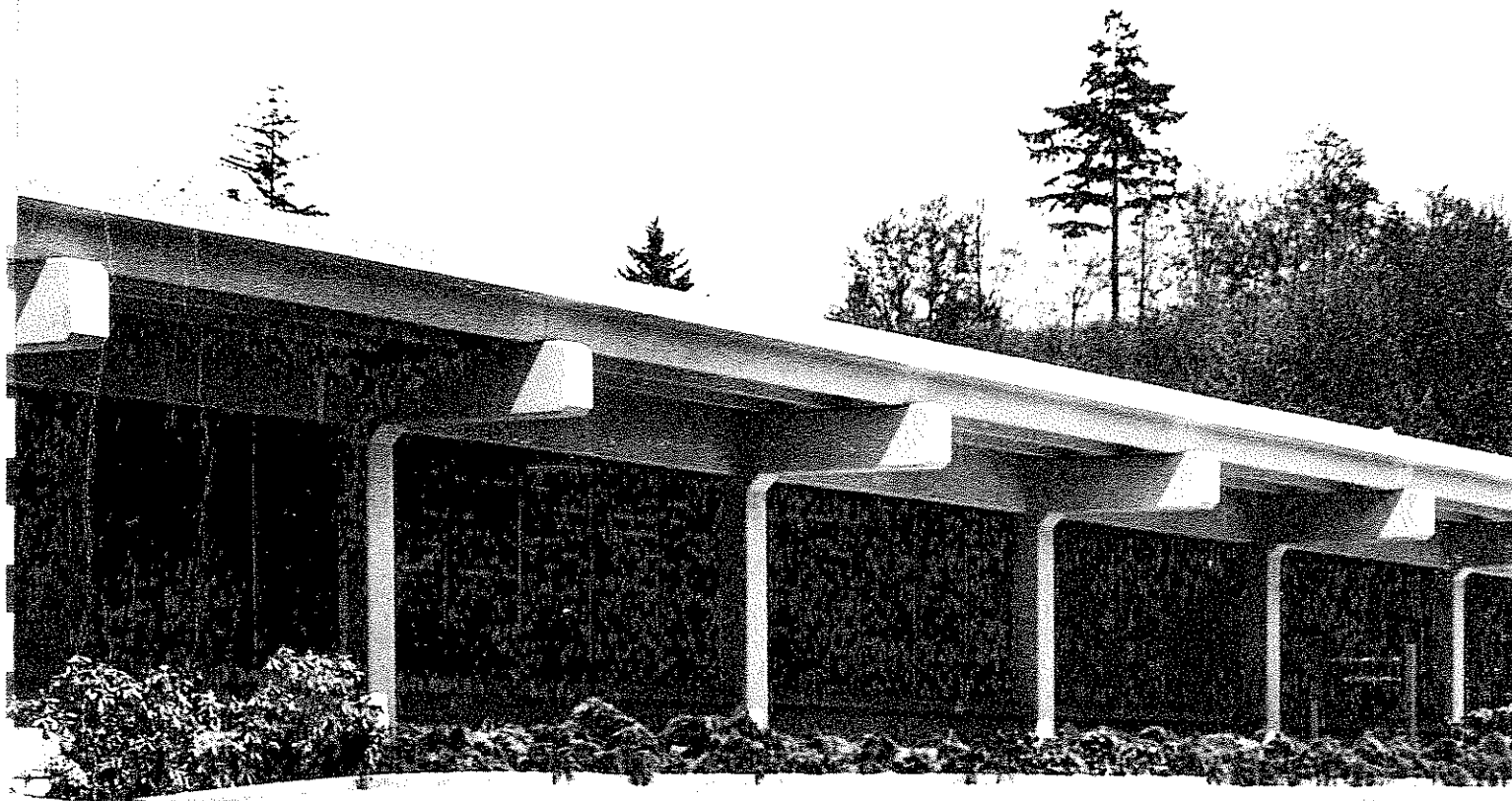


Instruction Manual



T. O 33A1-12-989-4
VOLTMETER, ELECTRONIC
MODEL 893A/AC
CONTRACT NO. F41608-74-D-1756



JOHN FLUKE mfg. co., inc.
SEATTLE WASHINGTON

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JOHN FLUKE MFG. CO., INC.

P.O. Box 43210

Mountlake Terrace, Washington 98043

T. O 33A1-12-989-4
VOLTMETER, ELECTRONIC
MODEL 893A/AC
CONTRACT NO. F41608-74-D-1756

WARRANTY

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

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

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

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

SHIPPING

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

CLAIM FOR DAMAGE IN SHIPMENT

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

The John Fluke Mfg. Co., Inc.* will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to: JOHN FLUKE MFG. CO., INC., P. O. Box 7428, SEATTLE, WASHINGTON 98133*.

* For European customers: FLUKE (Nederland) B.V.
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ADDENDUM

Model 893A/AC
Electronic Voltmeter
T.O. 33A1 - 12-989-4

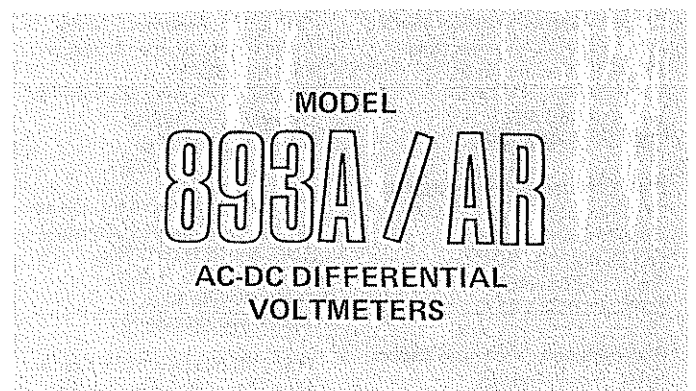
This Instruction Manual for the Model 893A AC/DC Differential Voltmeter has been modified to meet the requirements of Air Force Contract No. F41608-74-D-1756.

All information contained in this manual, modified as required, is applicable to instruments provided on this contract.

JOHN FLUKE MFG. CO., INC.

P.O. Box 43210

Mountlake Terrace, Washington 98043



Rev. 1 8/30/71 Rev. 2 9/22/71 Rev. 3 6/16/72 Rev. 4 7/23/73
Rev. 5 2/10/75

294272

MAY, 1969

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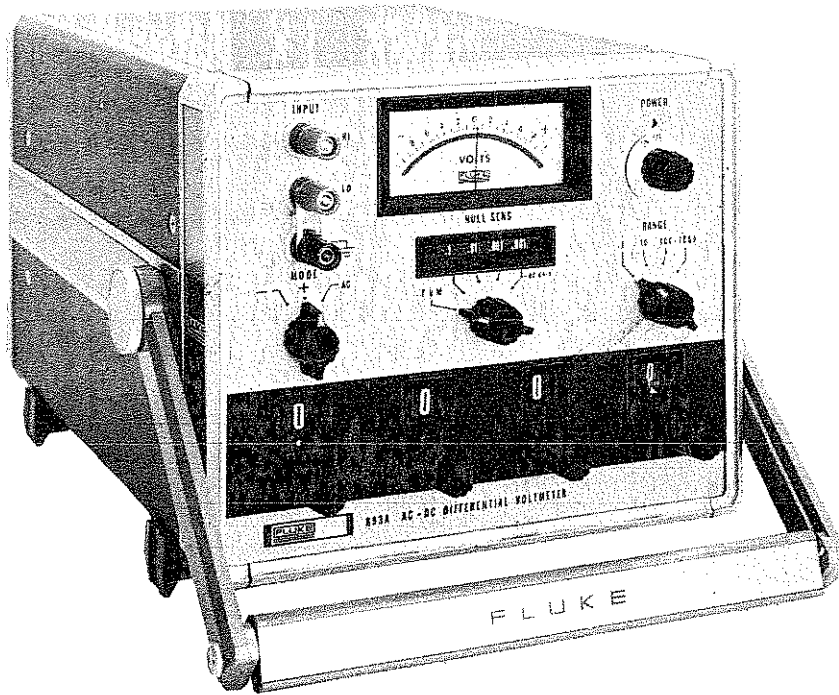
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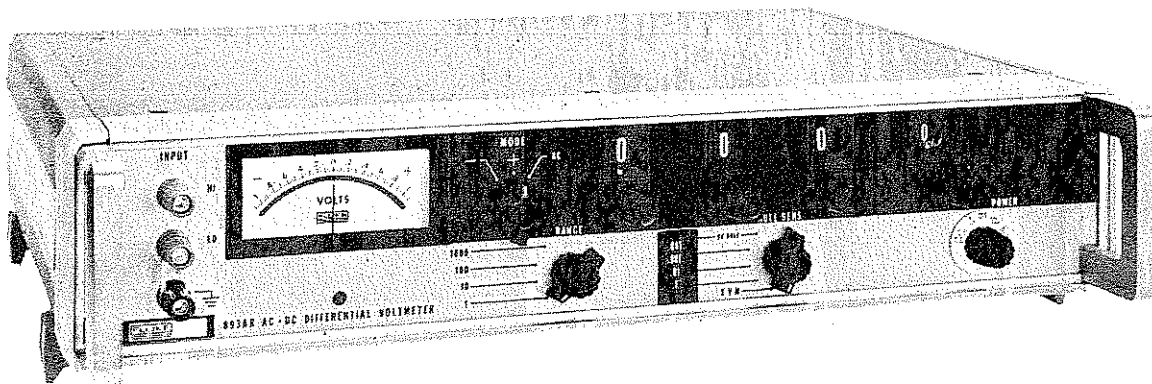
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MODEL 893A



MODEL 893AR



MODELS 893A AND 893AR AC-DC DIFFERENTIAL VOLTMETER

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. The Fluke Model 893A and AR AC-DC Differential Voltmeters provide conventional or differential measurements of ac voltages from one millivolt to 1100 volts ac and dc voltages from 10 microvolts to 1100 volts dc. Conventional (TVM) measurements are made with an accuracy of $\pm 3\%$ of the selected range to initially determine the magnitude of the measured voltage. The differential (NULL) mode is then used with an improved accuracy of up to 250% over that of the conventional mode to determine the exact value of the measured voltage. One linear meter-scale greatly simplifies all measurements made with the instrument. Whenever the instrument is operated on the differential mode, an in-line digital readout representing the magnitude of the measured voltage is available from the front panel Read-out dials.

1-3. Two versions of the instrument are available and are identified as the Model 893A or Model 893AR. The Model 893A is a portable unit, half-rack in width, with a tilt-down carrying handle. This handle detents into the instrument's feet to serve as a tilt-bale during bench-top use of the instrument. The Model 893AR is also a portable unit, but is of proper width for installation in a standard electronic equipment rack. Carrying of this instrument is provided by two front panel handles. A tilt-down bale located on the bottom of the instrument facilitates bench-top use of the instrument.

1-4. A rechargeable battery and recorder output options are also available for either version of the instrument. These options can be installed at the factory, upon request, or in the field. Option Kit 893A-7001 comprises the rechargeable battery pack and, when installed in the instrument, is identified as the -01 option on the rear panel decal. Option Kit 893A-7002 com-

prises the recorder output and, when installed in the instrument, is identified as the -02 option on the rear panel decal.

1-5. ELECTRICAL SPECIFICATIONS

1-6. DIFFERENTIAL VOLTMETER

DC ACCURACY

$\pm(0.01\%$ of input $+0.001\%$ of range $+10$ uv) from 0 to 1100 volts dc at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with up to 80% relative humidity.

$\pm(0.02\%$ of input $+0.001\%$ of range $+10$ uv) from 0 to 1100 volts dc at 10°C to 40°C (50°F to 104°F) with up to 70% relative humidity.

AC ACCURACY

At $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with less than 70% relative humidity:

50 Hz to 10 kHz

0.001 to 500 volts ac $\pm(0.05\%$ of input $+25$ uv)

500 to 1100 volts ac $\pm 0.1\%$ of input

At 10°C to 40°C with less than 70% relative humidity:

5 Hz to 10 Hz

0.001 to 1100 volts ac $\pm(1\%$ of input $+250$ uv)

10 Hz to 20 Hz

0.001 to 1100 volts ac $\pm(0.5\%$ of input $+100$ uv)

20 Hz to 50 Hz

0.001 to 1100 volts ac $\pm(0.15\%$ of input $+25$ uv)

50 Hz to 20 kHz

0.001 to 110 volts ac $\pm(0.1\%$ of input $+25$ uv)

110 to 1100 volts ac $\pm 0.15\%$ of input

20 kHz to 50 kHz

0.001 to 110 volts $\pm(0.15\%$ of input $+25$ uv)

50 kHz to 100 kHz
0.1 to 110 volts ac $\pm 0.5\%$ of input

INPUT AND NULL VOLTAGE RANGES

INPUT RANGES	DC NULL RANGES
1	0.001, 0.01, 0.1
10	0.001, 0.01, 0.1, 1.0
100	0.01, 0.1, 1.0, 10
1000	0.1, 1.0, 10, 100

INPUT RANGES	AC NULL RANGES
1	0.001, 0.01, 0.1
10	0.01, 0.1, 1.0
100	0.1, 1.0, 10
1000	1.0, 10, 100

DC INPUT RESISTANCE

Infinite at null from 0 to 1100 volts dc.

AC INPUT IMPEDANCE

One megohm shunted by less than 20 pf on all ranges.

OVERRANGE

10% overrange capability on each range.

METER RESOLUTION

10 microvolts maximum resolution.

1 ppm of range for dc ranges above one volt.

10 ppm on the one volt dc range and all ac ranges.

READOUT DIAL RESOLUTION

10 microvolts maximum (10 ppm of range).

1-7. CONVENTIONAL VOLTMETER (TVM)

DC VOLTMETER ACCURACY

$\pm 3\%$ of range.

AC VOLTMETER ACCURACY

5 Hz to 20 kHz

0.001 to 1100 volts ac $\pm 3\%$ of input

20 kHz to 100 kHz

0.001 to 110 volt ac $\pm 3\%$ of input

DC INPUT RESISTANCE

RANGE	INPUT RESISTANCE - Megohms
1000	100
100	100
10	100
1	100
*0.1-0-0.1	100
*0.01-0-0.01	10
*0.001-0-0.001	10

*These ranges obtained using null ranges with Readout dials set to zero.

AC INPUT IMPEDANCE

One megohm shunted by less than 20 pf on all ranges.

OVERRANGE

10% overrange capability on each range.

1-2

1-8. GENERAL SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

Completely solid-state

INPUT RESISTANCE OF NULL DETECTOR

10 megohms on the 0.01 and 0.001 volt ranges and 100 megohms on all other ranges.

REFERENCE ELEMENT

Temperature compensated zener diodes.

REGULATION OF REFERENCE SUPPLY

0.0005% for a 10% line change.

REFERENCE VOLTAGE STABILITY (Peak-to-Peak)

10 ppm per hour

20 ppm per day

40 ppm per month

90 ppm per year

KELVIN-VARLEY DIVIDER ACCURACY

$\pm 0.005\%$ of readout dial setting above 1/10 of full-scale.

RECORDER OUTPUT

Available as the -02 option, adjustable from 0 to ± 0.2 volts for an end-scale meter deflection. Low side grounded and loading does not effect deflection accuracy.

POLARITY

Reversible with front panel control.

WARM-UP TIME

Less than one minute.

DC COMMON MODE REJECTION

120 db (1 uv/volt of common mode voltage) for maximum of ± 500 volts.

AC COMMON MODE REJECTION

Up to 100 volt peak-to-peak, 50 to 500 Hz signal, produces no measurable instrument error for dc measurements.

INPUT POWER

115/230 volts ac, 50 to 500 Hz, at approximately four watts for line operation and approximately eight watts when recharging batteries on the -01 option equipped instruments. Minimum of eight hours operation on fully charged batteries of the -01 option equipped instruments.

1-9. ENVIRONMENTAL SPECIFICATIONS

OPERATING TEMPERATURE RANGE

Within dc accuracy specifications from 10°C to 40°C (50°F to 104°F), derated at 15 ppm/°C outside these limits to 0°C and 50°C (32°F and 122°F).

Within ac accuracy specifications from 10°C to 40°C (50°F to 104°F), derated at 40 ppm/°C outside these limits to 0°C and 50°C (32°F and 122°F).

HUMIDITY

Within all specifications up to 80% relative humidity below 25°C.

6/16/72

Within all specifications up to 70% relative humidity above 25°C.

STORAGE TEMPERATURE RANGE

Model 893A/AR -40°C to 70°C (-40°F to 158°F)
Model 893A/AR-01 -40°C to 60°C (-40°F to 140°F)

SHOCK AND VIBRATION
Meets MIL-T-945A.

1-10. MECHANICAL SPECIFICATIONS

SIZE

Model 893A
See Figure 1-1

Model 893AR
See Figure 1-2

WEIGHT
Model 893A
Approximately 12 pounds

Model 893AR
Approximately 12 pounds

Option -01 (Option kit 893A-7001)
Approximately 2 pounds

Option -02 (Option kit 893-7002)
Approximately 0.3 pounds

OPTION KIT 893A-7001
Provides rechargeable battery pack for installation in either version instrument.

OPTION KIT 893A-7002
Provides a recorder output for installation in either version instrument.

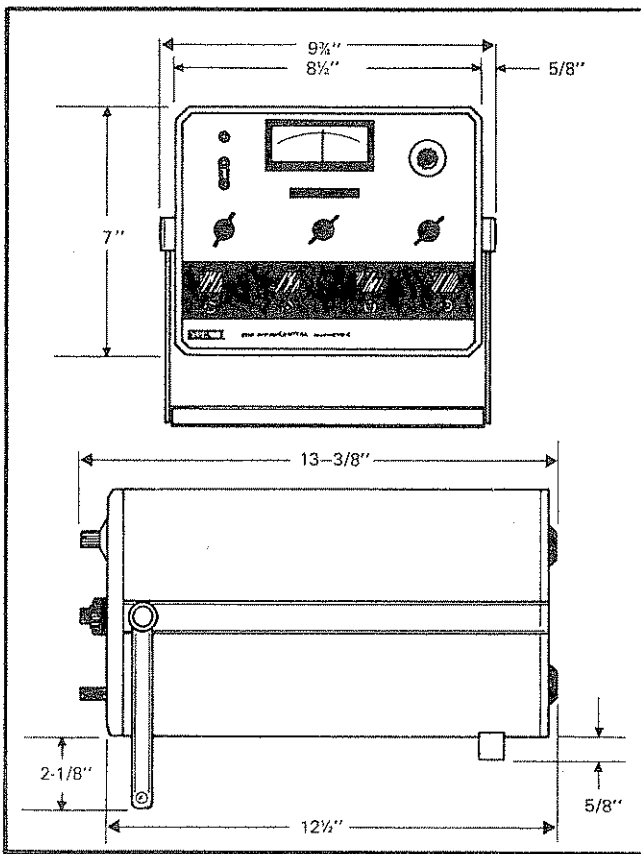


Figure 1-1. MODEL 893A OUTLINE DRAWING

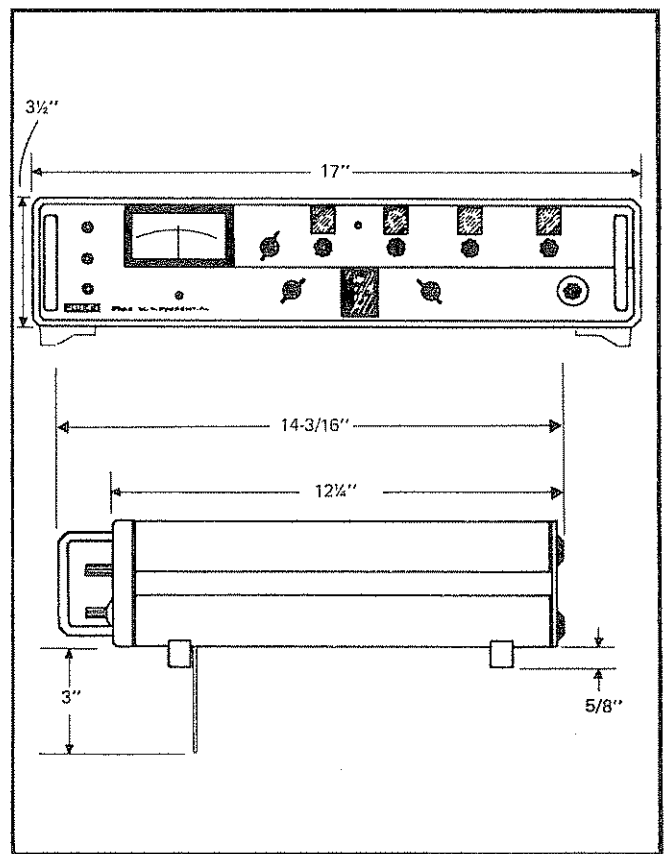


Figure 1-2. MODEL 893AR OUTLINE DRAWING

SECTION II

OPERATING INSTRUCTIONS

2-1. INTRODUCTION

2-2. This section of the manual contains information necessary for you to effectively operate your Model 893 AC/DC Differential Voltmeter. It is recommended that you thoroughly read and understand this section of the manual before attempting to operate your instrument.

2-3. Should any difficulties be encountered during the operation of your instrument, please feel free to contact your nearest John Fluke Sales Representative or write directly to the John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, Wn. 98043, with a statement of your problem. A complete list of Sales Representatives is contained at the rear of this manual.

2-4. OPERATING FEATURES

2-5. All of the controls, terminals, and indicators for the Model 893A and the Model 893AR are illustrated and described in Figure 2-1 and Figure 2-2.

2-6. OPERATION FROM 115/230 VOLT AC POWER LINES

2-7. The Model 893 may be operated from either a 115 or 230 volt ac power line. The input power transformer primary is composed of two windings which, when connected in parallel, allows the instrument to be operated from a 115 volt ac power line or, when the windings are connected in series, allows the instrument to be operated from a 230 volt ac power line.

2-8. A rear panel 115/230 slide switch (S5) provides the necessary power transformer primary winding connections when placed to the desired 115 or 230 volt position.

2-9. PRELIMINARY OPERATING PROCEDURES

2-10. Connect the Model 893 power cord to available line power. If your instrument does not contain the -01 option, perform only step a. If your instrument contains the -01 option, perform steps a through c.

WARNING!

The instrument case is connected to the round pin of the three-prong connector located on the power cord. Whenever the instrument is operated from ac line power, ensure that this round pin is connected to a high quality earth ground.

a. Place the instrument controls as follows and allow at least one minute of circuit stabilization before attempting any measurements.

POWER	ON/LINE OPR
RANGE	1000
NULLS SENS	TVM
MODE	+
Readout dials	000.00

Note!

The Readout dial labeled 00 in the preceding step, represents the extreme right-hand vernier dial.

- b. Place the -01 option equipped instrument POWER switch to BAT CHK, observing that the meter needle deflects to the left of the .2 volt increment. If the batteries are adequately charged, the instrument can be operated on battery power by placing the POWER switch to either BAT OPR or BAT OPR/LINE ISOL. To completely isolate your instrument from the line power ground, disconnect the power cord from line power.
- c. If the BAT CHK test results in a deflection of less than .2 volts on the meter, place the POWER switch to BAT CHG and operate the instrument from line power until the batteries are adequately charged. All measurements can be performed during recharging of the batteries. Should the batteries fail the BAT CHK test after 16 hours of recharging, replacement of the batteries may be necessary. Refer to Section IV, paragraph 4-19 and 4-20 for battery replacement instructions.

Note!

Battery manufacturers recommend that nickel-cadmium batteries should not be stored for extended periods of time without recharging at least every 90 days. Storage temperatures below 25°C are recommended.

2-11. OPERATIONAL TEST

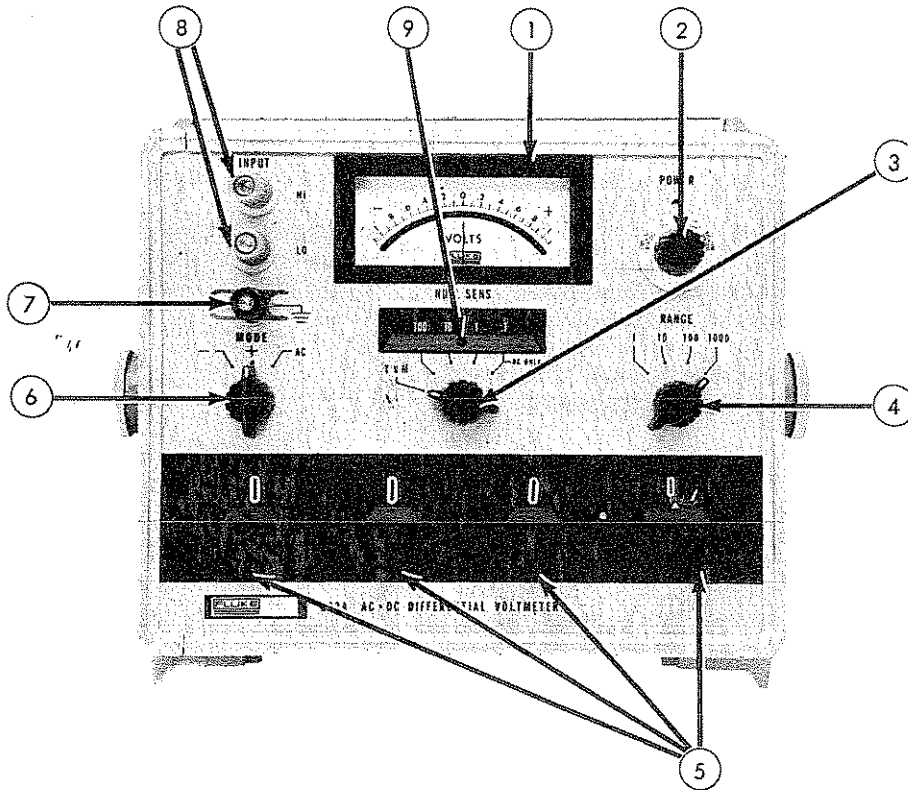
2-12. The following information is provided for the operator to initially verify instrument operation. These tests will only check relative instrument operation and are not intended as instrument performance checks. Should you wish to check the accuracy of the instrument against the specifications contained in Section I, refer to the Performance Checks contained in Section IV of this manual.

2-13. To determine relative instrument operation, perform the operations described in the Preliminary Operating Procedures (paragraphs 2-9 and 2-10) and proceed as follows:

- a. Place the RANGE control to 1.

2/10/75

2-1

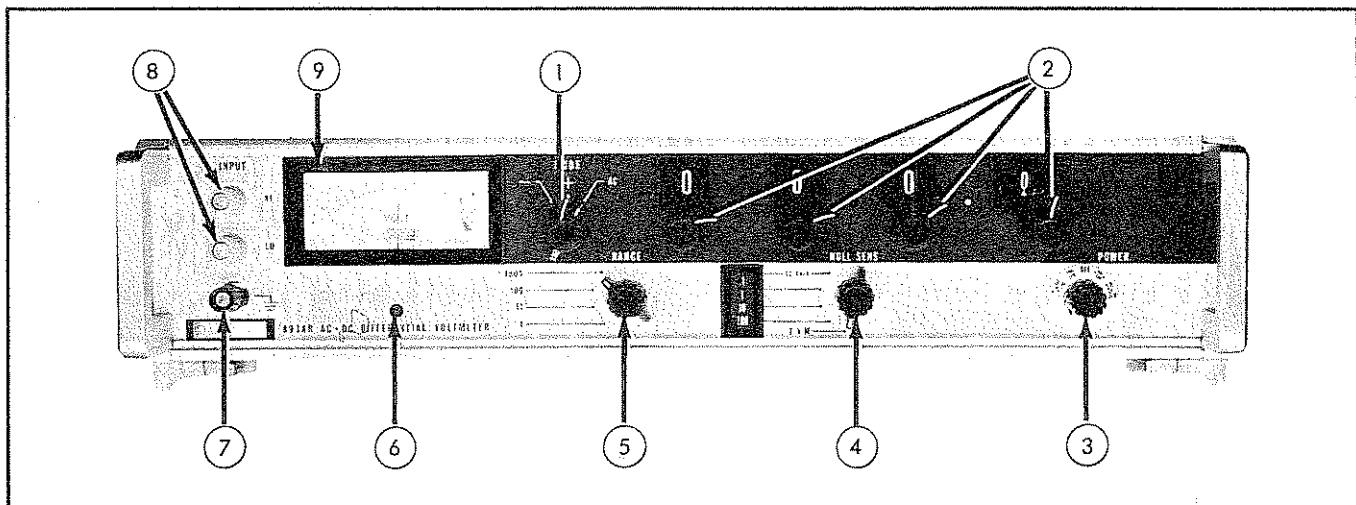


①	METER	Indicates the magnitude and polarity of the measured voltage on the TVM mode. On the differential mode, the meter + or - deflection indicates that the measured voltage is above or below the readout dial indication.
②	POWER SWITCH	Controls application of input power to the instrument. When placed to the LINE OPR position, the instrument is operated from the available line power. On instruments equipped with the 01 Option, additional switch positions of BAT CHK, BAT OPR-LINE ISOL, and LINE OPR-BAT CHG are included. When placed to the BAT CHK position, the front panel meter indicates the charge condition of the battery pack. A meter indication of at least -.2 is required before the instrument is to be operated from the battery power. When placed to the BAT OPR-LINE ISOL position, the instrument is operated from battery power and the power transformer is completely disconnected from line power. However, to completely isolate the instrument circuitry from power line ground, the line power cord must be disconnected. When placed to the LINE OPR-BAT CHG position, the instrument is operated from line power and the battery pack is being charged.
③	NULL SENS SWITCH	Provides selection of the TVM mode of operation and selection of the various full-scale null detector sensitivity ranges when the instrument is operated on the differential mode.
④	RANGE SWITCH	Allows selection of the desired input voltage range of the instrument, while at the same time simultaneously positioning the readout dial decimal point and selecting the available ranges of the NULL SENS switch.
⑤	READOUT DIALS	Provide an in-line digital readout of the measured voltage when the instrument is operated on the differential mode.
⑥	MODE SWITCH	Selects the AC or DC mode of operation. This switch should be placed to the + position on the DC TVM mode. The ± positions provide a means of reversing the internal reference supply voltage on the dc differential mode.

Figure 2-1. THE MODEL 893A CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 2)

⑦	GROUND TERMINAL	Provides for connection to earth ground, provided of course that the line cord is connected to available line power.
⑧	INPUT TERMINALS	Provide connection to the measured voltage source.
⑨	MECHANICAL ZERO CONTROL	Allows mechanical zeroing of the meter.

Figure 2-1. THE MODEL 893A CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 2)



①	MODE SWITCH	Selects the AC or DC mode of operation. This switch should be placed to the + position on the DC TVM mode. The ± positions provide a means of reversing the internal reference supply voltage on the dc differential mode.
②	READOUT DIALS	Provide an in-line digital readout of the measured voltage when the instrument is operated on the differential mode.
③	POWER SWITCH	Controls application of input power to the instrument. When placed to the LINE OPR position, the instrument is operated from the available line power. On instruments equipped with the 01 Option, additional switch positions of BAT CHK, BAT OPR-LINE ISOL, and LINE OPR-BAT CHG are included. When placed to the BAT CHK position, the front panel meter indicates the charge condition of the battery pack. A meter indication of at least .2 is required before the instrument is to be operated from the battery power. When placed to the BAT OPR-LINE ISOL position, the instrument is operated from battery power and the power transformer is completely disconnected from line power. However, to completely isolate the instrument circuitry from power line ground, the line power cord must be disconnected. When placed to the LINE OPR-BAT CHG position, the instrument is operated from the line power and the battery pack is being charged.
④	NULL SENS SWITCH	Provides selection of the TVM mode of operation and selection of the various full-scale null detector sensitivity ranges when the instrument is operated on the differential mode.
⑤	RANGE SWITCH	Allows selection of the desired input voltage range of the instrument, while at the same time simultaneously positioning the readout dial decimal point and selecting the available ranges of the NULL SENS switch.
⑥	MECHANICAL ZERO CONTROL	Allows mechanical zeroing of the meter.
⑦	GROUND TERMINAL	Provides for connection to earth ground, provided of course that the line cord is connected to available line power.
⑧	INPUT TERMINALS	Provide connection to the measured voltage source.

Figure 2-2. THE MODEL 893AR CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 2)

9	METER	Indicated the magnitude and polarity of the measured voltage on the TVM mode. On the differential mode, the meter+or-deflection indicates that the measured voltage is above or below the readout dial indication.
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Figure 2-2. THE MODEL 893AR CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 2)

- b. Touch the HI INPUT terminal and the chassis of the instrument with your hand, observing that the meter pointer deflects to the right or left.
- c. Place the MODE switch to the -DC position and repeat step b. The meter pointer should deflect in the opposite direction by approximately the same amount observed in step b. Place the MODE switch to the +DC position upon completion of this step.
- d. Remove the shorting strap from between the LO and ground INPUT terminals and connect the strap between the HI and LO INPUT terminals.
- e. Perform the Readout dials versus NULL SENS checks of Figure 2-3, observing that the meter pointer indicates -1 for each particular check.

READOUT DIALS	NULL SENS
.000 <u>X</u>	.001
.001 <u>00</u>	.001
.01 <u>000</u>	.01
.1 <u>0000</u>	.1

Figure 2-3. READOUT DIALS VERSUS NULL SENS CHECKS

- f. Place the Readout dials and NULL SENS switches to their respective .10000 and .1 positions, observing that the meter pointer indicates -1.
- g. Retaining the control positions of step f, place the RANGE switch to each available position, observing that the meter pointer indicates -1 in all positions of the RANGE switch.
- h. Place the Model 893 controls to the following positions:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	.001
MODE	AC
Readout dials	000. <u>00</u>

- i. Touch the HI INPUT terminal of the Model 893, observing that a deflection is obtained on the meter.

2-14. If the results of the Operational Test agree with information given, it can be assumed that the instrument is operating properly and measurements of ac and dc voltages can now be performed.

2-15. OPERATING NOTES

2-16. GROUND LOOP CURRENTS

2-17. A potential difference often exists between different points of power system grounds. Consequently,

2-4

current may flow from one power system ground through the voltmeter and the voltage source being measured to another power system ground during the measurement process. These ground loop currents should be avoided as they generate voltages that degrade measurement accuracy. To prevent these ground loop currents, when the system being measured is grounded, remove the shorting strap between the LO INPUT terminal and the ground terminal of the Model 893 or, if your instrument is equipped with the -01 Option, operate the instrument from battery power with the line cord disconnected from line power.

2-18. COMMON MODE VOLTAGES

2-19. Great care has been taken in the design and construction of this instrument to isolate the circuitry from chassis ground to reduce common mode measurement errors caused partly by leakage currents. Accurate dc measurements can be made in the presence of common mode voltages up to 500 volts dc or ac voltages up to 100 volts peak-to-peak at 50 to 500 Hz. If the common mode voltage is greater than 50 volts, the measurement should be made several minutes after the equipment connections for best accuracy due to the time required to charge the stray capacitance through the extremely high leakage resistance to ground.

2-20. USE OF SHORTING LINK

2-21. The INPUT ground terminal is directly connected to the chassis of the instrument to provide a convenient connection to earth ground whenever the line cord is connected to line power. Whenever measurements of voltages having a reference other than ground, but not exceeding 500 volts, are performed, the shorting link between the LO INPUT and ground terminal must be removed or damage to the measurement source, the Model 893, or both may occur.

2-22. DC DIFFERENTIAL OFF-NULL INPUT RESISTANCE

2-23. Input resistance of the Model 893 is infinite at null during dc differential measurements because no current flows between the measured source and the internal reference supply of the instrument. However, a small current does flow between the measured source and the internal reference supply whenever the instrument is not exactly nulled. For example, when the meter deflection is 10% of full-scale on the 0.001 volt NULL SENS range, the input resistance of the instrument is 10^{11} ohms per volt of the measured input voltage or 10^{12} ohms for an input measured voltage of 10 volts dc. A graph of these apparent off-null input resistances is contained in Figure 2-4.

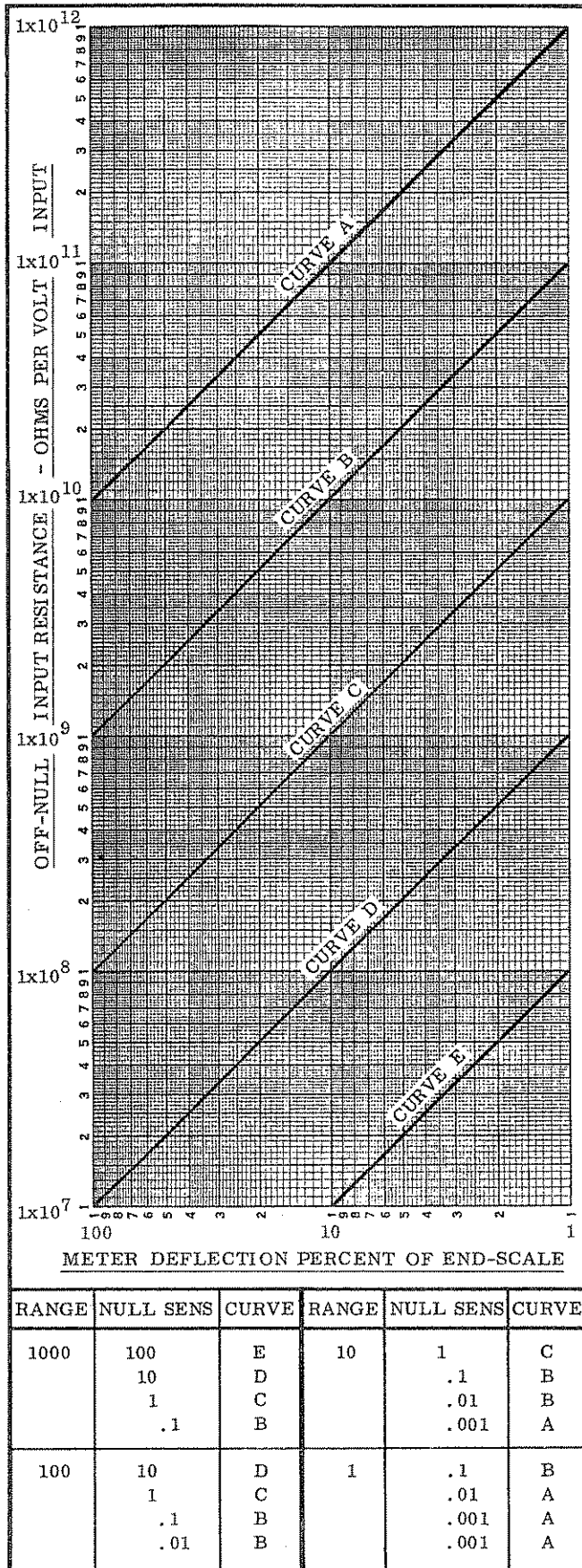


Figure 2-4. OFF-NULL DC INPUT RESISTANCES

2-24. TVM MODE OPERATION

2-25. The Model 893 can be used on the TVM mode to measure ac voltages from one millivolt to 1100 volts ac or dc voltages from 10 microvolts to 1100 volts dc with an accuracy of $\pm 3\%$ of the selected range. To operate the instrument on the TVM mode, perform the operations outlined in the Preliminary Operating Procedures (paragraphs 2-9 and 2-10) and proceed as follows:

- Place the MODE switch to the AC or +DC position that corresponds to the measurement source.
- Connect the circuit to be measured between the HI and LO INPUT terminals. If one side of the voltage source is grounded, connect the grounded side to the LO INPUT terminal.
- Place the RANGE switch to the lowest range possible that maintains an on-scale meter deflection. The meter deflection multiplied by the RANGE switch position is the value of the measured voltage. Left or right meter deflection during dc measurements corresponds to a negative or positive polarity of the measured dc voltage.
- Measurement of ac or dc voltages from 0.02 to 0.1 volts is accomplished on respective NULL SENS switch positions of 0.001 to 0.1. In this application, the RANGE switch is placed to the 1 VOLT range and the Readout dials to .000 00. The resulting meter deflection multiplied by the NULL SENS switch position is the value of the measured voltage.

2-26. DIFFERENTIAL MODE OPERATION

2-27. An improved accuracy of up to 250 times over that of the TVM mode is obtained when the instrument is operated as a differential voltmeter. To operate the instrument as an ac or dc differential voltmeter, proceed as follows:

- Determine the approximate value of the measured voltage by performing the TVM mode measurements described in paragraph 2-9 and 2-10.
- Place the MODE switch to the respective dc polarity observed on the TVM mode measurement and set the Readout dials to the TVM measurement value. If an ac measurement is being made, leave the MODE switch in its AC position.
- Place the NULL SENS switch to successively high null sensitivity positions and adjust the Readout dials to obtain a center-zero meter deflection.

CAUTION!

Whenever the NULL SENS switch is placed to a position other than TVM on the dc measurement mode, a voltage corresponding to the Readout dial indications is present between the HI and LO INPUT terminals. A personnel hazard does not exist as the source resistance is 90 megohms on the

100 and 1000 volt ranges, however, this potential can damage high input impedance semiconductor devices such as field effect transistors.

- d. The Readout dial digit indications correspond to the magnitude of the measured voltage. If dc measurements have been performed, the MODE switch position indicates the polarity of the measured dc voltage.

2-28. OPTIONAL RECORDER OUTPUT OPERATION

2-29. Instruments equipped with the -02 option provide an isolated recorder output voltage which is available at the rear panel terminals. The recorder output dc voltage is adjustable from zero to ± 0.2 volts dc for a full-scale meter deflection and is used to drive a center-zero recorder. To utilize the recorder output voltage, proceed as follows:

- a. Connect the recorder to the rear panel RECORDER OUTPUT terminals.

Note!

The LO RECORDER OUTPUT terminal is connected to chassis ground of the Model 893. If a ground reference is undesirable, operate the Model 893 on battery power with its line cord disconnected from line power.

- b. Turn the recorder on and place the Model 893 controls to the following positions:

POWER	ON/LINE-OPR
RANGE	10
NULL SENS	1
MODE	+DC
Readout dials	1.00 <u>00</u>

- c. Connect the shorting link between the HI and LO INPUT terminals and adjust the RECORDER OUTPUT LEVEL control for the desired left full-scale indication on the recorder. The left full-scale meter is now plotted and from this information the right full-scale point can be determined.

- d. Remove the shorting link from between the HI and LO INPUT terminals and proceed with the desired measurement. The external recorder will now record all meter excursions of the Model 893.

2-30. APPLICATIONS

2-31. INTRODUCTION

2-32. The Model 893 AC DC Differential Voltmeter, because of its calibrated meter end-scale and high dc mode input impedance, can be used in many special applications. These applications, to mention a few, are; measurement of ac or dc voltage excursions about a nominal value, measurement of extremely high resistances, operation as a dc null detector, and measurement of DBM.

2-6

2-33. MEASUREMENT OF VOLTAGE EXCURSIONS ABOUT A NOMINAL VALUE

2-34. Whenever the instrument is operated on the differential mode, the meter end-scale is calibrated to be a known voltage by the position of the NULL SENS switch, thus allowing rapid determination of any voltage excursions about a nominal value. For example, by selecting a null sensitivity of .1 with the RANGE switch on any voltage range, the full left or right scale meter deflection represents ± 0.1 volts deviation from the Readout dial settings. To measure voltage excursions about a nominal value, proceed as follows:

- a. Perform the Preliminary Operating Procedures of paragraph 2-9 and 2-10.
- b. Determine the nominal value of the ac or dc voltage being measured, using the TVM mode on the Model 893. Refer to paragraphs 2-24 and 2-25 for the TVM mode operating procedures.
- c. Place the Readout dials to the nominal value of the voltage measured in step b and select the desired full-scale meter sensitivity with the NULL SENS switch. The voltage excursions about the Readout dial settings can now be determined by the left or right meter deflections.

2-35. MEASUREMENT OF EXTREMELY HIGH RESISTANCES

2-36. The Model 893 can be used as a megohmmeter for measurements of high resistances from 10 to 10^6 megohms with a typical accuracy of $\pm 5\%$. To operate the instrument as a megohmmeter, perform the Preliminary Operating Procedures described in paragraphs 2-9 and 2-10 and proceed as follows:

- a. Place the Model 893 controls to the following positions:

POWER	ON/LINE OPR
RANGE	10
NULL SENS	.01 (.001 if the R is greater than 10^{10})
MODE	+DC
Readout dials	0.00 <u>00</u>

Note!

The 10 volt range has been used only as an example in step a. Other voltage ranges may be used to provide high resistance measurements at different voltage levels.

- b. Connect the unknown resistance between the HI and LO INPUT terminals. Use short isolated leads to prevent measuring the leakage resistance between the leads.
- c. Rotate the Readout dials to obtain a meter deflection of -1 and use the following calculations to determine the value of the unknown resistance.

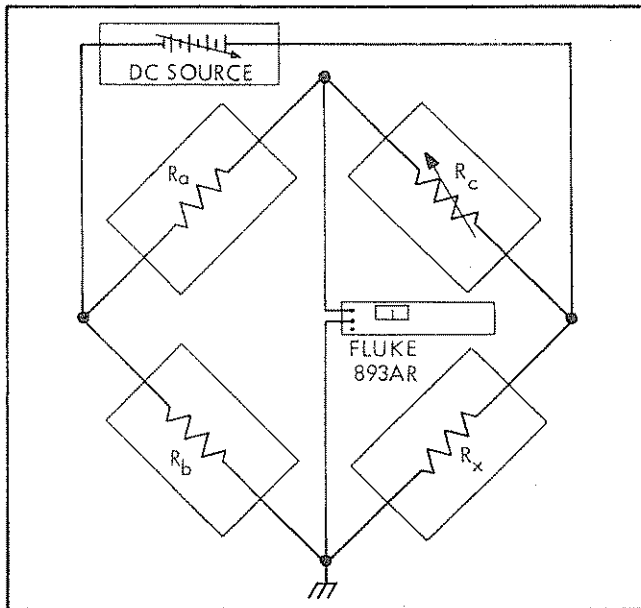


Figure 2-5. BRIDGE DETECTOR - FLOATING SUPPLY

$$R_x = \left(\frac{E_{RO}}{E_m} - 1 \right) R_{nd}$$

R_x = Unknown resistance

R_{nd} = Null detector input resistance of 10 megohms for NULL SENS settings of .01. Null detector input resistance is 100 megohms on all other settings.

E_{RO} = Readout dial voltage

E_m = Meter deflection in volts (Proportional to selected NULL SENS).

2-37. OPERATION AS A NULL DETECTOR

2-38. The Model 893, because of its high input impedance on the dc differential mode, can be used to monitor small voltage differences in bridge circuits, potentiometers, and other measuring devices. In most of these applications, the circuits are adjusted for a zero deflection or null on the Model 893. Equipment connections for two types of null detector configurations are illustrated in Figure 2-5 and 2-6. To operate the instrument as a null detector, perform the Preliminary Operating Procedures described in paragraphs 2-9 and 2-10, and proceed as follows:

- Select the desired equipment applications illustrated in Figure 2-5 and 2-6 and make the appropriate connections.
- Place the Model 893 MODE and NULL SENS switches to the +DC and desired null detector sensitivity

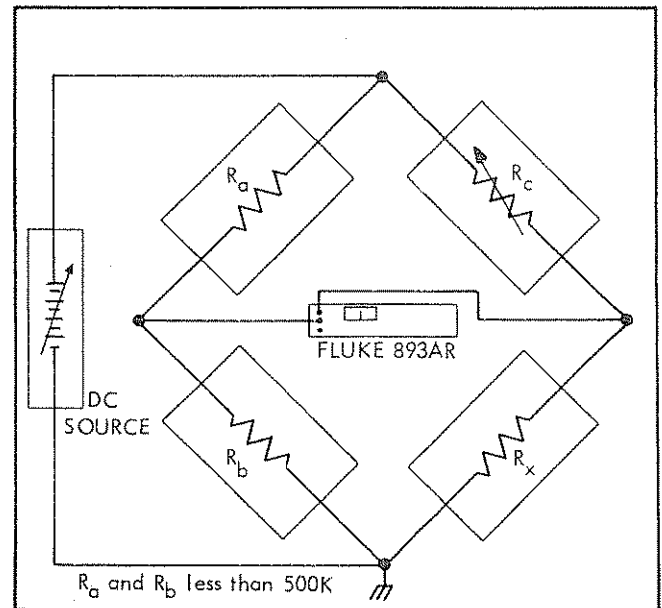


Figure 2-6. BRIDGE DETECTOR - FLOATING NULL DETECTOR

positions, respectively. Adjust the circuit being measured for a zero or null deflection on the Model 893.

2-39. MEASUREMENT OF DBM

2-40. The Model 893, when operated on either the TVM or Differential AC mode, can be used as an output meter. For this application, the output to be measured must be terminated into a 600 ohm load and the Model 893 INPUT connected across the 600 ohm load. The Model 893 is then operated on the TVM or Differential AC mode and the resulting deflection or Readout dial indication converted to DBM using the information contained in Figure 2-7. For DBM measurements above one volt ac, multiply the voltages listed in Figure 2-7 by ten for each range and then add 20 DBM for each range.

INDICATED VOLTAGE	DBM LEVEL FOR 1 VOLT RANGE (1 mw into 600Ω)
.0975	-18
.1227	-16
.1545	-14
.1946	-12
.2450	-10
.3088	-8
.3897	-6
.4887	-4
.6150	-2
.7746	0
.9752	+2

Figure 2-7. 1 VOLT RANGE DBM CONVERSION TABLE

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. The theory of operation for the Model 893 AC-DC Differential Voltmeter is contained in this section of the manual. A block diagram analysis is used to functionally describe the overall operation of the instrument which is then followed by a detailed circuit description of each particular block section. The functional block diagram is illustrated in Figure 3-1 and the schematic diagram is contained at the rear of the manual.

3-3. BLOCK DIAGRAM ANALYSIS

3-4. INTRODUCTION

3-5. The Model 893 circuitry is comprised of a reference supply, a Kelvin-Varley divider, a dc input divider, an ac converter, a null detector, a meter, and optional recorder output. This circuitry is interconnected by various switching arrangements when performing the desired ac or dc conventional or differential voltage measurements.

3-6. CONVENTIONAL TVM MODE

3-7. When the instrument is used as a conventional transistorized dc voltmeter, the circuitry is connected as illustrated in Figure 3-1. The input divider is connected across the input terminals of the instrument to provide a constant input impedance of 100 megohms on all ranges. With a full-scale input voltage applied to the input of the instrument, the selected tap of the input divider provides a dc input voltage of \pm one millivolt to the input of the null detector which drives the front panel meter. Gain of the null detector is precisely controlled by the negative feedback network and provides a full-scale meter deflection for any full-scale input. Positive or negative

voltage measurements are facilitated by reversing the meter terminals through the contacts of the MODE switch.

3-8. By placing the MODE switch of Figure 3-1 to the AC position, the instrument circuitry is connected as a conventional transistorized ac voltmeter. The resistor R12 and the ac converter are connected across the input terminals of the instrument and provide a constant input impedance of one megohm on all ac voltage ranges. The ac converter is an operational amplifier driving a full-wave detector whose overall gain is controlled by the negative feedback network selected with the RANGE switch. A full-scale input voltage at the input terminals of the instrument results in an ac converter output voltage of one volt dc which is applied to the input of the null detector. The null detector, whose gain is precisely controlled by the negative feedback network, drives the front panel meter which indicates the magnitude of the measured ac voltage.

3-9. DIFFERENTIAL NULL MODE

3-10. When the instrument is used as a dc differential voltmeter, the MODE and NULL SENS switches of Figure 3-1 are placed to their respective \pm DC and the desired full-scale meter sensitivity positions. On this mode of operation, the NULL SENS switch selects a suitable resistance value from the input divider resistors to determine the meter full-scale sensitivity and also applies the Kelvin-Varley divider output to the common input of the null detector. The dc input voltage applied to the instrument is then compared by the null detector to the Kelvin-Varley divider output voltage and any resulting difference used to drive the meter. Any right or left meter deflections correspond to an input voltage above or below the Kelvin-Varley divider output voltage. The

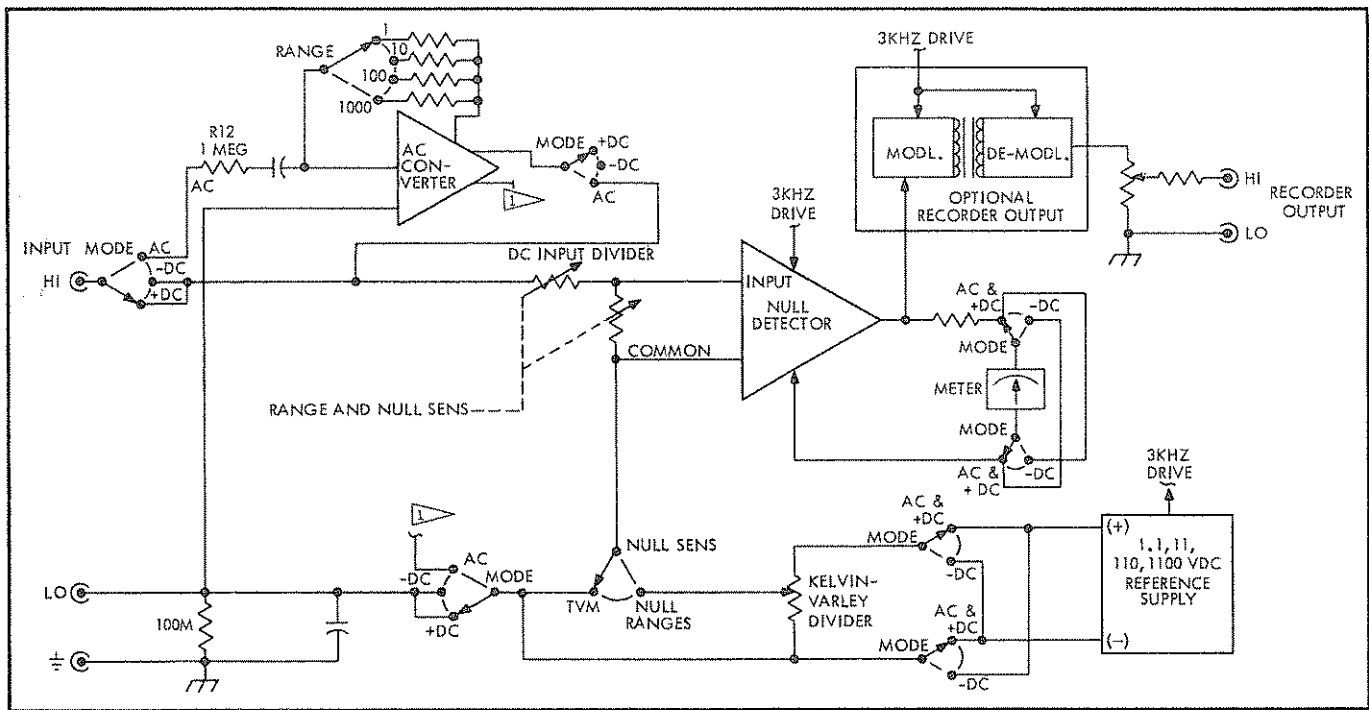


Figure 3-1. MODEL 893A/AR BLOCK DIAGRAM

Kelvin-Varley divider voltage polarity and the meter terminals can be reversed through the contacts of the MODE switch for \pm dc voltage measurements.

3-11. By placing the MODE switch of Figure 3-1 to the AC position. The instrument circuitry is connected as an ac differential voltmeter having an input impedance of one megohm. The ac converter operates in the same manner as on the AC TVM mode and supplies a full-scale input voltage of one volt dc to the dc measurement circuitry. The remaining circuitry operates similar to the dc differential mode with the only difference being the absence of the polarity reversal switching.

3-12. OPTIONAL RECORDER OUTPUT

3-13. The optional recorder output provides isolation between the null detector output and recorder output. The null detector output voltage is modulated by a 3 kHz drive signal derived from the reference supply. The modulated signal is transformer coupled to a demodulator driven at the same 3 kHz rate as the modulator. The signal is then demodulated, and the resulting dc voltage applied through a variable resistor to the recorder output terminals. The variable resistor provides adjustment of the full-scale recorder output voltage.

3-14. CIRCUIT ANALYSIS

3-15. INTRODUCTION

3-16. The circuitry contained in the Model 893 is comprised of a power supply/battery charger, a reference amplifier and a reference inverter, a Kelvin-Varley divider, an ac converter, a null detector, an optional recorder

output, a meter, a dc input divider, and RANGE, NULL SENS, MODE and POWER switches. These circuits will be described in detail in the following paragraphs using simplified circuit diagrams in addition to the functional schematic diagrams located at the rear of the manual.

3-17. POWER SUPPLY/BATTERY CHARGER

3-18. The input power transformer T1 receives 115 or 230 volts ac through the contacts of the POWER switch S2BR-2. The primary of T1 is constructed in such a manner as to allow the instrument to be operated from 115 volts ac, windings in parallel, or 230 volts ac, windings in series. Switch S5 performs the required 115 or 230 volt ac power connections in the primary of T1. Fuse F1 protects the circuitry from overloads. The secondary of T1 has four taps which supply ac voltages to the power supply and battery charger. The ac voltage present at pins 8 and 10 are full-wave rectified by diodes CR1 and CR2 and capacitors C1 and C2 located on the A2 Reference Amplifier Assembly.

3-19. On instruments equipped with the -01 option, the ac voltage present at pins 9 and 11 of T1 is fullwave rectified by diodes CR3 and CR4 and applied across R9 and BT1. When the POWER switch is placed to the BAT CHG position, the contacts of S2BF by-pass the resistor R9 to provide a maximum charge current for BT1. The lamp DS1 functions as a ballast to limit charging current at an optimum value for rapid charging of BT1. Resistor R9 is placed in the circuit on all other POWER switch positions to provide trickle-charging of BT1 when the instrument is operated from line power. Checking of BT1 is provided when the POWER switch is placed to the BAT CHK position. Switches S2BR-1, S2BR-2, S2BF, S2AF, and S2AR provide the necessary circuit connections that remove the ac voltage applied to T1 and place the meter

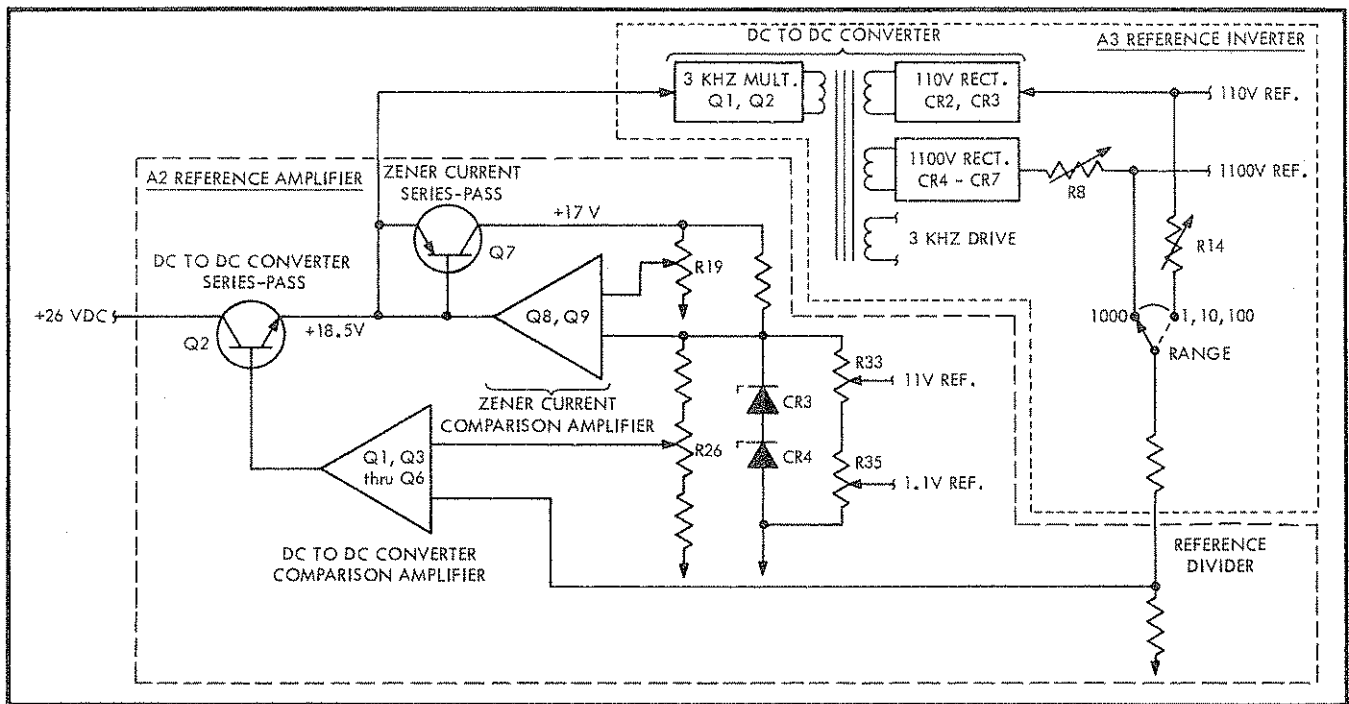


Figure 3-2. REFERENCE AMPLIFIER/REFERENCE INVERTER - SIMPLIFIED

in series with A2R4. The meter and A2R4 are also placed in parallel with the series-pass transistor A2Q2 with the POWER switch, thus providing a check of BT1 under an actual load condition.

3-20. THE REFERENCE SUPPLY

3-21. GENERAL. Reference voltages of 1.1, 11, 110, and 1100 volts dc, upon which the stability of the instrument relies, and a 3 kHz output signal are produced by the Reference Supply. The circuitry of the Reference Supply consists of two regulator stages and a dc-dc converter. A block diagram of these circuits is illustrated in Figure 3-2.

3-22. BLOCK DIAGRAM DESCRIPTION. The dc to dc converter regulator provides a pre-regulated voltage to the zener current regulator and a regulated voltage to the dc to dc converter. The zener current regulator provides a closely regulated dc current for the reference zener diodes of CR3 and CR4 from which the 1.1 and 11 volt dc reference voltages are derived. These same zener diodes also provide a stable reference voltage for the dc to dc converter comparison amplifier. The dc to dc converter produces the 110 and 1100 volt dc reference voltages and a 3 kHz drive signal. The reference divider junction provides a sample of the 110 and 1100 volt dc reference voltage to the dc to dc converter comparison amplifier which controls the input dc voltage to the dc to dc converter. Consequently, a stable 110 or 1100 volt dc reference voltage related to the zener reference voltage is obtained. The 3 kHz drive signal is used to produce operating voltages for null detector, ac converter, and optional recorder output circuits.

3-23. CIRCUIT DESCRIPTION. The unregulated dc voltage from the power supply or the dc output voltage of the battery pack is applied to terminal 3 of the Reference Amplifier Assembly. This voltage is used to provide an input dc voltage to the dc to dc converter regulator circuitry. Initial turn-on of the dc to dc converter regulator circuitry is accomplished with the circuitry comprised of A2R1, CR1, CR2, CR5 and Q4. The voltage developed at the junction of R1 and CR5 forward biases CR1 and transistor Q4. Conduction of Q4 is initially through the low impedance path of CR2, thus providing a dc input voltage to the zener current regulator. The resulting zener reference voltage biases the comparison amplifier circuitry of Q3, Q5, and Q6 into conduction. As the dc to dc converter regulator output approaches the nominal +18.5 volt dc level, diodes CR1 and CR2 are reversed biased, disconnecting the turn-on circuitry from the regulator circuitry. Transistor Q4 then functions as a buffer amplifier between the series-pass driver Q1 and the comparison amplifier output from Q5.

3-24. The zener current regulator circuitry is composed of transistors Q7 through Q9, zener diodes CR3 and CR4 and associated resistors. Transistor Q7 is the series-pass element while resistor R13 provides starting current to initially turn-on the reference elements of CR3 and CR4. The resistive network of R17 through R19 form a divider across the output of the zener current regulator and provides a sample of its output voltage to the base of Q9. Resistor R19 provides adjustment of the output voltage of the zener current regulator. Transistors Q8 and Q9 comprise a differentially connected comparison amplifier with the zener voltage of CR3 and CR4 providing a reference at the base of Q8. This reference voltage has a very low temperature coefficient from which the instrument

derives its measurement stability. The output of the differential connected comparison amplifier controls the conduction of the series-pass transistor Q7 and determines the output voltage of the zener current regulator. This output voltage establishes a fixed current through the zener diodes of CR3 and CR4. Two resistive dividers comprised of R26 through R31 and R32 through R36 are connected across the zener diodes of CR3 and CR4. The divider composed of R26 through R31 is used to provide a reference voltage to the dc to dc converter comparison amplifier Q3. The divider composed of R32 through R36 is used to produce the 1.1 and 11 volt dc reference voltage applied to the Kelvin-Varley divider on the 1 and 10 volt ranges of the instrument. Variable resistor R26 provides adjustment of the dc to dc converter regulator output voltage while R33 and R35 provide adjustment of the 1.1 and 11 volt dc reference voltages.

3-25. The dc to dc converter regulator circuitry is comprised of transistors Q1 through Q6 and associated resistors and capacitors. Transistor Q2 is the series-pass element whose conduction is controlled by the series-pass driver Q1 and the two differentially connected comparison amplifiers of Q3, Q5 and Q6. Transistor Q3 receives a reference voltage through R25 from the previously described zener current regulator. A sample of the Reference Inverter Assembly dc output voltage present at terminal 8 is developed across R21 and R22 and applied to the other base Q3. Transistor Q3 compares the sample of the Reference Inverter Assembly output voltage to the zener reference voltage and amplifies any resulting difference. Transistors Q5 and Q6 comprise the second stage of the comparison amplifier and amplify any resulting voltage difference detected by Q3. The output of Q5 is applied to the series-pass driver Q1 through the common-base buffer Q4. The series-pass driver controls the base current of Q2 which in turn determines the output voltage of the dc to dc converter regulator and consequently, any resulting output voltage of the Reference Inverter Assembly.

3-26. The output voltage of the dc to dc converter regulator is applied to terminal 3 of the Reference Inverter Assembly. This voltage is used to provide operating voltages for the 3 kHz transformer coupled multivibrator composed of Q1, Q2 and T1. A low-pass filter comprised of R1, C1 and C2 provides decoupling of any 3 kHz variations that could be applied back to the regulator circuitry. Resistor R2 provides the dc current to the bases of Q1 and Q2 necessary to initially start the multivibrator. Diode CR1 functions as a clamper and capacitor C1 bypasses CR1 to provide a low resistance source to the bases of Q1 and Q2. Upon application of an input dc voltage, assuming that Q1 will conduct harder than Q2, the collector of Q1 clamps the upper end of the center-tapped winding of T1 to zero volts dc. The base-drive winding associated with R3 applies a positive going signal to the base of Q1, driving the transistor into saturation. The lower end of the center-tapped winding is driven to +36 volts dc by autotransformer action causing the base-drive winding associated with R4 to apply a negative going signal to the base of Q2 cutting-off the transistor. This condition will persist for a period proportional to the flux capacity of the

transformer core, which in this case is approximately 150 microseconds. At the end of this period, the voltages across the transformer windings are reversed by the collapsing lines of flux, driving transistor Q1 into cut-off and Q2 into saturation, thus establishing the second half-cycle of the 3 kHz signal. The resulting 3 kHz signal is then coupled to the secondary of T1 where it is used to provide drive signals and the 110 and 1100 dc reference voltages. Variable resistor R5 provides a means of reducing any capacitive coupling effects to the winding in the shield of T1. Inductor L1 increases the circuit switching time to reduce higher frequency radiation.

3-27. The secondary signals of T1 that are available at terminals 6 through 10 of the Reference Inverter Assembly are used to provide drive signals to the Null Detector and optional Recorder Output circuitry. Two full-wave voltage doublers in the remaining secondary windings of T1 produce the 110 and 1100 volt dc reference voltages used by the Kelvin-Varley divider. These voltages are used on the 100 and 10000 voltage ranges of the instrument. The full-wave voltage doubler composed of CR3, CR4, R6 and C4 through C6 produces the 110 dc reference voltage available at terminal 2 of the Reference Inverter Assembly. Resistor R14 provides adjustment of this reference voltage. The full-wave voltage doubler composed of CR4 through CR7, R7 through R11 and C7 through C9 produces the 1100 volt dc reference voltage available at terminal 1 of the Reference Inverter Assembly. Resistor A2R26 provides adjustment of the resulting input voltage. A resistive divider comprised of R9 through R11 provides a load for the voltage doubler when this reference voltage is not being used and functions as a bleeder when power is removed from the circuit. Regulation of the 110 and 1100 volt dc reference voltage is accomplished by feeding a sample of the selected reference voltage back to the dc to dc converter regulator circuitry. Switches S1AR-1 and S1AR-2 select the desired sections of a resistive divider composed of R12 through R16 and the resistors R21 and R22 located in the Reference Amplifier Assembly. This sample of the output reference voltage controls the level of the input voltage applied to the 3 kHz multivibrator which determines the level of the secondary voltages of T1 and in turn controls the output level of the full-wave voltage doublers used to develop the 110 and 1100 volt dc reference voltages.

3-28. KELVIN-VARLEY DIVIDER

3-29. GENERAL. Continuous division of the reference supply voltages, while presenting a constant load to the reference supply, is accomplished with a Kelvin-Varley divider. The divider is composed of matched fixed resistors R1 through R34, trimmers R35 and R36, potentiometer R37 and rotary switches S6 through S8.

3-30. CIRCUIT DESCRIPTION. Rotary switch S6 controls the first order division of the reference supply voltage. The first resistive divider of R1 through R12 is arranged in 12 equal parts of 100K ohms. The contacts of S6 connect the 200K ohm effective resistance of the second divider in parallel with the selected two parts of the first divider, thus producing a selected resistance value of 100K ohms. This selected re-

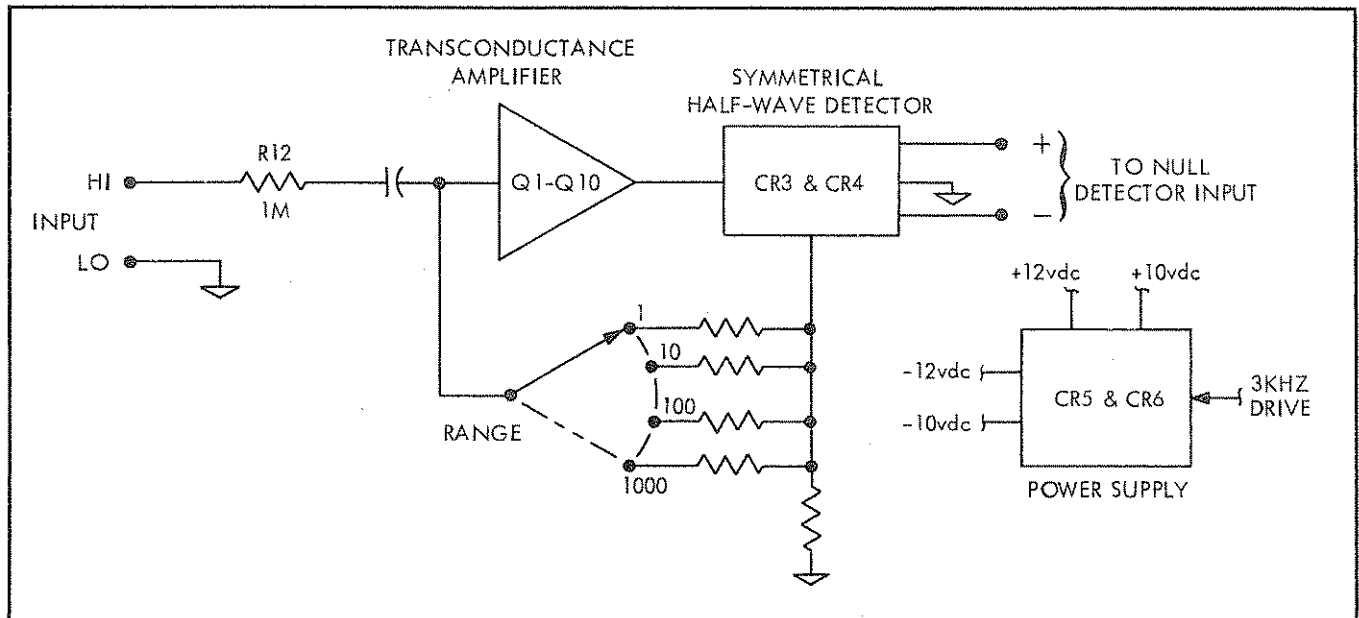


Figure 3-3. AC CONVERTER BLOCK DIAGRAM

sistance value is in series with the remaining ten 100K ohm parts of the first divider and presents a constant load resistance of 1.1M ohms to the reference supply. There are eleven equal voltage steps available from the first divider which can be selected by the rotary switch S6. Since the reference supply output voltage is either 1.1, 11, 110, or 1,100 volts dc, the rotary switch S6 is calibrated in 0.1, 1, 10, or 100 volt increments.

3-31. The second, third, and fourth order divisions of the reference supply voltage are provided by the corresponding resistive dividers R13 through R23, R24 through R34, and potentiometer R37. The second and third order dividers function in a manner similar to the first order divider with their associated switches S7 and S8 performing the desired connections. Each of these dividers are composed of 11 equal value resistors, thus providing ten equal divisions of the preceding divider output voltage. Potentiometer R37 comprises the fourth order divider which operates on the same principle as the preceding dividers but provides a continuously variable output voltage at its wiper. Resistors R35 and R36 provide the necessary trimming resistance for the fourth order divider.

3-32. The voltage appearing at the wiper of R37 is the output voltage of the Kelvin-Varley divider. This voltage directly corresponds to the readout dials digit value for the particular reference supply voltage being used. The RANGE switch S1AF2 selects the appropriate reference supply voltage of 1.1, 11, 110, or 1100 volts dc corresponding to the 1, 10, 100, or 1000 volt ranges of the instrument. The NULL switch S3AF applies the Kelvin-Varley output voltage to the null detector common on the various null ranges of the instrument. Whenever the instrument is operated on the TVM mode, S3AF disconnects the output of the Kelvin-Varley divider from null detector common and connects the low input common to null detector common. Reversal of the Kelvin-

Varley output voltage polarity is provided by the MODE switches S4AF1 and S4AF2.

3-33. AC CONVERTER

3-34. GENERAL. The AC Converter changes measured ac input voltages to dc voltages that can be measured with the dc portion of the instrument. Circuitry of the AC Converter consists of a transconductance amplifier comprised of Q1 through Q10 and the feedback networks selected with the RANGE switch, a symmetrical half-wave detector CR3 and CR4, and the power supply CR5 and CR6. A block diagram of these circuits is illustrated in Figure 3-3.

3-35. BLOCK DIAGRAM DESCRIPTION. All operating voltages for the AC Converter are produced by the half-wave rectifiers CR5 and CR6 and their associated filters. A 3 kHz signal derived from the Reference Inverter Assembly is used to drive the half-wave rectifiers. Input ac voltages applied to the AC Converter are amplified by the transconductance amplifier comprised of Q1 through Q10. The resulting transconductance amplifier output current flows through the symmetrical half-wave detectors which in turn produce a full-scale output voltage of one volt dc. This dc voltage is then applied to the dc measurement circuitry of the instrument for measurement. A voltage proportional to the transconductance amplifier output current is fed back to the amplifier input through a feedback network selected with the RANGE switch to establish a high degree of gain stability and provide ac ranging for the instrument.

3-36. CIRCUIT DESCRIPTION. The input circuit of the AC Converter is composed of R12 and a capacity compensator which maintains a high input impedance of one megohm shunted by less than 20 pf for all ac ranges. Overload protection for the AC Converter is provided by diodes CR1 and CR2. The input stage of Q1 is a field effect transistor (FET) utilized for its high input impedance and low noise features. The common-emitter stages of Q2,

Q4, Q5, and Q7 provide the necessary voltage gain of the ac input signal. Emitter-follower Q6 is the dynamic load at the amplifier output. Feedback from the emitter of Q7 through Q10 stabilizes the current and voltage gain of the amplifier. Transistors Q2 and Q9 provide a low-impedance bias voltage for their associated circuitry. Linearity compensation at the dynamic load output is provided through Q8. Loop gain of the amplifier is stabilized with the filters C7, R11 and C25, R44 selected with the RANGE switch S9BR-2. The output signal coupled through C12 drives the diodes CR3 and CR4 through their cross-over region very rapidly, thus producing very low cross-over distortion. The signal developed across R125 is fed back to the input of the AC Converter through the feedback network selected with the RANGE switch S9BR-1 and causes a current directly proportional to the ac input signal to flow through CR3 and CR4. The resulting dc voltages are then filtered by C13 and C14 and applied through the MODE switch S9 to the dc measurement section of the instrument. Calibration of the ac voltage ranges of the instrument is accomplished with the variable resistors R29, R30, R32, R34, variable capacitors C21 and C22, and the capacity compensator located across R12.

3-37. The 3 kHz drive signal applied between A7 terminals 6 and 7 is half-wave rectified by diodes CR5 and CR6. The resulting dc voltages are then reduced and filtered with R40, R41, C23, and C24 to provide the ± 12 and ± 10 volt dc operating voltages for the AC Converter.

3-38. NULL DETECTOR

3-39. GENERAL. The Null Detector is a chopper stabilized dc amplifier using an insulated field effect transistor as a chopper. DC operating voltages for the amplifier

are produced from a 3 kHz drive signal supplied by the dc-to-dc converter, thus providing maximum isolation for the amplifier circuitry free from power line frequency variations and harmonics. Circuitry of the Null Detector consists of a power supply, an 84 Hz multivibrator, a chopper driver, a chopper, a low-pass filter, a carrier amplifier, a synchronous demodulator and a meter. A block diagram of these circuits is illustrated in Figure 3-4.

3-40. BLOCK DIAGRAM DESCRIPTION. All operating voltages for the Null Detector circuitry are provided by the power supply comprised of half-wave rectifiers CR3 and CR4. These ± 6.8 volt dc voltages are produced from a 3 kHz drive signal developed in the Reference Inverter. The 84 Hz multivibrator provides chopper and demodulator drive voltages at a rate asynchronous to the power line frequency. Input dc voltages applied to the null detector input are passed through a low-pass filter to reduce any normal mode interference and then squarewave modulated at a 84 Hz rate by the chopper Q1. The chopper driver Q11 provides a 84 Hz drive signal to the gate of the chopper and a cancellation signal to the drain. This cancellation signal is 180° out of phase with the chopper gate signal and provides cancellation of any spikes generated internally in the chopper Q1. The carrier amplifier is comprised of five stages whose gain is controlled by negative emitter feedback. Any amplified ac signals are then demodulated by the synchronous demodulator Q8 which is driven in synchronism with the chopper Q1. The resulting dc voltage is then used to drive the front panel meter to indicate both the polarity and magnitude of the input voltage on the TVM mode or the off-null magnitude on the NULL mode. Negative feedback through the meter to the null detector input determines the overall gain of the null detector.

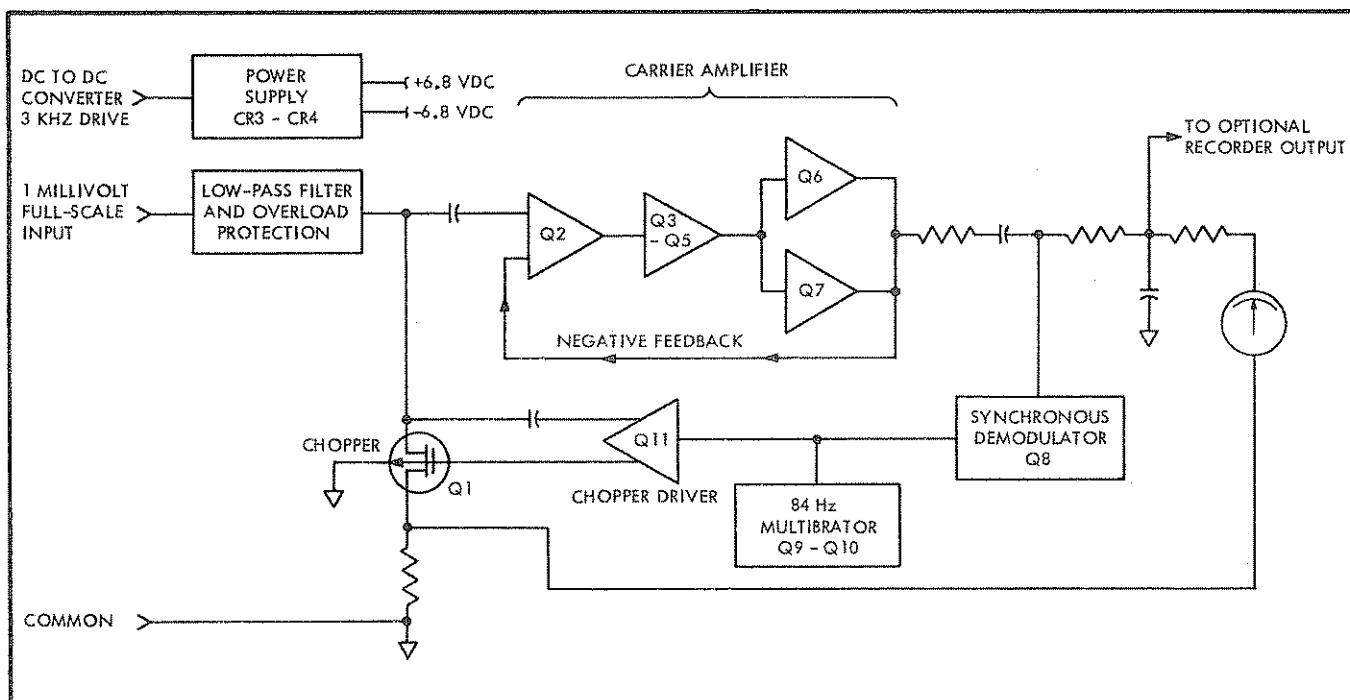


Figure 3-4. NULL DETECTOR BLOCK DIAGRAM

3-41. **CIRCUIT DESCRIPTION.** The 3 kHz drive signal applied to terminal 8 of the Null Detector Assembly is half-wave rectified to provide ± 6.8 volt dc operating voltages for the null detector circuitry. Diodes CR3 and CR4 along with C17 through C19 and R33 and R34 form the half-wave rectifiers used to produce the dc operating voltages. Synchronous drive voltages for the null detector circuitry are provided by the 84 Hz collector-coupled multivibrator comprised of Q9, Q10, C14, C15, and R23 through R26. The 84 Hz collector signal of Q9 is used to provide the demodulator drive for Q8. Transistor Q11 supplies an 84 Hz squarewave from its emitter to the gate of Q1. This signal is derived from the collector of Q10 in the 84 Hz multivibrator. Resistor R27 provides adjustment of the squarewave signal amplitude applied to the gate of Q1. The collector signal of Q11 is coupled by C5 and C4 to the output of Q1 where it is used to null out any spikes internally generated in Q1. Adjustment of this compensating signal is provided by potentiometer R31 located in the collector circuit of Q11.

3-42. The resulting squarewave signal present at the junction of R3 and Q1 is coupled by C3 to the input stage of the carrier amplifier. This signal is proportional to the difference between any feedback voltage from the meter circuit and the input voltage at terminal 2. The carrier amplifier is comprised of four common-emitter amplifiers of Q2 through Q5 and complementary push-pull output amplifier Q6 and Q7. Negative emitter feedback through the network composed of R10 and R15 through R18, C8 and C11 controls the gain of the carrier amplifier and consequently the null detector input impedance. Variable resistor R17 located in the feedback circuit provides adjustment of this input impedance. The emitter signal of Q6 and Q7 is coupled by C12 and R20 to the synchronous demodulator Q8. Transistor Q8 is driven in synchronism with the chopper Q1 and is operated in the inverse mode to secure minimum saturation voltage. The resulting demodulated signal is filtered by the low-pass filter comprised of R21 and C13 and applied to terminal 5 for use in the optional Recorder Output circuitry. This same voltage signal is applied through R22 and the meter circuit to Q1 as a negative feedback signal to control the gain of the null detector. Any current flow through this network causes a corresponding deflection

on the meter proportional to the magnitude of the null detector input voltage.

3-43. DC INPUT DIVIDER

3-44. **GENERAL.** Full-scale input voltages to the instrument on either mode of operation are reduced to one millivolt ($\pm 10\%$ overranging) at the input of the null detector by the DC Input Divider circuitry.

3-45. **CIRCUIT DESCRIPTION.** The DC Input Divider is composed of seven series connected resistors R1 through R7 that have a total resistance of 100.1 megohms. When the instrument is operated in the TVM mode, the input impedance is a constant 100 megohms on all dc voltage ranges and the RANGE switch is used to select the desired tap of the divider network. When the instrument is operated on the differential dc mode, the NULL and RANGE switches select various taps on the input divider network to provide an input impedance of 10 megohms on the .001 and .01 NULL switch positions, and 100 megohms on all other NULL switch positions.

3-46. OPTIONAL RECORDER OUTPUT

3-47. **GENERAL.** Instruments containing the -02 Option are provided with a RECORDER OUTPUT that is isolated from the null detector circuitry. The Recorder Output circuitry is composed of a modulator and demodulator separated by an isolation transformer. Each circuit is driven at a 3 kHz rate by a signal derived from the Reference Inverter Assembly.

3-48. **CIRCUIT DESCRIPTION.** The dc input voltage applied to terminal 1 of the Recorder Output Assembly is modulated at a 3 kHz rate by alternate conduction of Q1 and Q2. Conduction of Q1 and Q2 is controlled by the 3 kHz drive signal applied to terminal 3. Transformer T1 couples the resulting signal to its secondary winding where demodulation is accomplished by alternate conduction of Q3 and Q4. Conduction of Q3 and Q4 is controlled by the 3 kHz drive signal applied to terminal 4. The resulting isolated dc voltage is then filtered by C1 and R10. Variable resistor R10 provides adjustment of the RECORDER OUTPUT voltage.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. This section of the manual contains the information necessary for you to maintain your Model 893 AC-DC Differential Voltmeter. The information is arranged under headings of "SERVICE INFORMATION, DISASSEMBLY INSTRUCTIONS, GENERAL MAINTENANCE, PRECALIBRATION AND TROUBLESHOOTING, and CALIBRATION PROCEDURES." A list of the test equipment required for maintenance of this instrument is contained in Figure 4-1. If the recommended test equipment is not available, other instruments having the equivalent specifications may be substituted.

4-3. Your instrument was completely tested and aligned before leaving the factory and calibration should not be necessary during the first 90 days of operation. However, should you wish to check the instrument accuracy against most of the specifications contained in Section I, the information contained in the Calibration Procedures may be used. The Calibration Procedures are arranged in such a manner that by disregarding the

adjustment information that may be used as Instrument Performance Checks.

4-4. We recommend that you thoroughly read and understand this section of the manual before attempting any maintenance on your instrument.

4-5. SERVICE INFORMATION

4-6. Each instrument manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. Complete warranty information is contained in the Warranty page located at the rear of this manual.

4-7. Factory authorized calibration and repair service for all Fluke instruments are available at various world wide locations. A complete list of factory authorized service centers is located at the rear of this manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments beyond the warranty period.

EQUIPMENT NOMENCLATURE	SPECIFICATIONS	RECOMMENDED INSTRUMENT
AC calibration Source	Lo distortion, 1 mv to 1000 vac, 20 Hz to 100 kHz, with an accuracy of .02%	Hewlett Packard Model 745 with Companion 1000 Volt Amplifier
DC Calibration Source	0-1000 volts dc with an accuracy of 0.002%	Fluke Model 332B
Oscilloscope Probe	Sweep range: 50 usec/cm Vertical sensitivity: 5 mv/cm Passive 10:1	Tektronix 531 with Type L Plug-In Unit P6007
Multimeter	Ranges: AC-0 to 100 ma 0 to 300 vac DC-0 to 100 ma 0 to 1000 vdc OHMS - 0 to 100 megohms Accuracy: AC-±1% DC-±0.1%	Fluke Model 853A
Differential Voltmeter	Range - 0 to 1000 vdc Accuracy -±0.06% Input Impedance - Infinite at null	Fluke Model 895A

Figure 4-1. REQUIRED TEST EQUIPMENT

4-8. DISASSEMBLY INSTRUCTIONS

4-9. THE MODEL 893A DISASSEMBLY INSTRUCTIONS

4-10. The following procedure is to be used to gain access to various parts of the Model 893A:

- a. Remove the eight top dust cover attaching screws and remove the dust cover from the instrument.
- b. Remove the two screws from the circuit board retaining strap attached across the center of the instrument and remove the strap. This allows access to the Null Detector, Reference Amplifier, Reference Inverter, AC Converter, and NULL SENS switch S3.

Note!

Ensure that the retainer strap insulators are kept in a clean condition.

- c. Remove the top front and rear trim strip attaching screws and remove the trim strips from the instrument. This allows access to the front panel binding posts, components on the POWER switch S2, and (if the -01 option is installed) DS1.

Note!

The printed circuit boards are inserted in slide holders and will protrude approximately

three inches when the instrument is inverted. Place a strip of tape across the chassis of the instrument to hold the printed circuit boards in place if the instrument is to be inverted.

- d. Remove the eight lower dust cover attaching screws. This allows access to the Kelvin-Varley Divider Assembly.
- e. Remove the lower front and rear trim strip attaching screws and remove the trim strips from the instrument. This allows access to the Kelvin-Varley switches S6 through S8 and potentiometer R37.
- f. Remove the left and right knurled knobs from the handle assembly and remove the handle from the instrument.
- g. Remove the eight left and right rear panel attaching screws and slide the rear panel free from the instrument. This allows access to the power transformer T1, CR1, CR2 and any option components.
- h. Loosen the front panel control knob allen set screws and remove the knobs from the front panel. Loosen the two screws securing the shutter cabling to the front panel and then remove the nuts on the front panel binding posts and remove the terminal clips from the binding posts. Remove the left and right front panel attaching screws and slide the front panel forward until free of the instrument. This

allows access to the front panel meter and all switch linkages.

- i. Remove the right or left side panel attaching screws and remove the panel from the instrument. This allows access to the respective MODE or RANGE switch.

CAUTION!

Do not remove both side panels from the instrument at the same time or the structural-strength of the instrument will be impaired.

4-11. THE MODEL 893AR DISASSEMBLY INSTRUCTIONS

4-12. The following procedure is to be used to gain access to various parts of the Model 893AR:

- a. Remove the six top dust cover attaching screws and remove the dust cover from the instrument. This allows access to the mounting screws of the Kelvin-Varley Divider, Reference Inverter, and Null Detector printed circuit boards.
- b. Remove the top front and rear trim strip attaching screws and remove the trim strips from the instrument. This allows access to the front and rear panel components.
- c. Remove the six lower dust cover attaching screws and remove the dust cover from the instrument. This allows access to the Reference Inverter and AC Converter printed circuit board mounting screws, all of the switches used in the instrument, and potentiometer R37.
- d. Remove the lower front and rear trim strip attaching screws and remove the trim strips from the instrument. This allows further access to the front and rear panel components.
- e. Remove the left and right rear panel attaching screws and slide the rear panel free from the instrument. This allows access to the power transformer T1, CR1, CR2, and any option components.
- f. Loosen the front panel control knob set screws and remove all of the knobs from the front panel. Loosen the two screws securing the shutter cabling to the front panel. Remove the nuts from the front panel binding posts and remove the terminal clips from the binding posts. Remove the left and right front panel attaching screws and slide the front panel forward until free of the instrument. This allows access to the front panel meter and all switch linkages.

4-13. GENERAL MAINTENANCE

4-14. PERIODIC CLEANING

4-15. This instrument is completely enclosed, therefore no entry for dirt, dust, or lint is provided. Consequently, it is usually only necessary to clean the exterior of the instrument. To clean the exterior, use a cloth moistened

with anhydrous ethyl alcohol or Freon T. F. Degreaser (MS 180 Miller-Stephenson Chemical Co., Inc.). If either of these cleaning agents are not readily available, soap and water, applied sparingly to a cloth can be used to clean the exterior of the instrument.

4-16. If it becomes necessary to clean the interior of the instrument, a hot deionized or distilled water rinse followed by a thorough drying should be used. Drying temperatures in excess of 160° should be avoided.

CAUTION!

The use of solvents, particularly ketones, is not recommended because of possible damage to the dielectric materials used in the instrument.

4-17. FUSE REPLACEMENT

4-18. Input line power to the Model 893 instruments is fused to 1/8 ampere by F1. This fuse is located on the rear panel assembly of the instrument in a bayonet fuseholder. When replacing this fuse use a 1/8A, 250 volt, slo-blo, type fuse.

4-19. BATTERY REPLACEMENT

4-20. Battery replacement on instruments containing the -01 option is necessary when 16 continuous hours of battery charging will no longer result in a satisfactory battery check. To replace the batteries, proceed as follows:

- a. Obtain access to the battery pack installed on the rear panel using the disassembly procedures for your particular instrument that are described in paragraphs 4-8 through 4-12.
- b. Unsolder red (or white) and black battery pack wires from their respective circuit connections and wrap the exposed ends of the wires with electricians tape.
- c. Remove the four nuts and screws that attach the battery pack to the rear panel and lift the battery pack free from the instrument.
- d. Locate and replace the defective batteries observing proper polarities of connections.
- e. Mount the battery pack on the rear panel assembly using the screws and nuts removed in step c.
- f. Remove the tape from the black battery pack wire and solder this wire to the terminal on the power transformer from which it was removed in step b.
- g. Remove the tape from the red (or white) battery pack wire and solder this wire to the end of the resistor from which it was removed in step b.
- h. Reassemble the instrument and check the batteries as described in Section II paragraph 2-9 and 2-10.

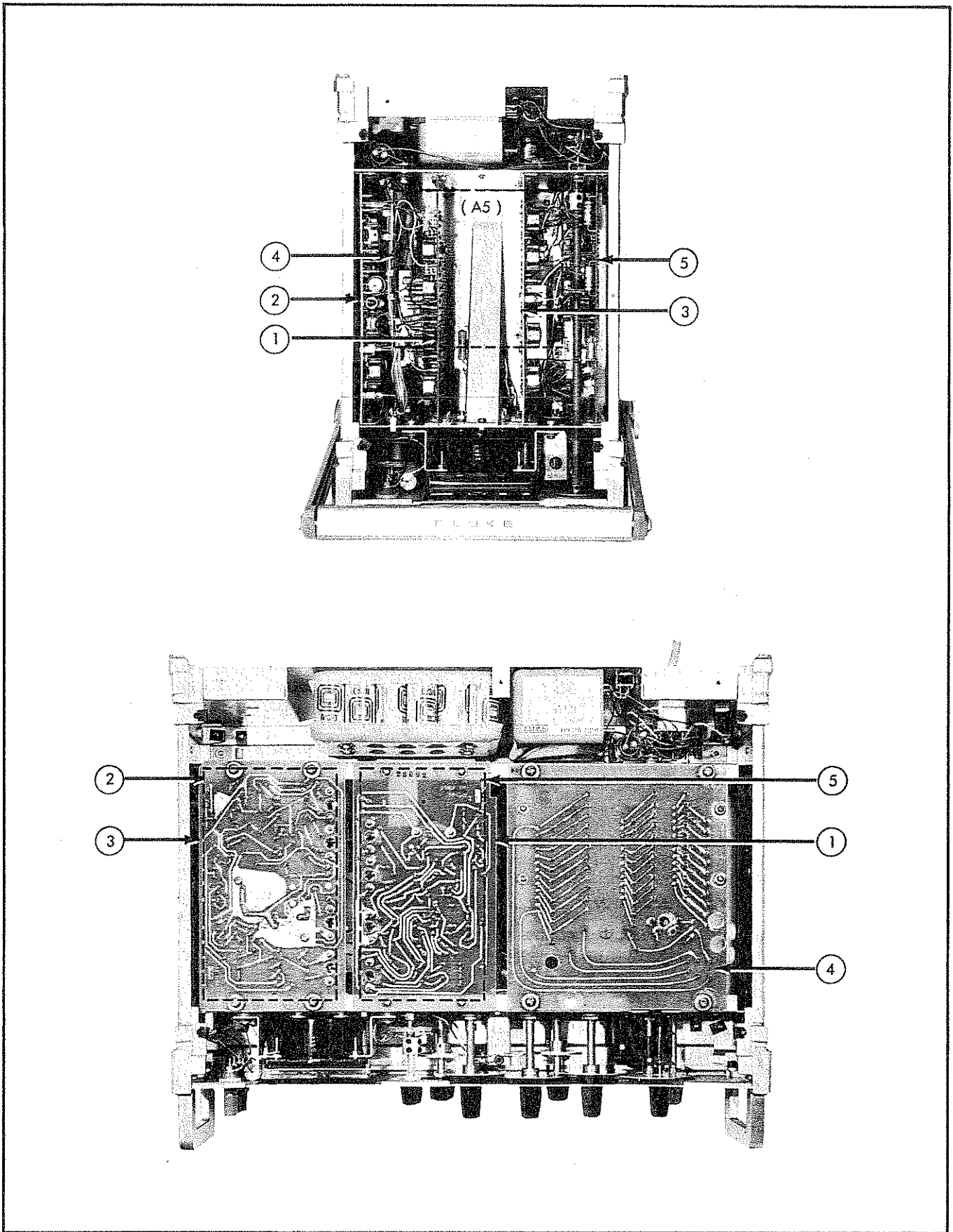


Figure 4-2. ADJUSTMENT AND TEST POINT LOCATIONS (Sheet 1 of 4)

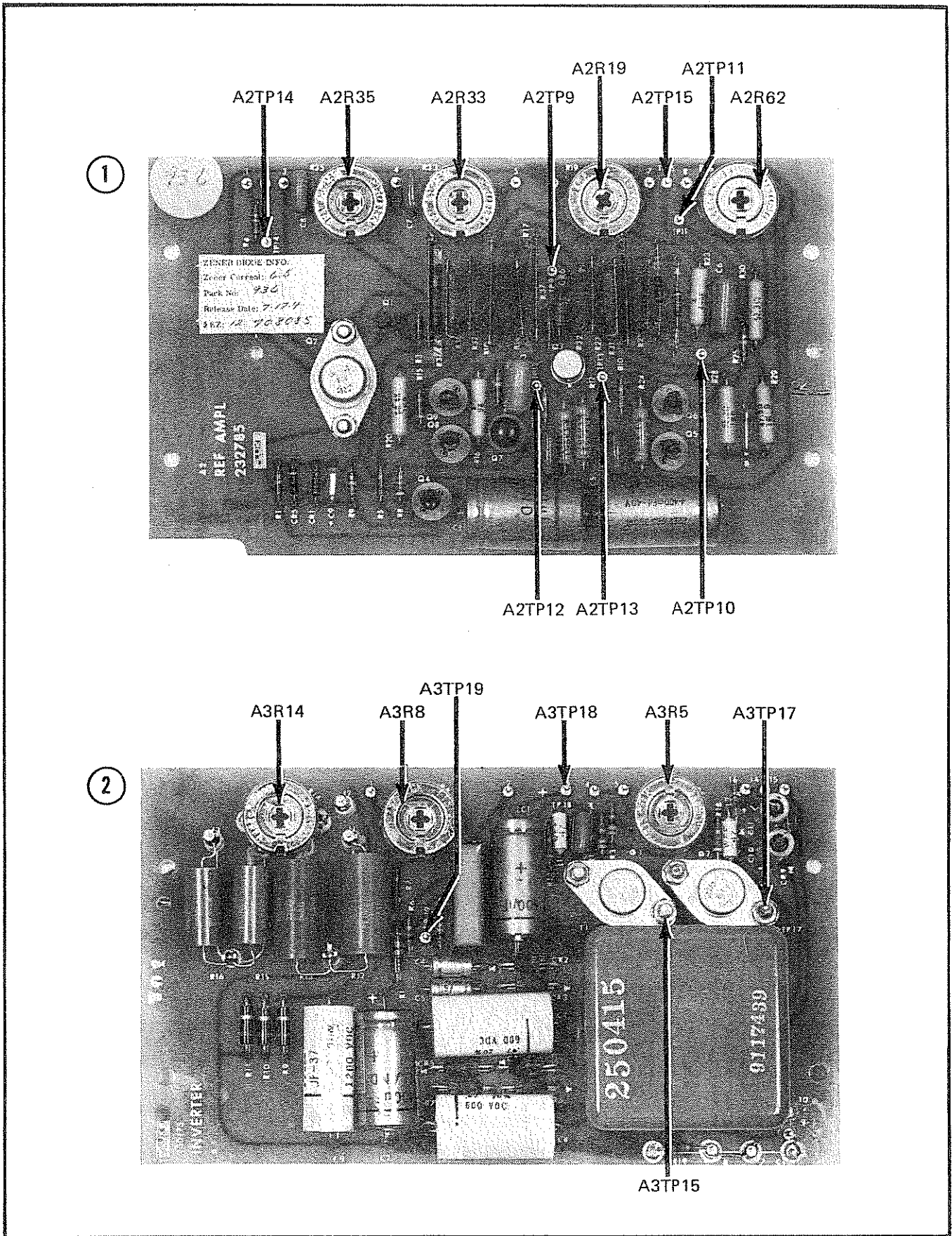
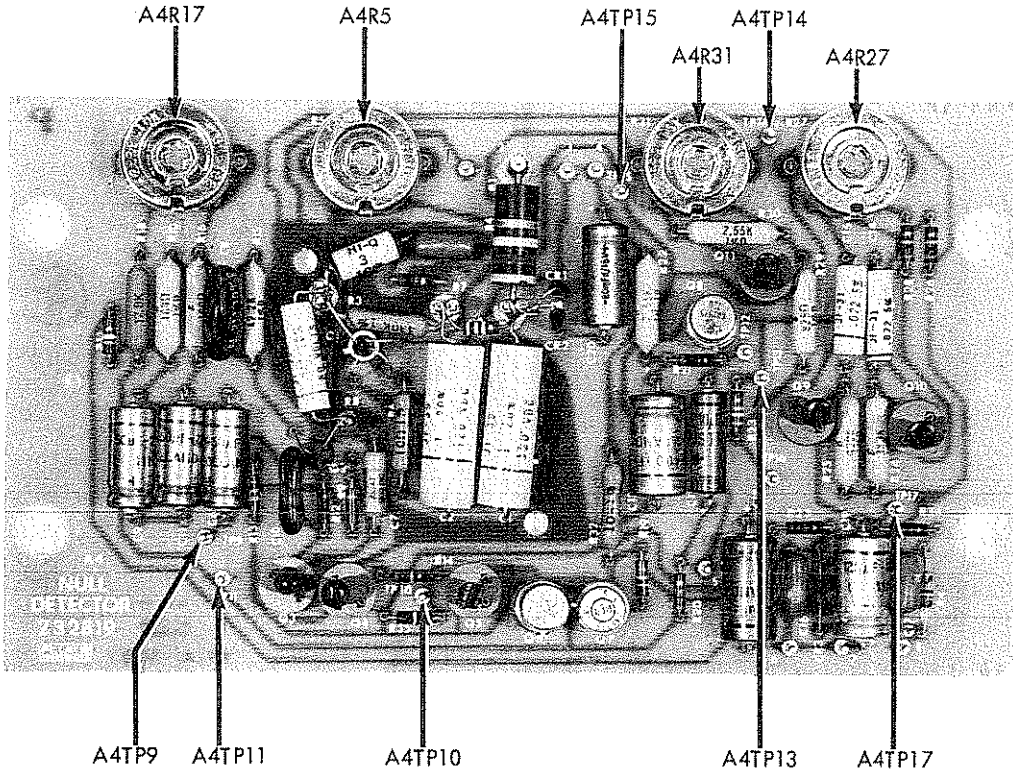


Figure 4-2. ADJUSTMENT AND TEST POINT LOCATIONS (Sheet 2 of 4)

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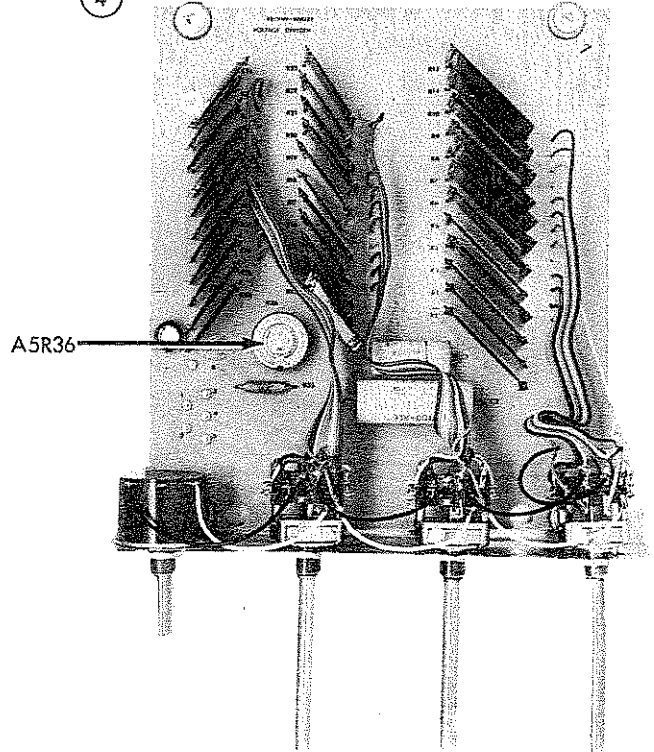


Figure 4-2. ADJUSTMENT AND TEST POINT LOCATIONS (Sheet 3 of 4)

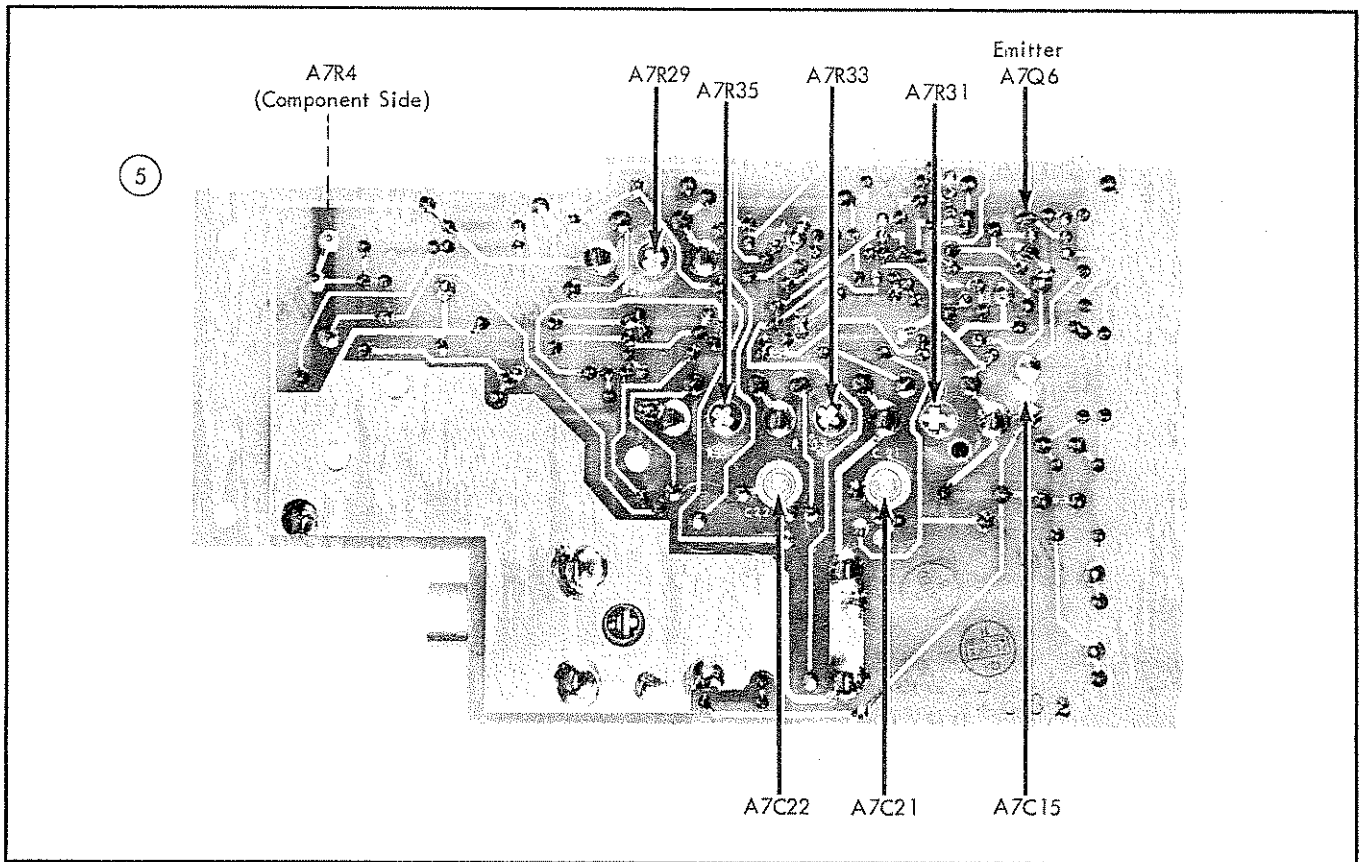


Figure 4-2. ADJUSTMENT AND TEST POINT LOCATIONS (Sheet 4 of 4)

4-21. PRECALIBRATION AND TROUBLESHOOTING

4-22. INTRODUCTION

4-23. Before attempting to calibrate the Model 893 AC-DC Differential Voltmeter, a parameter check of the major sections of the instrument circuitry should be performed. These precalibration checks, when the desired results are obtained, will ensure that each major section of the instrument is contributing the least possible error toward overall instrument inaccuracy. When performing these checks it may become necessary to replace component parts in order to obtain the desired results. Under these circumstances, general troubleshooting of the circuitry is necessary. As each malfunction is corrected, a complete recheck of the particular circuitry involved is also necessary.

4-24. The following tests should be performed in a draft free area at an ambient temperature of 21° to 25°C. Adjustment and test point locations are illustrated in Figure 4-2. At the beginning of each check the type of test equipment is given. Refer to Figure 4-1 for the recommended test equipment.

4-25. REFERENCE AMPLIFIER/REFERENCE INVERTER CHECKS

4-26. The Reference Amplifier/Reference Inverter Checks require an autotransformer, an ac ammeter,

an oscilloscope and a dc differential voltmeter. Circuit waveforms are illustrated in Figure 4-4. To perform the checks, proceed as follows:

- a. Remove the upper and lower dust covers from the instrument. Refer to paragraphs 4-8 through 4-12 for disassembly instructions.
- b. Make the equipment connections illustrated in Figure 4-3 and place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1000
NULL SENS	10V
MODE	+
Readout dials	00.0 00

- c. Apply 115 volts ac, 50-500 Hz, through the autotransformer to the Model 893. The ac ammeter should indicate less than 45 milliamperes.
- d. If your instrument is equipped with the -01 option, place the POWER switch to BAT CHG, observing that the ac ammeter indication does not exceed 60 milliamperes and the ballast lamp DS1 illuminates.
- e. Connect the oscilloscope signal input to terminal 3 of the Reference Amplifier Assembly and connect the oscilloscope ground to terminal 6 or 7. The

waveform observed on the oscilloscope CRT should not exceed a peak-to-peak indication of 2.5 volts.

- f. Disconnect the oscilloscope from the Model 893.
- g. Connect the input of the dc differential voltmeter to TP14 of the A2 Reference Amplifier Assembly and connect the common lead to A2 terminal 6 or 7. The voltmeter should indicate $+19 \pm 0.5$ volts dc.
- h. Remove ac power from the Model 893 and connect the dc differential voltmeter input to terminal 2 of the A5 Kelvin-Varley Divider Assembly.
- i. Reapply ac power to the Model 893, observing that the dc differential voltmeter indicates 1100 ± 0.13 volts dc.
- j. Rotate A2R26 to each available limit, observing that the dc differential voltmeter indication changes by at least ± 0.2 volts.
- k. Adjust A2R26 for an indication of 1100 volts dc on the dc differential voltmeter.
- l. Decrease the ac input voltage applied to the Model 893 to 103.5 volts ac with the autotransformer control. The voltage observed on the dc differential voltmeter should not vary more than ± 0.0055 volts.
- m. Increase the ac input voltage applied to the Model 893 to 126.5 volts ac with the autotransformer control. The voltage observed on the dc differential voltmeter should not vary more than ± 0.0055 volts.
- n. Remove ac power from the Model 893 and connect the dc differential voltmeter input to A2TP9.
- o. Reapply 115 volts ac to the Model 893, observing that the dc differential voltmeter indicates 17 ± 0.01 volts dc.
- p. Rotate A2R19 to each available limit, observing that the dc differential voltmeter indication changes by at least ± 100 millivolts.
- q. Adjust A2R19 for an indication of $+17 \pm 0.01$ volts dc on the dc differential voltmeter.
- r. Place the RANGE switch to 100 and connect the dc differential voltmeter input to terminal 2 of the A5 Kelvin-Varley Divider Assembly.
- s. The dc differential voltmeter should indicate 110 ± 0.009 volts dc.
- t. Rotate A3R14 to each available limit, observing that the dc differential voltmeter indication changes by at least ± 0.010 volts.
- u. Adjust A3R14 for an indication of 110 volts dc on the dc differential voltmeter.
- v. Place the RANGE switch to 10, observing that the dc differential voltmeter indicates 11 ± 0.0009 volts dc.

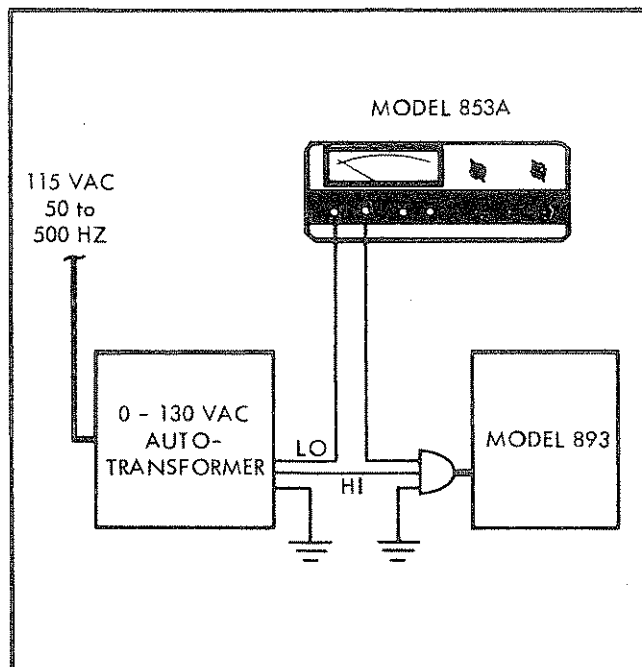


Figure 4-3. REFERENCE AMPLIFIER/REFERENCE INVERTER CHECKS - EQUIPMENT CONNECTIONS

- w. Rotate A2R33 to each available limit, observing that the dc differential voltmeter indication changes by at least \pm one millivolt.
- x. Adjust A2R33 for an indication of 11 volts dc on the dc differential voltmeter.
- y. Place the RANGE switch to 1, observing that the dc differential voltmeter indicates 1.1 volts dc ± 0.9 millivolts.
- z. Rotate A2R35 to each available limit, observing that the dc differential voltmeter indication changes by at least ± 1 millivolt.
- aa. Adjust A2R35 for an indication of 1.1 volt dc on the dc differential voltmeter.
- ab. Connect the dc differential voltmeter common to terminal 1 of the A4 Null Detector Assembly and the input to TP17.
- ac. Place the Model 893 NULL SENS switch to the TVM position and the RANGE switch to the 100 position.
- ad. The dc differential voltmeter should indicate -6.8 volts dc ± 400 millivolts. Record the exact value.
- ae. Place the Model 893 RANGE switch to the 1000 position.
- af. Rotate A3R8 to each available limit, observing that the dc differential voltmeter indication changes by at least ± 15 millivolts.
- ag. Adjust A3R8 for an indication on the dc differential voltmeter that is within 10 millivolts of the voltage recorded in step ad.

ah. Connect the oscilloscope signal input and ground to A3 terminals 10 and 9, respectively. A 3 kHz drive signal having a maximum amplitude of 13.5 volts peak-to-peak should be observed on the oscilloscope trace.

4-27. When the results of these checks agree with the information given, the Reference Amplifier/Reference Inverter Assemblies are functioning properly and the test equipment can be disconnected from the instrument.

4-28. NULL DETECTOR/DIVIDER CHECKS

4-29. The Null Detector/Divider Checks require a dc voltage calibrator, a dc differential voltmeter and a

10 megohm 1% resistor. Circuit waveforms are illustrated in Figure 4-6. To perform the checks, apply ac power to the instrument and proceed as follows:

a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	.001
MODE	+
Readout dials	.00100

b. Connect the dc differential voltmeter input to TP16 and the common lead to terminal 7 of the Null Detector Assembly. The voltmeter should indicate $+6.8 \pm 0.4$ volts dc.

c. Connect the dc differential voltmeter input to TP17, observing that the voltmeter indicates -6.8 ± 0.4 volts dc.

d. Disconnect the dc differential voltmeter from the Model 893.

e. Connect a shorting jumper between the LO and HI INPUT terminals and rotate A4R27 and A4R31 fully counter-clockwise.

f. Adjust A4R27 clockwise until a full-scale negative meter indication (-1) is obtained and then rotate the control an additional 10° clockwise.

g. Remove the shorting jumper and adjust A4R31 for an exact zero-center meter indication and then repeat steps f and g as necessary.

h. Connect the shorting jumper between the LO and HI INPUT terminals and adjust A4R5 to each available limit. The meter pointer should deflect above and below the minus 1 indication.

i. Adjust A4R5 for a full-scale (-1) indication on the meter.

j. Remove the shorting jumper between the INPUT terminals and replace with a 10 megohm 1% resistor.

k. Place the Readout dials to .00200 and adjust A4R17 to each available limit, observing that the meter pointer deflects above and below the minus 1 indication.

l. Adjust A4R17 for a full-scale (-1) indication on the meter.

m. Remove the 10 megohm resistor from between the INPUT terminals of the instrument and place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	.001
MODE	+
Readout dials	.00000

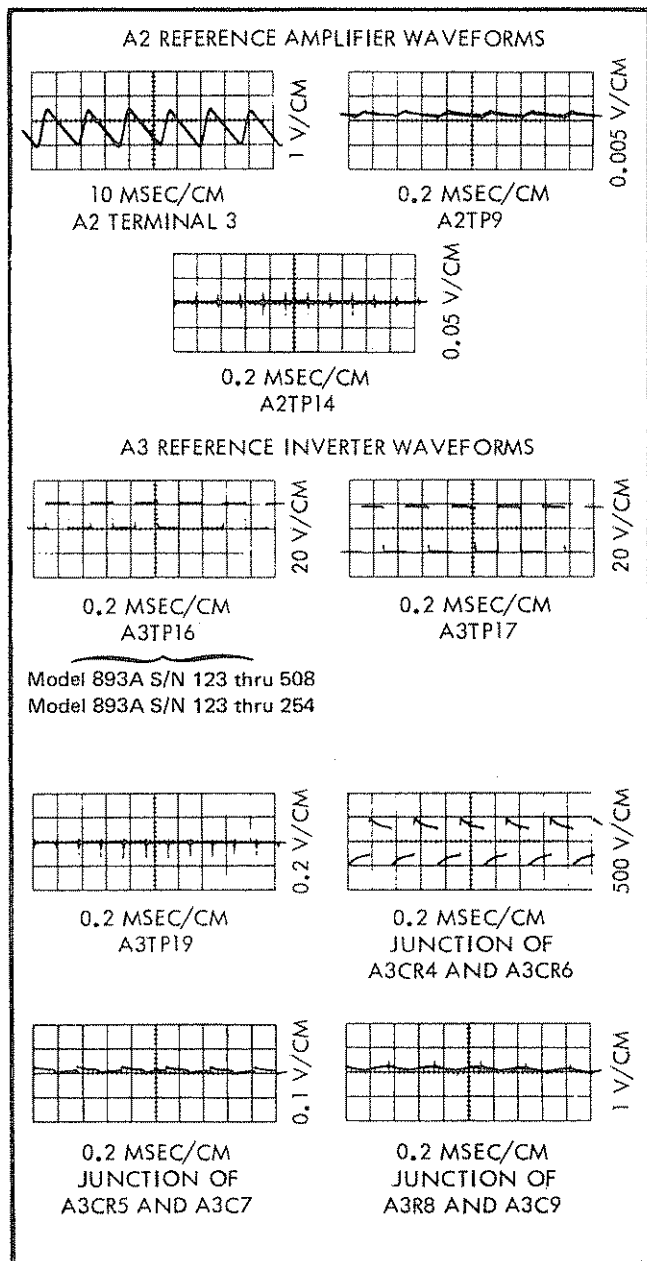


Figure 4-4. REFERENCE AMPLIFIER/REFERENCE INVERTER WAVEFORMS

- n. Connect the output of the dc voltage calibrator between the LO and HI INPUT terminals.
- o. Apply the dc input voltages versus the ranges indicated in Figure 4-5, observing that the meter indicates full-scale (+1) \pm 1-1/2 small divisions.

4-30. When the results of the checks agree with the information given, the Null Detector and Divider circuitry are functioning properly and the test equipment can be disconnected from the instrument.

INPUT DC VOLTAGE	RANGE	NULL SENS
.001	1	1 mv
.01	1	.01v
.1	1	.1 v
1.0	1	TVM
10.0	10	TVM
100.0	100	TVM
1000.0	1000	TVM

Figure 4-5. INPUT DC VOLTAGE VERSUS RANGE-CHECKS

4-31. KELVIN-VARLEY DIVIDER CHECKS

4-32. The Kelvin-Varley Divider Checks require the use of a dc voltage calibrator. The Precalibration and Troubleshooting Checks of paragraphs 4-21 through 4-30 must also have been performed to ascertain that the associated instrument circuitry is functioning correctly. To perform the checks, apply ac power to the instrument and proceed as follows:

- a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	10
NULL SENS	.001
MODE	+
Readout dials	10.000

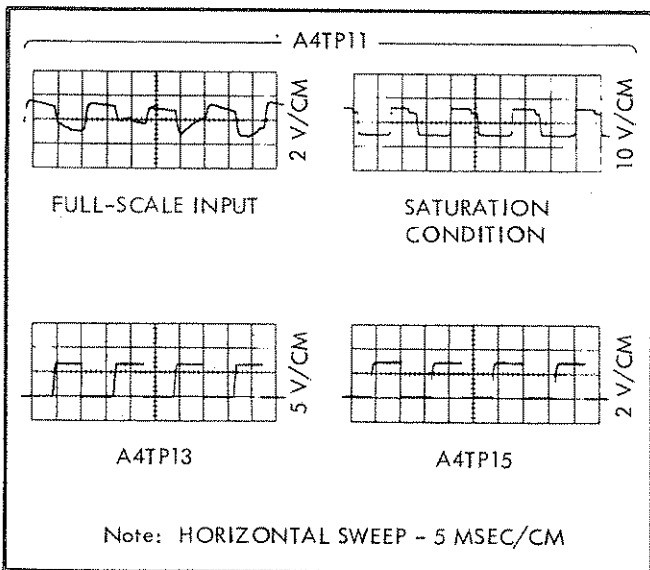


Figure 4-6. NULL DETECTOR WAVEFORMS

- b. Apply +10 volts dc from a dc voltage calibrator between the Model 893 LO and HI INPUT terminals.
- c. Adjust A2R33 for a zero-center meter indication on the Model 893.
- d. Apply the dc input voltages versus the Readout dial settings of Figure 4-7, observing that the Model 893 meter indicates zero-center within the major division deviation.

INPUT DC VOLTAGE	READOUT DIAL SETTINGS	MAJOR DIVISION DEVIATION
11.000	10.99 <u>X</u>	\pm 5.5
10.000	10.00 <u>O</u>	null reference
10.00	9.99 <u>X</u>	\pm 5.0
9.999	9.99 <u>90</u>	\pm 4.99
8.888	8.88 <u>80</u>	\pm 4.44
7.777	7.77 <u>70</u>	\pm 3.88
6.666	6.66 <u>60</u>	\pm 3.33
5.555	5.55 <u>50</u>	\pm 2.77
4.444	4.44 <u>40</u>	\pm 2.22
3.333	3.33 <u>30</u>	\pm 1.66
2.222	2.22 <u>20</u>	\pm 1.11
1.111	1.11 <u>10</u>	\pm .55
1.000	1.00 <u>0</u>	\pm .5

Figure 4-7. INPUT VOLTAGES VERSUS READOUT SETTINGS - CHECKS

4-33. When the results of these checks agree with the information given, the Kelvin-Varley Divider circuitry is functioning properly and the test equipment can be disconnected from the instrument.

4-34. RECORDER OUTPUT OPTION CHECKS

4-35. The Recorder Output Option Checks require the use of a dc differential voltmeter. Circuit waveforms are illustrated in Figure 4-8. To perform the checks, apply ac power to the instrument and proceed as follows:

- a. Connect the inputs of a dc differential voltmeter to the rear panel HI and LO RECORDER OUTPUT terminals and rotate the associated level control fully clockwise.
- b. Connect a shorting jumper between the LO and HI INPUT terminals of the Model 893 and place the controls as follows:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	.001
MODE	+
Readout dials	.00100

- c. A dc voltage of -0.2 to -0.28 volts dc should be indicated on the dc differential voltmeter connected to the RECORDER OUTPUT terminals.

- d. Rotate the RECORDER OUTPUT level control counter-clockwise, observing that the RECORDER OUTPUT voltage decreases to zero volts.
- e. Adjust the RECORDER OUTPUT level control for an indication of 0.2 volts on the dc differential voltmeter.
- f. Place the Model 893 Readout dials to .00010, observing that the RECORDER OUTPUT voltage indicated on the dc differential voltmeter is -0.02 volts dc.

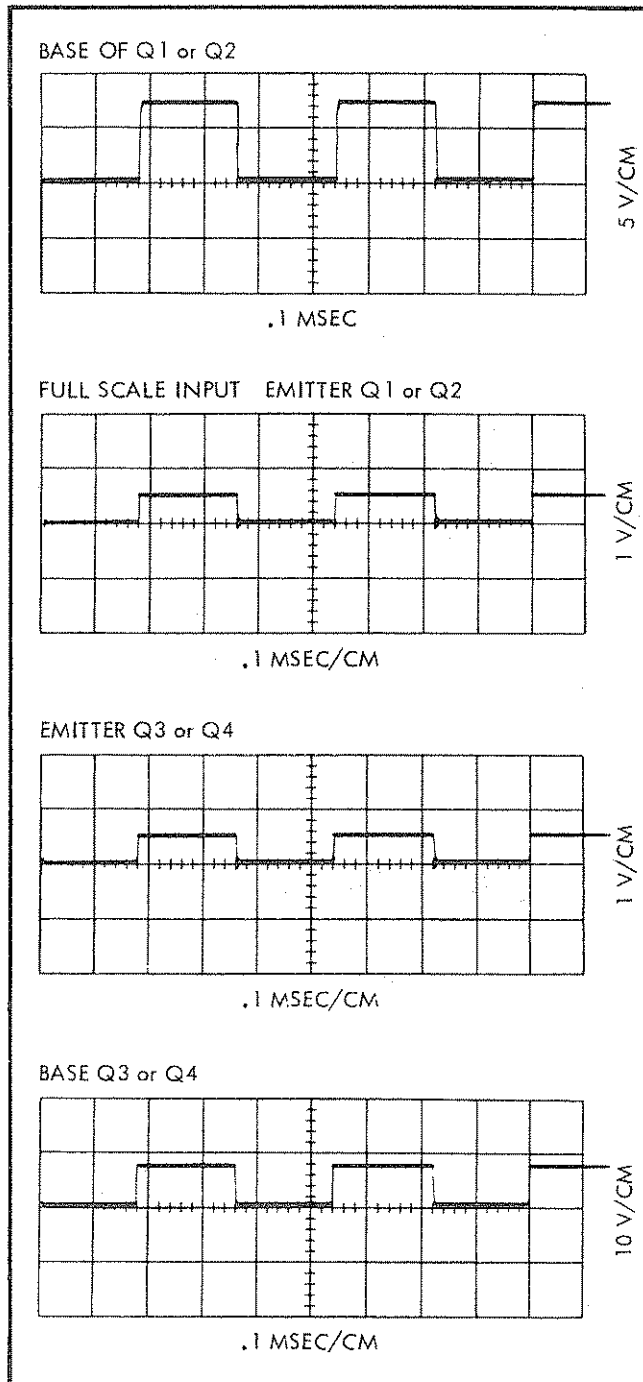


Figure 4-8. RECORDER OUTPUT WAVEFORMS

4-36. When the results of these checks agree with the information given, the Recorder Output Option circuitry is functioning properly and the test equipment can be disconnected from the instrument.

4-37. AC CONVERTER CHECKS

4-38. The AC Converter Checks require an ac calibration source, an oscilloscope, and a dc differential voltmeter. Circuit waveforms are illustrated in Figure 4-10. To perform the checks, apply ac power to the instrument and proceed as follows:

- a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	.001
MODE	AC
Readout dials	1.000 <u>00</u>

- b. Connect the dc differential voltmeter input to A7 terminal 7 and its common lead to A7 terminal 5. The voltmeter should indicate 12 ± 0.2 volts dc.
- c. Connect the voltmeter input to the junction of R41 and CR5, observing that the voltmeter indicates 10 ± 0.5 volts dc.
- d. Connect the voltmeter input to A7 terminal 6, observing that the voltmeter indicates -12 ± 0.2 volts dc.
- e. Connect the voltmeter input to the junction of R42 and CR6, observing that the voltmeter indicates -10 ± 0.5 volt dc. Disconnect the voltmeter upon completion of this step.
- f. Apply a calibrated one volt ac signal at 400 Hz between the LO and HI INPUT terminals of the instrument.
- g. Connect the oscilloscope input to the emitter of A7Q6 and the ground lead to A7 terminal 5. The signal observed on the oscilloscope CRT should be identical to the full scale A7Q6 emitter waveform illustrated in Figure 4-10. If necessary, adjust A7R35 to obtain a meter indication of 0 ± 0.5 major divisions.
- h. Apply a calibrated 0.1 volt ac signal at 400 Hz to the INPUT of the Model 893, observing that the waveform displayed on the oscilloscope CRT is identical to the A7Q6 1/10 scale input waveform illustrated in Figure 4-10.
- i. Perform the RANGE checks described in Figure 4-9 at 400 Hz, observing that the specified results are obtained. If necessary, adjust the associated adjustment to obtain the specified meter indication.
- j. Perform the AC Converter RANGE checks described in Figure 4-9, disregarding the adjustment and meter indications, at frequencies of 20 Hz, 20 kHz, 50 kHz, and 100 kHz. The waveforms observed on the oscilloscope CRT should be consistent with the peak-to-peak levels of A7Q6 illustrated in Figure 4-10.

MODEL 893 AC INPUT VOLTAGE	RANGE	A7Q6 EMITTER WAVEFORM	MODEL 893 METER INDICATION	A7 ADJUSTMENT
10	10	FULL-SCALE	0 ±0.5 m. d.	R33
100	100	FULL-SCALE	0 ±0.5 m. d.	R31
500	1000*	50% OF THE FULL-SCALE WAVEFORM AMPLITUDE	0 ±1 m. d.	R29

*Set the Readout dials to 500.00

Figure 4-9. AC CONVERTER RANGE CHECKS

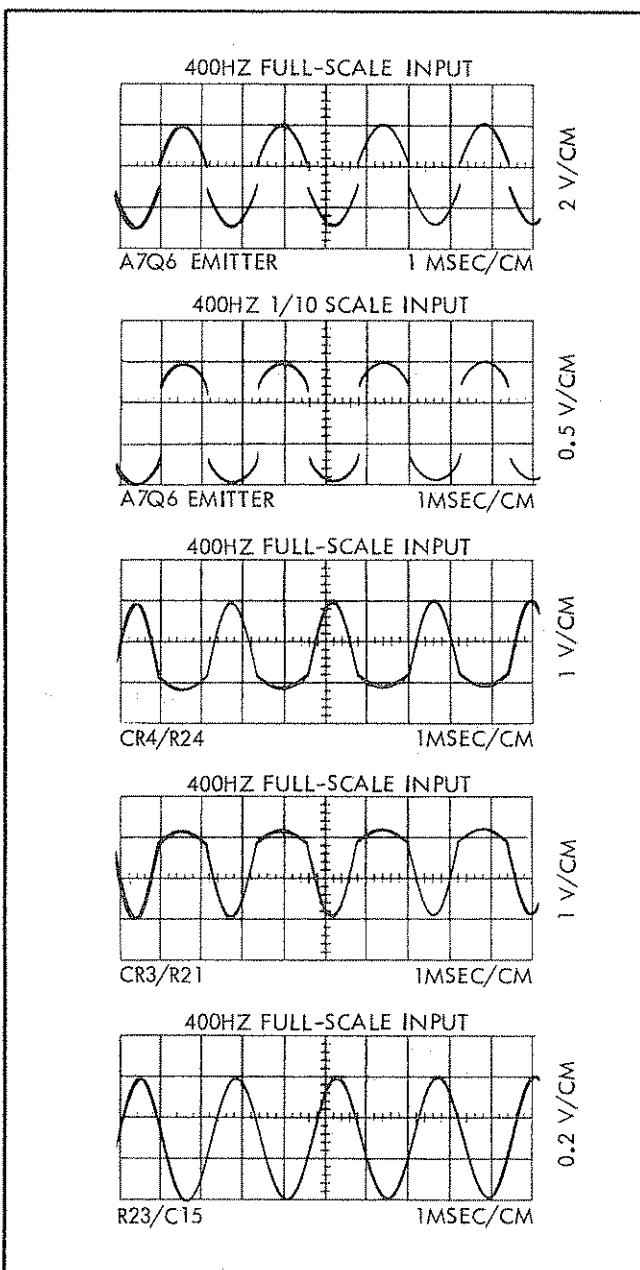


Figure 4-10. AC CONVERTER WAVEFORMS

4-39. When the results of these checks agree with the information given, the AC Converter is functioning properly and the test equipment can be disconnected from the instrument.

4-40. CALIBRATION PROCEDURES

4-41. INTRODUCTION

4-42. The Model 893 should be checked for calibration every 90 days. Before attempting to calibrate your instrument, it is recommended that the major portions of the instrument circuitry be checked using the methods described in the preceding Precalibration and Troubleshooting paragraphs.

SEE APPENDIX 2-16-90 Mem

4-43. It will be necessary to apply ac and dc voltages from a known accurate source to the input of the instrument during the calibration process. An ac calibration source such as the H.P. Model 745A can be used to obtain the accurate ac voltages, and a John Fluke Model 332B can be used to obtain the required dc voltages.

4-44. Calibration of the instrument should be performed on line power with the top and bottom dust covers removed from the instrument. An ambient room temperature from 21°C to 25°C, in a draft free area, should be maintained during the calibration process. Adjustment and testpoint locations are illustrated in Figure 4-2. Figure 4-11 contains a list of the calibration adjustments and their effects.

4-45. METER MECHANICAL ZERO ADJUST

4-46. With the power removed from the Model 893, proceed as follows:

- a. Position the instrument horizontally (normal position) on the bench.
- b. Adjust the meter mechanical zero screw, accessible from the front panel, until the meter pointer indicates zero-center. Back-off the screw adjustment just enough to disengage the cam once the center-zero indication is obtained.

CIRCUITRY	ADJUSTMENTS AND THEIR EFFECTS	
ZENER REFERENCE SUPPLY	A2R19	Used to adjust for 17 ± 0.01 volts dc at A2TP9 and has a minor effect on instrument calibration. Adjustment of this control establishes a specific voltage for the zener diodes which minimizes the zeners temperature coefficient and increases their voltage stability.
NULL DETECTOR	A4R27	Adjusts the gate signal drive level of Q1 for optimum chopping efficiency. Inadequate drive to the gate of Q1 will result in a lower than specified null detector input resistance and a lower gain. Excessive drive to the gate of Q1 (clockwise setting) will reduce the null detector stability.
	A4R31	Adjusts the level of the signal applied to the drain of Q1. This signal is used to cancel out the null detector open-circuit offset effects produced by the gate to drain capacitance of Q1. Misadjustment of this control will produce null detector open circuit offsets particularly noticeable on the .001 volt sensitivity.
	A4R5	Adjusts the null detector gain to compensate for variations in the carrier amplifier gain, full-scale meter sensitivity, and feedback resistor tolerances.
	A4R17	Adjusts the carrier amplifier gain which determines the input resistance of the null detector and to a minor degree affects null detector sensitivity.
	A3R8	Adjusted to provide uniform null detector voltages of ± 6.8 volts dc on all voltage ranges. This adjustment does not affect instrument calibration.
	A3R5	Adjusted to reduce the 3 kHz common mode signal from A3T1 that is present at the common terminal of the null detector. This adjustment does not affect instrument calibration.
KELVIN-VARLEY DIVIDER	A5R36	Provides a means of trimming the full-scale vernier dial range to compensate for potentiometer resistance tolerance.
1000 VOLT RANGE	A2R26	Adjusts the value of the reference voltage for the +18.5 volt dc regulator to a value necessary to calibrate the 1000 volt range. Adjustment of this resistor will also effect calibration of the 100 volt range but does not effect the 1 and 10 volt range calibration.
100 VOLT RANGE	A3R14	Adjusts the 110 volts dc applied to the Kelvin-Varley Divider on the 100 volt range. Adjustment of this resistor will not effect the calibration of any other voltage range.
10 VOLT RANGE	A2R33	Adjusts the 11 volts dc applied to the Kelvin-Varley Divider on the 10 volt range. Adjustment of this resistor will not effect the calibration of any other range.
1 VOLT RANGE	A2R35	Adjusts the 1.1 volts dc applied to the Kelvin-Varley Divider on the 1 volt range. Adjustment of this resistor will not effect the calibration of any other range.
1000 VOLT AC RANGE (400 Hz)	A7R29	Adjusts the AC Converter gain at low frequencies on the 1000 volt ac range. Adjustment of this resistor will not affect calibration of any other voltage range.
100 VOLT AC RANGE (400 Hz)	A7R31	Adjusts the AC converter gain at low frequencies on the 100 volt ac range. Adjustment of this resistor will not affect calibration of any other voltage range.

Figure 4-11. SUMMARY OF CALIBRATION ADJUSTMENTS (Sheet 1 of 2)

CIRCUITRY	ADJUSTMENTS AND THEIR EFFECTS	
100 VOLT AC RANGE (50 KHz)	STRAY CAPACITY COMPENSATOR	Adjusts the AC Converter gain at high frequencies on the 100 volt ac range. Adjustment of this compensator will affect high frequency calibration of all other ac ranges.
100 VOLT AC RANGE (50 KHz)	A7C15	Adjusts the high frequency response at 1/1000 of full-scale on the 100 volt ac range. Adjustment of this capacitor affects calibration of all other ac ranges.
10 VOLT AC RANGE (400 Hz)	A7R33	Adjusts the AC Converter gain at low frequencies on the 10 volt ac range. Adjustment of this resistor will not affect calibration of any other voltage range.
10 VOLT AC RANGE (50 KHz)	A7C21	Adjusts the AC Converter gain at high frequencies on the 10 volt ac range. Adjustment of this capacitor will not affect calibration of any other voltage range.
1 VOLT AC RANGE (400 Hz)	A7R35	Adjusts the AC Converter gain at low frequencies on the 1 volt ac range. Adjustment of this resistor will not affect calibration of any other voltage range.
1 VOLT AC RANGE (50 KHz)	A7C22	Adjusts the AC Converter gain at high frequencies on the 1 volt ac range. Adjustment of this capacitor will not affect calibration of any other voltage range.
AC CONVERTER	A7R4	Adjusted to provide a dc bias of +1.5 vdc across A7C16 in the AC Converter.

Figure 4-11. SUMMARY OF CALIBRATION ADJUSTMENTS (Sheet 2 of 2)

4-47. ZENER REFERENCE SUPPLY CALIBRATION

4-48. To calibrate the Zener Reference Supply, apply ac power to the instrument and proceed as follows:

a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	TVM
MODE	+
Readout dials	.00000

b. Connect a dc differential voltmeter to A2TP9 and adjust A2R19 for an indication of $+17 \pm 0.01$ volts dc.

c. Disconnect the dc differential voltmeter.

4-49. NULL DETECTOR CALIBRATION

4-50 To calibrate the Null Detector circuitry, proceed as follows:

a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1
NULL SENS	.001
MODE	+
Readout dials	.00100

b. Connect a shorting jumper between the LO and HI INPUT terminals and rotate A4R27 and A4R31 fully counter-clockwise.

- c. Adjust A4R27 clockwise until negative (-) deflection of the meter pointer reaches a maximum and then continue an additional 10° clockwise.
- d. Remove the INPUT terminals shorting jumper and adjust A4R31 for a meter pointer indication of zero center $\pm 1/2$ small divisions.
- e. Connect the shorting jumper between the LO and HI INPUT terminals and adjust A4R5 for an exact full-scale (-) meter pointer indication.
- f. Replace the shorting jumper between the INPUT terminals with a 10 megohm 1% resistor and place the Readout dials to .00200.
- g. Adjust A4R17 for an exact full-scale (-1) meter pointer indication.
- h. Repeat steps e through g until the specified results are obtained.
- i. Replace the resistor between the INPUT terminals with a shorting jumper.
- j. On each RANGE and NULL SENS switch setting, place the Readout dials to the voltage indicated on the NULL SENS switch, observing that the meter pointer indicates full-scale (-1) ± 1 small division. On the one volt range, perform the checks in both positions of the POLARITY switch.
- k. Remove the INPUT terminal shorting jumper and place the NULL SENS switch to TVM.
- l. Apply the dc voltages to the Model 893 INPUT terminals on the ranges indicated in Figure 4-12,

observing that the meter pointer indicates a corresponding positive or negative full-scale (± 1) ± 1 small division.

INPUT DC VOLTAGE ($\pm 0.3\%$)	RANGE
± 1	1
± 10	10
± 100	100
± 1000	1000

Figure 4-12. TVM RANGE CHECKS

- m. Remove the dc input voltage and connect a dc differential voltmeter between A4TP17 and the LO INPUT terminal.
- n. Place the RANGE switch to 100 and the Readout dials to 00.000 and record the dc differential voltmeter indication.
- o. Place the RANGE switch to 1000 and adjust A3R8 for a dc voltage within ± 10 millivolts of the voltage recorded in step n.
- p. Disconnect the dc differential voltmeter and connect an oscilloscope ground lead to the LO INPUT terminal and the input lead to terminal 1 of the A4 Null Detector Assembly.
- q. Place the RANGE switch to 1000 and the Readout dials to 100.00. Adjust A3R5 for minimum amplitude of the 3 kHz squarewave observed on the oscilloscope CRT.

4-51. KELVIN-VARLEY DIVIDER CALIBRATION

4-52. To calibrate the Kelvin-Varley Divider, apply ac power to the instrument and proceed as follows:

- a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	10
NULL SENS	.001
MODE	+
Readout dials	0.01 00

- b. Apply a dc input voltage between the LO and HI INPUT terminals and adjust its level to obtain a zero-center meter pointer indication.
- c. Place the Readout dials to 0.00 X and adjust A5R36 for a zero-center meter pointer indication.

4-53. DC VOLTAGE RANGE CALIBRATION

4-54. To calibrate the DC Voltage Ranges of the Model 893, apply ac power to the instrument and proceed as follows:

- a. Disconnect the shorting link from the LO INPUT terminal and place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	1000
NULL SENS	.1
MODE	+
Readout dials	1000.00

- b. Apply a dc calibration voltage of $1,000 \pm 0.002\%$ volts dc between the LO and HI INPUT terminals and center the adjustment A2R26, observing that the Model 893 meter indicates center-zero ± 6 md.
- c. If the result of step b is obtained, proceed with step f. If the desired results are not obtained, perform steps d through f.
- d. Remove ac power to the instrument and connect the jumpers illustrated in Figure 4-13 between their respective circuit board connections.
- e. Reapply ac power to the instrument and, using the information provided in Figure 4-14, clip the corresponding jumper or jumpers.

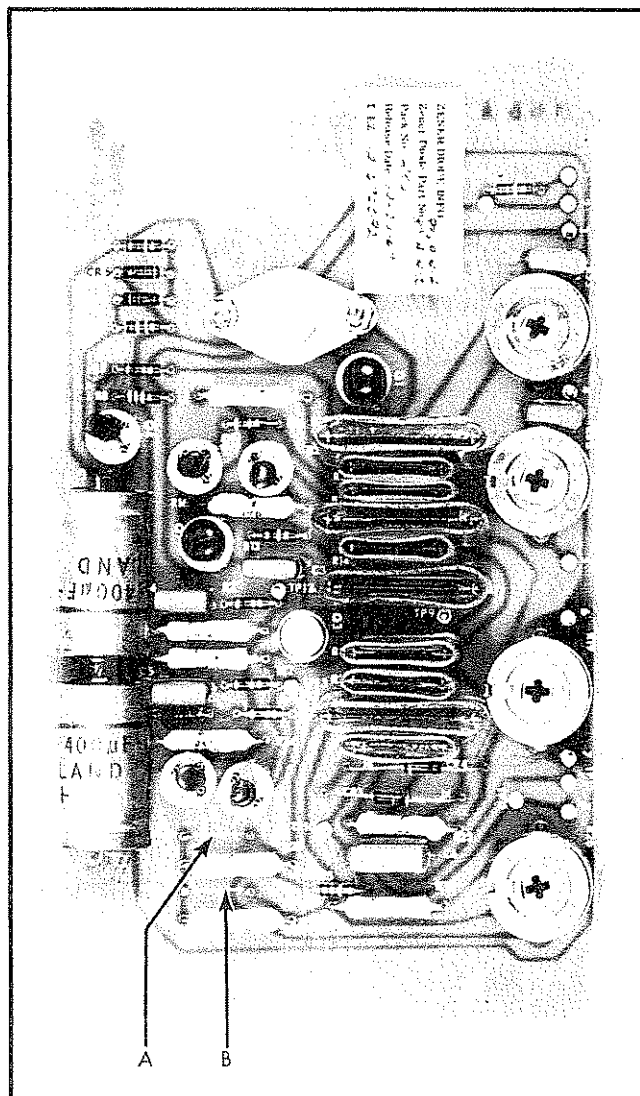


Figure 4-13. JUMPER WIRE LOCATION

METER INDICATION	JUMPER WIRE
0 to ± 0.6	NONE
-0.6 to -1.8	B
-1.8 to -3.0	A
-3.0 and above	BOTH

Figure 4-14. JUMPER WIRE SELECTION

- f. Adjust A2R26 for an exact zero-center meter indication.
- g. Reduce the calibration voltage to $100 \pm 0.002\%$ volts dc and place the RANGE switch to 100.
- h. With the NULL SENS switch to 0.01, adjust A3R14 for an exact zero-center meter pointer indication.
- i. Reduce the calibration voltage to $10 \pm 0.002\%$ volts dc and place the RANGE switch to 10.
- j. With the NULL SENS switch to .001, adjust A2R33 for an exact center-zero meter pointer indication.
- k. Reduce the calibration voltage to $1 \pm 0.002\%$ volts dc and place the RANGE switch to 1.
- l. With the NULL SENS switch to .001, adjust A2R35 for an exact zero-center meter pointer indication.
- m. Reduce the calibration voltage to 80 millivolts $\pm 0.1\%$ and place the RANGE switch to 100.
- n. Place the Readout dials to 00.080, observing that a zero-center meter indication is obtained within $\pm 1/2$ of a small division on the vernier Readout dial.
- o. If the results of step n are not obtained, adjust the vernier Readout dial for an exact zero-center meter indication and loosen the set screw that secures the vernier dial indicator to the potentiometer shaft. Refer to Figure 4-15 for location of the set screw.
- p. Position the vernier dial indicator for a front panel indication of 80 and securely tighten the set screw.
- q. Remove the calibration voltage from the Model 893 and place a shorting jumper between the LO and HI INPUT terminals.
- r. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	10
NULL SENS	.001
MODE	+
Readout dials	00.000
- s. Rotate the vernier Readout dial until a full-scale (-1) meter pointer indication is obtained, observing that the vernier Readout dial indication is between 9 and 11.

4-16

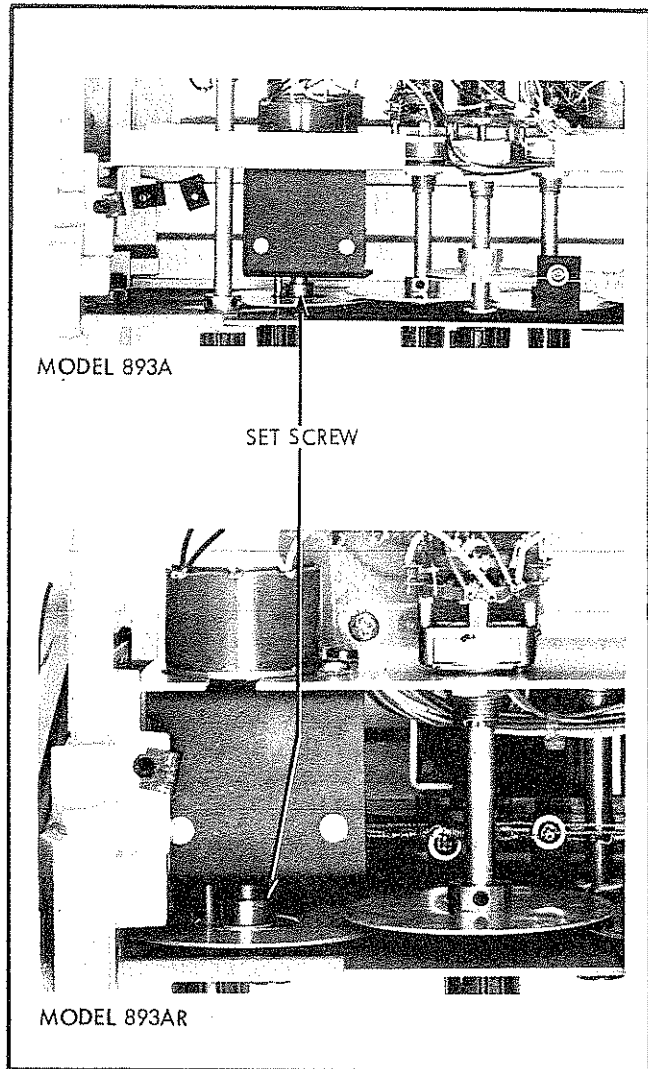


Figure 4-15. VERNIER DIAL SET SCREW LOCATION

4-55. AC CONVERTER CALIBRATION

4-56. To calibrate the AC Converter, apply ac power to the instrument and proceed as follows:

- a. Place the Model 893 controls as follows:

POWER	ON/LINE OPR
RANGE	100
NULL SENS	0.1
MODE	AC
Readout dials	100.000

- b. Apply a calibrated 100 volts ac signal at 400 Hz between the HIGH and LO INPUT terminals and adjust A7R31 for a meter indication of zero-center $\pm 1/2$ major division.
- c. Apply a calibrated 100 volt ac signal at 50 kHz between the HI and LO INPUT terminals and adjust the stray capacity compensator slightly, using

9/22/71

an insulated tool, for a meter indication of zero-center ± 1 major division. The stray capacity compensator is located between front panel and chassis of the instrument along with R12. This adjustment is accessible from the top of the Model 893A and from the bottom of the Model 893AR.

CAUTION!

The 100 VAC input voltage is present on the stray capacity compensator.

- d. Set the Readout dials to 01.0 00
- e. Apply a calibrated one volt ac signal at 400 Hz between the HI and LO INPUT terminals. A meter indication of zero-center \pm one small division should be obtained.
- f. Apply a calibrated one volt ac signal at 50 kHz between the HI and LO INPUT terminals and adjust A7C15 for the same meter indication obtained in step e.
- g. Repeat steps c through f until the specified results are obtained.
- h. Set the Readout dials to 10 0.0 00 and perform the checks indicated in Figure 4-16.

MODEL 893 AC INPUT VOLTAGE	METER INDICATION (\pm MAJOR DIVISIONS)
100 vac, 10 kHz	$\emptyset \pm 1.5$ m. d.
100 vac, 100 kHz	$\emptyset \pm 2$ m. d.*
100 vac, 20 Hz	$\emptyset \pm 7$ m. d.
*NULL SENSE TO 1.0	

Figure 4-16. 100 VOLT RANGE CHECKS

- i. Place the RANGE switch to its 10 volt range position and set NULL SENS TO .001.
- j. Apply a calibrated 10 volt ac signal at 400 Hz between the HI and LO INPUT terminals and adjust A7R33 for a meter deflection of zero-center $\pm 1/2$ major divisions.
- k. Apply a calibrated 10 volt ac signal at 50 kHz between the HI and LO INPUT terminals and adjust A7C21 for a meter indication of zero-center $\pm 1/2$ major divisions.
- l. Perform the 10 volt range checks indicated in Figure 4-17, observing that the specified results are obtained.

MODEL 893 AC INPUT VOLTAGE	METER INDICATION (\pm MAJOR DIVISIONS)
10 vac, 10 kHz	$\emptyset \pm 1.5$ m. d.
10 vac, 100 kHz	$\emptyset \pm 2$ m. d.*
10 vac, 20 Hz	$\emptyset \pm 7$ m. d..
*NULL SENSE TO .1	

Figure 4-17. 10 VOLT RANGE CHECKS

- m. Place the RANGE switch to its 1 volt range position and set NULL SENS TO .001.
- n. Apply a calibrated one volt ac signal at 400 Hz between the HI and LO INPUT terminals and adjust A7R35 for a meter indication of zero-center $\pm 1/2$ major divisions.
- o. Apply a calibrated one volt ac signal at 50 kHz between the HI and LO INPUT terminals and adjust A7C22 for a meter indication of zero-center $\pm 1/2$ major divisions.
- p. Perform the one volt range checks indicated in Figure 4-18, observing that the specified results are obtained.

MODEL 893 AC INPUT VOLTAGE	METER INDICATION (\pm MAJOR DIVISIONS)
1 vac, 10 kHz'	$\emptyset \pm 1.5$ m. d.
1 vac, 100 kHz	$\emptyset \pm 2.5$ m. d.*
1 vac, 20 Hz	$\emptyset \pm 7$ m. d.
* NULL SENS to .01	

Figure 4-18. 1 VOLT RANGE CHECKS

- q. Set the Readout dials to .10000 and perform the range checks contained in Figure 4-19, observing that the specified results are obtained.

MODEL 893 AC INPUT VOLTAGE	METER INDICATION (\pm SMALL DIVISIONS)
0.1 vac, 400 Hz	$\emptyset \pm 1$ s. d.
0.1 vac, 50 kHz	$\emptyset \pm 3$ s. d.

Figure 4-19. 1 VOLT RANGE (0.1 SCALE) CHECKS

- r. Set the Readout dials to .00100 and perform the range checks contained in Figure 4-20, observing that the specified results are obtained.

MODEL 893 AC INPUT VOLTAGE	METER INDICATION (\pm SMALL DIVISIONS)
0.001 vac, 50 kHz	$\emptyset \pm 1$ s. d.
0.001 vac, 400 Hz	$\emptyset \pm 1/2$ s. d.

Figure 4-20. 1 VOLT RANGE (0.001 SCALE) CHECKS

- s. Place the RANGE switch to its 1000 volt range position and set the Readout dials to 500. 00.
- t. Apply a calibrated 500 volt ac signal at 400 Hz between the HI and LO INPUT terminals and adjust

A7R29 for a meter indication of zero-center $\pm 1/2$ major divisions.

u. Apply a calibrated 500 volt ac signal at 10 kHz between the HI and LO INPUT terminals, observing that the meter indicates zero-center $\pm 1/2$ major divisions,

v. Set the Readout dials to 10 00.00 and apply a 1000 volt ac signal at 10 kHz, observing that the meter indicates zero-center ± 5 major divisions.

4-57. When the results of these calibration adjustments are obtained, the Model 893 is fully calibrated, and the test equipment can be disconnected from the instrument.

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section of the manual contains a listing of replaceable components for this instrument. The first listing contains a complete breakdown of all the major assemblies followed by subsequent listings that itemize the components on each major assembly. An illustration accompanies each major assembly listing to aid in locating the listed components.

5-3. Assemblies and subassemblies are identified by a reference designation beginning with the letter A followed by a number (e.g., A1 etc.). Electrical components appearing on the schematic diagram are identified by their schematic diagram reference designation. Components not appearing on the schematic diagram are consecutively numbered throughout the parts list. These components are identified with whole numbers on the arrow call-out illustrations and by index numbers on the grid illustrations. Flagnotes are used throughout the parts list and refer to special ordering explanations that are located in close proximity to the flagnotes.

5-4. COLUMN DESCRIPTION

- a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.
- b. The INDEX NO. column lists coordinates which locate the designated part on the associated grid illustrations.
- c. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, see the following page.
- d. The ten-digit part number, by which the item is identified at the John Fluke Mfg. Co., is listed

in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

- e. The Federal Supply Code for the item manufacturer is listed in the MFR column. An abbreviated list of Federal Supply Codes is included in the Appendix.
- f. The part number which uniquely identifies the item to the original manufacturer is listed in the MFR PART NO column. If a component must be ordered by description, the type number is listed.
- g. The TOT QTY column lists the total quantity of the items used in the instrument and reflects the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the TOT QTY column lists the total quantity of the item in that particular assembly.
- h. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.
- i. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List at the end of the parts list. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-5. HOW TO OBTAIN PARTS

5-6. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representative by using the Fluke part number. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-7. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co. if you include the following information:

a. Quantity.

- b. FLUKE Stock Number.
- c. Description.
- d. Reference Designation.
- e. Instrument model and serial number.

Example; 2 each, 4805-177105, Transistors, 2N3565, Q107-108 for 845AR, s/n 168.

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

5-8. LIST OF ABBREVIATIONS

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

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		AC/DC DIFFERENTIAL VOLTMETER Figure 5-1	893A					
A1		Front Panel Assembly (See Figure 5-2)						
A2		Reference Amplifier P/C Assembly (See Figure 5-3)	1702-232793 (891A-4001)	89536	1702-232793	1		
A3		Reference Inverter P/C Assembly (See Figure 5-4)	1702-250175 (893A-4002)	89536	1702-250175	1		
A4		Null Detector P/C Assembly (See Figure 5-5)	1702-232819 (891A-4003)	89536	1702-232819	1		
A5		Kelvin-Varley P/C Assembly (See Figure 5-6)	1702-232827 (891A-4004)	89536	1702-232827	1		
A7		AC Converter P/C Assembly (See Figure 5-7)	1702-250167 (893A-4001)	89536	1702-250167	1		
A8		Rear Panel Assembly (See Figure 5-8)						
M1		Meter, 100-0-100 ua	2901-236513	89536	2901-236513	1		
P1, P2		Line cord (not illustrated)	6005-226100	91934	2270			
R1		Res, car flm, 90M $\pm 1\%$, 2w	4703-192138	75042	MEHT-X	1		
R2		Res, car flm, 9M $\pm 0.5\%$, 1w	4703-107557	75042	Type C13	1		
R3		Res, car flm, 1M $\pm 1\%$, 1/2w	4703-107219	75042	Type C12	1		
R4		Res, car flm, 90k $\pm 0.5\%$, 1/2w	4703-107292	75042	Type C12	1		
R5		Res, car flm, 9k $\pm 0.5\%$, 1/2w	4703-107250	75042	Type C12	1		
R6		Res, car flm, 900 Ω $\pm 0.5\%$, 1/2w	4703-107771	75042	Type C12	1		
R7		Res, car flm, 100 Ω $\pm 0.5\%$, 1/2w	4703-107730	75042	Type C12	1		
R9		Res, comp, 1k $\pm 10\%$, 1w	4704-109371	01121	GB1021	1		
R12		Res, met flm, 1M, matched set with A7R37	4705-245597	89536	4705-245597	1		
R13, R14		Res, met flm, 100k $\pm 1\%$, 1/2w	4705-151316	75042	Type CEC-TO	2		D
S1		Switch, rotary, RANGE, DC section	5105-254573	89536	5105-254573	1		
S2		Switch, rotary, POWER	5105-242917	89536	5105-242917	1		
S3		Switch, rotary, NULL	5105-242875	89536	5105-242875	1		
S4		Switch, rotary, MODE	5105-250555	89536	5105-250555	1		
S4A		Switch wafer, MODE, deck "A"	5105-250530	89536	5105-250530	1		
1		Coupler, power switch, mode wafer	2402-104505	89536	2402-104505	2		
2		Cover, bottom (not illustrated)	3156-230169	89536	3156-230169	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
3		Cover, top (not illustrated)	3156-230151	89536	3156-230151	1		
4		Dial, 0-9	2403-232215	89536	2403-232215	2		
5		Dial, 0-10	2403-232207	89536	2403-232207	1		
6		Dial, 0-100	2403-242859	89536	2403-242859	1		
7		Foot, plastic (not illustrated)	3155-230037	89536	3155-230037	4		
8		Handle	2906-231456	89536	2906-231456	1		
9		Indicator, ON-OFF flag	3156-232223	89536	3156-232223	1		
10		Shaft, power switch	2406-250563	89536	2406-250563	1		
11		Trim strip, front (not illustrated)	3154-230771	89536	3154-230771	2		
12		Trim strip, rear (not illustrated)	3154-230789	89536	3154-230789	2		
13		Trim strip, side insert (not illustrated)	3155-230920	89536	3155-230920	2		

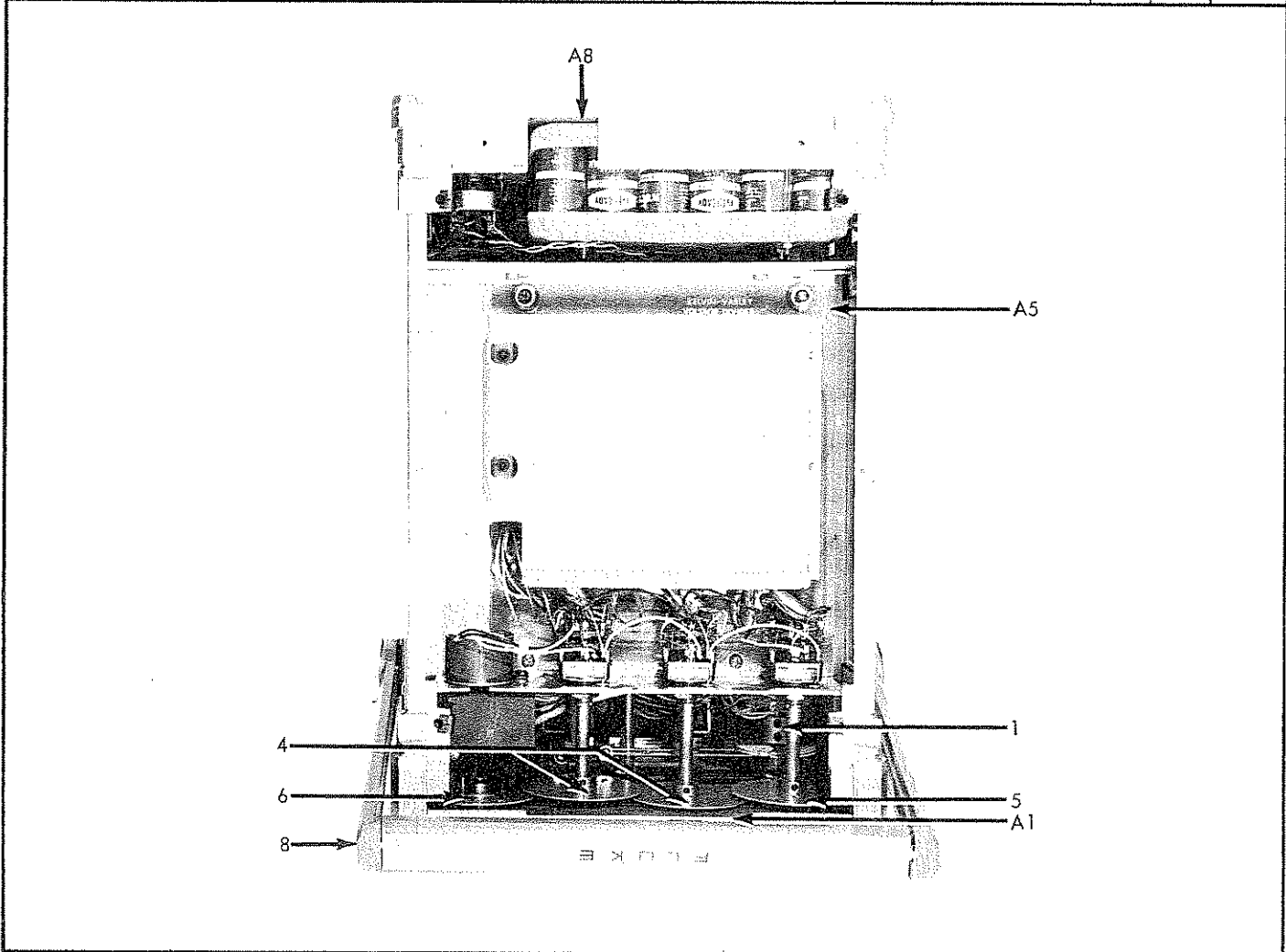


Figure 5-1. 893A AC/DC DIFFERENTIAL VOLTMETER (Sheet 1 of 2)

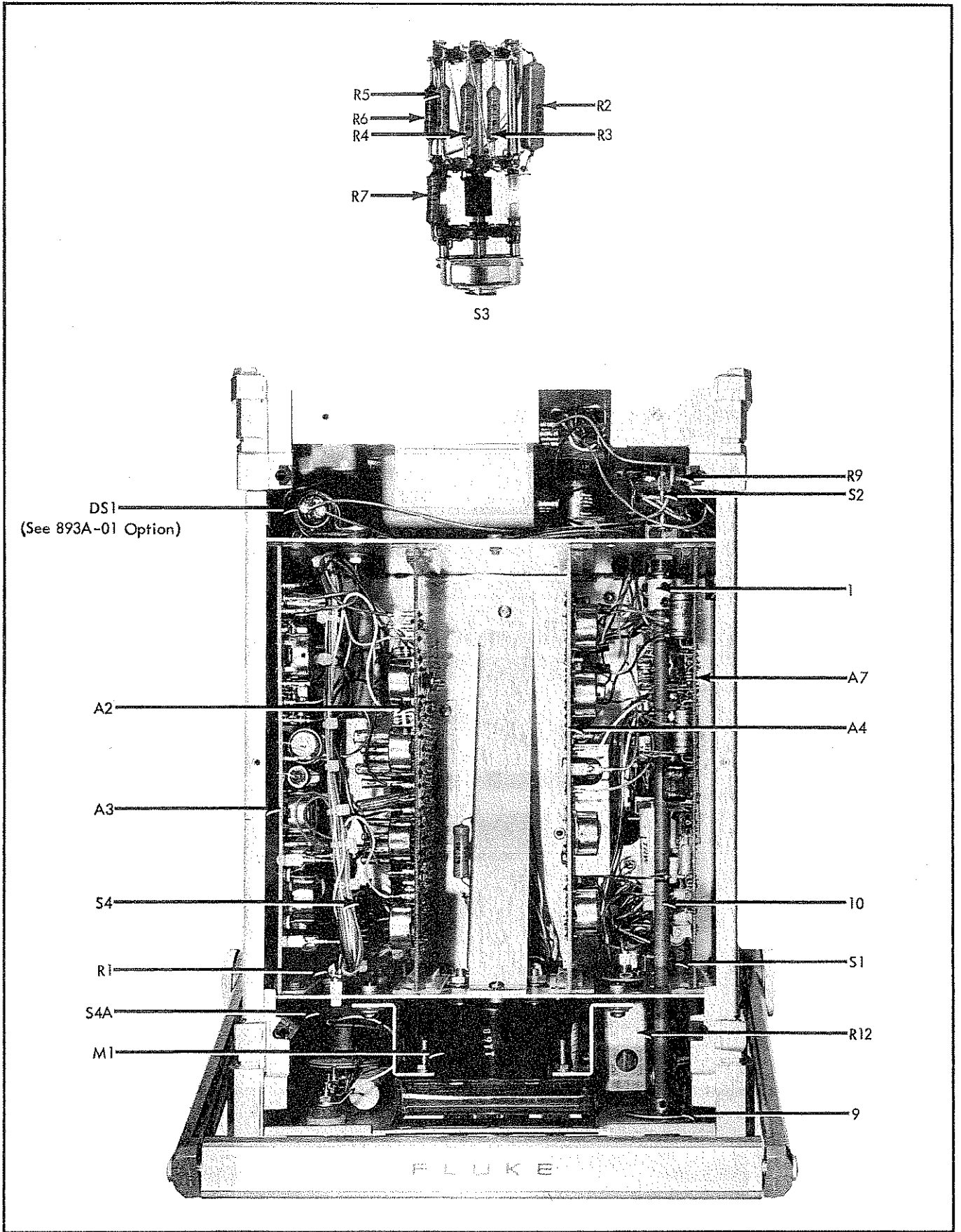


Figure 5-1. 893A AC/DC DIFFERENTIAL VOLTMETER (Sheet 2 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		FRONT PANEL ASSEMBLY (893A) Figure 5-2						
C1		Cap, plstc, 0.047 uf ±20%, 1.2kv (across J2 and J3)	1507-182683	99217	MR473L12	2		
J1		Binding post, red, HI	2811-226308	58474	DF21RC	2		
J2		Binding post, red, LO	2811-226308	58474	DF21RC	REF		
J3		Binding post, black GROUND	2811-226282	58474	DF21BC	1		
R8		Res, comp, 100M ±10%, 1/2w (across J2 and J3)	4704-190520	01121	EB1071	1		
14		Knob, Digit	2405-158949	89536	2405-158949	4		
15		Knob, NULL SENS, MODE, RANGE	2405-158956	89536	2405-158956	3		
16		Knob, POWER	2405-235689	89536	2405-235689	1		
17		Link, shorting	2811-101220	24655	938L	1		
18		Panel, front	1406-244558	89536	1406-244558	1		
18		Panel, front (893A/AC)	1406-314734	89536	1406-314724	1		

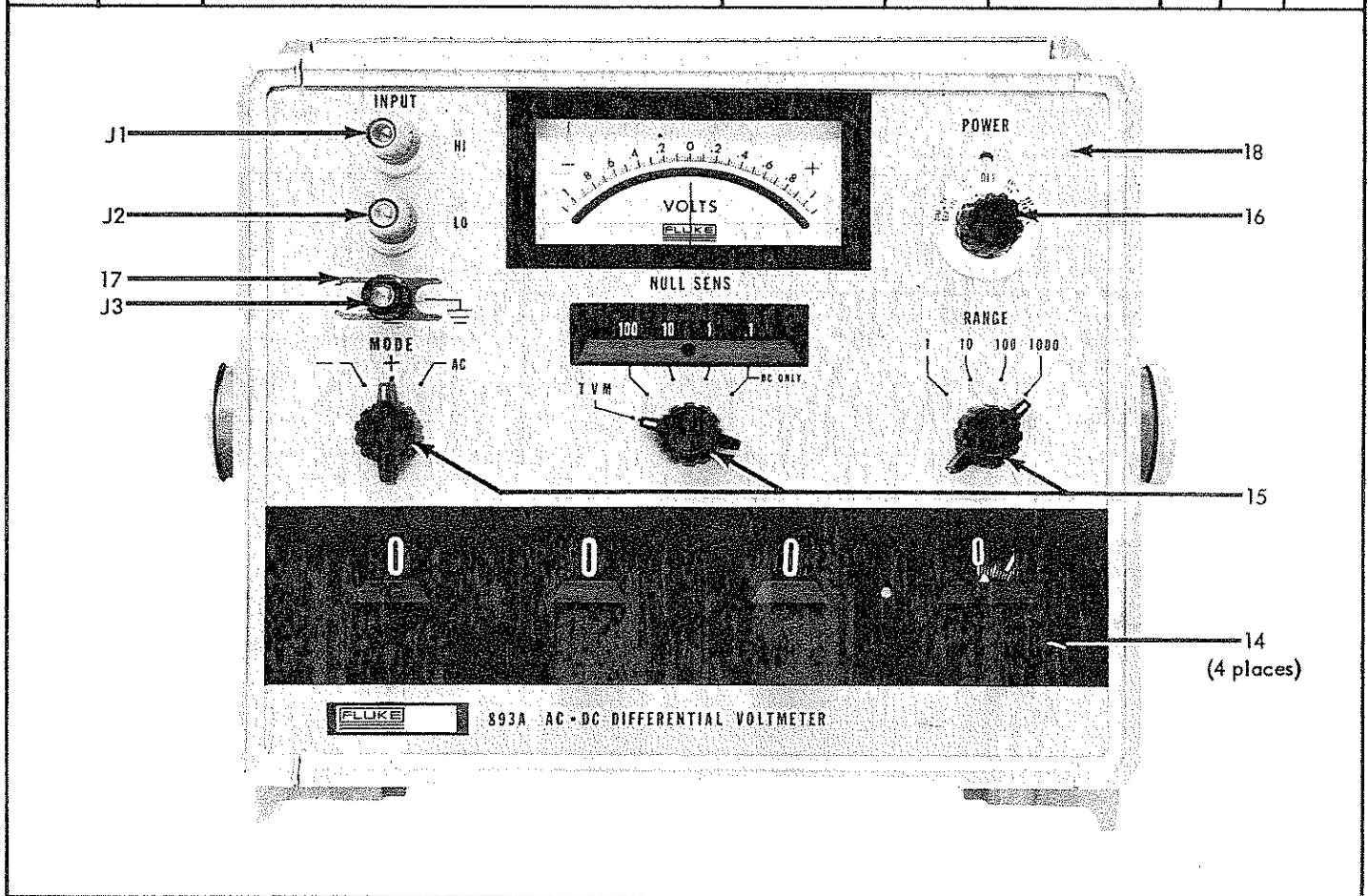




Figure 5-2. FRONT PANEL ASSEMBLY (893A)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2		REFERENCE AMPLIFIER P/C ASSEMBLY -Figure 5-3 NOTE: The Reference Amplifier P/C As- sembly (A2), the Reference Inverter P/C Assembly (A3) and their intermatched re- sistor set can be ordered under one part number, 1702-250209 (893A-4005).	1702-232793 (891A-4001)	89536	1702-232793	REF		
C1	F4-P1	Cap, elect, 400uf +50/-10%, 40v	1502-185868	73445	C437ARG400	2	1	
C2	D4-P1	Cap, elect, 400uf +50/-10%, 40v	1502-185868	73445	C437ARG400	REF		
C3	F4-R1	Cap, plstc, 0.22uf ±20%, 250v	1507-194803	73445	C280AE/ P220K	2		
C4	F2-Q1	Cap, plstc, 0.1uf ±20%, 250v	1507-161992	73445	C280AE/ P100K	7		
C5	F2-P5	Cap, plstc, 0.1uf ±20%, 250v	1507-161992	73445	C280AE/ P100K	REF		
C6	C3-S2	Cap, plstc, 0.22uf ±20%, 250v	1507-194803	73445	C280AE/ P220K	REF		
C7	H2-T5	Cap, plstc, 0.1uf ±20%, 250v	1507-161992	73445	C280AE/ P100K	REF		
C8	15-U1	Cap, plstc, 0.1uf ±20%, 250v	1507-161992	73445	C280AE/ P100K	REF		
C9	13-P3	Cap, Ta, 3.3uf ±10%, 20v	1508-182808	05397	K3R3C20K	1		
CR1	13-P3	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	2	1	
CR2	E1-P5	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	REF		
CR3	D1-S2	Diode, zener, matched						
CR4	D3-S3	Diode, zener, matched						
CR5	15-P3	Diode, zener, 15v	4803-246033	07910	IN965A	1	1	
CR6	F1-S1	Diode, silicon, 100 ma at 1.5v	4802-261370	22767	S1330	3	1	B
Q1	H4-R5	Tstr, silicon, PNP	4805-229898	04713	MPS6522	5	1	
Q2	I2-R1	Tstr, silicon, NPN	4805-183004	95303	40250	3	1	
Q3	E5-R2	Tstr, silicon, NPN	4805-220087	03508	12E-1516	1	1	
Q4	H2-P1	Tstr, silicon, NPN	4805-168708	03508	2N3391	11	1	
Q5	D2-Q1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q6	D1-Q3	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q7	F5-Q2	Tstr, silicon, PNP	4805-203364	07263	2N3638	2	1	
Q8	G4-Q1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q9	G4-Q5	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		

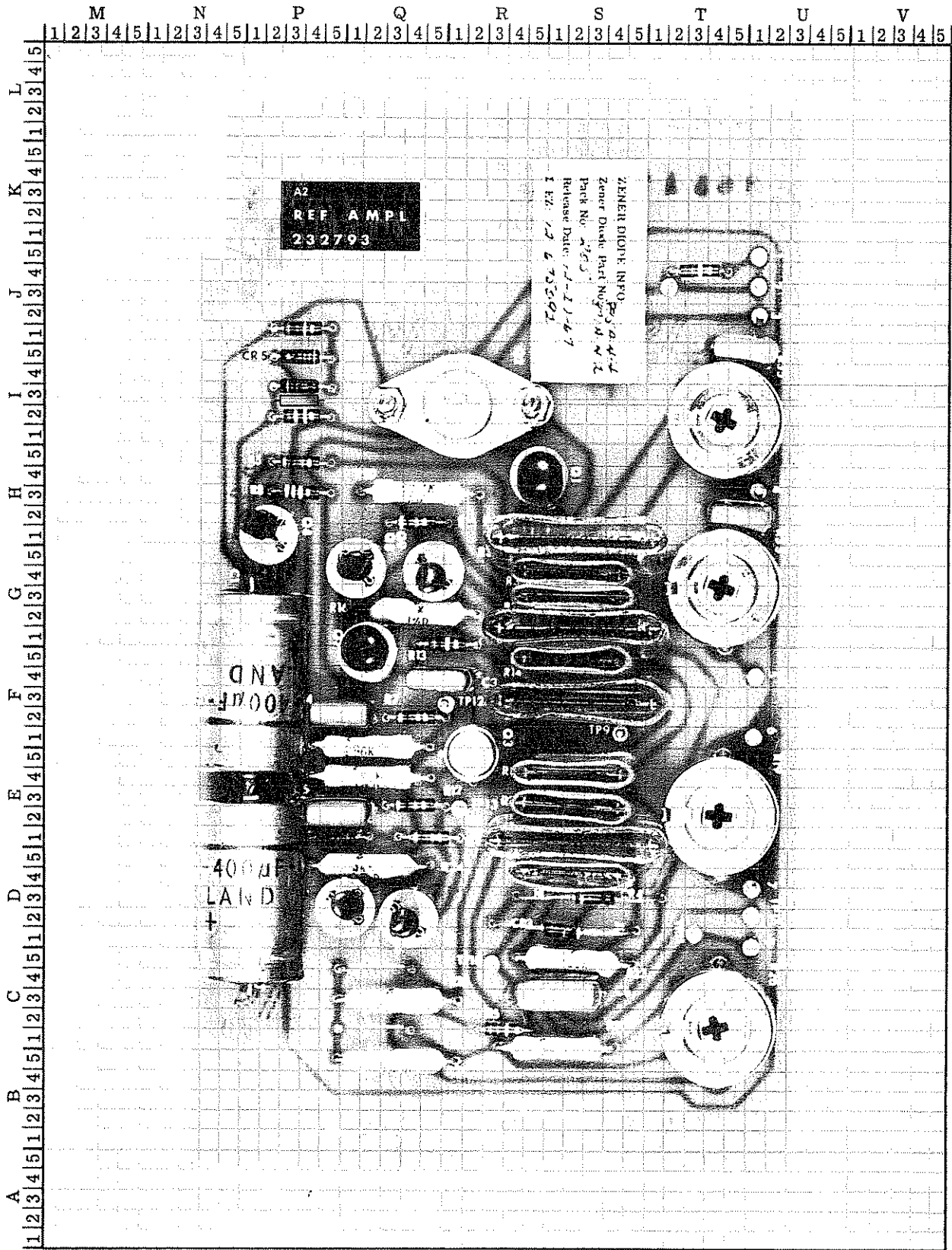






Figure 5-3. REFERENCE AMPLIFIER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R1	J1-P3	Res, comp, 15k \pm 5%, 1/4w	4704-148114	01121	CB1535	1		
R3	H1-R5	Res, comp, 2.7k \pm 5%, 1/4w	4704-170720	01121	CB2725	1		
R4	J4-T3	Res, comp, 62k \pm 5%, 1/4w	4704-220053	01121	CB6235	1		
R5	H5-P3	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	10		
R6	E5-Q3	Res, met flm, 196k \pm 1%, 1/2w	4705-161513	75042	Type CEC- TO	2		
R7	F2-Q4	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	REF		
R8	H3-P3	Res, comp, 47k \pm 5%, 1/4w	4704-148163	01121	CB4735	1		
R9	I2-P3	Res, comp, 680k \pm 5%, 1/4w	4704-188433	01121	CB6845	2		
R10	E1-Q5	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	REF		
R11	E4-Q2	Res, met flm, 196k \pm 1%, 1/2w	4705-161513	75042	Type CEC- TO	REF		
R12	E2-Q4	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	REF		
R13	G1-R1	Res, comp, 100k \pm 5%, 1/4w	4704-148189	01121	CB1045	3		
R14	F5-S1	Res, ww, matched						
R15	H2-Q4	Res, comp, 3k \pm 5%, 1/4w	4704-193508	01121	CB3025	1		
R16	G2-Q4	Res, met flm, 9k \pm 1%, 1/2w	4705-159434	75042	Type CEC- TO	1		
R17	F3-R5	Res, ww, 4k \pm 0.03%, 1w	4707-131672	89536	4707-131672	1		
R18	G1-R5	Res, ww, 10k \pm 0.05%, 1w	4707-131664	89536	4707-131664	1		
R19	E3-T4	Res, var, ww, 3k \pm 10%, 1-1/4w	4702-112458	71450	Type 110	1		
R20	H3-Q4	Res, met flm, 60.4k \pm 1%, 1/2w	4705-161067	75042	Type CEC- TO	1		
R21	D4-S2	Res, ww, 12.525k, matched						
R22	E4-S2	Res, ww, 12.525k, matched						
R23	C5-S2	Res, met flm, 499k \pm 1%, 1/2w	4705-151332	75042	Type CEC- TO	2		
R24	D4-Q2	Res, met flm, 34k \pm 1%, 1/2w	4705-151241	75042	Type CEC- TO	1		
R25	C1-R3	Res, comp, 22k \pm 5%, 1/4w	4704-148130	01121	CB2235	2		
R26	C2-T5	Res, var, ww, 1k \pm 20%, 1-1/4w	4702-111575	71450	Type 110	2		
R27	E2-S3	Res, ww, matched						
R28	C3-Q3	Res, met flm, 95.3 Ω \pm 1%, 1/2w	4705-155127	75042	Type CEC- TO	1		
R29	B5-Q3	Res, met flm, 47.5 Ω \pm 1%, 1/2w	4705-151290	75042	Type CEC- TO	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R30	B5-R5	Res, met flm 52. 3Ω ± 1%, 1/2w	4705-155069	75042	Type CEC- TO	1		
R31	E1-R4	Res, ww, 49. 488k ±0.05%, 1w	4707-163444	89536	4707-163444	1		
R32	G3-S2	Res, ww, matched	1					
R33	G3-T3	Res, var, ww, 25Ω ±10%, 1-1/4w	4702-161703	71450	Type 110	2		
R34	H1-S5	Res, ww, 49. 488k, matched	3					
R35	I3-T4	Res, var, ww, 25Ω ± 10%, 1-1/4w	4702-161703	71450	Type 110	REF		
R36	G4-S2	Res, ww, 5. 481k, matched	3					
R37	F1-R5	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		D



CR3, CR4, R14, R27 & R32 are a factory matched set and must be replaced as an entire set. For replacement, order Zener-Resistor Set, part number 4807-219303.



A2R21, A2R22/A3R12, A3R13, A3R15 & A3R16 are factory matched for tolerance and temperature coefficient. Individual resistors can be replaced by giving model, serial number, full reference designation and all information stamped on the resistor.



R34 & R36 are factory matched and must be replaced as a set. For replacement, order Reference Divider Resistor Set, part number 4710-219295.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A3		REFERENCE INVERTER P/C ASSEMBLY Figure 5-4 Note: The Reference Amplifier P/C Assembly (A2), the Reference Inverter P/C Assembly (A3) and their intermatched resistor set can be ordered under one part number, 1702-250209 (893A-4005).	1702-250175 (893A-4002)	89536	1702-250175	REF		
C1	F4-S4	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	2	1	
C2	H4-Q1	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	REF		
C3	E4-T3	Cap, plstc, 0.1 uf ±20%, 250v	1507-161992	73445	C280AE/P100K	REF		
C4	G4-R3	Cap, elect, 5 uf +50/-10%, 64v	1502-218966	73445	C426ARH5	2	1	
C5	G4-R2	Cap, elect, 5 uf +50/-10%, 64v	1502-218966	73445	C426ARH5	REF		
C6	G2-S4	Cap, plstc, 1 uf ±20%, 250v	1507-190330	73445	C280AE/P1M	1	1	
C7	G1-Q4	Cap, plstc, 0.47 uf ±20%, 600v	1507-105494	72928	363-114M	2		
C8	G1-P1	Cap, plstc, 0.47 uf ±20%, 600v	1507-105494	72928	363-114M	REF		
C9	I3-P5	Cap, plstc, 0.047 uf ±20%, 1.2 kv	1507-182683	99217	MR473L12	REF		
C10	B5-T2	Cap, Ta, 68 uf ±10%, 15v	1508-182824	05397	K68C15K	2		
C11	B5-T4	Cap, Ta, 68 uf ±10%, 15v	1508-182824	05397	K68C15K	REF		
C12	B5-N5	Cap, cer, 0.05 uf +80/-20%, 500v	1501-105676	56289	33C58	1		H
CR1	E3-T3	Diode, germanium, 80 ma, 100 piv	4802-149187	49956	1N270	5	1	
CR2	F3-R3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	6	1	
CR3	F3-R2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR4	F3-Q1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	4	1	
CR5	G3-Q1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR6	F3-P5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR7	G3-P5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR8	C3-T5	Diode, germanium, 80 ma, 100 piv	4802-149187	49956	1N270	REF		
CR9	B4-T1	Diode, germanium, 80 ma, 100 piv	4802-149187	49956	1N270	REF		
L1	G4-S1	Choke, 470 uh, 180 ma	1801-147827	72259	WEE-470	1		C
L1	E5-T3	Choke, 47 uh, 420 ma	1801-147850	72259	WEE-47	2		D
L2	C3-T2	Choke, 47 uh, 420 ma	1801-147850	72259	WEE-47	REF		D
L1	E5-T3	Choke, RF, 75 uh, 10mΩ	1804-286427	89536	1804-286427	2		G
L2	C3-T2	Choke, RF, 75 uh, 10mΩ	1804-286427	89536	1804-286427	REF		G
Q1	E2-S3	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
Q2	C5-S3	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
R1	H2-R4	Res, comp, 2Ω ±5%, 1/2w	4704-218735	01121	EB20G5	1		
R2	G4-S1	Res comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	6		
R3	E1-T4	Res, comp, 33Ω ±5%, 1/4w	4704-175034	01121	CB3305	2		

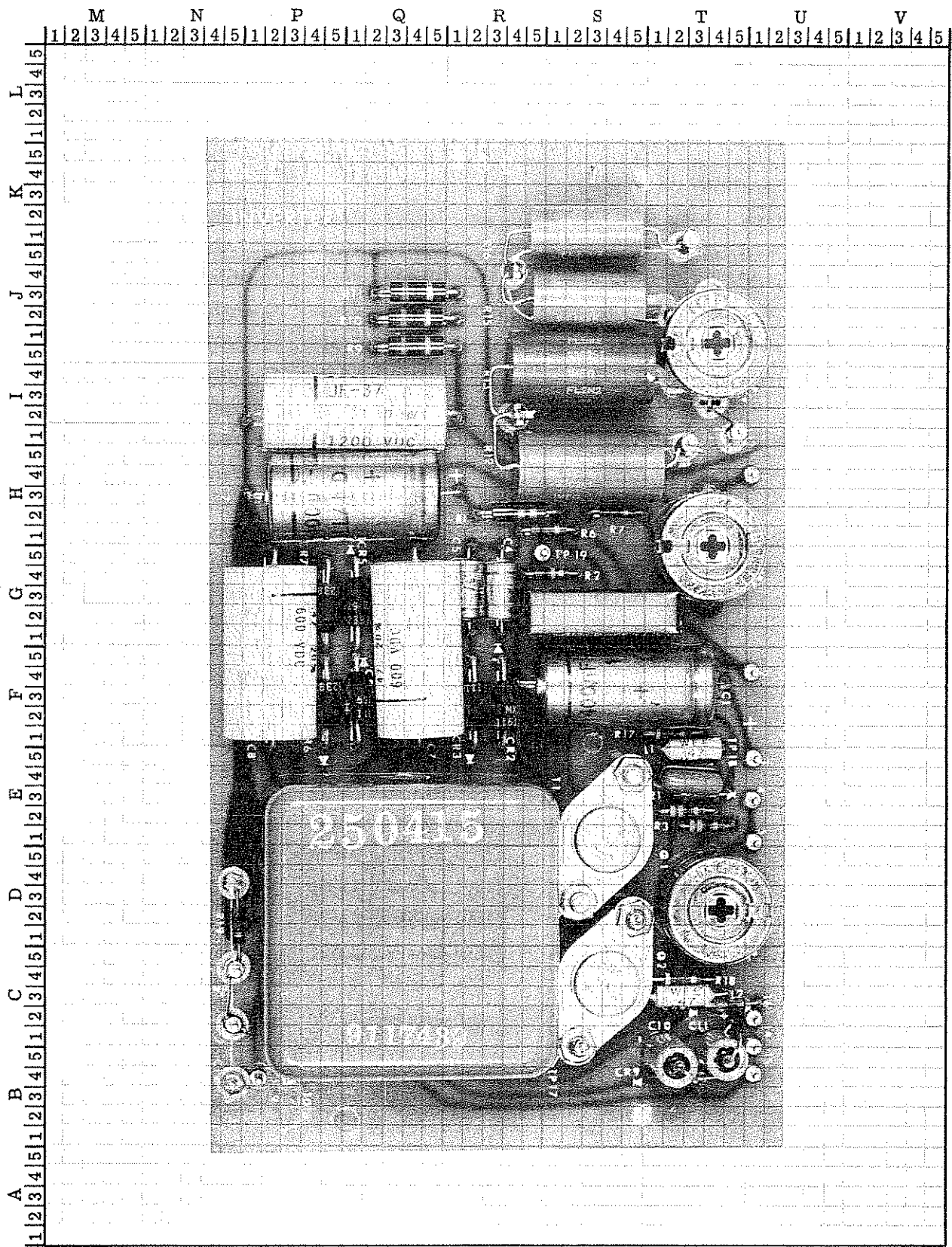






Figure 5-4. REFERENCE INVERTER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R4	E2-T2	Res, comp, 33Ω ±5%, 1/4w	4704-175034	01121	CB3305	REF		
R5	D2-T4	Res, var, ww, 1k ±20%, 1-1/4w	4702-111575	71450	Type 110	REF		
R6	H1-R5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	4		
R7	H2-S4	Res, comp, 5.1k±5%, 1/4w	4704-193342	01121	CB5125	1		
R8	H2-T3	Res, var, ww, 6k ±5%, 1-1/4w	4702-113209	71450	Type 110	2		
R9	J1-Q4	Res, comp, 5.6M ±10%, 1/2w	4704-178558	01121	EB5651	3		
R10	J2-Q4	Res, comp, 5.6M ±10%, 1/2w	4704-178558	01121	EB5651	REF		
R11	J3-Q4	Res, comp, 5.6M ±10%, 1/2w	4704-178558	01121	EB5651	REF		
R12	H5-S3	Res, ww, 1M, matched						
R13	I5-S2	Res, ww, 1M, matched						
R14	J1-T5	Res, var, ww, 100Ω ±20%, 1-1/4w	4702-112797	71450	Type 110	1		
R15	J3-S3	Res, ww, 98.582k, matched						
R16	K1-S3	Res, ww, 98.582k, matched						
R17	F1-T2	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	5		D
R18	C4-T2	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		D
R19	D1-N5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		H
T1	D3-Q5	Transformer, toroid	5602-250415	89536	5602-250415	1		



A2R21, A2R22/A3R12, A3R13, A3R15 & A3R16 are factory matched for tolerance and temperature coefficient. Individual resistors can be replaced by giving model, serial number, full reference designation and all information stamped on the resistor.

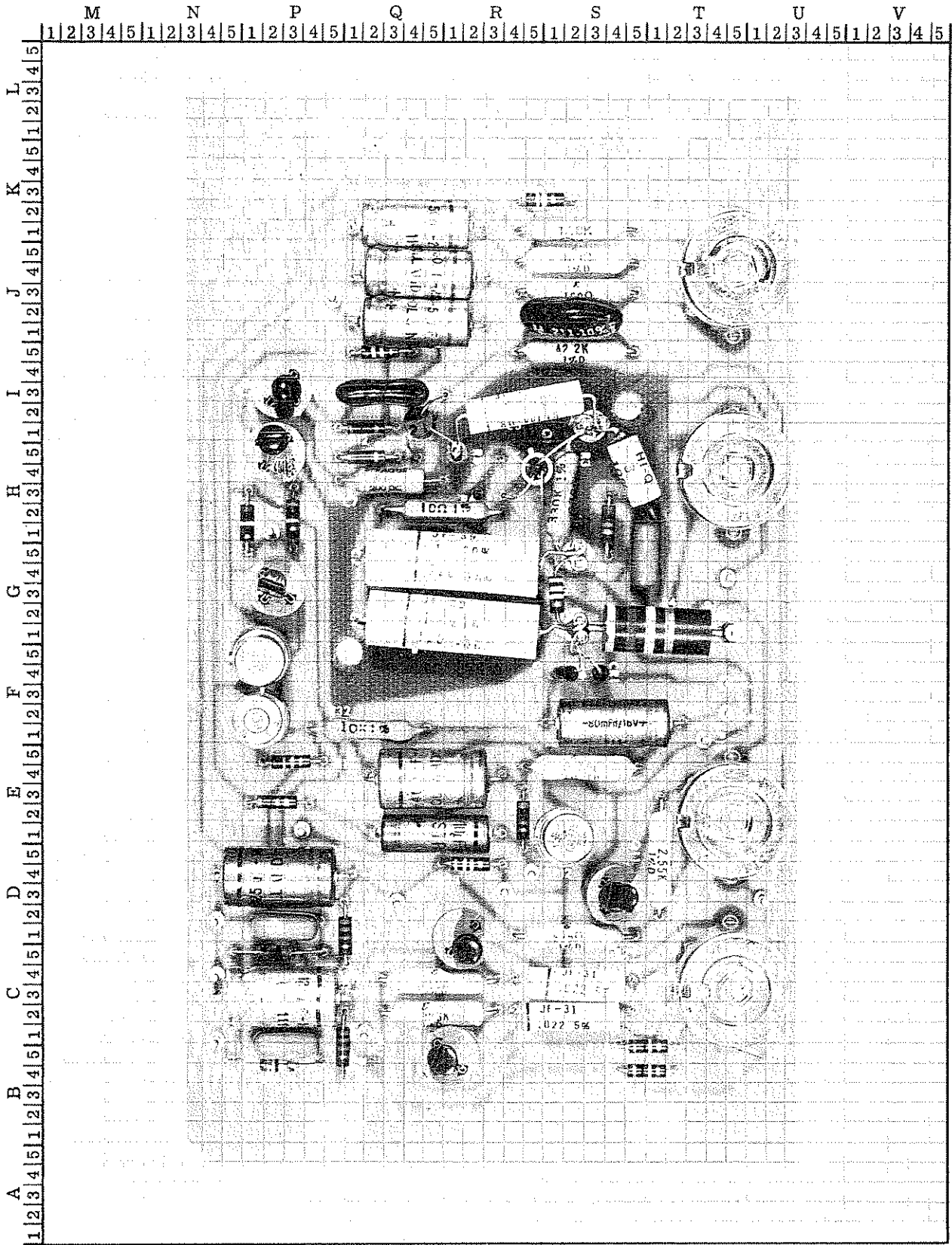


Figure 5-5. NULL DETECTOR P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A4		NULL DETECTOR P/C ASSEMBLY Figure 5-5	1702-232819 (891A-4003)	89536	1702-232819	REF		
C1	G1-Q5	Cap, plstc, 0.1uf $\pm 20\%$, 120v	1507-167460	99217	Type SEC	2		
C2	G4-Q5	Cap, plstc, 0.1uf $\pm 20\%$, 120v	1507-167460	99217	Type SEC	REF		
C3	I2-R5	Cap, plstc, 0.047uf $\pm 10\%$, 80v	1507-195099	56289	192P4739R8	2		
C4	H4-S5	Cap, cer, 3pf $\pm 10\%$, 500v	1501-226316	00656	Type C1-1	1		
C5	G5-T1	Cap, plstc, 0.1uf $\pm 20\%$, 250v	1507-161992	73445	C280AE/ P100K	REF		
C6	J1-Q4	Cap, elect, 50uf +50/-10%, 25v	1502-168823	73445	C426ARF50	4	1	
C7	H3-Q3	Cap, plstc, 0.0047uf $\pm 20\%$, 200v	1507-106054	56289	192P47202	1		
C8	J1-S2	Cap, plstc, 0.01uf $\pm 10\%$, 200v	1507-168450	14655	DMF2S1	1		
C9	K1-Q5	Cap, elect, 50uf +50/-10%, 25v	1502-168823	73445	C426ARF50	REF		
C10	I3-Q3	Cap, mica, 2, 200pf $\pm 5\%$, 500v	1504-148346	14655	CD19F222J	1		
C11	J4-Q5	Cap, elect, 50uf +50/-10%, 25v	1502-168823	73445	C426ARF50	REF		
C12	E1-Q5	Cap, elect, 10uf +50/-10%, 25v	1502-170266	73445	C426ARF10	1	1	
C13	E3-Q5	Cap, elect, 400uf +50/-10%, 4v	1502-187773	73445	C426ARB400	1	1	
C14	C2-S2	Cap, plstc, 0.022uf $\pm 5\%$, 200v	1507-233973	56289	192P22352	2		
C15	C3-S2	Cap, plstc, 0.022uf $\pm 5\%$, 200v	1507-233973	56289	192P22352	REF		
C16	D1-P3	Cap, plstc, 0.1uf $\pm 20\%$, 250v	1507-161992	73445	C280AE/ P100K	REF		E
C17	B5-P3	Cap, plstc, 0.1uf $\pm 20\%$, 250v	1507-161992	73445	C280AE/ P100K	REF		E
C18	D3-P3	Cap, elect, 125uf +50/-10%, 16v	1502-186296	73445	C426ARE125	2	1	
C19	C2-P3	Cap, elect, 125uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C20	F1-S4	Cap, elect, 80uf +50/-10%, 16v	1502-192914	73445	C426ARE80	1	1	
CR1	F4-S3	Diode, silicon, treated	4802-180885	89536	4802-180885	2	1	
CR2	F4-S2	Diode, silicon, treated	4802-180885	89536	4802-180885	REF		
CR3	C5-P3	Diode, germanium, 80ma, 100 piv	4802-149187	49956	IN270	REF		
CR4	B4-P2	Diode, germanium, 80ma, 100 piv	4802-149187	49956	IN270	REF		
Q1	H4-R5	Tstr, MOS, P-channel	4805-226043	07263	FT704	1	1	
Q2	I1-Q4	Tstr, silicon, NPN	4805-242065	04713	2N5089	2	1	
Q3	I3-P3	Tstr, silicon, NPN	4805-242065	04713	2N5089	REF		
Q4	H5-P2	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q5	G3-P2	Tstr, silicon, PNP	4805-229898	04713	MPS6522	REF		
Q6	F4-P2	Tstr, germanium, NPN	4805-117127	01295	2N1304	1	1	
Q7	F1-P2	Tstr, germanium, PNP	4805-190298	95303	2N1305	1	1	
Q8	D5-S2	Tstr, germanium, NPN	4805-182691	01295	GA3937	1	1	
Q9	C5-R2	Tsrt, silicon, NPN	4805-168708	03508	2N3391	REF		
Q10	B4-R1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q11	D2-S5	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
R1	G1-S5	Res, comp, 470k \pm 10%, 2w	4704-110247	01121	HB4741	1		
R2	G3-S1	Res, comp, 470k \pm 5%, 1/4w	4704-188441	01121	CB4745	1		
R3	H3-S2	Res, car flm, 330k \pm 1%, 1/2w	4703-107359	75042	Type C12	1		
R4	G2-T1	Res, comp, 56 Ω \pm 5%, 1/4w	4704-147900	01121	CB5605	1		
R5	H3-T4	Res, var, ww, 500 Ω \pm 10%, 1-1/4w	4702-112433	71450	Type 110	1		
R6	H2-R1	Res, car flm, 10 Ω \pm 1%, 1/2w	4703-107789	75042	Type C12	1		
R7	H1-S4	Res, comp, 10M \pm 5%, 1/4w	4704-194944	01121	CB1065	1		
R8	H5-R1	Res, comp, 3.3M \pm 10%, 1/2w	4704-108282	01121	EB3351	1		
R9	H5-Q2	Res, comp, 1.5M \pm 5%, 1/4w	4704-182857	01121	CB1555	1		
R10	J4-S2	Res, met flm, 169 Ω \pm 1%, 1/2w	4705-151183	75042	Type CEC- TO	2		
R11	K2-S1	Res, comp, 680k \pm 5%, 1/4w	4704-188433	01121	CB6845	REF		
R12	I1-Q2	Res, comp, 1M \pm 5%, 1/4w	4704-182204	01121	CB1055	1		
R13	I5-Q2	Res, comp, 27k \pm 5%, 1/4w	4704-148148	01121	CB2735	2		
R14	H1-F3	Res, comp, 10k \pm 5%, 1/4w	4704-148106	01121	CB1035	REF		
R15	I5-S2	Res, met flm, 80.6k \pm 1%, 1/2w	4705-150680	75042	Type CEC- TO	1		
R16	J3-S2	Res, met flm, 169 Ω \pm 1%, 1/2w	4705-151183	75042	Type CEC- TO	REF		
R17	J3-T4	Res, var, ww, 10k \pm 20%, 1-1/4w	4702-112862	71450	Type 110	7		
R18	K1-S2	Res, met flm, 10k \pm 1%, 1/2w	4705-151274	75042	Type CEC- TO	1		
R19	E4-F3	Res, comp, 27k \pm 5%, 1/4w	4704-148148	01121	CB2735	REF		
R20	E2-P2	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	REF		
R21	E1-R5	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	REF		
R22	E4-S3	Res, met flm, 2.55k \pm 1%, 1/2w	4705-176362	75042	Type CEC- TO	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R23	D4-R2	Res, comp, 39k $\pm 5\%$, 1/4w	4704-188466	01121	CB3935	1		
R24	C2-Q5	Res, met flm, 383k $\pm 1\%$, 1/2w	4705-176388	75042	Type CEC- TO	1		
R25	C3-Q5	Res, met flm, 499k $\pm 1\%$, 1/2w	4705-151332	75042	Type CEC- TO	REF		
R26	B4-T1	Res, comp, 10k $\pm 5\%$, 1/4w	4704-148106	01121	CB1035	REF		
R27	C2-T4	Res, var, ww, 10k $\pm 20\%$, 1-1/4w	4702-112862	71450	Type 110	REF		
R28	B5-T1	Res, comp, 10k $\pm 5\%$, 1/4w	4704-148106	01121	CB1035	REF		
R29	D1-S2	Res, met flm, 309 Ω $\pm 1\%$, 1/2w	4705-172130	75042	Type CEC- TO	1		
R30	D4-T1	Res, met flm, 2.55k $\pm 1\%$, 1/2w	4705-176362	75042	Type CEC- TO	REF		
R31	E1-T4	Res, var, ww, 10k $\pm 20\%$, 1-1/4w	4702-112862	71450	Type 110	REF		
R32	F1-Q1	Res, car flm, 10k $\pm 1\%$, 1/2w	4703-107128	75042	Type C12	1		
R33	D1-Q1	Res, comp, 110 Ω $\pm 5\%$, 1/4w	4704-193474	01121	CB1115	2		E
R34	B5-Q1	Res, comp, 110 Ω $\pm 5\%$, 1/4w	4704-193474	01121	CB1115	REF		E
R35	H1-P1	Res, comp, 100k $\pm 5\%$, 1/4w	4704-148189	01121	CB1045	REF		
		Shield (not illustrated)	3156-232082	89536	3156-232082	1		

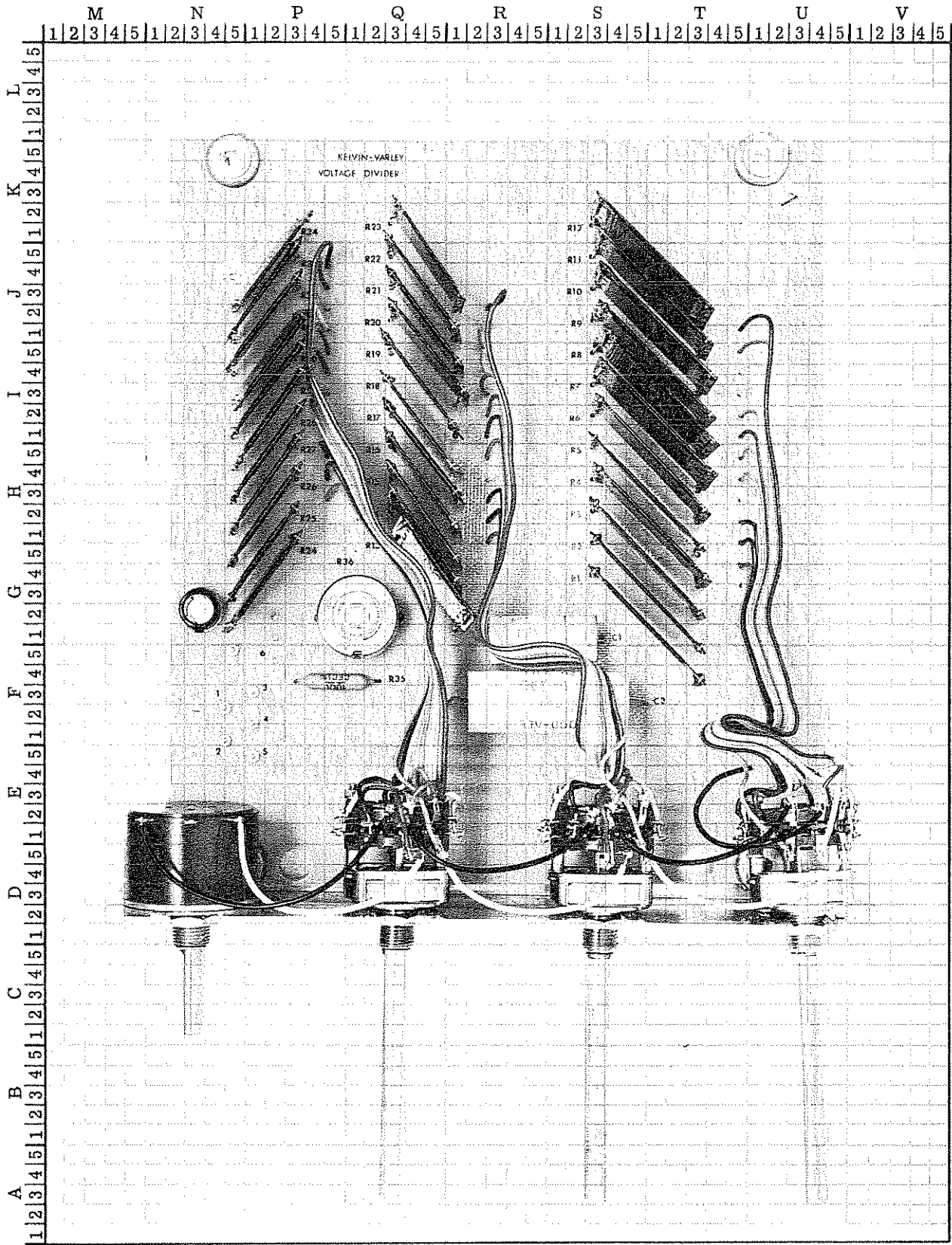



Figure 5-6. KELVIN-VARLEY P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5		KELVIN-VARLEY P/C ASSEMBLY Figure 5-6	1702-232827 (891A-4004)	89536	1702-232827	REF		
C1	G1-R4	Cap, plstc, 1uf $\pm 20\%$, 200v	1507-106450	84411	Type X663F	1		
C2	F3-R5	Cap, plstc, 1uf $\pm 20\%$, 120v	1507-193748	84411	JF-11	1		
R1	G3-S4	Res, ww, 100k						
R2	G4-S4	Res, ww, 100k						
R3	H1-S4	Res, ww, 100k						
R4	H3-S4	Res, ww, 100k						
R5	H4-S4	Res, ww, 100k						
R6	I1-S4	Res, ww, 100k						
R7	I3-S4	Res, ww, 100k						
R8	I4-S5	Res, ww, 100k						
R9	I5-S5	Res, ww, 100k						
R10	J2-S5	Res, ww, 100k						
R11	J4-S4	Res, ww, 100k						
R12	K1-S4	Res, ww, 100k						
R13	G2-R1	Res, ww, 20k						
R14	H3-Q3	Res, ww, 20k						
R15	H4-Q3	Res, ww, 20k						
R16	H5-Q3	Res, ww, 20k						
R17	H5-Q4	Res, ww, 20k						
R18	I3-Q3	Res, ww, 20k						
R19	I5-Q3	Res, ww, 20k						
R20	J2-Q3	Res, ww, 20k						
R21	J3-Q3	Res, ww, 20k						
R22	J5-Q3	Res, ww, 20k						
R23	J5-Q4	Res, ww, 20k						
R24	G5-P2	Res, ww, 4k						
R25	H1-P2	Res, ww, 4k						
R26	H3-P2	Res, ww, 4k						
R27	H5-P2	Res, ww, 4k						

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R28	I1-P2	Res, ww, 4k						
R29	I1-P1	Res, ww, 4k						
R30	I4-P2	Res, ww, 4k						
R31	I5-P2	Res, ww, 4k						
R32	J1-P1	Res, ww, 4k						
R33	J1-N5	Res, ww, 4k						
R34	J4-P1	Res, ww, 4k						
R35	F4-P5	Res, met flm, 34k $\pm 1\%$, 1/2w		4705-151241	75042	Type CEC- TO	REF	
R35	F4-P5	Res, met flm, 34.8k $\pm 1\%$, 1/2w	4705-236711	75042	TypeCEC-TO	1		F
R36	G2-P5	Res, var, ww, 10k $\pm 20\%$, 1-1/4w	4702-112862	71450	Type 110	REF		
R37	E1-N3	Res, var, ww, 10k $\pm 5\%$	4702-232868	89536	4702-232868	1		O
R37	E1-N3	Res, var, ww, 10k $\pm 5\%$	4702-338368	89536	4702-338368	1		P
S6	D4-U2	Switch, rotary, KV Dial "A"	5105-242891	89536	5105-242891	1		
S7	D4-S2	Switch, rotary, KV Dial "B"	5105-242909	89536	5105-242909	2		
S8	D4-Q4	Switch, rotary, KV Dial "C"	5105-242909	89536	5105-242909	REF		
		Cover (not illustrated)	3156-235697	89536	3156-235697	1		



R1 through R34 are factory matched for tolerance and temperature coefficient. Individual resistors can be replaced by giving model, serial number, full reference designation and all information stamped on the resistor.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7		AC CONVERTER P/C ASSEMBLY Figure 5-7	1702-250167 (893A-4001)	89536	1702-250167	REF		
C1	H1-Q3	Cap, plstc, 0.22uf ±20%, 1200v	1507-220079	84411	JF-17	1		
C2	F3-P2	Cap, plstc, 0.1uf ±20%, 250v	1507-161992	73445	C280AE/ P100K	REF		
C3	J2-Q2	Cap, elect, 200uf +50/-10%, 10v	1502-236935	73445	C426ARD200	2	1	
C4	I2-N5	Cap, Ta, 10uf ±20%, 15v	1508-193623	56289	196D106X- 0015	1		
C5	H1-P4	Cap, plstc, 0.047uf±10%, 80v	1507-195099	56289	192P4739R8	REF		
C6	G3-P4	Cap, cer, 7.5pf ±10%, 500v	1501-159939	00656	Type C1-1	2		
C7	I3-U5	Cap, mica, 100pf ±5%, 500v	1504-148494	14655	CD15F101J	1		
C8	D4-P1	Cap, Ta, 15uf ±10%, 20v	1508-153056	05397	K15C20K	1		
C9	C3-P1	Cap, mica, 220pf ±5%, 500v	1504-170423	14655	CD15F221J	2		
C10	D2-N1	Cap, mica, 10pf ±10%, 500v	1504-175216	14655	CD15C0100K	1		
C11	C3-N1	Cap, Ta, 39uf ±20%, 6v	1508-163915	56289	196D396X0006	1		
C12	B4-M4	Cap, elect, 200uf +50/-10%, 10v	1502-236935	73445	C426ARD200	REF		
C13	C1-R4	Cap, plstc, 5uf ±20%, 60v	1507-160952	72928	364W-505M	2	1	
C14	C1-S3	Cap, plstc, 5uf ±20%, 60v	1507-160952	72928	364W-505M	REF		
C15	C1-P4	Cap, var, 9-35pf, 200v	1509-153080	72982	538-002	1		
C16	E3-M5	Cap, elect, 50uf +50/-10%, 25v	1502-168823	73445	C426ARF50	REF		
C17	F3-M4	Cap, mica, 3000pf ±5%, 500v	1504-161786	14655	CD19F302J	1		
C18	I2-V1	Cap, mica, 820pf ±5%, 500v	1504-148395	14655	CD19F821J	1		
C19		Cap, mica, 150pf ±5%, 500v (below C20)	1504-148478	14655	CD15F151J	1		
C20	E4-R2	Cap, cer, 7.5pf ±10%, 500v	1501-159939	00656	Type C1-1	REF		
C21	D2-Q4	Cap, var, 0.8-10pf, 250v	1509-193912	91293	JMC2950	2		
C22	E3-Q4	Cap, var, 0.8-10pf, 250v	1509-193912	91293	JMC2950	REF		
C23	H2-P2	Cap, Ta, 22uf ±10%, 15v	1508-182816	05397	K22C15K	2		
C24	H2-M5	Cap, Ta, 22uf ±10%, 15v	1508-182816	05397	K22C15K	REF		
C25	I3-U1	Cap, mica, 220pf ±5%, 500v	1504-170423	14655	CD15F221J	REF		
CR1	F4-Q1	Diode, silicon, 100ma at 1.5v	4802-261370	22767	S1330	REF		
CR2	F5-Q1	Diode, silicon, 100ma at 1.5v	4802-261370	22767	S1330	REF		
CR3	B2-P3	Diode, silicon, 2ma at 1v	4802-161810	03877	SG5658	2	1	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR4	B3-P4	Diode, silicon, 2ma, at 1v	4802-161810	03877	SG5658	REF		
CR5	C4-P2	Diode, zener, 10v	4803-246611	07910	1N961B	2	1	
CR6	H2-N1	Diode, zener, 10v	4803-246611	07910	1N961B	REF		
Q1	F4-Q5	Tstr, silicon, FET, N-channel	4805-246066	17856	FN1215	1	1	
Q2	F5-P3	Tstr, silicon, PNP	4805-229898	04713	MFS6522	REF		
Q3	F5-P2	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
Q4	D3-N4	Tstr, silicon, PNP	4805-229898	04713	MS6522	REF		
Q5	D3-N2	Tstr, silicon, PNP	4805-229898	04713	MFS6522	REF		
Q6	C1-N1	Tstr, silicon, NPN	4805-218081	04713	MPS6520	3	1	
Q7	C4-M5	Tstr, silicon, NPN	4805-218081	04713	MFS6520	REF		
Q8	B4-N2	Tstr, silicon, NPN	4805-218081	04713	MFS6520	REF		
Q9	E4-N3	Tstr, silicon, PNP	4805-203364	07263	2N3638	REF		
Q10	D5-N1	Tstr, silicon, NPN	4805-168708	03508	2N3391	REF		
R2	E5-P2	Res, met flm, 3.16k \pm 1%, 1/8w	4705-235291	75042	Type CEA-TO	1		I
R2	E5-P2	Res, met flm, 6.34k \pm 1%, 1/8w	4705-267344	75042	Type CEA-TO	1		J
R3	I3-P1	Res, met flm, 200 Ω \pm 1%, 1/8w	4705-245340	75042	Type CEA-TO	1		
R4	I5-N5	Res, var, comp, 5k \pm 20%, 3/4w	4713-159905	73138	Type 78P	1		
R5	I1-N2	Res, met flm, 100 Ω \pm 1%, 1/8w	4705-168195	75042	Type CEA-TO	1		
R6	H2-N2	Res, met flm, 4.99k \pm 1%, 1/8w	4705-168252	75042	Type CEA-TO	1		I
R6	H2-N2	Res, met flm, 7.55k \pm 1%, 1/8w	4705-223529	75042	Type CEA-TO	1		J
R7	F3-N5	Res, met flm, 12.1k \pm 1%, 1/8w	4705-234997	75042	Type CEA-TO	1		
R8	G5-F1	Res, met flm, 52.3k \pm 1%, 1/8w	4705-237248	75042	Type CEA-TO	3		
R9	G4-P3	Res, met flm, 1k \pm 1%, 1/8w	4705-168229	75042	Type CEA-TO	1		
R10	E4-P1	Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	REF		
R11	J1-V1	Res, comp, 470 Ω \pm 5%, 1/4w	4704-147983	01121	CB4715	REF		
R12	E2-N4	Res, comp, 10k \pm 5%, 1/4w	4704-148106	01121	CB1035	REF		
R13	D3-N5	Res, comp, 100 Ω \pm 5%, 1/4w	4704-147926	01121	CB1015	REF		
R14	C5-N4	Res, met flm, 45.3k \pm 1%, 1/8w	4705-234971	75042	Type CEA-TO	1		
R15	E3-N4	Res, met flm, 21.5k \pm 1%, 1/8w	4705-168278	75042	Type CEA-TO	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R16	D1-N1	Res, comp, $1k \pm 5\%$, 1/4w	4704-148023	01121	CB1025	REF		
R17	C3-N2	Res, met flm, $32.4k \pm 1\%$, 1/8w	4705-182956	75042	Type CEA-TO	1		
R18	C2-N1	Res, comp, $1k \pm 5\%$, 1/4w	4704-148023	01121	CB1025	REF		
R19	C2-N3	Res, met flm, $121k \pm 1\%$, 1/8w	4705-229369	75042	Type CEA-TO	1		
R20	C5-M5	Res, comp, $200\Omega \pm 5\%$, 1/4w	4704-147959	01121	CB2215	1		
R21	B2-Q5	Res, met flm, $52.3k \pm 1\%$, 1/8w	4705-237248	75042	Type CEA-TO	REF		
R22	B4-Q5	Res, met flm, $52.3k \pm 1\%$, 1/8w	4705-237248	75042	Type CEA-TO	REF		
R23	B2-Q3	Res, ww, $556\Omega \pm 0.1\%$, 1/4w	4707-249292	89536	4707-249292	2		
R24	B4-Q3	Res, ww, $556\Omega \pm 0.1\%$, 1/4w	4707-249292	89536	4707-249292	REF		
R25	B5-N2	Res, comp, $2.2k \pm 5\%$, 1/4w	4704-148049	01121	CB2225	2		
R26	B4-N5	Res, comp, $22k \pm 5\%$, 1/4w	4704-148130	01121	CB2235	REF		
R27	C3-Q4	Res, ww, $125\Omega \pm 0.1\%$, 1/4w	4707-249284	89536	4707-249284	1		
R28	G3-N2	Res, met flm, $4.22k \pm 1\%$, 1/8w	4705-168245	75042	Type CEA-TO	1		
R29	F5-N2	Res, var, ww, $6k \pm 5\%$, 1-1/4w	4702-113209	71450	Type 110	REF		
R30	D4-P2	Res, met flm, $8.45k \pm 1\%$, 1/8w	4705-221671	75042	Type CEA-TO	2		
R31	C4-P5	Res, var, ww, $10k \pm 20\%$, 1-1/4w	4702-112862	71450	Type 110	REF		
R32	D5-Q5	Res, met flm, $8.45k \pm 1\%$, 1/8w	4705-221671	75042	Type CEA-TO	REF		
R33	D4-P5	Res, var, ww, $10k \pm 20\%$, 1-1/4w	4702-112862	71450	Type 110	REF		
R34	F1-Q4	Res, met flm, $7.5k \pm 1\%$, 1/8w	4705-223529	75042	Type CEA-TO	1		K L
R34	F1-Q4	Res, met flm, $6.04k \pm 1\%$, 1/8w	4705-285189	75042	Type CEA-TO	1		
R35	E4-P5	Res, var, ww, $10k \pm 20\%$, 1-1/4w	4702-112862	71450	Type 110	REF		
R36	B3-N2	Res, comp, $10k \pm 5\%$, 1/4w	4704-148106	01121	CB1035	REF		
R37	E5-R4	Res, met flm, 243k, matched set with chassis mounted R12 in Figure 5-1	4705-245597	89536	4705-245597	REF		
R38	I3-U3	Res, ww, $24.22k \pm 0.1\%$, 1/2w	4707-249326	89536	4707-249326	1		
R39	C5-R1	Res, ww, $2.311k \pm 0.1\%$, 1/2w	4707-249318	89536	4707-249318	1		
R40	E5-N2	Res, ww, $119.1\Omega \pm 0.1\%$, 1/4w	4707-249300	89536	4707-249300	1		
R41	C5-P2	Res, comp, $470\Omega \pm 5\%$, 1/4w	4704-147983	01121	CB4715	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R42	E3-N1	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R43	C5-N5	Res, comp, 270Ω ±5%, 1/4w	4704-160804	01121	CB2715	1		
R44	J1-U3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R45	D2-M4	Res, comp, 330k ±5%, 1/4w	4704-192948	01121	CB3345	1		
R46	D5-N2	Res, comp, 8.2k ±5%, 1/4w	4704-160796	01121	CB8225	1		
R47	E2-P1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R48	B5-P1	Res, comp, 100k ±5%, 1/4w	4704-148189	01121	CB1045	REF		
R49	I3-V2	Res, comp, 430Ω ±5%, 1/4w	4704-203869	01121	CB4315	1		
S9	G1-S1	Switch, rotary, RANGE, AC section	5105-246710	89536	5105-246710	1		
	H4-S1	Coupler, range switch	3153-248625	89536	3153-248625	1		

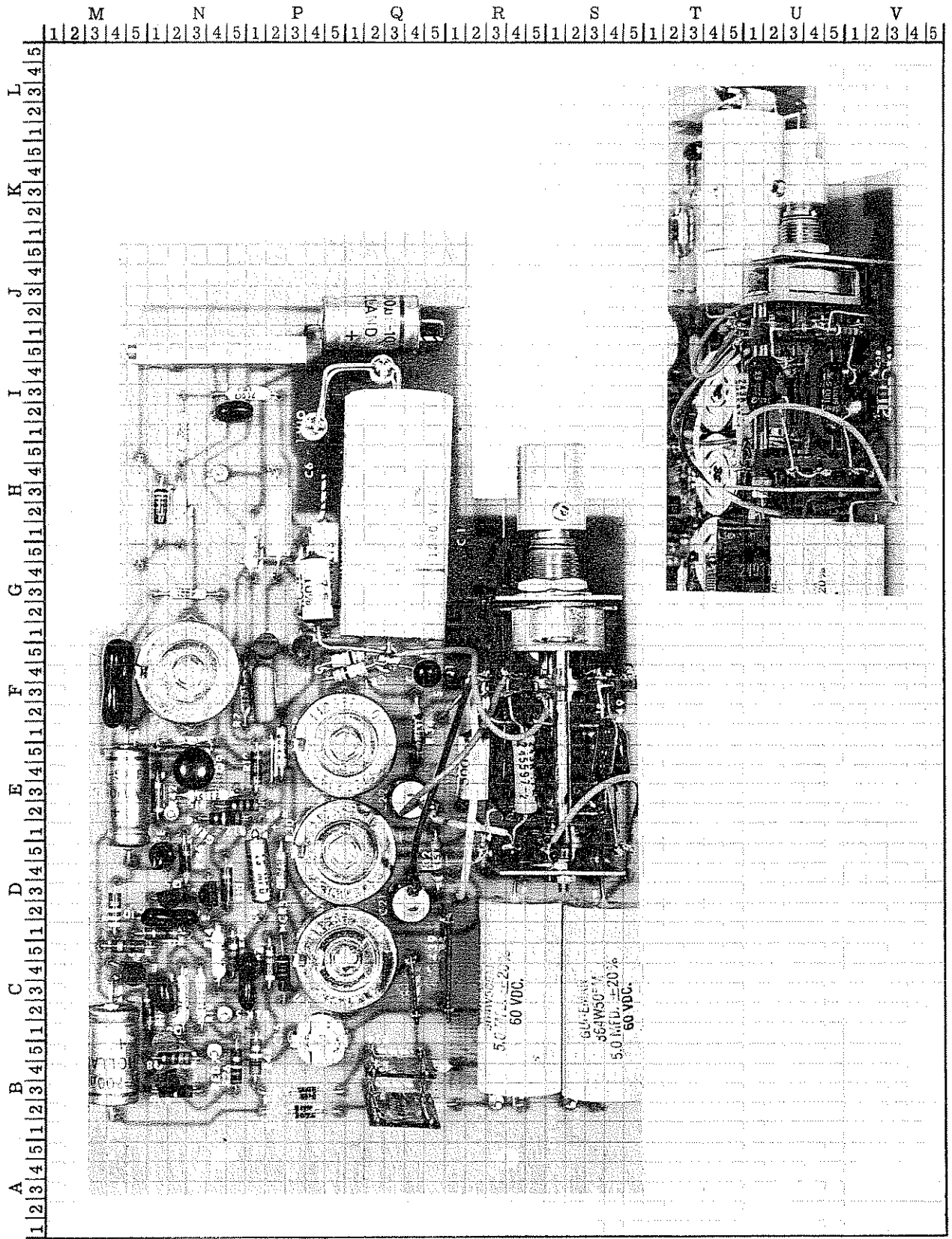


Figure 5-7. AC CONVERTER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A8		REAR PANEL ASSEMBLY (893A) Figure 5-8						
CR1		Diode, silicon, 1 amp, 100 piv	4802-116111	05277	IN4817	REF		
CR2		Diode, silicon, 1 amp, 100 piv	4802-116111	05277	IN4817	REF		
CR3		Diode, silicon, 1 amp, 100 piv (not illustrated)	4802-116111	05277	IN4817	REF		
CR4		Diode, silicon, 1 amp, 100 piv (not illustrated)	4802-116111	05277	IN4817	REF		
F1		Fuse, slow blow, 1/8 amp, 250v (for 115v operation) (not illustrated)	5101-166488	71400	Type MDL	1	2	
F1		Fuse, slow blow, 1/16 amp, 250v (for 230v operation) (not illustrated)	5101-163030	71400	Type MDL	1	2	
J4		Connector, male, 3 contact	2109-222612	82389	AC3G	1		
S5		Switch, slide	5106-226274	82389	46256-LF	1		
T1		Transformer, power	5602-223990	89536	5602-223990	1		
XF1		Holder, fuse	2102-160846	75915	342004	1		
19		Panel, rear	1406-231928	89536	1406-231928	1		

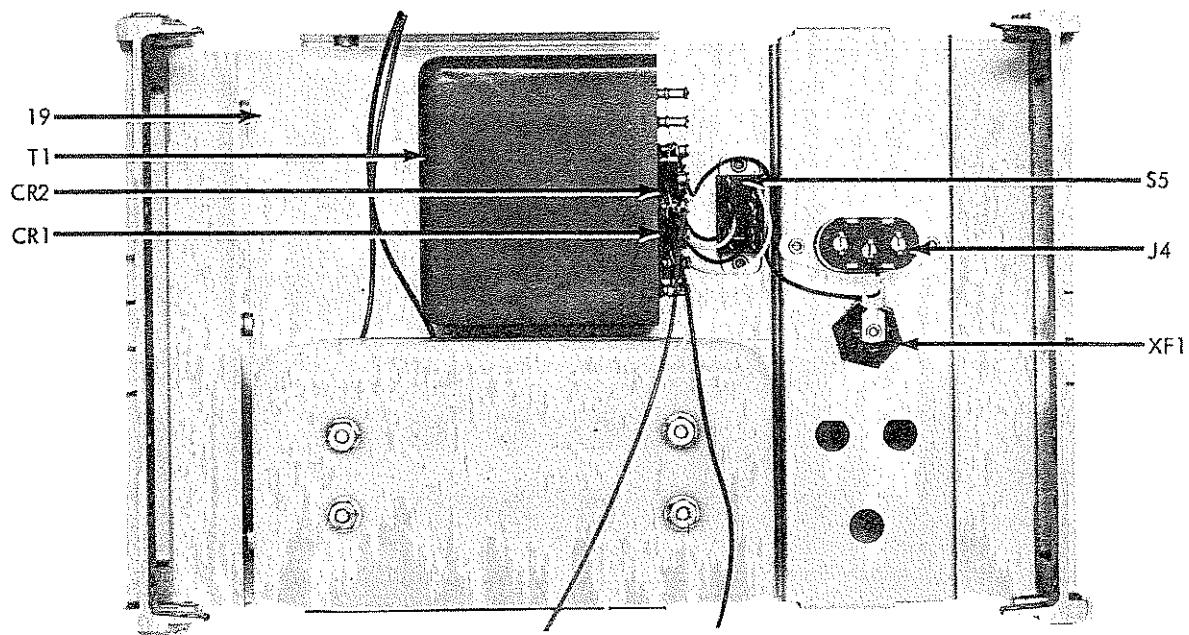


Figure 5-8. REAR PANEL ASSEMBLY (893A)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		AC/DC DIFFERENTIAL VOLTMETER Figure 5-9	893AR					
A1		Front Panel Assembly (See Figure 5-10)						
A2		Reference Amplifier P/C Assembly (See Figure 5-3)	1702-232793 (891A-4001)	89536	1702-232793	1		
A3		Reference Inverter P/C Assembly (See Figure 5-4)	1702-250175 (893A-4002)	89536	1702-250175	1		
A4		Null Detector P/C Assembly (See Figure 5-5)	1702-232819 (891A-4003)	89536	1702-232819	1		
A5		Kelvin-Varley P/C Assembly (See Figure 5-6)	1702-232827 (891A-4004)	89536	1702-232827	1		
A7		AC Converter P/C Assembly (See Figure 5-7)	1702-250167 (893A-4001)	89536	1702-250167	1		
A8		Rear Panel Assembly (see Figure 5-11)						
M1		Meter, 100-0-100ua	2901-236513	89536	2901-236513	1		
P1, P2		Line cord	6005-226100	91934	2270	1		
R1		Res, car flm, 90M $\pm 1\%$, 2w	4703-192138	75042	MEHT-X	1		
R2		Res, car flm, 9M $\pm 0.5\%$, 1w	4703-107557	75042	Type C13	1		
R3		Res, car flm, 1M $\pm 1\%$, 1/2w	4703-107219	75042	Type C12	1		
R4		Res, car flm, 90k $\pm 0.5\%$, 1/2w	4703-107292	75042	Type C12	1		
R5		Res, car flm, 9k $\pm 0.5\%$, 1/2w	4703-107250	75042	Type C12	1		
R6		Res, car flm, 900 Ω $\pm 0.5\%$, 1/2w	4703-107771	75042	Type C12	1		
R7		Res, car flm, 100 Ω $\pm 0.5\%$, 1/2w	4703-107730	75042	Type C12	1		
R9		Res, comp, 1k $\pm 10\%$, 1w	4704-109371	01121	GB1021	1		
R12		Res, met flm, 1M, matched set with A7R37	4705-245597	89536	4705-245597	1		
R13,R14		Res, met flm, 100k $\pm 1\%$, 1/2w	4705-151316	75042	Type CEC-TO	2		
S1		Switch, rotary, RANGE, DC Section	5105-254573	89536	5105-254573	1		D
S2		Switch, rotary, POWER	5105-242917	89536	5105-242917	1		
S3		Switch, rotary, NULL	5105-242875	89536	5105-242875	1		
S4		Switch, rotary, MODE	5105-250555	89536	5105-250555	1		
S4A		Switch wafer, MODE, deck "A"	5105-250530	89536	5105-250530	1		
20		Coupler, power switch, mode wafer	2404-104505	89536	2402-104505	2		
21		Cover, bottom (not illustrated)	3156-230383	89536	3156-230383	1		

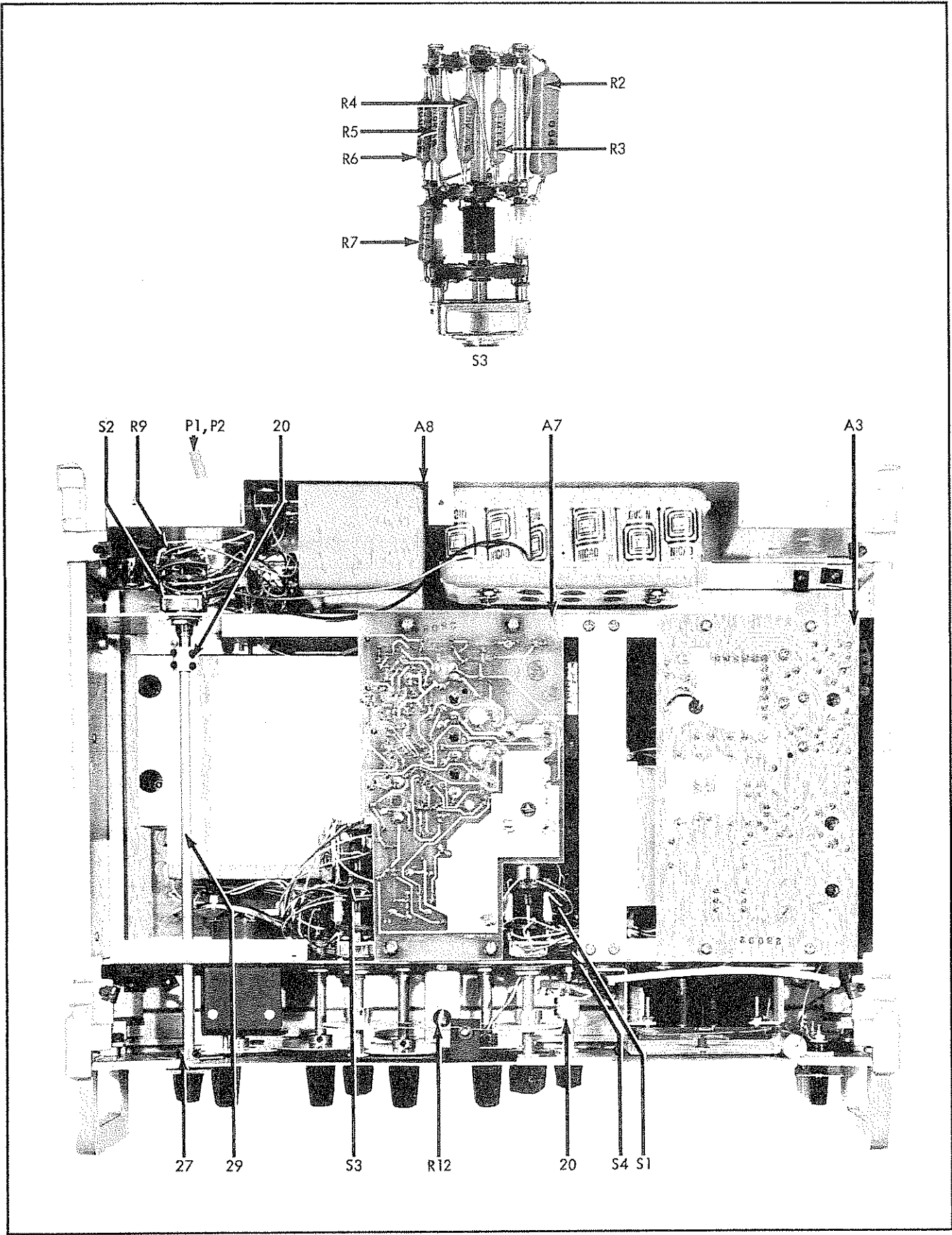


Figure 5-9. 893AR AC/DC DIFFERENTIAL VOLTMETER (Sheet 1 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
22		Cover, top (not illustrated)	3156-230375	89536	3156-230375	1		
23		Dial, 0-9	2403-232215	89536	2403-232215	2		
24		Dial, 0-10	2403-232207	89536	2403-232207	1		
25		Dial, 0-100	2403-242859	89536	2403-242895	1		
26		Foot, plastic (not illustrated)	3155-230037	89536	3155-230037	4		
27		Indicator, ON-OFF flag	3158-231886	89536	3158-231886	1		
28		Rack Mounting Kit (not illustrated)	2906-243287	89536	2906-243287	1		
29		Shaft, power switch	2406-231860	89536	2406-231860	1		
30		Tilt stand (not illustrated)	3154-231407	89536	3154-231407	1		
31		Trim strip, front (not illustrated)	3154-230813	89536	3154-230813	2		
32		Trim strip, rear (not illustrated)	3156-231852	89536	3156-231852	2		
33		Trim strip, side insert (not illustrated)	3155-230888	89536	3155-230888	2		

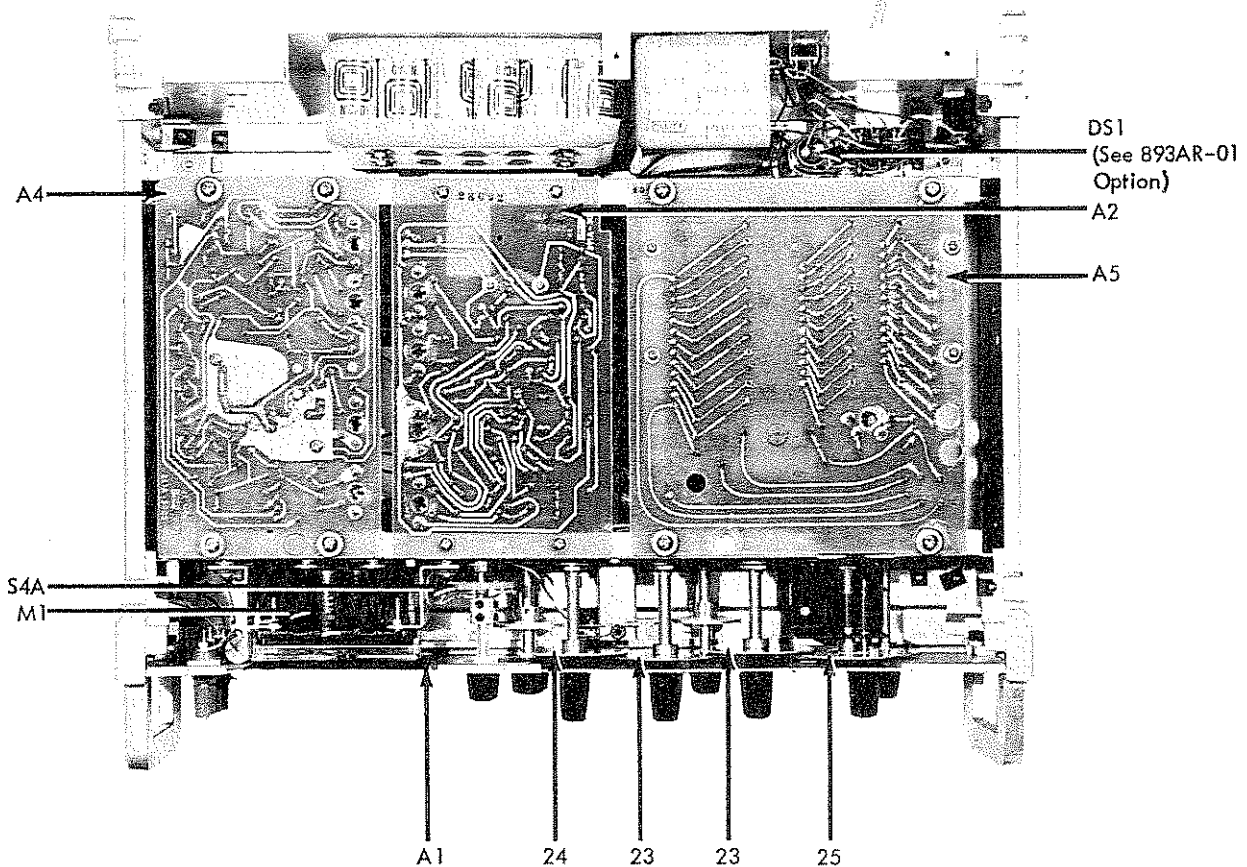


Figure 5-9. 893AR AC/DC DIFFERENTIAL VOLTMETER (Sheet 2 of 2)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		FRONT PANEL ASSEMBLY (893AR) Figure 5-10						
C1		Cap, plstc, 0.047uf $\pm 20\%$, 1.2kv (across J2 and J3)	1507-182683	99217	MR473L12	2		
J1		Binding post, red, HI	2811-226308	58474	DF21RC	2		
J2		Binding post, red, LO	2811-226308	58474	DF21RC	2	REF	
J3		Binding post, black, GROUND	2811-226282	58474	DF21BC	1		
R8		Res, comp, 100M $\pm 10\%$, 1/2w (across J2 and J3)	4704-190520	01121	EB1071	1		
34		Handle	2404-246306	89536	2404-246306	2		
35		Knob, Digit	2405-158949	89536	2405-158949	4		
36		Knob, NULL SENS, MODE, RANGE	2405-158956	89536	2405-158956	3		
37		Knob, POWER	2405-235689	89536	2405-235689	1		
38		Link, shorting	2811-101220	24655	938L	1		
39		Panel, front	1406-244673	89536	1406-244673	1		

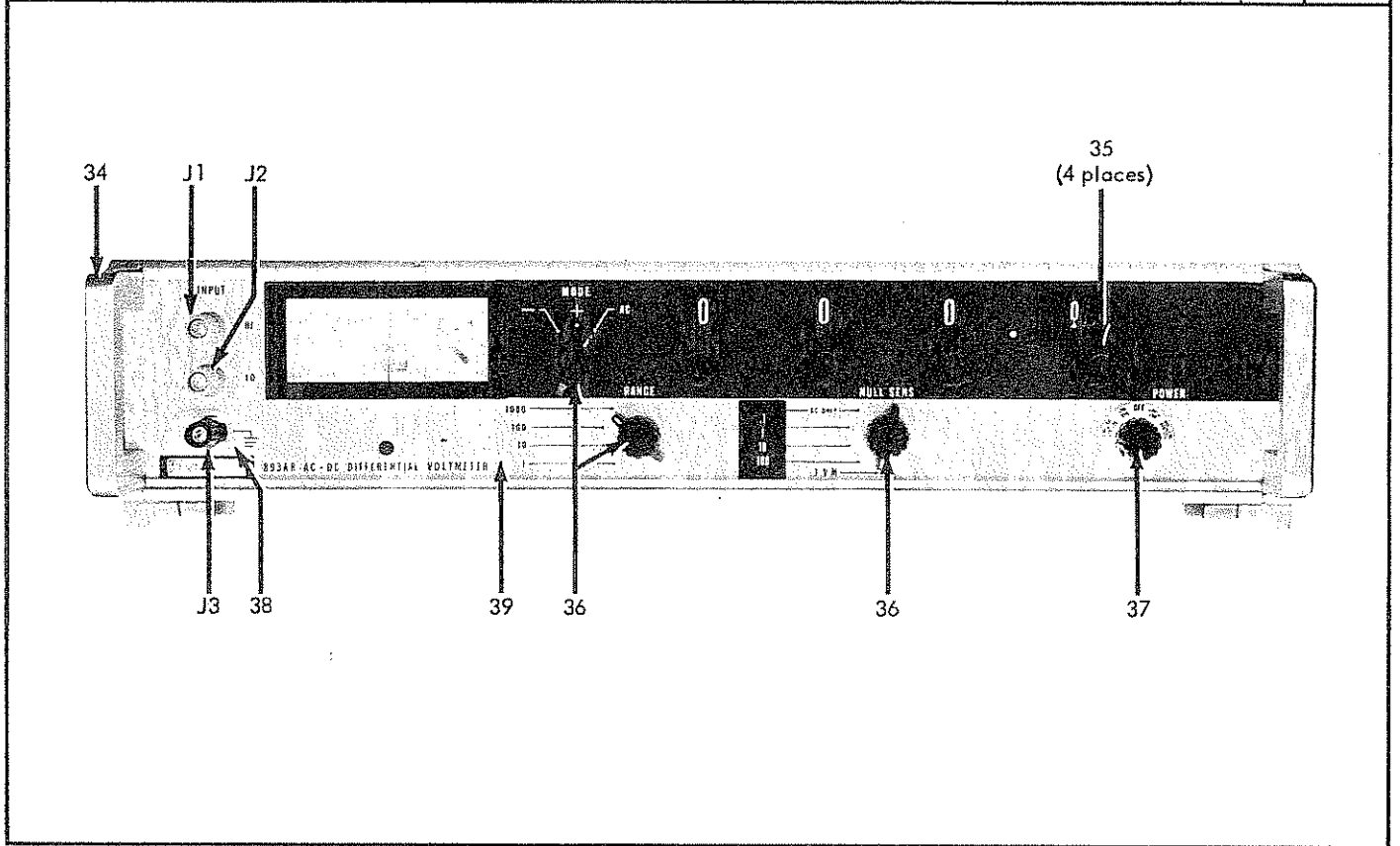


Figure 5-10. FRONT PANEL ASSEMBLY (893AR)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7		REAR PANEL ASSEMBLY (893AR) Figure 5-11						
CR1		Diode, silicon, 1 amp, 100 piv	4802-116111	05277	IN4817	REF		
CR2		Diode, silicon, 1 amp, 100 piv	4802-116111	05277	IN4817	REF		
CR3		Diode, silicon, 1 amp, 100 piv (not illustrated)	4802-116111	05277	IN4817	REF		
CR4		Diode, silicon, 1 amp, 100 piv (not illustrated)	4802-116111	05277	IN4817	REF		
F1		Fuse, slow blow, 1/8 amp, 250v (for 115v operation) (not illustrated)	5101-166488	71400	Type MDL	1	2	
F1		Fuse, slow blow, 1/16 amp, 250v (for 230v operation) (not illustrated)	5101-163030	71400	Type MDL	1	2	
J4		Connector, male, 3 contact	2109-222612	82389	AC3G	1		
S5		Switch, slide	5106-226274	82389	46256-LF	1		
T1		Transformer, power	5602-223990	89536	5602-223990	1		
XF1		Holder, fuse	2102-160846	75915	342004	1		
40		Panel, rear	1406-231795	89536	1406-231795	1		

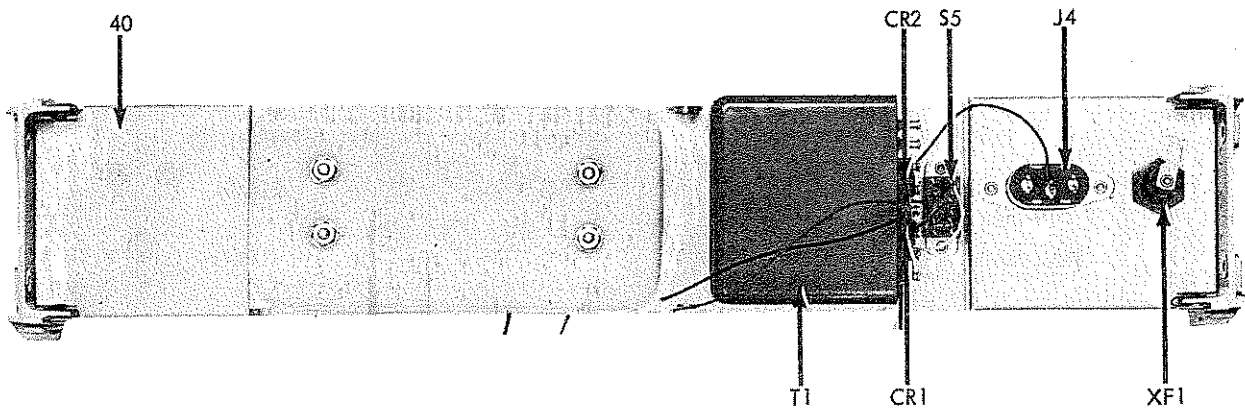


Figure 5-11. REAR PANEL ASSEMBLY (893AR)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		AC/DC DIFFERENTIAL VOLTMETER - BATTERY OPTION - Figure 5-12	893A-01 893AR-01					
		Note: The basic Model 893A or 893AR can be modified in the field by installing the Battery Option Kit, part number 2906- 242420. The kit includes BTI, DSI and the power knob.						
BT1		Battery pack	3158-232496	89536	3158-232496	1		
		Battery, Ni-Cad, 1.2v	4002-160390	06860	L 2SCL	18		
		Holder, battery	3155-232488	89536	3155-232488	2		
DS1		Lamp, incandescent, 24v (See Figures 5-1 and 5-9)	3901-218354	71744	1252	1		
		Knob, POWER	2405-235671	89536	2405-235671	1		
		AC/DC DIFFERENTIAL VOLTMETER - RECORDER OUTPUT OPTION Figure 5-12	893A-02 893AR-02					
		Note: The basic Model 893A or 893AR can be modified in the field by installing the Recorder Output Option Kit, part number 2906-242438. The kit includes J5, J6, R10, R11, and the A6 P/C assembly.						
A6		Recorder Output P/C Assembly (See Figure 5-12)	1702-239301 (891A-4201)	89536	1702-239301	1		
J5		Binding post, red, HI	2811-226308	58474	DF21RC	1		
J6		Binding post, black, LO	2811-226282	58474	DF21BC	1		
R10		Res, var, comp, 10k \pm 20%, 1/2w	4701-162800	12697	Series 37	1		
R11		Res, comp, 10k \pm 5%, 1/4w (mounted on R10)	4704-148106	01121	CB1035	1		M
R11		Res, comp, 1k \pm 5%, 1/4w	4704-148023	01121	CB1025	1		N
A6		RECORDER OUTPUT P/C ASSEMBLY Figure 5-12	1702-239301 (891A-4201)	89536	1702-239301	REF		
C1		Cap, elect, 10uf +50/-10%, 25v	1502-170266	73445	C426ARF10	1	1	
Q1		Tsts, germanium, PNP	4805-182709	01295	GA3938	2	1	
Q2		Tstr, germanium, NPN	4805-182691	01295	GA3937	2	1	
Q3		Tstr, germanium, PNP	4805-182709	01295	GA3938	REF		
Q4		Tstr, germanium, NPN	4805-182691	01295	GA3937	REF		

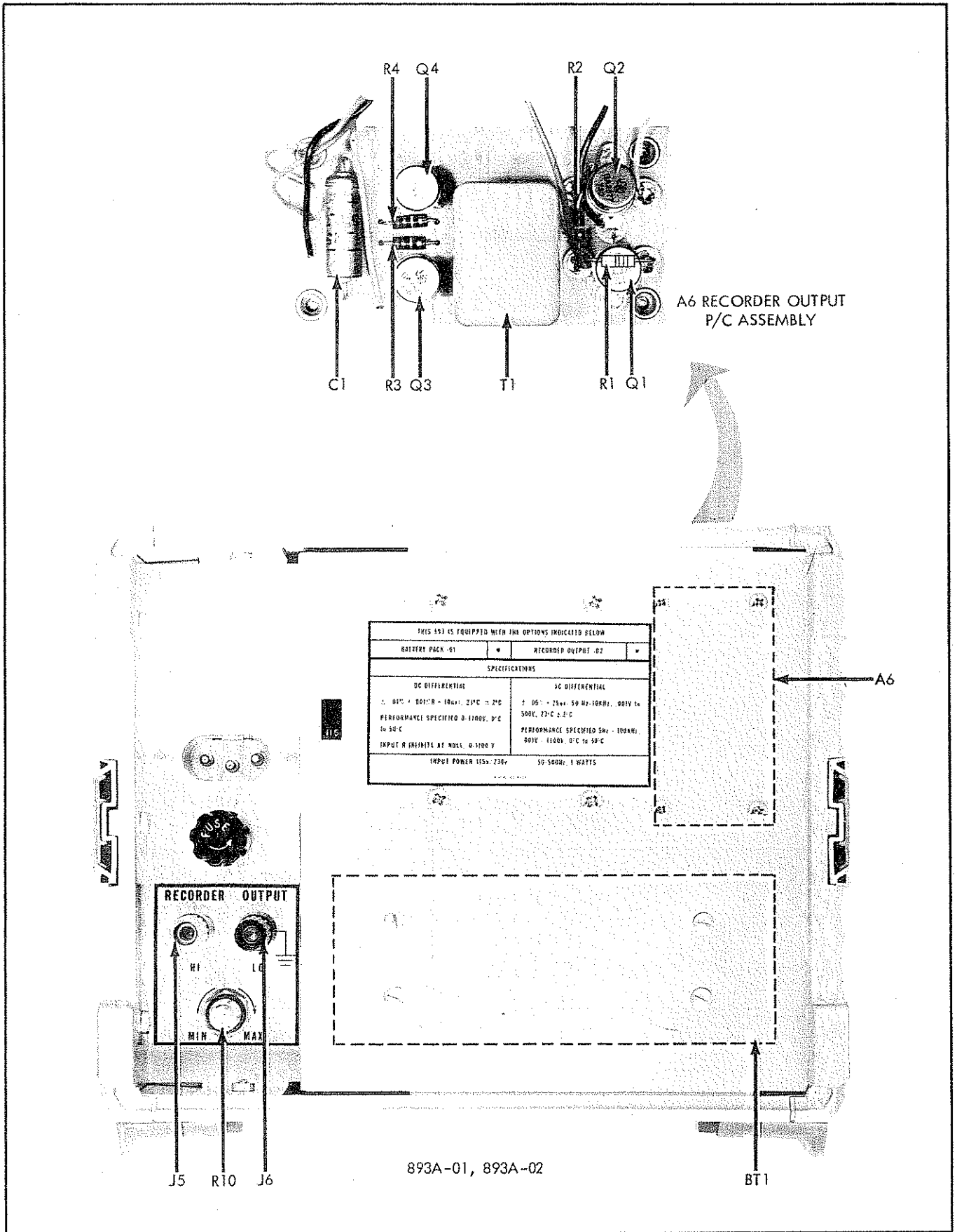
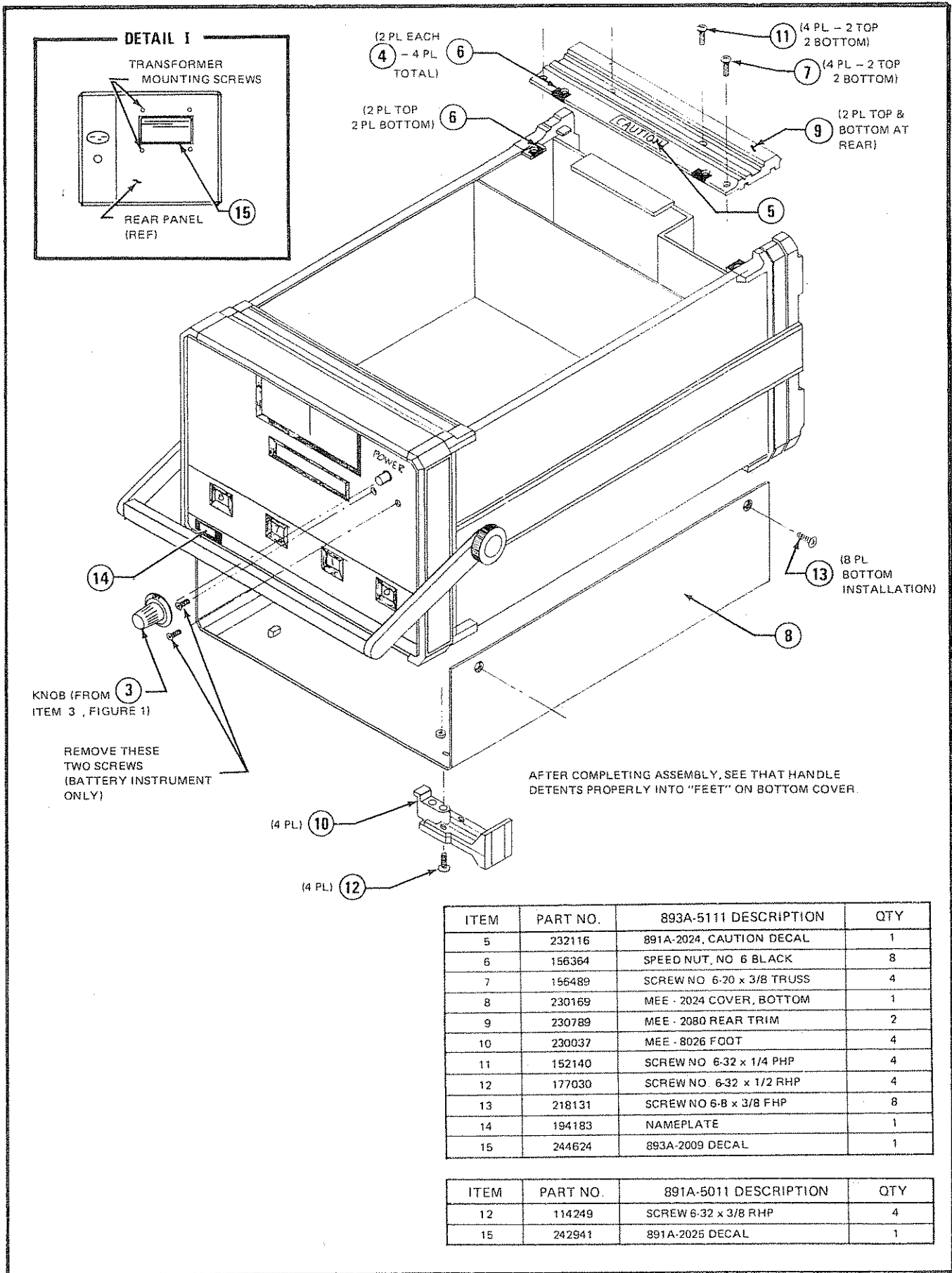
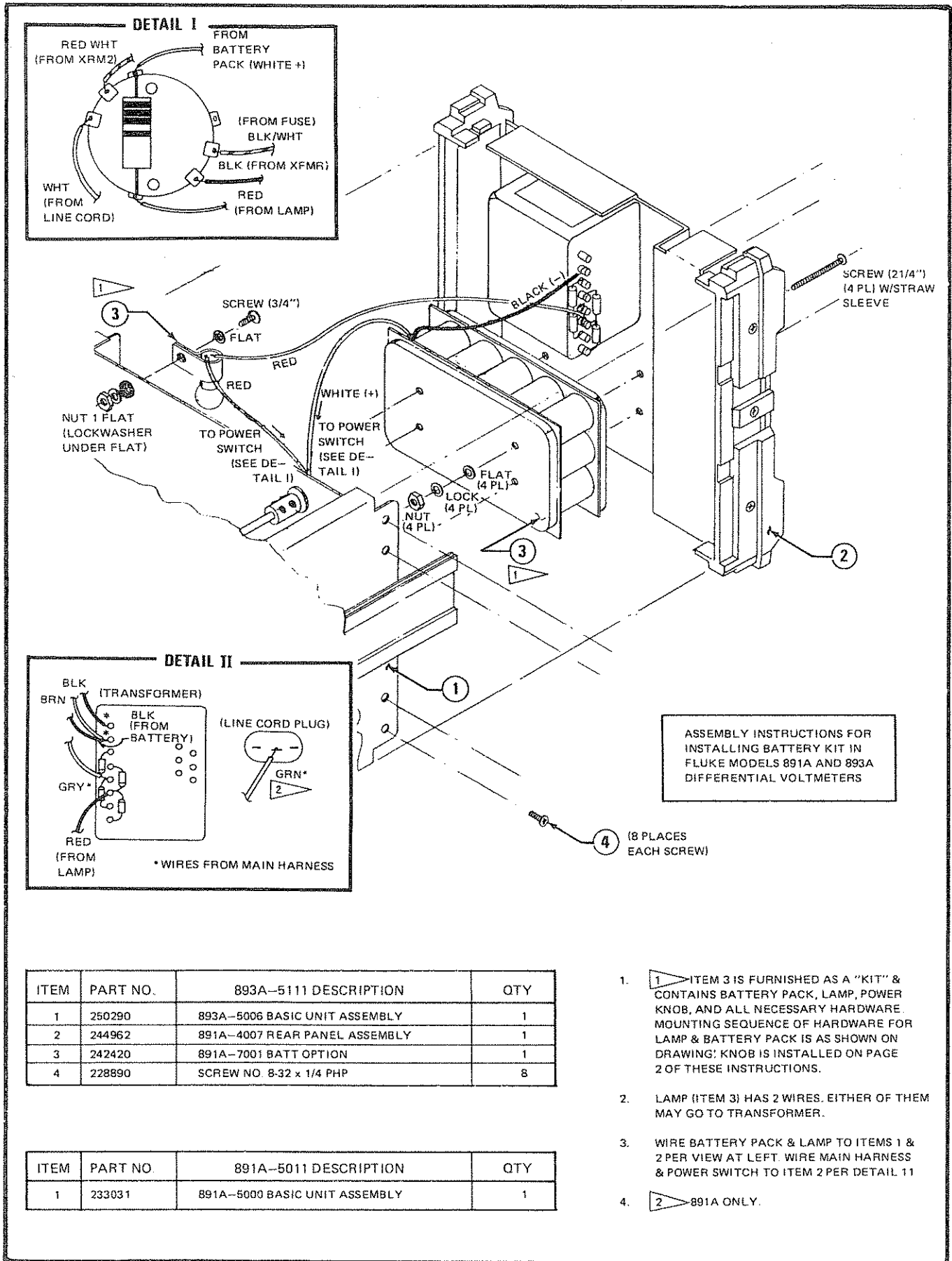


Figure 5-12. BATTERY AND RECORDER OUTPUT OPTIONS

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R1		Res, comp, 22k \pm 5%, 1/4w	4704-148130	01121	CB2235	4		
R2		Res, comp, 22k \pm 5%, 1/4w	4704-148130	01121	CB2235	REF		
R3		Res, comp, 22k \pm 5%, 1/4w	4704-148130	01121	CB2235	REF		
R4		Res, comp, 22k \pm 5%, 1/4w	4704-148130	01121	CB2235	REF		
T1		Transformer, recorder output	5602-242347	89536	5602-242347	1		





ASSEMBLY INSTRUCTIONS FOR
INSTALLING BATTERY KIT IN
FLUKE MODELS 891A AND 893A
DIFFERENTIAL VOLTMETERS

ITEM	PART NO.	893A-5111 DESCRIPTION	QTY
1	250290	893A-5006 BASIC UNIT ASSEMBLY	1
2	244962	891A-4007 REAR PANEL ASSEMBLY	1
3	242420	891A-7001 BATT OPTION	1
4	228890	SCREW NO. 8-32 x 1/4 PHP	8

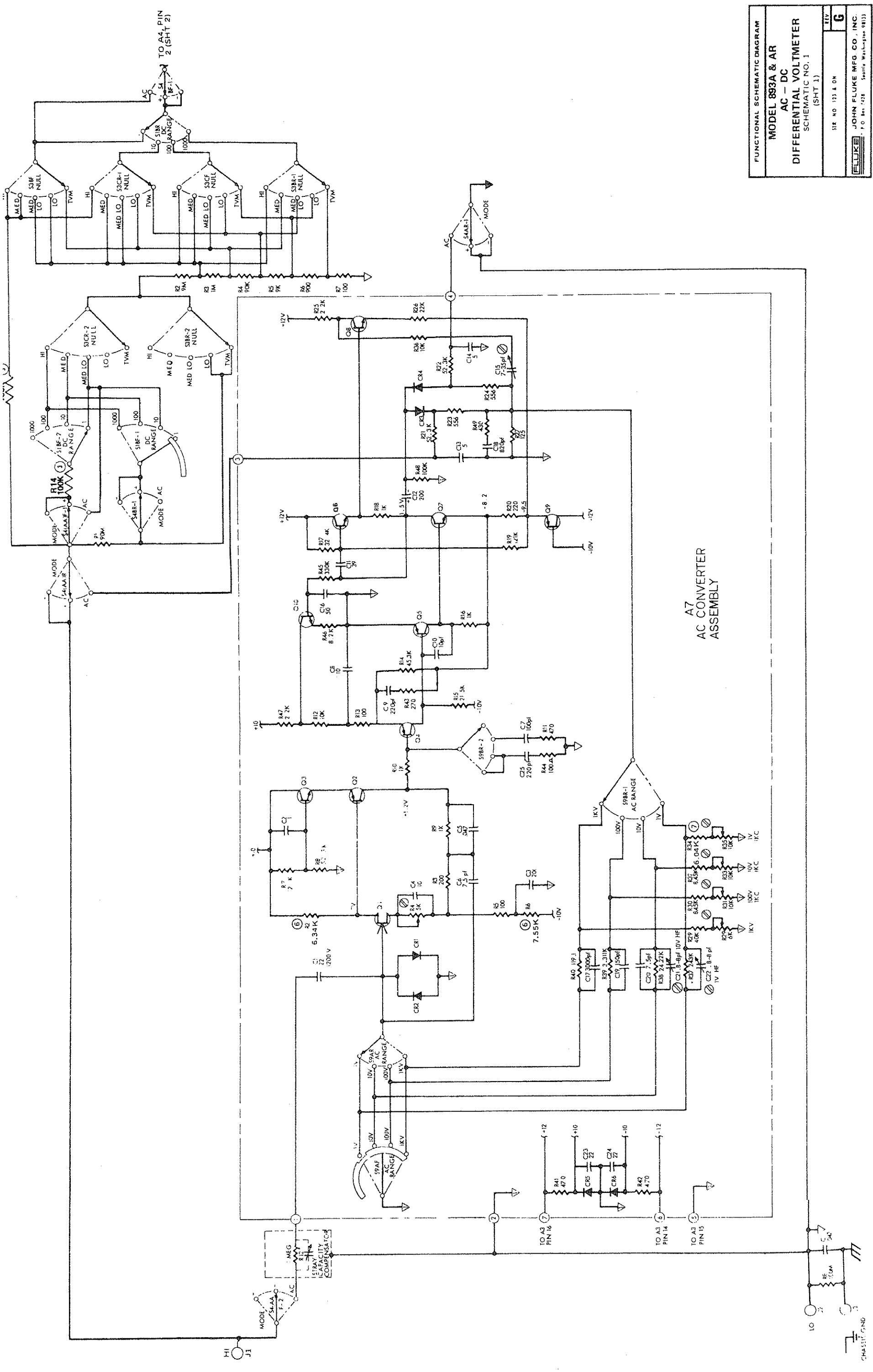
ITEM	PART NO.	891A-5011 DESCRIPTION	QTY
1	233031	891A-5000 BASIC UNIT ASSEMBLY	1

1. ITEM 3 IS FURNISHED AS A "KIT" & CONTAINS BATTERY PACK, LAMP, POWER KNOB, AND ALL NECESSARY HARDWARE. MOUNTING SEQUENCE OF HARDWARE FOR LAMP & BATTERY PACK IS AS SHOWN ON DRAWING; KNOB IS INSTALLED ON PAGE 2 OF THESE INSTRUCTIONS.
2. LAMP (ITEM 3) HAS 2 WIRES. EITHER OF THEM MAY GO TO TRANSFORMER.
3. WIRE BATTERY PACK & LAMP TO ITEMS 1 & 2 PER VIEW AT LEFT. WIRE MAIN HARNESS & POWER SWITCH TO ITEM 2 PER DETAIL 11
4. 891A ONLY.

5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the Model 893A and 893AR. 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.

USE CODE	EFFECTIVITY
NO CODE	Model 893A and 893AR Serial number 123 and on.
A	Model 893A serial number 123 thru 168. Model 893AR serial number 123 thru 153.
B	Model 893A serial number 169 and on. Model 893AR serial number 154 and on.
C	Model 893A serial number 123 thru 170. Model 893AR serial number 123 thru 203.
D	Model 893A serial number 171 thru 508. Model 893AR serial number 204 thru 254.
E	Model 893A serial number 123 thru 243. Model 893AR serial number 123 thru 203.
F	Model 893A serial number 244 and on. Model 893AR serial number 204 and on.
G	Model 893A serial number 509 and on. Model 893AR serial number 255 and on.
H	Model 893A serial number 171 thru 1503. Model 893AR serial number 204 thru 353.
I	Model 893 serial number 123 thru 988.
J	Model 893 serial number 989 and on.
K	Model 893 serial number 123 thru 1353.
L	Model 893 serial number 1354 and on.
M	Model 893 serial number 123 and on.
N	Model 893A/AC only.
O	Model 893 serial number 123 thru 1863.
P	Model 893 serial number 1864 and on.



FUNCTIONAL SCHEMATIC DIAGRAM
MODEL 893A & AR
AC - DC
DIFFERENTIAL VOLTMETER
 SCHEMATIC NO. 1
 (SHT 1)

SEE NO 173 & ON
FLUKE
 JOHN FLUKE MFG CO INC
 P.O. Box 1028 Seattle, Washington 98133

R13



BELOW IS A BRIEF EXPLANATION OF THE COMPLETE REFERENCE DESIGNATIONS OF SWITCHES S1 THRU S4 NULL SWITCH S3B-2 IS USED AS AN EXAMPLE

- (S2) THE BASIC REFERENCE DESIGNATION
- (S1) THE SWITCH DECK LOCATION AS VIEWED FROM THE FRONT-PANEL. 'B' IS THE SECOND DECK FROM THE FRONT-PANEL OF SWITCH S1.
- (R) 'R' INDICATES THE REAR SECTION OF THE ABOVE DECK. AN 'F' INDICATES THE FRONT SECTION.
- (1-2) INDICATES WHICH FUNCTION OF THE ABOVE DECK SECTION IS ILLUSTRATED. NO NUMBER IN THIS POSITION INDICATES THAT ONLY ONE FUNCTION IS ACCOMPLISHED BY THE DECK SECTION.

ALL VOLTAGE MEASUREMENTS SHOWN ARE TAKEN UNDER THE FOLLOWING CONDITIONS:

- (A) POWER SWITCH IN LINE OPERATE
- (B) LINE VOLTAGE AT 115.730 VOLTS, 50-60 HERTZ
- (C) ALL VOLTAGES MEASURED WITH A 2% 10 MEG OHM VOLTMETER FROM SPECIFIED TERMINAL TO REFERENCE SUPPLY-NULL DETECTOR COMMON. THE COMMON POINT IS REFERENCE SUPPLY-NULL DETECTOR COMMON WHEN IN THE TVM MODE OR WHEN IN A NULL MODE WITH ALL VOLTAGE DIALS SET TO C AND MODE SWITCH SET TO C.
- (D) SOME VOLTAGES MAY VARY AS MUCH AS 15 TO 20%.
- (E) BIAS VOLTAGES. DIFFERENCE BETWEEN EMITTER AND BASE VOLTAGES SHOULD REMAIN APPROXIMATELY THE SAME.
- (F) ALL VOLTAGES ARE DC UNLESS OTHERWISE INDICATED.

POWER SWITCH (S2) POSITIONS WITHIN DASHED LINES ARE USED ONLY IN UNITS CONTAINING THE OPTIONAL RECHARGEABLE BATTERY SUPPLY

ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE INDICATED

FLAGS WITH THE SAME NUMBERS ARE CONNECTED

TEST POINT

INTERNAL ADJUSTMENT

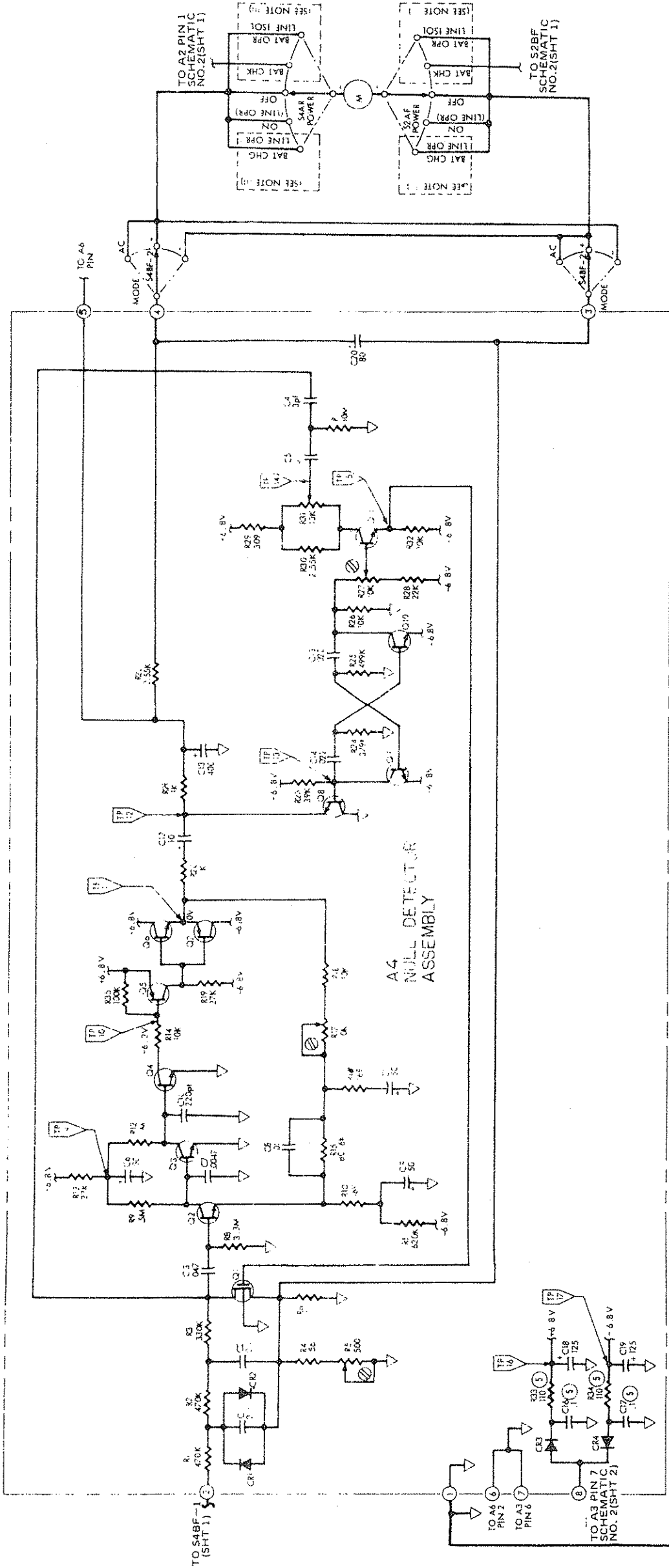
* FACTORY SELECTED COMPONENT

REFERENCE SUPPLY COMMON

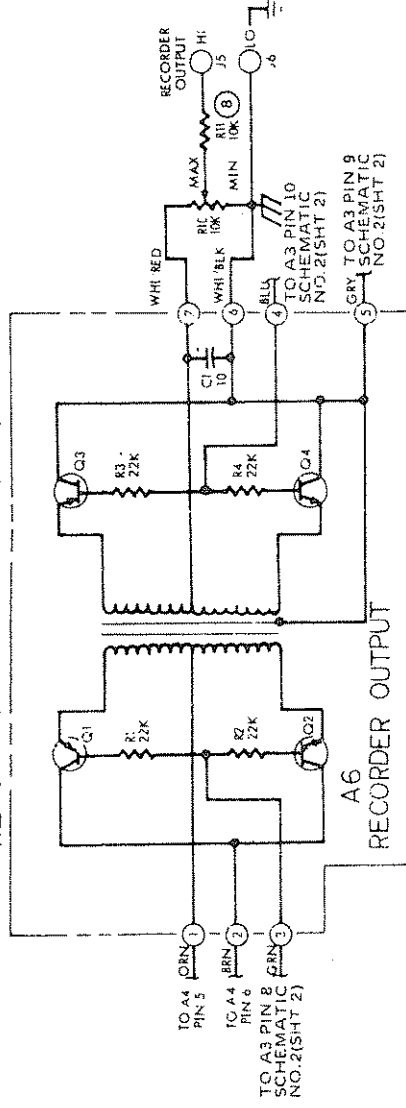
NULL DETECTOR COMMON

DC REFERENCE COMMON

LO INPUT COMMON

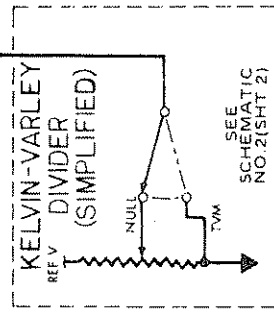


RECORDER OUTPUT OPTION -02



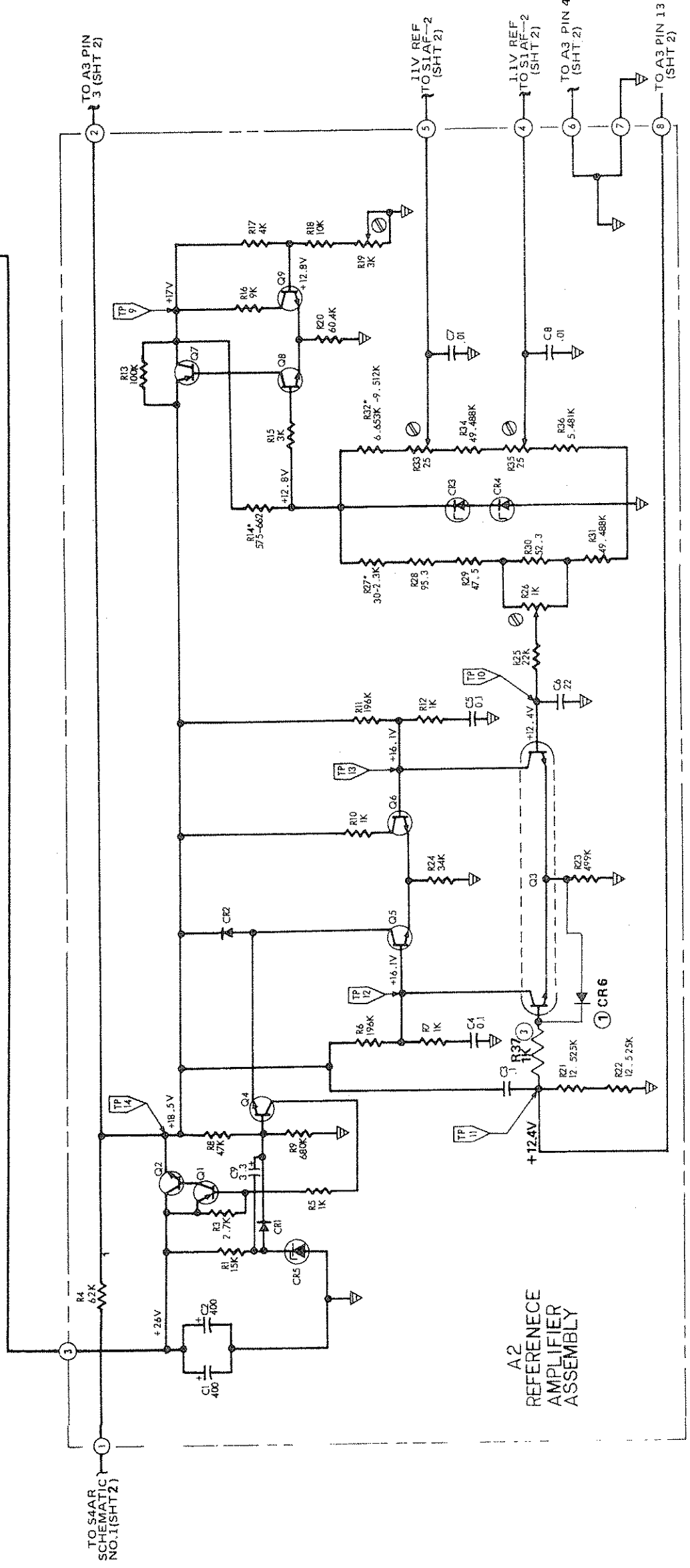
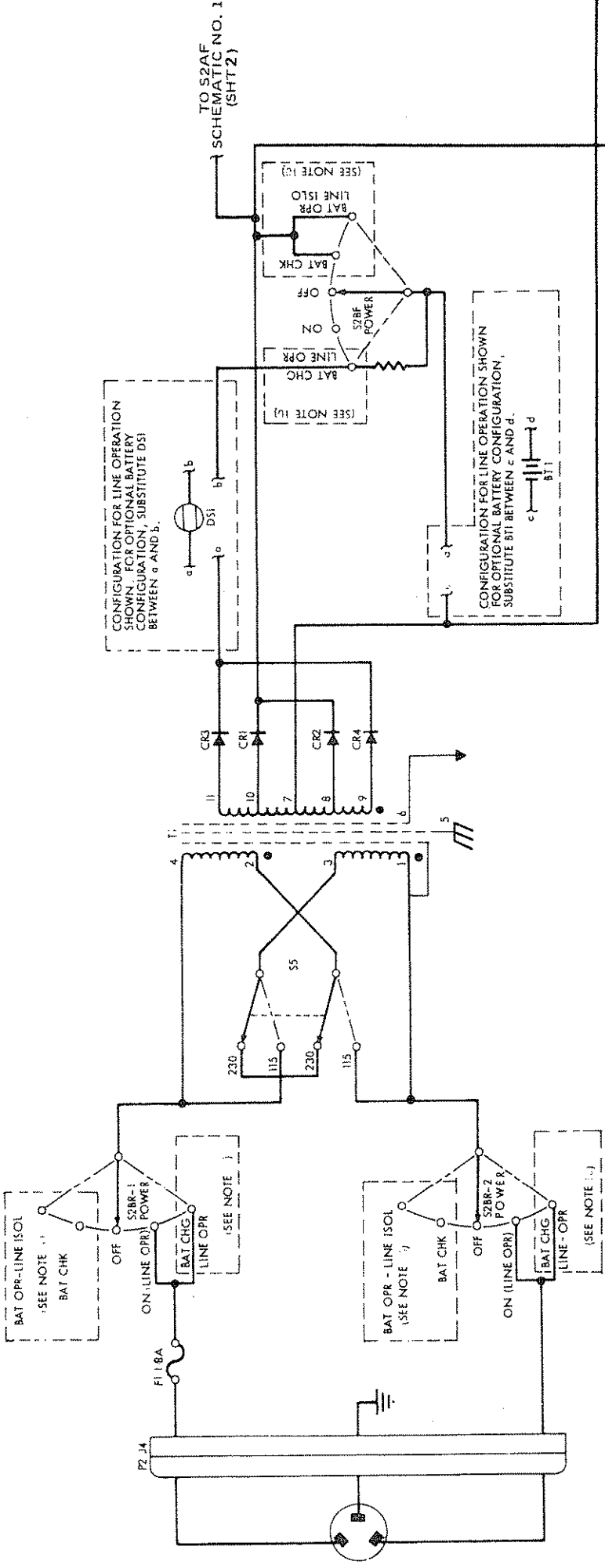
CHANGES:

- ① 893A S/N 169 AND ON: 893AR S/N 154 AND ON: A2CR6 ADDED
- ② 893A S/N 123 THRU 170: 893AR S/N 123 THRU 203: A3L1 WAS 470uh
- ③ 893A S/N 171 AND ON: 893AR S/N 204 AND ON: R13, R14 ADDED A2R37 ADDED A3C12 ADDED A3L2 ADDED A3R16, R17, R18 ADDED
- ④ 893A S/N 123 THRU 243: 893AR S/N 123 THRU 203: A6R35 WAS 34K
- ⑤ 893A S/N 244 AND ON: 893AR S/N 204 AND ON: A4C16, C17 DELETED A4R33, R34 DELETED
- ⑥ 893 S/N 123 THRU 988: A7R2 WAS 3.16K A7R6 WAS 4.99K
- ⑦ 893 S/N 123 THRU 1353: A7R34 WAS 7.5K
- ⑧ 893A/AC A6R11 IS 1K



FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 893A & AR	
AC - DC	
DIFFERENTIAL VOLTMETER	
SCHEMATIC NO. 1	
(SHT 2)	
SER. NO. 123 & ON	REV. 6
FLUKE JOHN FLUKE MFG. CO., INC. Seattle, Washington 98133	





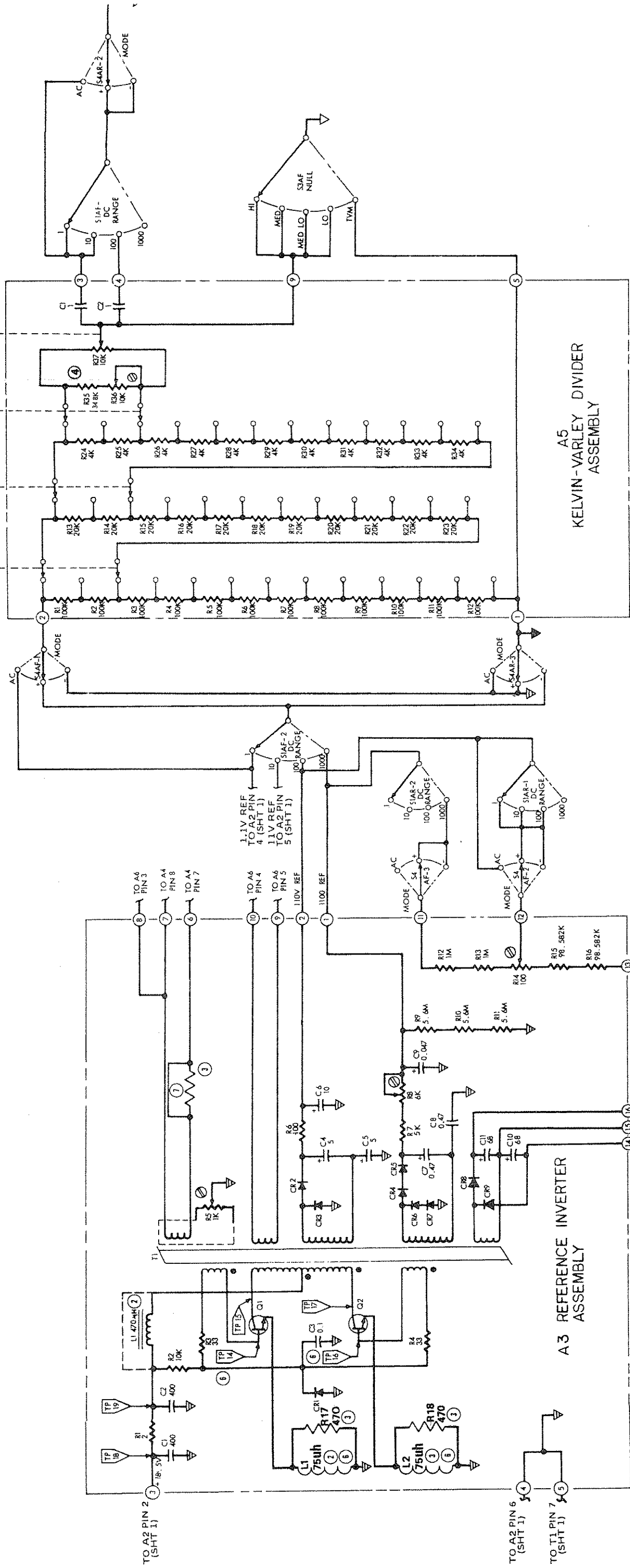
FRONT PANEL READOUT DIALS:

1ST DIAL 56

2ND DIAL 57

3RD DIAL 58

4TH DIAL



A5
KELVIN-VARLEY DIVIDER
ASSEMBLY

A3 REFERENCE INVERTER
ASSEMBLY

CHANGES:

- ① 893A S/N 169 AND ON
893AR S/N 154 AND ON:
A2CR6 ADDED
- ② 893A S/N 123 THRU 170:
893AR S/N 123 THRU 203
A3L1 WAS 470 µh
- ③ 893A S/N 171 AND ON
893AR S/N 204 AND ON:
R13, R14 ADDED
A2R37 ADDED
A3C12 ADDED
A3L2 ADDED
A3R17, R18, R19 ADDED
- ④ 893A S/N 123 THRU 243:
893AR S/N 123 THRU 203:
A5R35 WAS 34K
- ⑤ 893A S/N 244 AND ON:
893AR S/N 204 AND ON:
A4C16, C17 DELETED
A4R33, R34 DELETED
- ⑥ 893A S/N 509 AND ON:
893AR S/N 255 AND ON:
A3TP14 and TP16 DELETED
A3L1 AND A3L2 WERE 47 µh
- ⑦ 893A S/N 1504 AND ON:
893AR S/N 354 AND ON:
A3C12 DELETED
A3R19 DELETED

FUNCTIONAL SCHEMATIC DIAGRAM	
MODEL 893A & AR	
AC - DC	
DIFFERENTIAL VOLTMETER	
SCHEMATIC NO.2 (SHT 2)	
REV.	G
SEE NO 173 & ON	
JOHN FLUKE MFG. CO., INC. P. O. Box 7478 Seattle, Washington 98133	

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	03877	Transitron Electronic Corp. Wakefield, Massachusetts	05397	Union Carbide Corp Electronics Div. New York, New York	07263	Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California
00327	Welwyn International, Inc Westlake, Ohio	03888	Pyrofilm Resistor Co., Inc. Cedar Knolls, New Jersey	05571	Sprague Electric Co. Pacific Div. Los Angeles, California	07344	Bircher Co., Inc Rochester, New York
00656	Aerovox Corp. New Bedford, Massachusetts	03911	Clairax Corp New York, New York	05574	Viking Industries Chatsworth, California	07792	Lerna Engineering Corp. Northampton, Massachusetts
00686	Film Capacitors Passaic, New Jersey	03980	Muirhead Instruments, Inc. Mountainside, New Jersey	05704	Alac, Inc Glendale, California	07910	Teledyne Corp. (Continental Device) Hawthorne, California
00779	AMP Inc Harrisburg, Pennsylvania	04009	Arrow Hart and Hegemen Electronic Company Hartford, Connecticut	05820	Wakefield Engineering Ind Wakefield, Massachusetts	08225	Industro Transistor Corp. Long Island City, New York
01121	Allen-Bradley Co. Milwaukee, Wisconsin	04062	Replaced by 72136	06001	General Electric Company Capacitor Department Irmo, South Carolina	08530	Reliance Mica Corp. Brooklyn, New York
01281	TRW Semiconductors Lawndale, California	04202	Replaced by 81312	06136	Replaced by 63743	08792	Discontinued
01295	Texas Instruments, Inc. Semiconductor Components Div. Dallas, Texas	04217	Essex Wire Corp Wire & Cable Div Anaheim, California	06473	Amphenol Space & Missile Sys. Chatsworth, California	08806	General Electric Co. Miniature Lamp Dept. Cleveland, Ohio
01686	RCL Electronics Inc Manchester, New Hampshire	04221	Aemco, Div of Midtex Inc. Mankato, Minnesota	06555	Beede Electrical Instrument Co. Penacook, New Hampshire	08863	Nylomatic Corp. Norrisville, Pennsylvania
01730	Deleted	04222	Aerovox Corp. (H-Q) Myrtle Beach, South Carolina	06739	Electron Corp. Littleton, Colorado	08988	Skottie Electronics Inc. Archbald, Pennsylvania
01884	Dearborn Electronics Inc. Orlando, Florida	04645	Replaced by 75376	06743	Clevite Corp. Cleveland, Ohio	09353	C and K Components Watertown, Massachusetts
02114	Ferroxcube Corp Saugerties, New York	04713	Motorola Semiconductor Products Inc. Phoenix, Arizona	06751	Sencor Div., Components, Inc. Phoenix, Arizona	09423	Scientific Components, Inc Santa Barbara, California
02606	Replaced by 15801	05082	Replaced by 94154	06860	Gould National Batteries Inc. City of Industry, California	09922	Burndy Corp. Norwalk, Connecticut
02660	Amphenol-Borg Elect. Corp. Broadview, Illinois	05236	Jonathan Mfg. Co. Fullerton, California	06980	Varian-Elmac San Carlos, California	11236	CTS of Berne Berne, Indiana
02799	Arco Capacitors, Inc Torrence, California	05277	Westinghouse Electric Corp. Semiconductor Dept. Youngwood, Pennsylvania	07115	Replaced by 14674	11237	Chicago Telephone of Calif., Inc. (CTC) Paso Robles, California
03508	General Electric Co Semiconductor Products Syracuse, New York	05278	Replaced by 43543	07138	Westinghouse Electric Corp., Electronic Tube Division Elmira, New York	11358	Discontinued
03614	Replaced by 71400	05397	Union Carbide Corp Electronics Div. Cleveland, Ohio	07256	Silicon Transistor Corp. Garden City, New York	11403	Best Products Co Chicago, Illinois
03651	Replaced by 44655	05279	Southwest Machine & Plastic Co. Los Angeles, California				

11503	Keystone Mfg Div. of Axis Industrial Corp Warren, Michigan	15909	Replaced by 17870	28478	Deltrol Controls Corp. Milwaukee, Wisconsin	66150	Winslow Tele-Tronics Inc Asbury Park, New Jersey
11726	Qualidyne Corp Santa Clara, California	16299	Corning Glass Raleigh, North Carolina	28480	Hewlett Packard Co. Palo Alto, California	70563	Amperite Company Union City, New Jersey
12014	Chicago Rivet & Machine Co Bellwood, Illinois	16332	Replaced by 28478	28520	Heyman Mfg Co Kenilworth, New Jersey	70903	Belden Mfg. Co Chicago, Illinois
12040	National Semiconductor Corp Danbury, Connecticut	16473	Cambridge Scientific Ind. Inc Cambridge, Maryland	29083	Monsanto, Co., Inc Santa Clara, California	71002	Birnbach Radio Co., Inc New York, New York
12060	Diodes, Inc. Chatsworth, California	16758	Deleo Radio Div. of General Motors Kokomo, Indiana	30323	Illinois Tool Works, Inc. Chicago, Illinois	71236	"ELMENC0" Willimantic, Connecticut
12136	Philadelphia Handle Co Camden, New Jersey	17091	ITT Cannon Santa Ana, California	32539	Mira Corp Great Neck, New York	71400	Bussmann Mfg. Div. of McGraw - Edison Co St. Louis, Missouri
12323	Presin Co., Inc Shelton, Connecticut	17069	Circuit Structures Lab. Upland, California	32767	Griffith Plastic Products Co Burlingame, California	71450	CTS Corp. Elkhart, Indiana
12327	Freeway Washer & Stamping Co Cleveland, Ohio	17856	Siliconix, Inc. Sunnyvale, California	32879	Advanced Mechanical Components Northridge, California	71468	ITT Cannon Electric Inc. Los Angeles, California
12400	Replaced by 75042	17870	Daven-Div of Thomas A. Edison Ind. - McGraw - Edison Co Manchester, New Hampshire	32897	Lric Technological Products, Incorporated Frequency Control Div. Carlisle, Pennsylvania	71482	Clare, C. P. & Co Chicago, Illinois
12617	Hamlin Inc Lake Mills, Wisconsin	18083	Deleted	33173	General Electric Co., Tube Dept. Owensboro, Kentucky	71590	Centralab Div. of Globe Union Inc. Milwaukee, Wisconsin
12697	Carostat Mfg Co. Dover, New Hampshire	18178	Vactec Inc Maryland Heights, Missouri	34333	Silicon General Westminster, California	71707	Coto Coil Co., Inc. Providence, Rhode Island
12749	James Electronics Chicago, Illinois	18612	Vishay Intertechnology Inc. Malvern, Pennsylvania	34335	Advanced Micro Devices. Sunnyvale, California	71744	Chicago Miniature Lamp Works Chicago, Illinois
12856	Micrometals Sierra Madre, California	18736	Volttronics Corp. Hanover, New Jersey	37942	Mallory, P. R. & Co., Inc Indianapolis, Indiana	71785	Cinch Mfg. Co. & Howard B. Jones Div. Chicago, Illinois
12954	Dickson Electronics Corp Scottsdale, Arizona	19429	Discontinued, use 89536	42498	National Company Melrose, Massachusetts	72005	Driver, Wilber B., Co Newark, New Jersey
12969	Unitrode Corp. Watertown, Massachusetts	19451	Perine Machinery & Supply Co. Seattle, Washington	43543	Nytronics Inc Transformer Co. Div. Alpha, New Jersey	72092	Replaced by 06980
13103	Thermalloy Co Dallas, Texas	19701	Electra Mfg. Co. Independence, Kansas	44655	Ohmite Mfg. Co. Skokie, Illinois	72136	Electro Motive Mfg. Co Willimantic, Connecticut
13511	Amphenol Corp Los Gatos, California	20584	Enochs Mfg. Co. Indianapolis, Indiana	49671	Radio Corp. of America New York, New York	72259	Nytronics Inc Berkeley Heights, New Jersey
13606	Sprague Electric Co Transistor Div Concord, New Hampshire	20891	Self-Organizing Systems, Inc. Dallas, Texas	49956	Raytheon Company Lexington, Maine	72354	Deleted
13839	Replaced by 23732	22767	ITT Semiconductors Div. of ITT Palo Alto, California	53021	Sanamo Electric Co. Springfield, Illinois	72619	Dialight Corp. Brooklyn, New York
14099	Semtech Corp Newbury Park, California	23050	Product Comp. Corp Mount Vernon, New York	55026	Simpson Electric Company Chicago, Illinois	72653	G. C. Electronics Rockford, Illinois
14193	California Resistor Corp. Santa Monica, California	23732	Tracor Rockville, Maryland	56289	Sprague Electric Co. North Adams, Massachusetts	72665	Replaced by 90303
14298	American Components, Inc. Conshohocken, Pennsylvania	23880	Stanford Applied Engrng. Santa Clara, California	58474	Superior Electric Co. Bristol, Connecticut	72794	Dzus Fastener Co., Inc. West Islip, New York
14655	Cornell-Dubilier Electronics Newark, New Jersey	23936	Pamotor Div., Wm. J. Purdy Co Burlingame, California	60399	Torrington Mfg. Co. Torrington, Connecticut	72928	Gudeman Co. (Gulton Industries) Chicago, Illinois
14674	Discontinued, see 16299	24248	Southco Div. of South Chester Corp. Lester, Pennsylvania	62460	Deleted	72982	Erie Tech. Products Inc Erie, Pennsylvania
14752	Electro-Cube Inc San Gabriel, California	24655	General Radio Co West Concord, Massachusetts	63743	Ward Leonard Electric Co. Mount Vernon, New York	73138	Beckman Instruments Inc. Helipot Division Fullerton, California
14869	Replaced by 96853	24759	Lenox-Fugle Electronics Plainfield, New Jersey	64834	West Mfg. Co. San Francisco, California	73445	Amperex Electronic Corp Hicksville, New York
15636	Flec-Trol Inc. Northridge, California	25403	Amperex Electronic Corp. Semiconductor & Receiving Tube Division Statersville, Rhode Island	65092	Weston Instruments Inc. Newark, New Jersey	73559	Carling Electric Inc. Hartford, Connecticut
15801	Genwal Electronics Inc Framingham, Massachusetts	27014	National Semiconductor Corp. Santa Clara, California			73586	Circle F Industries Trenton, New Jersey
15818	Amelco Semiconductor Div. of Teledyne Inc Mountain View, California	27264	Moles Products Downers Grove, Illinois			73734	Federal Screw Products Inc. Chicago, Illinois
15849	USICO Inc. Mt. Vernon, New York	28425	Bohannon Industries Fort Worth, Texas				
15898	International Business Machines (IBM) Essex Junction, Vermont						

73743	Fisciter Special Mfg. Co. Cincinnati, Ohio	80145	API Instruments Co. Chesterland, Ohio	86684	Radio Corp. of America Electronic Components & Devices Harrison, New Jersey	95263	Lecraft Mfg. Co. Long Island City, New York
73899	J-D Electronics Co. Brooklyn, New York	80183	Sprague Products North Adams, Massachusetts	86689	Deleted	95264	Replaced by 98278
73949	Guardian Electric Mfg. Co. Chicago, Illinois	80294	Bourns Inc. Riverside, California	87034	Marco-Oak Inc. Anaheim, California	95275	Vitramon Inc. Bridgeport, Connecticut
74199	Quant Nichols Co. Chicago, Illinois	80583	Hammarlund Co., Inc. Mars Hill, North Carolina	88245	Litton Products Inc. Van Nuys, California	95303	Radio Corp. of America Solid State & Receiving Tube Div. Cincinnati, Ohio
74217	Radio Switch Corp. Marlboro, New Jersey	80640	Stevens, Arnold Inc. Boston, Massachusetts	88419	Use 14655	95354	Method Mfg. Corp. Rolling Meadows, Illinois
74276	Signalite Inc. Neptune, New Jersey	81073	Grayhill Inc. La Grange, Illinois	88690	Replaced by 04217	95712	Dupe Electric Co., Inc. Franklin, Indiana
74306	Piezo Crystal Co. Carlisle, Pennsylvania	81590	Korzy Mfg. Co. Seattle, Washington	89536	Fluke, John Mfg. Co., Inc. Seattle, Washington	95987	Weekesser Co., Inc. Chicago, Illinois
74542	Hoyt Elect. Instr. Works Penacook, New Hampshire	81312	Winchester Electronics Div. of Litton Industries Oakville, Connecticut	89730	Replaced by 08806	96733	San Fernando Electric Mfg. Co. San Fernando, California
74970	Johnson, E. F., Co. Waseca, Minnesota	81439	Therm-O-Disc Inc. Mansfield, Ohio	90201	Mallory Capacitor Co. Indianapolis, Indiana	96853	Rustrak Instrument Co. Manchester, New Hampshire
75042	IRC Inc. (Div. of TRW) Philadelphia, Pennsylvania	81483	International Rectifier Corp. Los Angeles, California	90215	Best Stamp & Mfg. Co. Kansas City, Missouri	96881	Thomson Industries, Inc. Manhasset, New York
75376	Kurz-Kasch, Inc. Dayton, Ohio	81741	Chicago Lock Corp. Chicago, Illinois	90211	Square D Co. Chicago, Illinois	97540	Master Mobile Mounts Div. of Whitehall Electronics Corp. Los Angeles, California
75382	Kulka Electric Corp. Mount Vernon, New York	82305	Palmer Electronics South Gate, California 90280	90303	Mallory Battery Co. Tarrytown, New York	97913	Industrial Electronic Hardware Corp. New York, New York
75915	Littlefuse Inc. Des Plaines, Illinois	82389	Switchcraft Inc. Chicago, Illinois	91293	Johanson Mfg. Co. Boonton, New Jersey	97945	White, S. S. Co. Plastics Div. New York, New York
76854	Oak Mfg. Co. Crystal Lake, Illinois	82415	Price Electric Corp. Frederick, Maryland	91407	Replaced by 58474	97966	Replaced by 11358
77342	Potter & Brumfield Div. of Amer. Machine & Foundry Princeton, Indiana	82872	Roanwell Corp. New York, New York	91506	Augat Attleboro, Mass.	98094	Replaced by 49956
77969	Rubbercraft Corp. of Calif. LTD. Torrance, California	82877	Rotron Mfg. Co., Inc. Woodstock, New York	91637	Dale Electronics Inc. Columbus, Nebraska	98159	Rubber-Teck, Inc. Gardena, California
78189	Shakeproof Div. of Illinois Tool Works Elgin, Illinois	82879	ITT Wire & Cable Div. Pawtucket, Rhode Island	91662	Elco Corp. Willow Grove, Pennsylvania	98278	Microdot Inc. Pasadena, California
78277	Sigma Instruments, Inc. South Braintree, Massachusetts	83003	Varo Inc. Garland, Texas	91737	Gremar Mfg. Co., Inc. (ITT) Woburn, Massachusetts	98291	Sealectro Corp. Conhex Div. Mamaroneck, New York
78488	Stackpole Carbon Co. Saint Marys, Pennsylvania	83298	Bendix Corp. Electric Power Division Eatontown, New Jersey	91802	Industrial Devices, Inc. Edgewater, New Jersey	98388	Accurate Rubber & Plastics Culver City, California
78553	Tinnerman Products Cleveland, Ohio	83330	Smith, Herman H., Inc. Brooklyn, New York	91836	King's Electronics Tuckahoe, New York	98743	Replaced by 12749
79136	Waldes Kohinoor Inc. Long Island City, New York	83478	Rubbercraft Corp. of America New Haven, Connecticut	91929	Honeywell Inc. Micro Switch Div. Freeport, Illinois	98925	Deleted
79497	Western Rubber Company Goshen, Indiana	83594	Burroughs Corp. Electronic Components Div. Plainfield, New Jersey	91934	Müller Electric Co., Inc. Pawtucket, Rhode Island	99120	Plastic Capacitors, Inc. Chicago, Illinois
79963	Zierick Mfg. Corp. New Rochelle, New York	83740	Union Carbide Corp. Consumer Products Div. New York, New York	93332	Sylvania Electric Products Semiconductor Products Div. Woburn, Massachusetts	99217	Southern Electronics Corp. Burbank, California
80031	Mepco Div. of Sessions Clock Co. Morristown, New Jersey	84171	Arco Electronics, Inc. Great Neck, New York	94145	Replaced by 49956	99392	STM Oakland, California
		84411	TRW Ogallala, Nebraska	94154	Tung-Sol Div. of Wagner Electric Corp. Newark, New Jersey	99515	Marshall Industries Capacitor Div. Monrovia, California
		86577	Precision Metal Products Stoneham, Massachusetts	95146	Alco Electronics Products Inc. Lawrence, Massachusetts	99779	Barnes Corp. Lansdowne, Pennsylvania Toyo Electronics (R-Ohm Corp.) Irvine, California 92664 National Connector Minneapolis, Minn. 55436

Sales Representatives

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BCS Associates, Inc.
3322 S. Memorial Parkway
P.O. Box 1273
Tel. (205) 881-6220
Zip 35801

ALASKA

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

ARIZONA

PHEONIX
Barnhill Associates
7319 E. Stetson Dr.
Tel. (602) 947-7841
Scottsdale, AZ 85251

CALIFORNIA

LOS ANGELES
Instrument Specialists, Inc.
2020 N. Lincoln Street
Burbank, CA 91504
Tel. (213) 849-7181

SANTA CLARA
Instruments Specialists, Inc.
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Tel. (408) 244-1505
Zip 95050

SAN DIEGO
Instrument Specialists, Inc.
4805 Mercury St., Ste. 1
Tel. (714) 565-2555
Zip 92111

COLORADO

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1980 South Quebec St.
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P.O. Box 165
Glastonbury, CT 06033
Tel. (203) 633-0777

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ORLANDO
BCS Associates, Inc.
940 N. Fern Creek Ave.
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(305) 843-1510
Zip 32803

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Industrial Electronics, Inc.
646 Queen Street
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Zip 96817

ILLINOIS

CHICAGO
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1301 N. Rand Road
Des Plaines, IL 60016
Tel. (312) 298-3600

INDIANA

INDIANAPOLIS
Cozzens & Cudahy, Inc.
Port O'Call Executive Ctr.
21 Beachway Drive
Tel. (317) 244-2456
Zip 46244

KENTUCKY

VALLEY STATION
BCS Associates, Inc.
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