-sensitive demodulator operates identically to Q209 and Q210. The output from Q207 and Q208 is fed back to R208 at the input of the null detector for gain stabilization.

3-15. The null detector has a basic sensitivity of 1 mv, except for the two most sensitive null ranges of the 1 volt range and the most sensitive null range on the 10, 100, and 1000 volt ranges, in which the sensitivity of the null detector is increased to 100 uv. It should be noted that there is a slight loading effect on the input attenuator due to the tvm attenuator, especially on the 100 volt range. However, this loading is compensated by increasing the null detector sensitivity, and causes negligible measurement error.

3-16. TVM ATTENUATOR. In tvm operating mode, one position on the tvm attenuator, selected by range switch section S3G, provides the necessary reduction of the 1 volt range for proper null detector input. A second position on the tvm attenuator is used for the 10, 100, and 1000 volt ranges, because the input attenuator of the instrument reduces the 100 and 1000 volt ranges to the equivalent of the 10 volt range. In the null operating mode, the voltage difference of the unknown voltage minus the reference voltage - or the unknown voltage divided down, minus the reference voltage - is reduced as necessary by positions on the tvm attenuator selected by null switch sections S3G and S3E to provide the basic null detector input of 1 millivolt or 100 microvolts.

3-17. CHOPPER DRIVE CIRCUIT. The chopper drive circuit provides ac drive for the photo-chopper modulator and for the phase-sensitive demodulators. Auxiliary power supply voltages for the null detector are also obtained from the chopper drive circuit. The chopper drive is essentially a transformer-chopper multivibrator. Assume that Q107 has been conducting, and Q106 turns on. Conduction of Q106 applies +18 volts between pins 1 and 2 of T101, which induces a voltage between pins 4 and 5. The secondary winding of pins 4 and 5 is connected between the bases of Q106 and Q107. The two windings are phased so that the voltage between pins 4 and 5, approximately 12 volts, adds to the voltage at the base of Q106, which is effectively clamped at +18 volts. The resulting voltage biases Q107 off. After Q107 is biased off, capacitor C104 begins to discharge through R131 and R132. When the voltage across C104 approaches +18 volts, Q107 begins to turn on, and the preceeding cycle is repeated with Q107 conducting. Resistor R132 is used for frequency adjustment.

3-18. AC voltage for the +15 volt, +10 volt, and -15 volt auxiliary supplies are obtained from one transformer winding. Diodes CR206 and CR207, and capacitors C214 and C215 form two half-wave rectifiers. Regulation of the +10 volt supply is provided by zener diode CR203.

3-19. RECORDER OUTPUT. A recorder output proportional to meter deflection is provided by R8 and R9. The AMP ADJ control R8 provides for adjusting the recorder output voltage to at least 0.5 volt at full-scale meter deflection (1.0). The recorder output is driven by the same demodulator that drives the panel meter. The low side of the RECORDER OUTPUT is connected to chassis ground.

3-20. 0 TO 11 VOLT REFERENCE

3-21. GENERAL. In making differential voltage measurements between 0 and 11 volts, an internal reference voltage is nulled directly against the unknown voltage. The extremely accurate reference voltage required is obtained from the 0 to 11 volt reference, which is composed of a well-regulated +18 volt power supply that supplies current to a pair of stable zener reference diodes, a range divider, and a five-decade Kelvin-Varley divider.

3-22. +18 VOLT POWER SUPPLY. The +18 volt power supply uses diode CR102 and filter capacitor C101 to supply unregulated dc voltage to series pass transistor Q101. In the Model 885AB, unregulated dc voltage can also be supplied by a set of batteries (BT1) in the BAT OPR and BAT CHECK modes. The +18 volts is regulated by comparing a sample of the output voltage, tapped off divider string R113, R114, and R115, with the voltage from zener reference diodes CR103 and CR104 in a two-stage differential amplifier. Transistor Q103 is a dual transistor, having matched current gain and matched $\triangle V_{be}$, which insures minimum voltage change due to temperature in the +18 volt reference voltage. The output from Q103, which is proportional to the difference between the two inputs, is applied to a second stage of differential amplification, Q104 and Q105. The output from Q104 is applied to the base of series pass transistor Q101. The differential amplifier adjusts the voltage drop across the series pass transistor so as to maintain a constant output voltage. The +18 volt provides operating current for the chopper drive multivibrator, and supplies a constant current through R121 and R122 to its own zener reference diodes CR103 and CR104. If the instrument is turned on with the battery voltage below about 5 volts, there is a possibility that transistor Q101 may not begin conduction. Thus, when the power switch is set to BAT CHECK, the meter would indicate an adequate battery change, because all of the voltage drop appears across Q101. When the instrument is first turned on, the base-emitter junction of Q102 is forward biased, and Q102 conducts, which causes transistor Q101 to conduct and become saturated. As the output voltage of the +18 volt supply rises above +11 volts, transistor Q102 becomes biased off, and the differential amplifier controls the conductance of Q101.

3-23. For instrument serial numbers 624 and on, zener diodes CR103 and CR104 are enclosed in a proportionally-controlled oven, Q111, Q112, Q113, and associated components. The oven heater is R147. Transistors Q112 and Q113 are connected as a differential amplifier, with the base voltage of Q113 fixed by R153 and R154. The base voltage of Q112 is set by R150 and R155. Since R155 is temperature-sensitive, the base voltage of Q112 varies inversely with temperature. The output from the collector of Q112, which is proportional to the difference between the base voltages of Q112 and Q113, is applied to the base of Q111 and controls the conduction of Q111, which controls heater current. For example, as the oven temperature increases, the resistance of R155 decreases. This causes a more positive output from the collector of Q112, which reduces the conduction of Q111, thus reducing current through the heater R147, and decreasing heating of R147. C-105 is designed to eliminate any oscillations appearing at the base of Q112, thus providing temperature regulated DC for R147.

3-24. RANGE DIVIDER. The range divider attenuates the voltage from the zener reference diodes CR103 and

CR104, before the reference voltage is applied to the Kelvin-Varley divider. In the 10, 100, and 1000 volt ranges, the zener reference voltage is connected to the Kelvin-Varley divider through resistors R124 and R125, which attenuates the zener reference voltage to 11 volts at the input of the divider. In the 1 volt range, resistors R126, R127, and R128 attenuate the reference voltage to 1.1 volts.

3-25. KELVIN-VARLEY DIVIDER. The five-decade Kelvin-Varley divider, composed of resistors R301 to R366, is capable of dividing the reference voltage into 1,100,000 equal increments, thus providing the extremely accurate reference voltage required. The decades are adjusted by voltage dials A through E. The first decade has twelve 5K resistors (4,999.1 ohms plus a 2 ohm trimmer). Two of these resistors are shunted by the 10K total resistance of the second decade. Between the two wipers of S5 there is therefore a total resistance of 5K (10K in parallel with 10K). Thus, the first decade divides the voltage across it into eleven equal parts, with one of the parts appearing across the two shunted resistors. Similarly, the voltage across the second, third, and fourth decades is divided into 10 equal parts. Note that the second, third, and fourth decades each have eleven 1K resistors. The resistors may have the same value because of padding resistors R338-R339 and R351-R352, which are used across the second and third decades to provide the correct resistance matching. The last decade with its associated shunt resistance is a potentiometer which can be set to increments of 1/100 of the voltage across its input. The Kelvin-Varley resistors are matched for resistance tolerance and temperature coefficient, thus providing an overall accuracy of ±0.0012% of setting from 1/10 of full scale to full scale. It should be noted that resistors R301, R302, R303, and R304, R305, R306, in the first decade are parallel combinations to provide increased resolution for calibration.

3-26. REFERENCE VOLTAGE ADJUSTMENTS. Variable resistor R115 is used during calibration to set the reference supply to +18 volts. This adjustment should have to be repeated only when a component of the reference supply is replaced. The voltage from the zener reference diodes is attenuated to 11 volts at the input of the Kelvin-Varley divider by adjusting R125. Variable resistor R127 is then adjusted for 1.1 volts at the input of the Kelvin-Varley divider for the 1 volt range. The trimmer resistors in the first decade, and trimmer resistors R338, R351, and R364, should require adjustment only if a component in the Kelvin-Varley divider is replaced.

3-27. POLARITY SWITCH

3-28. The polarity switch, S4, reverses the transistorized voltmeter-reference voltage connection with respect to the input. Note that a 0.047 uf capacitor, C1, is connected from the COMMON post to the chassis ground post to reduce the effect of circulating ac currents. If the instrument did not contain a polarity switch, the grounded side of a negative voltage would have to be connected to the INPUT terminal, which would place C1 across the input. The polarity switch prevents this occurrence, and provides equal convenience and accuracy in measuring positive and negative voltages.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. Maintenance of the 885A DC Differential Voltmeter should consist primarily of occasional cleaning and calibration. To determine if the instrument is operating within specifications, its performance can be tested by using the performance tests in this section. Information on troubleshooting is also included.

4-3. TEST EQUIPMENT REQUIRED

4-4. Figure 4-1 is a list of test equipment recommended for performance testing, calibration, and troubleshooting. If the recommended equipment is not available, other equipment which meets the required specifications may be used.

4-5. PERIODIC MAINTENANCE

4-6. Periodic maintenance consists primarily of occasional cleaning to remove dust, grease, and other contamination. Since the voltmeter is completely enclosed, the need for cleaning is minimized. Special care has been taken to prevent leakage across critical switch wafers, areas of some printed circuit boards, and from the printed circuit boards to chassis ground. The power, range, null, polarity, and voltage readout switches are vacuum impregnated with polybutane oil. These switches are also isolated from the chassis with Lexan spacers. The printed circuit boards are coated with a moisture sealant and are isolated from chassis ground by polyethelene grommets.

4-7. Clean the instrument as follows:

CAUTION!

Avoid touching the polyethelene grommets. Contamination can cause excessive electrical leakage.

a. Remove accumulations of dust and other foreign matter with low-pressure, clean, dry air. Pay particular attention to the input binding posts, binding post wiring, switches, and polyethelene grommets.

b. Clean the polyethelene grommets, binding post, and front panel with anhydrous ethyl alcohol, or an aerosol can of Freon TF Degreaser (Miller-Stephenson Chemical Co, Inc.) and, if necessary, a clean cloth or cotton swab.

CAUTION!

Do not use Metriclene, acetone, lacquer thinner, or any ketone, since they will react with the Lexan switch rotors. Also, be careful not to saturate the switch contacts, which have been lubricated for life.

c. When necessary, clean all exposed dielectric surfaces of switches with denatured alcohol, using a small, stiff-bristle brush which has been wrapped with a clean cloth to prevent saturating the switch contacts.

d. After cleaning, recoat the exposed switch insulating material with oranite 8E polybutane oil. This prevents leakage due to moisture on these surfaces.

4-8. PERFORMANCE TESTING

4-9. GENERAL

4-10. The following tests are designed to compare the instrument's performance with the specifications. The tests may be used during routine maintenance, and for receiving inspection. Performance should be tested just before calibration of the instrument. When used in this way, the performance tests provide a valuable history of the characteristics of each instrument. Just prior to calibration, the instrument should be within specifications; if not, troubleshooting should be performed to correct the cause of the error before calibrating the instrument. Localizing the problem to a particular area of the instrument may be done by an analysis of the performance results.

RECOMMENDED EQUIPMENT	SPECIFICATIONS REQUIRED	USE
VTVM, RCA Voltohmyst, or equivalent	Range: 0 to 30 vdc 0 to 300 vac Accuracy: ±3% dc ±5% ac Input Impedance: 10M, 5 pf, dc 1M, 100 pf, ac	CORRECTIVE MAINTENANCE Voltage Level Measurements
Autotransformer, General Radio Model W5MT3 Variac (W5HMT for 230 volt instruments).	103 to 127 volts (207 to 253 volts for 230 volt instruments).	CORRECTIVE MAINTENANCE Reference Voltage Regulation
DC Differential Voltmeter, Fluke Model 801B, or equivalent	Range: 10 to 500 volts Accuracy: ±0.05% Null Range: 10 mv, minimum	CORRECTIVE MAINTENANCE Reference Voltage Regulation
Standard Cell Bank, Guidline Instruments Model MB3, or equivalent	Accuracy: 0.0005%	PERFORMANCE TESTING Differential Measurement Test CALIBRATION CORRECTIVE MAINTENANCE Common Mode Test
DC Power Supply, Fluke Model 412B, or equivalent	Output Voltage: 1 to 1100 vdc Output Current: 2 ma Stability: ±0.005% per hour Resolution: 5 mv	PERFORMANCE TESTING Differential Measurement Test CALIBRATION CORRECTIVE MAINTENANCE Common Mode Test Kelvin-Varley Divider Test Kelvin-Varley Divider Adjustment
Null Detector, Fluke Model 845A, or equivalent	Range: 1 uv to 1 mv end scale.	PERFORMANCE TESTING Differential Measurement Test CALIBRATION CORRECTIVE MAINTENANCE Kelvin-Varley Divider Test Kelvin-Varley Divider Adjustment
Kelvin-Varley Divider, Fluke Model 720A, or equivalent	Ratio Accuracy: 1 ppm from 1/10 full-scale to full-scale.	PERFORMANCE TESTING Differential Measurement Test CORRECTIVE MAINTENANCE Kelvin-Varley Divider Test Kelvin-Varley Divider Adjustment
Lead Compensator, Fluke Model 721A, or equivalent	Resolution: 0.010 ohms Divider Ratios: .1 to 1	CORRECTIVE MAINTENANCE Kelvin-Varley Divider Test Kelvin-Varley Divider Adjustment
Counter, Hewlett Packard Model 5221A, or equivalent	Count: 84 Hz, ±1%	CORRECTIVE MAINTENANCE Photochopper Frequency Adjustment
Voltage Reference Divider, Fluke Model 750A, or equivalent	Output Voltage: 1, 10, 100, and 1000 volts dc. Accuracy: Calibrated to ±0.0006% + 2 uv.	PERFORMANCE TESTING Differential Measurement Test CALIBRATION

Figure 4-1. TEST EQUIPMENT REQUIRED

4-11. NULL DETECTOR SENSITIVITY TEST

4-12. The null detector is tested in this procedure by using the instrument's internal reference supply and Kelvin-Varley divider. If the instrument fails to pass this test, it may be due to a faulty reference supply or Kelvin-Varley divider. In this case, measuring an accurate voltage in the TVM mode will indicate if the null detector is operating correctly. Proceed as follows:

a. Set meter to zero with mechanical zero control.
b. Set POWER switch to ON (or LINE OPR) and allow the instrument to warmup for 5 minutes.
c. Set polarity switch to +.
d. Short INPUT post to COMMON post.
e. Set switches on voltmeter as shown in Figure 4-2. The meter should indicate within 1-1/2 small scale divisions (±3% of null range) of the value shown in Figure 4-2.
f. Remove the short between the INPUT and COMMON posts.

4-13. DIFFERENTIAL MEASUREMENT TEST

4-14. The following procedure tests the instrument at 10%, 50%, and 100% of full-scale. This method tests the accuracy of the instrument with a minimum number of measurements. Proceed as follows:

a. Set the meter to zero with the mechanical zero control.
b. Set POWER switch to ON (or LINE OPR), and allow the voltmeter to warmup to equilibruim temperature (about 5 minutes).
c. Connect the necessary equipment to provide dc voltages of 1, 5, and 10 volts at an accuracy of ±(0.001% + 2 uv). Proceed as follows:

(1) Equipment connection is illustrated in Figure 4-3. Connect the 845A to the null detector terminals of the 750A, and connect a standard cell to the standard cell terminals of the 750A.

CAUTION

Be sure that the high voltage switch of the 412B is set to off.

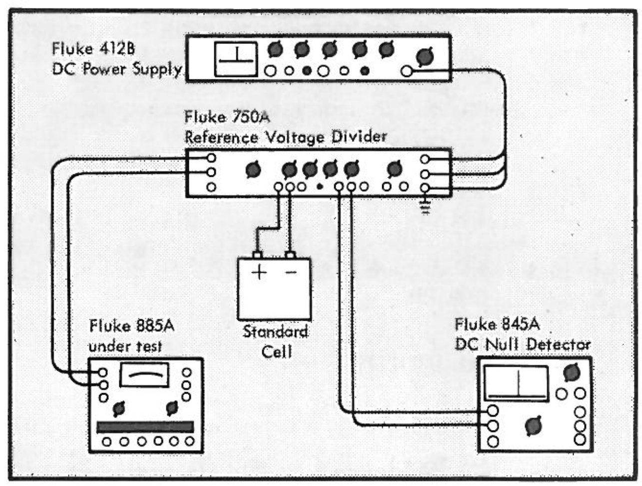


Figure 4-3. CONNECTION FOR TEST VOLTAGES

(2) Connect the 412B to the input voltage terminals of the 750A.
(3) Turn on all equipment and allow it to warmup for about 30 minutes.
(4) Set the standard cell voltage dials on the 750A to the correct standard cell voltage.
(5) Set the input voltage switch on the 750A to 1000 volts.
(6) Set the voltage dials on the 412B to 1000, and set the high voltage switch to on.
(7) Set the 845A to 100 microvolt sensitivity.
(8) Adjust the voltage dials on the 412B and the coarse and fine dials on the 750A for a null in successively more sensitive null ranges of the 845A. Final null should be on the 10 microvolt range. Zero the 845A as necessary.
(9) Voltages of 1, 5, and 10 volts are available at the output voltage terminals of the 750A when the output voltage switch is set to the desired position.

VOLTMETER SWITCH SETTINGS			METER INDICATION
RANGE	NULL	VOLTAGE READOUT DIALS A B C D E	
10	1.0	1. 0 0 0 00	-1.0
10	.1	0. 1 0 0 00	-1.0
10	.01	0. 0 1 0 00	-1.0
10	.001	0. 0 0 1 00	-1.0
1	.1	.1 0 0 0 00	-1.0
1	.01	.0 1 0 0 00	-1.0
1	.001	.0 0 1 0 00	-1.0
1	.0001	.0 0 0 1 00	-1.0
100	10	1 0.0 0 00	-1.0
100	1	0 1.0 0 00	-1.0
100	.1	0 0.1 0 00	-1.0
100	.01	0 0.0 1 00	-1.0
1000	100	1 0 0.0 00	-1.0
1000	10	0 1 0.0 00	-1.0
1000	1	0 0 1.0 00	-1.0
1000	.1	0 0 0.1 00	-1.0
10	1	0. 1 0 0 00	-0.1
10	1	0. 2 0 0 00	-0.2
10	1	0. 3 0 0 00	-0.3
10	1	0. 4 0 0 00	-0.4
10	1	0. 5 0 0 00	-0.5
10	1	0. 6 0 0 00	-0.6
10	1	0. 7 0 0 00	-0.7
10	1	0. 8 0 0 00	-0.8
10	1	0. 9 0 0 00	-0.9
10	1	1. 0 0 0 00	-1.0
10	1	1. 1 0 0 00	-1.1

Figure 4-2. SETTINGS FOR NULL DETECTOR CHECK

d. Zero the null detector of the 885A as follows:

(1) Connect the 885A ground post to line ground.
(2) Short the INPUT post to the COMMON post.
(3) Set the RANGE switch to 1, NULL switch to 100 uv, and all voltage readout dials to zero.
(4) If necessary, null the panel meter by adjusting electronic zero resistor R204. The top cover must be removed to gain access to this resistor.
(5) Remove the short between the INPUT and the COMMON posts.

e. Set the NULL switch to .1, and set the voltage dials to 1.000000.
f. Apply 1 volt dc ±(0.001% + 2 uv) between the INPUT and COMMON posts.
g. Adjust the voltage readout dials for zero meter deflection in successively more sensitive null ranges. Final readout dial setting should be between .999969 and 1.000131.
h. Set RANGE switch to 10, NULL switch to 1, and voltage readout dials to 5.00000.
i. Apply 5 volts dc ±(0.001% + 2 uv) between the INPUT and COMMON posts.
j. Adjust voltage readout dials for zero meter deflection in successively more sensitive null ranges. Final readout dial setting should be between 4.99986 and 5.00014.
k. Set the NULL switch to 1, and the voltage readout dials to 10.00000.
l. Apply 10 volts dc ±(0.001% + 2 uv) between the INPUT and COMMON posts.
m. Adjust the voltage readout dials for zero meter deflection in successively more sensitive null ranges. Final readout dial setting should be between 9.99974 and 10.00026.

4-15. CALIBRATION

4-16. GENERAL

4-17. It is recommended that the instrument be calibrated every sixty days to maintain an accuracy of ±(0.005% + 5 uv) between 16° C and 32° C (60° F and 90° F), at less than 70% relative humidity. For applications requiring an accuracy of ±(0.0025% of input + 0.0001% of range + 5 uv) at 23 (±1)° C (73.4 (±1.8)° F), less than 70% relative humidity, it is recommended that the instrument be calibrated every thirty days. Calibration should be accomplished in a draft-free area with an ambient temperature of 23 (±1)° C, at less than 70% relative humidity, and with a constant line voltage.

4-18. The calibration procedure consists of six parts: Equipment Setup, Null Detector Calibration, 10 Volt Range Calibration, 1 Volt Range Calibration, 100 Volt Range Calibration, and 1000 Volt Range Calibration. Calibration must be done in the given sequence. The recommended equipment and the specifications required are shown in Figure 4-1. All calibration controls are identified inside the instrument.

4-19. EQUIPMENT SETUP

4-20. To provide the necessary calibration voltages, perform step c. of paragraph 4-14.

4-21. NULL DETECTOR CALIBRATION

a. Set switches on voltmeter as follows:

RANGE	1
NULL	100 UV
Polarity	+
Voltage readout dials	zero

3% of RANGE

b. Short INPUT and COMMON posts with a piece of copper wire.
c. Adjust R204 for zero meter deflection.
d. Set switches on voltmeter as follows:

RANGE	1
NULL	.1
Polarity	+
Voltage readout dials	.100000

e. Adjust R224 for full-scale meter deflection to the left (-1.0).
f. Set switches on voltmeter as follows:

5% of RANGE

RANGE	1
NULL	100 UV
Polarity	+
Voltage readout dials	.000100

g. Adjust R228 for full-scale meter deflection to the left (-1).
h. Remove the short from the INPUT and COMMON posts.

4-22. 10 VOLT RANGE CALIBRATION

Note!

The 10 volt range must be calibrated before attempting calibration of the 1 volt range. Use an insulated screwdriver to adjust R125, R127, R106, and R109.

a. Set switches on voltmeter as follows:

RANGE	10
NULL	1 MV
Polarity	+
Voltage readout dials	10.00000

b. Apply 10 volts dc (±0.001% + 2 uv) between the INPUT and COMMON posts.
c. Adjust R125 for zero meter deflection in the 1 MV null range.

4-23. 1 VOLT RANGE CALIBRATION

a. Set switches on voltmeter as follows:

RANGE	1
NULL	100 UV
Polarity	+
Voltage readout dials	1.000000

b. Apply 1 volt dc (±0.001% + 2 uv) between the INPUT and COMMON posts.
c. Adjust R127 for zero meter deflection in the 100 UV null range.

4-24. 100 VOLT RANGE CALIBRATION

a. Set switches on voltmeter as follows:

RANGE	100
NULL	.01
Polarity	+
Voltage readout dials	100.0000

b. Apply 100 volts dc (±0.001%) between the INPUT and COMMON posts. Note that the voltage dials of the 412B and the coarse and fine dials of the 750A may require readjustment for a null on the 845A due to loading of the voltmeter on the 750A Reference Divider.

c. Adjust R106 for zero meter deflection in the .01 null range.

4-25. 1000 VOLT RANGE CALIBRATION

a. Set switches on voltmeter as follows:

RANGE	1000
NULL	.1
Polarity	+
Voltage readout dials	1000.000

b. Apply 1000 volts dc (±0.001%) between the INPUT and COMMON posts.

c. Adjust R109 for zero meter deflection in the .1 null range.

4-26. CORRECTIVE MAINTENANCE

4-27. GENERAL

4-28. If the 885A does not perform correctly before or after calibration, the information given here may be used as a guide for locating and correcting the source of trouble. The equipment required for maintaining the instrument is given in Figure 4-1.

4-29. TROUBLESHOOTING

4-30. The purpose of troubleshooting is to quickly and accurately correct the cause of defective operation. Thus, servicing should begin with an attempt to localize the general area of malfunction. By performing a complete performance test, as outlined in paragraph 4-8, the trouble may be isolated to the null detector, reference supply, Kelvin-Varley divider, or input attenuator. The causes and remedies of some of the more common troubles that might occur are listed in the troubleshooting chart, Figure 4-4. However, an understanding of the theory of operation and frequent reference to the schematic diagram is the best way to locate the cause of any malfunction.

4-31. VISUAL INSPECTION. Trouble can sometimes be found by a thorough visual inspection. Look for:

a. Accumulations of dirt, dust, moisture, or grease. Remove contamination as outlined in paragraph 4-5.

SYMPTOM	PROBABLE CAUSE	REMEDY
Drift of reference supply evidenced by null detector meter needle drift when measuring an extremely stable voltage	Battery voltage low.	Charge Battery.
	Faulty Zener diode.	Monitor voltage across Zener diode pair. Look for drift of Zener voltage. Replace if defective.
	Q101, Q102, Q103, Q104, or Q105 defective.	Check by replacement.
Meter rattle or drift	Moisture, dust, or other contamination on printed circuit boards or switches.	Clean instrument as outlined in paragraph 4-7.
Measurements are out of tolerance on every range when Kelvin-Varley divider is dialed to any setting other than 10999100.	Out of adjustment or one of the Kelvin-Varley divider resistors is out of tolerance.	Check accuracy of Kelvin-Varley divider using paragraph 4-40. If these checks indicate an out of tolerance condition, first try adjusting Kelvin-Varley divider using procedure of paragraph 4-41. If Kelvin-Varley divider cannot be adjusted, use out of tolerance data obtained from procedure of paragraph 4-41 to isolate defective resistor.
Meter cannot be brought to zero with ZERO control.	Chopper drive not symmetrical.	Readjust photochopper drive circuit using procedure of paragraph 4-36.
	CR201 or CR202 defective.	Check and replace if defective.
Meter beating with voltage under measurement.	Chopper drive circuit out of adjustment.	Adjust chopper drive circuit using procedure of paragraph 4-36.

Figure 4-4. TROUBLESHOOTING CHART

b. Scorched or burned parts. Damage of this type is usually due to a defective component. Determine the cause of damage before replacing the overheated part.

CAUTION!

Avoid touching the polyethelene grommets. Contamination can cause excessive electrical leakage.

c. Cracks, cuts, and other damage to the polyethelene grommets. Replace grommets, using a plastic bag over the hand to prevent contamination.

d. Input Divider Resistors R101, R102, R103, R104, R105, R107, R108, and R110 touching the printed circuit board. When these resistors touch the circuit board, leakage paths are created which can result in erroneous measurements.

e. Loose or intermittent connections.

4-32. MEASURING VOLTAGE LEVELS. When the trouble has been localized to a circuit, the defective part may be isolated in some cases by voltage level measurements at the transistor terminals. Pin voltage of the transistors is listed in Figure 4-5. When making measurements on printed circuit boards, use a sharp probe and press firmly while rotating the probe to break through the moisture-proof coating. Measurements that differ widely from those listed in the transistor voltage chart can be used to trace the trouble to a specific part.

CAUTION!

When measuring voltages, care should be exercised to prevent momentary short circuits, which could damage transistors.

4-33. TROUBLESHOOTING TESTS. The following tests can be used to determine correct operation of specific portions of the instrument.

4-34. Reference Supply Voltage. Test the reference supply voltage for accuracy, regulation, and shift as follows:

a. Connect the autotransformer to the line, and connect the voltmeter to the output of the autotransformer. Set the autotransformer for 115 volts output (230 volts for 230 volt instruments).

b. Set the POWER switch to ON (or LINE OPR).

c. Set the NULL switch to TVM, and set the polarity switcht to +.

d. Connect the differential voltmeter between the COMMON post and the collector of Q101.

TRANSISTOR	EMITTER	BASE	COLLECTOR
Q101	+24.4 ①	+23.7	+17.9
Q102	+17.9 ②	+12.5	+23.6
Q103 ①	+12.2	+12.8	+15.6
②	+12.2	+12.8	+15.6
Q104	+15.0	+15.6	+23.6
Q105	+15.0	+15.6	+17.9
Q106	+17.9	+22.2	+.50
Q107	+17.9	+22.3	+.40
Q201	- .05	- .05	- .05
Q202	0	0	- .50
Q203	0	0	- .50
Q204	+ .52	+4.70	0
Q205	+4.7	+4.7	+16.1
Q206	+4.7	+4.7	0
Q207	0	-9.4	- .50
Q208	- .53	+8.4	- .53
Q209	-1.05	+4.45	-1.55
Q210	-1.02	-6.70	-1.53

The above operating voltage levels are measured under the following conditions: (a) line voltage at 115/230 vac, 50 to 440 cps; (b) all voltages measured with a 3%, 10 megohm, 5 pf voltmeter from specified terminal to the reference-supply/null-detector common. The COMMON post is reference supply - null detector common when in TVM mode, or when in a NULL mode with all voltage dials set to 0, and polarity switch set to +; (c) some voltages may vary as much as 15 to 20%; (d) bias voltages (difference between emitter and base voltages) should remain approximately the same; (e) all voltages are dc unless otherwise indicated.

NOTES: ① Emitter of Q101 as measured with a differential voltmeter should be between +21.5 and +26 vdc for 115/230 vac line operation, +19.5 and +21.5 vdc for BAT OPR (885AB only), and not less than +21.5 vdc for BAT CHG (885AB only). ② Collector of Q101 and emitter of Q102 should be between +17.9 and +18.1 vdc as measured with a differential voltmeter.

Figure 4-5. TRANSISTOR VOLTAGE CHART

e. Set the voltmeter to differentially measure +18.0 volts.
f. If necessary, adjust R115 so that the voltmeter indicates +18.0 (±0.1) volts.

Note!

If R115 is adjusted, it will be necessary to recalibrate the 10 volt range according to paragraph 4-22.

g. Set the autotransformer for 103 volts output (207 volts if the instrument is wired for 230 volt operation), and adjust the differential voltmeter for zero meter deflection.
h. Set the autotransformer for 127 volts output (253 volts for 230 volt instruments). The voltage change indicated by the differential voltmeter should not exceed 800 microvolts.
i. For the 885AB, set the autotransformer to 115 volts output (230 volts for 230 volt instruments), and adjust the differential voltmeter for zero meter deflection.
j. Set the POWER switch from LINE OPR to BAT OPR. The voltage change indicated by the differential voltmeter should not exceed 800 microvolts.
k. Connect the 801B to measure the voltage across C101. With the POWER switch set to ON (or LINE OPR), the voltmeter should indicate +23.75 (±2.25) volts dc.
(1) For the 885AB, set the POWER switch to BAT OPR. The voltmeter should indicate +20.5 (±1) volts dc.
m. For the 885AB, set the POWER switch to BAT CHG. The voltmeter should indicate not less than +21.5 volts dc.

4-35. Meter Rattle Test. Proceed as follows:

a. Set the switches on the voltmeter as follows:

RANGE	1
NULL	100 UV
Polarity	+
Voltage readout dials	zero

b. Set the POWER switch to ON (or LINE OPR) and allow the instrument to warmup for about 5 minutes.
c. Short INPUT and COMMON posts. Random deflection of the meter needle should be less than 1 small division peak-to-peak. If rattle is excessive, check the photochopper drive circuit.

4-36. Adjustment of Photochopper Frequency. The photochopper frequency may require adjustment if a part in the circuit is replaced, if there is difficulty in zeroing the meter, or if line operation causes the meter to oscillate due to the relationship of the photochopper frequency with the line frequency. Proceed as follows:

a. Set the POWER switch to ON (or LINE OPR).
b. Set the RANGE switch to TVM, and set the polarity switch to +.
c. Connect the counter between the COMMON post and the base of Q209 or Q210.
d. Adjust R132 so that the counter indicates a frequency of 84 (±1) Hz.

4-37. Null Detector Voltages.

a. Connect the voltmeter across C214.
b. Set the POWER switch to ON (or LINE OPR).
c. The voltmeter should indicate +16 (±3) volts dc.
d. Connect the voltmeter across C215.
e. The voltmeter should indicate -16 (±3) volts dc.
f. Connect the voltmeter between the COMMON post and the emitter of Q205.
g. The voltmeter should indicate +5.5 (±1.5) volts dc.

4-38. Line Regulation.

a. Connect the autotransformer to the line, and connect the voltmeter to the output of the autotransformer. Set the autotransformer for 103 volts output (207 volts for 230 volt instruments).
b. Set the controls on the 885A as follows:

RANGE	1
NULL	100 UV
Readout dials	zero
POWER	ON (or LINE OPR)

c. Short the INPUT post to the COMMON post.
d. Set the autotransformer for 127 volts output (253 volts for 230 volt instruments). The change in the panel meter null should not exceed 2 microvolts.

4-39. Common-Mode Measurement Test. If the instrument is suspected of making incorrect measurement in the presence of common-mode voltages, perform the following test:

a. Measure the voltage of a standard cell, using the 1 volt range and positive polarity. The standard cell must not be grounded.
b. Connect 500 volts dc from the chassis ground post to the COMMON post, and wait for 3 minutes.
c. Measure the standard cell voltage. If the two measurements differ by more than 50 microvolts, there is excess electrical leakage to ground. Clean the instrument according to paragraph 4-5.

4-40. Kelvin-Varley Divider Test. The Kelvin-Varley test requires connections to the Kelvin-Varley divider inside the instrument. Also, the Kelvin-Varley test requires a considerable amount of time. Therefore, this test should be performed only if the differential measurement test (paragraph 4-13) indicates there is a problem, or if the Kelvin-Varley divider has been adjusted (paragraph 4-41). Proceed as follows:

a. Set the POWER switch to OFF, and set the NULL switch to TVM.
b. Disconnect the 885A from line power.
c. Remove bottom panel and top panel.
d. Locate high input wire (wire from point 13, or R326, on Kelvin-Varley board to range switch S1), high output wire (wire from R366 to null switch S4), and input-output common wire (point 1 on Kelvin-Varley board.

CAUTION!

Be sure that the 412B high voltage switch is set to off.

e. Connect the equipment as shown in Figure 4-6.

f. Turn on all equipment and allow it to warmup for about 30 minutes.

g. Set voltage dials on 412B for an output of 33.0 volts dc.

h. Set 885A voltage readout dials to 000000, and set 720A dials to 0000000.

i. Set 845A to 100 microvolts.

j. Set 721A mode switch to $R_S > R_X$.

k. Set 721A voltage switch to off.

l. Zero 845A Null Detector.

m. Set 721A voltage switch to on.

n. Adjust 721A low balance controls for a null on 845A. It may be necessary to temporarily reduce the sensitivity of the 845A.

o. Set 885A voltage dials to 10999100, and set 720A dials to 109999910.

p. Set 721A voltage switch to off.

q. Zero 845A null detector.

r. Set 721A voltage switch to on.

s. Adjust 721A high balance controls for a null on 845A. It may be necessary to temporarily reduce the sensitivity of the 845A.

t. Set 845A Null Detector to 300 microvolts sensitivity, and change to 100 microvolts if required.

u. Set 885A voltage readout dials and 720A readout dials to the first positions shown in Figure 4-7. The 845A Null Detector indication should be less than the listed deviation.

v. Repeat step u. for the remaining switch positions shown in Figure 4-7. If the Kelvin-Varley divider is out of tolerance between settings of 1000000 and 0999100, readjust according to paragraph 4-41. If a resistor-trimmer combination of the first deck can not be adjusted for a null during adjustment, the 5049.5 ohm resistor(s) are defective, and must be replaced. If the Kelvin-Varley divider is out of tolerance for remaining settings, be sure padding resistors for the remaining decks are adjusted correctly (paragraph 4-41) before attempting to replace a resistor.

4-41. Kelvin-Varley Divider Adjustment. The Kelvin-Varley divider should be adjusted only after a resistor has been replaced, or after the Kelvin-Varley divider test (paragraph 4-40) indicates that the Kelvin-Varley divider is out of tolerance. Proceed as follows:

a. Set POWER switch to OFF, and set NULL switch to TVM.

b. Disconnect 885A from power line.

c. Remove bottom cover of the instrument.

d. Open jumpers marked U, V, W, X, Y, and Z. Also unsolder high input wire of Kelvin-Varley divider (wire from point 13 to switch S1).

e. Connect equipment as shown in Figure 4-8.

f. Turn on all equipment and allow it to warmup for about 30 minutes.

CAUTION!

Do not allow the 412B output voltage to exceed 20 volts, as damage to the Kelvin-Varley resistors may result.

g. Set the 412B for an output of 4 volts dc.

h. Connect points A and C of Figure 4-8 to test points 14 and 16, respectively, of the Kelvin-Varley circuit board.

i. Balance lead resistance as follows:

(1) Set 845A to 30 microvolt range.

(2) Set 720A readout dials to 0000000.

(3) Connect point B of Figure 4-8 to test point that point C is connected to.

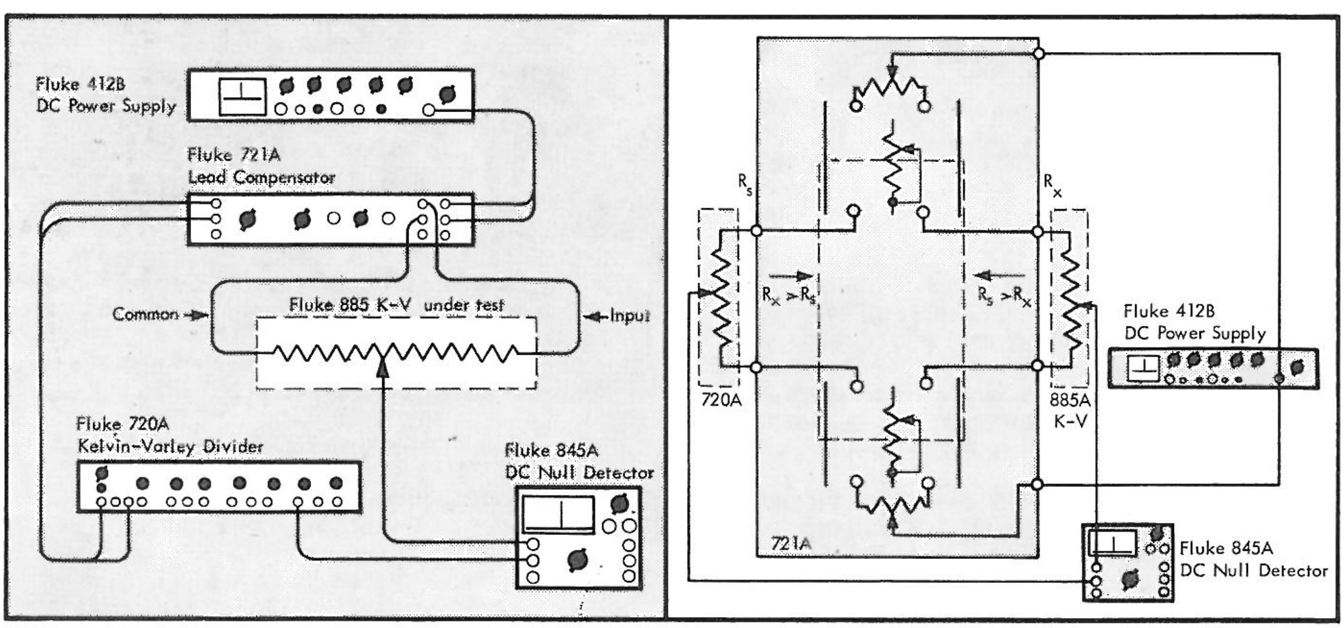


Figure 4-6. KELVIN-VARLEY DIVIDER TEST

885A Voltage Dial Settings	Standard Divider Settings	Maximum Deviation (± microvolts for input voltage of 33.0 vdc)
1000000	10000000	360
9999100	10000000	360
900000	9000000	324
8999100	9000000	324
800000	8000000	288
7999100	8000000	288
700000	7000000	252
6999100	7000000	252
600000	6000000	216
5999100	6000000	216
500000	5000000	180
4999100	5000000	180
400000	4000000	144
3999100	4000000	144
300000	3000000	108
2999100	3000000	108
200000	2000000	72
1999100	2000000	72
100000	1000000	36
0999100	1000000	36
090000	0900000	36
0899100	0900000	36
080000	0800000	36
0799100	0800000	36
070000	0700000	36
0699100	0700000	36
060000	0600000	36
0599100	0600000	36
050000	0500000	36
0499100	0500000	36
040000	0400000	36
0399100	0400000	36
030000	0300000	36
0299100	0300000	36
020000	0200000	36
0199100	0200000	36
010000	0100000	36
0099100	0100000	36
009000	0090000	36
0089100	0090000	36
008000	0080000	36
0079100	0080000	36

885A Voltage Dial Settings	Standard Divider Settings	Maximum Deviation (± microvolts for input voltage of 33.0 vdc)
007000	0070000	36
0069100	0070000	36
006000	0060000	36
0059100	0060000	36
005000	0050000	36
0049100	0050000	36
004000	0040000	36
0039100	0040000	36
003000	0030000	36
0029100	0030000	36
002000	0020000	36
0019100	0020000	36
001000	0010000	36
0009100	0010000	36
000900	0009000	36
0008100	0009000	36
000800	0008000	36
0007100	0008000	36
000700	0007000	36
0006100	0007000	36
000600	0006000	36
0005100	0006000	36
000500	0005000	36
0004100	0005000	36
000400	0004000	36
0003100	0004000	36
000300	0003000	36
0002100	0003000	36
000200	0002000	36
0001100	0002000	36
000100	0001000	36
0000100	0001000	36
000090	0000900	36
000080	0000800	36
000070	0000700	36
000060	0000600	36
000050	0000500	36
000040	0000400	36
000030	0000300	36
000020	0000200	36
000010	0000100	36
000000	0000000	36

Figure 4-7. KELVIN-VARLEY DIVIDER ERROR LIMITS

(4) Set 721A mode switch to $R_s > R_x$.

(5) Set 721A voltage switch to off.

(6) Zero 845A Null Detector.

(7) Set 721A voltage switch to on.

(8) Adjust 721A low balance controls for a null on the 845A. It may be necessary to temporarily reduce the sensitivity of the 845A

(9) Set 720A readout dials to 10000000.

(10) Connect point B of Figure 4-8 to test point that point A is connected to.

(11) Set 721A voltage switch to off.

(12) Zero 845A Null Detector.

(13) Set 721A voltage switch to on.

(14) Adjust 721A high balance controls to null 845A. It may be necessary to temporarily reduce the sensitivity of the 845A.

j. Set voltage dial E to 50.

k. Connect point B of Figure 4-8 to test point 15.

l. Set the 720A readout dials to 5000000.

m. Eliminate error due to thermal voltages as follows:

(1) Set 721A voltage switch to off.

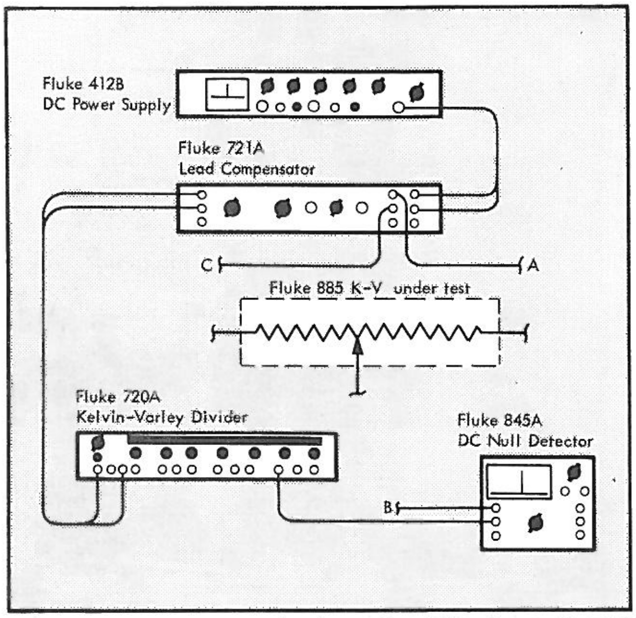


Figure 4-8. KELVIN-VARLEY ADJUSTMENT SETUP

(2) Set 845A Null Detector to 30 microvolts, and adjust the zero control to null meter.

(3) Set 721A voltage switch to on.

n. Set 845A Null Detector to 1 millivolt range.

o. Adjust R364 (adjustment P) so that 845A indicates 0 (±0.0002) volts.

p. Reconnect points A and C to test points 17 and 18, respectively.

q. Reconnect jumpers Y and Z.

r. Repeat step i.

s. Connect point B to test point 19.

t. Repeat steps m and n.

u. Adjust R351 (adjustment N) so that 845A indicates 0 (±0.0005) volts.

v. Connect points A and C to test points 20 and 21, respectively.

w. Reconnect jumpers W and X.

x. Repeat step i.

y. Connect point B to test point 22.

z. Repeat steps m and n.

aa. Adjust R338 (adjustment M) so that 845A indicates 0 (±0.00002) volts.

ab. Set 412B for an output voltage of 18 volts dc.

ac. Connect points A and C to test points 23 and 24, respectively

ad. Reconnect jumper V.

ae. Repeat step i.

af. Connect point B to test point 25.

ag. Set 720A readout dials to .6666667.

ah. Perform adjustments given in each horizontal line of Figure 4-9.

ai. Reconnect jumper U, and reconnect high input wire of Kelvin-Varley divider.

aj. Check accuracy of Kelvin-Varley divider using the procedure of paragraph 4-40.

4-42. MECHANICAL DRUM ADJUSTMENTS

4-43. Occasionally the need may arise to align the polarity switch drum or one of the voltage dial drums in the readout windows. Also, if the drive gear on a switch or dial shaft is no longer in line with the drum shaft, the gears may bind as the dials are turned. Proceed as follows:

a. Remove both front side-covers and the bottom cover from 885A.

b. Stand instrument on rear.

c. Make sure that drive gear on polarity switch shaft and drive gear on shaft of voltage dial E are in line with drum shaft. If not, loosen set screw of drive gear with a 1/16" hex key and align drive gear with drum shaft.

d. Loosen adjusting bracket at left side of instrument and position drum shaft up or down until there is just discernible backlash. That is, until polarity drum just moves when rotated with a finger without moving drive on polarity switch shaft.

e. Loosen adjusting bracket at right side of instrument and position drum shaft until there is just discernible backlash for drum of voltage dial E.

Set Voltage Dial A To	Short Test Points	Eliminate Thermal Voltage Errors as in step m	Set 845A Null Detector to 100 microvolts	Adjust Control to Within ±15 microvolts of Null at Point (for input voltage of 18.0 volts dc)		Remove Short from Between
0	2 to 3	"	"	R301	A	2 and 3
0	1 to 2	"	"	R304	B	1 and 2
2	4 to 5	"	"	R307	C	4 and 5
2	3 to 4	"	"	R309	D	3 and 4
4	6 to 7	"	"	R311	E	6 and 7
4	5 to 6	"	"	R313	F	5 and 6
6	8 to 9	"	"	R315	G	8 and 9
6	7 to 8	"	"	R317	H	7 and 8
8	10 to 11	"	"	R319	I	10 and 11
8	9 to 10	"	"	R321	J	9 and 10
10	12 to 13	"	"	R323	K	12 and 13
10	11 to 12	"	"	R325	L	11 and 12

Figure 4-9. KELVIN-VARLEY "A" DECK ADJUSTMENT

f. Turn polarity switch and all voltage dials fully counterclock wise.

g. Loosen set screw of drive gear for drum being aligned and slide drive gear toward back of instrument.

Note!

See step 1. for adjustment of voltage dial E.

h. Insert finger through window and hold drum being aligned in desired position.

i. Insert hex key into set screw of drive gear and lift drive gear into place allowing it to turn counter clockwise as the teeth mesh.

j. When drive gear is in line with drum shaft tighten set screw.

k. Check character alignment in window. If necessary, loosen set screw and rotate drive gear slightly for inal adjustment.

l. To align drum for voltage dial E, loosen set screw of drive gear and slide toward rear of instrument.

m. Insert hex key into set screw of drive gear and lift drive gear into alignment with drive shaft while noting how much drum turns.

n. Slide drive gear toward rear of instrument.

o. Position drum so that 00 position will line up with pointer when gear is raised into position.

p. Raise drive gear into alignment with drum shaft and position 00 in line with pointer by rotating drive gear slightly before tighting set screw.

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section contains information necessary to describe all normally replaceable parts. Separate assembly lists are used to describe the parts on the final assembly and various assemblies and subassemblies. Each list has a corresponding illustration on which the parts for that list are identified. Parts are called out on both lists and illustrations by reference designations from the schematic diagram. Those parts (mechanical) which have no reference designation are shown on the illustrations by Fluke stock number.

5-3. Each list provides the following information on each part:

a. The REF DESIG. column indicates the reference designation used on the schematic diagram.

b. The DESCRIPTION column describes the part in words, along with any applicable values, tolerances, etc. Indentation is used to show assembly, subassembly, and parts relationship. See abbreviations and symbols on next page.

c. Entries in the FLUKE STOCK NO. column indicate the number by which Fluke stocks the part. This number should be used when ordering parts from the Fluke factory or your Fluke representative.

d. Entries in the MFR. column indicate a typical manufacture of the part by the manufacturer's code number. Appendix A lists the manufacturers and their code numbers.

e. Entries in the MFR. PART NO. column are part numbers assigned by the manufacturer indicated in the Mfg. column.

f. The number in the TOT. QTY. column indicates the total quantity of the part used in the instrument. "REF" indicates that the total quantity of the part has been previously given. The total quantity of each part is listed the first time the part appears. All other listings of the same part refer back to the reference designation of the first appearance of the part for the total quantity.

g. The number in the REC. QTY. column indicates the recommended spares quantity necessary to support approximately one to five instruments for a period of two years. The basis used to select the recommended spares quantity is that a small group of parts will be required to correct a majority of the problems that occur. Since there is a chance that any part may fail, a stock of at least one of every part used in addition to the recommended parts will be needed for complete maintenance during one year of isolated service.

h. The USE CODE column identifies certain parts which have been added, deleted, or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List at the end of this section. These changes are normally made when improved components become available or when the latest circuit improvements are developed by our engineering department. The serial number listed indicates the instruments in which that particular part was used. The symbol "~" is used to indicate an approximate use code. If a different part should be used for replacement, it is listed by Fluke stock number in the description column.

5-4. HOW TO OBTAIN PARTS

5-5. Standard components have been used whenever possible. Thus, most parts can be obtained locally. However, parts may be ordered directly from the manufacturer using the manufacturer's part number or from Fluke using the Fluke stock number. In addition, the most commonly replaced parts that can not be obtained locally may be obtained from your Fluke representative. If a part you have ordered has been replaced by a new or improved part, Fluke will normally send you this part along with an explanation.

5-6. When ordering parts from Fluke always include:

a. Reference designation, description, and Fluke stock number.

b. Instrument model and serial number.

c. Most structural parts are not listed. In this case, give complete description, function, and location of part.

5-7. ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

ac	alternating current	mw	milliwatt
Al	aluminum	na	nanoampere
assy	assembly	pf	picofarad
cap	capacitor	piv	peak inverse voltage
car flm	carbon film	plstc	plastic
cer	ceramic	pp	peak-to-peak
comp	composition	ppm	parts per million
conn	connector	rect	rectifier
cps	cycles per second	res	resistor
db	decibel	rms	root-mean-square
dc	direct current	sb	slow-blow
dpdt	double pole double throw	Si	silicon
dpst	double pole single throw	S/N	serial number
elect	electrolytic	sw	switch
fxd	fixed	spdt	single pole double throw
Ge	germanium	spst	single pole single throw
gmv	guaranteed minimum value	Ta	tantalum
Hz	hertz (cycles per second)	tc	temperature coefficient
K	kilohm	tstr	transistor
kc or Kc	kilocycle	ua	microampere
kHz or KHz	kilohertz (kilocycles per sec)	uf	microfarad
kv	kilovolt	uv	microvolt
kva	kilovolt-ampere	va	volt ampere
ma	milliampere	vac	alternating current volts
Mc or MC	megacycle	var	variable
MHz	megahertz (megacycles per sec)	vdc	direct current volts
meg or M	megohm	w	watt
met flm	metal film	wvdc	direct current working volts
mfg	manufacturer	ww	wirewound
mv	millivolt		

PREFIX SYMBOLS

T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
K or k	kilo	10^{3}
h	hecto	10^{2}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
u	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	anto	10^{-18}

QUANTITY SYMBOLS

a or amp	ampere
f	farad
h	henry
hr	hour
Ω	ohm
sec	second
v or V	volt
w or W	watt

SPECIAL NOTES AND SYMBOLS

~ Approximate use code, or serial number.

Use 0000-000000 — Part number indicated should be used if replacement is required.

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Final Assembly (see Figure 5-1)						
	(Line-powered model)	885A					
	(Battery/line-powered model)	885AB					
	Front Panel Assembly (see Figure 5-2)						
	(885A)	3158-180869	89536	3158-180869	1		
	(885AB)	3158-180976	89536	3158-180976	1		
	Wiring Assembly (see Figure 5-3)						
	(885A)	3158-180851	89536	3158-180851	1		
	(885AB)	3158-180968	89536	3158-180968	1		
	Reference Board Assembly (see Figure 5-4)	1702-180828 (885A-401)	89536	1702-180828	1		
	Null Board Assembly (see Figure 5-6)	1702-196188 (895A-402)	89536	1702-196188	1		
	Kelvin-Varley Assembly (see Figure 5-7)	5111-180884 (885A-403)	89536	5111-180884	1		
BT1	Battery, Ni-Cad 9.6V, 0.5AH (885AB)	4002-160408	06860	9.6V/500BH	2		
F1	Fuse, 1/16 amp, 115V, slow blowing (not illustrated) (Model 885A - 115V operation) (Model 885AB - 230V operation)	5101-163030	03614	Type MDL	1	5	
	Fuse 1/8 amp, 230V, slow blowing (not illustrated) (Model 885AB - 115V operation)	5101-166488	03614	Type MDL	1	5	
	Fuse 1/32 amp, 230V, slow blowing (not illustrated) (Model 885A - 230V operation)	5101-163022	03614	Type MDL	1	5	
J4	Binding post, red	2811-142976	58474	DF31RC	2		
J5	Binding post, black	2811-142984	58474	DF31RC	1		
P1, J6	Line Cord Assembly	6005-161638	89536	6005-161638	1		
P2	Plug, 3 prong	2109-160275	01730	M-1550-G2	1		
R8	Res, var, comp, 10K ±20%, 1/2W	4703-162800	12697	Series 37	1		
R9	Res, comp, 3.9K ±10%, 1/2W (not illustrated)	4704-161406	01121	EB3921	1		
T1	Transformer	5602-167783	89536	5602-167783	1		
	Drum Assembly, polarity	2403-162883	89536	2403-162883	1		
	Drum Assembly 0-10	2403-162891	89536	2403-162891	3		
	Drum Assembly 0-100	2403-162909	89536	2403-162909	1		
	Gear, nylon	3155-154682	08863	3155-154682	5		
	Fuseholder	2102-160846	75915	342004	1		

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Knob 5/8" dia.	2405-158949	89536	2405-158949	6		
	Knob 1" dia. w/bar	2405-158956	89536	2405-158956	3		
	Bail, wire (not illustrated)	3153-163386	89536	3153-163386	1		
	Rubber feet (not illustrated)	2819-103309	89536	2819-103309	4		
	Handle	2404-101857	12136	919-415-173	1		
	Top cover	3156-162180	89536	3156-162180	1		
	Side cover, front	3156-162164	89536	3156-162164	2		
	Side cover, rear	3156-162172	89536	3156-162172	2		
	Bottom cover (not illustrated)	3156-162198	89536	3156-162198	1		

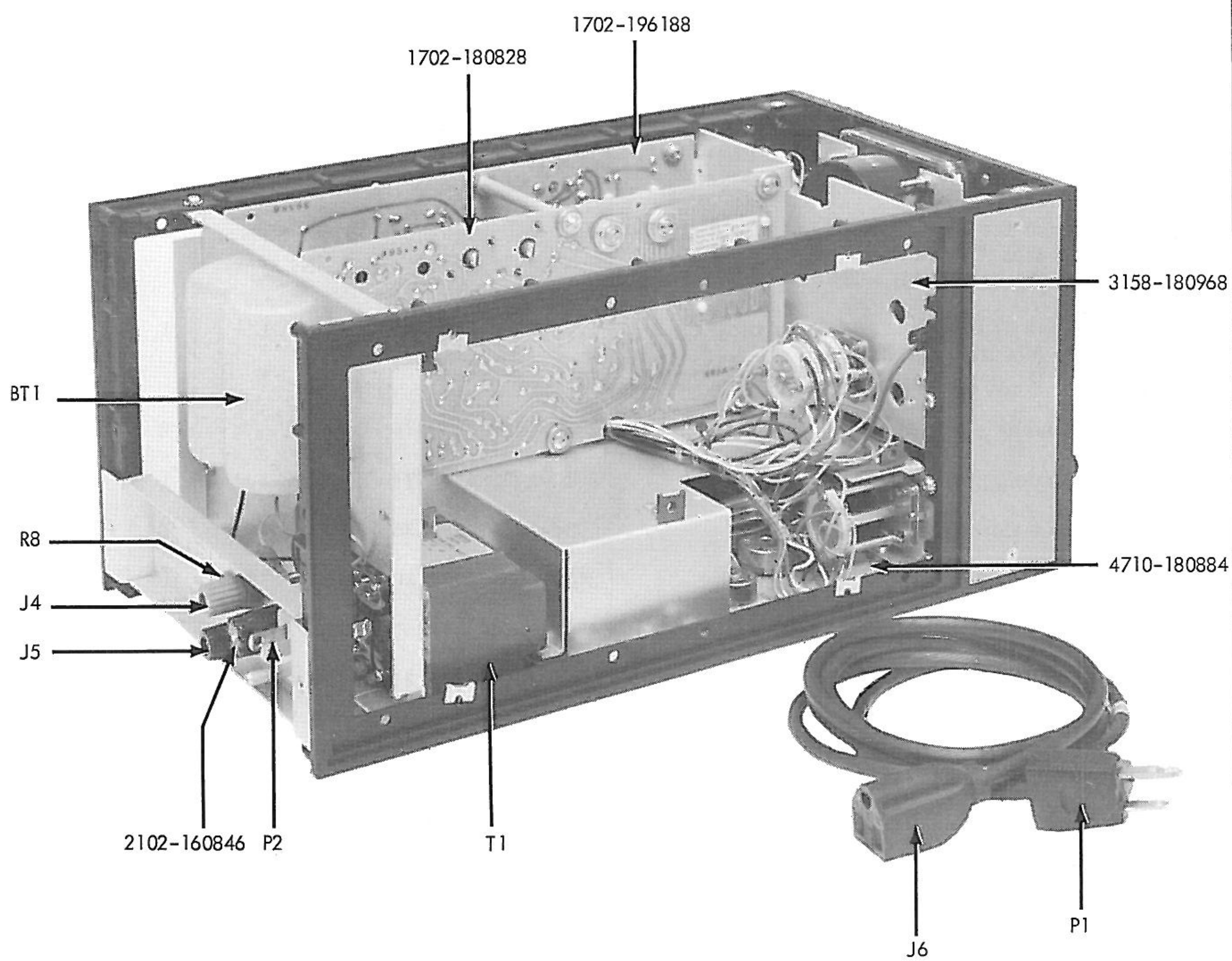


Figure 5-1. FINAL ASSEMBLY (Sheet 1 of 2)

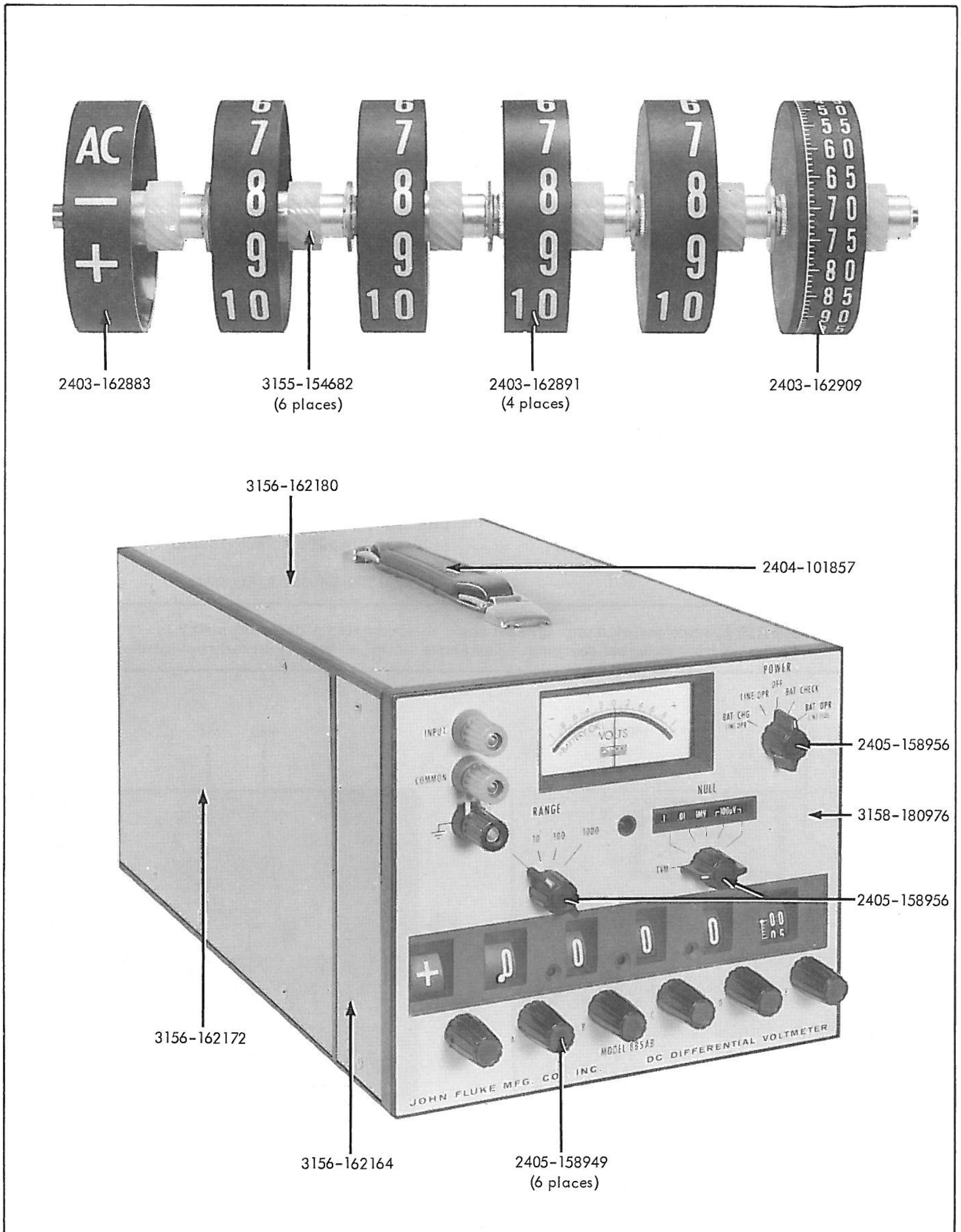


Figure 5-1. FINAL ASSEMBLY (Sheet 2 of 2)

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Front Panel Assembly - Figure 5-2						
	(885A)	3158-180869	89536	3158-180869	REF		
	(885AB)	3158-180976	89536	3158-180976	REF		
C1	Cap, plstc, 0.047 uf ±20%, 500V	1507-182683	84411	JF-37	1		
C2*	Cap, elect, 640 uv, -10/+50%, 6.4V	1502-178608	73445	C437ARC640	2	1	
J1, J2	Binding post, red	2811-149864	58474	DF31RC	2		
J3	Binding post, black	2811-149856	58474	BHB10208G21	1		
M1*	Meter, 100-0-100 ua, 900Ω						
	(885A)	2901-159202	89536	2901-159202	1		
	(885AB) (not illustrated)	2901-160382	89536	2901-160382	1		
R10*	Res, comp, 270Ω, 1/2W	4704-108241	01121	EB2711	1		
	Null Range Shutter	3156-180737	89536	3156-180737	1		
	Nylon Bushing	2502-160499	96881	4L2-FF	9		
	Panel, Front						
	(885A)	1406-180729	89536	1406-180729	1		
	(885AB) (not illustrated)	1406-180950	89536	1406-180950	1		
	Shorting Link	2811-101220	24655	938L	1		

*C2 and R10 provide meter damping. On some instruments, a different meter is used not requiring external damping. The above listing is the preferred replacement.

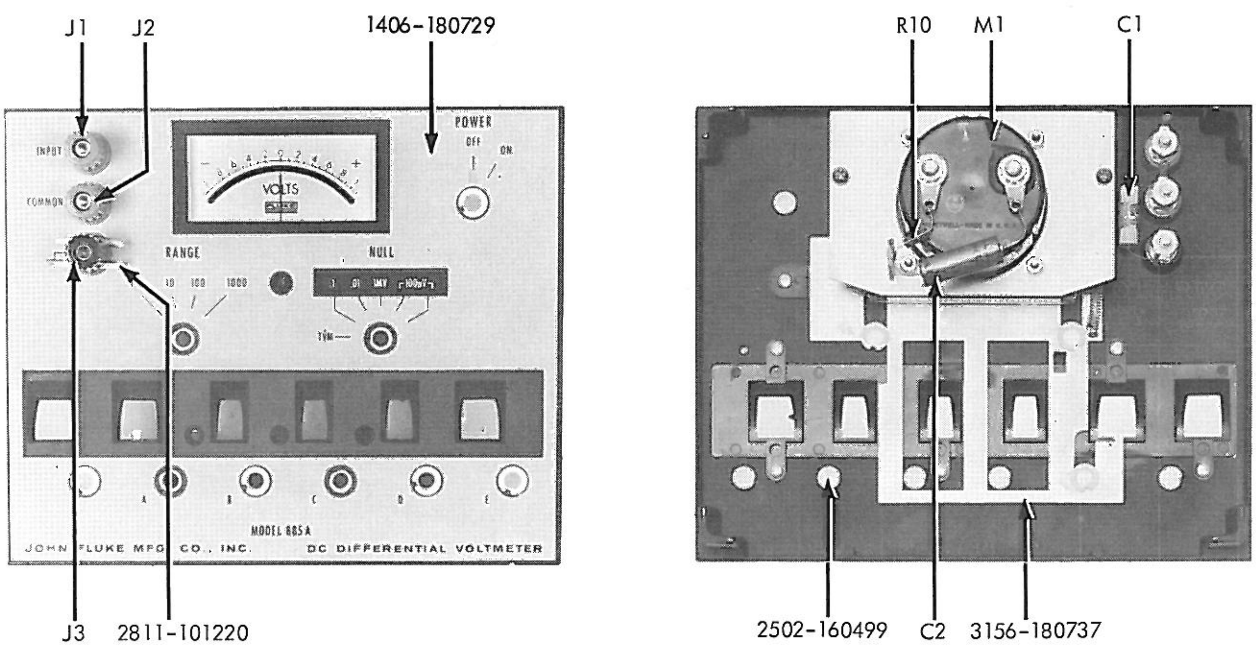


Figure 5-2. FRONT PANEL ASSEMBLY

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Wiring Assembly Figure 5-3						
	(885A)	3158-180851 (885A-404)	89536	3158-180851	REF		
	(885AB)	3158-180968 (885AB-401)	89536	3158-180968	REF		
R1, R2	Res, met flm, 4.5M ±1%, 1/2W	4705-159418	75042	Type CEC-TO	2		
R3	Res, met flm, 900K ±1%, 1W	4705-159509	19701	Type MFBC	1		
R4	Res, met flm, 90K ±1%, 1/2W	4705-159426	75042	Type CEC-TO	1		
R5	Res, met flm, 9K ±1%, 1/2W	4705-159434	75042	Type CEC-TO	1		
R6	Res, met flm, 1K ±1%, 1/2W	4705-151324	75042	Type CEC-TO	1		
R7	Res, comp, 62K ±5%, 1/2W (885AB)	4704-108522	01121	EB6235	1		A
	Res, comp, 68K ±5%, 1/2W (885AB)	4704-159624	01121	EB6835	1		B
S1	Sw, rotary, 8 poles, 4 sections, 4 positions (885A)	5105-180661	89536	5105-180661	1		
S2	Sw, rotary, 2 poles, 1 section, 2 positions (885AB)	5105-180679	89536	5105-180679	1		
	Sw, rotary, 5 poles, 3 sections, 5 positions	5105-180687	89536	5105-180687	1		
S3	Sw, rotary, 8 poles, 4 sections, 6 positions	5105-180653	89536	5105-180653	1		
S4	Sw, rotary, 4 poles, 1 section, 2 positions	5105-180646	89536	5105-180646	1		

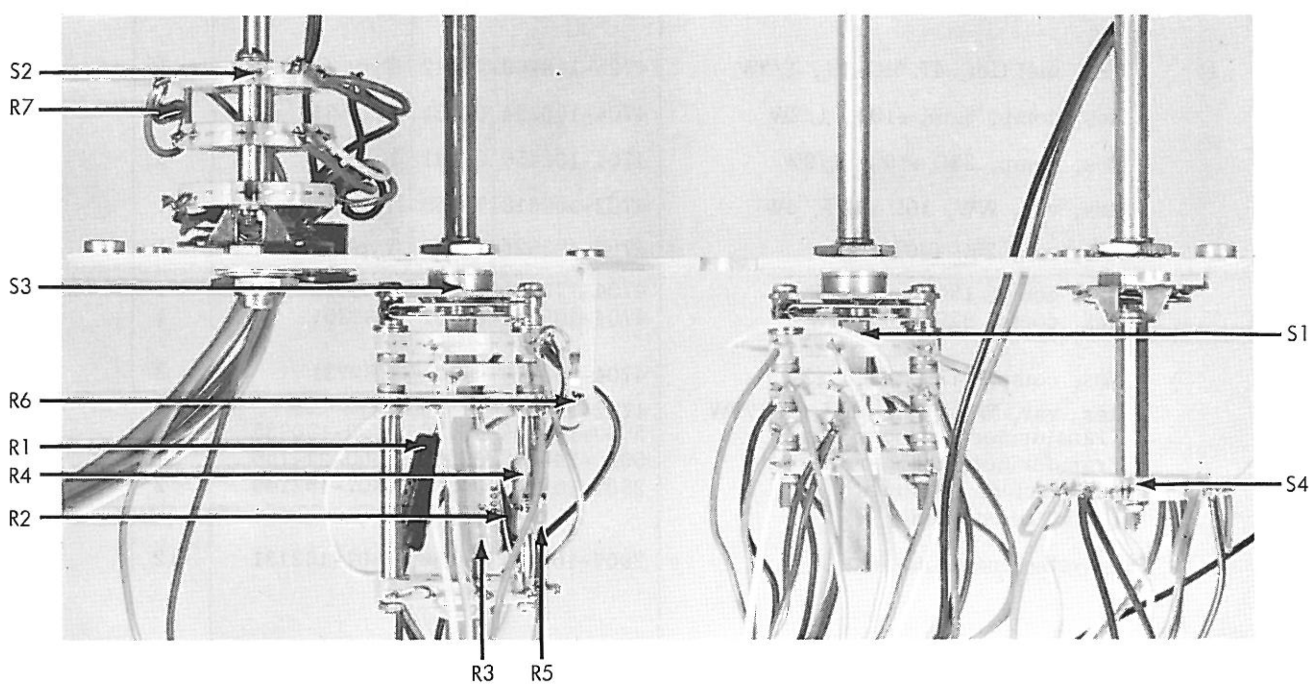


Figure 5-3. WIRING ASSEMBLY

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Reference Supply Board Assembly (see Figure 5-4)	1702-180828 (885A-401)	89536	1702-180828	REF	6	
A101	Zener Diode Oven Assembly (see Figure 5-5)	1702-232710 (885A-415)	89536	1702-232710	1		D
C101	Cap, elect, 250 uf -10/+50%, 40V	1502-178616	73445	CA437ARG250	1	1	
C102	Cap, plstc, 0.022 uf ±10%, 75V	1507-159400	56289	192P2239R8	1		
C103, C104	Cap, plstc, 0.22 uf ±10%, 75V	1507-159392	56289	192P2249R8	2		
CR101, CR102	Diode, Si, 250 ma, 140V PIV	4802-180240	81483	4D4	6	2	
Q101	Tstr, type MPS3638	4805-169375	04713	MPS3638	1	1	
Q102	Tstr, type 2N1304	4805-117127	01295	2N1304	2	1	
Q103	Tstr, Fairchild Semiconductor type SP10422	4805-182246	07263	SP10422	1	1	
Q104, Q105	Tstr, type 2N3391	4805-168708	03508	2N3391	7	2	
Q106, Q107	Tstr, Texas Instruments type GA2817	4805-182600	01295	GA2817	2	1	
R106	Res, var, WW, 10K ±20%, 1-1/4W	4702-182642	71450	Type AW	2		
R109	Res, var, WW, 10K ±20%, 1-1/4W	4702-182642	71450	Type AW	REF		
R111, R112	Res, comp, 330K ±10%, 1/2W	4704-108274	01121	EB3341	2		
R115	Res, var, WW, 500Ω ±10%, 1-1/4W	4702-112433	71450	Type 110	1		
R116 to R118	Res, met flm, 17.8K ±1%, 1/2W	4705-162545	75042	Type CEC-TO	3		
R119	Res, met flm, 47.5K ±1%, 1/2W	4705-148908	75042	Type CEC-TO	1		
R120	Res, comp, 5.6K ±10%, 1/2W	4704-108324	01121	EB5621	1		
R123	Res, comp, 33Ω ±10%, 1/2W	4704-108456	01121	EB3301	2		
R125	Res, var, WW, 10Ω ±10%, 5W	4702-182618	71450	Type UPM-AW	1		
R127	Res, var, 25Ω ±10%, 5W	4702-182626	71450	Type UPM-AW	1		
R129	Res, comp, 150Ω ±5%, 1W	4704-178566	01121	GB1515	1		A
	Res, comp, 82Ω ±10%, 1W	4704-109884	01121	GB8201	1		B
R130, R131	Res, comp, 27K ±10%, 1/2W	4704-108878	01121	EB2731	2		
R132	Res, var, WW, 10K ±20%, 1-1/4W	4702-112862	71450	Type 110	2		
T101	Transformer, chopper drive	5600-180935	89536	5600-180935	1		G
	Transformer, chopper drive	5600-244756	89536	5600-244756	1		H
	Polyethelene grommet (not illustrated)	2807-162149	89536	2807-162149	2		
	Polyethelene grommet	2807-162131	89536	2807-162131	12		

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Matched Zener-Res. Set	4807-176123	89536	4807-176123	1		
CR103, CR104	Diode, zener graded	[1]	89536		2		C
R113	Res, WW, 8K, 1W	4707-131946	89536	4707-131946	1		
R114	Res, factory selected	[2]	89536		1		
R121	Res, factory selected	[2]	89536		1		
R122	Res, factory selected	[2]	89536		1		
R124	Res, factory selected	[2]	89536		1		
	Matched Input Divider Set	4710-180893	89536	4710-180893	1		
R101 to R104	Res, WW, 2.25M ±0.01%/W	[2]	89536		4		
R105	Res, WW, 530Ω ±1%, 1/4W	[2]	89536		1		
R107	Res, WW, 899.73K ±0.02%, 3/4W	[2]	89536		1		
R108	Res, WW, 50Ω, ±1%, 1/4W	[2]	89536		1		
R110	Res, WW, 99.975K ±0.02%, 1/4W	[2]	89536		1		
	1 Volt Divider Set	4710-180901	89536	4710-180901	1		
R126	Res, WW, 49.488K ±0.02%/W	[2]	89536		1		
R128	Res, WW, 6.111K ±0.02%, 1/4W	[2]	89536		1		

[1] If replacement is required, replace Zener-Resistor set 4807-176123.

[2] These resistors are factory matched for resistance tolerance and temperature coefficient for each instrument. When ordering, include all information stamped on old resistor.

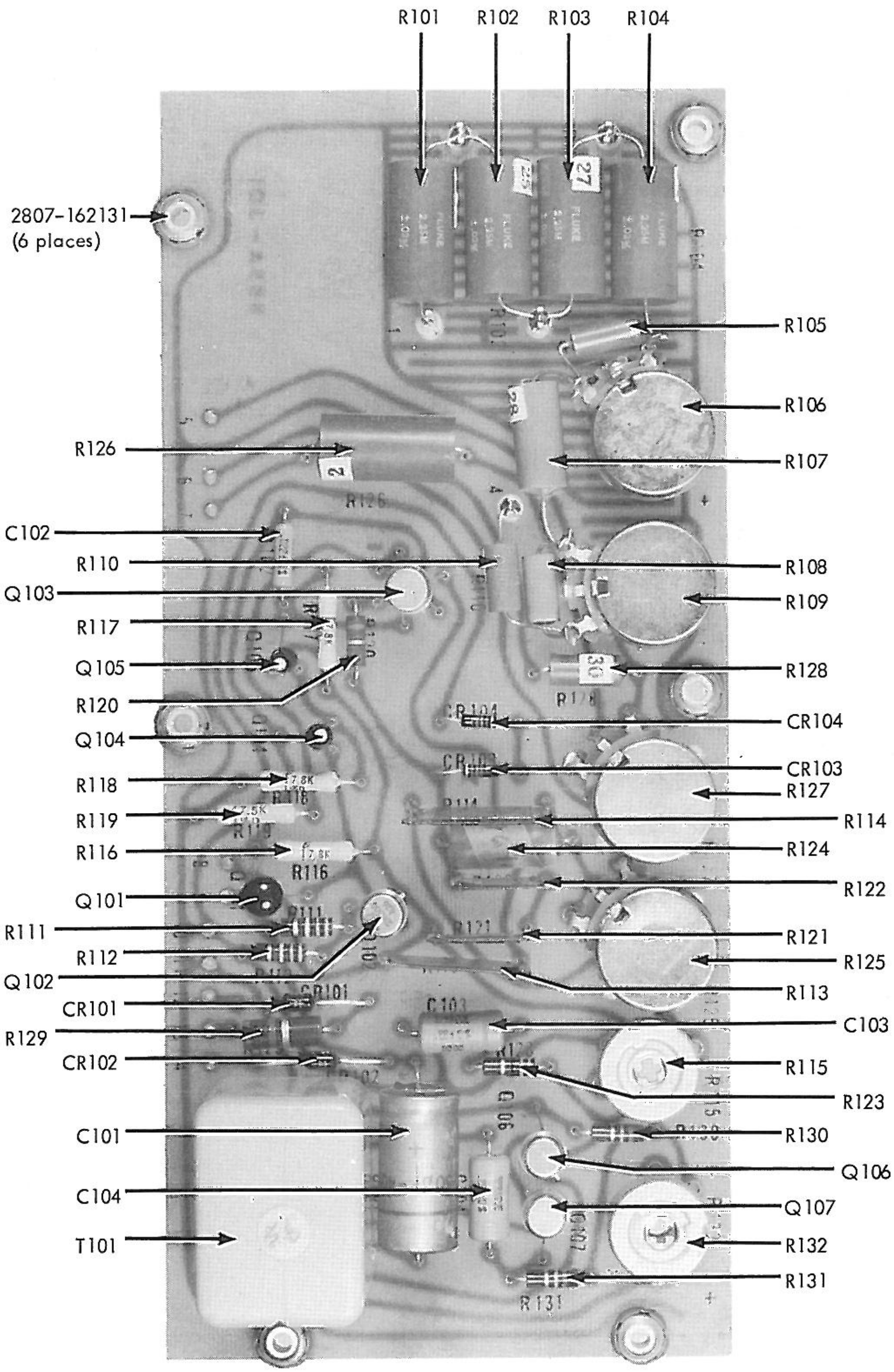


Figure 5-4. REFERENCE SUPPLY BOARD ASSEMBLY

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
A101	**ZENER DIODE OVEN ASSEMBLY Figure 5-5**	1702-232710 (885A-415)	89536	1702-232710	REF		D
A102	Zener Diode Oven	5301-232462	89536	5301-232462	1		D
CR103, CR104	Diode, zener, factory selected (not illustrated)	1					D
R147	Res, factory selected (not illustrated)	1					D
R155	Thermistor, factory selected (not illustrated)	1					D
C105	Cap, disc, cer, 0.01 uf ±20% 100v	1501-149153	56289	C023B101F103M	1		D
Q111	Tstr, selected Motorola SM4144	4805-159491	89536	4805-159491	1		D
Q112 Q113	Tstr, type 2N3391	4805-168708	03508	2N3391	REF		D
R148 R149	Res, comp 3.9K ±5%, 1/4W	4704-148064	01121	CB3925	2		D
R150	Res, met flm, 66.5K ±1%, 1/2W	4705-187955	75042	Type CEC-TO	2		D
R151	Res, comp, 2.7K ±5%, 1/4W	4704-170720	01121	CB2725	1		D
R152	Res, comp, 3.9K ±5%, 1/4W	4704-148064	01121	CB3925	REF		D
R153	Res, met flm, 66.5K ±1%, 1/2W	4705-187955	75042	Type CEC-TO	REF		D
R154	Res, met flm, 23.2K ±1%, 1/2W	4705-159459	75042	Type CEC-TO	1		D

1 If replacement is required, replace with complete Zener Diode Oven, part number 5301-232462.

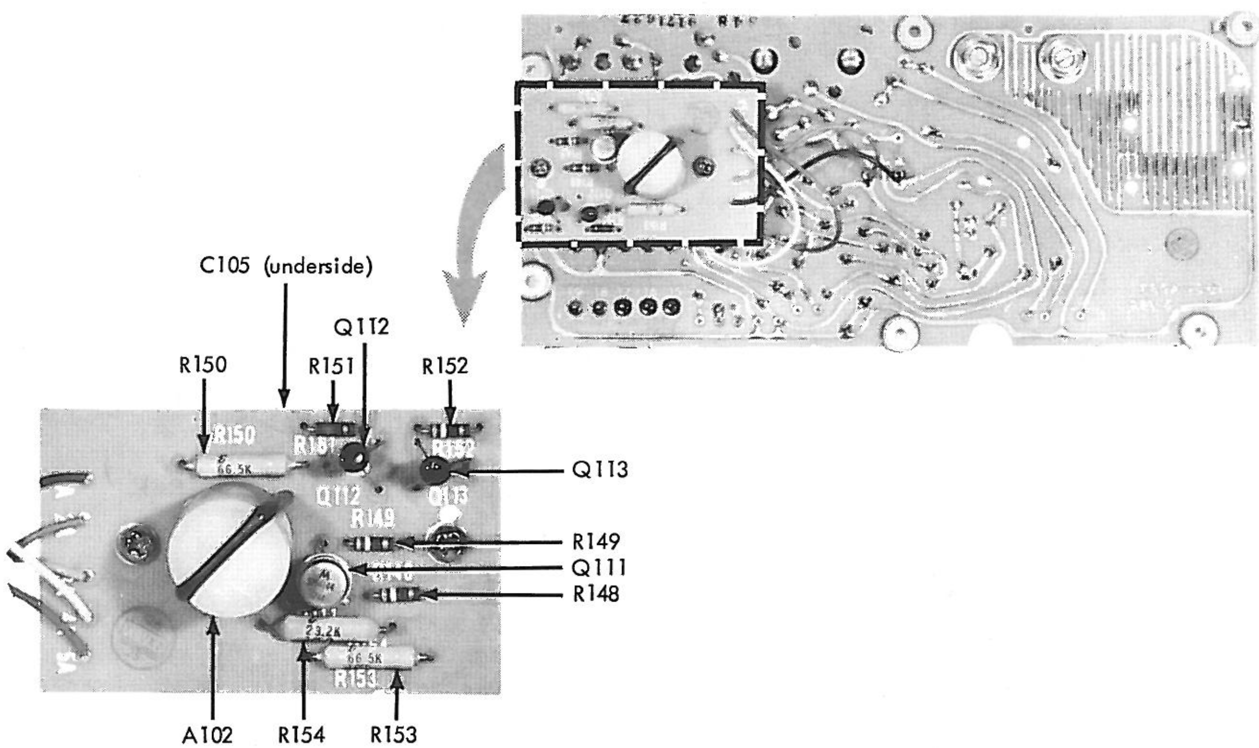


Figure 5-5. Zener Diode Oven Assembly

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Null Detector Board Assembly Figure 5-6 ▷1	1702-180836 (885A-402) 1702-196188 (895A-402)	89536 89536	1702-180836 1702-196188	 REF		
C201, C202	Cap, plastic, 0.22 uf ±20%, 120V	1507-167452	99217	Type Sec	2		
C203	Cap, plastic, 0.1 uf ±20%, 120V	1507-167460	99217	Type Sec	1		
C204	Cap, elect, 400 uf, -10/+50%, 25V	1502-168153	73445	C437ARF400	4	1	
C205	Cap, plastic, 0.047 uf, 100V	1507-106096	84411	663UW47301	1		
C206	Cap, cer, 500 pf ±10%, 1000V	1501-105692	56289	CO67B102E501K	2		
C207	Cap, elect, 1250 uf, -10/+50%, 4V	1502-166330	73445	C437ARB1250	1	1	
C208	Cap, plastic, 0.22 uf ±10%, 75V	1507-159392	56289	192P2249R8	1		
C209	Cap, cer, 500 pf ±10%, 1000V	1501-105692	56289	CO67B102E501K	REF		
C210	Cap, elect, 50 uf, -10/+50%, 25V	1502-168823	73445	C426ARF50	1	1	
C211	Cap, elect, 640 uf, -10/+50%, 6.4V	1502-178608	73445	C437ARC640	REF		
C212	Cap, elect, 400 uf, -10/+50%, 25V	1502-168153	73445	663UW47301	REF		
C213	Cap, plastic, 0.1 uf, ±10%, 200V	1507-106013	56289	192P10492	1		
C214, C215	Cap, elect, 400 uf, -10/+50, 25V	1502-168153	73445	663UW47301	REF		
CR201, CR202	Diode, Si, 10 ma, 2 PIV, epoxy coated	4802-180885	89536	4802-180885	2		
CR203	Diode, zener, 12V, 1N759	4803-159780	07910	1N759	1	1	
CR204 to CR207	Diode, Si, 250 ma, 140V, PIV	4802-180240	81483	4D4	REF		
DS201, DS202	Lamp, neon	3902-162602	89730	NE2U	2	2	
PC201, PC202	Photo cell, 15K - 50M	3700-199752	89536	3700-199752	2	2	
Q201	Tstr, tested, type S7563	4805-198812	89536	4805-198812	1	1	
Q202 to Q204	Tstr, type 2N3391	4805-168708	03508	2N3301	REF		
Q205	Tstr, type 2N1304	4805-117127	01295	2N1304	REF		
Q206	Tstr, type 2N1307	4805-148643	01295	2N1307	REF		
Q207	Tstr, selected GA2875	4805-182691	89536	4805-182691	2	1	
Q208, Q209	Tstr, selected 2N1303	4805-182709	89536	4805-182709	2	1	

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
Q210	Tstr, selected GA2875	4805-182691	89536	4805-182691	REF		
R201	Res, comp, 270K ±10%, 2W	4704-110023	01121	HB2741	1		
R202	Res, comp, 180K ±10%, 1/2W	4704-108431	01121	EB1841	2		
R203	Res, comp, 100K ±10%, 1/2W	4704-108126	01121	EB1041	1		
R204	Res, var, comp, 100K ±20%, 1/4W	4701-163873	71450	UPE200	1		
R205	Res, comp, 560K ±10%, 1/2W	4704-108795	01121	EB5641	1		
R206	Res, comp, 680K ±10%, 1/2W	4704-108340	01121	EB6841	1		
R207	Res, comp, 47K ±10%, 1/2W	4704-108480	01121	EB4731	4		
R208	Res, met flm, 10Ω ±1%, 1/2W	4705-151043	75042	Type CEC-TO	1		
R209	Res, comp, 1M ±10%, 1/2W	4704-108134	01121	EB1051	2		
R210	Res, comp, 6.8M ±10%, 1/2W	4704-108662	01121	EB6851	1		
R211	Res, comp, 1.5M ±10%, 1/2W	4704-108175	01121	EB1551	1		
R212	Res, comp, 47K ±10%, 1/2W	4704-108480	01121	EB4731	REF		
R213	Res, comp, 4.7Ω ±10%, 1/2W (not illustrated)	4704-165746	01121	EB47G1	1		
R214	Res, comp, 180K ±10%, 1/2W	4704-108431	01121	EB1841	REF		
R215	Res, comp, 5.6M ±10%, 1/2W	4704-178558	01121	EB5651	1		
R216	Res, comp, 10K ±10%, 1/2W	4704-108118	01121	EB1031	1		
R217	Res, comp, 1M ±10%, 1/2W	4704-108134	01121	EB1051	REF		
R218	Res, comp, 47K ±10%, 1/2W	4704-108480	01121	EB4731	REF		
R219, R220	Res, comp, 22K ±10%, 1/2W	4704-108209	01121	EB2231	2		
R221	Res, comp, 220Ω ±10%, 1/2W	4704-108191	01121	EB2211	1		
R222	Res, met flm, 4.99K ±1%, 1/2W	4705-148890	75042	Type CEC-TO	2		E
	Res, met flm, 4.75K ±1%, 1/2W	4705-192500	75042	Type CEC-TO	1		F
R223	Res, met flm, 40.2K ±1%, 1/2W	4705-161059	75042	Type CEC-TO	1		E
	Res, met flm, 42.2K ±1%, 1/2W	4705-182501	75042	Type CEC-TO	1		F
R224	Res, var, WW, 1K ±20%, 1-1/4W	4702-111575	71450	Type 110	2		
R225	Res, comp, 33Ω ±10%, 1/2W	4704-108456	01121	EB3301	REF		
R226, R227	Res, comp, 12K ±10%, 1/2W	4704-108977	01121	EB1231	2		
R228	Res, var, WW, 10K ±20%, 1-1/4W	4702-112862	71450	Type 110	REF		
R229	Res, met flm, 49.9K ±1%, 1/2W	4705-182980	75042	Type CEC-TO	1		
R230	Res, met flm, 4.99K ±1%, 1/2W	4705-148890	75042	Type CEC-TO	REF		
R231	Res, comp, 47K ±10%, 1/2W	4704-108480	01121	EB4731	REF		
T201	Transformer, Output	5600-195958	89536	5600-195958	1		
	Polyethelene grommet (not illustrated)	2807-162131	89536	2807-162131	REF		

1 If replacement of the Null Detector Board Assembly is required, use part number 1702-196188

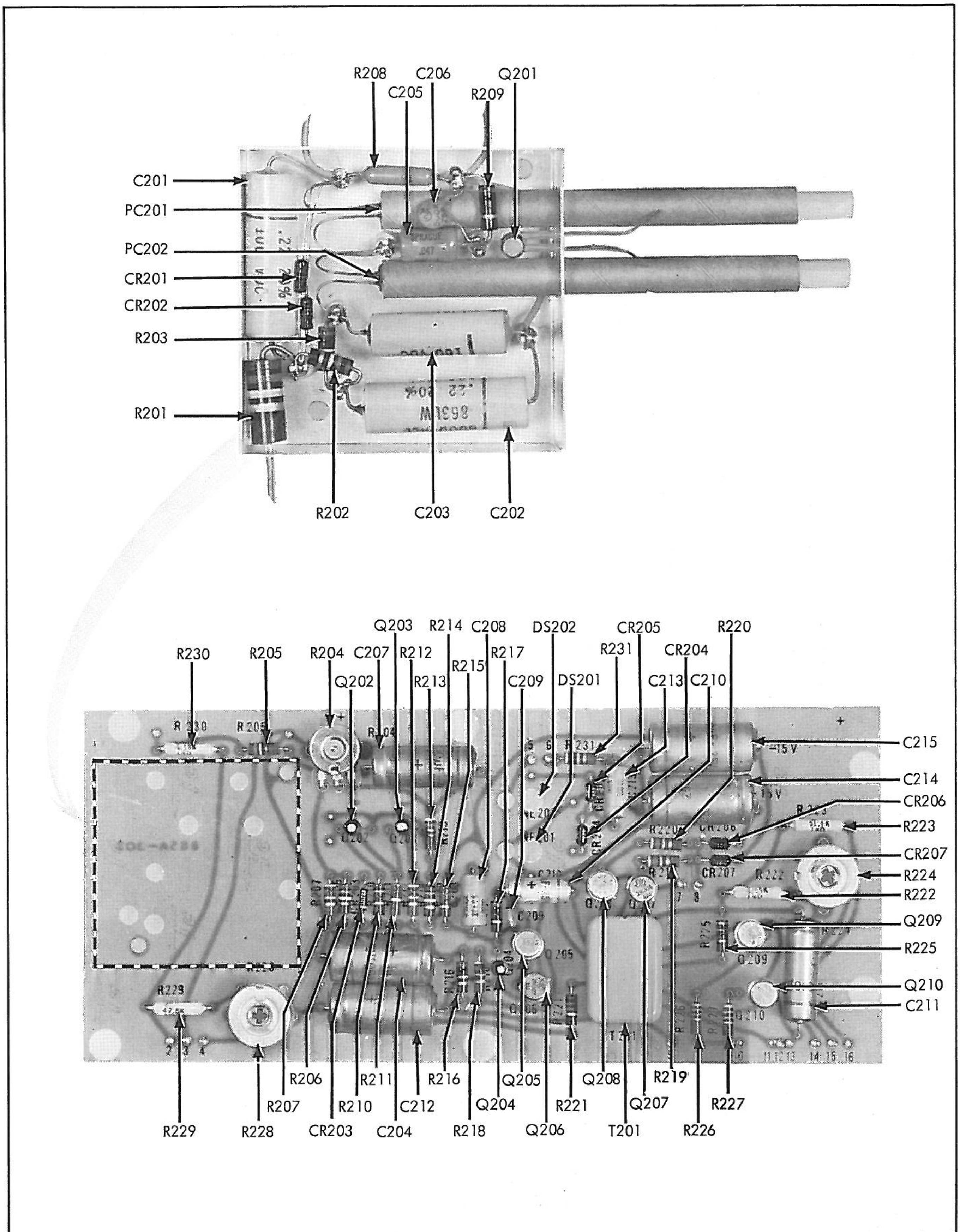


Figure 5-6. NULL DETECTOR BOARD ASSEMBLY

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
	Kelvin-Varley Assembly Figure 5-7	5111-180844 (885A-403)	89536	5111-180844	REF		
C301	Cap, plastic, 1 uf ±20%, 200V	1507-106450	84411	Type X663F	1		
R301	Res, var, WW, 25K ±10%, 5W	4702-182634	71450	Type UPM-AW	2		
R302	Res, WW, 500K ±1%, 1W	4707-177063	80031	Type WM4SF	2		
R303	Res, WW, 5.05K ±0.02%, 3/4W	▷1	89536		2		
R304	Res, var, WW, 25K ±10%, 5W	4702-182634	71450	Type UPM-AW	REF		
R305	Res, WW, 500K ±1%/W	4707-177063	80031	Type WM4SF	REF		
R306	Res, WW, 5.05K ±0.02%, 3/4W	▷1	89536		REF		
Odd no. from R307 to R325	Res, var, WW, 2Ω ±10%, 2W	4702-182410	71450	Type 115 special	12		
Even no. from R308 to R326	Res, WW, 5K +0.01/-0.03%, 3/4W	▷1	89536		10		
R327 to R337	Res, WW, 1K +0.02/-0.018%, 1/4W	▷1	89536		11		
R338	Res, var, WW, 2Ω ±10%, 2W	4702-182410	71450	Type 115 Special	REF		
R339	Res, WW, 2.499K ±0.02%, 1/2W	▷2	89536		2		
R340 to R350	Res, WW, 1K ±0.04%, 1/2W	▷2	89536		22		
R351	Res, var, WW, 2Ω ±10%, 2W	4702-182410	71450	Type 115 Special	REF		
R352	Res, WW, 2.499K ±0.02%, 1/2W	▷2			REF		
R353 to R363	Res, WW, 1K ±0.04%, 1/2W	▷2			REF		
R364	Res, var, WW, 1K ±20%, 1-1/4W	4702-111575	71450	Type 110	REF		
R365	Res, met flm, 9.35K ±1%, 1/2W (not illustrated)	4705-159442	75042	Type CEC-TO	1		
R366	Res, var, WW, 2.5K ±0.05%	4711-163154	89536	4711-163154	1		
S5	Sw, rotary, 2 poles, 2 sections, 11 positions	5105-162644	89536	5105-162644	1		
S6	Sw, rotary, 2 poles, 2 sections, 10 positions	5105-162636	89536	5105-162636	2		

REF DESIG.	DESCRIPTION	FLUKE STOCK NO.	MFR.	MFR. PART NO.	TOT. QTY.	REC. QTY.	USE CODE
S7	Sw, rotary, 2 poles, 2 sections, 10 positions	5105-162651	89536	5105-162651	1		
S8	Sw, rotary, 2 poles, 2 sections, 10 positions	5105-162636	89536	5105-162636	REF		

1 These resistors are factory matched according to resistance, tolerance, and temperature coefficient. When ordering, include all information stamped on old resistor.

2 These resistors are factory matched according to resistance and tolerance. When ordering, include all information stamped on old resistors.

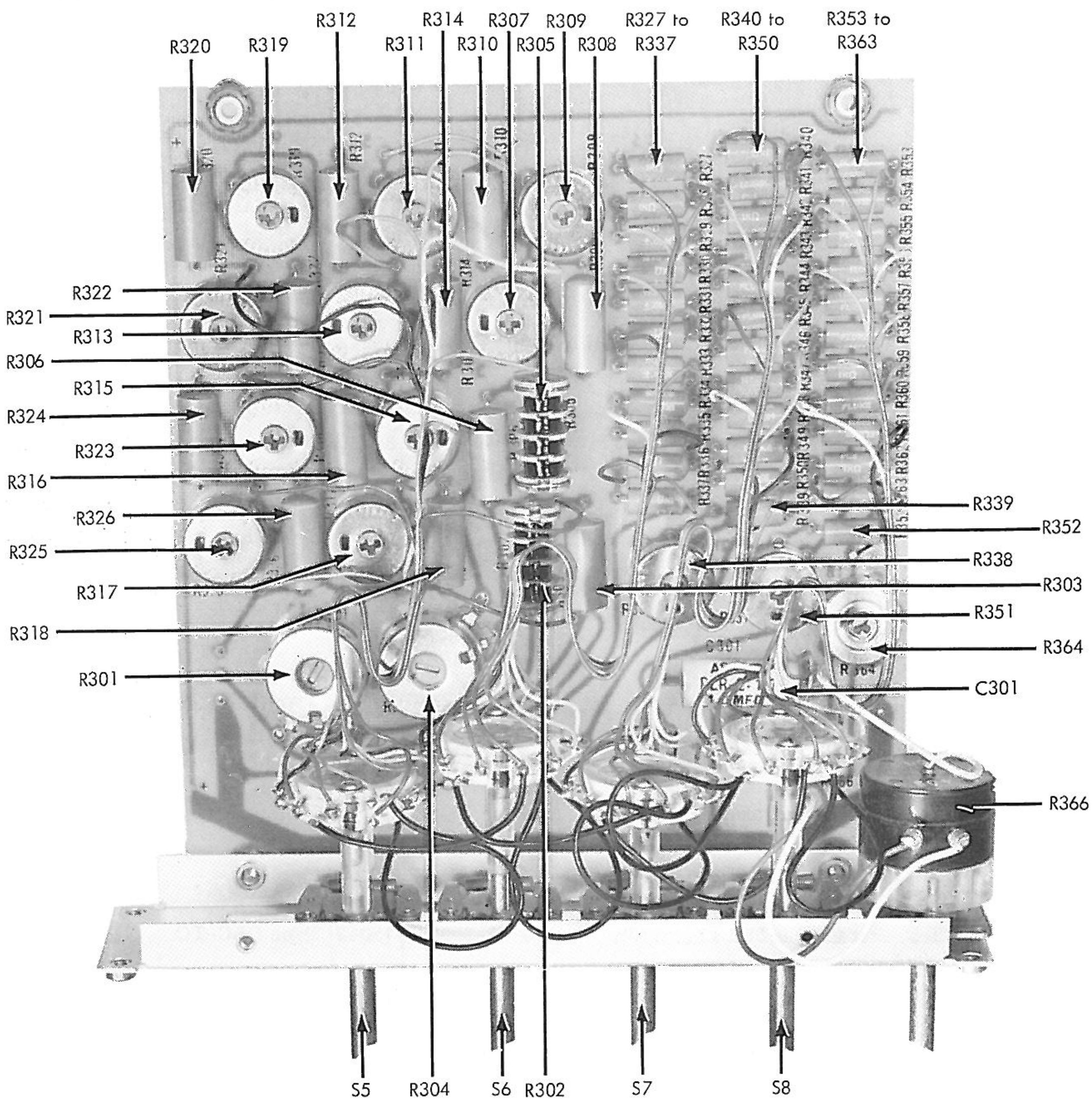


Figure 5-7. KELVIN-VARLEY BOARD ASSEMBLY

5-8. USE CODE EFFECTIVITY

5-9. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the 885A. 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.

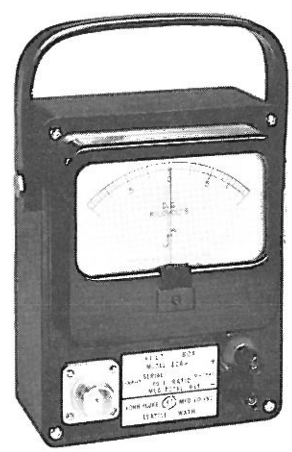
USE CODE	EFFECTIVITY
No Code	Model 885A and 885AB serial number 123 and on
A	Model 885AB serial number 123 to 622
B	Model 885AB serial number 623 and on
C	Model 885A & 885AB serial number 123 to 552, 556 to 592 and 596 to 623
D	Model 885A & 885AB serial number 553 to 555, 593 to 595, 624 and on
E	Model 885A & 885AB serial number 123 to 700
F	Model 885A & 885AB serial number 701 and on
G	Model 885A and 885AB serial number 123 to 698
H	Model 885A & 885AB serial number 699 and on

SECTION VI

ACCESSORIES

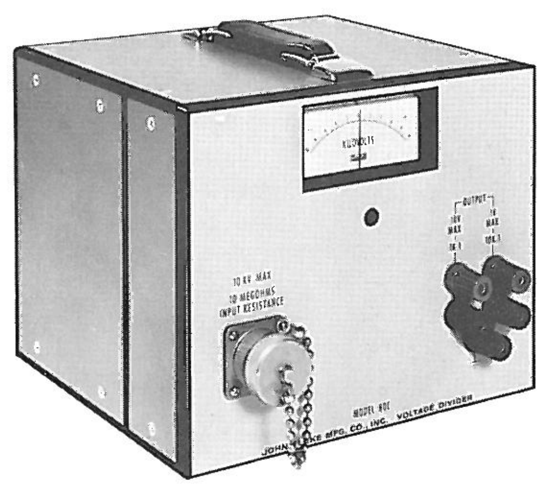
6-1. PRECISION VOLTAGE DIVIDERS

6-2. The FLUKE 80A, 80D, and 80E Voltage Dividers provide the FLUKE 800 Series Differential Voltmeters with the ability to make high accuracy measurements up to 30,000 volts DC. All models contain a zero center panel meter which allows the polarity and approximate magnitude of the unknown high voltage to be easily observed. At maximum input, all units draw but 1 ma of current from the unknown. The extreme accuracy and excellent long term stability of these dividers are obtained by using properly aged precision wirewound resistors which have a very low temperature coefficient. To further ensure high accuracy and long term stability at very high voltages, the 80D dividers have all resistance components immersed in oil within a hermetically sealed container. As an additional feature, all 80D and 80E models are provided with a 1 volt tap which allows measurements of high voltages with a laboratory potentiometer. Specifications for the standard models are shown on next page. Other intermediate models are available upon special request.



MODEL 80A

MODEL 80D



MODEL 80E

Model No.	Maximum Input Voltage	Total Resistance	Current Drawn At Max. Input	Division Ratio			Division Ratio Accuracy	Stability of Division Accuracy Per Year
				500V Out	10V Out	1V Out		
80A-1 80A-2	1 KV 2 KV	1 M 2 M	1 ma 1 ma	2:1 4:1	—— ——	—— ——	±0.015% ±0.015%	—— ——
80E-5 80E-10	5 KV 10 KV	5 M 10 M	1 ma 1 ma	— —	500:1 1000:1	5,000:1 10,000:1	±0.01% ±0.01%	±0.01% ±0.01%
80D-30	30 KV	30 M	1 ma	60:1	3000:1	30,000:1	±0.01%	±0.01%

MODELS	SIZE	INPUT CONNECTOR	OUTPUT CONNECTOR
80A	6-3/4" high 5-1/4" wide 2-1/4" deep	UG-560U with mating connector supplied	Insulated binding posts on 3/4" centers
80E	7" high 8-1/2" wide 8" deep	MS3102A-18-165 with mating connector supplied	Insulated binding posts on 3/4" centers for both outputs
80D	13" high 9-3/4" wide 16" deep	Special 5" ceramic standoff with mating 6" guard supplied	Insulated binding post on 3/4" centers for both outputs

MODEL A88 ISOLATION AMPLIFIER

6-3. ISOLATION AMPLIFIER

6-4. The FLUKE Model A88 all solid-state isolation amplifier is designed to provide isolation between the output of a differential voltmeter and the input of a recorder. Thus, the A88 will allow the use of a wide range of strip chart recorders for recording the voltmeter reading without regard to the input isolation characteristics of the recorder. The A88 is also excellent for making accurate dc microvolt and nanoampere measurements in the presents of common mode voltages up to 1100 vdc and 3 vac, 50 to 500 cycles.

GAIN: 1 volt output per microampere input.

GAIN ACCURACY: ±2%.

INPUT CURRENT RANGE: 0 to 2 microamperes.

INPUT VOLTAGE RANGE: 0 to 2 millivolts nominal.

INPUT RESISTANCE: 950 ohms (±5%).

OUTPUT VOLTAGE RANGE: 0 to 2 volts open circuit.

OUTPUT RESISTANCE: 1000 ohms (±5%).

INPUT ISOLATION FROM CHASSES: Greater than 5×10^{11} ohms at 25°C (77°F), 60% RH and 1×10^{10} ohms at 50°C (122°F), 80% RH.

APPENDIX A

FEDERAL SUPPLY CODE FOR MANUFACTURERS

A-1. CODE TO NAME

A-2. The following five-digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00213	Sage Electronics Corp. Rochester, New York
00327	Welwyn International, Inc. Westlake, Ohio
00656	Aerovox Corp. New Bedford, Massachusetts
00779	AMP Inc. Harrisberg, Pennsylvania
01121	Allen-Bradley Co. Milwaukee, Wisconsin
01281	TRW Semiconductors Lawndale, California
01295	Texas Instruments, Inc. Semiconductor Components Div. Dallas, Texas
01686	RCL Electronics Inc. Manchester, New Hampshire
01730	Deleted
01884	Dearborn Electronics Inc. Orlando, Florida
02114	Ferroxcube Corp. Saugerties, New York
02606	Replaced by 15801
02660	Amphenol-Borg Elect. Corp. Broadview, Illinois
02799	Arco Capacitors, Inc. Los Angeles, California
03614	Replaced by 71400
03651	Replaced by 44655
03797	Eldema Corp. Compton, California
03877	Transitron Electronic Corp. Wakefield, Massachusetts
03888	Pyrofilm Resistor Co., Inc. Cedar Knolls, New Jersey
03911	Clairex Corp. New York, New York
03980	Muirhead Instruments, Inc. Mountainside, New Jersey
04009	Arrow Hart and Hegemen Electronic Company Hartford, Connecticut
04062	Replaced by 72136
04202	Replaced by 81312
04217	Essex Wire Corp Wire & Cable Div. Anaheim, California
04221	Aemco Div. of Midtex Inc. Mankato, Minnesota
04645	Replaced by 75376
04713	Motorola Semiconductor Products Inc. Phoenix, Arizona
05082	Replaced by 94154
05236	Jonathan Mfg. Co. Fullerton, California
05277	Westinghouse Electric Corp. Semiconductor Dept. Youngwood, Pennsylvania
05278	Replaced by 43543
05397	Union Carbide Corp. Electronics Div. Cleveland, Ohio
05571	Sprague Electric Co Pacific Div. Los Angeles, California
05704	Alac, Inc. Glendale, California
05820	Wakefield Engineering Ind. Wakefield, Massachusetts
06001	General Electric Company Capacitor Department Irmo, South Carolina
06136	Replaced by 63743
06473	Amphenol Space & Missile Sys. Chatsworth, California
06555	Beede Electrical Instrument Co. Penacook, New Hampshire
06739	Electron Corp. Littletown, Colorado
06743	Clevite Corp. Cleveland, Ohio
06751	Semcor Div. Components Phoenix, Arizona
06860	Gould National Batteries Inc. City of Industry, California
06980	Eitel-McCullough, Inc. San Carlos, California
07115	Replaced by 14674
07138	Westinghouse Electric Corp. Electronic Tube Div. Elmira, New York
07263	Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California
07344	Bircher Co., Inc. Rochester, New York
07792	Lerma Engineering Corp Northampton, Massachusetts
07910	Continental Device Corp. Hawthorne, California
08530	Reliance Mica Corp. Brooklyn, New York
08792	CBS Electronics Semiconductor Operations-Div. of CBS Inc. Lowell, Massachusetts
08806	General Electric Co. Miniature Lamp Dept. Cleveland, Ohio
08863	Nylomatic Corp. Norrisville, Pennsylvania
08988	Skottie Electronics Inc. Archbald, Pennsylvania
09922	Burndy Corp. Norwalk, Connecticut
11237	Chicago Telephone of Calif. Inc. South Pasadena, California
11358	CBS Electronics Div. of CBS Inc. Newburyport, Massachusetts
11403	Best Products Co. Chicago, Illinois
11503	Keystone Mfg Div. of Avis Industrial Corp. Warren, Michigan
12014	Chicago Rivet & Machine Co. Bellwood, Illinois
12040	National Semiconductor Corp. Danburry, Connecticut
12060	Diodes, Inc. Chatsworth, California
12136	Philadelphia Handle Co. Camden, New Jersey
12323	Presin Co., Inc. Shelton, Connecticut
12327	Freeway Washer & Stamping Co. Cleveland, Ohio
12400	Replaced by 75042
12617	Hamlin Inc. Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Dover, New Hampshire
12749	James Electronics Chicago, Illinois

12856	Micrometals Sierra Madre, California
12954	Dickson Electronics Corp. Scottsdale, Arizona
13606	Sprague Electric Co. Transistor Div. Concord, New Hampshire
13839	Replaced by 23732
14099	Semtech Corp. Newbury Park, California
14193	California Resistor Corp. Santa Monica, California
14298	American Components, Inc. Conshohocken, Pennsylvania
14655	Cornell-Dubilier Electronics Newark, New Jersey
14674	Corning Glass Works Corning, New York
14752	Electro Cube Inc. San Gabriel, California
14869	Replaced by 96853
15636	Elec-Trol Inc. Northridge, California
15801	Fenwal Electronics Inc. Framingham, Massachusetts
15818	Amelco Semiconductor Div. of Teledyne Inc. Mountain View, California
15849	Useco, Inc. Mt. Vernon, New York
15909	Replaced by 17870
16332	Replaced by 28478
16473	Cambridge Scientific Ind. Inc. Cambridge, Maryland
16742	Paramount Plastics Downey, California
16758	Delco Radio Div. of General Motors Kokomo, Indiana
17069	Circuit Structures Lab. Upland, California
17856	Siliconix, Inc. Sunnyvale, California
17870	Daven-Div. of Thomas A. Edison Ind.--McGraw-Edison Co. Manchester, New Hampshire
18083	Deleted
18178	Vactec Inc. Maryland Heights, Missouri
18736	Voltronics Corp. Hanover, New Jersey
19429	Montronics, Inc. Seattle, Washington
19451	Perine Machinery & Supply Co. Seattle, Washington
19701	Electra Mfg. Co. Independence, Kansas
20584	Enochs Mfg. Co. Indianapolis, Indiana
22767	ITT Semiconductors Div. of ITT Palo Alto, California
23732	Tracor Rockville, Maryland
24248	Southco Div. of South Chester Corp. Lester, Pennsylvania
24655	General Radio Co. West Concord, Massachusetts
25403	Amperex Electronic Corp Semiconductor & Receiving Tube Division Slatersville, Rhode Island
28478	Deltrol Controls Corp. Milwaukee, Wisconsin
28520	Heyman Mfg. Co. Kenilworth, New Jersey
30323	Illinois Tool Works Inc. Chicago, Illinois
33173	General Electric Co. Tube Dept. Owensboro, Kentucky
37942	Mallory, P. R., & Co., Inc. Indianapolis, Indiana
38315	Honeywell Inc. Precision Meter Div. Manchester, New Hampshire
42498	National Company Melrose, Massachusetts
43543	Nytronics Inc. Transformer Co. Div. Alpha, New Jersey
44655	Ohmite Mfg. Co Skokie, Illinois
49671	Radio Corp. of America New York, New York
49956	Raytheon Company Lexington, Maine
53021	Sangamo Electric Co. Springfield, Illinois
55026	Simpson Electric Company Chicago, Illinois
56289	Sprague Electric Co. North Adams, Massachusetts
58474	Superior Electric Co. Bristol, Connecticut
60399	Torrington Mfg. Co. Torrington, Connecticut
62460	Deleted
63743	Ward Leonard Electric Co. Mount Vernon, New York
64834	West Mfg. Co. San Francisco, California
65092	Weston Instruments Inc. Newark, New Jersey
66150	Winslow Tele-Tronics Inc. Asbury Park, New Jersey
70563	Amperite Company Union City, New Jersey
70903	Belden Mfg. Co. Chicago, Illinois
71002	Birnbach Radio Co., Inc. New York, New York
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Missouri
71450	CTS Corp. Elkhart, Indiana
71468	ITT Cannon Electric Inc. Los Angeles, California
71482	Clare, C P & Co. Chicago, Illinois
71590	Centralab Div. of Globe Union Inc. Milwaukee, Wisconsin
71707	Coto Coil Co., Inc. Providence, Rhode Island
71744	Chicago Miniature Lamp Works Chicago, Illinois
71785	Cinch Mfg. Co. & Howard B Jones Div. Chicago, Illinois
72005	Driver, Wilber B., Co. Newark, New Jersey
72092	Replaced by 06980
72136	Electro Motive Mfg. Co. Willimantic, Connecticut
72259	Nytronics Inc. Berkeley Heights, New Jersey
72354	Deleted
72619	Dialight Corp Brooklyn, New York
72653	G. C. Electronics Rockford, Illinois
72665	Replaced by 90303
72794	Dzus Fastener Co., Inc. West Islip, New York
72928	Gudeman Co. Chicago, Illinois
72982	Erie Tech. Products Inc. Erie, Pennsylvania
73138	Beckman Instruments Inc. Helipot Division Fullerton, California
73293	Hughes Aircraft Co. Electron Dynamics Div. Newport Beach, California
73445	Amperex Electronic Corp. Hicksville, New York
73559	Carling Electric Inc. Hartford, Connecticut
73586	Circle F Industries Trenton, New Jersey
73734	Federal Screw Products, Inc. Chicago, Illinois
73743	Fischer Special Mfg. Co. Cincinnati, Ohio
73899	JFD Electronics Co. Brooklyn, New York
73949	Guardian Electric Mfg. Co. Chicago, Illinois
74199	Quam Nichols Co. Chicago, Illinois
74217	Radio Switch Corp. Marlboro, New Jersey
74276	Signalite Inc. Neptune, New Jersey
74306	Piezo Crystal Co. Carlisle, Pennsylvania
74542	Hoyt Elect. Instr. Works Penacook, New Hampshire
74970	Johnson, E. F., Co. Waseca, Minnesota
75042	IRC Inc. Philadelphia, Pennsylvania
75376	Kurz-Kasch, Inc. Dayton, Ohio
75382	Kulka Electric Corp. Mt. Vernon, New York
75915	Littlefuse Inc. Des Plaines, Illinois
76854	Oak Mfg. Co. Crystal Lake, Illinois
77342	Potter & Brumfield Div. of Amer. Machine & Foundry Princeton, Indiana
77969	Rubbercraft Corp. of Calif. LTD. Torrance, California

78189	Shakeproof Div. of Illinois Tool Works Elgin, Illinois
78277	Sigma Instruments, Inc. South Braintree, Massachusetts
78488	Stackpole Carbon Co. St. Marys, Pennsylvania
78553	Tinnerman Products Cleveland, Ohio
79136	Waldes Kohinoor Inc. Long Island City, New York
79497	Western Rubber Company Goshen, Indiana
79963	Zierick Mfg. Corp. New Rochelle, New York
80031	Mepco Div. of Sessions Clock Co. Morristown, New Jersey
80145	API Instruments Co. Chesterland, Ohio
80183	Sprague Products North Adams, Massachusetts
80294	Bourns Inc. Riverside, California
80583	Hammarlund Co., Inc. Mars Hill, North Carolina
80640	Stevens, Arnold Inc. Boston, Massachusetts
81073	Grayhill Inc. La Grange, Illinois
81312	Winchester Electronics Div. of Litton Industries Oakville, Connecticut
81439	Therm-O-Disc Inc. Mansfield, Ohio
81483	International Rectifier Corp. El Segundo, California
81590	Korry Mfg. Co. Seattle, Washington
82376	Deleted
82389	Switchcraft Inc. Chicago, Illinois
82415	Price Electric Corp. Frederick, Maryland
82872	Roanwell Corp. New York, New York
82877	Rotron Mfg. Co., Inc. Woodstock, New York
82879	ITT Wire & Cable Div. Pawtucket, Rhode Island
83003	Varo Inc. Garland, Texas
83298	Bendix Corp. Electric Power Division Eatontown, New Jersey
83330	Smith, Herman H., Inc. Brooklyn, New York
83478	Rubbercraft Corp. of America New Haven, Connecticut
83594	Burroughs Corp. Electronic Components Div. Plainfield, New Jersey
83740	Union Carbide Corp. Consumer Products Div. New York, New York
84171	Arco Electronics, Inc. Great Neck, New York
84411	TRW Ogallala, Nebraska
86577	Precision Metal Products Stoneham, Massachusetts
86684	Radio Corp. of America Electronic Components & Devices Harrison, New Jersey
86689	Deleted
87034	Marco-Oak Inc. Anaheim, California
88419	Use 14655
88690	Replaced by 04217
89536	Fluke, John Mfg. Co., Inc. Seattle, Washington
89730	Replaced by 08806
90201	Mallory Capacitor Co. Indianapolis, Indiana
90215	Best Stamp & Mfg. Co. Kansas City, Missouri
90211	Square D Co. Chicago, Illinois
90303	Mallory Battery Co. Tarrytown, New York
91293	Johanson Mfg. Co. Boonton, New Jersey
91407	Replaced by 58474
91637	Dale Electronics Inc. Columbus, Nebraska
91662	Elco Corp. Willow Grove, Pennsylvania
91737	Gremar Mfg. Co., Inc. Wakefield, Massachusetts
91802	Industrial Devices, Inc. Edgewater, New Jersey
91836	King's Electronics Tuckahoe, New York
91929	Honeywell Inc. Micro Switch Div. Freeport, Illinois
91934	Miller Electric Co., Inc. Pawtucket, Rhode Island
93332	Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts
94145	Replaced by 49956
94154	Tung-Sol Div. of Wagner Electric Corp. Newark, New Jersey
95146	Alco Electronics Products Inc. Lawrence, Massachusetts
95263	Leecraft Mfg. Co. Long Island City, New York
95264	Replaced by 98278
95275	Vitramon Inc. Bridgeport, Connecticut
95303	Radio Corp. of America Solid State & Receiving Tube Div. Cincinnati, Ohio
95354	Methode Mfg. Corp. Rolling Meadows, Illinois
95712	Dage Electric Co., Inc. Franklin, Indiana
95987	Weckesser Co., Inc. Chicago, Illinois
96733	San Fernando Electric Mfg. Co. San Fernando, California
96853	Rustrak Instrument Co. Manchester, New Hampshire
96881	Thomson Industries, Inc. Manhasset, New York
97540	Master Mobile Mounts Div. of Whitehall Electronics Corp. Los Angeles, California
97913	Industrial Electronic Hdware Corp. New York, New York
97945	White, S. S. Co. Plastics Div. New York, New York
97966	Replaced by 11358
98094	Replaced by 49956
98278	Microdot Inc. Pasadena, California
98291	Sealectro Corp. Conhex Div Mamaroneck, New York
98388	Accurate Rubber & Plastics Culver City, California
98743	Replaced by 12749
98925	Deleted
99120	Plastic Capacitors, Inc. Chicago, Illinois
99217	Southern Electronics Corp. Burbank, California
99515	Marshall Industries Capacitor Div. Monrovia, California

Revised August 1, 1968
Using H4-1 and H4-2
Dated June , 1968

WARRANTY

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

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

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

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

CLAIM FOR DAMAGE IN SHIPMENT

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

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON

SALES & SERVICE REPRESENTATIVES

ALABAMA

HUNTSVILLE
BCS Associates, Inc.
3322 South Memorial Parkway
Tel. (205) 881-6220
Zip 35801

ALASKA

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5950 Sixth Ave. South
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Seattle, Washington 98108
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ARIZONA

PHOENIX
Barnhill Associates
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Zip 85251

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LOS ANGELES
Instrument Specialists, Inc.
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SAN FRANCISCO
Instrument Specialists, Inc.
2359 De La Cruz
Santa Clara, California 95050
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SAN DIEGO
Instrument Specialists Inc.
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Tel. (714) 453-1833

COLORADO

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CONNECTICUT

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INDIANA

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Zip 46234

MARYLAND

BALTIMORE
Electronic Marketing Assoc.
11501 Huff Court
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Tel. (301) 881-5300

MASSACHUSETTS

BOSTON
Instrument Representatives, Inc.
1046 Massachusetts Avenue
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MICHIGAN

DETROIT
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13657 Grand River Ave.
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Zip 48227

MINNESOTA

MINNEAPOLIS
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Zip 55435

MISSOURI

ST. LOUIS
Cozzens & Cudahy, Inc.
P.O. Box 10013
Lambert Field 63145
Tel. (314) 423-1234

NEW JERSEY

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SBM Associates, Inc.
1519 Stuyvesant Avenue
Union, New Jersey 07083
Tel. (201) 687-8737

NEW MEXICO

ALBUQUERQUE
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827 Pennsylvania N.E.
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LONG ISLAND
SBM Associates, Inc.
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Plainview, Long Island 11803
Tel. (516) 433-1421

ROCHESTER
SBM Associates, Inc.
800 Linden Avenue
Tel. (716) 381-8330
Zip 14625

SYRACUSE
SBM Associates, Inc.
138 Pickard Bldg.
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Tel. (315) 454-9377
Zip 13211

NORTH CAROLINA

GREENSBORO
BCS Associates, Inc.
1039 E. Wendover Avenue
Tel. (919) 273-1918
Zip 27405

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North Olmsted, Ohio 44070
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1250 W. Dorothy Lane
Tel. (513) 298-9964
Zip 45409

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King of Prussia, Pennsylvania
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Zip 19406

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Zip 75080

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3810 Westheimer
Tel. (713) 621-0040
Zip 77027

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Seattle, Washington 98108
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WASHINGTON, D.C.

Electronic Marketing Associates
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Kensington, Maryland 20795
Tel. (301) 881-5300

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BRITISH COLUMBIA

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Annacis Industrial Estate
New Westminster
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376 Churchill Avenue — Suite 106
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Osaka, Japan

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M. - C International
I.P.O. Box 1355
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