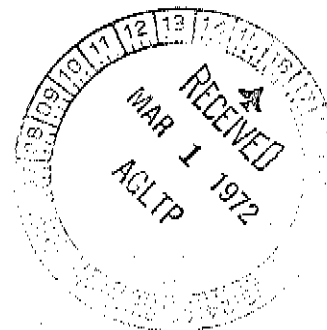


FLUKE - 335A/335D

JOHN FLUKE MFG. CO., INC.

P. O. Box 7428
Seattle, Washington 98133

FOR REFERENCE PURPOSES ONLY



MODEL
335A/335D
DC VOLTAGE STANDARD-
DIFFERENTIAL VOLTMETER-
NULL DETECTOR

Rev. 1 8/18/71

January 1969

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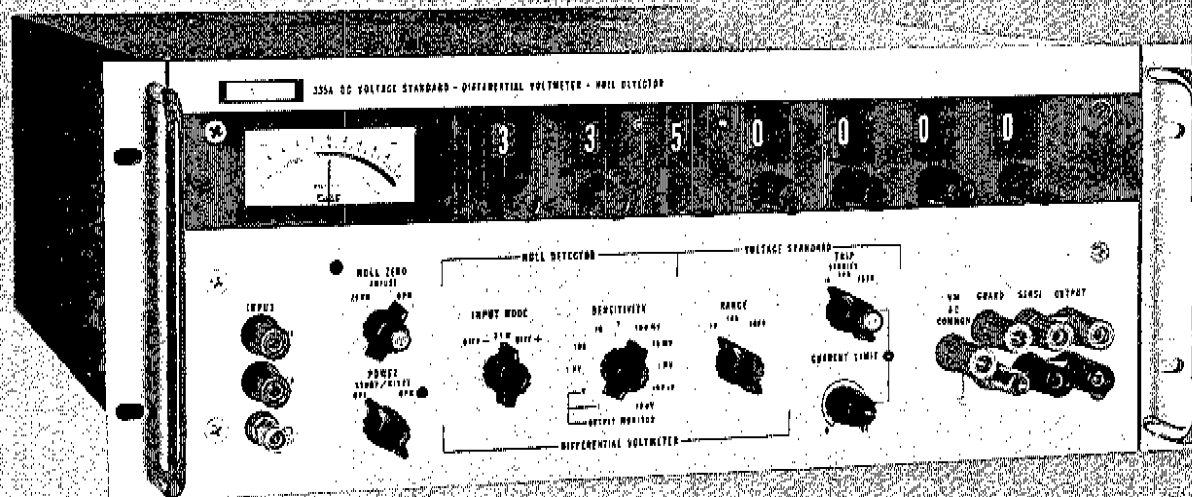
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MODEL 335A & 335D DC VOLTAGE STANDARD-
DIFFERENTIAL VOLTMETER - NULL DETECTOR

Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 335A and 335D Voltage Standards combine dc voltage source and dc voltage measurement capabilities in one instrument. Precision dc voltages from 0 to 1100 volts, variable by way of the front panel readout dials, are provided at the OUTPUT terminals of the instrument. Measurement capabilities from 10 microvolts to 1000 volts are provided by a precision dc differential voltmeter. This combination allows flexible use of the instrument as either a voltage standard, differential voltmeter, or null detector.

1-3. Protection against possible equipment failures or operator errors, which might otherwise damage expensive instruments, is incorporated. The VOLTAGE TRIP and VERNIER controls provide a means of limiting the output voltage within the range. Should the output voltage exceed a preset limit, the OUTPUT terminals are de-energized. A current limiting circuit limits the available current to a level determined by the setting of the CURRENT LIMIT control. Therefore, it is able to provide currents up to, but not exceeding the level determined by the setting of the CURRENT LIMIT control.

1-4. The inner chassis and circuitry are surrounded by an isolation guard which is also isolated from the front panel and the outside cover. When properly connected, the guard bypasses any circulating ground currents which otherwise may cause error. Remote sensing of the output voltage is also used with the instrument to reduce errors caused by voltage drop in external cables.

1-5. Most of the instrument circuitry is mounted on modular plug-in cards. An extender card is provided as an accessory to aid in the maintenance and adjustment of the instrument.

1-6. ELECTRICAL SPECIFICATIONS

1-7. Voltage Standard

OUTPUT VOLTAGE

0 to 1111.1110 volts dc.

VOLTAGE RANGES

Range (volts)	Output (volts)
10	0 to 11.111110 (1 uv steps)
100	0 to 111.11110 (10 uv steps)
1000	0 to 1111.1110 (100 uv steps)

RESOLUTION

0.1 ppm of range (1 uv maximum).

ACCURACY OF OUTPUT

The following accuracies are absolute, relative to NBS standards, and include effects of stability, line regulation, load regulation, and calibration uncertainties under standard reference conditions of $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and up to 70% relative humidity.

Range (volts)	335A		335D	
	90 Days		60 Days	
10	$\pm(0.002\% \text{ of setting} + 10 \text{ uv})$		$\pm(0.001\% \text{ of setting} + 10 \text{ uv})$	
100	$\pm(0.002\% \text{ of setting} + 0.00002\% \text{ of range})$		$\pm(0.001\% \text{ of setting} + 0.00002\% \text{ of range})$	
1000	$\pm(0.002\% \text{ of setting} + 0.00002\% \text{ of range})$		$\pm(0.0015\% \text{ of setting} + 0.00002\% \text{ of range})$	

TEMPERATURE COEFFICIENT OF OUTPUT

Less than (0.0002% of setting + 1 uv) per $^{\circ}\text{C}$ from 0° to $+50^{\circ}\text{C}$.

STABILITY OF OUTPUT

Range (volts)	335A	335D
10	$\pm(0.001\%$ of setting + 10 uv) per month $\pm(0.002\%$ of setting + 20 uv) per year	$\pm(5$ ppm of setting + 7 uv) per month
100, 1000	$\pm(0.001\%$ of setting + 20 uv) per month $\pm(0.002\%$ of setting + 40 uv) per year	$\pm(5$ ppm of setting ± 30 uv) per month

OUTPUT CURRENT

0 to 50 milliamperes at any output voltage.

OVERCURRENT PROTECTION

Continuously variable front-panel control. Automatically limits output current at any present level between one and 60 milliamperes. Panel lamp illuminates during limiting. Normal operation restored upon removal of overload.

OVERVOLTAGE PROTECTION

Front-panel control continuously variable from 1v to 1200v. Automatically disables output voltage if level exceeds selected value. Manual reset.

RIPPLE AND NOISE

Range (volts)	Ripple and Noise (uv rms)
10	20
100	30
1000	40

OUTPUT RESISTANCE

Less than 0.0005 ohms or $(0.0001E_0)$ ohms, whichever is greater, at dc.

SETTLING TIME

Within 10 ppm of final output, less than 20 seconds after a range change.

LINE REGULATION

0.0002% of setting or 10 uv for a 10% line voltage change from nominal.

LOAD REGULATION

0.0002% of setting or 10 uv for full load change.

COMMON MODE REJECTION

Better than 125 db from dc to 400 Hz up to 700 volts rms or 1000 volts dc. (Output voltage changes less than 10^{-7} of the applied common mode voltage.)

ISOLATION

Either output terminal may be floated up to 1000 volts dc from chassis.

REMOTE SENSE

Separate terminals are provided for sensing the output voltage directly at the load, thus reducing errors due to voltage drop in the output leads between the instrument and the load.

1-8. Differential Voltmeter

ABSOLUTE ACCURACY

The following accuracies apply after 1 hour warm up at standard reference conditions of $23(\pm 1)^{\circ}\text{C}$.

Range (volts)	Accuracy
10	$\pm(0.002\%$ of setting + 10 uv)
100	$\pm(0.002\%$ of setting + 20 uv)
1000	$\pm(0.002\%$ of setting + 40 uv)

TEMPERATURE COEFFICIENT OF ACCURACY

Less than $\pm 0.0002\%$ setting + 1 uv/ $^{\circ}\text{C}$ from 0 to 50°C .

INPUT RANGES

Range (volts)	Input (volts)
10	0 to 11.11110 (1 uv steps)
100	0 to 111.1110 (10 uv steps)
1000	0 to 1111.1110 (100 uv steps)

STABILITY

Same as voltage standard.

SENSITIVITY RANGES

Nine decades from 10 uv to 1000 volts.

NULL SENSITIVITY

10 millivolts full scale.

METER RESOLUTION

0.1 ppm of range on all ranges.

INPUT RESISTANCE

Infinite at null over entire range.

METER ACCURACY

3% of full scale.

ISOLATION FROM GROUND

10^8 ohms at less than 70% relative humidity at 50°C .

LINE REGULATION

0.0002% + 10 uv for 10% line change from nominal at constant load.

MOMENTARY OVERLOAD

1200 volts at any range for 5 seconds.

1-9. NULL DETECTOR

ACCURACY

3% of full scale.

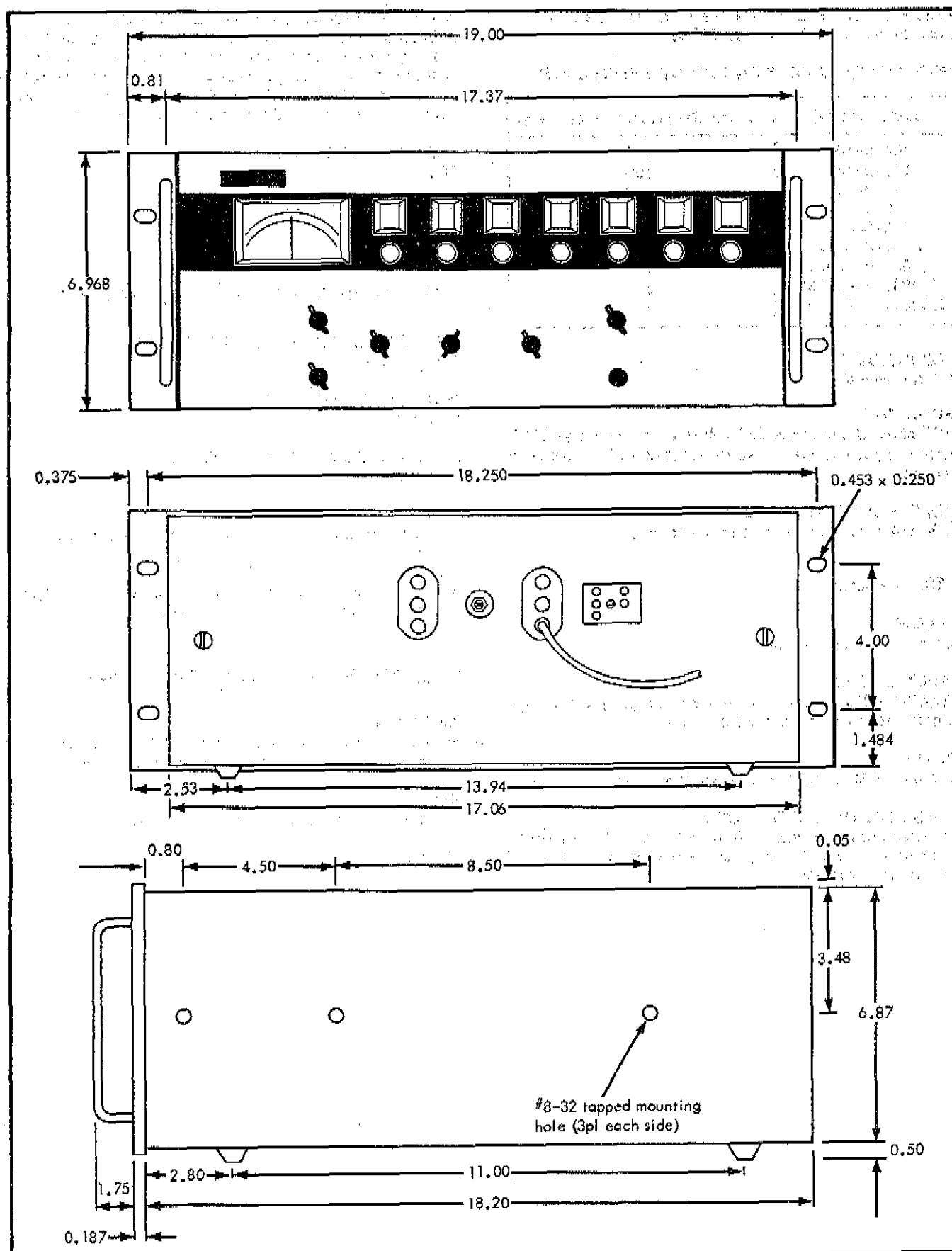


Figure 1-1. OUTLINE DRAWING

TEMPERATURE COEFFICIENT OF ACCURACY
Less than 0.2 uv/°C at 0 to 50°C.

SENSITIVITY RANGES AND INPUT RESISTANCE

Range (volts)	Input Resistance (megohms)
1000-0-1000	100
100-0-100	100
10-0-10	100
1-0-1	100
0.1-0-0.1	10
0.01-0-0.01	10
0.001-0-0.001	1
0.0001-0-0.0001	1
0.00001-0-0.00001	1

RESOLUTION
0.5 microvolts.

ISOLATION
1012 ohms at less than 60% relative humidity and 25°C.
Either input terminal can be floated 1000 volts from ground.

MOMENTARY OVERLOAD
1200 volts on any range for 5 seconds.

1-10. General

DESIGN
Solid-state throughout.

INPUT POWER
115/230 volts dc $\pm 10\%$, 50-60 Hz, single phase. Approximately 130 va under full load.

FUSES
One power line and one high voltage fuse.

STABILITY OF METER ZERO
On most sensitive range (10 uv full scale); 0.5 uv peak-to-peak noise and 0.5 uv peak-to-peak stability for 10% line voltage variation.

RECORDER ISOLATION AMPLIFIER OUTPUT
Adjustable from 0 to over one volt for end scale meter deflection; source resistance 5 to 8 kilohms; linearity better than $\pm 0.5\%$ of end-scale. Gain as an isolation amplifier is 1v/SENSITIVITY range. Recorder output may be grounded or floating up to 100 volts dc.

FUNGUS NUTRIENTS
None.

MERCURIC COMPONENTS
None.

1-11. ENVIRONMENTAL SPECIFICATIONS

OPERATING TEMPERATURE RANGE
0°C to 50°C.

RELATIVE HUMIDITY
0 to 70%.

STORAGE TEMPERATURE RANGE
-40°C to +65°C.

ALTITUDE
10,000 feet operating, 50,000 feet non operating.

SHOCK
Meets all test requirements of MIL-T-945A, rigidly mounted or rack mounted with slides.

1-12. MECHANICAL SPECIFICATIONS

MOUNTING
Standard EIA relay rack (tapped for attachment of slides), resilient feet provided for bench use.

SIZE
7" high x 19" wide x 18-1/2" behind panel.

WEIGHT
60 pounds.

Section 2

Operating Instructions

2-1. INTRODUCTION

2-2. This section consists of information about operating and applying the instrument. Prior to initial instrument operation, you may become familiar with the functions of the instrument controls by reading the information contained in paragraph 2-4, "CONTROLS, TERMINALS, AND INDICATORS". Prior to instrument application, a few optional control adjustments and terminal connections, that enhance the instruments performance and safety to external equipment, should be considered. Paragraph 2-8, "PRELIMINARY OPERATION", describes these adjustments and connections. Instructions for operating and applying the Model 335A as either a voltage standard, high impedance voltmeter, null detector, or differential voltmeter are described in paragraphs 2-22, 2-24, and 2-26, respectively. A few additional instrument applications, described in paragraph 2-30 ("APPLICATIONS"), conclude this section.

2-3. If any problem is encountered in operation of the instrument, contact your nearest John Fluke Sales Representative or write directly to the John Fluke Manufacturing Company with a statement of the problem. Please include the serial number of the instrument in such correspondence.

2-4. CONTROLS, TERMINALS AND INDICATORS

2-5. The name and function of the front and rear panel controls, terminals, and indicators are illustrated and described in Figure 2-1. The numbers at the tails of

the arrow callouts correspond to the reference numbers in the chart immediately following the photographs.

2-6. INPUT POWER

2-7. The power transformer of the instrument has dual primary windings. Normally, these primary windings are connected in parallel for 115 volt operation. Upon request, the primary windings are connected in series at the factory for 230 volt operation. Should it become desirable to convert the instrument from one type of power line operation to the other, refer to section 4-19.

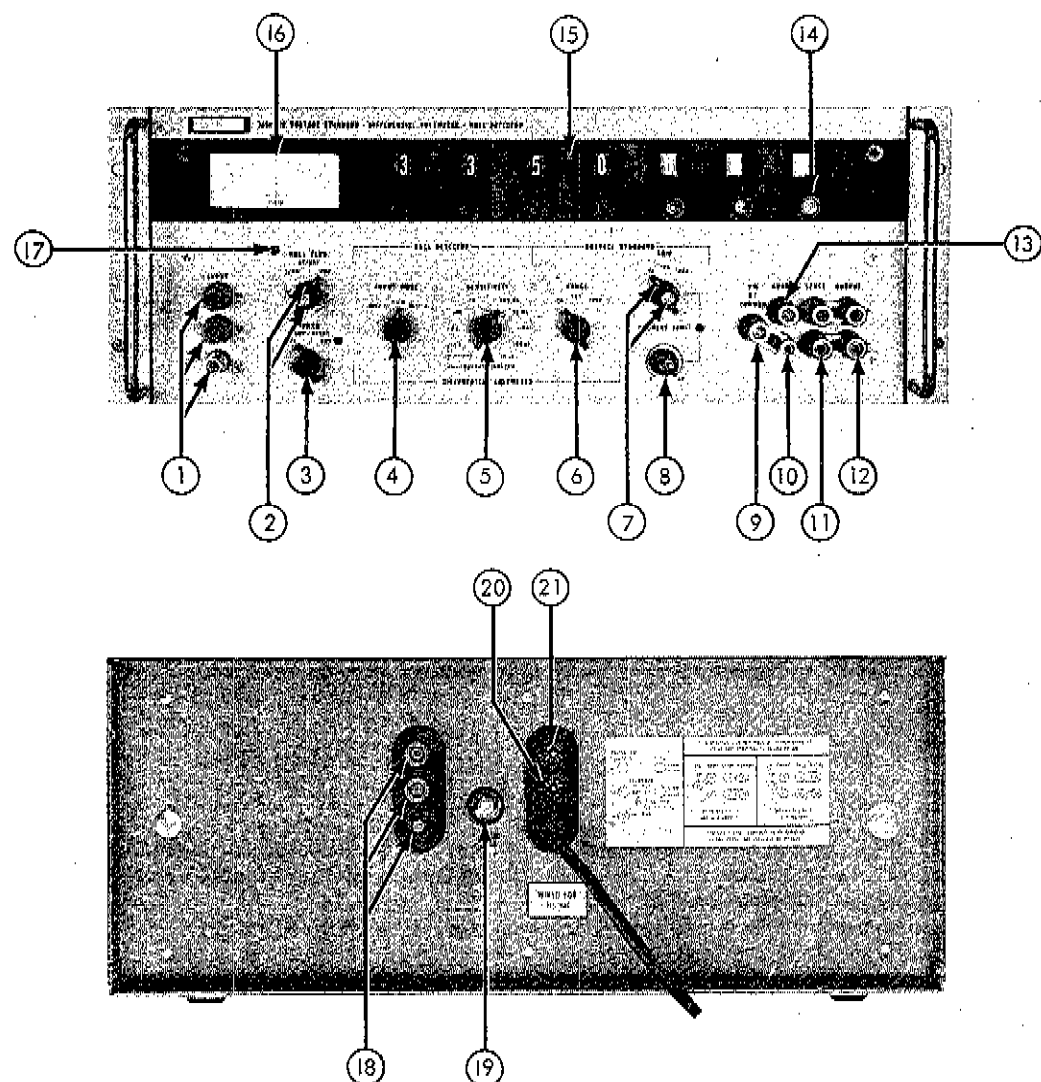
2-8. PRELIMINARY OPERATION

2-9. General

2-10. Before operating the instrument as a voltage source or voltmeter, some preliminary settings and connections should be considered. Whether to use these settings and connections, or not, depends upon the degree of equipment safety and accuracy required. The following five paragraphs discuss the merits and procedures for each of the settings and connections.

2-11. Trip Setting

2-12. The TRIP switch and VERNIER control provide protection to external equipment by limiting the maximum allowable output voltage to the external load. The range of voltage limiting is selected with the TRIP switch. Refinement of the value of the voltage to be limited is accomplished with the VERNIER control. If



REF. NO.	NAME	FUNCTION
①	INPUT terminals	The HI, LO, and $\pm$ (power line ground) terminals provide a convenient means of connecting a dc voltage source to the voltmeter input.
②	NULL ZERO switch and ADJUST control	Placing the NULL ZERO switch in the ZERO position, the ADJUST control may be varied to electrically zero the meter. Optimum meter electrical zero is accomplished in the 10 microvolt position of the SENSITIVITY switch (5). After adjustment of the electrical zero the NULL ZERO switch should be returned to the OPR position.
③	POWER switch	Applies line power to the auxiliary power supplies within the instrument, when in the STDBY/RESET position. The instrument is completely energized when the POWER switch is in the OPR position and the red indicator lamp near the switch is illuminated.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 3)

REF. NO.	NAME	FUNCTION
④	INPUT MODE switch	Allows selection of either Differential Voltmeter operation, in DIFF- or DIFF+, or Null Detector operation, in TVM (Transistor VoltMeter).
⑤	SENSITIVITY switch	Provides selection of 10 microvolts through 1 kilovolt full scale input ranges for Null Detector operation. Also, selects 10 microvolts through 1 kilovolt null sensitivity ranges for Differential Voltmeter operation. The "I" and "V" positions allow monitoring of the current and voltage output of the Voltage Standard portion of the instrument.
⑥	RANGE switch	Allows selection of one of three ranges (10, 100 and 1000 volts) for use in either Voltage Standard or Differential Voltmeter operation of the instrument.
⑦	TRIP switch and VERNIER control	The TRIP switch provides a means of limiting the output voltage in three ranges (10, 100, and 1000 volts) independent of the RANGE switch. The VERNIER control varies the amount of limiting within the ranges of the TRIP switch. When an over-voltage condition exists, the red indicator lamp near the TRIP switch will illuminate and the red lamp near the POWER switch will be extinguished.
⑧	CURRENT LIMIT control	Provides a means of setting a limit on the magnitude of the output current within a range to 0 to 60 milliamperes. An over-current condition is signified when the indicator lamp, near the CURRENT LIMIT control, illuminates.
⑨	VM AC COMMON terminal	Provides optimum common mode rejection when connected to the GUARD terminal (13) for Voltage Standard operation. Provides minimum common mode voltage at the INPUT terminals (1), when connected to the $\div$ terminal (10) for voltmeter operation.
⑩		Power line ground.
⑪	SENSE terminals	Allows the regulating circuitry within the Model 335A to be connected directly to the OUTPUT terminals (12) or to the load for optimum regulation.
⑫	OUTPUT terminals	Provides a convenient means of connecting the load to the output of the Model 335A.
⑬	GUARD terminal	Provides a means of eliminating circulating ground currents through the load, when properly connected.
⑭	Readout Dials	Used to select the desired output voltage from the Voltage Standard portion of the instrument. Also, indicates the value of an unknown voltage when used in conjunction with the Differential Voltmeter portion of the instrument. When a dial is set to "X"(10), it represents 0 with a 1 carry-over to the digit to the immediate left. For example: 10 . X X X X X X represents 11.11110 volts.
⑮	Decimal Lamps	These lamps indicate the proper decimal point setting when illuminated and are controlled by the RANGE switch.
⑯	Meter	Indicates the full value of a voltage applied to the INPUT terminals (1) when the INPUT MODE switch (4) is in the TVM position. When the INPUT MODE switch is in the DIFF+ or DIFF- positions, the meter indicates the difference between an unknown voltage at the INPUT terminals and the voltage indicated on the Readout Dials. The meter provides an indication of the output voltage when

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 3)

REF. NO.	NAME	FUNCTION
①6 (con't)	Meter	the SENSITIVITY (5) switch is in the "V" position. An indication of the output current may be determined from the red meter scale when the SENSITIVITY switch is in the "I" position.
①7	Mechanical Zero adjust	Provides a means of setting the meter mechanical zero. Adjustment should be made after the instrument has been completely de-energized for at least 3 minutes.
①8	RECORDER OUTPUT terminals	Terminals provided for the connection of a recording instrument. The (black) terminal is connected to power line ground.
①9	RECORDER OUTPUT ADJUST control	Allows adjustment of the Model 335A/335D recorder output level from 0 to 1 volt, for an end scale deflection of the front-panel meter.
②0	Fuse, line	A 3 ampere slow-blow fuse for 115 volt power line operation. Use a 1-1/2 ampere slow-blow fuse for instruments converted to 230 volt power line operation.
②1	Fuse, high voltage	A 1/4 ampere slow-blow fuse electrically located at the output of the high voltage rectifier circuit.

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 3 of 3)

no degree of limiting is required within the ranges of the instrument, set the TRIP switch to 1000 and the VERNIER fully clockwise. Should some degree of limiting be desirable, proceed as follows:

- a. Without the load connected to the OUTPUT terminals and the POWER switch in the STDBY/RESET position, set the front-panel controls as follows:

RANGE	As desired
TRIP	To the lowest range that overlaps the desired trip voltage
VERNIER	Fully cw
CURRENT LIMIT	As desired
INPUT MODE	TVM
SENSITIVITY	V
Readout Dials	Desired trip voltage

- b. Set the POWER switch from the STDBY/RESET position to OPR.
- c. Slowly rotate the VERNIER control counter-clockwise until the indicator lamp near the TRIP switch illuminates and the red lamp near the POWER switch is extinguished. The voltage trip is now set to the value indicated on the readout dials and the instrument is tripped to the STDBY mode.
- d. To reset the instrument, set the readout dials to a value less than the trip voltage and place the POWER switch in the STDBY/RESET position, then to OPR.

2-13. Current Limit Setting

2-14. The CURRENT LIMIT control provides a means of limiting the amount of output current. If no limiting

within the current range of the instrument is desirable, set the CURRENT LIMIT control to the fully clockwise position (60). Should some degree of current limiting be desirable, proceed as follows:

- a. With the POWER switch in the STDBY/RESET position, set the front panel controls as follows:

RANGE	As desired
TRIP and VERNIER	As desired
CURRENT LIMIT	Fully clockwise
INPUT MODE	TVM
SENSITIVITY	I
Readout Dials	1 volt

- b. Place a short across the OUTPUT terminals.
- c. Set the POWER switch to the OPR position.
- d. Adjust the CURRENT LIMIT control until the current indicated on the meter is the value of the desired limiting current.
- e. Place the POWER switch in the STDBY/RESET position. Remove the short. Current limiting is now set to the desired value for any output voltage.

2-15 VM AC Common Connections

2-16. For optimum common mode rejection, connect the VM AC COMMON terminal to either the GUARD or ground terminal with the shorting link provided. Figure 2-2 illustrates the proper connections depending upon whether the instrument is operated as a voltage source or as a voltmeter.

2-17. Sense Connections

2-18. When a load is connected, there may be an appreciable voltage drop between the instrument and

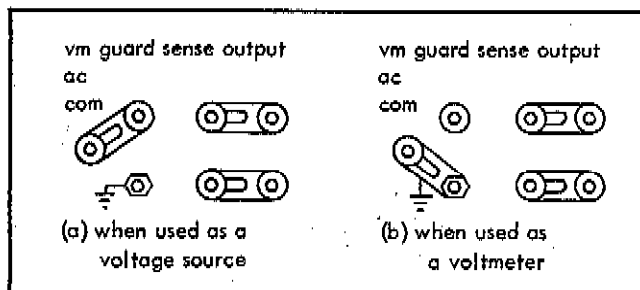


Figure 2-2. VM AC COMMON CONNECTIONS

the load due to the length and gauge of the connecting wire leads. The nomograph, in Figure 2-3, can be used to determine the approximate voltage across the connecting wire leads.

2-19. Using the nomograph of Figure 2-3, lay a straight edge from the value of the output current, represented on scale 1, to the gauge of the connecting wires used, represented on scale 2. The voltage across the connecting wires, expressed in millivolts per foot, is obtained from scale 3. To determine the total voltage across the connecting wires, multiply the total length in feet by the value obtained from scale 3. For example, assume that two AWG #28 wires, each 3 feet long, are used to connect a load, requiring 50 milliamperes, to the instrument. With a straight edge, connect the known current on scale 1 (50 ma) and the wire size on scale 2 (#28). The resulting IR drop on scale 3 is approximately 3.2 millivolts per foot. Therefore, the connecting wires develop a total voltage of 19.2 millivolts ($2 \times 3\text{ ft} \times 3.2\text{ mv/ft} = 19.2\text{ mv}$), which is several times the published load regulation of the instrument at 1000 volts output. To compensate for this, the instrument is equipped with remote sensing, which maintains regulation at the load. Consequently, the voltage across the connecting wires will have no effect. Determine if the wire leads, used to connect the instrument to the load, will cause a voltage drop in excess of the load regulation specifications. If this voltage drop is excessive, remote sensing should be used. To prepare the instrument for remote sensing, proceed as follows:

- a. With the POWER switch set to OFF, or to STDBY/RESET, remove the front-panel shorting links between the SENSE and OUTPUT terminals.
- b. Using a twisted pair of insulated wires, connect the + SENSE terminal to the positive side of the load, and connect the - SENSE terminal to the negative side of the load.

CAUTION!

Insure that the SENSE terminals are connected to the load in the proper polarity. Incorrect connections will result in loss of regulation and possible damage to the instrument.

2-20. Guard Connection

2-21. When the instrument is connected to another instrument (both instruments grounded through their res-

pective power cords), a potential difference may exist between the power line grounds of these two instruments. This potential difference can cause circulating ground currents, which could cause errors in the output voltage. To prevent these errors from occurring, the instrument is equipped with a guard. This guard, when properly connected to the load, will provide a separate path for the circulating ground currents; thus eliminating possible errors in the output voltage. For proper connection, connect the GUARD terminal directly to the grounded side of the load, at the load. Figure 2-4 illustrates the correct GUARD terminal connection and the rerouted circulated ground current path.

2-22. OPERATION AS A VOLTAGE STANDARD

2-23. Operate the instrument in accordance with following procedure:

- a. Set the voltmeter controls as follows:

NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	V

- b. Set the POWER switch in the STDBY/RESET position. Allow at least a 10 minute warm-up period, if the instrument has just been energized.
- c. Connect the SENSE terminals to the OUTPUT terminals with the shorting links provided.
- d. Set the CURRENT LIMIT control fully clockwise (60) or to a predetermined value, using the procedure of paragraph 2-13.
- e. Set the RANGE switch to the desired output voltage range (10, 100, or 1000).
- f. Set the voltage TRIP and VERNIER controls fully clockwise or to a predetermined value, using the procedure of paragraph 2-11.
- g. Set the readout dials to the value of the output voltage desired.
- h. Connect the VM AC COMMON terminal to the GUARD terminal with the shorting link provided. If desired, connect the GUARD terminal to the grounded side of the load in accordance with paragraph 2-20. The SENSE terminals may remain connected to the OUTPUT terminals. Should remote sensing be desired, connect the SENSE terminals to the load in accordance with paragraph 2-17.
- i. Connect the load to the OUTPUT terminals.
- j. Set the POWER switch to the OPR position.
- k. The output voltage provided to the load will be the voltage indicated on the readout dials. Should it be desirable to monitor the output voltage or current, place the SENSITIVITY switch in either the V (voltage) or I (current) position.

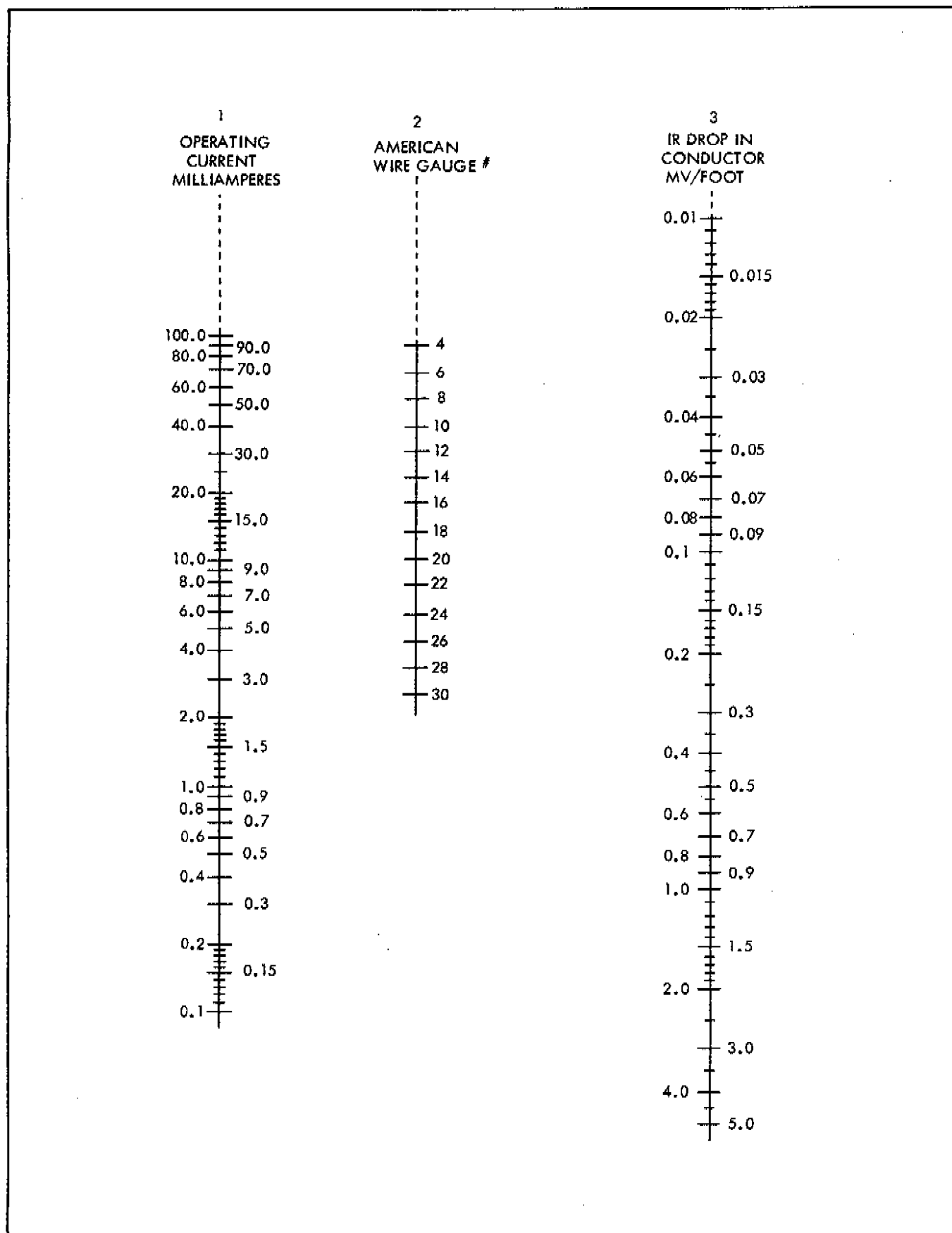


Figure 2-3. NOMOGRAPH OF VOLTAGE DROP ACROSS LOAD WIRES

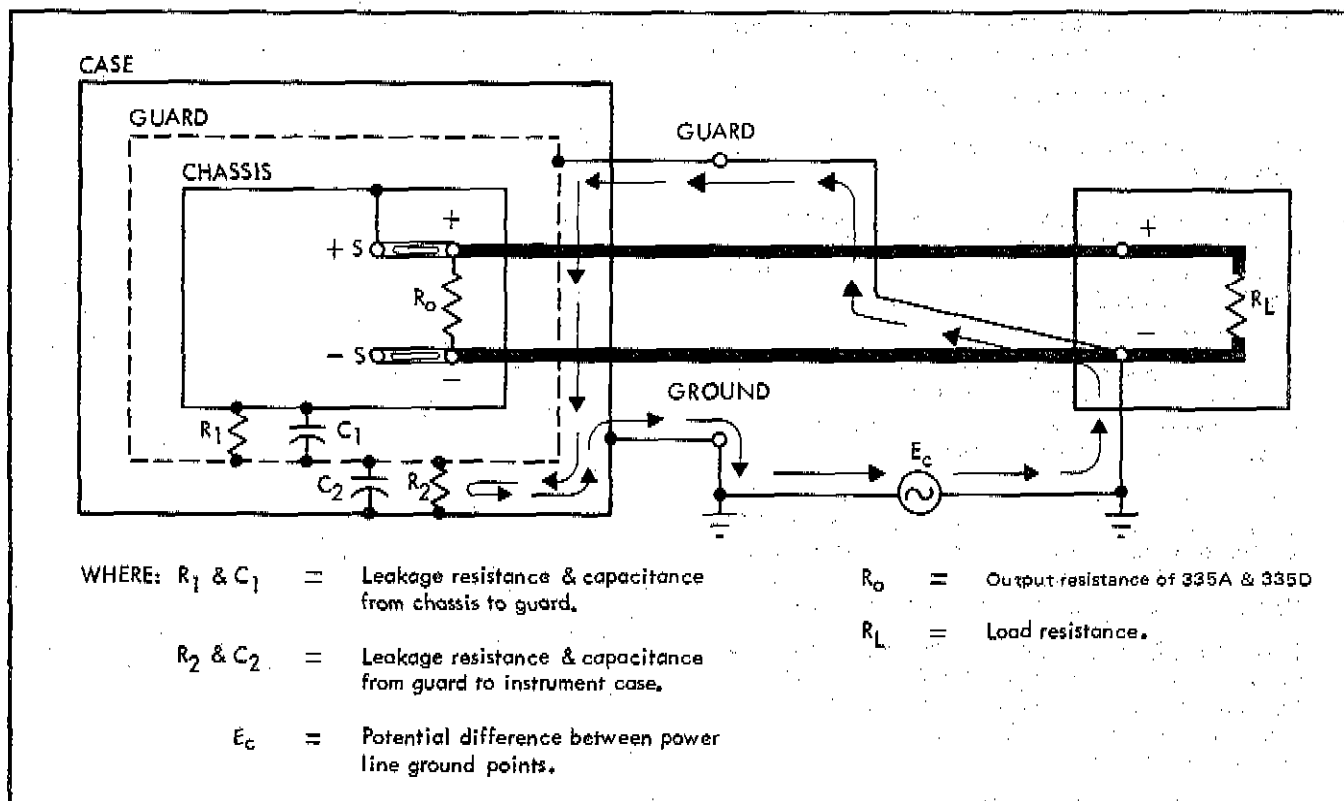


Figure 2-4. GUARD CONNECTION

2-24. OPERATION AS A HIGH IMPEDANCE VOLTMETER OR NULL DETECTOR

2-25. Use the following procedure for operating the instrument as a high impedance voltmeter. Since it incorporates a center-scale zero meter, the instrument may also be used as a null detector. In this application, the following procedure also applies.

- a. Set the VOLTAGE STANDARD controls as follows:

RANGE	10
TRIP	10
VERNIER	Fully clockwise
CURRENT LIMIT	Fully clockwise
Readout Dials	All zero

- b. Set the NULL DETECTOR controls as follows:

NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	1 KV

- c. Connect the VM AC COMMON to the ground terminal with the shorting link provided.

- d. Set the **POWER** switch to the **STDBY/RESET** position.

- e. Connect the voltage source to the INPUT terminals of the Model 335A or 335D.

- i. Set the SENSITIVITY switch to the highest sensitivity range that will allow an on-scale deflection.

As indicated on the meter, a deflection to the left of zero represents a negative input voltage; whereas a deflection to the right of zero represents a positive input voltage.

- g. When using the higher sensitivity ranges (1 mv, 100 uv, or 10 uv), the electrical zero should be adjusted. Set the NULL ZERO switch to the ZERO position and the SENSITIVITY switch to the 10 uv position. Rotate the ADJUST control until the meter indicates zero. After the adjustment has been completed, return the SENSITIVITY switch to its original position; then set the NULL ZERO switch to the OPR position.

2-26. OPERATION AS A DIFFERENTIAL VOLTMETER

2-27. To operate the instrument as a differential voltmeter, proceed as follows:

- a. Set the front-panel controls as follows:

POWER	STDBY/RESET
NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	1 KV
RANGE	As desired
TRIP	1000
VERNIER	Fully clockwise
CURRENT LIMIT	Fully clockwise (60)
Readout Dials	All zero

- b. Connect the VM AC COMMON terminal to the ground terminal with the shorting link provided.
- c. Set the POWER switch to the OPR position.
- d. Connect the external voltage source to the INPUT terminals.
- e. Use the instrument as a high impedance voltmeter to determine the approximate value of the unknown input voltage. Adjust the RANGE switch and Readout Dials, such that this value is indicated on the front-panel readout.
- f. If the front-panel meter indicates to the right (+) side of zero, set the INPUT MODE switch to DIFF+. If the front-panel meter indicates to the left (-) side of zero, set the INPUT MODE switch to DIFF-.
- g. Adjust the readout dials for a null (zero) indication on the front-panel meter. Set the SENSITIVITY switch to successively more sensitive positions while adjusting the Readout Dials for a null indication on the front-panel meter at each setting.
- h. Check and adjust, if necessary, the meter electrical zero in accordance with paragraph 2-25, step g. If an electrical zero adjustment was necessary, re-adjust the Readout Dials for a null indication on the front-panel meter.
- i. The value of the voltage indicated on the front panel readout is that of the external voltage source.

2-28. OPERATION WITH A RECORDER

2-29. To use the instrument with a recorder for measuring a voltage or voltage excursions, proceed as follows:

- a. Set the front-panel controls as follows:

POWER	STDBY/RESET
NULL ZERO	OPR
INPUT MODE	DIFF+
SENSITIVITY	1
RANGE	10
Readout Dials	1.0 0 0 0 0 0
TRIP	1000
VERNIER	Fully clockwise
CURRENT LIMIT	Fully clockwise (60)
Terminal	See Figure 2-2 (b)
Connections	

- b. Connect the recorder to the RECORDER OUTPUT terminals at the rear panel. The recorder outputs may be floated up to 100 volts dc above ground.
- c. Short the HI and LO INPUT terminals.
- d. Set the POWER switch to the OPR position.
- e. The front-panel meter should indicate full scale to the left of zero (-1). This full-scale deflection will allow up to 1 volt at the RECORDER OUTPUT terminals, depending upon the setting of the RECORDER OUTPUT ADJUST control.

- f. Adjust the RECORDER OUTPUT ADJUST control to provide the desired recorder deflection for the full scale front-panel meter deflection.
- g. Set the INPUT MODE switch to the TVM position and remove the short from the INPUT terminals.
- h. Set the SENSITIVITY switch to the 1000 volt position.
- i. Connect the voltage source to be measured to the INPUT terminals and operate the instrument as either a differential voltmeter (paragraph 2-26) or high impedance voltmeter (paragraph 2-24).

2-30. APPLICATIONS

2-31. General

2-32. The instrument may be used in many applications. A few of these applications are described in the following paragraphs. These applications include using it in conjunction with a precision reference divider to obtain 10 ppm voltage accuracy, traceable to the National Bureau of Standards. Another application discussed, deals with using it as a comparison device for accurate measurement of standard cells. Finally, a short procedure for using the instrument as a power transfer device is described.

2-33. Operation With A Reference Voltage Divider

2-34. The output voltage of the Voltage Standard portion, may be standardized to the known emf of a standard cell by operating the instrument in conjunction with the Fluke Model 750A Reference Divider. This instrument combination will provide a range of voltages from 0.1 to 1100 volts with an accuracy of 10 ppm and traceability to the National Bureau of Standards. For proper operation of this instrument combination, proceed as follows:

- a. Set the Model 750A controls as follows:

INPUT VOLTAGE ADJUST switch	RESET
INPUT VOLTAGE ADJUST controls (COARSE and FINE)	midposition
STANDARD CELL CIRCUIT switch	OPEN
STANDARD CELL VOLTAGE	value of standard to be used
OUTPUT VOLTAGE switch	as desired

- b. Set the Model 335A, 335D controls as follows:

POWER	STDBY/RESET
NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	1
RANGE	as desired
Readout Dials	as desired
TRIP and VERNIER	as desired
CURRENT LIMIT	2 ma

- c. Connect the equipment as illustrated in Figure 2-5. Insure that the equipment connections are in the proper polarity.

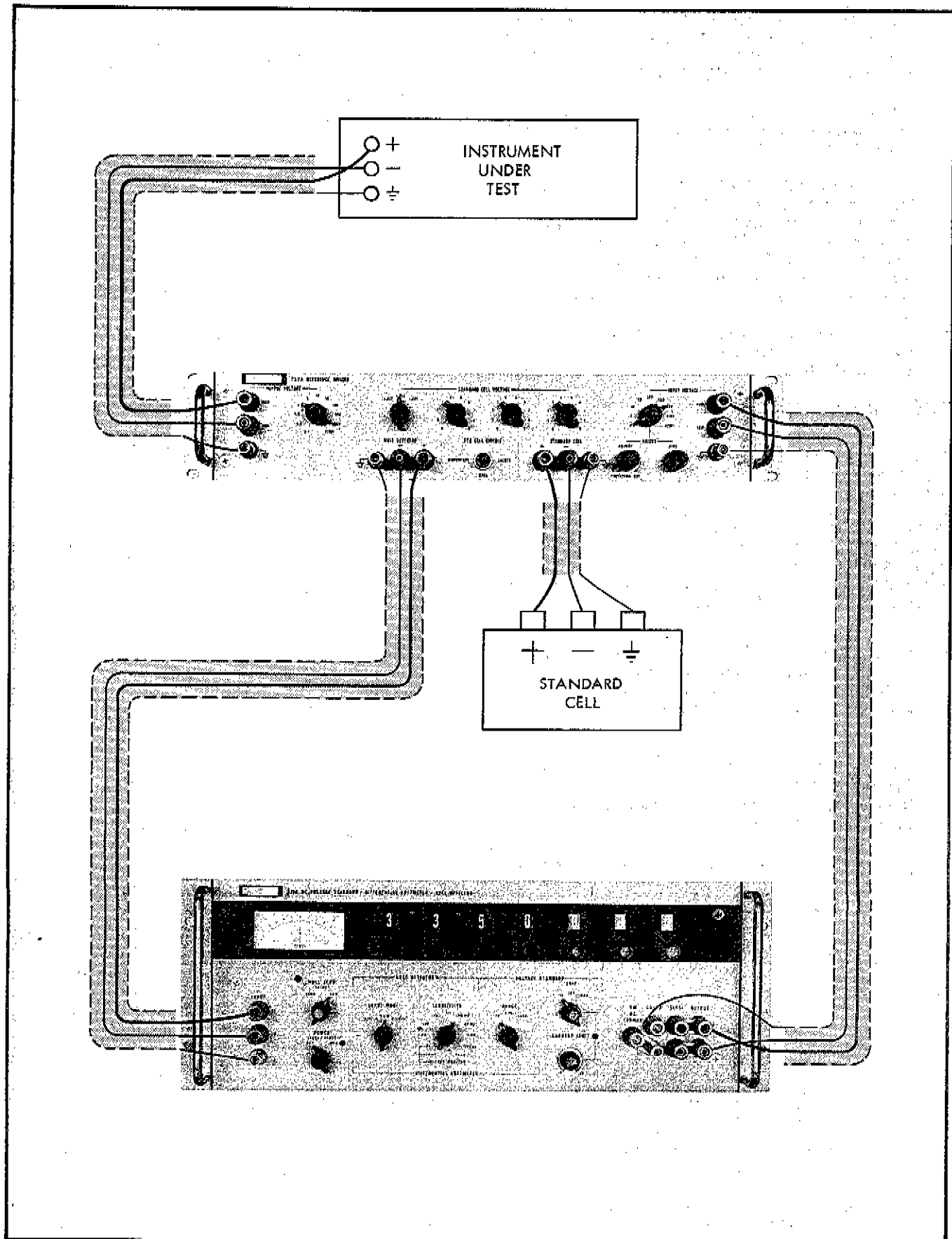


Figure 2-5. OPERATION WITH A REFERENCE DIVIDER

- d. Adjust the Model 335A, 335D to provide an output voltage corresponding to the desired input voltage level of the Model 750A. Set the POWER switch of the Model 335A, 335D to OPR.
- e. Set the INPUT VOLTAGE switch of the Model 750A to the position corresponding to the dialed voltage of the Model 335A, 335D.
- f. Place the STANDARD CELL CIRCUIT switch of the Model 750A to the MOMENTARY position and note the deflection on the meter of the Model 335A, 335D. Place the SENSITIVITY switch of the Model 335A, 335D to successively more sensitive ranges, while performing the above adjustments, until a zero indication is obtained on the meter in the 10 microvolt range.
- g. The selected output voltage is now available at the OUTPUT VOLTAGE terminals of the Model 750A accurate to within 10 ppm.

2-35. Standard Cell Comparison

2-36. The instrument may be used to a greater accuracy than specified by using it as a transfer device for comparing voltages. In such an application, it could be used to minimize the time necessary to make accurate measurements of saturated and unsaturated standard cells. Using the Model 335A, 335D in this application, the measurements would be accomplished as illustrated in Figure 2-6. The following procedure may be used to determine the value of the standard cell to be measured:

- a. Using the Model 335A, 335D as a differential voltmeter, measure the laboratory reference standard cell voltage (E_s). Obtain a null on the 10 microvolt sensitivity range and record the readout indication. Label this value as E_1 .
- b. Measure the value of the standard cell to be checked. Obtain a null on the 10 microvolt sensitivity range and record the readout indication. Label this value E_2 .
- c. Determine the value of E_x using the following equations:

$$E_2 - E_1 = \Delta E \quad (1)$$

$$E_x = E_s + \Delta E \quad (2)$$

Where: E_1 = value of the referenced standard cell, measured with the Model 335A, 335D.

E_2 = value of the unknown standard cell, measured with the Model 335A, 335D.

E_s = Certified value of the reference standard.

E_x = Calculated value of the unknown standard cell.

2-37. These comparison measurements can be accomplished at the standard cell level of accuracy to better

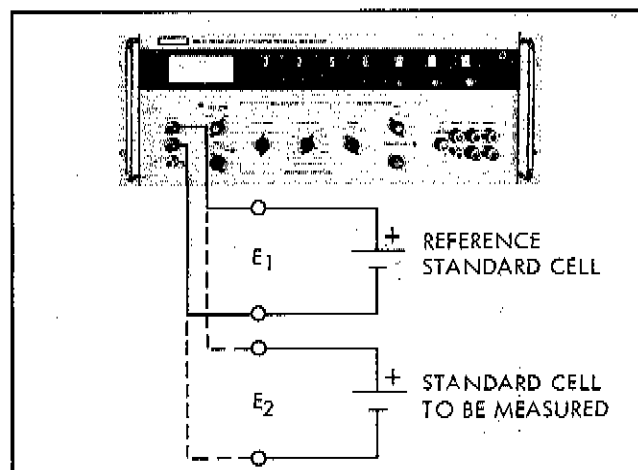


Figure 2-6. STANDARD CELL COMPARISON

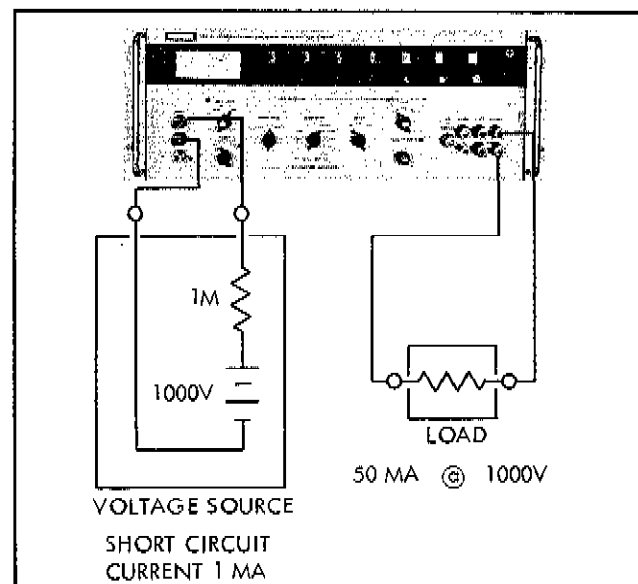


Figure 2-7. POWER TRANSFER

than 0.0005%. Several factors contribute to this total uncertainty. The short term stability of the Model 335A, 335D is typically 1 ppm. Linearity of the sample string resistors is also 1 ppm. Since standard cell voltage changes normally take place at the one millivolt level, and the resistors in this corresponding decade are matched to 20 ppm, a 1 millivolt change would constitute a 0.02 microvolt error. Operator error, thermals, and resolution would cause approximately a 2 ppm error. Therefore, the total uncertainty would equal approximately 4 ppm or 0.0004%.

2-38. Power Transfer Device

2-39. The Model 335A, 335D may be used to obtain an increased power output at the same voltage level as the measured input. Figure 2-7 illustrates a typical connection to conveniently use it as a power transfer device in the differential voltmeter mode of operation. The same arrangement, illustrated in Figure 2-7, could be used for distributing voltages at the standard cell level to areas outside of the laboratory.

Section 3

Theory of Operation

3-1. INTRODUCTION

3-2. The Model 335A, 335D unites a precision voltage standard and high impedance voltmeter-null detector in one chassis. In addition to using the voltmeter-null detector and voltage standard separately, they may be combined to function as a differential voltmeter. How it accomplishes these functions will be described in this section. Use the text in conjunction with the functional schematic diagrams at the end of this manual. Paragraphs 3-3 and 3-38 describe the voltage standard and voltmeter functions, respectively.

3-3. VOLTAGE STANDARD FUNCTION

3-4. General

3-5. The voltage standard portion is a series regulated power supply basically consisting of the voltage control circuitry, pre-regulation circuitry, and protection circuitry. The voltage control circuits are the main regulation circuits and respond to load, RANGE, and readout dial changes. Figure 3-1 illustrates a simplified schematic diagram of the voltage control circuitry. Both the error amplifier and series pass element, illustrated in the shaded portion, constitute a dc operational amplifier. The tendency of the operational amplifier is to maintain the summing point effectively at + SENSE potential. In this condition the output voltage of the voltage standard is equal to the ratio of the sample string resistance (R_{READOUT}) to the range resistance (R_{RANGE}) times the reference voltage ($E_{\text{REFERENCE}}$), as illustrated in Figure 3-1. The constant reference voltage ($E_{\text{REFERENCE}}$), in combination with the appropriate series resistance (R_{RANGE}), provides a constant current to the sample string. Due to the constant current, the output is proportional to the resistance of the sample string (R_{READOUT}). Since the tendency of the operational amplifier is to maintain the summing point at + SENSE potential, the output voltage is equal to the sample string voltage. Changing the setting of the readout dials (sample string)

causes the output voltage to change correspondingly. Each change in the RANGE switch setting causes the constant current to change by a factor of 10; thus the output voltage changes by the same factor. A detailed block diagram is illustrated in the Functional Block Diagram (335A-1000), following Section V. In this diagram, the chopper amplifier, differential amplifier, and series pass driver constitute the error amplifier of Figure 3-1.

3-6. Series regulated power supplies have the inherent disadvantage of low efficiency. When providing a low level output, the series pass element of the supply must dissipate the bulk of the power supplied by the high voltage transformer circuit. A unijunction oscillator circuit monitors the voltage across the series pass element and provides voltage level information to a pre-regulation circuit. The pre-regulation circuit utilizes this information to provide full-wave phase control of the input line voltage to the primary of the high voltage transformer. Thus, the power supplied by the high voltage transformer is controlled to provide only that amount necessary for the load requirements. This in turn increases the overall efficiency of the instrument. This also accounts for symbolizing the unregulated dc voltage, in Figure 3-1, as a variable dc voltage.

3-7. Circuitry for protection of personnel as well as external equipment, is contained in the instrument. The instrument contains an interlock system to de-energize the high voltage circuits within the instrument for personal safety. A limit may be set for the output voltage and/or current. Whenever the output voltage or current tries to exceed the set limits, the instrument output is de-energized. Therefore, sensitive external equipment can be protected from excessive voltage and current.

3-8. Voltage Control Circuitry

3-9. REFERENCE CIRCUITS. The basic reference voltage for the instrument is supplied by zener diode

CR1402. This diode is located in a proportionally controlled oven on the Master Voltage Reference P/C Assembly (A5A1-Schematic 335A-1002). Current through the reference zener diode is maintained constant by a constant current source consisting of Q1401, CR1401, R1403, and R1. These components, except for R1, are also contained in the oven assembly for environmental stability.

3-10. A constant temperature is maintained in the proportionally controlled oven by the temperature regulating circuitry, located on the Master Voltage Reference P/C Assembly (A5A1). The temperature regulator circuitry consists of a differential amplifier (Q3 and Q4), a Darlington amplifier (Q1 and Q2, and associated circuitry). One input to the differential amplifier, the base of Q3, is connected to common. Consequently, the output current from the collector of Q3 is proportional to the current into the base of Q4. The temperature coefficient of R1402 is negative. Therefore as temperature decreases, the current into the base of Q4 increases, which increases the base drive of Q2. The increased current into the base of Q2 increases the conduction of both Q2 and Q1, which increases the current through the heater (R1401). Because of the Darlington configuration of Q1 and Q2, a small change in current into the base of Q2 results in a significant change in current through R1401; thus providing close regulation of the oven temperature.

3-11. The constant output voltage from the reference zener diode is applied to the Reference Calibration P/C Assembly (A4-Schematic 335A-1001). This assembly provides three constant operating currents to the sample string for the three output ranges. The zener reference diode provides a constant voltage of approximately 6.3

volts. This voltage is reduced by R1, calibration adjustment R2, and R3 to 6.02 volts. Resistors R9 and R10 provide a 1 milliamperere current for the 1000 volt range. Resistors R7 and R8 provide a 0.1 milliamperere current for the 100 volt range. Resistors R4, R5, and R6 provide a 0.01 milliamperere current for the 10 volt range. One of the three constant currents is selected and supplied to the sample string, depending upon the position of the RANGE switch.

3-12. The Sample String P/C Assembly (A2-Schematic 335A-1003) is a resistance string whose value is controllable by the front-panel readout dials. The resistance of the sample string is such that the constant current through it develops a voltage equal to the value set on the readout dials.

3-13. CHOPPER AMPLIFIER. The voltage at the summing junction is applied through pin 5 to the junction of R1 and R4 on the Differential Amplifier P/C Assembly (A5A3-Schematic 335A-1002). One path is provided for dc changes through R1 and pin 6 to the input of the Chopper Amplifier P/C Assembly (A5A4-Schematic 335A-1002). The other path is for ac changes through the differential amplifier circuitry to be described later. The chopper amplifier compares the summing point voltage to the + sense voltage and provides an amplified dc error signal proportional to the difference. The + sense voltage is applied through a divider network, consisting of R7 through R12 located on the Temperature Regulator P/C Assembly (A5A1-Schematic 335A-1001), at pin 5. This network provides an internally adjustable dc bias to the chopper amplifier for compensation of offset voltages, when the instrument is set to zero output.

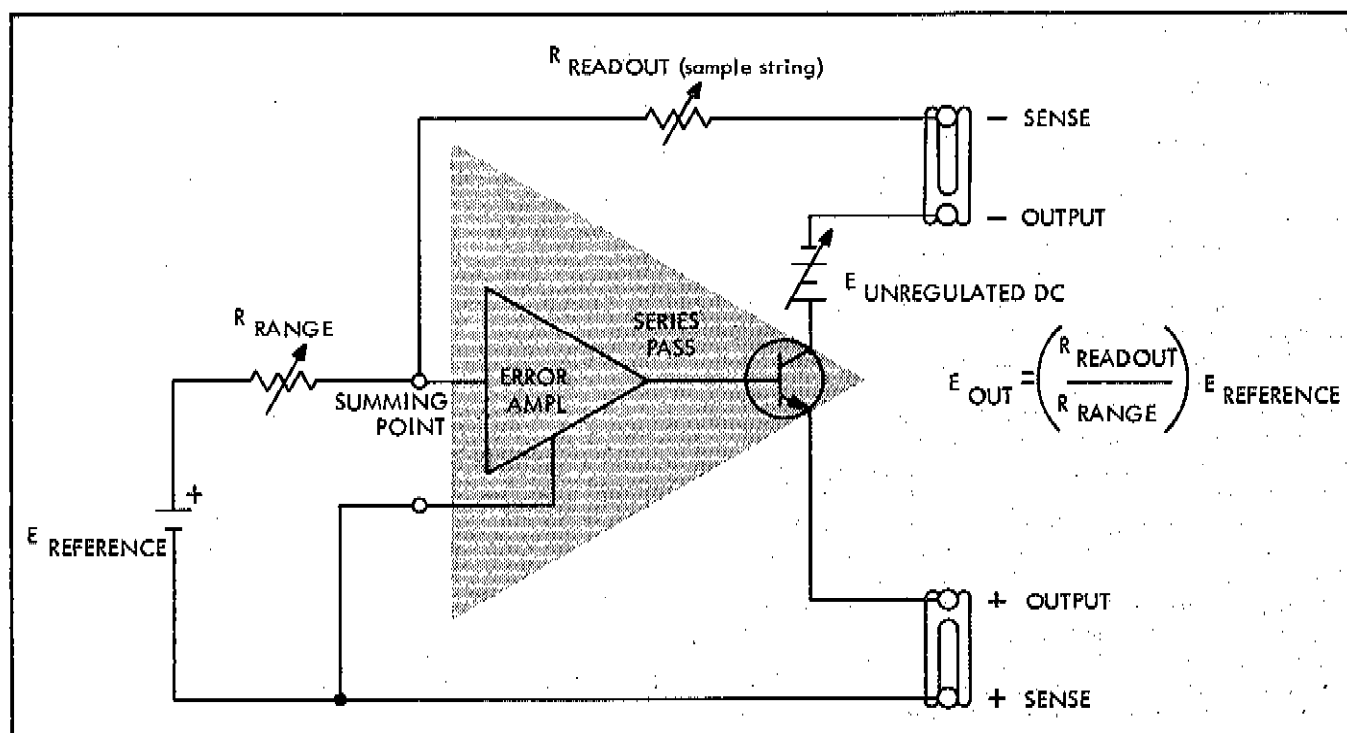


Figure 3-1. VOLTAGE CONTROL CIRCUITRY

3-14. The mechanical chopper, G1, samples the difference between the summing point voltage and the compensated + sense voltage at a 60 Hz rate. The resulting waveform is applied to the gate of Q1. Transistor Q2 amplifies the output of Q1. Transistors Q3 and Q4 are direct coupled amplifiers, with negative feedback applied from the collector of Q4 to the emitter of Q3. Transistor Q5 is a para-phase amplifier, which provides two essentially identical waveforms differing in phase by 180°. The two waveforms are demodulated by chopper G1 and filtered by R24, R25, C14, and C15. This amplified dc error signal is then applied to one input of the Differential Amplifier P/C Assembly (A5A3) at pin 3.

3-15. **DIFFERENTIAL AMPLIFIER.** Error signals, in the form of ac changes, are applied to the differential amplifier through C1 to the gate of Field Effect Transistor (FET) Q2. Error signals appearing as dc changes are applied to the chopper amplifier at the base of Q6. Using a separate path for ac changes allows rapid regulation of the output voltage for rapid changes in load requirements. The Differential Amplifier P/C Assembly provides an output that is proportional to the amplified dc error signal from the Chopper Amplifier P/C Assembly.

3-16. Use of a Field Effect Transistor for Q2 provides high input impedance and low noise. Transistor Q8 is a current source for one stage of the differential amplifier. Use of the current source provides high gain and good common mode rejection at the input of the amplifier. The compound configuration of Q4-Q5 and Q6-Q7 provides high input impedance and minimizes temperature effects. The output signal from the collector of Q9 is applied to the base of the common collector amplifier Q11. Transistor Q11 provides impedance matching between the high output impedance of Q9 and the low input impedance of the series pass driver circuit.

3-17. **SERIES PASS DRIVER.** The Series Pass Driver P/C Assembly (A5A2-Schematic 335A-1001), accomplishes two functions. One function is to de-energize the output in the case of an overvoltage or overcurrent condition, which will be described later. The other function is to provide sufficient drive current for error signals to the series pass element. Transistors Q5, Q6, Q7 and associated circuitry constitute the driver portion. Transistor Q7 is a common-base amplifier which provides part of the voltage gain necessary for control of the series pass element. Current gain is provided by common collector amplifiers Q6 and Q5. The output of Q5 is applied to the main series pass transistor Q8, on the Series Pass Element P/C Assembly (A8A1-Schematic 335A-1001).

3-18. **SERIES PASS ELEMENT.** The series connection of transistors Q1 through Q8 constitute the series pass element. This element is located on the Series Pass P/C Assembly (A8A1-Schematic 335A-1001). Transistors Q1 through Q7 are normally saturated by the base voltage supplied by the 150 volt power supply. Consequently, the entire voltage drop required for regulation is across Q8. Should the OUTPUT terminals be shorted or should the instrument be rapidly down-ranged, the voltage across Q8 may exceed 150 volts. Should this occur, transistors Q1 through Q7 will come out of

saturation to share the voltage drop. The pre-regulator circuitry (paragraph 3-23), sensing the increased voltage across Q8, decreases the unregulated supply voltage. As soon as the voltage across Q8 decreases below 150 volts, Q1 through Q7 become biased to saturation and Q8 absorbs the entire regulation voltage.

3-19. **POWER SUPPLIES.** Operating voltages for the temperature regulating circuit, zener reference circuit, chopper amplifier, and differential amplifier are provided by the Auxiliary Power Supply P/C Assembly (A5A5-Schematic 335A-1004). The auxiliary power supply consists of the 25 volt supply and -15 volt supply circuits. The auxiliary supply reference element is located in the 25 volt supply. The output of the 25 volt supply is then used as the reference for regulation of the -15 volt supply.

3-20. In the 25 volt supply, CR1 through CR4, C2, R4, and C3 provide unregulated dc voltage to the regulation circuitry consisting of Q2 through Q6. Transistors Q5 and Q6 constitute a differential amplifier. The base of Q6 is held at a constant voltage by zener diode CR6. The base of Q5 is connected to a voltage divider, consisting of R8, R9, and R10, referenced to the output of the supply. Variations in the +25 volt output of the supply are sensed at the base of Q5. Any difference between the base voltages of Q5 and Q6 is amplified by the differential pair and applied from the collector of Q5 to the base of series pass driver Q3. The amplified error signal controls the conduction of Q3, which in turn controls the series pass element Q4. Transistor Q2 is a constant current source to supply base drive to Q3.

3-21. In the -15 volt supply, CR7 through CR10, R14, and C8 provide the unregulated dc voltage to the regulating circuit consisting of series pass element Q7 and differential pair Q8 and Q9. The base of Q9 is connected to a voltage divider referenced to the +25 volt supply output. The base of Q8 is connected to the positive side of the -15 volt supply. Variations in the output voltage are sensed at the base of Q9. Any difference between the base voltages of Q8 and Q9 is amplified by the differential pair and applied from the collector of Q8 to the base of series pass element Q7. The amplified error signal controls the conduction of Q7 and consequently the magnitude of the output voltage. The positive side of the -15 volt supply is connected to the negative side of the +25 volt supply through pins 11 and 12. The + sense line is connected to this junction and is the common for the auxiliary power supply.

3-22. The ±35 volt operating voltages for the series pass driver circuitry, on the Series Pass Driver P/C Assembly (A5A2), is provided by a power supply located on the Current Limiter P/C Assembly (A5A6-Schematic 335A-1004). In the diode bridge configuration of CR1 through CR4, diodes CR1 and CR2, R1 and C1 provide a positive unregulated dc voltage. Diodes CR3 and CR4, R4, and C4 provide negative unregulated dc voltage. The positive unregulated dc voltage is applied to the regulating circuit of Q1 and CR5 and through a voltage divider to the RANGE switch, for application to the appropriate decimal lamp. The 36 volt reference voltage, established by CR5, provides the input signal for the emitter follower configuration of Q1. This emitter

follower configuration provides the necessary low output impedance and power gain of the power supply. The -35 volt supply functions in the same manner as the +35 volt supply.

3-23. Pre-Regulation Circuitry

3-24. **OSCILLATOR.** A unijunction oscillator, consisting of Q9 and associated circuitry, is located on the Series Pass Element P/C Assembly (A8A1-Schematic 335A-1001). Applied to base 2 of Q9 is a 6.8v clipped, full-wave rectified, 60 Hz sine wave. The potential at the emitter of Q9 depends upon the charge of C4 and C5. The charge of C5 depends upon the voltage across the main series pass element, Q8. At the trailing edge of each pulse at the base 2 of Q9, the oscillator provides a series of positive pulses until the leading edge of the next +6.8 volt pulse occurs. With an increased charge across C4 and C5, the initial output pulse of the oscillator will occur earlier in each half cycle. The initial pulse from the oscillator during each half cycle will switch the preregulator off to control the amount of line power supplied to the high voltage transformer. If the series pass element voltage of Q8 increases, the preregulator is switched off earlier in each half cycle. This, in turn, reduces the series pass element voltage of Q8 to its equilibrium value.

3-25. The +6.8 volt operating voltage for the oscillator circuit is taken from the +150 volt supply for the series pass element. A portion of the +150 volt supply is applied to the voltage divider consisting of R1 through R3. The divided down voltage is regulated by zener diode CR6 to approximately +6.8 volts.

3-26. **PRE-REGULATOR.** The series of unijunction pulses are coupled across A8T1 to the input of the preregulator on the Pre-Regulator P/C Assembly (A8A2-Schematic 335A-1001). At the beginning of each 60 Hz half cycle, Q5 is turned on by the positive going +V voltage, through R17 and L2. Conduction of Q5 saturates Q4, Q2, and Q1 (pre-regulator control transistor). Conduction of Q1 allows current to flow in the primary of the high voltage transformer. Sometime, during each half cycle, the initial pulse from the unijunction oscillator will trigger the regenerative pair (Q6 and Q7) into saturation. With Q6 and Q7 conducting, Q5, Q4, and Q1 turn off and remain off as long as Q6 and Q7 are conducting. Transistors Q6 and Q7 remain conducting until the end of each half cycle. At this time, the current through them automatically drops below the regenerative value, due to the zero crossing of the full-wave rectified 60 Hz sine wave voltage (-V) at the emitter of Q7. Therefore transistor Q1 is held off for the remainder of the half cycle. This limits the amount of power to the high voltage transformer and reduces the power dissipation requirements for the series pass element.

3-27. Operating voltages for the pre-regulator circuitry are provided by the diode bridge configuration of CR1 through CR4. Diodes CR2 and CR4 provide a negative full-wave rectified voltage for -V. Diodes CR1 and CR3 provide a positive full-wave rectified voltage for +V. A portion of the +V voltage is filtered by C4 and C5 to provide the +10 volt supply voltage. Diode CR5 serves to isolate the +V voltage from the filter capacitors.

3-28. Protection Circuitry

3-29. **TRIP.** The purpose of the trip circuit is to remove ac power from the primary of the high voltage transformer and open the negative output path, if an overvoltage or catastrophic overcurrent condition exists. The trip circuitry is located on the Series Pass P/C Assembly (A5A2-Schematic 335A-1001). Transistor Q3 is a constant current source for relays A8K1 and A8A2K2. With A8A2K2 (on the Pre-Regulator P/C Assembly) closed, current is provided to A8A2K1 which completes the primary circuit for the high voltage transformer. With relay A8K1 (on the High Voltage Motherboard P/C Assembly) closed, the negative output path is completed and power may be supplied to the load. The current sensing resistor, R22, is effectively connected through R24 to the base of normally off Q4. In the event of a catastrophic failure, in which the current limiting circuitry would not function, an excessive current approaching 120 milliamperes would develop sufficient voltage across R22 to turn on Q4. Because of the regenerative configuration, transistors Q4 and Q2 would become saturated. With Q2 saturated, the potential at pin 10 becomes nearly the same as the positive buss potential. This bypasses the current away from the relays, which causes them to open. With the relays open, the OUTPUT terminals are de-energized, the input power to the high voltage transformer is interrupted, and the OPR indicator lamp goes out. To reset the instrument, the POWER switch is placed in the STDBY/RESET position; then to the OPR position once the cause of the overload has been corrected. With the POWER switch in the STDBY/RESET position, the circuit common is connected through a section of the POWER switch and pin 10 to the emitter of Q2. This results in turning off both Q2 and Q4, and thus returning them to their original state.

3-30. The overvoltage trip element is Q1. The base of Q1 is connected to R15 and the appropriate resistor selected by the TRIP switch. The voltage trip point is selected by the VERNIER control (R5), which sets a reference bias on Q1 (maintaining Q1 cut off). As the output voltage increases, the voltage at the base of Q1 increases negatively until it exceeds the selected trip voltage and causes Q1 to conduct. The conduction of Q1 saturates Q2 and results in de-energizing the instrument output terminals, as previously described.

3-31. **CURRENT LIMIT.** The current limit circuitry, located on the Current Limiter P/C Assembly (A5A6-Schematic 335A-1002), provides a means of varying the limiting point of the output current. Current sensing resistor R22, on the Series Pass Driver P/C Assembly (A5A2), provides a voltage to the current limiter circuit that is proportional to the output current. This voltage is applied through pin 10 and CR12 to the base of Q5. The emitter of Q5 is connected to the wiper of the CURRENT LIMIT control (R6), which provides a variable bias for the base-emitter junction. Transistor Q5 is normally off. However, when the output current exceeds the set limit, Q5 turns on. Conduction of Q5 causes both Q4 and Q3 to conduct. Conduction of Q3 causes Q1, on the Differential Amplifier P/C Assembly, to conduct and bypass some of the sample string current. This causes the output voltage to be reduced and consequently the output current is reduced. The conduction of Q3 also

turns on the regenerative pair, Q6 and Q7, which supply current to the red indicator lamp.

3-32. INTERLOCKS. The instrument is equipped with an interlock circuit for personnel safety. When either the top or bottom inner covers or printed circuit Assemblies A8A2, A8, A8A1, A5A1, A5A3, A5A4, A5A5, or A5A6 are removed, the ground return for the A8K1 and A8A2K2 relays is opened. This results in removal of the input power to the high voltage transformer (T1) and opens the negative output side of the instrument.

3-33. TIME DELAY. The purpose of the time delay circuit, located on the Time Delay P/C Assembly (A7-Schematic 335A-1001), is to provide a short interval for the auxiliary voltages to rise to nominal value. This insures that the control amplifiers are operating before the high voltage is available. The time delay circuit momentarily holds open relays A8K1 and A8A2K2, which prevent the closure of A8A2K1. The time delay is approximately 3 seconds. Diodes CR1 and CR2 provide a full-wave rectified voltage from a secondary winding of the power transformer between pins 20 and 22. When the POWER switch is in the STDBY/RESET position, a small current flows through R2001, S1c, K2001, R2004, and C2001. This current, although too small to actuate K2001, charges C2001. Capacitor C2001 charges until it reaches the firing point of Q2001, approximately 2 to 3 seconds. At this point Q2001 conducts, increasing the current through K2001. The relay actuates and closes contact K2001A (which provides the current path when the POWER switch is in the OPR position) and opens contact K2001B. When K2001B opens, the grounding circuit is removed from the constant current source supplying A8K1 and A8A2K2, and these relays are allowed to actuate.

3-34. Miscellaneous Circuitry

3-35. OUTPUT CIRCUIT CURRENT SOURCE. In addition to the main high voltage bridge rectifier, CR1 through CR10 on the High Voltage Mother Board P/C Assembly (A8-Schematic 335A-1001), is another high voltage bridge (CR13 through CR20). This bridge rectifier is in series with R27 and R28 and forms a quasi-constant current source, connected in opposition to the output of the instrument. This current flows through the series pass transistors and acts as a minimum load to insure that their transconductance is held above a minimum value. Another purpose of the quasi-constant current source is to provide a quick discharge path for the output capacitor C1, when down ranging. This helps to reduce the settling time.

3-36. CAPACITOR SWITCH. The capacitor switch circuitry is located on the Capacitor Switch P/C Assembly (A3-Schematic 335A-1001). When down ranging from 1000 volts, capacitor C4 (on the chassis) will tend to charge to a voltage level proportional to the difference between the charge on C5 and the parallel combination of the output capacitors C1 and C2. If this difference is too great, C4 will receive a charge of sufficient magnitude to cause a dielectric absorption problem; thus excessive settling time will result. (Dielectric absorption is the tendency of the dielectric material of the capacitor to absorb and retain a small charge.) To prevent this occurrence, C5 is discharged through R7

(on A3) when the RANGE switch is down ranged from 1000 volts to 10 or 100 volts. In doing so the decay rate of C5 and the parallel combination of C1 and C2 will be equal; thus C4 does not receive an over charge. After C5 has discharged sufficiently (several seconds), the K1A contacts (on A3) close and parallel the low resistance of R6 with R7. This essentially shorts C5 and returns the loop gain to the required amount. The capacitor switch circuitry is responsible for allowing a time delay before closing the K1A contacts. When down ranging from 1000 volts, C1 is charged by the +35 volt supply through R2 and R1. After several seconds, C1 accumulates a sufficient charge to cause Q1 to conduct. Conduction of Q1 energizes relay K1 which closes the K1A contacts.

3-37. CROWBAR CIRCUIT. If the output voltage was suddenly turned to zero with a load connected to the instrument, the voltage across the filter capacitors C1, C2, and C3 (located on the High Voltage Mother Board P/C Assembly, A8) would appear across the series pass transistors. This voltage could damage the series pass transistors. To protect the series pass transistors from this kind of damage, a "crowbar" circuit is utilized. (The term "crowbar" is derived from the use of such a device to discharge large capacitor banks in transmitter power supplies.) The "crowbar" circuit consists of transistor Q10 and associated circuitry on the Series Pass Element P/C Assembly, A8A1. Also, relay K2 on the High Voltage Mother Board P/C Assembly, A8. When the voltage across the series pass element reaches approximately 225 volts, transistor Q10 conducts. Since relay K2 is in the collector circuit of Q10, the relay is energized and closes the K2A contacts. With the K2A contacts closed, a discharge path through R15 is provided for the filter capacitors.

3-38. VOLTMETER FUNCTION

3-39. General

3-40. BASIC VOLTMETER OPERATION. The voltmeter section may be operated as either a high impedance voltmeter, null detector or differential voltmeter. A simplified schematic diagram of the basic voltmeter operation is illustrated in Figure 3-2. When operated as a high impedance voltmeter or null detector (INPUT MODE switch in TVM), the input divider is connected directly across the INPUT terminals (HI and LO). In this configuration, the front-panel meter indicates the full value of the unknown voltage applied to the INPUT terminals. For differential voltmeter operation, the INPUT MODE switch is placed in the DIFF+ position. This places a variable precision reference voltage in series with the input divider across the INPUT terminals. The polarity of the reference voltage must be such as to oppose that of the unknown voltage. The voltage difference between the unknown voltage and that of the reference voltage is displayed by the front-panel meter. When the meter indicates a zero volt difference, the reference voltage is equal to the unknown voltage. The Voltage Standard section provides the precision voltage reference needed for the differential voltmeter mode of operation. When the meter indicates a zero voltage difference between the voltage standard and unknown voltage, the readout dials display the exact value of the unknown voltage, with the specified accuracy.

3-41. **BLOCK DIAGRAM ANALYSIS.** A detailed block diagram of the voltmeter section is illustrated in Figure 3-3. The voltmeter section basically consists of the input circuitry, Null Detector Amplifier P/C Assembly (A6A2), Null Power Supply P/C Assembly (A6A1), and the indicator circuits.

3-42. The input circuit divider provides a reduced dc voltage to the Null Detector Amplifier P/C Assembly. In TVM operation, the divider provides a reduced dc voltage proportional to the dc input voltage. In DIFF $\pm$ operation, the divider provides a reduced dc voltage proportional to the difference between the input voltage and the voltage indicated on the readout dials. This proportional voltage is then chopped at an 84 Hz rate by a photo-chopper circuit on the Null Detector Amplifier P/C Assembly. Magnitude and polarity information is contained in the amplitude and phase, respectively, of the chopped signal. This chopped signal is then applied to a high input impedance ac amplifier whose gain is controlled by the resistance selected by the SENSITIVITY switch. Demodulation of the amplified signal is accomplished by the synchronous demodulator. The demodulator reconstructs the amplified dc level and polarity information and applies it to a fixed gain dc amplifier. A portion of the dc amplifier output is fed back to the input of the Null Detector Amplifier to control the overall amplifier gain. The other portion of the dc amplifier output is applied to the isolation amplifier, located on the Null Power Supply P/C Assembly (A6A1). Here the dc signal is again modulated at 84 Hz, coupled across an isolation transformer, demodulated to reconstruct dc level and polarity information, and applied to the meter and recorder output terminals. In the TVM position of the INPUT MODE switch, the meter will indicate the full value of the applied dc input voltage. In the DIFF+ and DIFF- positions, the meter will indicate

the difference between the applied dc input voltage and the voltage set on the front-panel readout dials. In either case, the full scale sensitivity will be that indicated by the position of the SENSITIVITY switch.

3-43. Circuit Descriptions

3-44. **NULL POWER SUPPLY.** The Null Power Supply P/C Assembly (A6A1) consists of the 84 Hz multivibrator, multivibrator power supply, ± 15 volt power supply, and isolation amplifier. Refer to Schematic 335A-1005 for the following circuit descriptions.

3-45. The multivibrator power supply consisting of bridge rectifier CR1 through CR4, filter R1-C1, and regulating element CR5 is driven by a secondary winding of power transformer T1 between pins 11 and 12. The 17 volt rms signal is rectified, filtered, and regulated to provide a 10 volt dc operating voltage for the 84 Hz multivibrator. The 84 Hz multivibrator consists of Q1 and Q2; frequency determining elements C2, R2, R3, and frequency adjustment R4; and the primary windings of T1. A portion of the 84 Hz signal from the secondary of T1 is used to drive the neon drive circuit on the Null Detector Amplifier P/C Assembly. The secondary of T1 also provides an 84 Hz signal to drive the synchronous demodulator Q6, on the Null Detector Amplifier P/C Assembly, and the bases of Q3 and Q4 in the modulator section of isolation amplifier, on the Null Power Supply P/C Assembly. Still another portion of the 84 Hz signal from the secondary of T1 is rectified and filtered by CR6, CR7, C3, and C4 to provide the ± 15 volts dc operating voltages for the Null Detector Amplifier P/C Assembly. The collectors of Q1 and Q2, in the 84 Hz multivibrator, provide two signals 180° out of phase to the bases of Q6 and Q5 respectively, in the

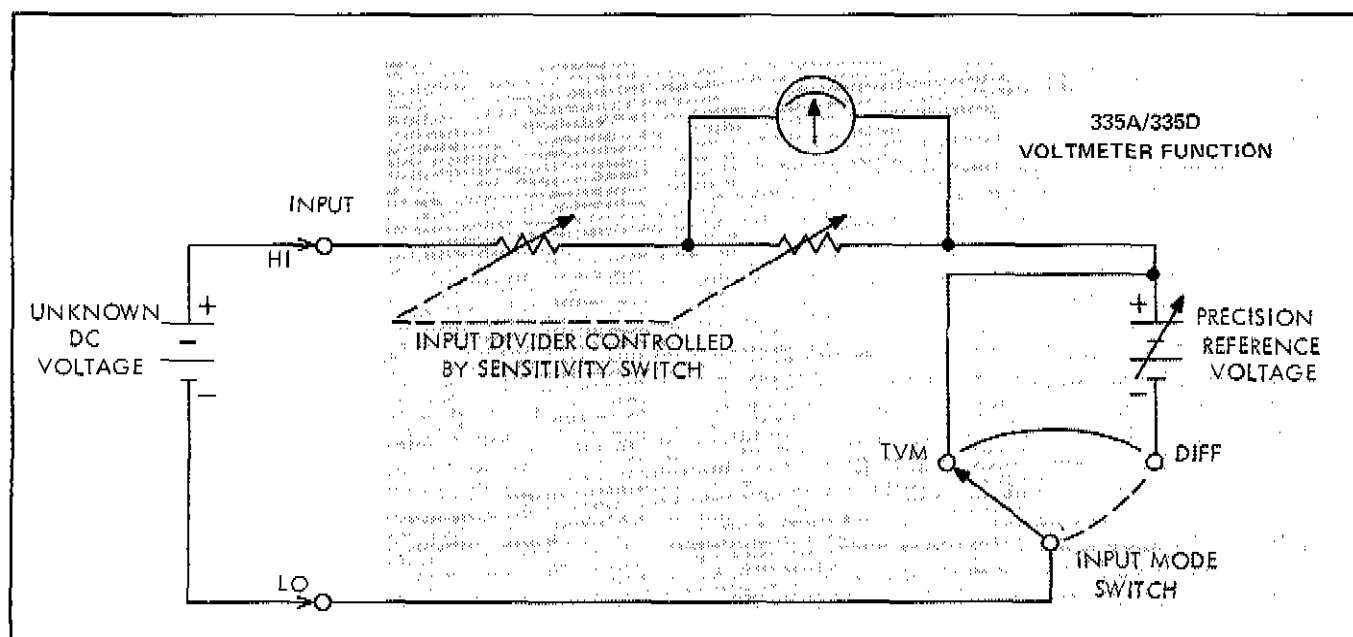


Figure 3-2. BASIC VOLTMETER OPERATION

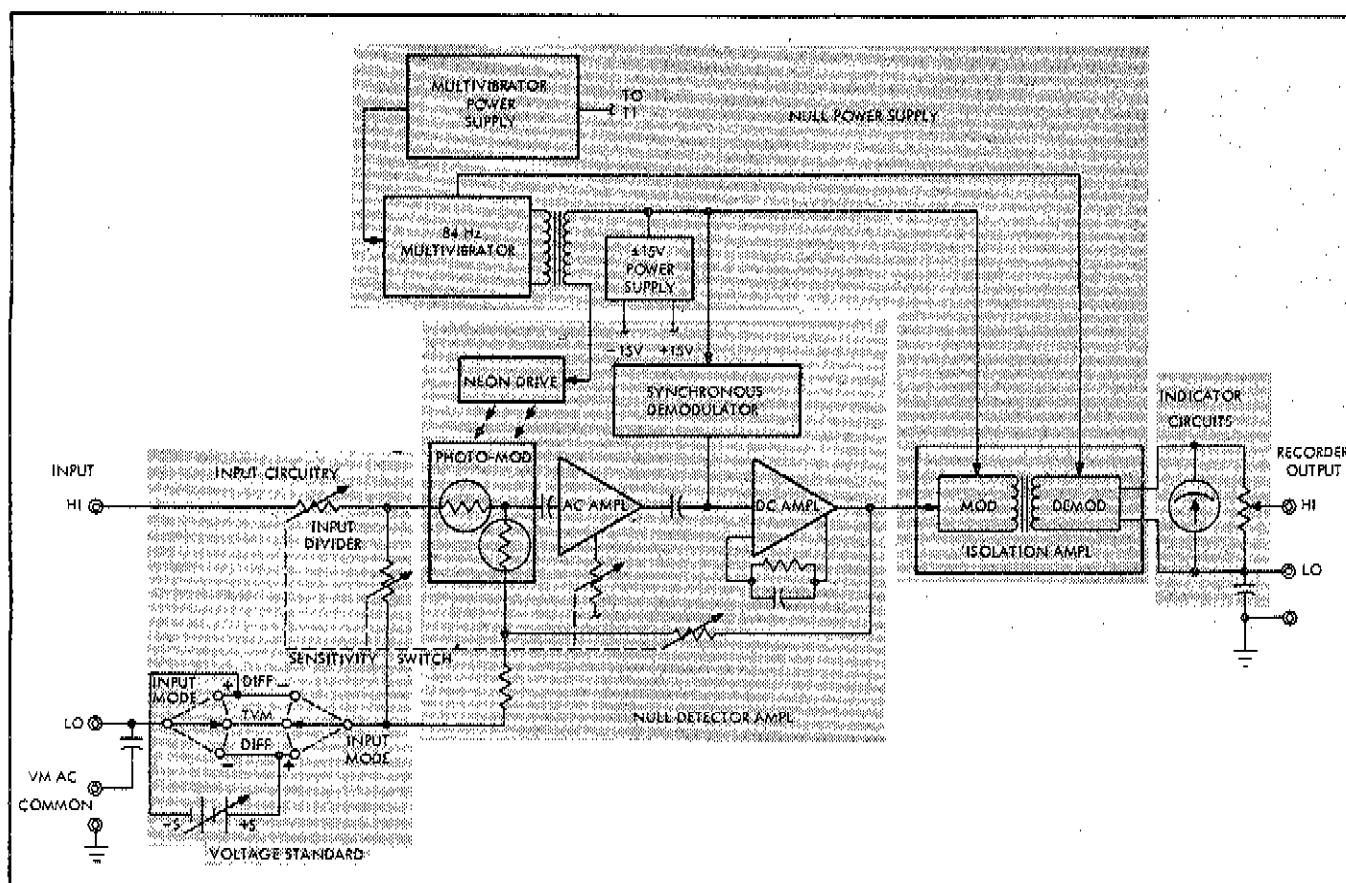


Figure 3-3. VOLTmeter FUNCTIONAL BLOCK DIAGRAM

demodulator section of the isolation amplifier. Although the isolation amplifier is located on the Null Power Supply P/C Assembly, its operation will be discussed under paragraph 3-48, "NULL DETECTOR AMPLIFIER", since it provides the signal flow path between the null detector amplifier and the indicator circuits.

3-46. INPUT CIRCUITRY. The null detector has three basic sensitivities for full scale meter deflection: 1 millivolt, 100 microvolts, and 10 microvolts. Input voltages above 1 millivolt are reduced by the divider, consisting of R9 through R16 and two functions of the SENSITIVITY switch (S5a and S5b). At 1 millivolt and below, a fixed input resistance of 1 megohm (R12) is connected across the INPUT terminals. The input resistance is 10 megohms in the 10 and 100 millivolt ranges and 100 megohms at 1 volt and above.

3-47. Placing the divider in the proper configuration for either null detector or differential voltmeter operation is accomplished by the INPUT MODE switch. In the TVM position, the INPUT MODE switch connects the divider directly across the HI and LO INPUT terminals. The null detector amplifier senses across a portion of the divider. This portion of the divider provides a voltage proportional to the total input voltage. In the DIFF+ positions the instrument is connected in series with the divider in such a polarity as to oppose the unknown input voltage. The null detector amplifier then senses a voltage proportional to the

difference between the voltage set on the readout dials and the unknown input voltage.

3-48. NULL DETECTOR AMPLIFIER. The proportional dc voltage from the input divider is filtered by a three stage low-pass RC-filter composed of R1-C2, R3-C3, and R4-C4. This filter reduces any ac voltage having a frequency above 1 Hz. The filtered voltage is then chopped by the photo-cells V1 and V2, which are driven alternately at an 84 Hz rate by the neon driver circuit consisting of DS1, DS2, CR3, CR4, R2, and C1. The resulting chopped signal, containing dc level and polarity information, is coupled through C5 to a high input impedance ac amplifier consisting of Q1, Q2, Q3. The gain of the ac amplifier is controlled by the common emitter resistance selected by SENSITIVITY switch S5e. The output of Q3 is coupled through C10 to a two stage current amplifier consisting of Q4 and Q5. A fixed negative feedback, from the emitter of Q5 through C11 and R19 to the base of Q4, holds the gain of these stages constant.

3-49. The output of Q5 is coupled through C12 and R22 to the emitter of Q6 for demodulation. An 84 Hz drive signal, in-phase with the photo-chopper drive signal is applied to the base of Q6, causing detection of the magnitude and polarity of the amplified signal. The demodulated signal is filtered by R24 and C15 before application to the dc amplifier.

3-50. The dc amplifier amplifies the detected dc signal. Transistors Q7 through Q12 comprise a two-stage differential amplifier with a complementary emitter-follower output. Negative feedback from the emitters of Q11 and Q12 through C17, C18, and R31 to the base of Q8 controls the dc amplifier gain. The output of the dc amplifier is taken from the common emitters of Q11 and Q12. One portion of the output is applied to the isolation amplifier and the other portion through S5f and the selected SENSITIVITY range resistor for overall null detector amplifier gain.

3-51. The isolation amplifier, located on the Null Power Supply P/C Assembly, receives a portion of the dc amplifier output through the center tap of the primary of T2. The dc signal is modulated at an 84 Hz rate by Q3 and Q4, with a phase dependent upon the polarity of the input voltage. This modulated signal is coupled across transformer T2 for isolation. The phase of the waveform at the secondary of T2 permits conduction of either Q5 or Q6 during alternate halves of the cycle, causing detection of the modulated signal.

3-52. INDICATING CIRCUITS. In addition to indicating voltage during null detector or differential volt-meter operation, the meter also indicates the output voltage ("V" position of the SENSITIVITY switch) or output current ("I" position of SENSITIVITY switch and red meter scale). Resistors R3 through R6 (Series Pass Driver P/C Assembly) and the resistors selected by the RANGE switch S2f provide a drive current to the meter that is proportional to the output voltage, when the SENSITIVITY switch is in the "V" position. Resistors R1 and R2 (Series Pass Driver P/C Assembly) provide a drive current to the meter that is proportional to the output current, when the SENSITIVITY switch is in the "I" position.

3-53. A recorder output, directly proportional to meter deflection, is provided through R29, R30, and filter capacitor C8. Recorder output level adjust, R29, provides an adjustable output from 0 to 1 volt for end scale meter deflection. The LO RECORDER OUTPUT terminal is isolated from ground by a 0.47 microfarad capacitor and may be floated up to 100 volts dc from ground.

Section 4

Maintenance

4-1. INTRODUCTION

4-2. Information concerning the maintenance and calibration is contained in this section. Paragraph 4-6, GENERAL MAINTENANCE, covers unique and miscellaneous maintenance procedures. A series of checks to determine if the instrument operates properly, plus information to aid in localizing possible problem areas, should any of these checks fail, is covered under paragraph 4-21, PERFORMANCE TESTS. Paragraph 4-45, CALIBRATION, contains procedures for alignment of circuits and final accuracy adjustments.

4-3. SERVICE INFORMATION

4-4. Each instrument manufactured by the John Fluke Manufacturing Company 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 front of this manual.

4-5. 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 the manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Maintenance Access

4-8. The chassis may be easily removed from the outer case by unfastening the two Dzus fasteners, located at the rear of the case. To obtain access to the circuitry within the chassis, the top and/or bottom inner covers must be removed. Removal of the top and/or bottom covers opens one or both of the interlock switches. To have the instrument fully operable, with the top and/or bottom covers off, the interlocks must be "cheated".

DANGER

The inner chassis is at +OUTPUT potential.
Hazardous voltages may exist on chassis.

4-9. Located on the left hand side of the instrument, behind the second bulkhead, is an extender card. This board is used as an extender for the plug-in circuit board assemblies to provide access to adjustments and test points. Simply remove the plug-in circuit board assembly to be investigated, insert the extender card in it's place, and plug the circuit board assembly into the extender card.

4-10. Unique Maintenance Procedures

4-11. CLEAN BOARDS. Certain circuit board assemblies are ultrasonically cleaned at the factory to prevent the possibility of electrical leakage, caused by contamination from handling during assembly. These circuit board assemblies include the Null Detector Amplifier P/C Assembly (A5A3), Sample String P/C Assembly (A2), and Capacitor P/C Assembly (A1). When components are replaced on these assemblies that require soldering, the land pattern side of the board should be cleaned as described in paragraph 4-14. Should contamination be suspected on the component side of the circuit board, use Freon TF Degreaser (Miller-Stephenson Chemical Co.).

4-12. PHOTOCELL REPLACEMENT. Should the photocell assembly on the Null Detector P/C Assembly (A5A3) have to be replaced, be very careful not to contaminate the photocell assembly or the plastic light transmission rods. The recommended procedure is to wear clean white gloves when handling them. Should the photocell assembly or plastic rods become contaminated, clean them with ethyl alcohol, then with de-ionized water and air dry. When replacing the photocell assembly, insure that the plastic rods are tight against the neon lamps and photocells.

4-13. **SHIELDED CAPACITORS.** On the Chopper Amplifier P/C Assembly (A5A4), capacitors C1 through C4 are wrapped with adhesive copper foil for shielding purposes. Should any of these four capacitors need replacing, wrap the new capacitor(s) with the original copper foil (if the adhesive needs to be activated, use (GM NAMEPLATE INC.)). If the original copper foil is not salvageable, wrap a new piece of copper foil (Permacel-type EE3990 or Mystik Tape-type 7420) around the capacitor. Insure that the copper foil does not extend beyond the edges of the capacitor and touch either of the leads. Solder one end of a length of #22 buss wire to the copper foil and the other end to the associated printed circuit board land.

4-14. **CIRCUIT BOARD SEALANT.** The land pattern side of all printed circuit boards within the instrument have been coated with epocast (a polyurethane resin) to inhibit fungus growth and moisture absorption. When soldering to a printed circuit land, the heat from the soldering iron decomposes the epocast resin, leaving a charred residue. Upon completion of soldering, this residue should be removed with a solvent, such as toluol.

CAUTION!

The following precautions should be adhered to when using toluol: avoid inhaling the vapors, avoid excessive contact with the skin, and keep away from open flames. Insure that plastic components do not come into contact with toluol, since it will dissolve most types of plastic.

After removal of the epocast residue, the affected area should be recoated with a sealant. A spray can of Circuit Coat (Furane Plastic Inc., 4516 Brazil Street, Los Angeles, California or 16 Spielman Road, Fairfield New Jersey) may be used for recoating.

4-15. Fuse Replacement

4-16. The fuses are contained in bayonet type fuse holders located at the rear of the instrument. Listed below are the correct values for the fuses:

REF DESIG	FUNCTION	TYPE
F1	High Voltage	1/4A, slow blow
F2	Line	3A, slow blow, 115V conn. 1-1/2A, slow blow, 230V conn.

Under no circumstances should replacement fuses with higher current ratings be installed in the instrument.

4-17. Lamp Replacement

4-18. The indicator lamps are located immediately behind the front panel. The instrument may be partially removed from the case to gain access to the lamps. The decimal lamps are easily accessible and removable from the top of the instrument without the need of any special tools. To replace either the over current-voltage lamp or the operate lamp, remove the screw securing the lamp holder to its mounting, then remove the bayonet base lamp.

4-19. 115/230V Conversion

4-20. Depending upon the connection of the power transformers primary windings, the instrument may be operated from either a 115 or 230 volt ac power line. To convert it from one type of power line operation to the other, use the following procedure:

- Disconnect the line cord from the power line.
- Remove the instrument from the case and place upside down on a suitable work space.
- Orient the instrument and perform the appropriate electrical connections as illustrated in Figure 4-1.
- Use the proper fuse corresponding to the selected conversion, as discussed in paragraph 4-15.

4-21. PERFORMANCE TESTS

4-22. Introduction

4-23. The following tests are intended for checking the performance of the Model 335A, 335D. These tests may be used for incoming inspection, periodic inspections, and precalibration checks. It is recommended that these tests be performed prior to each calibration.

4-24. The tests in paragraphs 4-29 through 4-44 are divided into two groups; those associated with the voltage standard and those associated with the voltmeter portion of the instrument. In each case, a short introductory paragraph, prior to each test, briefly describes the purpose of each test and the circuitry involved. An understanding of the purpose of each test and the circuitry involved should aid the technician in analyzing a malfunction.

4-25. During the following tests, it will not be necessary to remove the instrument from the case. All external equipment will be connected to the terminals provided on the instrument. Figure 4-2 lists the equipment needed for testing and calibrating.

4-26. Voltage Standard

4-27. **GENERAL.** Since the load, line, and ripple checks do not rely on any calibration adjustments, a major or minor out of tolerance indication should be investigated by troubleshooting. The remaining voltage standard checks do rely on proper calibration adjustments. Should minor out of tolerance indications be observed during these checks, calibration will more than likely correct these problems. However, should the calibration adjustments be ineffectual or at their extreme limits, you will have to investigate the cause of the problem.

4-28. In the event that a malfunction is discovered, complete as many of the performance tests as possible. Record which tests the instrument does not successfully pass and any abnormal indications. This will help in analyzing the problem and lead to more efficient troubleshooting.

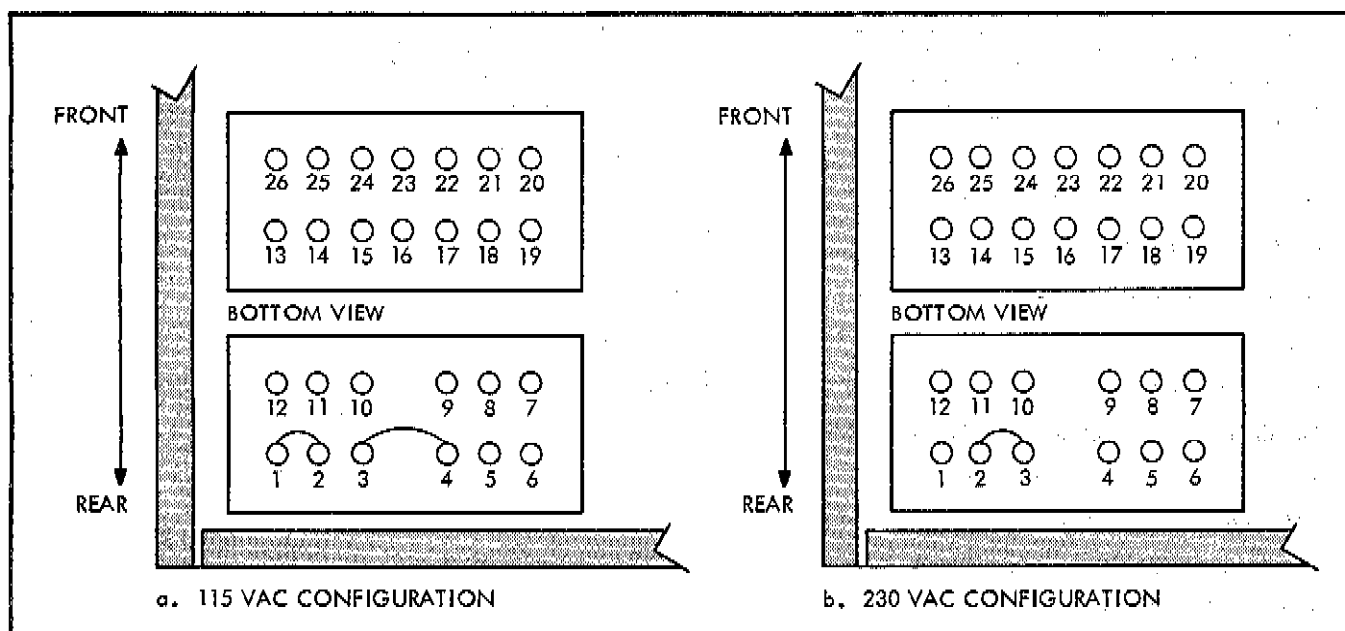


Figure 4-1. 115/230 VAC CONVERSION

EQUIPMENT REQUIRED	SPECIFICATIONS REQUIRED
Volt/Ohmmeter - RCA Voltohmyst or equivalent	DC Accuracy of $\pm 3\%$ and input impedance of 10 M.
Metered Autotransformer - General Radio Variac W5MT3A or equivalent	Output of 0 to 130 vac at 3 amperes.
DC Differential Voltmeter - Fluke Model 885A	DC Accuracy of $\pm 0.0025\%$ with 100 uv null detector.
RMS Voltmeter - Fluke Model 931B or equivalent. Preamplifier	Accuracy of 1% from 50 Hz to 30 kHz. Gain of 1000 and bandpass of 10 Hz to 10 kHz.
Oscilloscope - Tektronix Type 541 or equivalent. Preamplifier - Tektronix Type L	General purpose. 5 mv/cm sensitivity.
General Purpose Power Supply	Provide 5.5 volts.
DC Milliammeter	0 to 100 milliamperes $\pm 5\%$.

Figure 4-2. TEST AND CALIBRATION EQUIPMENT REQUIRED (Sheet 1 of 2)

EQUIPMENT REQUIRED	SPECIFICATIONS REQUIRED
Load Resistor Box - Clarostat 240-C	Resistance range of 20 to 20,000 Ω at $\pm 5\%$. Capable of handling up to 80 watts.
Resistor, Composition	100k Ω $\pm 5\%$, 1/2w
Lead Set	Low-leakage; low-thermal emf
Standard Cell Enclosure - Guildline Model 9152	Accuracy of $\pm 0.0003\%$.
DC Voltage Calibration System - Fluke Model 7101B consisting of the following equipment, or an equivalent system: Voltage Standard, Model 332B Null Detector, Model 845AR Voltage Divider, Model 750A Kelvin-Varley Voltage Divider, Model 720A	Capable of measuring 0.1 to 1100 vdc with 5 ppm accuracy.

Figure 4-2. TEST AND CALIBRATION EQUIPMENT REQUIRED (Sheet 2 of 2)

4-29. **LINE REGULATION.** The line regulation test determines whether the output voltage will remain constant, within specified limits, for a low to high line input power change.

- Connect the line cord through an auto-transformer connected to an ac power line. Set the auto-transformer to 115 volts ac.
- Set the front panel controls as follows:

POWER	STDBY/RESET
NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	I
RANGE	10
READOUT	All Zero
TRIP	1000
VERNIER	Clockwise
CURRENT LIMIT	Clockwise (60)

Terminal Connections See Figure 2-2(a)

- Connect the Model 885A to the SENSE terminals and the 240-C Load Resistor Box to the OUTPUT terminals.
- Set the RANGE switch, readout dials, and load box to the values indicated in the first group of settings in the following chart. Set the POWER switch to the OPR position. Note the voltage indicated on the Model 885A. Set the autotransformer to 103 volts

ac. The output voltage change, indicated on the Model 885A, should not exceed the 25 microvolt specification listed in the chart. Return the autotransformer setting to 115 volts ac. Note the voltage indication on the Model 885A. Set the autotransformer to 127 volts ac. The voltage change, indicated on the Model 885A, should not exceed the 25 microvolt specification. Repeat this procedure for each group of settings in Figure 4-3.

4-30. **LOAD REGULATION.** The load regulation test determines if the output voltage will remain constant, within specified limits, when the output is subjected to a no-load to full-load condition.

- Connect the line cord to an autotransformer connected to an ac power line. Set the autotransformer to 115 volts ac.
- Set the front panel controls as follows:

POWER	STDBY/RESET
NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	I
RANGE	10
Readout	All Zero
TRIP	1000
VERNIER	Clockwise
CURRENT LIMIT	Clockwise (60)

Terminal Connections See Figure 2-2(a)

RANGE	READOUT	LOAD (50 ma)	SPEC.
10	1	20 Ω	10 μ v
10	10	200 Ω	20 μ v
100	10	200 Ω	20 μ v
100	100	2000 Ω	200 μ v
1000	100	2000 Ω	200 μ v
1000	1000	20,000 Ω	2.5 mv

Figure 4-3. CONTROL SETTINGS, LOAD REQUIREMENTS, AND LIMITS FOR LINE REGULATION

- c. Connect the Model 885A to the SENSE terminals.
- d. Set the autotransformer to 103 volts ac.
- e. Set the RANGE switch and Readout Dials to the values indicated in the first group of settings listed in the following chart. Set the POWER switch to the OPR position. Note the voltage indicated on the Model 885A. Connect the 20-ohm load to the OUTPUT terminals of the instrument, and note the output voltage change on the Model 885A. This change should not exceed the 20 microvolt specification listed in the chart. Repeat this procedure with the autotransformer set to 127 volts ac. Repeat steps d and e for each group of settings.
- c. With the autotransformer set to nominal line voltage (115 vac), set the POWER switch to OPR. The ripple indicated on the Model 931B should not exceed 20 microvolts rms (Indication is via 1000X amplifier.)
- d. Set the readout dials to 10 volts. The ripple indicated on the Model 931B should not exceed 20 microvolts rms.
- e. Connect the 200-ohm load resistor to the OUTPUT terminals. The ripple indicated on the Model 931B should not exceed 20 microvolts rms. Disconnect the load resistor.

4-31. RIPPLE. The ripple test determines if the rms value of the super-imposed ac component, on the dc output is within specified limits.

- a. Connect the preamplifier to the OUTPUT terminals. Connect the Model 931 RMS Voltmeter to the output of the preamplifier.
- b. Set the front panel controls as follows:

POWER	STDBY/RESET
NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	I
RANGE	10
Readout	All Zero
TRIP	1000
VERNIER	Clockwise
CURRENT LIMIT	Clockwise (60)
- f. Set the readout dials to zero, and set the RANGE switch to 100. The ripple indicated on the Model 931B should exceed 30 microvolts rms.
- g. Set the readout dials to 100 volts. The ripple indicated on the Model 931B should not exceed 30 microvolts rms.
- h. Connect the 2,000-ohm load resistor to the OUTPUT terminals. The ripple indicated by the Model 931B should not exceed 30 microvolts rms. Disconnect the load resistor.
- i. Set the readout dials to zero, and set the RANGE switch to 1000. The ripple indicated on the Model 931B should not exceed 40 microvolts rms.
- j. Set the readout dials to 400 volts. The ripple indicated on the Model 931B should not exceed 40 microvolts rms.
- k. Connect the 8,000-ohm load resistor to the OUTPUT terminals. The ripple indicated on the Model 931B should not exceed 40 microvolts rms. Disconnect the load resistor.

Terminal Connections See Figure 2-2(a)

RANGE	READOUT	LOAD (50 ma)	SPEC
10	1	20 Ω	10 μ v
10	10	200 Ω	20 μ v
100	10	200 Ω	20 μ v
100	100	2000 Ω	200 μ v
1000	100	2000 Ω	200 μ v
1000	1000	20,000 Ω	2.5 mv

Figure 4-4. CONTROL SETTINGS, LOAD REQUIREMENTS, AND LIMITS FOR LOAD REGULATION

4-32 VOLTAGE STANDARD ACCURACY. If the voltage standard has successfully passed the line, load, and ripple specifications, it can be assumed to be operating correctly. The output voltage can now be checked and compared to the accuracy specifications. These checks should be accomplished after the unit has warmed up for 1 hour at standard reference conditions of 23°C $\pm$ 1°C, up to 70% relative humidity, and constant line voltage. One method of checking the instruments accuracy is by comparing the output voltages to a standard cell by means of a reference divider. Use the equipment and connections shown in Figure 4-14 and the procedure of paragraph 4-64, disregarding the adjustments.

4-33. V - I MONITOR. This check investigates the circuitry involved with monitoring and displaying, on the front-panel meter, the output voltage and current.

- With the SENSITIVITY switch in the "V" position, set the RANGE switch and readout dials for 100 volts output.
- The front-panel meter should indicate 100 volts $\pm$ 3.0 volts.
- Check the meter linearity at the following cardinal points, Figure 4-5. All meter indications should be within $\pm$ 3% of full scale.

RANGE	READOUT
10	1.000000
100	10.000000
1000	100.000000
10	10.000000
1000	1000.000000

Figure 4-5. CONTROL SETTINGS FOR V-I MONITOR TEST

- Set the RANGE switch to 10 volts, the readout dials to 5 volts, the CURRENT LIMIT control maximum clockwise, and the SENSITIVITY switch to "I".
- Connect a 0 to 100 dc milliammeter across the OUTPUT terminals.
- Rotate the CURRENT LIMIT control counter-clockwise until the external meter indicates 50 milliamperes. The front-panel meter should also indicate 50 milliamperes on the red scale.
- Set the RANGE switch to 100 volts then to 1000 volts. The front-panel meter should indicate 50 milliamperes in each position of the RANGE switch.

4-34. CURRENT LIMIT. This check determines the range of the CURRENT LIMIT control, which should be from 2 to 60 milliamperes.

- Set the POWER switch to STDBY/RESET, the RANGE switch to 10 volts, the readout dials to 5 volts, and the CURRENT LIMIT control maximum clockwise.

- Connect a 0 to 100 dc milliammeter across the output terminals.
- Set the POWER switch to OPR. The external meter should indicate 60 milliamperes.
- Rotate the CURRENT LIMIT control maximum counter-clockwise. The external meter should indicate 2 milliamperes.

4-35. VOLTAGE TRIP. This test determines if the trip circuit will actuate during an overvoltage condition on each RANGE setting.

- Set the TRIP VERNIER maximum clockwise. Set the RANGE, TRIP, and readout dials to the values indicated in Figure 4-6. In each case, rotate the VERNIER counter-clockwise from the maximum clockwise position until the trip circuitry just actuates. In each case the VERNIER control should be approximately 30° from the maximum clockwise position.

RANGE	TRIP	READOUT DIALS
10	10	11 volts
100	100	110 volts
1000	1000	1111 volts

Figure 4-6 CONTROL SETTINGS FOR VOLTAGE TRIP CHECK

- Set the output of the instrument for 4 volts on the 10 volt range. Set the TRIP switch to the 10 volt position and the VERNIER control to the 12 o'clock position.
- Set the RANGE switch to 100 volts. The trip circuit should actuate.
- Set the TRIP switch to the 100 volt position and reset the instrument.
- Set the RANGE switch to the 1000 volt position. The trip circuit should actuate.
- Set the TRIP switch to the 1000 volt position and the VERNIER control maximum clockwise. Reset the instrument.
- Set the RANGE switch to 100 volts then to 10 volts. The trip circuit should not actuate in either position.

4-36. Voltmeter

4-37. GENERAL. A good indication of correct operation of the null detector is the electrical zero test. Should the instrument fail this test, you should investigate the cause of the problem.

4-38. LEAKAGE RESISTANCE. This test determines if the isolation between the LO INPUT terminal and ground, in the TVM mode, is at least 10^{12} ohms.

- Disconnect the Model 335A, 335D from the power line and connect to the Models 415B and 845AB, as illustrated in Figure 4-7, with teflon coated leads.

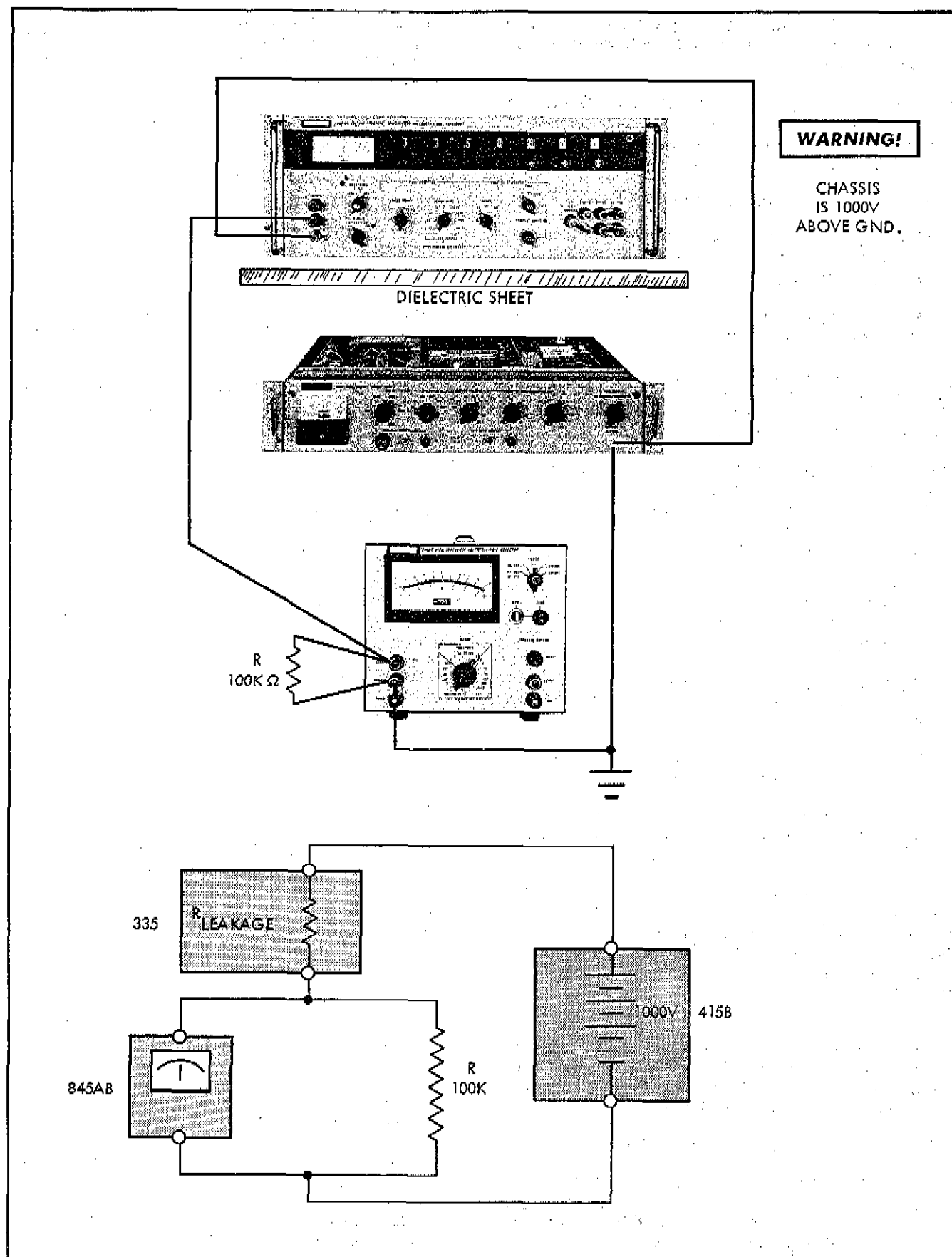


Figure 4-7. LEAKAGE RESISTANCE TEST CONNECTIONS

- b. Connect a 100 kilo-ohm ($\pm 5\%$) 1/2 watt resistor across the INPUT and COMMON terminals of the Model 845AB.
- c. Set the Model 845A POWER switch to ON and the RANGE switch to 100 microvolts. Set the INPUT MODE switch to TVM and insure that the VM AC COMMON terminal is linked to (ground).
- d. Apply 1000 volts from the Model 415B.
- e. The indication on the Model 845AB should not exceed 100 microvolts. This indicates that the isolation is 10^{12} ohms or greater.
- f. Return the Model 415B to zero output and remove all equipment interconnections.

4-39. **MECHANICAL ZERO.** With the instrument still de-energized, adjust mechanical zero screw (located just below the meter) so that the meter pointer is over the center scale zero position.

4-40. **ELECTRICAL ZERO.** Connect the instrument to the power line and set the POWER switch to the STDBY/RESET position. Proceed as follows:

- a. Set the controls as follows:

Readout Dials	All Zero
INPUT MODE	TVM
NULL ZERO	ZERO
SENSITIVITY	10 uv

- b. Rotate the NULL ZERO control through its full range. The meter pointer should deflect a total of 16 microvolts.
- c. Set the meter pointer over the center scale zero position with the NULL ZERO control.
- d. Observe the meter pointer for a period of 10 seconds. The peak-to-peak excursions of the pointer should not exceed 0.5 microvolts.

4-41. **VOLTMETER ACCURACY.** The null detector accuracy can now be checked. Place the INPUT MODE switch in the TVM position. Known voltages may be applied to the INPUT terminals to check the null detector at the desired cardinal points. Null Detector accuracy is $\pm 3\%$ of full scale.

4-42. The differential voltmeter operation may also be checked for accuracy by placing the INPUT MODE switch in the DIFF $\pm$ positions. When doing so, observe the same standard reference conditions used for checking the voltage standard accuracy.

4-43. RECORDER OUTPUT VOLTAGE.

- a. With the INPUT MODE switch in the TVM position, set the SENSITIVITY switch to the 1 millivolt position and apply one millivolt to the INPUT terminals. The meter should deflect full scale.
- b. Connect a Model 885A to the RECORDER OUTPUT terminals.

- c. Vary the RECORDER OUTPUT ADJUST to both extremes. The voltage at the RECORDER OUTPUT terminals should vary from 0 to over 1 volt (typically 1.2 volts).

- d. Disconnect the Model 885A and the 1 millivolt source.

4-44. RECORDER OUTPUT GROUND ISOLATION.

- a. With the INPUT MODE switch in the TVM position, set the SENSITIVITY switch to the 10 microvolt position and apply 10 microvolts to the INPUT terminals.
- b. Apply ± 100 volts, from the Model 335A OUTPUT terminals, between the LO and $\frac{1}{2}$ (ground) RECORDER OUTPUT terminals.
- c. The change in deflection on the front-panel meter should be less than 0.5 microvolts.
- d. Remove connections.

4-45. CALIBRATION

4-46. Introduction

4-47. The following procedures are intended for calibration. The equipment required is listed in Figure 4-2. During the first portion of the calibration procedure, the instrument will have to be removed from its case. The top inner cover will also have to be removed. However, upon removal of the top inner cover it will be necessary to "cheat" the interlock located on the top right-hand edge of the instrument chassis.

4-48. Voltmeter

4-49. **MECHANICAL ZERO.** With the instrument de-energized for at least 3 minutes, adjust the mechanical zero screw (located just below the front-panel meter) so that the meter pointer is over the center scale zero position.

4-50. **NULL DETECTOR DRIVE FREQUENCY.** Extend the Null Detector Power Supply P/C assembly (A6A1) on the extender card provided. Set the POWER switch to STDBY/RESET and allow approximately one minute for warm-up. Proceed as follows:

- a. Set the oscilloscope vertical input to 20 volts/centimeter and the horizontal sweep for 2 milliseconds/centimeter.
- b. Connect the oscilloscope between the collectors of Q1 and Q2.
- c. Refer to Figure 4-8 and adjust R4 until the period of the square wave is 11.9 milliseconds.

4-51. **NULL SENSITIVITY ADJUST.** Proceed as follows:

- Adjust the meter electrical zero. Set the INPUT MODE switch to TVM and the SENSITIVITY switch to the 1 millivolt position.
- Apply +1 millivolt to the INPUT terminals.
- Refer to Figure 4-8 and adjust R9 for a full scale meter deflection $(1.0) \pm 1/2$ a small division.
- Apply -1 millivolt to the INPUT terminals. The meter pointer should deflect full scale to the left of zero $\pm 1/2$ a small division.
- Apply to each of the remaining SENSITIVITY ranges, the corresponding voltage that will cause a full scale deflection. In each case, the meter pointer should deflect full scale, ± 1 small division.

4-52. Voltage Standard

4-53. AUXILIARY POWER SUPPLY. With POWER switch in the OFF position, connect the Model 335A, 335D through an autotransformer to the power line. Adjust the autotransformer for nominal line voltage. Extend the Auxiliary Power Supply P/C Assembly (A5A5) on the extender card provided. Set the POWER switch to the STDBY/RESET position. Allow approximately 10 minutes for warm-up; then proceed as follows:

- Using the +SENSE terminal as common, connect a Model 885A to pin 10 on the Auxiliary Power Supply P/C Assembly.
- Referring to Figure 4-8, adjust R9 until the Model 885A indicates 25 volts, ± 10 millivolts.
- While varying the line voltage from 100 to 130 volts ac, the Model 885A indication should not change more than 20 millivolts.
- Set the POWER switch to OFF. Disconnect the Model 885A. Replace the Auxiliary Power Supply P/C Assembly. Return the POWER switch to the STDBY/RESET position.

4-54. CURRENT LIMIT. Proceed as follows:

- Set the controls as follows:

POWER	STDBY/RESET
RANGE	10
Readout Dials	5.0 0 0 0 0 0
TRIP	1000
VERNIER	maximum clockwise
CURRENT LIMIT	maximum clockwise

- Connect a 0 to 100 dc milliammeter across the OUTPUT terminals. Set the POWER switch to OPR.
- Referring to Figure 4-8, adjust R23 for a 60 milliamperes indication on the external meter.
- Rotate the CURRENT LIMIT control maximum counter-clockwise. Referring to Figure 4-8, adjust R24 for a 2 milliamperes indication on the external meter.

- If necessary, readjust R23 and R24 until the range of the CURRENT LIMIT control is from 2 to 60 milliamperes.

- Set the POWER switch to STDBY/RESET. Replace the top inner cover on the Model 335A.

4-55. OUTPUT CURRENT MONITOR. Proceed as follows:

- Set the SENSITIVITY switch to "I".
- Adjust the CURRENT LIMIT control to obtain a 50 milliamperes indication on the external meter.
- Rotate the adjustment labelled OUTPUT CURRENT METER ADJUST until the front-panel meter pointer indicates 50 milliamperes on the red scale.
- Set the RANGE switch to 100 volts; then to 1000 volts. The front-panel meter should indicate 50 milliamperes in each position of the RANGE switch.
- Set the POWER switch to STDBY/RESET. Remove the external meter connections from the instrument.

4-56. OUTPUT VOLTAGE MONITOR. Proceed as follows:

- Set the front panel controls as follows:

SENSITIVITY	V
RANGE	100
Readout Dials	10 0.0 0 0 0 0

- Rotate the adjustment labelled OUTPUT VOLT-METER ADJUST until the front-panel meter indicates 100 volts ± 0.5 volts.
- Meter linearity may be checked at the cardinal points listed in Figure 4-9. All meter indications should be within $\pm 3\%$ of the readout dial settings.

4-57. VOLTAGE TRIP. Proceed as follows:

- Set the controls as follows:

RANGE	100
Readout Dials	10 X.0 0 0 0 0
VOLTAGE TRIP-OUT	maximum counter-clockwise
ADJUST (top cover)	clockwise
TRIP	100
VERNIER	30° from maximum clockwise

- Rotate the VOLTAGE TRIP-OUT ADJUST until the output is de-energized, as indicated by the illumination of the red indicator lamp and the audible "click" of relays.
- Set the POWER switch to STDBY/RESET. Rotate the VERNIER control to the maximum clockwise position.
- Set the POWER switch to OPR. Set the RANGE switch, TRIP switch, and readout dials as listed in Figure 4-10. Check the trip action on each

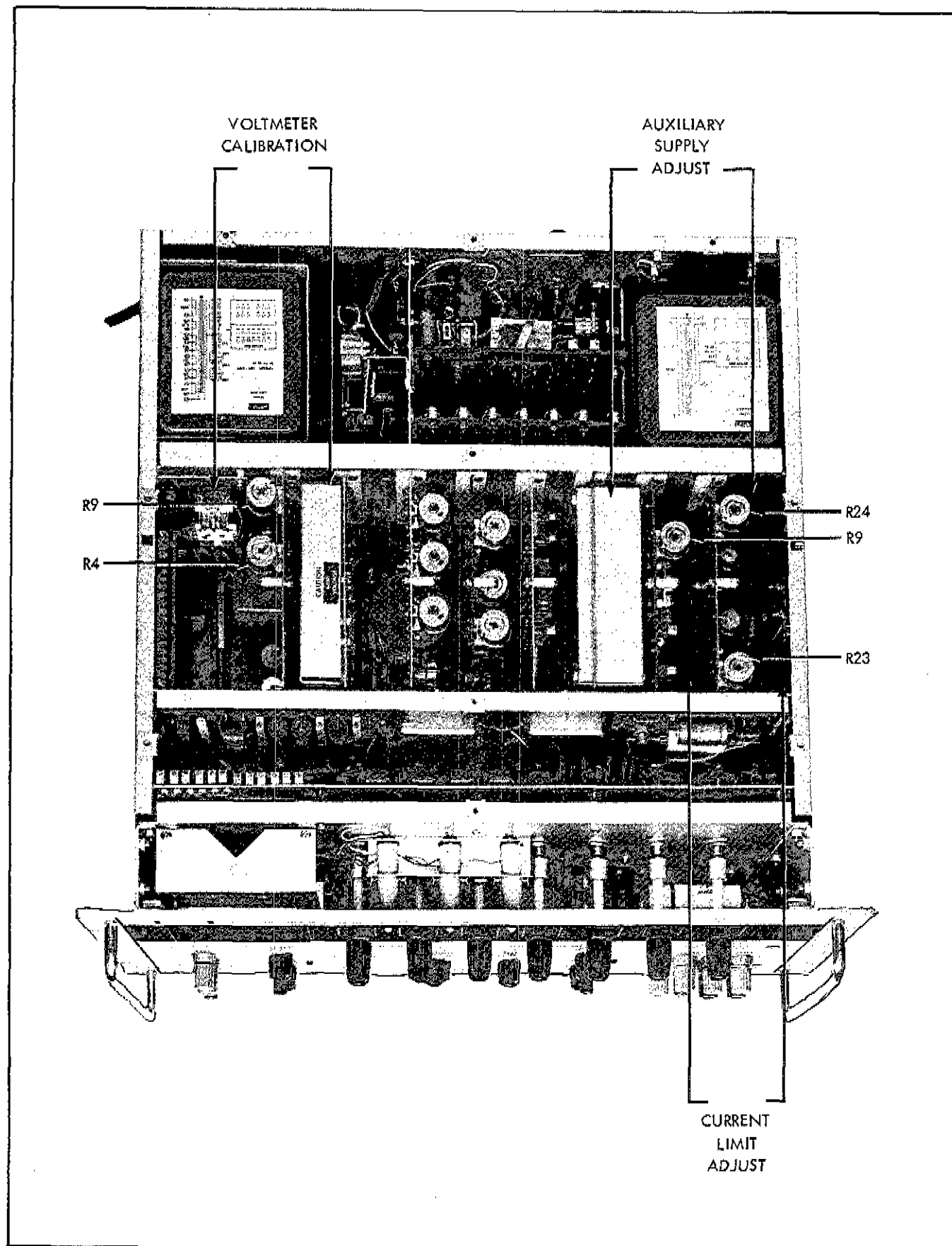


Figure 4-8. LOCATION OF ADJUSTMENTS

RANGE	READOUT DIALS
10	1.000000
100	10.00000
1000	100.0000
10	1.000000
1000	1000.0000

Figure 4-9. CONTROL SETTINGS FOR VOLTAGE MONITOR LINEARITY CHECK

range by rotating the VERNIER control counter-clockwise. The trip point should occur in each RANGE switch position when the VERNIER control is approximately 30° from the maximum clockwise position.

TRIP	RANGE	READOUT DIALS
10	10	10.X00000
1000	1000	10XX.X000

Figure 4-10. CONTROL SETTINGS FOR TRIP RANGE CHECK

4-58. MASTER REFERENCE. Proceed as follows:

a. Set the controls as follows:

POWER	OPR
RANGE	1000
Readout Dials	00X.0000
VOLTAGE TRIP	1000
VERNIER	maximum clockwise
CURRENT LIMIT	maximum clockwise

- b. Connect a Model 885A to the MASTER REFERENCE TEST points through the top inner cover.
- c. Adjust CAL 1000, CAL 100 and CAL 10 mechanically to mid-point of travel.
- d. Rotate the MASTER REFERENCE adjustment to obtain an indication of 6.02 volts (± 10 uv) on the Model 885A.
- e. Set the POWER switch to STDBY/RESET.

4-59. VOLTAGE STANDARD OUTPUT.

4-60. The voltage standard is calibrated by setting the zero output and adjusting the sample string resistors and the range resistors. Adjustment of sample string resistors determines output voltage ratio accuracy and adjustment of range resistors determines absolute voltage accuracy. The linearization adjustment involves adjusting corresponding resistors in adjacent decades so they are in exact ten-to-one ratio of each other.

4-61. The instrument should be warmed up for at least four hours at standard reference conditions of 23° ± 1 °C, up to 70% relative humidity and constant line voltage

before adjustments are made. The instrument must be operated in its case with the RANGE switch and readout dials set for 100 volts output.

4-62. ZERO OUTPUT ADJUSTMENTS. Proceed as follows:

- Slide the instrument chassis out of the case just far enough to reach the ZERO OUTPUT adjustment holes (10V, 100V, 1000V) in the cover.
- Connect a Model 885A differential voltmeter or a Model 845AR null detector across the OUTPUT terminals. Set the voltage standard dial readout to all zeros and the POWER switch to OPR.
- At each RANGE switch position, vary the corresponding ZERO OUTPUT adjustments (10V, 100V, 1000V) for a null indication (± 1 microvolt) on the voltmeter.
- Slide the chassis back into the case and recheck the zero output adjustments. Refine the adjustments if necessary.

4-63. SAMPLE STRING LINEARIZATION. Proceed as follows:

- Connect the equipment as shown in Figure 4-11.
- Self-calibrate the Model 720A according to its instruction manual.
- Turn on the reference voltage source (Model 332B) and allow to stabilize at equilibrium temperature.

Note!

Linearization adjustments do not depend on the calibrated accuracy of the Model 332B used as an external reference. Another 10 volt source of equivalent output stability may be used.

- Set the voltage reference source for 10 volts output. Set the Model 720A to 1.000000.
- Slide the unit out of the case just far enough to reach the SAMPLE STRING ADJUST (DECK A AND DECK B) and CAL (1000V, 100V) access holes.
- Set the Model 750A INPUT VOLTAGE switch to 100 and the OUTPUT VOLTAGE switch to 10.
- Set the POWER switch to OPR, set the RANGE switch to 1000 and the dial readout to 00X.0000.
- Rotate the CAL 1000V adjustment to obtain a null (± 5 uv) on the null detector.
- Set the Model 845AR to ZERO mode. Set the instrument dial readout to 010.0000.
- Set the Model 845AR to OPR mode. Rotate adjustment 1 of DECK B for a null (± 5 uv) indication.

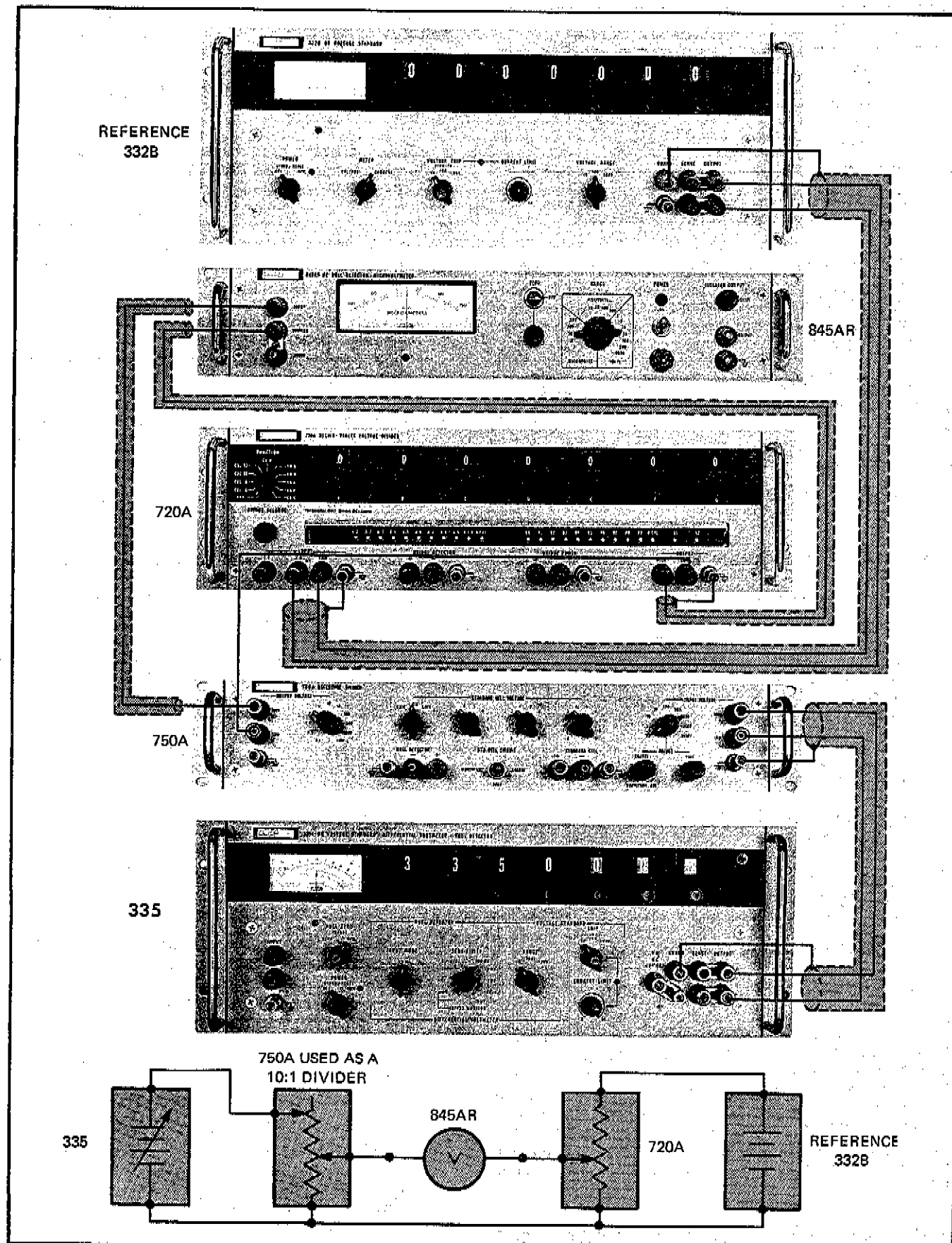


Figure 4-11. CONNECTIONS FOR LINEARIZATION ADJUSTMENT

k. Repeat the procedure for steps c through g of Figure 4-12.

l. Set the RANGE switch to 100 and perform the adjustments listed in Figure 4-13 for the A DECK.

4-64. RANGE CALIBRATION. Proceed as follows:

a. Connect the equipment as shown in Figure 4-14. Use low-thermal (copper) leads with space lugs; the leads should be as short as possible.

b. On the Model 335A/335D, connect the OUTPUT and SENSE terminals together and connect the OUTPUT terminals to the OUTPUT terminals on the Model 750A. Connect the GUARD terminal to the shield of the output cable and connect the VM AC COMMON terminal to the ground ($\perp$) terminal.

c. Set the front panel controls as follows:

NULL ZERO	OPR
INPUT MODE	TVM
SENSITIVITY	V
RANGE	10
TRIP	1000
TRIP VERNIER	Maximum clock- wise
CURRENT LIMIT	Approx. 10° from maximum counter- clockwise
Readout Dials	10.000000
POWER	STDBY/RESET

d. On the Model 750A, connect the standard cell to the STANDARD CELL terminals and the null detector to the NULL DETECTOR terminals. Set the Model 845AR for reduced sensitivity. Set the Model 750A controls as follows:

OUTPUT VOLTAGE	10
STANDARD CELL VOLTAGE	OPEN
STANDARD CELL VOLTAGE	Voltage of cell in use
INPUT VOLTAGE	RESET

e. Slide the instrument chassis out of the case just far enough to reach the CAL adjustment holes (10V, 100V, 1000V) in the top cover.

f. Set the POWER switch to OPR. Set the Model 750A STANDARD CELL CIRCUIT switch to MOMENTARY and note the deflection on the Model 845AR.

g. Adjust the CAL 10V increasing null detector sensitivity until zero volts (± 1.0 microvolts) is indicated in the Model 845AR for the 335A (± 0.5 uv, 335D).

h. Repeat the adjustments for the 100 and 1000 volt ranges according to Figure 4-15.

CAUTION:

The overvoltage protection feature of the Model 750A is nullified when the test voltage is applied to the OUTPUT VOLTAGE terminals. Always reduce the applied voltage before reducing the Model 750A OUTPUT VOLTAGE switch setting.

STEP	335 DIAL SETTING	720A DIAL SETTING	ADJUSTMENT	NULL TOLERANCE (uv)
a.	00X.0000	.1000000	CAL 1000V	(335A = 2) (335D = .5)
b.	010.0000	.1000000	1	(335A = 2) (335D = .5)
c.	020.0000	.2000000	2	(335A = 2) (335D = 1)
d.	040.0000	.4000000	4	2
e.	060.0000	.6000000	6	3
f.	080.0000	.8000000	8	3
g.	0X0.0000	1.0000000	X	3

Figure 4-12. DECK B ADJUSTMENT INSTRUCTIONS

STEP	335 DIAL SETTING	720A DIAL SETTING	ADJUSTMENT	NULL TOLERANCE (uv)
a.	0X.00000	.1000000	CAL 100 V	(335A = 2) (335D = .5)
b.	10.00000	.1000000	1	(335A = 2) (335D = .5)
c.	20.00000	.2000000	2	(335A = 2) (335D = 1)
d.	40.00000	.4000000	4	2
e.	60.00000	.6000000	6	3
f.	80.00000	.8000000	8	3
g.	100.00000	1.0000000	10	3

Figure 4-13. DECK A ADJUSTMENT INSTRUCTIONS

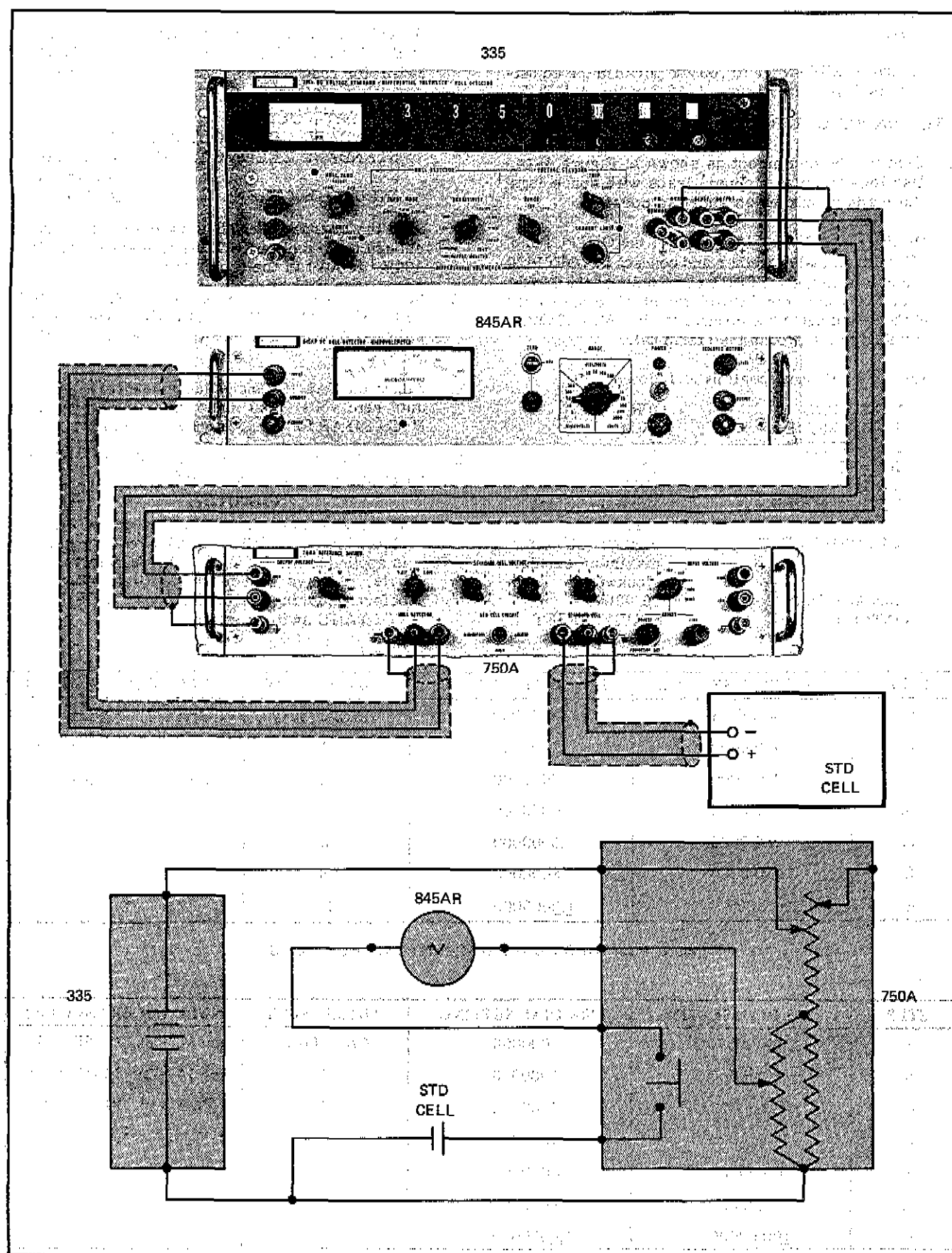


Figure 4-14. CONNECTIONS FOR RANGE CALIBRATION

- i. Slide the chassis back into the case and check the accuracy of output at the RANGE and dial readout settings listed in Figure 4-15. The indication on the Model 845AR should be within the given tolerance.

4-65. TROUBLESHOOTING

4-66. A thorough understanding of the principles of operation is absolutely necessary to efficiently troubleshoot the instrument. It is recommended that you review Section III before attempting to troubleshoot the unit in detail.

4-67. The following troubleshooting procedure is in such sequence that it can be applied to any unit, including one in which the trouble is totally unknown and there is doubt whether power can be applied without causing damage. If the unit is operable, the Resistance Measurement and Standby Power Check, Paragraphs 4-68 and 4-70 may be omitted. The checkout follows the guidelines listed below, and is intended to localize the trouble to an assembly which may be tested individually.

- Remove the Pre-Regulator P/C Assembly.
- Check all auxiliary supplies and the reference voltage.

	335		ADJ.	750A OUTPUT	845AR NULL TOLERANCE (μ V)
	RANGE	READOUT			
Adjust- ments	1000	1000.0000	CAL 1000V	1000	(335A ± 1.0) (335D $\pm .5$)
	100	100.00000	CAL 100V	100	(335A ± 1.0) (335D $\pm .5$)
	10	10.000000	CAL 10V	10	(335A ± 1.0) (335D $\pm .5$)
Checks	10	5.000000	-----	5	± 5.0
	10	10.000000	-----	10	± 5.0
	100	05.00000	-----	5	± 5.0
	100	10.00000	-----	10	± 5.0
	100	50.00000	-----	50	± 5.0
	1000	100.00000	-----	100	± 5.0
	1000	005.0000	-----	5	± 10.0
	1000	010.0000	-----	10	± 5.0
	1000	050.0000	-----	50	± 5.0
	1000	100.0000	-----	100	± 5.0
	1000	500.0000	-----	500	± 5.0
	1000	1000.0000	-----	1000	± 5.0
	1000	10X0.0000	-----	1100	± 5.0

Figure 4-15. CONTROL SETTINGS AND TOLERANCES FOR RANGE CALIBRATION

- Check the Control Amplifier to ensure that it operates properly when provided with an error signal.
- Verify that the Pre-Regulator is being turned on and off by the Unijunction Oscillator.

When it can be verified that the Pre-Regulator is controlling power to the High Voltage Rectifier, the POWER switch may be set to the OPR position and the Series Pass Element checked.

WARNING!

The inner chassis is at the same potential as the +OUTPUT terminal. Avoid contact with the inner chassis and exposed parts. The Pre-Regulator circuitry is at line voltage above ground. When changing P/C boards, use the POWER switch OFF position and wait a few seconds after removing power to allow capacitors to discharge. When changing the Pre-Regulator Assembly, set the POWER switch to OFF.

4-68. Resistance Measurements

4-69. These checks verify correct output resistance of auxiliary voltage supplies. A check of the sample string may reveal an open resistor, which is sometimes a cause of loss of regulation. An ohmmeter (RCA VoltOhmyst or equivalent) is required for this test.

- Disconnect the instrument power plug from ac power. Disengage the chassis from the case by loosening the two Dzus fasteners on the rear of the instrument. Slide the unit out of the case and remove the top inner cover. This will open the interlock.
- Remove the Pre-Regulator P/C Assembly. Set the instrument POWER switch to OFF and set the readout dials to all zeros.
- Measure the resistance between the following test points and the +SENSE terminal. Connect the assembly to the mother board by using the extender card.

ASSEMBLY	PIN	RESISTANCE (Approx.)
Auxiliary Power Supply	9	9.0 kilohms
Auxiliary Power Supply	10	2.2 kilohms
Current Limiter	1	5.0 kilohms
Current Limiter	3	3.0 kilohms

- Disconnect the shorting links between the SENSE and OUTPUT terminals. Remove the Differential Amplifier Assembly and connect an ohmmeter between pin 5 of the Differential Amplifier socket and the -SENSE terminal. The ohmmeter should indicate less than 0.5 ohm. Step each dial through its range; the resistance should increase according to the following table. Return each dial to zero after checkout.

Note!

This check detects gross errors only, such as an open resistor. Resistors are factory selected for accuracy and temperature coefficient.

READOUT DIAL	RESISTANCE INCREASE OHMS PER STEP
Seventh	0.1
Sixth	1.0
Fifth	10
Fourth	100
Third	1000
Second	10,000
First	100,000

- e. Reconnect the links between the SENSE and OUTPUT terminals and replace the Differential Amplifier Assembly.

4-70. Standby Power

4-71. This check measures power consumption in the STDBY/RESET mode. It reveals possible gross faults such as shorted components in the auxiliary power supply, voltage control circuitry and protection circuitry. A metered Variac and differential voltmeter are required for this test.

- a. Remove the top inner cover and the Pre-Regulator Assembly if not already accomplished.
- b. Connect the instrument through a Variac to a 115 volt, 60 Hz, power line with a wattmeter or ammeter in series between the Variac and the instrument. Set the Variac output to zero. Set the front panel controls as follows:

POWER	OFF
VOLTAGE RANGE	100
VOLTAGE TRIP	1000
VERNIER	maximum clockwise
CURRENT LIMIT	maximum clockwise
Readout Dials	50.00000

- c. Set the POWER switch to STDBY/RESET and slowly increase the output of the Variac to 115 volts. The CURRENT LIMIT and center decimal lights should operate. The wattmeter should indicate 30 to 40 watts power drain.

4-72. Auxiliary Supply Voltages

4-73. This procedure checks out the bias voltages, master reference voltage and the series pass element voltage.

- a. Using the Model 885A differential voltmeter, measure the voltage between the test points listed in Figure 4-16 and the +SENSE terminal, which is common.
- b. Where indicated, perform the adjustment to determine that it can be made. These should be rechecked during calibration of the instrument.

ASSEMBLY	PIN	VOLTS DC
Auxiliary Power Supply	10	23 to 27
Auxiliary Power Supply	9	-14 to -16
Current Limiter	1	-33 to -39
Current Limiter	3	33 to 39
Reference Calibration	Test Points	5.9 to 6.1
Master Reference	Collector Q1	26 to 35
Series Pass	Collector Q8	Approx. 140
Rear bulkhead power resistor, 100 kilohms	Yellow lead	650

Adjustable to 25 $\pm$ 10 volts with R9

Adjustable to 6.02 $\pm$ 10 volts with R2

Approximately 1 volt at turn-on, rising to 26 to 35 volts after 10 minute warmup.

Figure 4-16. REFERENCE AND AUXILIARY VOLTAGES

4-74. Unijunction Oscillator and Amplifier

4-75. This check verifies operation of the unijunction oscillator and the flow of error signal through the chopper amplifier, differential amplifier and series pass driver. An oscilloscope and a general purpose power supply are required for this test.

- a. Connect the oscilloscope with a 10X isolation probe between pins 14 (common) and 15 (input) of the Series Pass P/C Assembly. Set the oscilloscope sweep speed to 2 milliseconds/cm and vertical sensitivity to 50 millivolts/cm.
- b. Set the POWER switch to STDBY/RESET. Positive going pulses of 0.7 to 2.5 volts peak-to-peak should be observed.
- c. Set the POWER switch to ON. The pulses should disappear.
- d. Connect a general purpose power supply, set for 5.5 volts output, to the OUTPUT terminals: positive to positive and negative to negative.
- e. Set the RANGE switch to 10 and the readout dials to 5.000000; unijunction pulses should appear on the oscilloscope. Set the readout dials to 6.000000; the unijunction pulses should disappear. These results verify correct control amplifier operation.
- f. To check out the additional RANGE switch circuitry, set the RANGE and readout dials as follows:

RANGE	READOUT DIALS	UNIJUNCTION PULSES
100	05.0000	should appear
100	06.0000	should disappear
1000	005.0000	should appear
1000	006.0000	should disappear

4-76. Pre-Regulator

4-77. This check verifies operation of the Pre-Regulator circuitry Q1 through Q8. An oscilloscope and a power line isolation adapter are required for this test.

- Set the POWER switch to OFF. Install the Pre-Regulator P/C Assembly.

- Set the front panel controls as follows:

POWER	OFF
RANGE	1000
VOLTAGE TRIP	1000
VERNIER	maximum clockwise
CURRENT LIMIT	maximum clockwise

- Connect the oscilloscope power plug to the ac line via a line isolator (two-to-three wire adapter). The oscilloscope must be operated ungrounded when observing pre-regulator waveforms.
- Connect the oscilloscope common to the emitter (blue) of Q1 and connect the input to the base (yellow). (Q1 is the stud-mounted power transistor.) Set the vertical input to DC, sweep speed to 2 millisecond/cm and the vertical sensitivity to 1.0 volt/cm.
- Set the POWER switch to STDBY/RESET. The oscilloscope waveform should appear as shown in Figure 4-17.
- Set the POWER switch to OPR. The waveform should appear as shown in Figure 4-18.

4-78. Series Pass Element

4-79. If the procedure has been completed satisfactorily thus far, the main parts of the voltage control circuitry

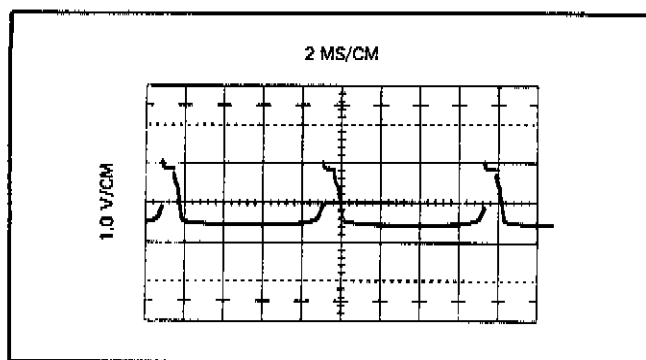


Figure 4-17. PRE-REGULATOR Q1, WAVEFORM ON STDBY/RESET

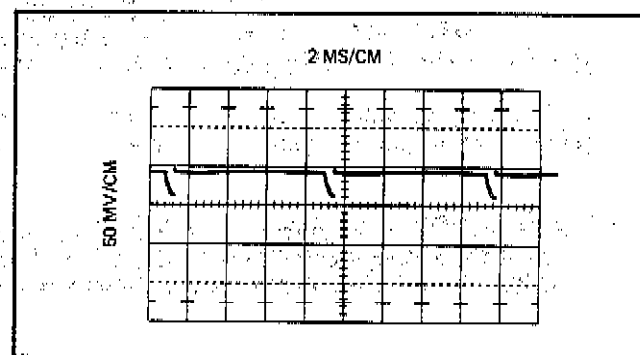


Figure 4-18. PRE-REGULATOR Q1, WAVEFORM ON OPR

have been checked out excluding the Series Pass P/C Assembly. A simple check of the series pass function is to measure ac line power consumption in OPR mode with 1000 volts dc output. A metered Variac, a differential voltmeter and a load resistor box are required for this test.

- Set the front panel controls as follows:

METER	VOLTAGE
POWER	STDBY/RESET
RANGE	1000
VOLTAGE TRIP	1000
VERNIER	maximum clockwise
CURRENT LIMIT	maximum clockwise
Readout Dials	All zeros

- Close the interlock switches. Set the POWER switch to OPR and step the first voltage dial from 0 to 10. The wattmeter indication at 1000 volts output should be 60 to 70 watts. If the indication is 80 watts or greater, it is possible that the series pass function is faulty, assuming that any trouble in the pre-regulator was detected by the preceding check.
- The capability of the series pass element to regulate may be checked by measuring the voltage drop across the series pass transistors. Connect a dc high-impedance voltmeter between pins 11 (positive) and 5 (common). Set the RANGE switch to 10 and the readout dials to all zeros. Adjust the line voltage to 100 volts. The voltmeter indication should be less than 85 volts.
- Connect the voltmeter between the collector of Q8 and pin 5. Measure the voltage across Q8 at the following control settings and line voltages. The voltage should be within the given limits.

RANGE	READOUT DIALS	LINE VOLTAGE	VOLTAGE LIMITS ACROSS Q8	
			MIN	MAX
10	All zeros	100	70	100
10	All zeros	130	65	100

- Set the POWER switch to STDBY/RESET and connect the Load Resistor Box, set for 18.3 kilohms (60 ma load), to the OUTPUT terminals. Set the POWER switch to OPR and measure the voltage across Q8 at the following control settings and line voltages.

RANGE	READOUT DIALS	LINE VOLTAGE	VOLTAGE LIMITS ACROSS Q8	
			MIN	MAX
1000	10X0.0000	100	40	55
1000	10X0.0000	130	40	55

- f. Set the POWER switch to STDBY/RESET and disconnect the Load Resistor Box. On the 1000 volt RANGE, set the readout dials for output voltages

of 100, 500, and 1100. At each output connect a shorting jumper across the OUTPUT terminals. Observe the panel meter and remove the shorting jumper. The output should return to normal on removal of the short.

- g. If the voltage standard successfully passes the foregoing checks, the Performance Test should be performed to determine if the instrument will perform within specifications.

Section 5

List of Replaceable Parts

5-1. INTRODUCTION

5-2. This section contains complete descriptions of those parts one might normally expect to replace during the life of the instrument. The first listing is a breakdown of all of the major assemblies in the instrument. Subsequent listings itemize the components in each assembly. Every listing is accompanied by an illustration identifying each component in the listing. Assemblies and subassemblies are identified by a reference designation beginning with the letter A, (e.g., A1, etc.). Components are identified by the schematic diagram reference designation (e.g., R1, C107, DS1). Parts not appearing on the schematic diagram are numbered consecutively throughout the parts list with a whole number in arrow call-out illustrations and are identified by index number only in grid illustrations. Flagnotes are used throughout the parts list and refer to ordering explanations. The flagnote explanations appear at the end of the parts list in which they are listed.

5-3. COLUMNAR INFORMATION

- a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.
- b. The INDEX NO. column lists coordinates which locate the designated part on the associated 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 item used in the instrument. Second and subsequent listing of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, the TOT QTY column lists the total quantity of the item in that particular assembly.
- 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.
- 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. As Use Codes are added to the list, the TOT QTY column listings are changed to reflect the most current information. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-4 HOW TO OBTAIN PARTS

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

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

a. 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.

5-7. SERIAL NUMBER EFFECTIVITY

5-8. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all instruments with serial numbers above 123. New codes will be added as required by instrument changes.

USE CODE

EFFECTIVITY

None	Model 335A/335D serial number 123 and on.
A	Model 335A serial number 123 thru 147.
B	Model 335A/335D serial number 148 and on.
C	Model 335A serial number 123 thru 151, 153 thru 169, 171 thru 176, 178, 180, 182 thru 184, 187 and 190 thru 197.
D	Model 335A/335D serial number 152, 170, 177, 179, 181, 185, 186, 188, 189 and 198 and on.
E	Model 335A serial number 123 thru 197.
F	Model 335A serial number 198 thru 338.
G	Model 335A/335D serial number 339 and on.
H	Model 335A serial number 123 thru 219.
I	Model 335A/335D serial number 220 and on.
J	Model 335A serial number 123 thru 337.
K	Model 335A/335D serial number 338 and on.
L	Model 335A serial number 123 thru 209.
M	Model 335A/335D serial number 210 and on.
N	Model 335A/335D serial number 444, 454, 458, 467, 470, 480 and on.
O	Model 335A serial number 123 thru 486.

P	Model 335A/335D serial number 487 and on.
Q	Model 335A serial number 123 thru 576.
R	Model 335A/335D serial number 577 and on.
S	Model 335A serial number 123 thru 599, 601 thru 620.
T	Model 335A/335D serial number 600, 621 and on.
U	Model 335A serial number 210 thru 576.
V	Model 335A serial number 123 thru 671.
W	Model 335A/335D serial number 672 and on.
X	Model 335A/335D serial number 123 thru 629, 631 thru 761 and 777 and on.
Y	Model 335A/335D serial number 630 and 762 thru 776.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NULL DETECTOR Figure 5-1	335A or 335D					
A1		Capacitor P/C Assembly (See Figure 5-2)	1702-219212 (335A-4062)	89536	1702-219212	1		
A2		Sample String P/C Assembly (See Figure 5-3)				1		
A3		Capacitor Switch P/C Assembly (See Figure 5-4)	1702-227603 (335A-4092)	89536	1702-227603	1		
A4		Reference Calibration P/C Assembly (See Figure 5-5)	1702-219113 (335A-4052)	89536	1702-219113	1		
A5		Main Mother Board P/C Assembly (See Figure 5-6)	1702-219238 (335A-4064)	89536	1702-219238	1		
A5A1		Master Voltage Reference P/C Assembly (See Figure 5-7)	1702-298653 (335A-4101)	89536	1702-298653	1		
A5A2		Series Pass Driver P/C Assembly (See Figure 5-8)	1702-219154 (335A-4056)	89536	1702-219154	1		
A5A3		Differential Amplifier P/C Assembly (See Figure 5-9)	1702-219162 (335A - 4057)	89536	1702-219162	1		
A5A4		Chopper Amplifier P/C Assembly (See Figure 5-10)	1702-219170 (335A-4058)	89536	1702-219170	1		
A5A5		Auxiliary Power Supply P/C Assembly (See Figure 5-11)	1702-219188 (335A-4059)	89536	1702-219188	1		
A5A6		Current Limiter P/C Assembly (See Figure 5-12)	1702-219196 (335A - 4060)	89536	1702-219196	1		
A6		Isolated Mother Board P/C Assembly (See Figure 5-13)	1702-219147 (335A - 4055)	89536	1702-219147	1		
A6A1		Null Detector Power Supply P/C Assembly (See Figure 5-14)	1702-219121 (335A - 4053)	89536	1702-219121	1		
A6A2		Null Detector Amplifier P/C Assembly (See Figure 5-15)	1702-219139 (335A - 4054)	89536	1702-219139	1		
A7		Time Delay P/C Assembly (See Figure 5-16)	1702-192260 (332A - 420)	89536	1702-192260	1		
A8		High Voltage Mother Board P/C Assembly (See Figure 5-17)	1702-219220 (335A - 4063)	89536	1702-219220	1		
A8A1		Series Pass Element P/C Assembly (See Figure 5-18)	1702-219204 (335A-4061)	89536	1702-219204	1		
A8A2		Preregulator P/C Assembly (See Figure 5-19)	1702-222000 (335A-4082)	89536	1702-222000	1		
A9		Extender P/C Board	1702-187344 (332A-415)	89536	1702-187344	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C1		Cap, oil, 4 uf $\pm 10\%$, 1, 200v	1505-183541	01884	CMLE405K12	1		
C2		Cap, cer, 0.01 uf, gm, 1, 600v (located on C1)	1501-106930	71590	DD16-103	2		
C3		Cap, cer, 0.005 uf $\pm 20\%$, 3, 000v	1501-188003	71590	DD30-502	1		
C4		Cap, plstc, 0.1 uf $\pm 10\%$, 1, 500v	1507-234260	96733	C-60232A	2		
C5		Cap, plstc, 0.1 uf $\pm 10\%$, 1, 500v	1507-234260	96733	C-60232A	REF		
C6		Cap, cer, 0.1 uf $\pm 80/-20\%$, 500v	1501-105684	56289	41C92	2		
C7		Cap, cer, 0.1 uf $\pm 80/-20\%$, 500v	1501-105684	56289	41C92	REF		
C8		Cap, Ta, 10 uf $\pm 10\%$, 20v	1508-160259	05397	K10C20K	5		
C9		Cap, plstc, 0.47 uf $\pm 20\%$, 250v	1507-184366	73445	C280AE/P470K	2		
CR1		Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	55	5	
CR2		Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	48	5	
CR3		Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
DS1		Lamp, incandescent, 28v (not illustrated)	3901-175265	89730	757	5	5	
DS2		Lamp, incandescent, 28v (not illustrated)	3901-175265	89730	757	REF		
DS3		Lamp, incandescent, 28v (not illustrated)	3901-175265	89730	757	REF		
DS4		Lamp, incandescent, 28v (not illustrated)	3901-175265	89730	757	REF		
DS5		Lamp, incandescent, 28v (not illustrated)	3901-175265	89730	757	REF		
F1		Fuse, Type MDL, slow blow, 1/4 amp, 250v (not illustrated)	5101-166306	71400	Type MDL	1	5	
F2		Fuse, Type MDA, slow blow, 3 amp, 250v (For 115v operation) (not illustrated)	5101-109280	71400	Type MDA	1	5	
F2		Fuse, Type MDX, slow blow, 1-1/2 amp, 250v (For 230v operation) (not illustrated)	5101-109231	71400	Type MDX	1	5	
J1		Binding post, red, OUTPUT	2811-149856	58474	BHB10208G22	6		
J2		Binding post, black, OUTPUT	2811-149864	58474	BHB10208G21	3		
J3		Binding post, red, SENSE	2811-149856	58474	BHB10208G22	REF		
J4		Binding post, black, SENSE	2811-149864	58474	BHB10208G21	REF		
J5		Binding post, blue, GUARD	2811-233833	58474	DF31BLC	2		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
J6		Binding post, blue, VM AC COMMON	2811-233833	58474	DF31BLC	REF		
J7		Binding post, GROUND	2811-155911	58474	GP30NC	2		
J8		Binding post, red, INPUT HI	2811-149856	58474	BHB10208G22	REF		
J9		Binding post, red, INPUT LO	2811-149856	58474	BHB10208G22	REF		
J10		Binding post, GROUND	2811-155911	58474	GP30NC	REF		
J11		Binding post, red, RECORDER OUT- PUT HI	2811-149856	58474	BHB10208G22	REF		
J12		Binding post, red, RECORDER OUT- PUT LO	2811-149856	58474	BHB10208G22	REF		
J13		Binding post, black	2811-149864	58474	BHB10208G21	REF		
K1		Relay, armature, 115 vac, dpdt	4504-196675	89536	4504-196675	1		J
K1		Relay, armature, 115 vac, dpdt	4504-148940	73949	A410-060713- 00	1		K
M1		Meter, 100-0-100 ua, 325 Ω	2901-218925	89536	2901-218925	1		
R1		Res, met flm, 100k $\pm$ 1%, 1/2w	4705-151316	75042	Type CEC-TO	2		
R2		Res, met flm, 1M $\pm$ 1%, 1/2w	4705-161075	75042	Type CEC-TO	1		
R3		Res, car flm, 5M $\pm$ 1%, 1w	4703-107458	75042	Type C13	2		
R4		Res, car flm, 5M $\pm$ 1%, 1w	4703-107458	75042	Type C13	REF		
R5		Res, var, ww, 5k $\pm$ 10%, 5w	4702-219758	71450	Type AW	1		
R6		Res, var, ww, 300 Ω $\pm$ 10%, 5w	4702-219741	71450	Type AW	1		
R7		Res, comp, 100M $\pm$ 10%, 1/2w	4704-190520	01121	EB1071	1		
R8		Res, comp, 270 Ω $\pm$ 10%, 2w	4704-110189	01121	HB2711	2		
R9		Res, car flm, 9M, matched						
R10		Res, car flm, 900k $\pm$ 1/2%, 1/2w	4703-107391	75042	Type C12	1		
R11		Res, car flm, 90M, matched						
R12		Res, car flm, 1M, matched						
R13		Res, car flm, 100k, matched						
R14		Res, car flm, 10k, matched						
R15		Res, car flm, 1k, matched						
R16		Res, car flm, 100 Ω , matched						
R17		Res, comp, 18 Ω $\pm$ 5%, 1/4w	4704-219022	01121	CB1805	1		
R18		Res, comp, 270 Ω $\pm$ 5%, 1/4w	4704-160804	01121	CB2715	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R19		Res, met flm, 1M, matched	2					
R20		Res, met flm, 100k, matched	2					
R21		Res, met flm, 10k, matched	2					
R22		Res, var, comp, 5M $\pm 20\%$, 0.2w	4701-219733	71450	Type 70	1		
R25		Res, comp, 1k $\pm 10\%$, 1/2w	4704-108563	01121	EB1021	5		
R26		Res, ww, 500 Ω $\pm 5\%$, 25w	4706-183533	14193	Type MC250	1		
R27		Res, ww, 100k $\pm 1\%$, 10w	4706-177121	14193	Type SP1127	2		
R28		Res, ww, 100k $\pm 1\%$, 10w	4706-177121	14193	Type SP1127	REF		
R29		Res, var, car, 10k $\pm 20\%$, 1/2w	4703-162800	12697	Series 37	1		
R30		Res, comp, 4.7k $\pm 10\%$, 1/2w	4704-108381	01121	EB4721	3		
S1		Switch, POWER, STDBY/RESET wafer	5107-187864	76854	Type HC	1		
		Switch, POWER, OPR wafer	5107-187872	76854	248214HC	1		
S2		Switch, RANGE, rotary, 11p, 3 pos, 5 sect	5105-237305	89536	5105-237305	1		
S3		Switch, TRIP, rotary, 3 pos, 2 sect	5105-240739	89536	5105-240739	1		
S4		Switch, INPUT MODE, rotary, 3 pos, 2 sect	5105-240705	89536	5105-240705	1		
S5		Switch, SENSITIVITY, rotary, 11 pos, 6 sect	5105-240713	89536	5105-240713	1		
S6		Switch, NULL ZERO, rotary, 2 pos, 1 sect	5105-240721	89536	5105-240721	1		
S7		Switch, interlock	5104-187708	91929	V3L-78	2		
S8		Switch, interlock	5104-187708	91929	V3L-78	REF		
T1		Transformer, power	5602-222315	89536	5602-222315	1		
T2		Transformer, high voltage	5602-222307	89536	5602-222307	1		
W1		Line cord	6005-102822	89536	6005-102822	1		
XDS1 thru XDS3		Holder, lamp	2110-100131	95263	7-14	3		
XDS4, XDS5		Holder, lamp	2110-103523	72619	7-08	2		
XF1, XF2		Holder, fuse	2102-160846	75915	342004	2		
1		Coupler, dial	3153-130252	89536	3153-130252	7		
2		Coupler, R5 to S3	2402-193557	89536	2402-193557	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
3		Coupler, R22 to S6	2402-228787	89536	2402-228787	1		
4		Coupler, Digit Switches to detents (not illustrated)	3153-228779	89536	3153-228779	7		
5		Coupler, Digit Switches, S1, S4, S5, R6	2402-104505	89536	2402-104505	11		
6		Coupler, S3, S6	3153-246058	89536	3153-246058	2		
7		Coupler, S1 shaft to chassis front	2402-198374	89536	2402-198374	1		
8		Coupler, S1 shaft to S1 wafer	2402-200592	89536	2402-200592	1		
9		Cover (not illustrated)	1402-227280	89536	1402-227280	1		
10		Detent, S1	5108-240895	89536	5108-240895	1		
11		Detent, Digit Switches	5108-240887	89536	5108-240887	7		
12		Dial, 0-10	2506-236984	89536	2506-236984	1		
13		Dial, 0-X	2506-236976	89536	2506-236976	6		
14		Foot, rubber (not illustrated)	2819-103309	77969	9102W	4		
15		Handle, chrome plated bras	2404-101717	05704	807	2		
16		Knob, CURRENT LIMIT	2405-190249	89536	2405-190249	1		
17		Knob, DIGITS 1-7	2405-158949	89536	2405-158949	7		
18		Knob, INPUT MODE, POWER, RANGE SENSITIVITY	2405-158956	89536	2405-158956	4		
19		Knob, NULL ZERO, TRIP						
19a		concentric	2405-162347	89536	2405-162347	2		
19b		vernier	2405-241018	89536	2405-241018	2		
19c		trim disc	2405-236950	89536	2405-236950	2		
20		Lens, decimal, clear	3155-222596	89536	3155-222596	3		
21		Lens, decimal, red	3155-228056	89536	3155-228056	2		
22		Link, shorting, brass	2811-101220	24655	938L	1		
23		Link, shorting, copper	2811-190728	24655	938LG	2		
24		Panel, front	1406-224741	89536	1406-224741	1		
25		Shaft, S3 (not illustrated)	3103-227272	89536	3103-227272	1		
26		Shaft, S6 (not illustrated)	3103-225151	89536	3103-225151	1		
27		Shaft, S1	3103-186858	89536	3103-186858	1		
28		Shaft, Digit Switches, S1, S4, S5, R6	3103-226928	89536	3103-226928	11		
29		Toggle arm, S1	3156-224857	89536	3156-224857	2		
30		Toggle link, S1	3156-224832	89536	3156-224832	1		

1

These resistors are a factory matched set, part number 4710-227132. If replacement of one or more resistors is required, replace the entire set.

2

These resistors are a factory matched set, part number 4707-239293. If replacement of one or more resistors is required, include all information stamped on the resistor along with the information described in paragraph 5-6. Should the information on the resistor not be discernible, include all of the above information about the adjacent resistors.

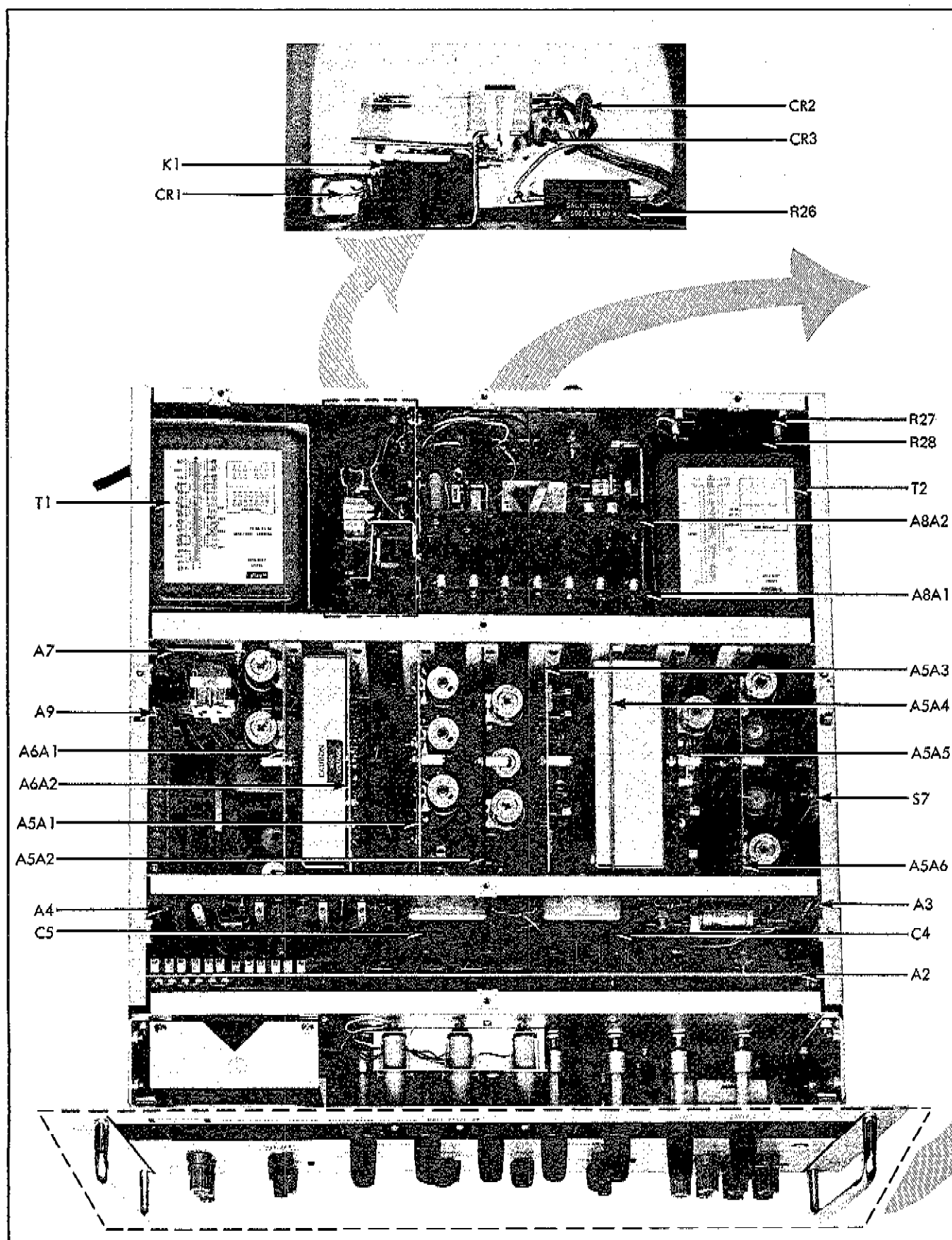


Figure 5-1. DC VOLTAGE STANDARD -DIFFERENTIAL VOLTMETER-NULL DETECTOR (Sheet 1 of 5)

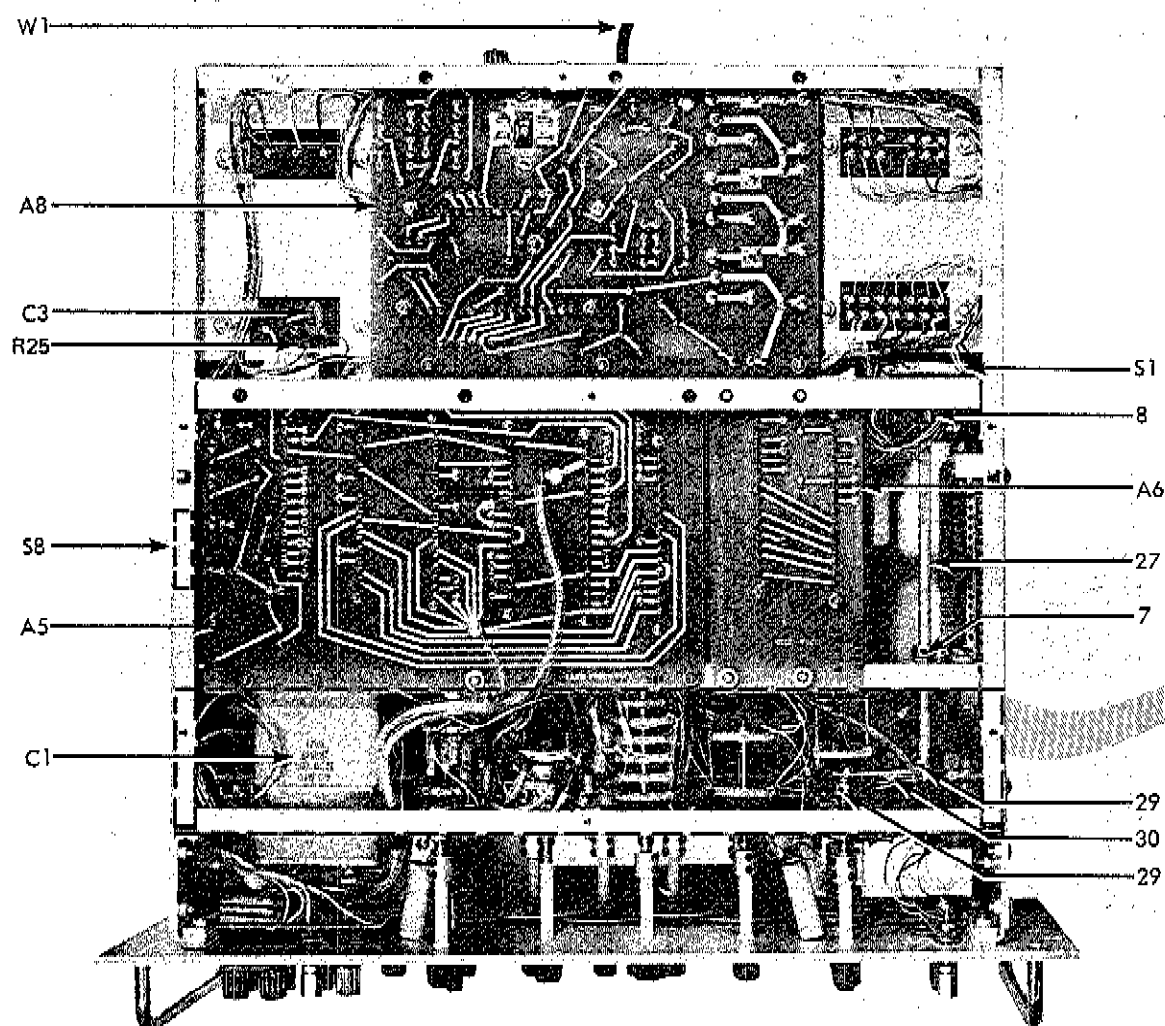


Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NUL DETECTOR (Sheet 3 of 5)

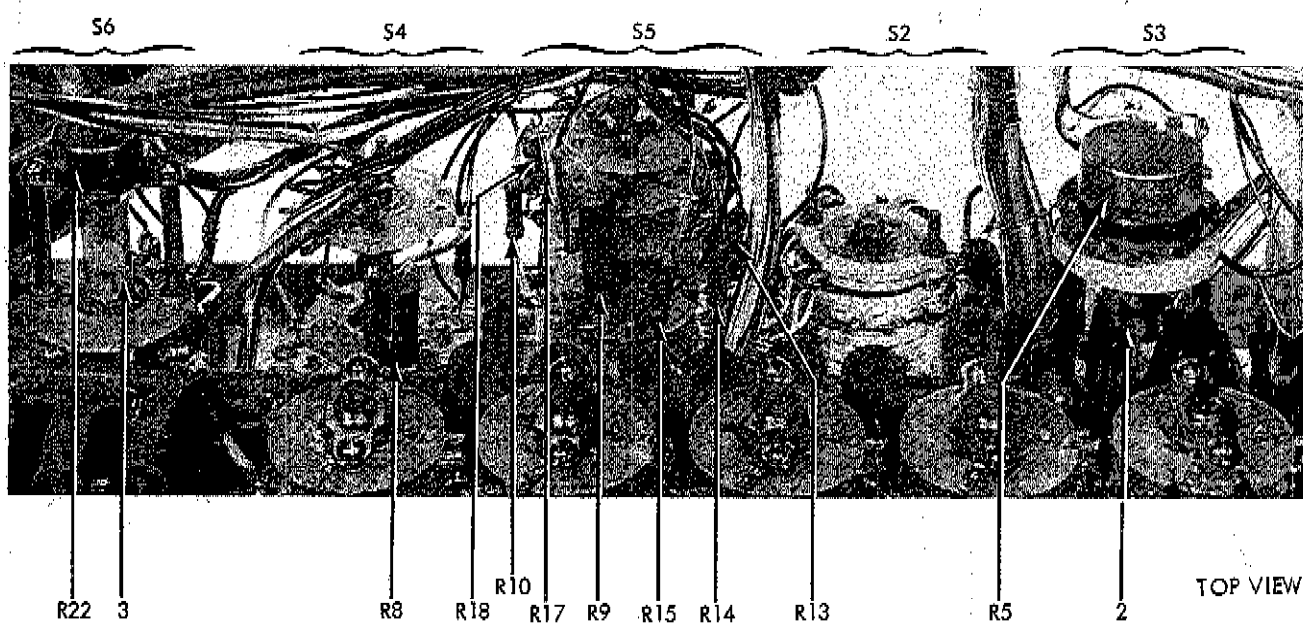
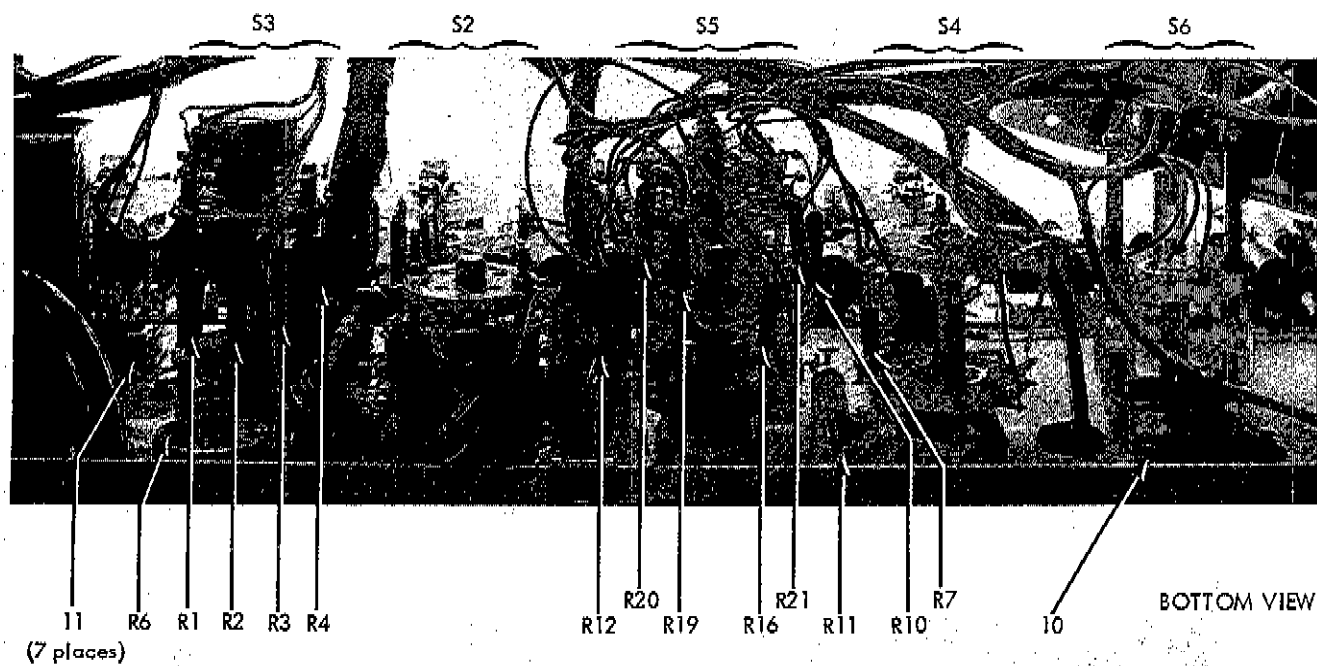


Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NUL DETECTOR (Sheet 4 of 5)

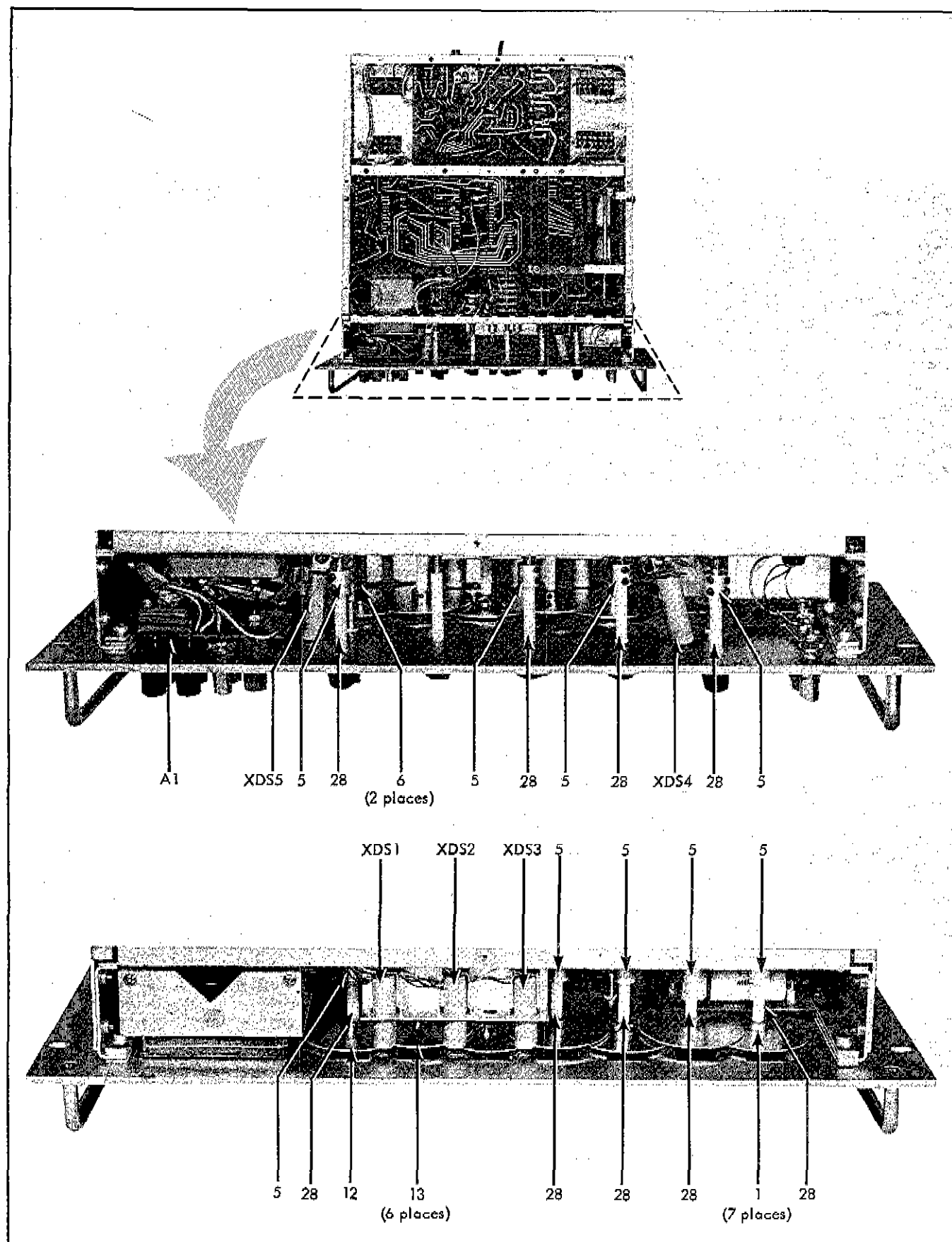


Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTmeter-NULl DETECTOR (Sheet 5 of 5)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		CAPACITOR P/C ASSEMBLY Figure 5-2	1702-219212 (335A-4062)	89536	1702-219212	REF		
C1	F2-L1	Cap, plstc, 1 uf $\pm 20\%$, 250v	1507-190330	73445	C280AE/P1M	3		
C2	E1-H4	Cap, plstc, 1 uf $\pm 20\%$, 250v	1507-190330	73445	C280AE/P1M	REF		
C3	D1-K5	Cap, plstc, 0.25 uf $\pm 10\%$, 1200v	1507-183616	84411	JF6	2		
C4	D1-M2	Cap, plstc, 0.25 uf $\pm 10\%$, 1200v	1507-183616	84411	JF6	REF		
CR1	E3-J3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2	E4-I2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		

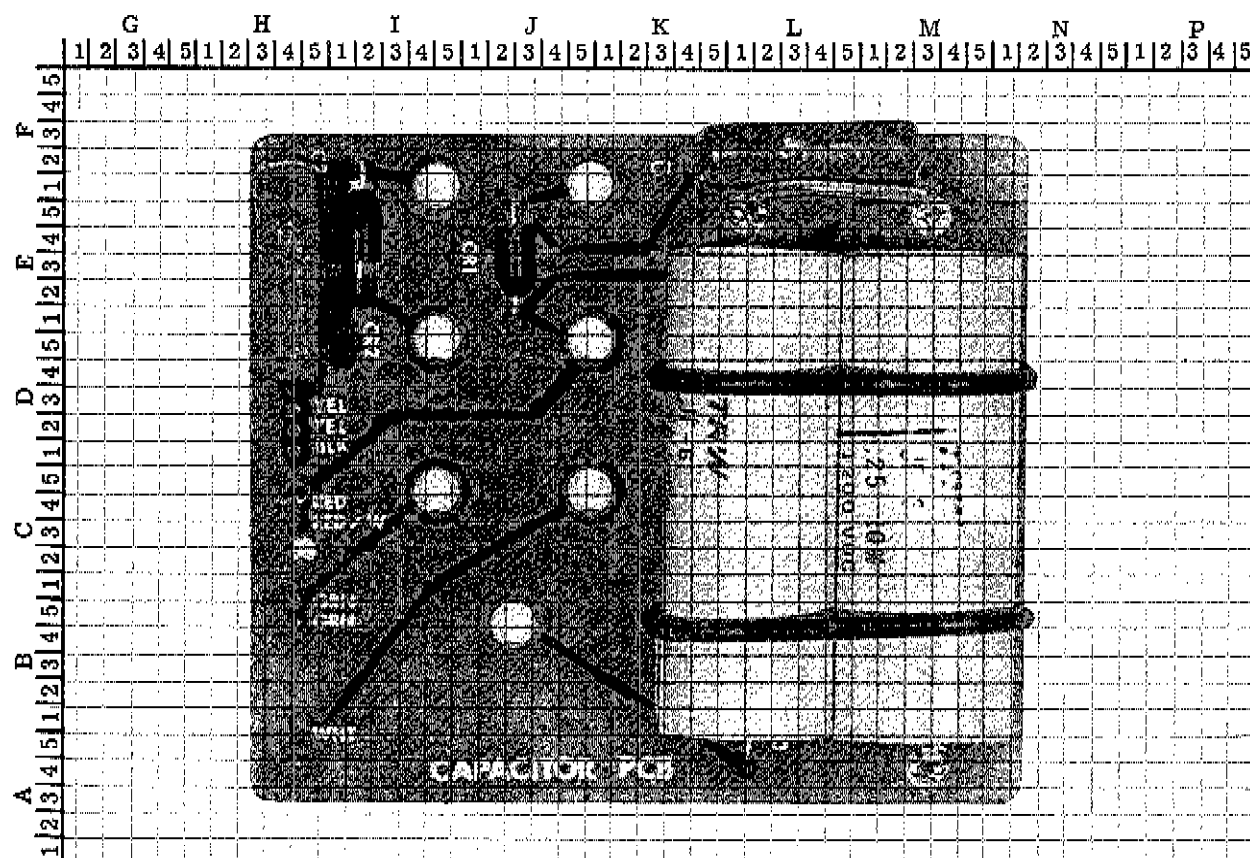


Figure 5-2. CAPACITOR P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2		SAMPLE STRING P/C ASSEMBLY Figure 5-3						
R1	B2-N5	Res, ww, 99.955k, matched						
R2	B1-P3	Res, ww, 99.955k, matched						
R3	B1-Q2	Res, var, met flm, 200Ω ±20%, 3/4w	4701-186213	73138	78PR200	5		
R4	B2-Q2	Res, var, met flm, 200Ω ±20%, 3/4w	4701-186213	73138	78PR200	REF		
R5	B3-P3	Res, ww, 99.955k, matched						
R6	B4-N5	Res, ww, 99.955k, matched						
R7	C1-N5	Res, ww, 99.955k, matched						
R8	B5-P3	Res, ww, 99.955k, matched						
R9	B3-Q2	Res, var, met flm, 200Ω ±20%, 3/4w	4701-186213	73138	78PR200	REF		
R10	B4-Q2	Res, var, met flm, 200Ω ±20%, 3/4w	4701-186213	73138	78PR200	REF		
R11	C2-P3	Res, ww, 99.955k, matched						
R12	C4-N5	Res, ww, 99.955k, matched						
R13	D2-N5	Res, ww, 99.955k, matched						
R14	C4-P3	Res, ww, 99.955k, matched						
R15	B5-Q2	Res, var, met flm, 200Ω ±20%, 3/4w	4701-186213	73138	78PR200	REF		
R16	C1-Q2	Res, var, met flm, 100Ω ±20%, 3/4w	4701-159889	73138	78PR100	1		
R17	D1-P3	Res, ww, 99.955k, matched						
R18	E4-N5	Res, ww, 19.991k, matched						
R19	C2-Q2	Res, var, met flm, 20Ω ±30%, 3/4w	4701-186197	73138	78PR20	5		
R20	C3-Q2	Res, var, met flm, 20Ω ±30%, 3/4w	4701-186197	73138	78PR20	REF		
R21	F1-N5	Res, ww, 19.991k, matched						
R22	F3-N5	Res, ww, 19.991k, matched						
R23	C4-Q2	Res, var, met flm, 20Ω ±30%, 3/4w	4701-186197	73138	78PR20	REF		
R24	C5-Q2	Res, var, met flm, 20Ω ±30%, 3/4w	4701-186197	73138	78PR20	REF		
R25	F2-Q1	Res, ww, 19.991k, matched						
R26	E3-Q3	Res, ww, 19.991k, matched						
R27	D1-Q2	Res, var, met flm, 20Ω ±30%, 3/4w	4701-186197	73138	78PR20	REF		
R28	D2-Q2	Res, var, met flm, 10Ω ±30%, 3/4w	4701-186205	73138	78PR10	2		
R29	F1-Q3	Res, ww, 19.991k, matched						

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R30	F4-Q3	Res, ww, 19.991k, matched	3					
R31	F4-N5	Res, ww, 2k, matched	3					
R32	G1-N5	Res, ww, 2k, matched	3					
R33	G3-N5	Res, ww, 2k, matched	3					
R34	G5-Q3	Res, ww, 2k, matched	3					
R35	G2-Q3	Res, ww, 2k, matched	3					
R36	G2-Q1	Res, ww, 1k, matched	3					
R37	G5-N5	Res, ww, 200 Ω , matched	3					
R38	H1-N5	Res, ww, 200 Ω , matched	3					
R39	H2-N5	Res, ww, 200 Ω , matched	3					
R40	H4-Q2	Res, ww, 200 Ω , matched	3					
R41	H3-Q2	Res, ww, 200 Ω , matched	3					
R42	H3-Q2	Res, ww, 100 Ω , matched	3					
R43	H5-N5	Res, ww, 20 Ω , matched	3					
R44	H4-N5	Res, ww, 20 Ω , matched	3					
R45	I1-N5	Res, ww, 20 Ω , matched	3					
R46	I2-Q2	Res, ww, 20 Ω , matched	3					
R47	I1-Q2	Res, ww, 20 Ω , matched	3					
R48	I3-Q2	Res, ww, 10 Ω , matched	3					
R49	I2-N5	Res, ww, 2 Ω , matched	3					
R50	I3-N4	Res, ww, 2 Ω , matched	3					
R51	I4-N4	Res, ww, 2 Ω , matched	3					
R52	I5-N4	Res, ww, 2 Ω , matched	3					
R53	I4-Q2	Res, ww, 2 Ω , matched	3					
R54	I4-Q2	Res, ww, 1 Ω , matched	3					
R55	J3-T3	Res, ww, 0.2 Ω , matched	3					V
R55		Resistance wire, 0.1 Ω (See S7)						W
R56	J3-T2	Res, ww, 0.2 Ω , matched	3					V
R56		Resistance wire, 0.1 Ω (See S7)						W
R57	J3-T3	Res, ww, 0.2 Ω , matched	3					V
R57		Resistance wire, 0.1 Ω (See S7)						W

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R58	J4-T4	Res, ww, 0.2 Ω , matched						V
R58		Resistance wire, 0.1 Ω (See S7)						W
R59	J3-U1	Res, ww, 0.2 Ω , matched						V
R59		Resistance wire, 0.1 Ω (See S7)						W
R60	J3-T5	Res, ww, 0.1 Ω , matched						V
R60		Resistance wire, 0.1 Ω (See S7)						W
R61 thru R64		Resistance wire, 0.1 Ω (See S7)						W
S1	D1-P4	Switch, DIGIT 1, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	6		
S2	F1-P4	Switch, DIGIT 2, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	REF		
S3	G1-P4	Switch, DIGIT 3, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	REF		
S4	H1-P4	Switch, DIGIT 4, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	REF		
S5	H5-P4	Switch, DIGIT 5, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	REF		
S6	J1-P4	Switch, DIGIT 6, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	REF		
S7	J4-T4	Switch, DIGIT 7, rotary, 11 pos, 2 sect	5105-240697	89536	5105-240697	REF		V
S7	J5-P4	Switch, DIGIT 7, rotary, (Includes R55 thru R64, 0.1 Ω resistance wire. For replacement of resistance wire, order a new S7 digit switch.)	5110-291021	89536	5110-291021	1		W
 Factory matched for resistance accuracy and temperature coefficient. When ordering, include all information stamped on the resistor (if not legible include information on adjacent resistors) in addition to the in- formation requested in paragraph 5-6.								

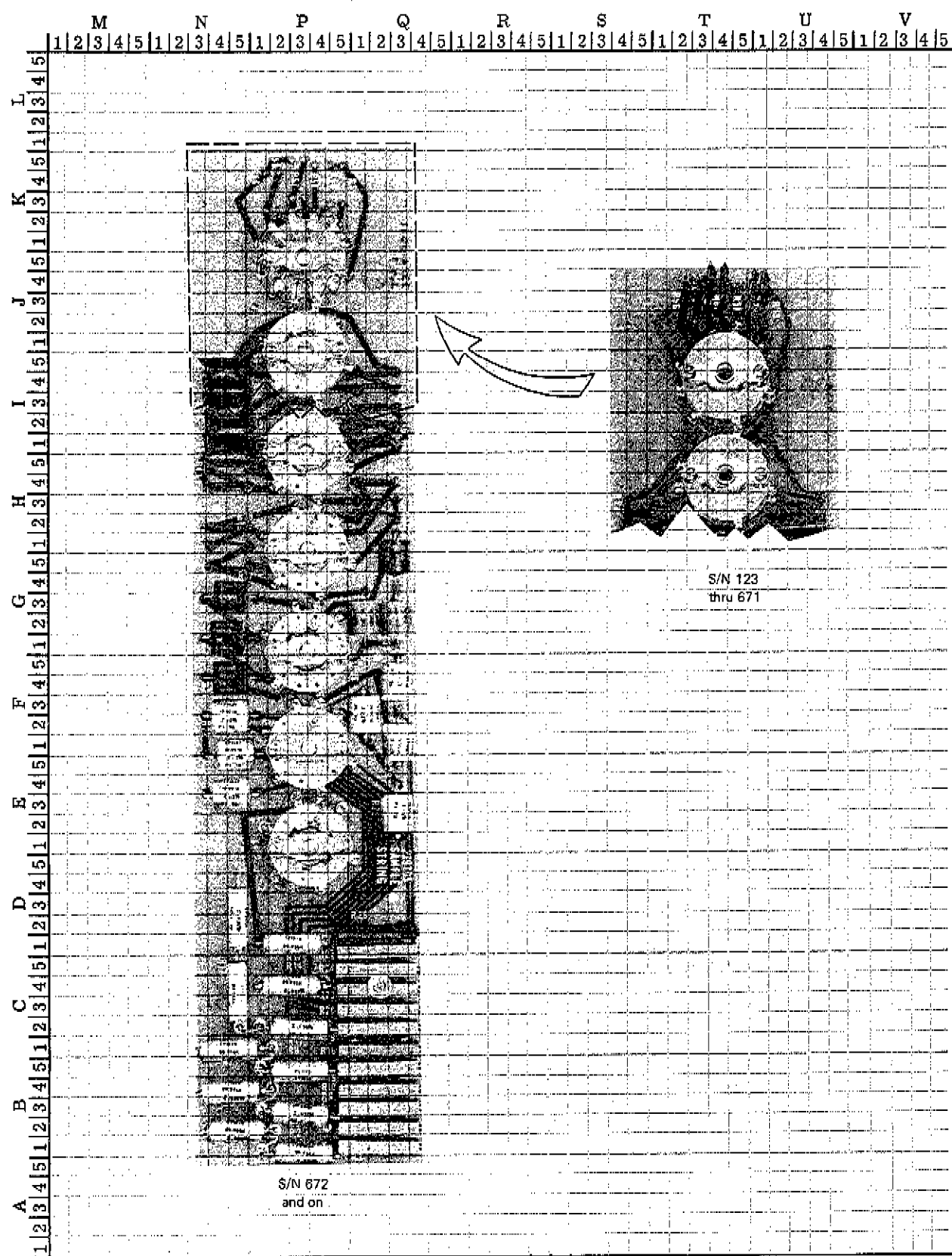


Figure 5-3. SAMPLE STRING P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A3		CAPACITOR SWITCH P/C ASSEMBLY Figure 5-4	1702-227603 (335A-4092)	89536	1702-227603	REF		
C1	D5-K1	Cap, elect, 400 uf +50/-10%, 25v	1502-168153	73445	C437ARF400	1	1	
CR1	D4-M2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
K1	C5-I5 C5-J5	Relay, reed, 1,000v Coil, reed relay, 24v	5103-233916 1802-186155	12617 71707	Type DRR-5 SP-24-P	1 4		
Q1	D4-H4	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	18	5	
R1	D5-M4	Res, comp, 100Ω ±10%, 1/2w	4704-108100	01121	EB1011	2		
R2	D5-N2	Res, comp, 15k ±10%, 1/2w	4704-108530	01121	EB1531	6		
R3	C3-M4	Res, comp, 470Ω ±10%, 1/2w	4704-108415	01121	EB4711	2		
R4	E3-H4	Res, comp, 10k ±10%, 1/2w	4704-108118	01121	EB1031	8		
R5	D1-H5	Res, comp, 1k ±10%, 1/2w	4704-108563	01121	EB1021	REF		
R6	B5-I2	Res, comp, 100Ω ±10%, 1/2w	4704-108100	01121	EB1011	REF		
R7	B5-J5	Res, comp, 39k ±5%, 1w	4704-236729	01121	GB3935	1		

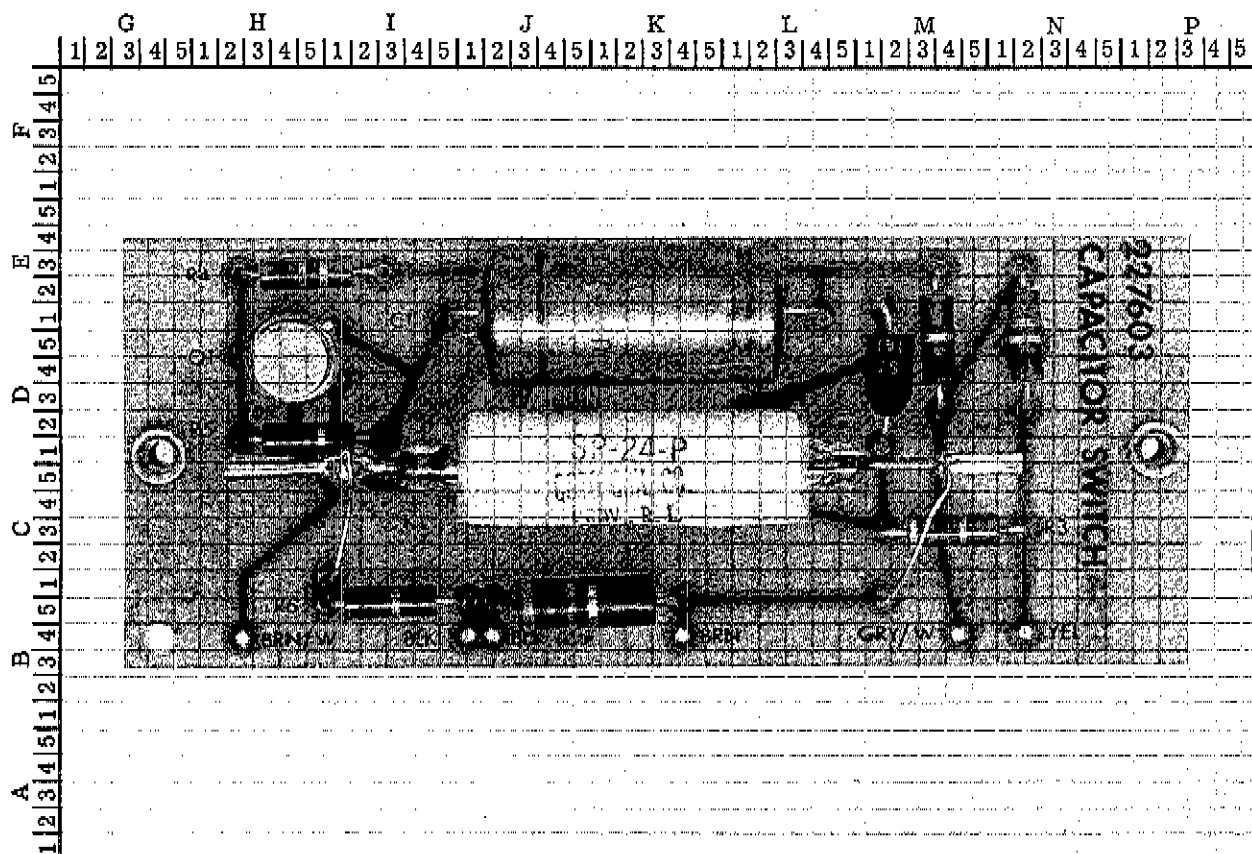
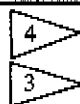


Figure 5-4. CAPACITOR SWITCH P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A4		REFERENCE CALIBRATION P/C ASSEMBLY - Figure 5-5	1702-219113 (335A-4052)	89536	1702-219113	REF		
C1	D1-I1	Cap, plstc, 0.1 uf $\pm 10\%$, 200v	1507-106013	56289	192P10492	1		
CR1	D3-G4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
R1	C2-J1	Res, ww, Factory selected	4					
R2	D1-H3	Rcs, var, ww, $500\Omega \pm 5\%$, $\frac{3}{4}w$	4702-187740	12697	Type 76JA-3	1		
R3	C5-J1	Res, ww, factory selected	4					
R4	D1-K1	Rcs, var, met flm, $500\Omega \pm 20\%$, $\frac{3}{4}w$	4701-159897	73138	78PR500	1		
R5	D1-K4	Res, ww, 300.85k, matched	3					
R6	D1-L3	Res, ww, 300.85k, matched	3					
R7	D2-M1	Res, var, met flm, $50\Omega \pm 20\%$, $\frac{3}{4}w$	4701-186189	73138	78PR50	1		
R8	D2-M4	Res, ww 60.17k, matched	3					X
R8	D2-M4	Res, ww, 30.085k, matched						Y
R9	D2-N2	Res, var, met flm, $10\Omega \pm 30\%$, $\frac{3}{4}w$	4701-186205	73138	78PR10	REF		
R10	D2-N4	Rcs, ww, 6.015k, matched						X
R10	D2-N4	Res, ww, 3.0075k, matched	3					Y
R11	C2-N4	Res, ww, 3.0075k, matched						Y
R12	C2-M4	Res, ww, 30.085k, matched						Y
	D3-J3	Test point, red	2109-170480	74970	105-0752	1		
	D3-I5	Test point, black	2109-149112	74970	105-0753	1		



Factory Selected. If replacement is required, include all information stamped on the resistor (if not legible include all information on the zener over decal) in addition to the information requested in paragraph 5-6.



Factory matched for resistance accuracy and temperature coefficient. When ordering, include all information stamped on the resistor (if not legible include information on adjacent resistors) in addition to the information requested in paragraph 5-6.

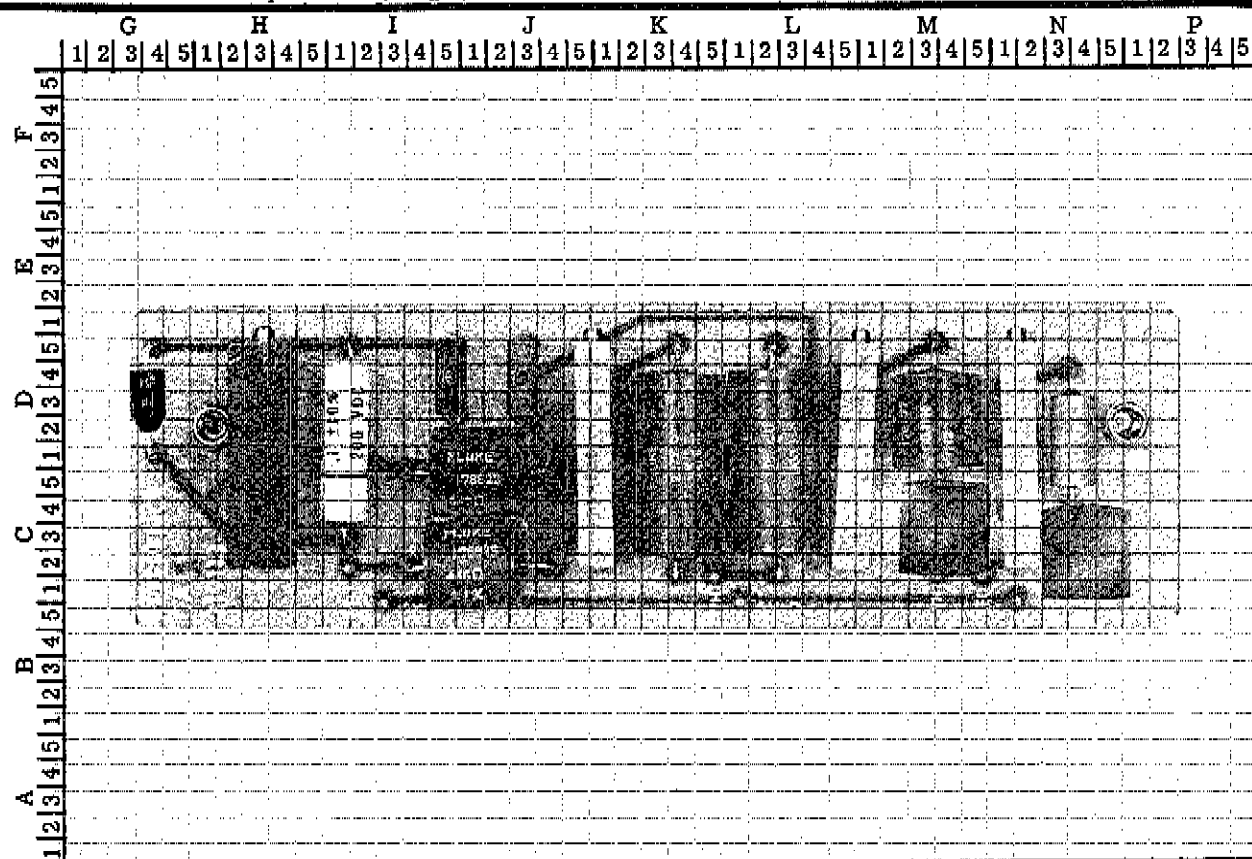


Figure 5-5. REFERENCE CALIBRATION P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5		MAIN MOTHER BOARD P/C ASSEMBLY - Figure 5-6	1702-219238 (335A-4064)	89536	1702-219238	REF		
A5A1		Master Voltage Reference P/C Assembly (See Figure 5-7)	1702-298653 (335A-4101)	89536	1702-298653	REF		
A5A2		Series Pass Driver P/C Assembly (See Figure 5-8)	1702-219154 (335A-4056)	89536	1702-219154	REF		
A5A3		Differential Amplifier P/C Assembly (See Figure 5-9)	1702-219162 (335A-4057)	89536	1702-219162	REF		
A5A4		Chopper Amplifier P/C Assembly (See Figure 5-10)	1702-219170 (335A-4058)	89536	1702-219170	REF		
A5A5		Auxiliary Power Supply P/C Assembly (See Figure 5-11)	1702-219188 (335A-4059)	89536	1702-219188	REF		
A5A6		Current Limiter P/C Assembly (See Figure 5-12)	1702-219196 (335A-4060)	89536	1702-219196	REF		
C1	J4-T4	Cap, platc, 0.1 uf $\pm 20\%$, 200v	1507-106435	56289	192P10402	5		
DS1	B3-Q2	Lamp, neon	3902-185017	74276	NE-7	2	5	
DS2	B4-P3	Lamp, neon	3902-185017	74276	NE-7	REF		
R1	B2-T3	Res, met flm, 23.7k $\pm 1\%$, 1/2w	4705-169383	75042	Type CEC-TO	2		
R2	B2-T1	Res, met flm, 25.5k $\pm 1\%$, 1/2w	4705-219006	75042	Type CEC-TO	1		
R3	B2-S4	Res, met flm, 267k $\pm 1\%$, 1/2w	4705-218990	75042	Type CEC-TO	1		
R4	B2-S3	Res, met flm, 274k $\pm 1\%$, 1/2w	4705-218982	75042	Type CEC-TO	1		
R5	A5-R2	Res, car flm, 1.82M $\pm 1\%$, 1/2w	4703-219089	75042	Type C12	3		
R6	B1-R2	Res, car flm, 1.82M $\pm 1\%$, 1/2w	4703-219089	75042	Type C12	REF		
R7	B2-R2	Res, car flm, 1.82M $\pm 1\%$, 1/2w	4703-219089	75042	Type C12	REF		
R8	C1-R3	Res, comp, 1k $\pm 10\%$, 1w	4704-109371	01121	GB1021	1		
R9	A5-P2	Res, comp, 470 Ω $\pm 10\%$, 1w	4704-109710	01121	GB4711	1		
XA5A1	K3-P5	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	10		
XA5A2	I5-Q1	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		
XA5A3	H2-Q2	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		
XA5A4	F4-Q3	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		
XA5A5	D5-Q3	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		
XA5A6	C2-Q4	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		

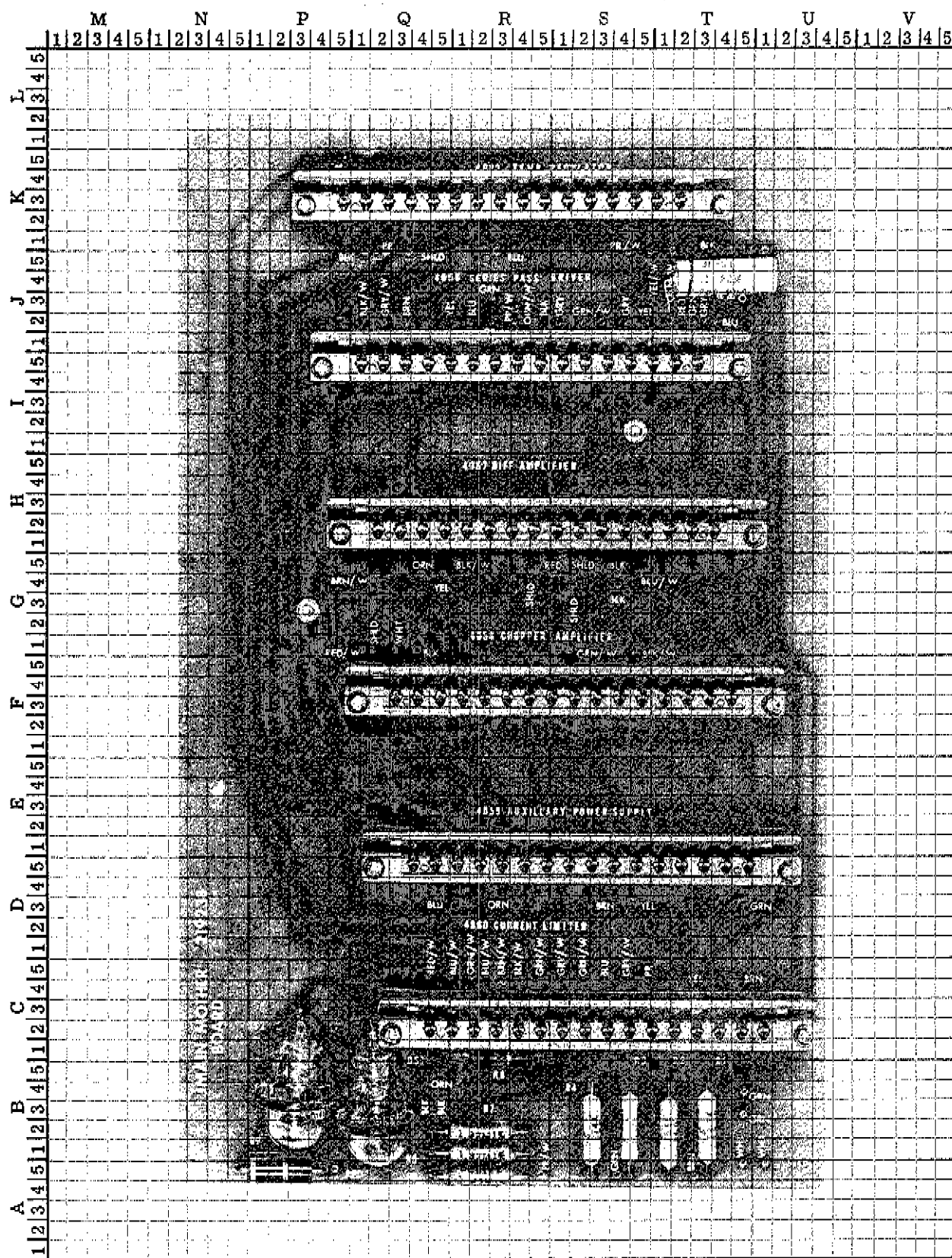


Figure 5-6. MAIN MOTHER BOARD P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A1		MASTER VOLTAGE REFERENCE P/C ASSEMBLY - Figure 5-7	1702-298653 (335A-4101)	89536	1702-298653	REF		
C1	F3-R2	Cap, mica, 470 pf $\pm 5\%$, 500v	1504-148429	14655	CD19F471J	1		N
CR1	E3-P1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
P1	B1-P4	Connector, male, 16 contact	2816-187724	91862	02-016-0135-200	10		
Q1	C2-P1	Tstr, silicon, NPN	4805-183004	95303	40250	6	1	
Q2	F2-P3	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q3	F2-N5	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q4	G2-N5	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
R1	D3-T3	Res, ww, factory selected						
R2	E3-P3	Res, comp, 10k $\pm 10\%$, 1/2w	4704-108118	01121	EB1031	REF		
R3	G2-P3	Res, comp, 75k $\pm 5\%$, 1/2w	4704-108928	01121	EB7535	4		
R4	G2-P4	Res, comp, 33k $\pm 10\%$, 1/2w	4704-178541	01121	EB3331	2		
R5	F5-P5	Res, met flm, 75k $\pm 1\%$, 1/2w	4705-193961	75042	Type CEC-TO	1		
R6	G2-P2	Res, comp, 24k $\pm 5\%$, 1/2w	4704-108654	01121	EB2435	1		
R7	G3-Q3	Res, var, ww, 10k $\pm 10\%$, 1-1/4w	4702-195164	71450	Type 115 special	3		
R8	F4-Q4	Res, met flm, 6.04k $\pm 1\%$, 1/2w	4705-162586	75042	Type CEC-TO	REF		
R9	G3-S2	Res, var, ww, 10k $\pm 10\%$, 1-1/4w	4702-195164	71450	Type 115 special	REF		
R10	F4-S3	Res, met flm, 6.04k $\pm 1\%$, 1/2w	4705-162586	75042	Type CEC-TO	REF		
R11	G3-T3	Res, var, ww, 10k $\pm 10\%$, 1-1/4w	4702-195164	71450	Type 115 special	REF		
R12	F4-T4	Res, met flm, 6.04k $\pm 1\%$, 1/2w	4705-162586	75042	Type CEC-TO	REF		
S1	K3-Q5	Thermostat, snap acting (not illustrated)	5301-228999	01295	9700L-21-11	1	1	
	C5-N5	Heat sink	4806-186759	89536	4806-186759	3		
	D1-R5	Oven Assembly						
CR1401	K3-R5	Diode, zener, matched						
CR1402	I5-S1	Diode, zener, matched						
Q1401	J4-Q5	Tstr, silicon, PNP	4805-190389	04713	SM4144	4	1	
R1401	J2-S3	Res, ww, 110 Ω $\pm 5\%$	4707-183830	89536	4707-183830	1		
R1402	I2-S3	Thermistor, 500k at 25°C	4708-185975	15801	GA55P2	1	1	
R1403	I4-R1	Res, met flm, selected						

 Factory Selected. If replacement is required, include all information stamped on the resistor (if not legible please include all information on the zener oven decal) in addition to the information requested in paragraph 5-6.

 CR1401 and CR1402 comprise a specially matched zener reference set. Many of the resistors on the Master Voltage Reference Assembly are selected and/or matched to the characteristics of these reference elements. Consequently, should either or both of these units require replacing, it is recommended that the complete Master Voltage Reference Assembly (A5A1), part number 1702-298653, be replaced. A4R1 and A4R3 must also be replaced and are included under this part number.

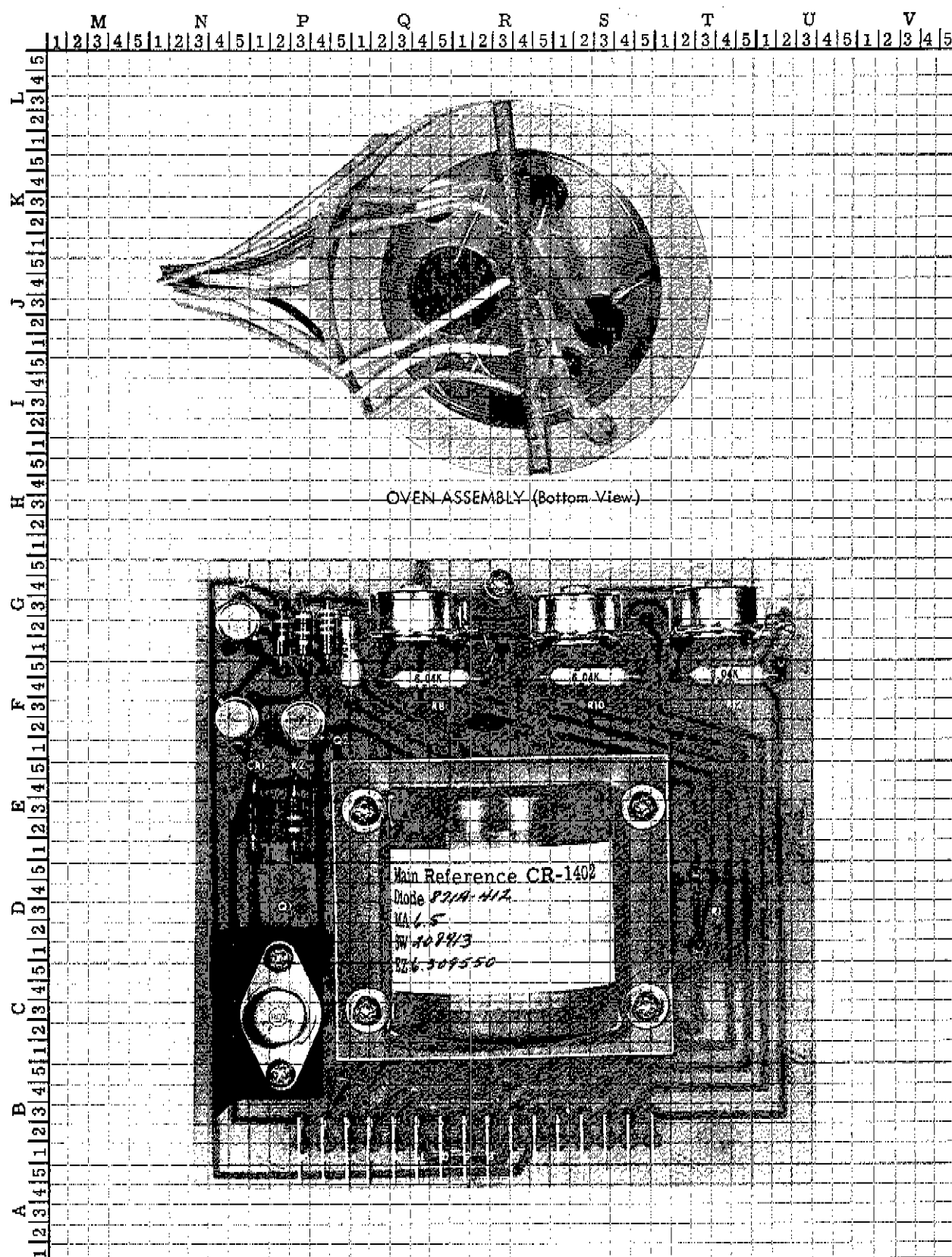


Figure 5-7. MASTER VOLTAGE REFERENCE P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A2		SERIES PASS DRIVER P/C ASSEMBLY - Figure 5-8	1702-219154 (335A-4056)	89536	1702-219154	REF		
C1	G4-P4	Cap, plstc, 0.47 uf $\pm 20\%$, 250v	1507-184366	73445	C280AE/P470 K	REF		
C2	F2-Q5	Cap, Ta, 2.2 uf $\pm 10\%$, 20v	1508-160226	05397	K2R2C20K	1		
C3	E2-Q5	Cap, plstc, 0.1 uf $\pm 20\%$, 200v	1507-106435	56289	192P10402	REF		
C4	G2-U5	Cap, plstc, 0.22 uf $\pm 10\%$, 80v	1507-159392	56289	192P2249R8	1		
C5	H1-Q1	Cap, Ta, 15 uf $\pm 10\%$, 20v	1508-153056	05397	K15C20K	2		
CR1	I4-R1	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	5	1	E
CR1	I4-R1	Diode, silicon, 200 ma, 25 piv	4802-190272	93332	1N456A	2		F
CR1	I4-R1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		G
CR2	I4-S1	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	REF		E
CR2	I4-S1	Diode, silicon, 200 ma, 25 piv	4802-190272	93332	1N456A	REF		F
CR2	I4-S1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		G
CR3	F5-R3	Diode, zener, 10v	4803-113324	07910	1N961A	5	1	
CR4	E5-Q3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR5	H3-U3	Diode, zener, 10v	4803-113324	07910	1N961A	REF		
CR6	F4-T1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR7	D5-U2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR8	D3-T4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR9	D1-T4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR10	F2-T3	Diode, germanium, 75 ma, 125 piv	4802-150342	93332	1N277	1	1	Q
CR10	F2-T3	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	4		R
CR11	F1-U2	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	REF		
CR12	E3-U4	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	REF		
CR13	E3-R2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR14	H2-P2	Diode, zener, 4.3v (not illustrated)	4803-180455	07910	1N749A	1	1	
CR15		Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		G
P1	C2-Q2	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	F3-Q5	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	11	2	
Q2	G5-R2	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q3	G4-N4	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
Q4	H1-Q3	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q5	E5-S4	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q6	G5-U2	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q7	E3-T4	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q8	E1-Q1	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	REF		
R1	E2-N3	Res, met flm, 4.02k $\pm$ 1%, 1/2w	4705-167478	75042	Type CEC-TO	2		
R2	J3-T3	Res, var, ww, 2k $\pm$ 10%, 1-1/4w	4702-198416	71450	Type 110	2		
R3	E3-N1	Res, comp, 2.7k $\pm$ 10%, 1w	4704-109496	01121	GB2721	1		
R4	E3-M5	Res, met flm, 4.02k $\pm$ 1%, 1/2w	4705-167478	75042	Type CEC-TO	REF		
R5	J3-P4	Res, var, ww, 3k $\pm$ 20%, 1-1/4w	4702-149781	71450	Type 110	3		
R6	I5-S5	Res, met flm, 5.62k $\pm$ 1%, 1/2w	4705-219014	75042	Type CEC-TO	1		
R7	G2-R2	Res, comp, 100k $\pm$ 10%, 1/2w	4704-108126	01121	EB1041	3		
R9	G1-P2	Res, comp, 2.4k $\pm$ 5%, 1/2w	4704-108902	01121	EB2425	1		
R10	I1-P5	Res, comp, 47 Ω $\pm$ 10%, 2w	4704-144352	01121	HB4701	2		
R11	E2-P2	Res, comp, 47 Ω $\pm$ 10%, 2w	4704-144352	01121	HB4701	REF		
R12	E3-N5	Res, comp, 36k $\pm$ 5%, 1/2w	4704-185991	01121	EB3635	4		
R13	I1-R5	Res, var, ww, 3k $\pm$ 20%, 1-1/4w	4702-149781	71450	Type 110	REF		
R14	D3-S1	Res, met flm, 1k $\pm$ 1%, 1/2w	4705-151324	75042	Type CEC-TO	1		
R15	E2-R4	Res, met flm, 221k $\pm$ 1%, 1/2w	4705-182527	75042	Type CEC-TO	3		
R16	G2-S4	Res, comp, 3.9k $\pm$ 10%, 1/2w	4704-161406	01121	EB3921	1		
R17	E1-S3	Res, comp, 20k $\pm$ 5%, 1/2w	4704-109041	01121	EB2035	3		
R18	G3-T3	Res, comp, 16k $\pm$ 5%, 1/2w	4704-159632	01121	EB1635	3		
R19	G5-S3	Res, comp, 10k $\pm$ 10%, 1/2w	4704-108118	01121	EB1031	REF		
R20	F5-T2	Res, comp, 27k $\pm$ 5%, 1/2w	4704-186023	01121	EB2735	1		
R21	F4-U2	Res, comp, 220 Ω $\pm$ 5%, 1/2w	4704-186031	01121	EB2215	1		Q R
R21	F4-U2	Res, comp, 27 Ω $\pm$ 5%, 1/2w	4704-260984	01121	EB2705	1		
R22	E1-U2	Res, met flm, 10 Ω $\pm$ 1%, 1/2w	4705-151043	75042	Type CEC-TO	1		
R23	D2-S5	Res, comp, 47k $\pm$ 5%, 1/2w	4704-108738	01121	EB4735	2		
R24	H2-S2	Res, comp, 620 Ω $\pm$ 5%, 1/2w	4704-108704	01121	EB6215	2		
R25	H4-Q5	Res, comp, 47k $\pm$ 5%, 1/2w	4704-108738	01121	EB4735	REF		
R26	D3-P5	Res, comp, 180 Ω $\pm$ 10%, 2w	4704-155457	01121	HB1811	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R27	D1-Q5	Res, comp, 2k $\pm$ 5%, 1/2w	4704-169854	01121	EB2025	3		
R28	E5-P5	Res, comp, 8.2k $\pm$ 5%, 1/2w	4704-147777	01121	EB8225	2		
	G1-N1	Heat sink	4806-186759	89536	4806-186759	REF		

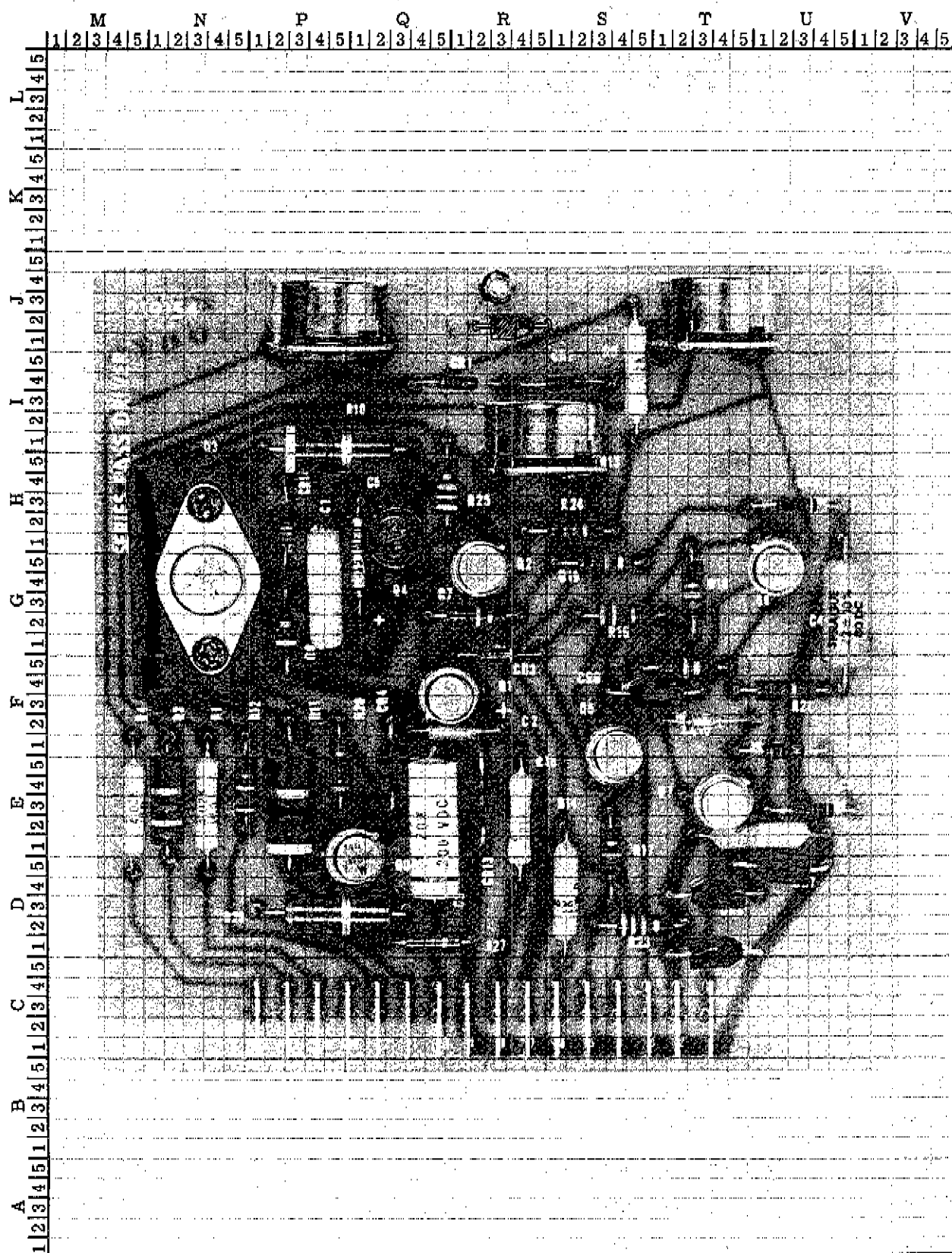


Figure 5-8. SERIES PASS DRIVER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A3		DIFFERENTIAL AMPLIFIER P/C ASSEMBLY -Figure 5-9	1702-219162 (335A-4057)	89536	1702-219162	REF		
C1	E3-P5	Cap, plstc, 0.1 uf $\pm 10\%$, 50v	1507-150318	56289	194P1049R5	1		
C2	F4-Q5	Cap, mica, 510 pf $\pm 5\%$, 500v	1504-148411	88419	CD19F511J	2		
C3	G1-P3	Cap, Ta, 15 uf $\pm 10\%$, 20v	1508-153056	05397	K15C20K	REF		
C4	I4-R4	Cap, elect, 250 uf $+50/-10\%$, 40v	1502-178616	73445	C437ARG250	1	1	
C5	I1-S4	Cap, mica, 27 pf $\pm 5\%$, 500v	1504-177998	88419	CD15E270J	1		U
CR1	D4-R1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2	E5-S1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR3	G1-S2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR4	E4-R5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR5	F5-R5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR6	F3-R1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR7	F1-R1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR8	G2-R1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR9	G1-R1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR10	E5-S4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR11	G1-S5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR12	G1-T1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR13	G1-Q2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR14	G1-N5	Diode, zener, 10v	4803-113324	07910	1N961A	REF		
CR15	I3-T2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
P1	C3-Q2	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	D2-T1	Tstr, silicon, NPN	4805-177105	07263	2N3565	9		
Q2	D5-N2	Tstr, J-FET, silicon N-channel	4805-166223	15818	U-1249	2		
Q3	F2-N2	Tstr, silicon, PNP	4805-190389	04713	SM4144	REF		
Q4	H2-Q1	Tstr, tested, silicon, NPN	4805-198812	89536	4805-198812	3	1	V
Q4	H2-Q1	Tstr, silicon, NPN	4805-168716	07263	S19254	3	1	W
Q5	I1-Q2	Tstr, silicon, PNP	4805-190389	04713	SM4144	REF		
Q6	D2-T5	Tstr, tested, silicon, NPN	4805-198812	89536	4805-198812	REF		V
Q6	D2-T5	Tstr, silicon, NPN	4805-168716	07263	S19254	REF		W
Q7	D2-U3	Tstr, silicon, PNP	4805-190389	04713	SM4144	REF		
Q8	H3-R3	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q9	I2-T6	Tstr, silicon, PNP	4805-183558	04713	2N3250	3	1	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q10	E4-U3	Tstr, silicon, PNP	4805-183558	04713	2N3250	REF		
Q11	I1-U4	Tstr, silicon, PNP	4805-183558	04713	2N3250	REF		
Q12	E1-U3	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
R1	D3-S1	Res, comp, 22k $\pm 5\%$, 1/2w	4704-186064	01121	EB2235	7		
R2	D3-R3	Res, comp, 100 Ω $\pm 5\%$, 1/2w	4704-188508	01121	EB1015	6		
R3	D3-R5	Res, comp, 100 Ω $\pm 5\%$, 1/2w	4704-188508	01121	EB1015	REF		
R4	D3-S3	Res, ww, 10k $\pm 0.2\%$, 1/4w	4707-112177	89536	4707-112177	1		
R5	E5-S3	Res, comp, 100 Ω $\pm 5\%$, 1/2w	4704-188508	01121	EB1015	REF		
R6	F5-S3	Res, comp, 100 Ω $\pm 5\%$, 1/2w	4704-188508	01121	EB1015	REF		
R7	E4-T1	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	9		
R8	D3-Q3	Res, comp, 3.3k $\pm 5\%$, 1/2w	4704-165761	01121	EB3325	4		
R9	D3-Q2	Res, comp, 3k $\pm 5\%$, 1/2w	4704-109090	01121	EB3025	2		
R10	D3-P5	Res, comp, 510 Ω $\pm 5\%$, 1/2w	4704-108951	01121	EB5115	1		
R11	E1-P1	Res, comp, 22M $\pm 10\%$, 1/2w	4704-108233	01121	EB2261	1		
R12	F1-M5	Res, comp, 6.2k $\pm 5\%$, 1/2w	4704-108621	01121	EB6225	3		
R13	G1-N3	Res, comp, 2.2k $\pm 5\%$, 1/2w	4704-108506	01121	EB2225	2		
R14	G1-P1	Res, comp, 1.2k $\pm 10\%$, 1/2w	4704-108803	01121	EB1221	1		
R15	F5-P5	Res, met flm, 100k $\pm 1\%$, 1/2w	4705-151316	75042	Type CEC-TO	REF		
R16	I1-P1	Res, met flm, 221k $\pm 1\%$, 1/2w	4705-182527	75042	Type CEC-TO	REF		
R17	H4-P1	Res, met flm, 40.2k $\pm 1\%$, 1/2w	4705-161059	75042	Type CEC-TO	2		
R18	G4-R1	Res, met flm, 75 Ω $\pm 1\%$, 1/2w	4705-150870	75042	Type CEC-TO	2		
R19	E4-T4	Res, met flm, 75 Ω $\pm 1\%$, 1/2w	4705-150870	75042	Type CEC-TO	REF		
R20	E4-T5	Res, met flm, 221k $\pm 1\%$, 1/2w	4705-182527	75042	Type CEC-TO	REF		
R21	F4-U4	Res, met flm, 40.2k $\pm 1\%$, 1/2w	4705-161059	75042	Type CEC-TO	REF		
R22	H4-S3	Res, met flm, 6.04k $\pm 1\%$, 1/2w	4705-162586	75042	Type CEC-TO	REF		
R23	H1-S5	Res, met flm, 42.2k $\pm 1\%$, 1/2w	4705-182501	75042	Type CEC-TO	1		
R24	H2-S5	Res, met flm, 9.09k $\pm 1\%$, 1/2w	4705-151258	75042	Type CEC-TO	1		
R25	I5-T5	Res, met flm, 15k $\pm 1\%$, 1/2w	4705-151498	75042	Type CEC-TO	1		
R26	F4-U3	Res, met flm, 1.58k $\pm 1\%$, 1/2w	4705-182543	75042	Type CEC-TO	2		
R27	G5-T4	Res, met flm, 1.58k $\pm 1\%$, 1/2w	4705-182543	75042	Type CEC-TO	REF		
R28	G5-U1	Res, met flm, 9.76k $\pm 1\%$, 1/2w	4705-182485	75042	Type CEC-TO	3		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R29	H3-V1	Res, comp, 10k $\pm 5\%$, 1/2w	4704-109165	01121	EB1035	2		
R30	H2-U4	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		Q
R30	H2-U4	Res, comp, 1.5k $\pm 10\%$, 1/2w	4704-108159	01121	EB1521	1		R
R31	E3-T2	Res, comp, 2k $\pm 5\%$, 1/2w	4704-169854	01121	EB2025	REF		

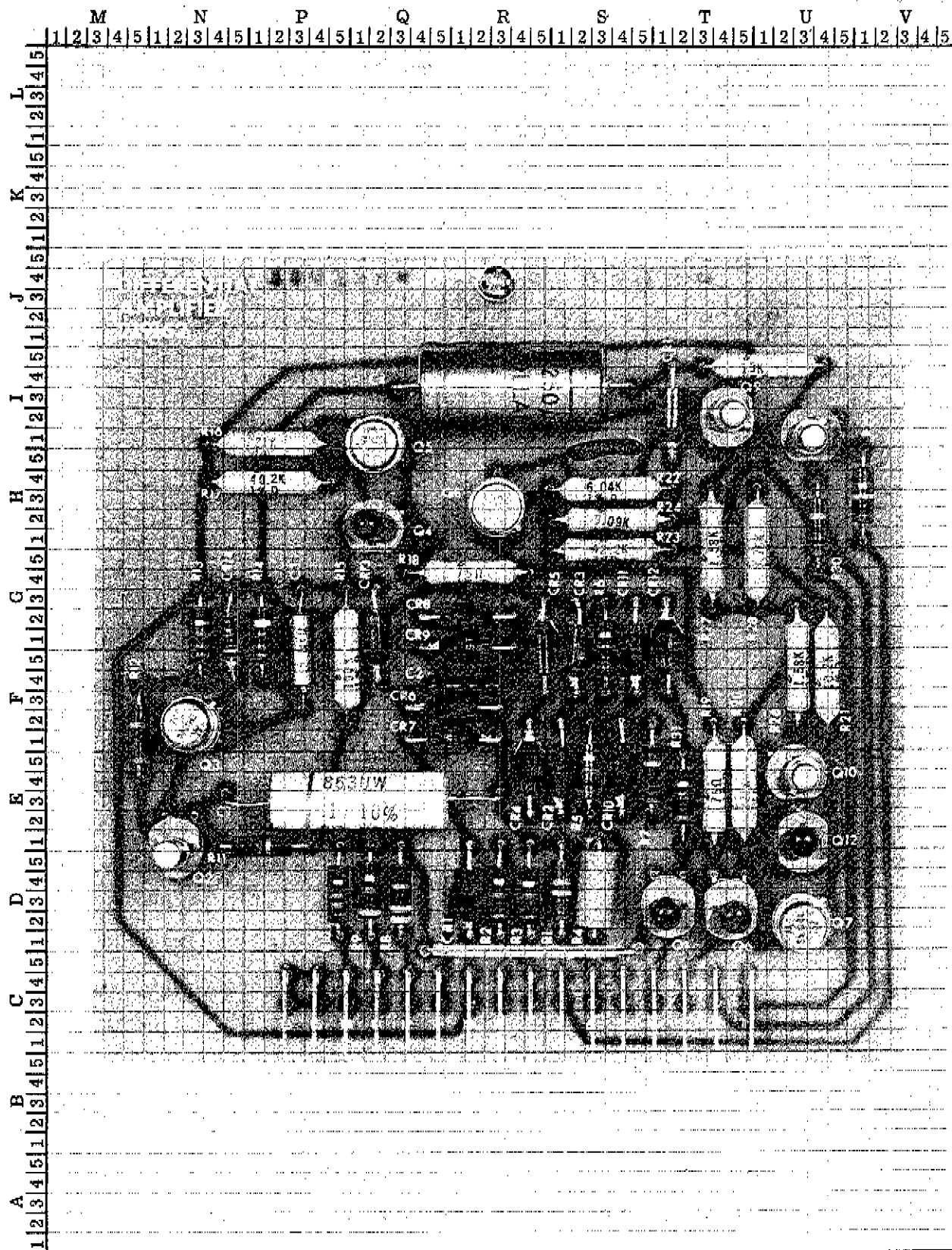


Figure 5-9. DIFFERENTIAL AMPLIFIER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A4		CHOPPER AMPLIFIER P/C ASSEMBLY - Figure 5-10	1702-219170 (335A-4058)	89536	1702-219170	REF		
C1	E3-T3	Cap, plstc, 0.033 uf $\pm 10\%$, 200v 	1507-106062	56289	192P33392	2		
C2	E5-T3	Cap, plstc, 0.033 uf $\pm 10\%$, 200v 	1507-106062	56289	192P33392	REF		
C3	E1-T3	Cap, plstc, 0.1 uf $\pm 20\%$, 200v 	1507-106435	56289	192P10402	REF		
C4	F3-T1	Cap, plstc, 0.01 uf $\pm 20\%$, 100v 	1507-235390	84411	Type 663UW	1		
C5	G2-T4	Cap, cer, 0.01 uf $\pm 20\%$, 100v	1501-149153	56289	C023B101F- 103M	2		
C6	F4-U4	Cap, elect, 100 uf $+75/-10\%$, 25v	1502-106518	56289	30D107G025- DH4	2	1	
C7	H2-U2	Cap, elect, 20 uf $+75/-10\%$, 50v	1502-106229	80183	TE1305	9	1	
C8	I4-S2	Cap, cer, 0.0012 uf $\pm 10\%$, 500v	1501-106732	71590	CF-122	1		
C9	H1-S4	Cap, elect, 100 uf $+75/-10\%$, 25v	1502-106518	56289	30D107G025- DH4	REF		
C10	J1-P5	Cap, elect, 20 uf $+75/-10\%$, 50v	1502-106229	80183	TE1305	REF		
C11	I1-Q2	Cap, cer, 0.01 uf $\pm 20\%$, 100v	1501-149153	56289	C023B101F- 103M	REF		
C12	G2-Q1	Cap, elect, 20 uf $+75/-10\%$, 50v	1502-106229	80183	TE1305	REF		
C13	H2-P2	Cap, elect, 20 uf $+75/-10\%$, 50v	1502-106229	80183	TE1305	REF		
C14	G3-N3	Cap, Ta, 330 uf $\pm 10\%$, 6v	1508-193011	05397	K330J6K	2		
C15	E3-N3	Cap, Ta, 330 uf $\pm 10\%$, 6v	1508-193011	05397	K330J6K	REF		
CR1	D4-P3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2	D5-P2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR3	F1-N5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR4	E3-P4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
G1	G2-R2	Chopper, mechanical, dpdt, 10v	5901-104349	80640	CH1413	1		
P1	C4-Q3	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	F5-T2	Tstr, FET, silicon N-channel	4805-166223	15818	U-1249	REF		
Q2	G4-T2	Tstr, silicon, PNP	4805-190389	04713	SM4144	REF		C
Q2	G4-T2	Tstr, silicon, PNP	4805-218388	07263	2N3645	1		D
Q3	I4-U2	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q4	I4-T1	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
Q5	I2-N3	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
R1	E4-S4	Res, comp, 22k $\pm 5\%$, 1/2w	4704-186064	01121	EB2235	REF		
R2	F1-S1	Res, comp, 2.2k $\pm 5\%$, 1/2w	4704-108506	01121	EB2225	REF		
R3	D3-T1	Res, met flm, 604k $\pm 1\%$, 1/2w	4705-182493	75042	Type CEC-TO	1		
R4	D1-T1	Res, met flm, 604k $\pm 1\%$, 1/2w	4705-182493	75042	Type CEC-TO	REF		H
R4	D1-T1	Res, met flm, 750k $\pm 1\%$, 1/2w	4705-155192	75042	Type CEC-TO	1		I
R5	D1-R5	Res, comp, 10 Ω $\pm 10\%$, 1/2w	4704-108092	01121	EB1001	1		H
R5	D1-R5	Res, comp, 12 Ω $\pm 10\%$, 1/2w	4704-187831	01121	EB1201	1		I
R6	F2-T2	Res, comp, 3.3M $\pm 10\%$, 1/2w	4704-108282	01121	EB3351	1		
R7	D2-U4	Res, comp, 16k $\pm 5\%$, 1/2w	4704-159632	01121	EB1635	REF		
R8	F3-U2	Res, comp, 200 Ω $\pm 5\%$, 1/2w	4704-169839	01121	EB2015	1		C
R8	F3-U2	Res, comp, 360 Ω $\pm 5\%$, 1/2w	4704-192559	01121	EB3615	2		D
R9	F5-U1	Res, comp, 15k $\pm 10\%$, 1/2w	4704-108530	01121	EB1531	REF		
R10	G3-T1	Res, comp, 6.2k $\pm 5\%$, 1/2w	4704-108621	01121	EB6215	REF		
R11	H5-T5	Res, comp, 15k $\pm 10\%$, 1/2w	4704-108530	01121	EB1531	REF		
R12	H5-U4	Res, met flm, 150 Ω $\pm 1\%$, 1/2w	4705-182550	75042	Type CEC-TO	1		
R13	H4-T2	Res, comp, 120k $\pm 10\%$, 1/2w	4704-108779	01121	EB1241	1		
R14	H4-T3	Res, comp, 47k $\pm 10\%$, 1/2w	4704-108480	01121	EB4731	1		
R15	I3-P5	Res, comp, 15k $\pm 10\%$, 1/2w	4704-108530	01121	EB1531	REF		
R16	J1-S4	Res, met flm, 23.7k $\pm 1\%$, 1/2w	4705-169383	75042	Type CEC-TO	REF		
R17	G2-S1	Res, comp, 10k $\pm 10\%$, 1/2w	4704-108118	01121	EB1031	REF		
R18	I5-N4	Res, comp, 30k $\pm 5\%$, 1/2w	4704-186015	01121	EB3035	1		
R19	H4-Q1	Res, comp, 15k $\pm 10\%$, 1/2w	4704-108530	01121	EB1531	REF		
R20	H2-N5	Res, met flm, 3.01k $\pm 1\%$, 1/2w	4705-196709	75042	Type CEC-T2	2		
R21	H2-P4	Res, met flm, 3.01k $\pm 1\%$, 1/2w	4705-196709	75042	Type CEC-T2	REF		
R22	F4-P3	Res, met flm, 9.76k $\pm 1\%$, 1/2w	4705-182485	75042	Type CEC-TO	REF		
R23	F4-P4	Res, met flm, 9.76k $\pm 1\%$, 1/2w	4705-182485	75042	Type CEC-TO	REF		
R24	D3-Q2	Res, comp, 36k $\pm 5\%$, 1/2w	4704-185991	01121	EB3635	REF		
R25	E2-P2	Res, comp, 20k $\pm 5\%$, 1/2w	4704-109041	01121	EB2035	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
XG1	E1-R1	Socket, chopper, 9 contact	2112-104356	91662	40083EG-3/32	1		
	J1-R1	Cap, chopper	2103-103234	80640	252-05	1		
		Cover, front (not illustrated)	3156-186809	89536	3156-186809	1		
		Cover, rear (not illustrated)	3156-186817	89536	3156-186817	1		
 See Section 4-13 for replacement instructions.								

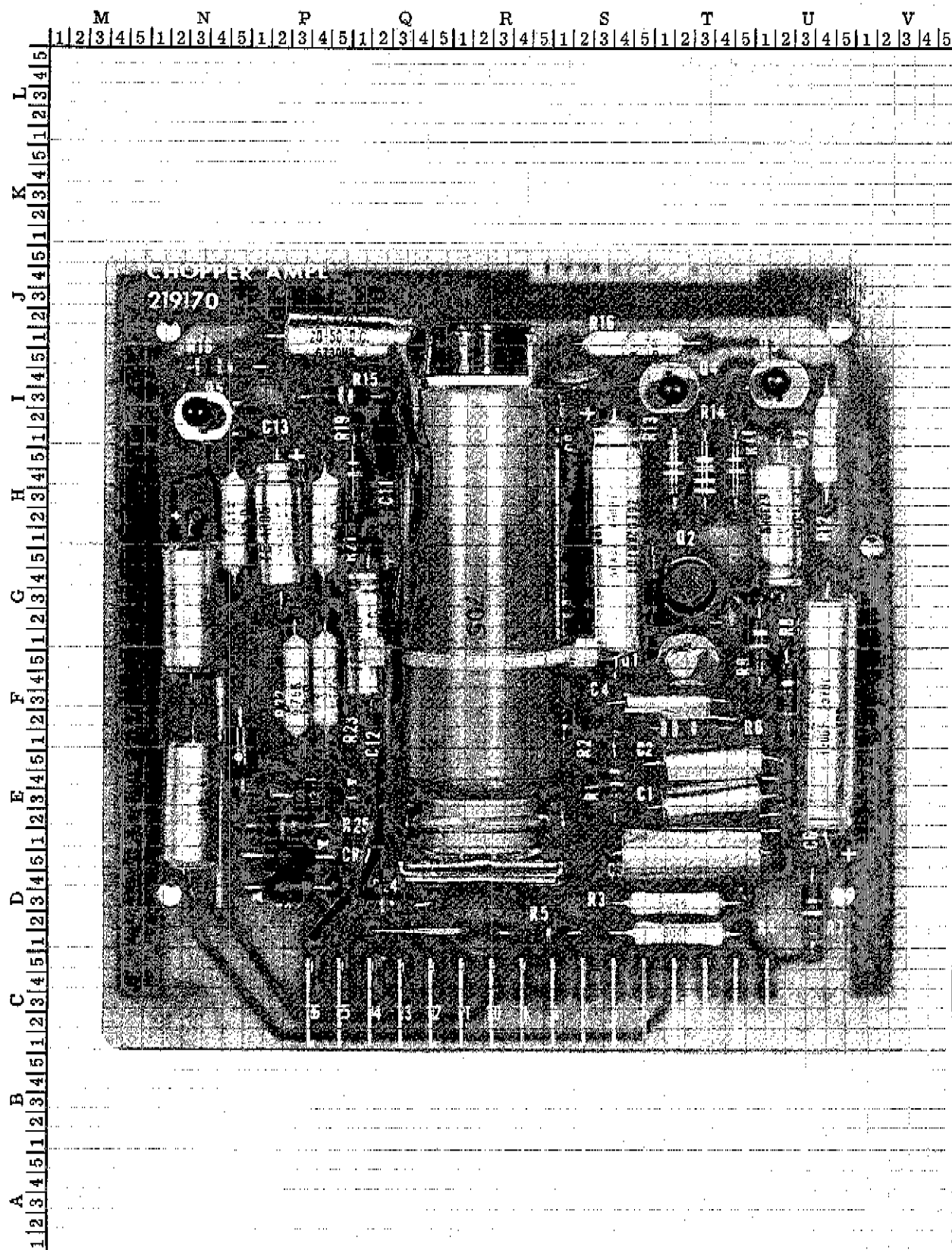


Figure 5-10. CHOPPER AMPLIFIER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A5		AUXILIARY POWER SUPPLY P/C ASSEMBLY - Figure 5-11	1702-219188 (335A-4059)	89536	1702-219188	REF		
C1	G1-P5	Cap, Ta, 68 uf $\pm 10\%$, 15v	1508-182824	05397	K68C15K	1		
C2	G1-N3	Cap, elect, 250 uf $+50/-10\%$, 64v	1502-185850	73445	C437ARH250	4	1	
C3	G1-P2	Cap, elect, 50 uf $+75/-10\%$, 50v	1502-105122	80183	TE1307	3	1	
C4	J1-P3	Cap, cer, 220 pf $\pm 10\%$, 500v	1501-105528	72982	315-024X5UD- 221K	1		O
C5	H1-R3	Cap, plstc, 2 uf $\pm 20\%$, 100v	1507-106963	84411	Type X663FR	2		
C6	E2-R3	Cap, plstc, 0.1 uf $\pm 20\%$, 200v	1507-106435	56289	192P10402	REF		
C7	H5-R2	Cap, elect, 20 uf $+75/-10\%$, 50v	1502-106229	80183	TE1305	REF		
C8	E3-U3	Cap, elect, 50 uf $+75/-10\%$, 50v	1502-105122	80183	TE1307	REF		
C9	H1-T1	Cap, plstc, 0.0012 uf $\pm 10\%$, 200v	1507-106088	56289	192P12292	1		
C10	E2-T1	Cap, plstc, 2 uf $\pm 20\%$, 100v	1507-106963	84411	Type X663FR	REF		
C11	I1-U5	Cap, elect, 20 uf $+75/-10\%$, 50v	1502-106229	80183	TE1305	REF		
C12	H5-P5	Cap, plstc, 0.1 uf $\pm 20\%$, 200v	1507-106435	56289	192P10402	REF		P
CR1	E2-N5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2	D3-N5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR3	E4-N5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR4	D5-N5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR5	J1-M5	Diode, zener, 3.9v	4803-113316	07910	1N748	2	1	
CR6	E1-R5	Diode, zener, 6.3v	4803-172148	03877	1N3496	1	1	
CR7	F1-U5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR8	F1-T5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR9	D5-U5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR10	D5-T5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
P1	C4-Q4	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	D5-Q3	Silicon controlled rectifier, 1.6 amp, 50v	4805-192567	03508	C-6F	2	1	
Q2	I4-N4	Tstr, selected, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q3	I5-Q1	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q4	I5-R5	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
Q5	F3-R1	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q6	F3-R5	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q7	G4-U2	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
Q8	I4-T2	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q9	G1-T2	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
R1	E5-P5	Res, comp, 10k $\pm 5\%$, 1/2w	4704-109165	01121	EB1035	REF		
R2	E5-Q3	Res, comp, 390 Ω $\pm 5\%$, 1/2w	4704-109082	01121	EB3915	1		
R3	E5-Q2	Res, comp, 5.6k $\pm 5\%$, 1/2w	4704-187880	01121	EB5625	1		
R4	H3-N3	Res, comp, 15 Ω $\pm 10\%$, 2w	4704-155549	01121	HB1501	1		
R5	I1-N5	Res, comp, 15k $\pm 10\%$, 1/2w	4704-108530	01121	EB1531	REF		
R6	J1-P1	Res, comp, 3k $\pm 5\%$, 1/2w	4704-109090	01121	EB3025	REF		
R7	I4-Q4	Res, comp, 33k $\pm 10\%$, 1/2w	4704-178541	01121	EB3331	REF		
R8	G4-R3	Res, met flm, 7.15k $\pm 1\%$, 1/2w	4705-186072	75042	Type CEC-TO	1		
R9	J4-T2	Res, var, ww, 1k $\pm 20\%$, 1-1/4w	4702-113266	71450	Type 110	1		
R10	E2-R1	Res, met flm, 2.55k $\pm 1\%$, 1/2w	4705-176362	75042	Type CEC-TO	1		
R11	G3-S2	Res, comp, 6.2k $\pm 5\%$, 1/2w	4704-108621	01121	EB6225	REF		
R12	E2-S1	Res, met flm, 2.37k $\pm 1\%$, 1/2w	4705-182519	75042	Type CEC-TO	1		
R13	G1-S2	Res, comp, 12k $\pm 10\%$, 1/2w	4705-108977	01121	EB1231	1		
R14	G2-V1	Res, comp, 82 Ω $\pm 10\%$, 2w	4704-110239	01121	HB8201	1		
R15	H4-S4	Res, comp, 8.2k $\pm 5\%$, 1/2w	4704-147777	01121	EB8225	REF		
R16	H4-T4	Res, comp, 3.3k $\pm 10\%$, 1/2w	4704-108373	01121	EB3321	1		
R17	H2-T2	Res, comp, 4.7k $\pm 10\%$, 1/2w	4704-108381	01121	EB4721	REF		
R18	E4-S4	Res, met flm, 8.45k $\pm 1\%$, 1/2w	4705-159475	75042	Type CEC-TO	1		
R19	E4-T3	Res, met flm, 4.99k $\pm 1\%$, 1/2w	4705-148890	75042	Type CEC-TO	1		
R20	J1-P3	Res, comp, 2k $\pm 5\%$, 1/2w	4704-169854	01121	EB2025	REF		P

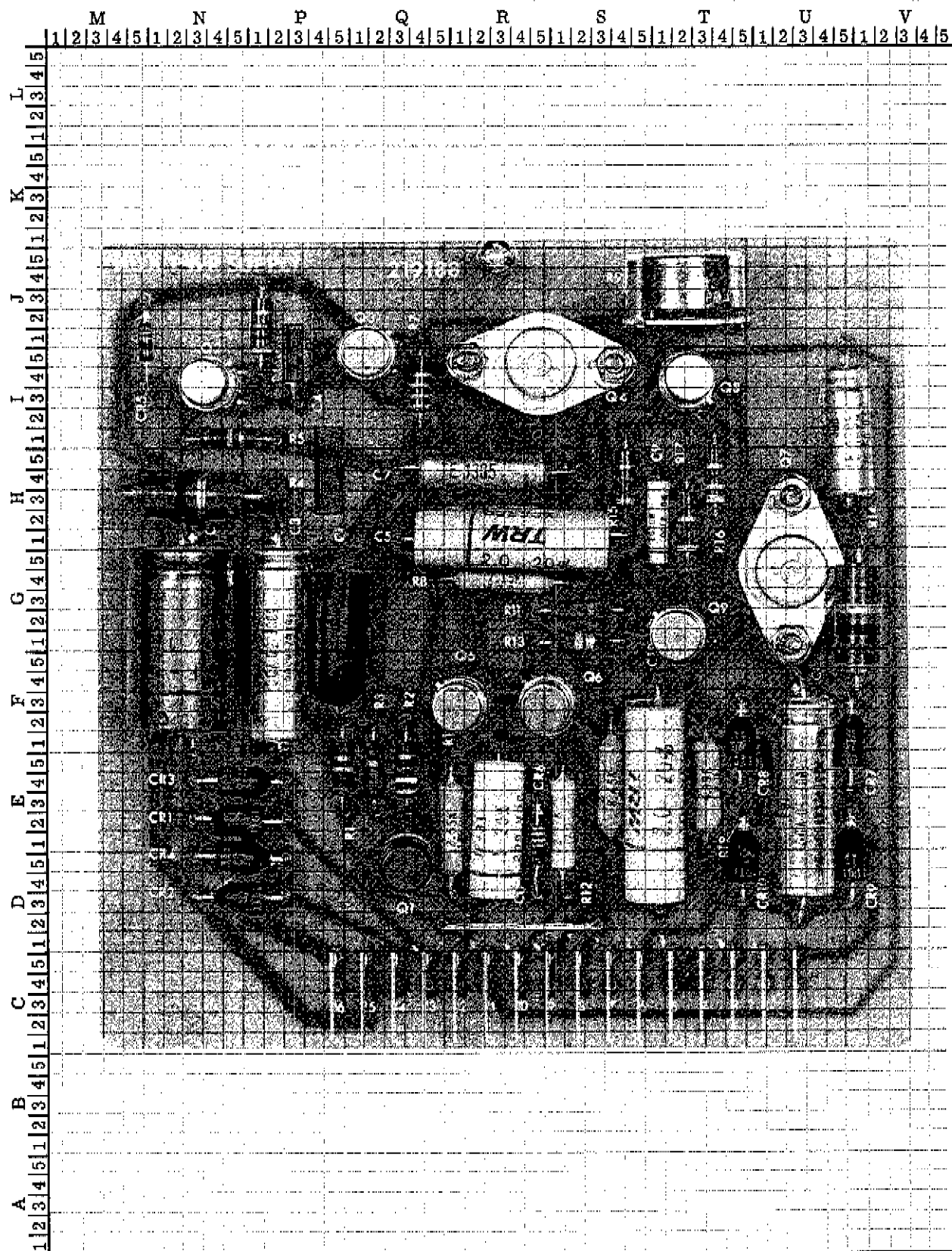


Figure 5-11. AUXILIARY POWER SUPPLY P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A6		CURRENT LIMITER P/C ASSEMBLY - Figure 5-12	1702-219196 (335A-4060)	89536	1702-219196	REF		
C1	G5-Q2	Cap, elect, 250 uf +50/-10%, 64v	1502-185850	73445	C437ARH250	REF		
C2	I3-U2	Cap, elect, 20 uf +75/-10%, 50v	1502-106229	80183	TE1305	REF		
C3	H5-R5	Cap, elect, 20 uf +75/-10%, 50v	1502-106229	80183	TE1305	REF		
C4	H5-S5	Cap, elect, 250 uf +50/-10%, 64v	1502-185850	73445	C437ARH250	REF		
C5	J1-U2	Cap, elect, 20 uf +75/-10%, 50v	1502-106229	80183	TE1305	REF		
C6	I4-Q2	Cap, elect, 250 uf +50/-10%, 64v	1502-185850	73445	C437ARH250	REF		
C7	H5-N1	Cap, plstc, 0.047 uf ±20%, 100v	1507-106096	72928	335B473M	1		
C9	E2-N3	Cap, elect, 2 uf +75/-10%, 50v	1502-105197	80183	TE1301	1	1	
C10	E5-Q5	Cap, elect, 160 uf +50/-10%, 64v	1502-170274	73445	C437ARH160	1	1	
CR1	E1-U4	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR2	E1-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR3	F2-S3	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR4	E5-S3	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR5	I5-R1	Diode, zener, 36v	4803-186163	07910	1N974B	2	1	
CR6	D3-P1	Diode, zener, 3.9v	4803-113316	07910	1N748	REF		
CR7	J4-T3	Diode, zener, 36v	4803-237354	04713	1N3033A	1	1	
CR8	G1-Q5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR9	I2-P1	Diode, zener, 12v	4803-159780	07910	1N759	1	1	
CR10	G2-P3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR11	I1-P1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR12	F5-P3	Diode, silicon, 150 ma, 6 piv	4802-113308	07910	CD13161	REF		
P1	C5-Q4	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	G3-S4	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
Q2	G5-U2	Tstr, germanium, PNP	4805-152868	95303	2N2869	1	1	
Q3	J1-N2	Tstr, selected, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q4	H1-N3	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q5	F2-N3	Tstr, selected, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q6	D4-P5	Tstr, selected, silicon, PNP	4805-159491	89536	4805-159491	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q7	E4-P5	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
R1	E5-U2	Res, comp, $10\Omega \pm 10\%$, 2w	4704-110163	01121	HB1001	4		
R2	H2-T3	Res, comp, $3.3k \pm 5\%$, 1/2w	4704-165761	01121	EB3325	REF		
R3	D3-T1	Res, comp, $150\Omega \pm 5\%$, 2w	4704-235192	01121	HB1515	1		
R4	F3-U2	Res, comp, $10\Omega \pm 10\%$, 2w	4704-110163	01121	HB1001	REF		
R5	I5-R3	Res, comp, $3.3k \pm 5\%$, 1/2w	4704-165761	01121	EB3325	REF		
R6	D3-P2	Res, comp, $7.5k \pm 5\%$, 1/2w	4704-108910	01121	EB7525	3		
R7	H5-R1	Res, comp, $100k \pm 10\%$, 1/2w	4704-108126	01121	EB1041	REF		
R8	F5-R4	Res, comp, $120\Omega \pm 10\%$, 2w	4704-155531	01121	HB1211	4		
R9	E1-T1	Res, comp, $120\Omega \pm 10\%$, 2w	4704-155531	01121	HB1211	REF		
R10	E2-Q1	Res, comp, $4.7k \pm 10\%$, 1/2w	4704-108381	01121	EB4721	REF		
R11	F1-P3	Res, comp, $10k \pm 10\%$, 1/2w	4704-108118	01121	EB1031	REF		
R12	D3-N4	Res, comp, $10k \pm 10\%$, 1/2w	4704-108118	01121	EB1031	REF		
R13	D3-N1	Res, comp, $16k \pm 5\%$, 1/2w	4704-159632	01121	EB1635	REF		
R14	D3-N2	Res, comp, $1k \pm 10\%$, 1/2w	4704-108563	01121	EB1021	REF		
R15	I3-P1	Res, comp, $2.2k \pm 10\%$, 1/2w	4704-108605	01121	EB2221	1		
R16	G2-N4	Res, comp, $100k \pm 10\%$, 1/2w	4704-108126	01121	EB1041	REF		
R17	H4-P1	Res, comp, $36k \pm 5\%$, 1/2w	4704-185991	01121	EB3635	REF		
R18	G2-N3	Res, comp, $330k \pm 5\%$, 1/2w	4704-150201	01121	EB3345	1		
R19	G2-Q5	Res, comp, $7.5k \pm 5\%$, 1/2w	4704-108910	01121	EB7525	REF		
R20	F4-P3	Res, comp, $7.5k \pm 5\%$, 1/2w	4704-108910	01121	EB7525	REF		
R21	F2-P3	Res, comp, $1k \pm 10\%$, 1/2w	4704-108563	01121	EB1021	REF		
R22	J3-P1	Res, met flm, $12.1k \pm 1\%$, 1/2w	4705-182535	75042	Type CEC-TO	1		
R23	J5-N2	Res, var, ww, $10k \pm 10\%$, 1-1/4w	4702-162115	71450	Type 110	1		
R24	J4-U3	Res, var, ww, $150\Omega \pm 10\%$, 1-1/4w	4702-113092	71450	Type 110	1		
R25	E3-T2	Res, comp, $120\Omega \pm 10\%$, 2w	4704-155531	01121	HB1211	REF		
R26	E2-R4	Res, comp, $120\Omega \pm 10\%$, 2w	4704-155531	01121	HB1211	REF		
	F5-S2	Heat sink	4806-186759	89536	4806-186759	REF		
	H4-V1	Heat sink	4806-186742	89536	4806-186742	1		

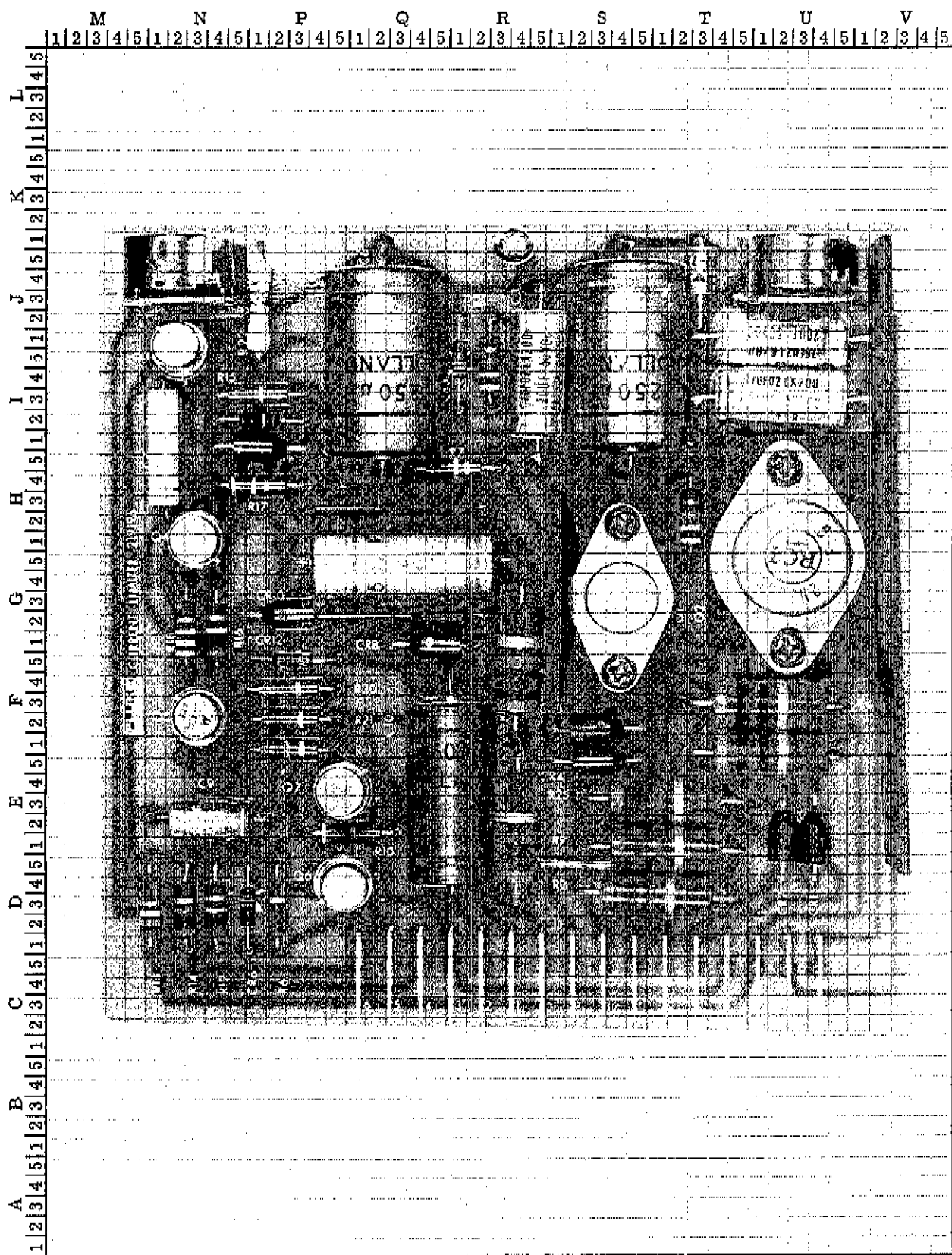


Figure 5-12. CURRENT LIMITER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A6		ISOLATED MOTHER BOARD P/C ASSEMBLY - Figure 5-13	1702-219147 (335A-4055)	89536	1702-219147	REF		
A6A1		Null Detector Power Supply P/C Assembly (See Figure 5-14)	1702-219121 (335A-4053)	89536	1702-219121	REF		
A6A2		Null Detector Amplifier P/C Assembly (See Figure 5-15)	1702-219139 (335A-4054)	89536	1702-219139	REF		
XA6A1	E2-J2	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		
XA6A2	C2-J3	Connector, female, 16 contact	2107-187732	91662	00-5009-016- 153-001	REF		

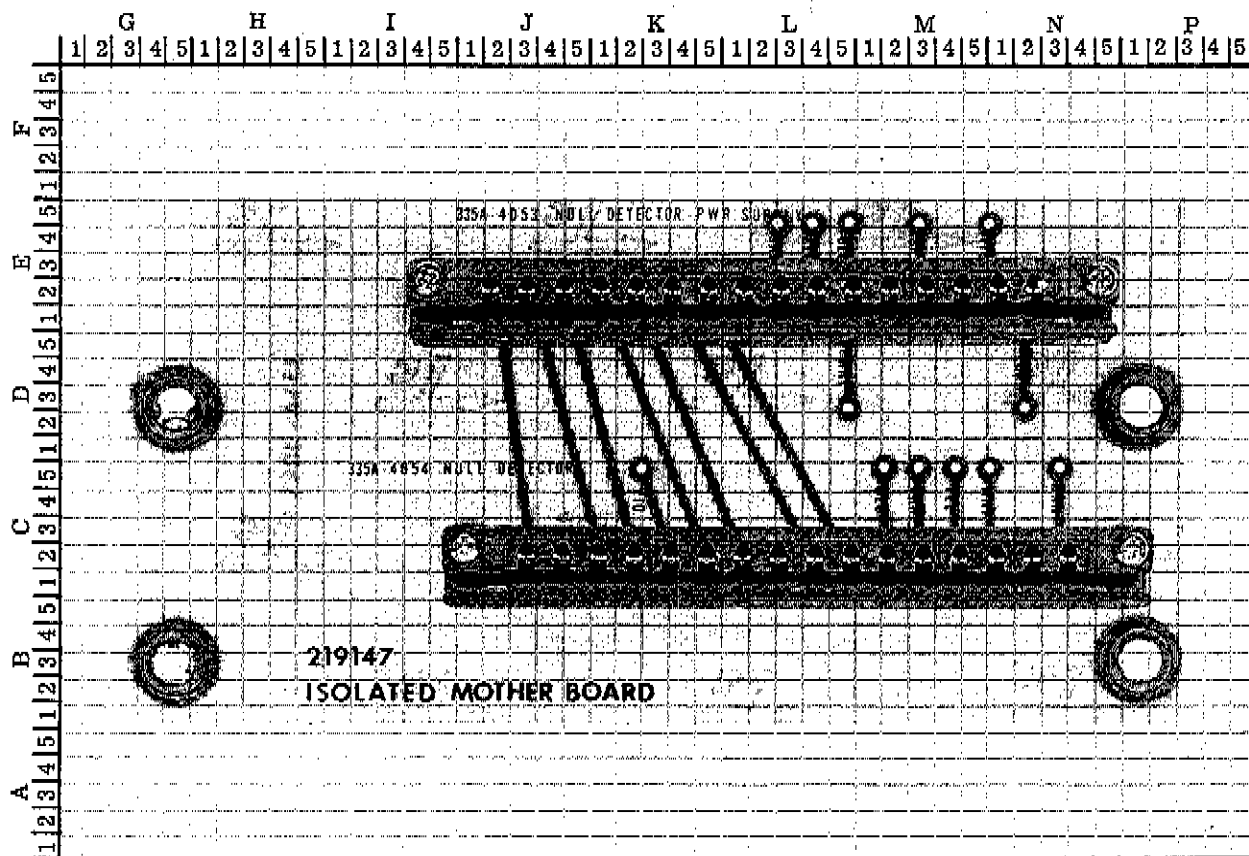


Figure 5-13. ISOLATED MOTHER BOARD P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A6A1		NULL DETECTOR POWER SUPPLY P/C ASSEMBLY - Figure 5-14	1702-219121 (335A-4053)	89536	1702-219121	REF		
C1	D4-N2	Cap, elect, 1,000 uf +50/-10%, 16v	1502-193896	73445	C437ARE1000	4	1	
C2	G5-P1	Cap, plstc, 1 uf $\pm$ 20%, 250v	1507-190330	73445	C280AE/P1M	REF		
C3	G4-U4	Cap, elect, 1,000 uf +50/-10%, 16v	1502-193896	73445	C437ARE1000	REF		
C4	G4-T3	Cap, elect, 1,000 uf +50/-10%, 16v	1502-193896	73445	C437ARE1000	REF		
C5	F2-P2	Cap, elect, 400 uf +50/-10%, 4v	1502-187773	73445	C426ARB400	2	1	
C6	H2-M5	Cap, elect, 50 uf +50/-10%, 25v	1502-168823	73445	C426ARF50	1	1	
CR1	D5-P4	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	8	2	
CR2	D4-P3	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
CR3	D3-P4	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
CR4	D2-P3	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
CR5	E3-N5	Diode, zener, 10v	4803-113324	07910	1N961A	REF		
CR6	E3-U2	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
CR7	E1-U2	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
P1	C3-P3	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	H4-N5	Tstr, germanium, PNP	4805-182600	01295	GA2817	2	1	
Q2	H4-P3	Tstr, germanium, PNP	4805-182600	01295	GA2817	REF		
Q3	D4-T2	Tstr, germanium, PNP	4805-182709	01295	GA2877	2	1	
Q4	E2-S4	Tstr, germanium, NPN	4805-182691	01295	GA2875	3	1	
Q5	G1-P3	Tstr, germanium, NPN	4805-182691	01295	GA2875	REF		
Q6	G1-N5	Tstr, germanium, NPN	4805-182691	01295	GA2875	REF		
R1	E2-P3	Res, comp, 150 Ω $\pm$ 5%, 1/2w	4704-186056	01121	EB1515	1		
R2	I1-N3	Res, comp, 5.1k $\pm$ 5%, 1/2w	4704-109108	01121	EB5125	2		
R3	I1-P5	Res, comp, 5.1k $\pm$ 5%, 1/2w	4704-109108	01121	EB5125	REF		
R4	J3-Q2	Res, var, ww, 2k $\pm$ 10%, 1-1/4w	4702-198416	71450	Type 110	REF		
R5	E5-T2	Res, comp, 22k $\pm$ 5%, 1/2w	4704-186064	01121	EB2235	REF		
R6	F1-S5	Res, comp, 22k $\pm$ 5%, 1/2w	4704-186064	01121	EB2235	REF		
R7	G1-Q1	Res, comp, 22k $\pm$ 5%, 1/2w	4704-186064	01121	EB2235	REF		
R8	G1-N3	Res, comp, 22k $\pm$ 5%, 1/2w	4704-186064	01121	EB2235	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R9	J3-N2	Res, var, ww, 3k $\pm$ 20%, 1-1/4w	4702-149781	71450	Type 110	REF		
R10	I5-Q1	Res, comp, 10k $\pm$ 10%, 1/2w	4704-108118	01121	EB1031	REF		
R11	F5-M5	Res, comp, 1k $\pm$ 10%, 1/2w	4704-108563	01121	EB1021	REF		
T1	H1-R1	Transformer, driver	5602-227207	89536	5602-227207	1		
T2	E1-R1	Transformer, output	5602-227215	89536	5602-227215	1		

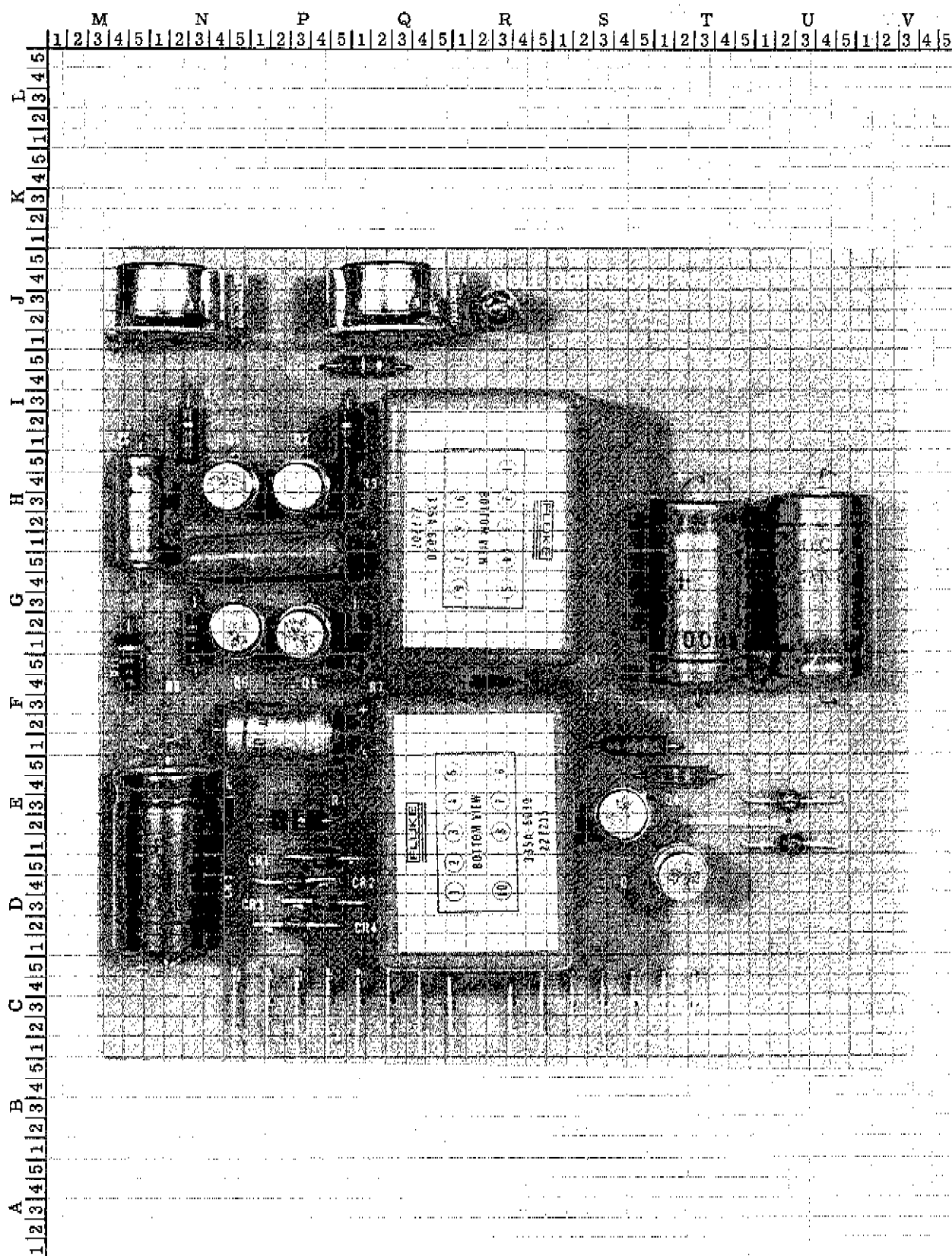


Figure 5-14. NULL DETECTOR POWER SUPPLY P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A6A2		NULL DETECTOR AMPLIFIER P/C ASSEMBLY - Figure 5-15	1702-219139 (335A-4054)	89536	1702-219139	REF		
C1	C1-U3	Cap, plstc, 0.22 uf $\pm 20\%$, 250v	1507-194803	73445	C280AE/ P220K	1		
C2	G5-P1	Cap, plstc, 0.22 uf $\pm 20\%$, 120v	1507-167452	84411	JF39	1		
C3	H5-P1	Cap, plstc, 0.47 uf $\pm 20\%$, 120v	1507-190553	84411	JF36	2		
C4	J1-P1	Cap, plstc, 0.47 uf $\pm 20\%$, 120v	1507-190553	84411	JF36	REF		
C5	J3-T2	Cap, plstc, 0.1 uf $\pm 20\%$, 250v	1507-161992	73445	C280AE/P100K	3		
C6	I4-S3	Cap, cer, 300 pf $\pm 10\%$, 500v	1501-105734	71590	BB60301KW7W	2		
C7	I2-R5	Cap, elect, 250 uf $+50/-10\%$, 16v	1502-187765	73445	C437ARE250	1	1	
C8	I3-S4	Cap, cer, 300 pf $\pm 10\%$, 500v	1501-105734	71590	BB60301KW7W	REF		
C9	I2-T3	Cap, Ta, 10 uf $\pm 10\%$, 20v	1508-160259	05397	K10C20K	REF		
C10	E2-S1	Cap, plstc, 0.1 uf $\pm 20\%$, 250v	1507-161992	73445	C280AE/P100K	REF		
C11	E3-T2	Cap, plstc, 0.0047 uf $\pm 20\%$, 200v	1507-106054	56289	192P47202	1		
C12	G5-T5	Cap, Ta, 10 uf $\pm 10\%$, 20v	1508-160259	05397	K10C20K	REF		
C13	D2-S1	Cap, elect, 400 uf $+50/-10\%$, 4v	1502-187773	73445	C428ARB400	REF		
C14	D4-P4	Cap, elect, 1250 uf $+50/-10\%$, 4v	1502-166330	73445	C437ARB1250	1	1	
C15	G2-N5	Cap, Ta, 10 uf $\pm 10\%$, 20v	1508-160259	05397	K10C20K	REF		
C16	F4-Q1	Cap, plstc, 0.1 uf $\pm 20\%$, 250v	1507-161992	73445	C280AE/P100K	REF		
C17	D1-N1	Cap, Ta, 22 uf $\pm 10\%$, 15v	1508-182816	05397	K22C15K	1		
C18	E2-P2	Cap, Ta, 10 uf $\pm 10\%$, 20v	1508-160259	05397	K10C20K	REF		
CR1	G4-Q4	Diode, treated, silicon, 10 ma, 2 piv	4802-180885	89536	4802-180885	2	1	
CR2	H3-Q4	Diode, treated, silicon, 10 ma, 2 piv	4802-180885	89536	4802-180885	REF		
CR3	E4-U5	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
CR4	E4-U4	Diode, silicon, 400 ma, 400 piv	4802-180240	81483	4D4	REF		
CR5	I3-R4	Diode, zener, 10v	4803-113324	07910	1N961A	REF		
DS1	D2-U2	Lamp, neon, Type NE2U	3902-162602	89730	NE2U	2	1	
DS2	D2-U5	Lamp, neon, Type NE2U	3902-162602	89730	NE2U	REF		
P1	C3-P1	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	I5-S5	Tstr, selected, silicon, NPN	4805-194456	89536	4805-194456	1	1	

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q2	I3-T1	Tstr, tested, silicon, NPN	4805-198812	89536	4805-198812	REF		V
Q2	I3-T1	Tstr, silicon, NPN	4805-168716	07263	S19254	REF		W
Q3	H5-S5	Tstr, silicon, NPN	4805-168708	03508	2N3391	1	1	
Q4	E1-R3	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
Q5	F3-T3	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
Q6	F4-S5	Tstr, germanium, PNP	4805-182709	01295	GA2877	REF		
Q7	F5-N2	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
Q8	E3-N2	Tstr, silicon, NPN	4805-177105	07263	2N3565	REF		
Q9	F3-P1	Tstr, silicon, PNP	4805-169375	04713	MPS3638	2	1	
Q10	E3-P1	Tstr, silicon, PNP	4805-169375	04713	MPS3638	REF		
Q11	F4-S1	Tstr, germanium, NPN	4805-117127	95303	2N1304	1	1	
Q12	F3-R3	Tstr, germanium, PNP	4805-190298	95303	2N1305	1	1	
R1	E5-Q5	Res, car flm, 300k $\pm 1\%$, 2w	4703-107425	91637	Type C14	1		
R2	C3-U3	Res, comp, 33k $\pm 5\%$, 1/2w	4704-108761	01121	EB3335	1		
R3	H3-R1	Res, comp, 47k $\pm 5\%$, 1/4w	4704-148163	01121	CB4735	2		
R4	I3-R1	Res, comp, 100k $\pm 5\%$, 1/4w	4704-148189	01121	CB1045	4		
R5	H3-Q2	Res, comp, 470 Ω $\pm 5\%$, 1/4w	4704-147983	01121	CB4715	1		
R6	D2-Q2	Res, comp, 430k $\pm 5\%$, 1/4w	4704-226381	01121	CB4345	1		
R7	H2-R2	Res, ww, 10 Ω $\pm 1\%$, 1/2w	4707-193946	89536	4707-193946	1	1	
R8	J3-S3	Res, comp, 1.2M $\pm 10\%$, 1/2w	4704-108407	01121	EB1251	1		
R9	I2-R2	Res, comp, 10k $\pm 5\%$, 1/4w	4704-148106	01121	CB1035	2		
R10	I2-S2	Res, comp, 10M $\pm 10\%$, 1/2w	4704-108142	01121	EB1061	1		
R11	H2-S3	Res, comp, 1.2M $\pm 5\%$, 1/4w	4704-188425	01121	CB1255	1		
R12	H2-S4	Res, comp, 47k $\pm 5\%$, 1/4w	4704-148163	01121	CB4735	REF		
R13	H2-T1	Res, comp, 68k $\pm 5\%$, 1/4w	4704-148171	01121	CB6835	2		
R14	H2-T3	Res, comp, 82k $\pm 5\%$, 1/4w	4704-188458	01121	CB8235	1		
R15	H2-T2	Res, comp, 39 Ω $\pm 5\%$, 1/4w	4704-193391	01121	CB3905	1		
R16	F1-T3	Res, comp, 100k $\pm 5\%$, 1/4w	4704-148189	01121	CB1045	REF		
R17	F4-U1	Res, comp, 22k $\pm 5\%$, 1/4w	4704-148130	01121	CB2235	3		
R18	D5-T1	Res, comp, 39k $\pm 5\%$, 1/4w	4704-188466	01121	CB3935	1		
R19	E2-T1	Res, comp, 100k $\pm 5\%$, 1/4w	4704-148189	01121	CB1045	REF		
R20	D4-T1	Res, comp, 100 Ω $\pm 5\%$, 1/4w	4704-147926	01121	CB1015	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R21	D4-S2	Res, comp, 150k $\pm 5\%$, 1/4w	4704-182212	01121	CB1545	3		
R22	G2-S4	Res, comp, 10k $\pm 5\%$, 1/4w	4704-148106	01121	CB1035	REF		
R23	E5-Q3	Res, comp, 22k $\pm 5\%$, 1/4w	4704-148130	01121	CB2235	REF		
R24	G2-Q2	Res, comp, 15k $\pm 5\%$, 1/4w	4704-148114	01121	CB1535	2		
R25	G1-P1	Res, comp, 150k $\pm 5\%$, 1/4w	4704-182212	01121	CB1545	REF		
R26	F4-Q3	Res, comp, 68k $\pm 5\%$, 1/4w	4704-148171	01121	CB6835	REF		
R27	F1-P3	Res, comp, 15k $\pm 5\%$, 1/4w	4704-148114	01121	CB1535	REF		O
R27	F1-P3	Res, comp, 150k $\pm 5\%$, 1/4w	4704-182212	01121	CB1545	REF		P
R28	F5-P4	Res, comp, 22k $\pm 5\%$, 1/4w	4704-148130	01121	CB2235	REF		
R29	F1-N2	Res, comp, 100k $\pm 5\%$, 1/4w	4704-148189	01121	CB1045	REF		
R30	D4-N2	Res, comp, 15k $\pm 5\%$, 1/4w	4704-148114	01121	CB1535	REF		
R31	C4-N2	Res, comp, 3.9M $\pm 5\%$, 1/4w	4704-188417	01121	CB3955	1		
R32	F4-S3	Res, comp, 1k $\pm 5\%$, 1/4w	4704-148023	01121	CB1025	2		
R33	E5-Q3	Res, comp, 1k $\pm 5\%$, 1/4w	4704-148023	01121	CB1025	REF		
V1	I5-U2	Photocell assembly	3700-194449	89536	3700-194449	1	1	
V2	I5-U5							
	I1-U3	Photocell support	3155-194613	89536	3155-194613	1		
	H2-U2	Rod, light	3800-237362	89536	3800-237362	2		
	H2-U5	Rod, light	3800-237362	89536	3800-237362	REF		
		Shield, input (not illustrated)	3156-226886	89536	3156-226886	1		

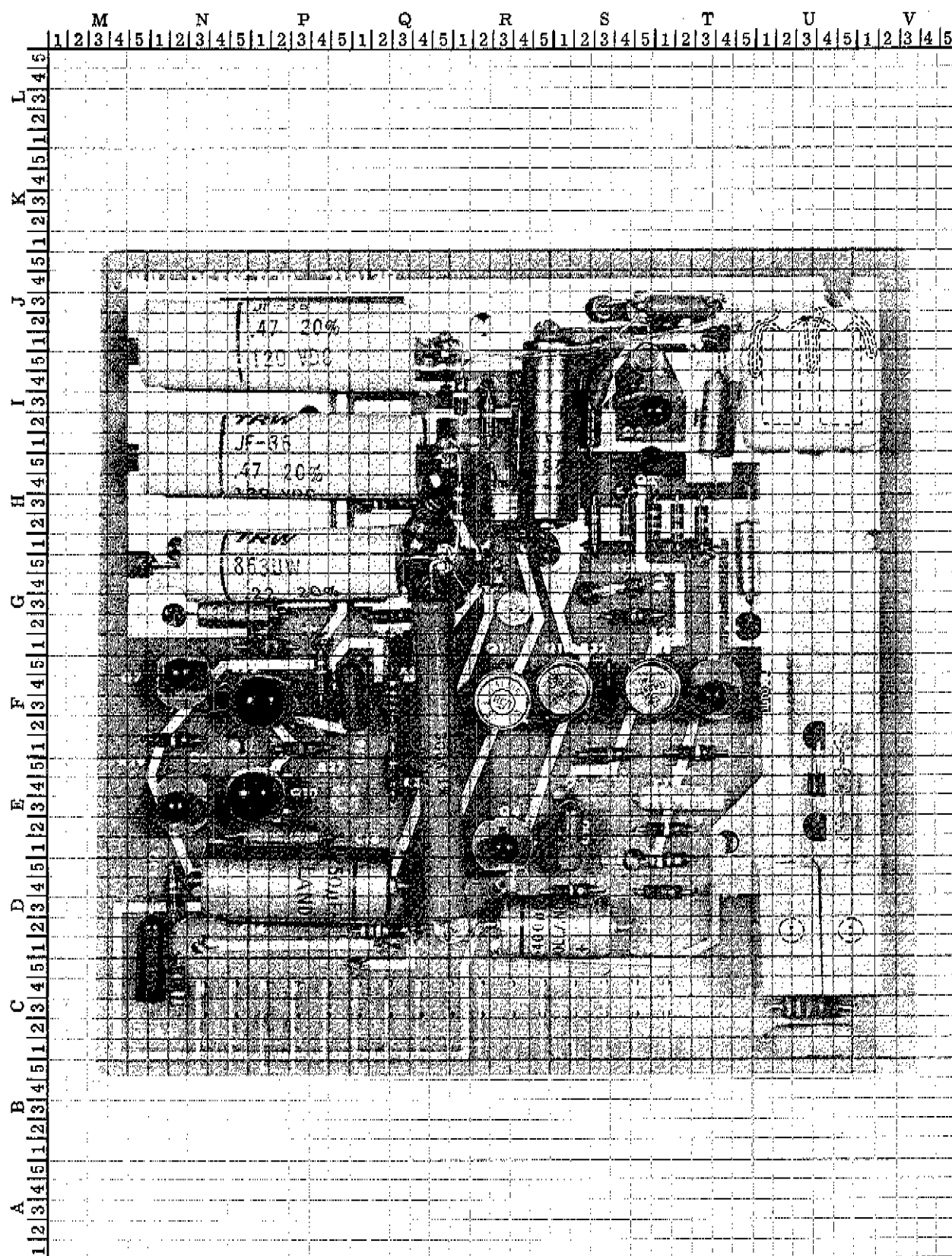


Figure 5-15. NULL DETECTOR AMPLIFIER P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7		TIME DELAY P/C ASSEMBLY Figure 5-16	1702-192260 (332A-420)	89536	1702-192260	REF		
C2001	E1-J3	Cap, elect, 400 uf +50/-10%, 40v	1502-185868	73445	C437ARG400	1	1	
CR2001	C4-I3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2002	C1-I5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2003	C5-I1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
K2001	C2-M2	Relay, armature, 12 vdc, dpdt	4504-176347	80089	62-760	1		
Q2001	E4-M2	Silicon controlled rectifier, 1.6 amp, 50v	4805-192567	03508	C-6F	REF		
R2001	A5-K5	Res, comp, 2.2k $\pm$ 10%, 2w	4704-109967	01121	HB2221	2		
R2002	E3-K3	Res, comp, 5.6k $\pm$ 10%, 1/2w	4704-108324	01121	EB5621	1		
R2003	F2-L3	Res, comp, 390 Ω $\pm$ 10%, 1/2w	4704-108365	01121	EB3911	1		
R2004	D4-K5	Res, comp, 10k $\pm$ 10%, 1/2w	4704-108118	01121	EB1031	REF		

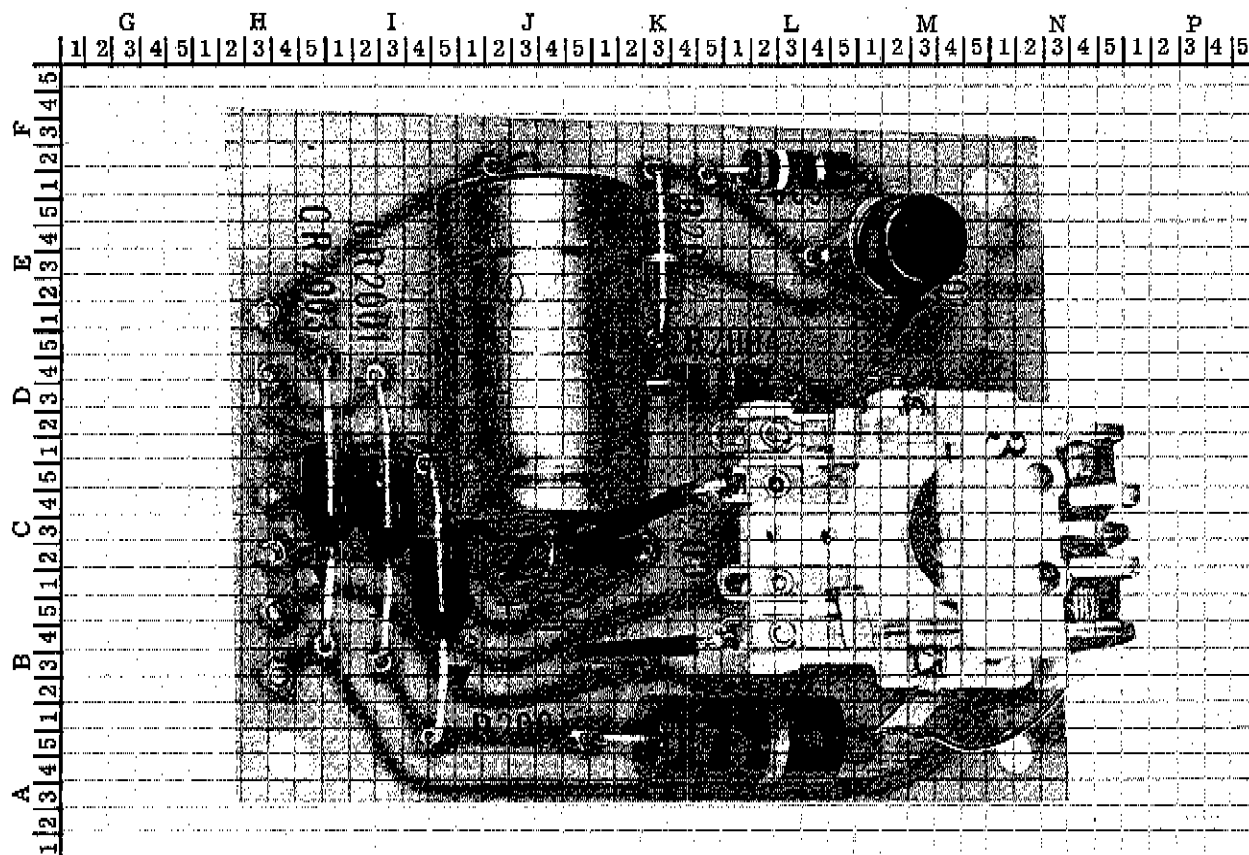


Figure 5-16. TIME DELAY P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A8		HIGH VOLTAGE MOTHER BOARD P/C ASSEMBLY - Figure 5-17	1702-219220 (335A-4063)	89536	1702-219220	REF		
A8A1		Series Pass Element P/C Assembly (See Figure 5-18)	1702-219204 (335A-4061)	89536	1702-219204	REF		
A8A2		Preregulator P/C Assembly (See Figure 5-19)	1702-222000 (335A-4082)	89536	1702-222000	REF		
C1	E4-N4	Cap, elect, 125 uf +50/-10%, 450v	1502-106336	56289	Type 66D	3	1	
C2	G4-N4	Cap, elect, 125 uf +50/-10%, 450v	1502-106336	56289	Type 66D	REF		
C3	I2-N4	Cap, elect, 125 uf +50/-10%, 450v	1502-106336	56289	Type 66D	REF		
C4	E1-S4	Cap, elect, 8 uf +50/-10%, 450v	1502-194068	56289	39D805F450H- E4	3		
C5	E2-Q1	Cap, elect, 8 uf +50/-10%, 450v	1502-194068	56289	39D805F450H- E4	REF		
C6	F5-T3	Cap, plstc, 1 uf ±20%, 200v	1507-106450	84411	Type X663F	2		
C7	H5-Q5	Cap, elect, 50 uf +75/-10%, 50v	1502-105122	80183	TE1307	REF		
C8	I1-Q3	Cap, cer, 0.001 uf ±20%, 3 kv	1501-105635	80183	29C300	1		
C9	F2-T4	Cap, cer, 0.01 uf, gmv, 1600v	1501-106930	71590	DD16-103	REF		B
C10	H5-S2	Cap, oil, 3 uf ±20%, 230v	1505-185926	56289	200P1640	1		
CR1	H5-V1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR2	H4-V1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR3	H3-V1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR4	H3-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR5	H4-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR6	H5-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR7	I1-V1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR8	I2-V1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR9	I3-V1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR10	I3-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR11	I2-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR12	I1-U2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR13	G1-Q1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR14	F5-Q1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR15	F4-Q1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR16	F4-Q5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR17	G2-Q1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR18	G2-Q5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR19	G1-Q5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR20	F5-Q5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR21	F5-R4	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR22	H3-R3	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
K1	H1-S1	Relay, reed, 5,000v	5103-184440	12617	DRVT-1	2		
	H1-R2	Coil, reed relay, 24v	1802-186155	71707	SP-24-P	REF		
K2	F3-S4	Relay, reed, 5,000v	5103-184440	12617	DRVT-1	REF		
	F3-S1	Coil, reed relay, 24v	1802-186155	71707	SP-24-P	REF		
R1	F2-N1	Res, comp, 220k $\pm 10\%$, 2w	4704-110197	01121	HB2241	6		
R2	G4-N1	Res, comp, 220k $\pm 10\%$, 2w	4704-110197	01121	HB2241	REF		
R3	H5-N1	Res, comp, 220k $\pm 10\%$, 2w	4704-110197	01121	HB2241	REF		
R4	E3-R3	Res, comp, 470k $\pm 5\%$, 1w	4704-109819	01121	GB4745	2		
R5	E5-Q4	Res, comp, 470k $\pm 5\%$, 1w	4704-109819	01121	GB4745	REF		
R6	G1-T3	Res, comp, 10 Ω $\pm 10\%$, 2w	4704-110163	01121	HB1001	REF		
R7	I1-R2	Res, comp, 470 Ω $\pm 10\%$, 1/2w	4704-108415	01121	EB4711	REF		
R8	I3-Q2	Res, comp, 5.1 Ω $\pm 5\%$, 1w	4704-219071	01121	GB51G5	1		
R9	I5-S1	Res, comp, 10 Ω $\pm 10\%$, 2w	4704-110163	01121	HB1001	REF		
R10	F1-S4	Res, comp, 270 Ω $\pm 10\%$, 2w	4704-110189	01121	HB2711	REF		
R11	F1-Q1	Res, comp, 2.2k $\pm 10\%$, 2w	4704-109967	01121	HB2221	REF		
R12	H5-M4	Res, comp, 220k $\pm 10\%$, 2w	4704-110197	01121	HB2241	REF		
R13	G5-M4	Res, comp, 220k $\pm 10\%$, 2w	4704-110197	01121	HB2241	REF		
R14	F3-M4	Res, comp, 220k $\pm 10\%$, 2w	4704-110197	01121	HB2241	REF		
R15	G1-S4	Res, ww, 2k $\pm 5\%$, 10w	4706-155416	06136	Type 10F	1		
T1	F4-U5	Transformer, pulse	5600-185827	89536	5600-185827	1		
XA8A1	E5-R5	Connector, female, 16 contact	2107-187732	91662	00-5009-016-153-001	REF		
XA8A2	G3-R4	Connector, female, 16 contact	2107-187732	91662	00-5009-016-153-001	REF		

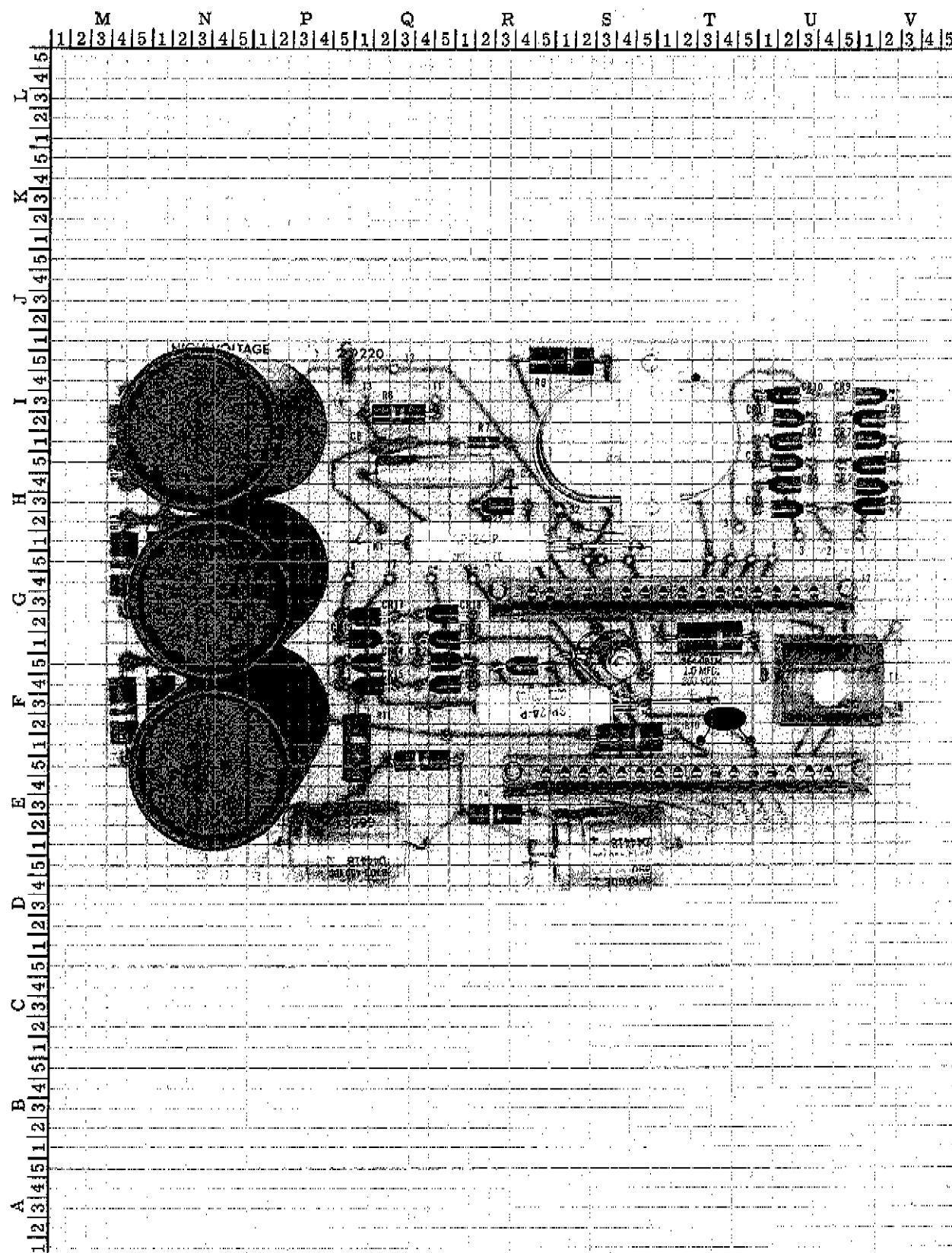


Figure 5-17. HIGH VOLTAGE MOTHER BOARD P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A8A1		SERIES PASS ELEMENT P/C ASSEMBLY - Figure 5-18	1702-219204 (335A-4061)	89536	1702-219204	REF		
C1	E4-Q5	Cap, cer, 0.05 uf +80/-10%, 500v	1501-105676	56289	33C58B	6		
C2	D5-T1	Cap, elect, 8 uf +50/-10%, 450v	1502-194068	56289	39D805F450- HE4	REF		
C3	G1-R4	Cap, cer, 0.05 uf +80/-10%, 500v	1501-105676	56289	33C58B	REF		
C4	D5-P4	Cap, plstc, 0.068 uf ±10%, 100v	1507-182170	88419	DMF1S68	1		S
C5	D5-P2	Cap, plstc, 0.047 uf ±10%, 80v	1507-195099	56289	192P4739R8	1		
CR1	D4-R2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR2	D4-S1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR3	D4-R1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR4	D4-R4	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR5	D4-S2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR6	D5-Q3	Diode, zener, 6.8v	4803-187195	07910	CD36554	1	1	
CR7	G1-N2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR8	G1-M5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR9	G2-N5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR10	G2-P1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR11	H2-Q4	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR12	G2-Q2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR13	G5-S5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR14	G4-S2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR15	H2-R5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR16	G4-T3	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR17	G4-U4	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR18	D5-Q5	Diode, zener, 20v	4803-113340	07910	1N968A	1	1	
CR19	F5-R5	Diode, zener, 36v	4803-186163	07910	1N974B	REF		
CR20	D5-Q2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR21	C3-V1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR22	C3-U3	Diode, zener, 6.2v	4803-180497	07910	1N753	1	1	
CR23	F4-Q1	Diode, zener, 200v	4803-217422	04713	1N3051A	8	1	
CR24	J1-N1	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR25	J1-P2	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		
CR26	J1-Q2	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		
CR27	J1-R3	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		
CR28	J1-S3	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		
CR29	J1-T4	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		
CR30	J1-U5	Diode, zener, 200v	4803-217422	04713	1N3051A	REF		
CR31	F2-S4	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR32	D5-P1	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
P1	C3-P1	Connector, male, 16 contact	2816-187724	91662	02-016-013- 5-200	REF		
Q1	I5-M5	Tstr, silicon, NPN	7			8	8	
Q2	I5-P1	Tstr, silicon, NPN	7			REF		
Q3	I5-Q2	Tstr, silicon, NPN	7			REF		
Q4	I5-R3	Tstr, silicon, NPN	7			REF		
Q5	I5-S3	Tstr, silicon, NPN	7			REF		
Q6	I5-T4	Tstr, silicon, NPN	7			REF		
Q7	I5-U5	Tstr, silicon, NPN	7			REF		
Q8	E3-U3	Tstr, silicon, NPN	7			REF		
Q9	D1-N2	Tstr, silicon, unijunction	4805-117176	03508	2N1671A	1	1	
Q10	C4-T4	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
R1	F2-Q1	Res, comp, 1.8k $\pm 10\%$, 2w	4704-185983	01121	HB1821	3		
R2	F3-N4	Res, comp, 1.8k $\pm 10\%$, 2w	4704-185983	01121	HB1821	REF		
R3	E5-N4	Res, comp, 1.8k $\pm 10\%$, 2w	4704-185983	01121	HB1821	REF		
R4	C4-U2	Res, comp, 360 Ω $\pm 5\%$, 1/2w	4704-192559	01121	EB3615	REF		L
R4	C4-U2	Res, comp, 62k $\pm 5\%$, 1/2w	4704-108522	01121	EB6235	2		M
R5	F1-R5	Res, comp, 270k $\pm 10\%$, 2w	4704-110023	01121	HB2741	1		L
R5	F1-R5	Res, comp, 100k $\pm 10\%$, 2w	4704-158659	01121	HB1041	1		M
R6	H2-N3	Res, comp, 56k $\pm 5\%$, 1/2w	4704-219048	01121	EB5635	1		
R7	H2-M5	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		
R8	H2-P1	Res, comp, 62k $\pm 5\%$, 1/2w	4704-108522	01121	EB6235	REF		
R9	H2-P3	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		
R10	H2-Q1	Res, comp, 68k $\pm 5\%$, 1/2w	4704-159624	01121	EB6835	1		
R11	H2-Q2	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOI QTY	REC QTY	USE CODE
R12	H2-R4	Res, comp, 75k $\pm 5\%$, 1/2w	4704-108928	01121	EB7535	REF		
R13	H2-R2	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		
R14	H2-S5	Res, comp, 82k $\pm 5\%$, 1/2w	4704-195966	01121	EB8235	1		
R15	H3-S5	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		
R16	H2-T5	Res, comp, 91k $\pm 5\%$, 1/2w	4704-219030	01121	EB9135	1		
R17	H2-T3	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		
R18	H5-U4	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	9		
R19	H3-U4	Res, comp, 1k $\pm 5\%$, 1/2w	4704-108597	01121	EB1025	REF		
R20	C4-U5	Res, comp, 1.1 Ω $\pm 5\%$, 1/2w	4704-163717	01121	EB11G5	1		
R21	H2-N5	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R22	H2-P4	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R23	H2-Q5	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R24	H2-S2	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R25	H5-S5	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R26	G5-U4	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R27	H2-U4	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R28	G1-P3	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	7		
R29	G4-Q3	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	REF		
R30	F5-Q3	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	REF		
R31	G2-S5	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	REF		
R32	F5-S5	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	REF		
R33	F4-U3	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	REF		
R34	G1-U3	Res, comp, 22k $\pm 10\%$, 2w	4704-109975	01121	HB2231	REF		
R35	F3-Q5	Res, comp, 75k $\pm 5\%$, 1/2w	4704-108928	01121	EB7535	REF		
R36	F5-R3	Res, comp, 75k $\pm 5\%$, 1/2w	4704-108928	01121	EB7535	REF		
R37	E1-N2	Res, comp, 36k $\pm 5\%$, 1/2w	4704-185991	01121	EB3635	REF		
R38	D4-P5	Res, comp, 180 Ω $\pm 5\%$, 1/2w	4704-108944	01121	EB1815	2		
R39	E1-M5	Res, comp, 100 Ω $\pm 5\%$, 1/2w	4704-188508	01121	EB1015	REF		
R40	H2-N2	Res, comp, 100k $\pm 5\%$, 1/2w	4704-168054	01121	EB1045	REF		
R41	E3-N5	Res, met flm, 4.75k $\pm 1\%$, 1/2w	4705-192500	75042	Type CEC-TO	2		S

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R42	E3-N3	Res, met flm, 4.75k $\pm$ 1%, 1/2w	4705-192500	75042	Type CEC-TO	REF		S
	E1-V1	Heat sink	4806-192245	89536	4806-192245	1		



Q1 thru Q8 may be Fluke Part No. 4805-190710, Mfr 04713, (Mfr Part No. 2N3739; or Fluke Part No. 4805-225573), Mfr 95303, Mfr Part No. 2N4299. It is necessary, however, that all eight must be the same type. Example; if all eight are 2N4299, a replacement of one or more should be a 2N4299.

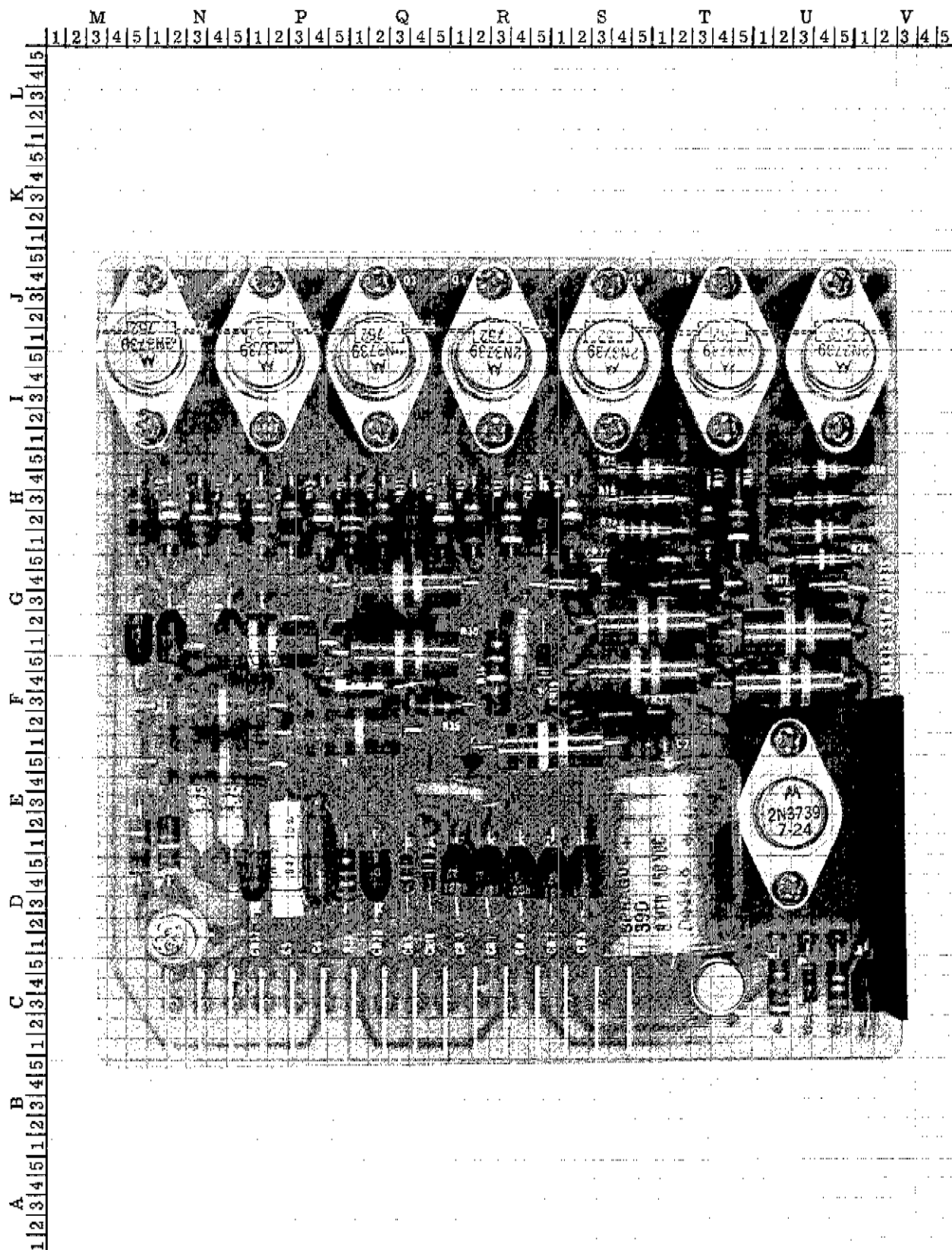


Figure 5-18. SERIES PASS ELEMENT P/C ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOI QTY	REC QTY	USE CODE
A8A2		PREREGULATOR P/C ASSEMBLY Figure 5-19	1702-222000 (335A-4082)	89536	1702-222000	REF		
C1	D2-Q4	Cap, cer, 0.05 uf +80/-10%, 500v	1501-105676	56289	33C58B	REF		
C2	D3-Q2	Cap, cer, 0.05 uf +80/-10%, 500v	1501-105676	56289	33C58B	REF		
C3	E2-P5	Cap, plstc, 1 uf $\pm$ 20%, 200v	1507-106450	84411	Type X663F	REF		
C4	F2-R4	Cap, elect, 1,000 uf +50/-10%, 16v	1502-193896	73445	C437ARE1000	REF		
C5	E4-S3	Cap, cer, 0.05 uf +80/-10%, 500v	1501-105676	56289	33C58B	REF		
C6	I5-P5	Cap, cer, 0.05 uf +80/-10%, 500v	1501-105676	56289	33C58B	REF		
C7	G3-P1	Cap, cer, 0.01 uf +80/-20%, 500v	1501-105668	80183	29C9B5	1		
C8	G5-R3	Cap, mica, 510 pf $\pm$ 5%, 500v	1504-148411	88419	CD19F511J	REF		
CR1	D3-P2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR2	E4-R2	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	7	1	
CR3	D1-P2	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR4	D5-R3	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	REF		
CR5	E1-S1	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	REF		
CR6	H5-U5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR7	F1-U1	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR8	F5-T5	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR9	H5-V2	Diode, silicon, 1 amp, 600 piv	4802-112383	05277	1N4822	REF		
CR10	J3-P3	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	REF		
CR11	J2-N4	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	REF		
CR12	H5-N5	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	REF		
CR13	I4-N4	Diode, silicon, 3 amp, 200 piv	4802-187716	04713	MR1032B	REF		
CR14	D5-N3	Diode, zener, 200v	4803-187617	04713	1N3350RA	1	1	
CR15	H5-P5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
CR16	H5-Q5	Diode, silicon, 1 amp, 100 piv	4802-116111	05277	1N4817	REF		
K1	H5-T5	Relay, armature, 115 vac, dpdt	4501-106864	16332	100-5ADPDT	1		
K2	G2-U5	Relay, reed, 500v	5103-136630	12617	Type DRG-1	1		
	F2-U5	Coil, reed relay, 24v	1802-186155	71707	SP-24-P	REF		
L1	F5-Q1	Inductor, 1,000 uh, 140 ma	1801-147819	72559	WEE-1,000	1		
L2	G5-S1	Inductor, 220 uh, 280 ma	1801-147835	72559	WEE-220	1		
P1	C3-P3	Connector, male, 16 contact	2816-187724	91862	02-016-013- 5-200	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q1	H3-N3	Tstr, silicon, NPN	4805-193953	05277	320C034H31	1	1	
Q2	H1-P3	Tstr, silicon, NPN	4805-183004	95303	40250	REF		
Q3	I4-R4	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q4	G2-T1	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q5	H1-R1	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
Q6	F1-Q3	Tstr, tested, silicon, PNP	4805-159491	89536	4805-159491	REF		
Q7	F2-P4	Tstr, silicon, NPN	4805-203489	07910	CDQ10656	REF		
R1	D5-P4	Res, comp, 68 Ω $\pm$ 10%, 2w	4704-110205	01121	HB6801	1		
R2	J1-R1	Res, ww, 0.192 Ω $\pm$ 1%, 3w	4707-238741	89536	4707-238741	1	1	
R4	J3-V1	Res, ww, 2k $\pm$ 5%, 5w	4706-113506	06136	Type 5F	1		
R5	I4-P4	Res, comp, 22k $\pm$ 5%, 1/2w	4704-186064	01121	EB2235	REF		
R6	E1-U1	Res, ww, 10 Ω $\pm$ 10%, 5w	4706-112300	06136	Type 10F	2		
R7	D1-U1	Res, ww, 10 Ω $\pm$ 10%, 5w	4706-112300	06136	Type 10F	REF		
R8	I2-Q3	Res, comp, 430 Ω $\pm$ 5%, 1/2w	4704-109058	01121	EB4315	1		Q R
R8	I2-Q3	Res, comp, 560 Ω $\pm$ 5%, 1/2w	4704-109124	01121	EB5615	1		
R9	I1-Q1	Res, comp, 360 Ω $\pm$ 5%, 1/2w	4704-192559	01121	EB3615	REF		
R10	F5-N5	Res, comp, 20k $\pm$ 5%, 1/2w	4704-109041	01121	EB2035	REF		
R11	I2-S1	Res, comp, 100 Ω $\pm$ 5%, 1/2w	4704-188508	01121	EB1015	REF		
R12	H2-T1	Res, comp, 1k $\pm$ 5%, 1/2w	4704-108597	01121	EB1025	REF		
R13	H5-S2	Res, comp, 270 Ω $\pm$ 5%, 1/2w	4704-159616	01121	EB2715	2		
R14	G1-P3	Res, comp, 180 Ω $\pm$ 5%, 1/2w	4704-108944	01121	EB1815	REF		
R15	G1-S1	Res, comp, 4.7k $\pm$ 5%, 1/2w	4704-108886	01121	EB4725	1		
R16	E5-N5	Res, comp, 3.3k $\pm$ 5%, 1/2w	4704-165761	01121	EB3325	REF		
R17	G3-R5	Res, comp, 270 Ω $\pm$ 5%, 1/2w	4704-159616	01121	EB2715	REF		
R18	H2-S1	Res, comp, 620 Ω $\pm$ 5%, 1/2w	4704-108704	01121	EB6215	REF		
	D4-T1	Heat sink	3156-227256	89536	3156-227256	1		
	F1-N1	Heat sink	4806-186767	89536	4806-186767	1		

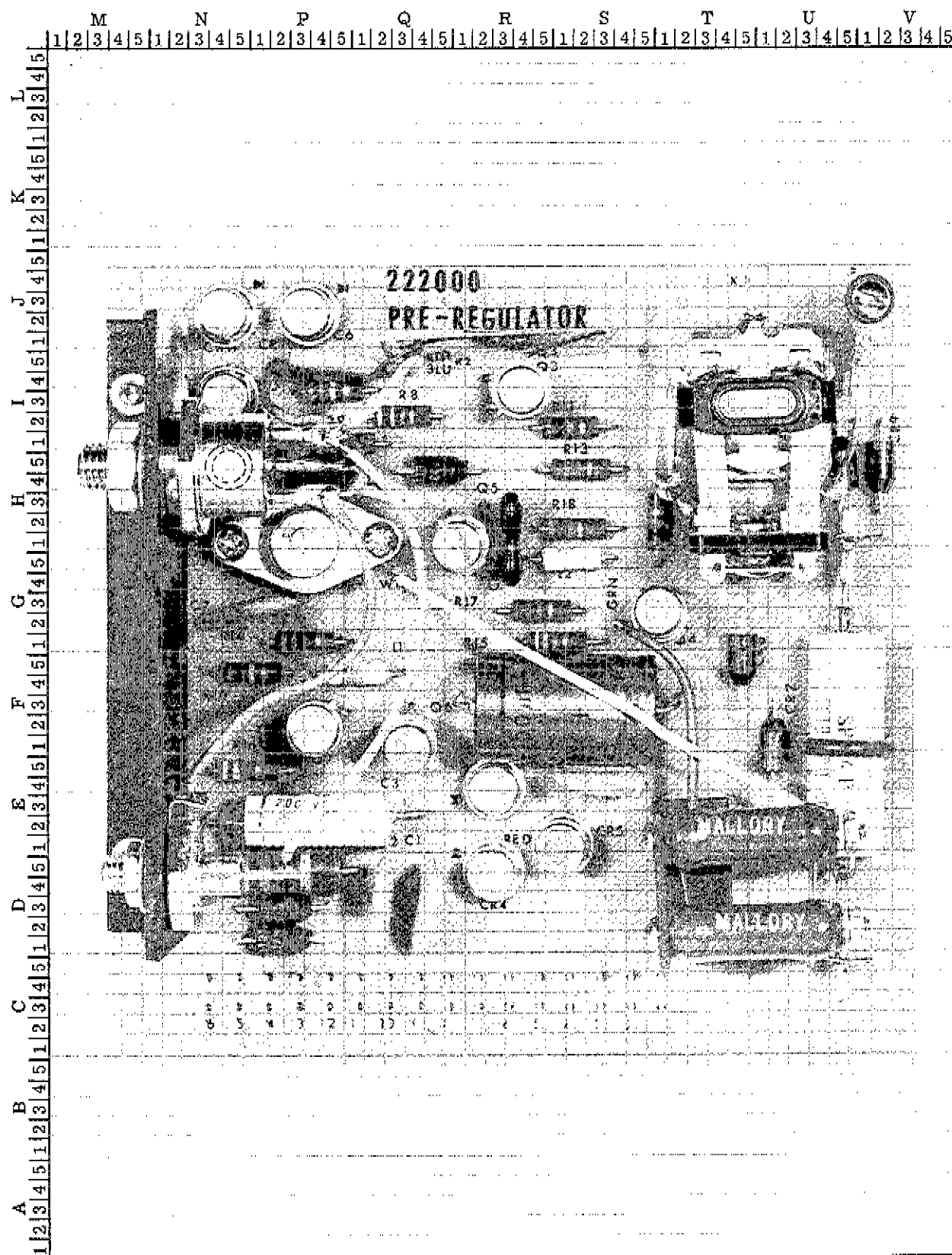


Figure 5-19. PREREGULATOR P/C ASSEMBLY

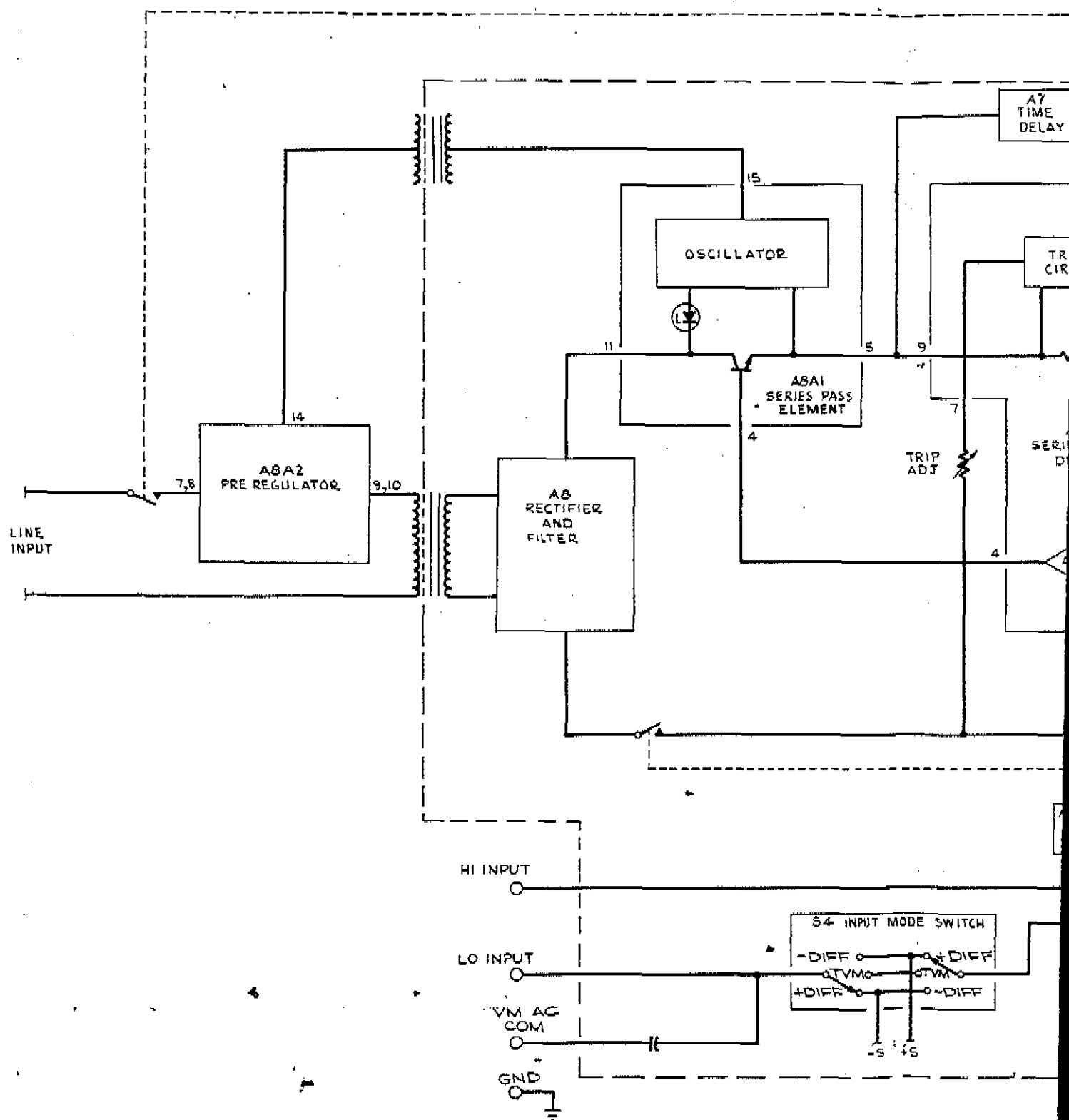
Appendix B

List of Abbreviations

A,amp	ampere	m	milli or 10^{-3}
ampl	amplifier	mm	millimeter
ac	alternating current	n	nano or 10^{-9}
assy	assembly	neg	negative
BCD	binary coded decimal	Ω	ohm
cap	capacitor	osc	oscilloscope
car	carbon	ppm	parts per million
cm	centimeter	piv	peak inverse voltage
C	centigrade	p-p	peak to peak
cer	ceramic	p	pico or 10^{-12}
cw	clockwise	plstc	plastic
CMRR	common mode rejection ratio	$\pm$	plus or minus
comp	composition	pos	positive
CCW	counterclockwise	pps	pulses per second
conn	connector	PCB	printed circuit board
CRT	cathode ray tube	QTY	quantity
cps	cycles per second	rf	radio frequency
db	decibel	rfi	radio frequency interference
dvm	digital voltmeter	REC	recommended
dc	direct current	REF	reference
dpdt	double-pole, double-throw	RH	relative humidity
dpst	double-pole, single-throw	res	resistor
elect	electrolytic	rms	root mean square
ext	external	rtry	rotary
f	fahrenheit	sec	second
F	farad	sect	section
FET	field effect transistor	S/N	serial number
flm	film	Si	silicon
Ge	germanium	scr	silicon controlled rectifier
g	giga or 10^9	spdt	single-pole, double-throw
gnd	ground	spst	single-pole, single-throw
gmV	guaranteed minimum value	sw	switch
grd	guard	Ta	tantalum
h	henry	TC	temperature coefficient
Hz	hertz	t	tera or 10^{12}
hf	high frequency	xfmr	transformer
IC	integrated circuit	tstr	transistor
if	intermediate frequency	tvm	transistor voltmeter
int	internal	uhf	ultra high frequency
kc	kilocycle	vtvm	vacuum tube voltmeter
k	kilo (10^3)	var	variable
lf	low frequency	vhf	very high frequency
mc	megacycle	vlf	very low frequency
M	meg or mega (10^6)	V	volt
met	metal	VCO	voltage controlled oscillator
MOS	metal oxide silicon	w	watt
μ	micro or 10^{-6}	ww	wire wound

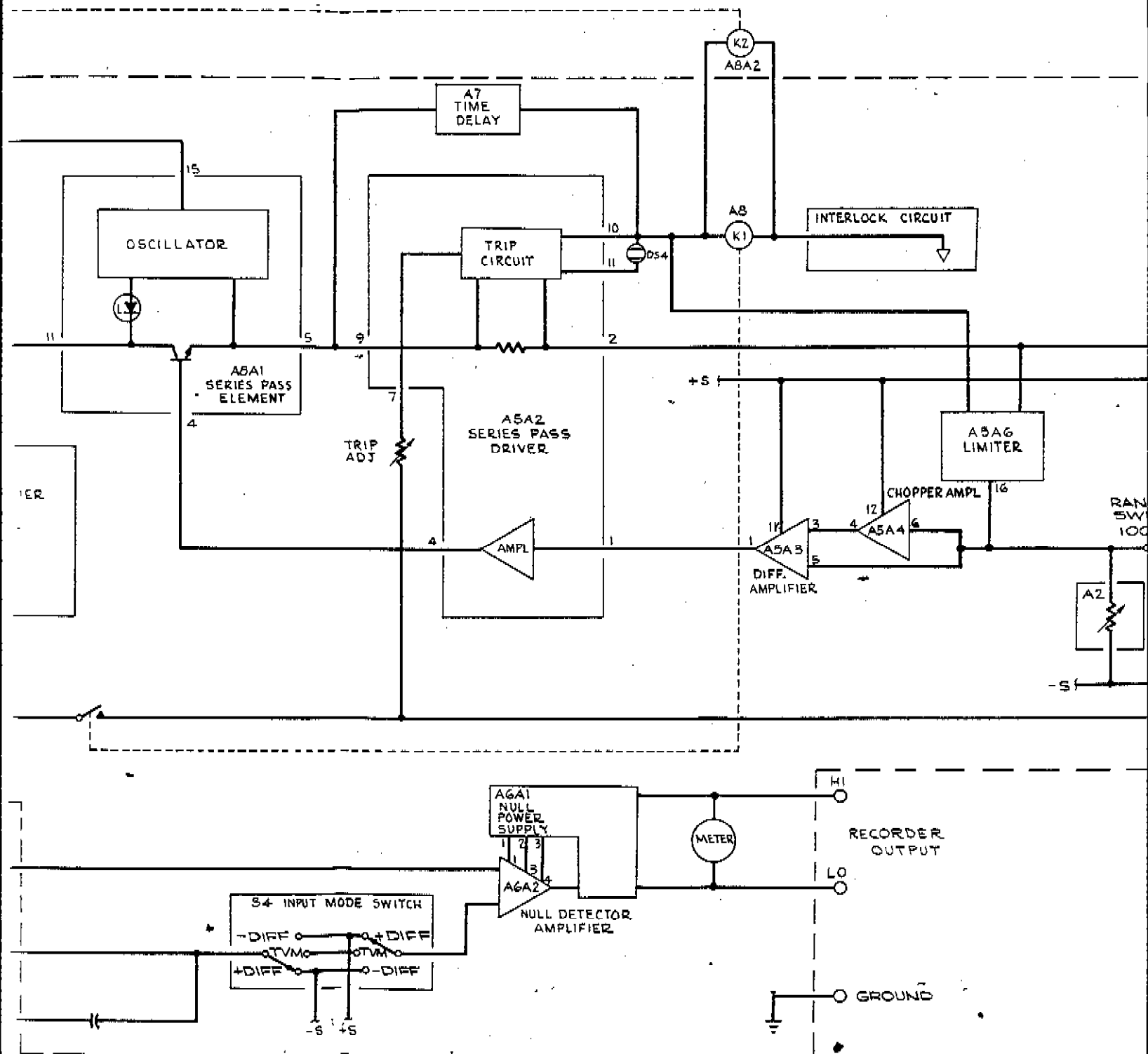
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SHT. 1 OF 3



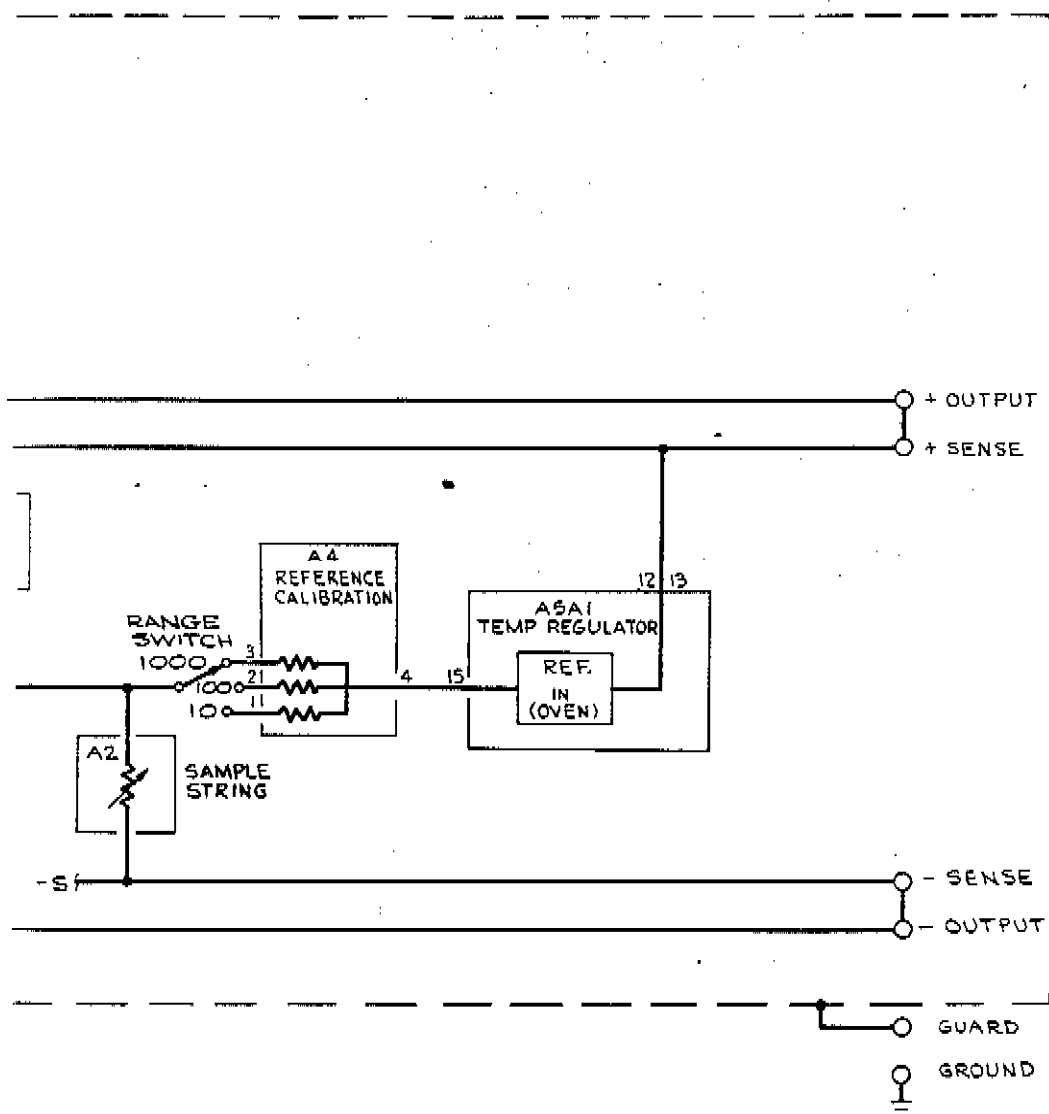
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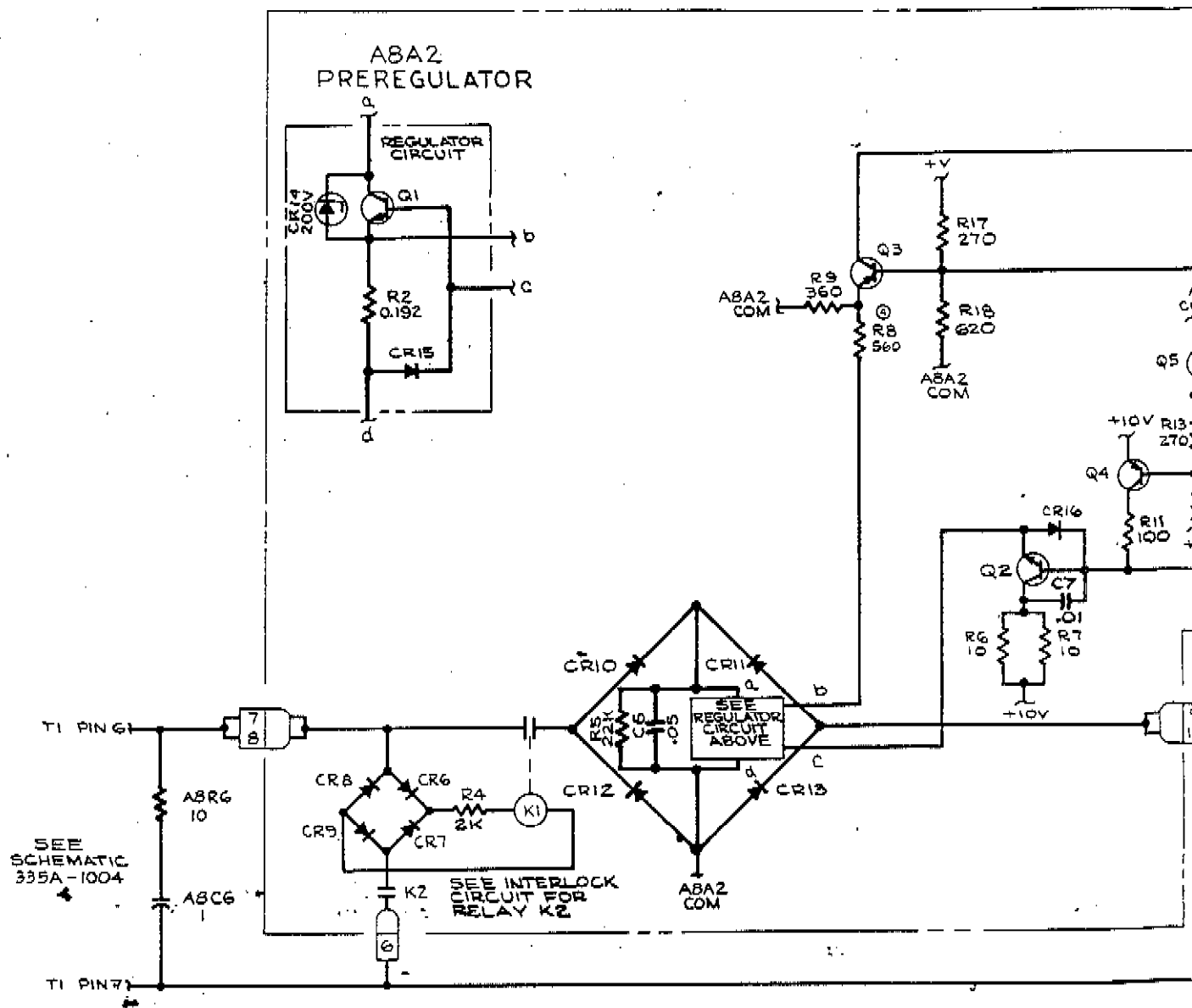
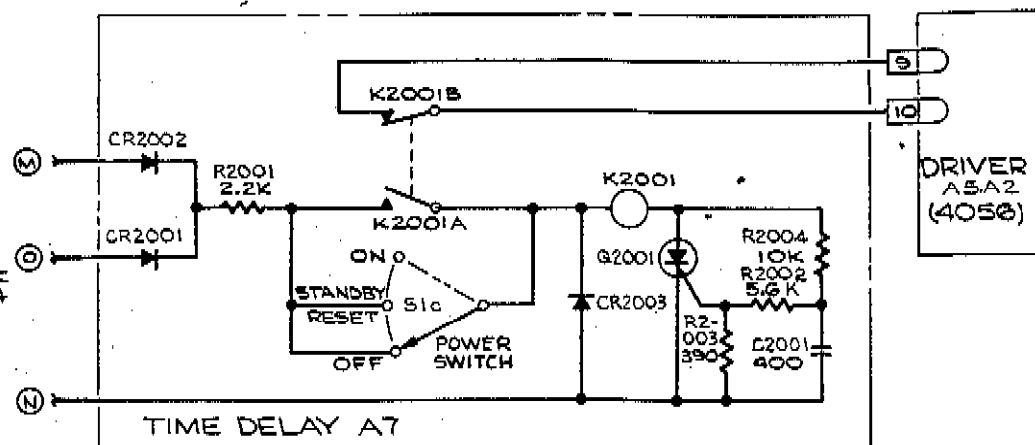
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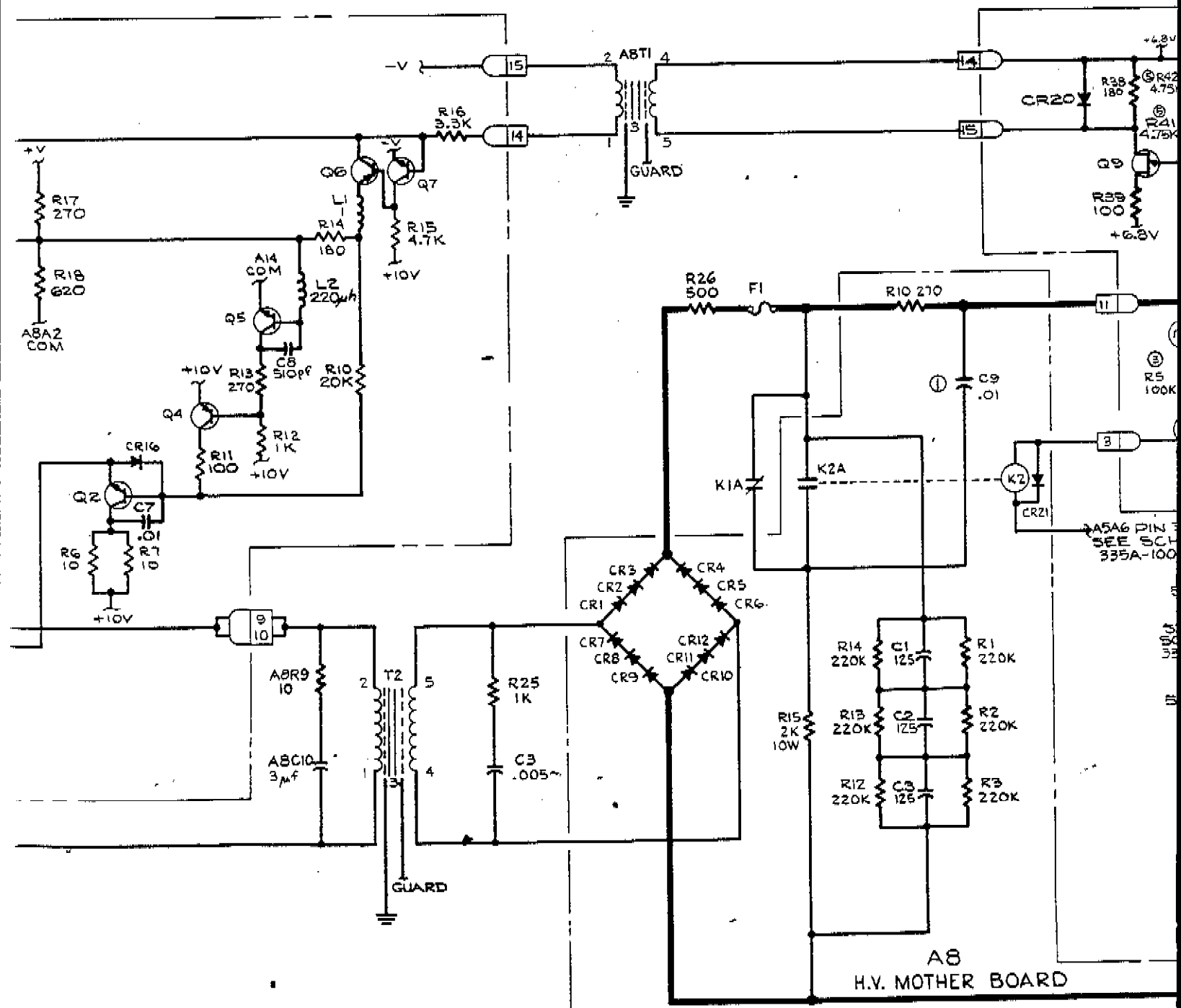
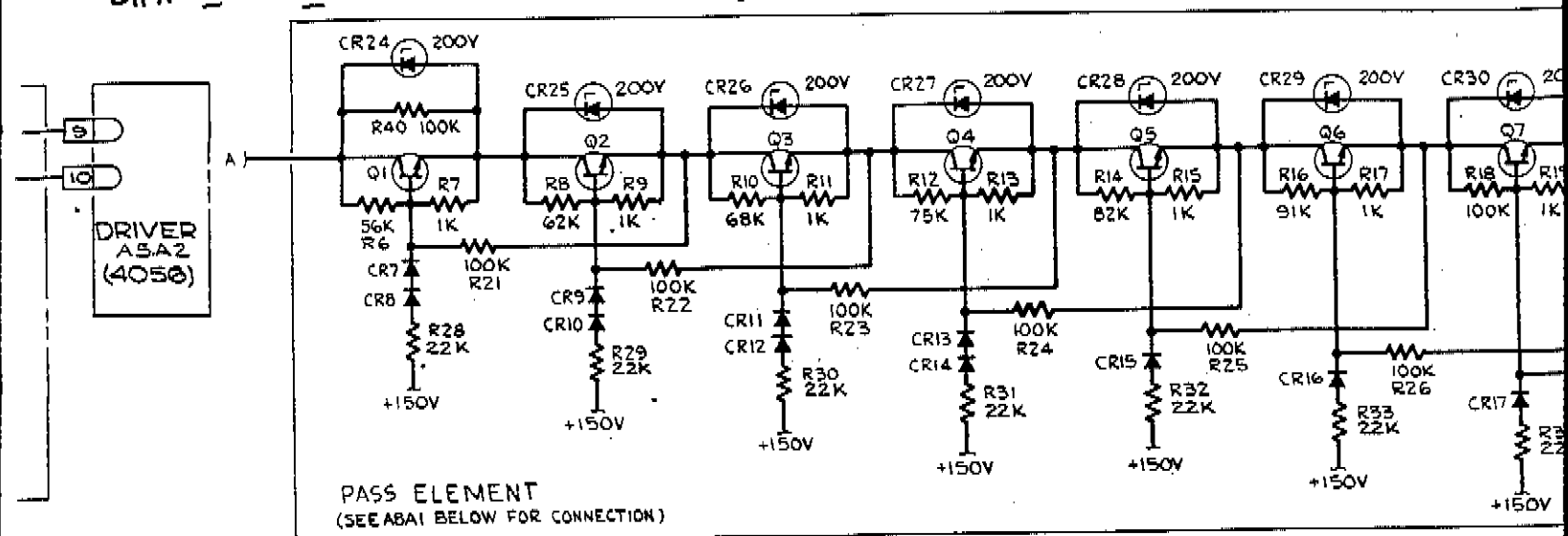


FUNCTIONAL BLOCK DIAGRAM	
MODEL 335A	
DC VOLTAGE STANDARD/ DIFFERENTIAL VOLTMETER/ NULL DETECTOR	
335A-1000	
SER. NO. 123 & DN	REV. Q
 JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98135	

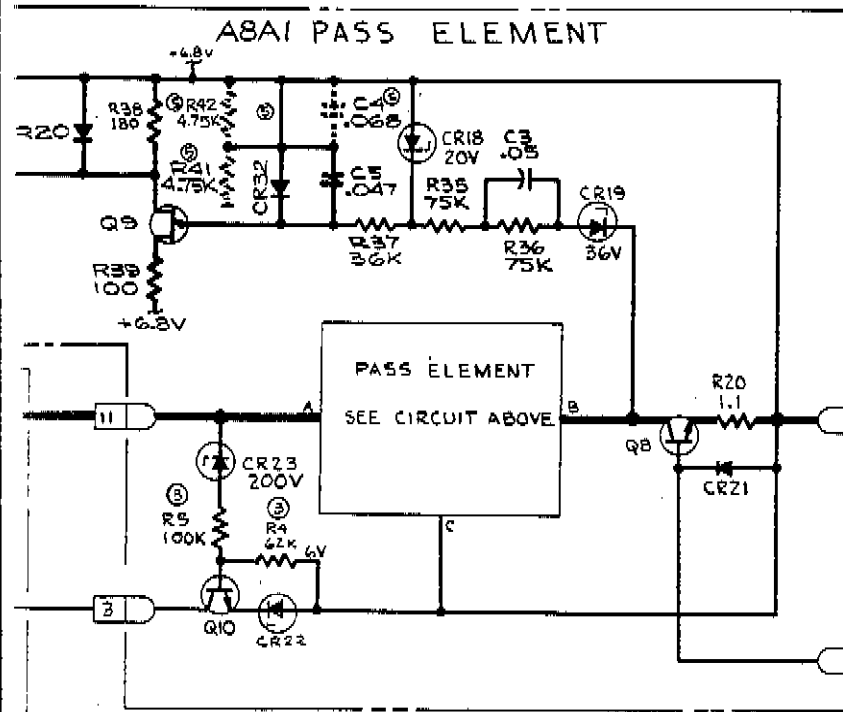
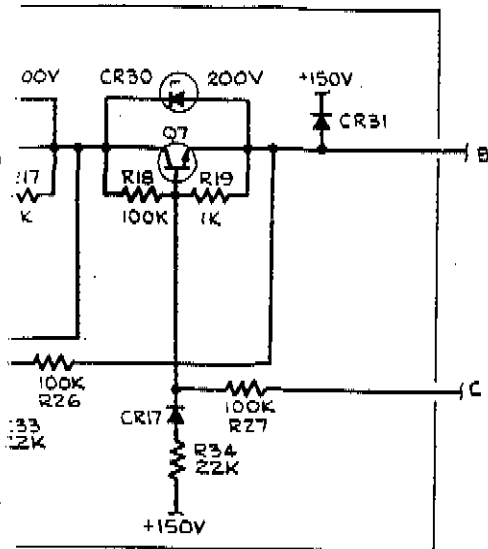
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SCHEMATIC
335A-1004



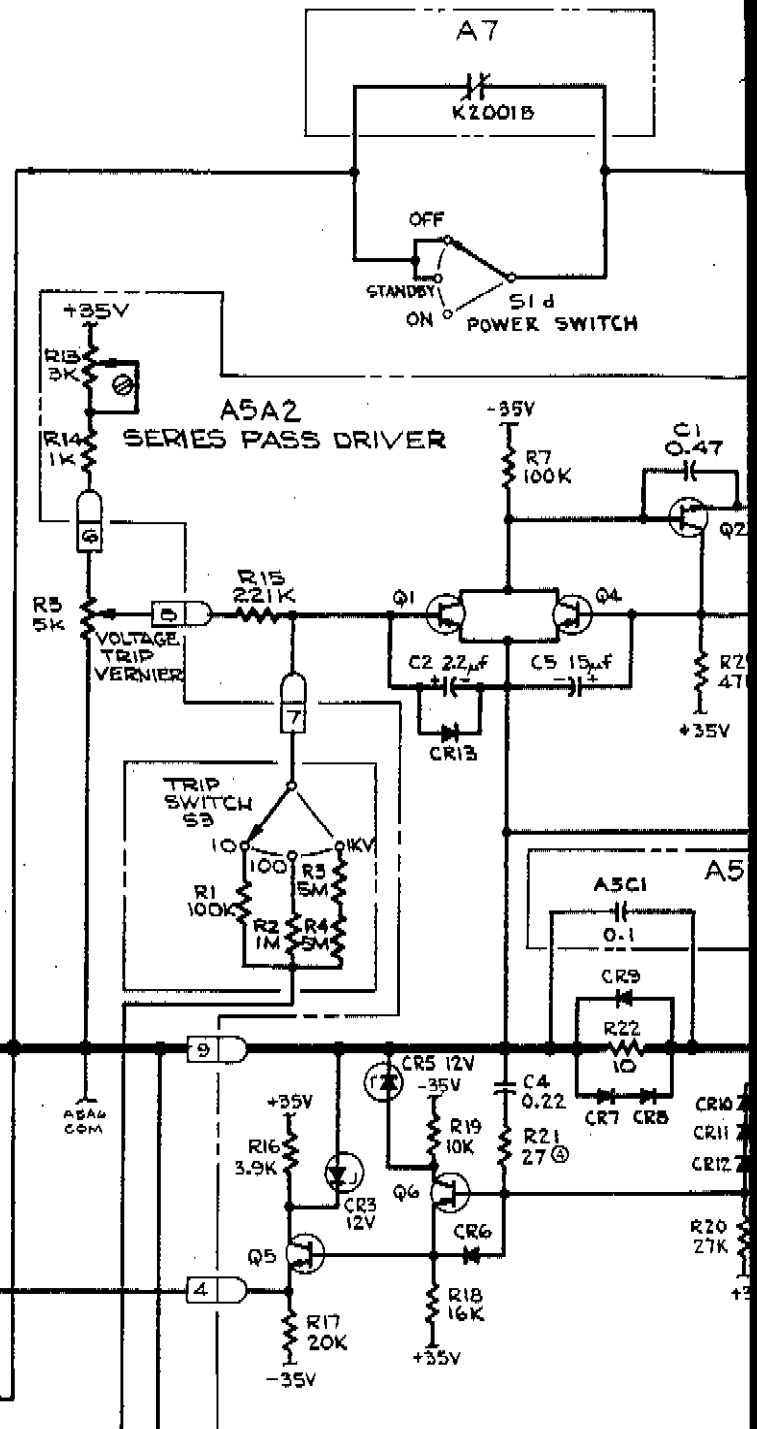
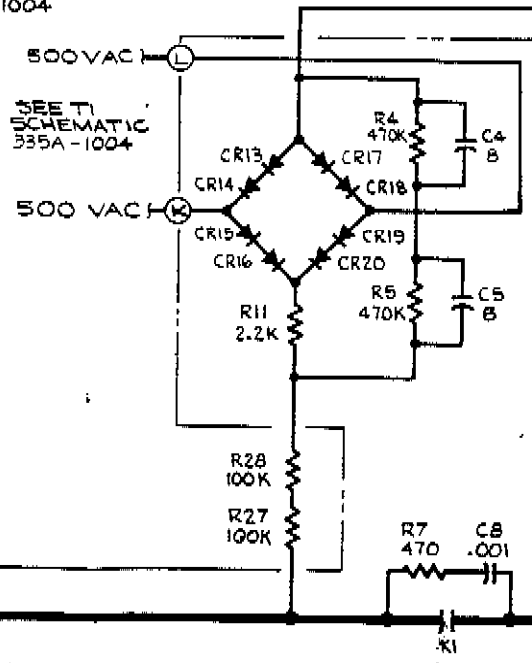
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SHT. 3 OF 6



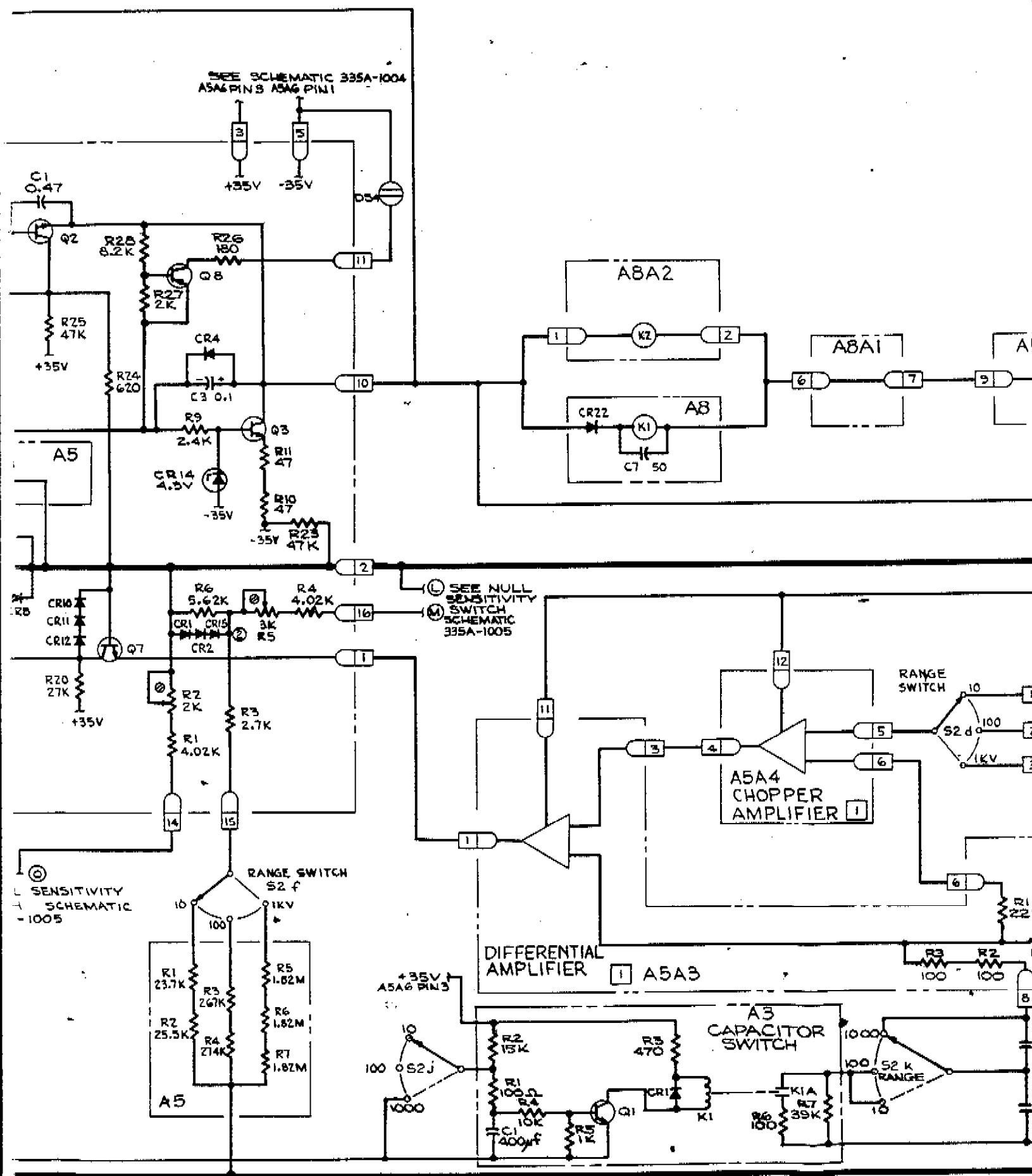
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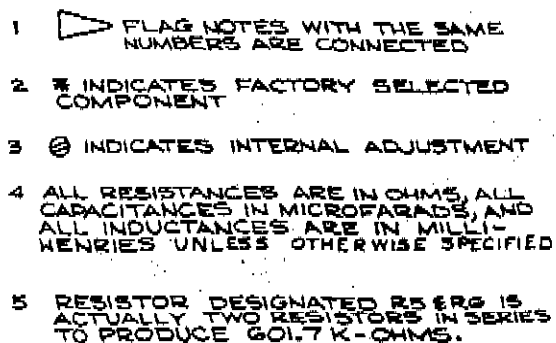


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SWITCH SCHE
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SHT. 4 OF 6

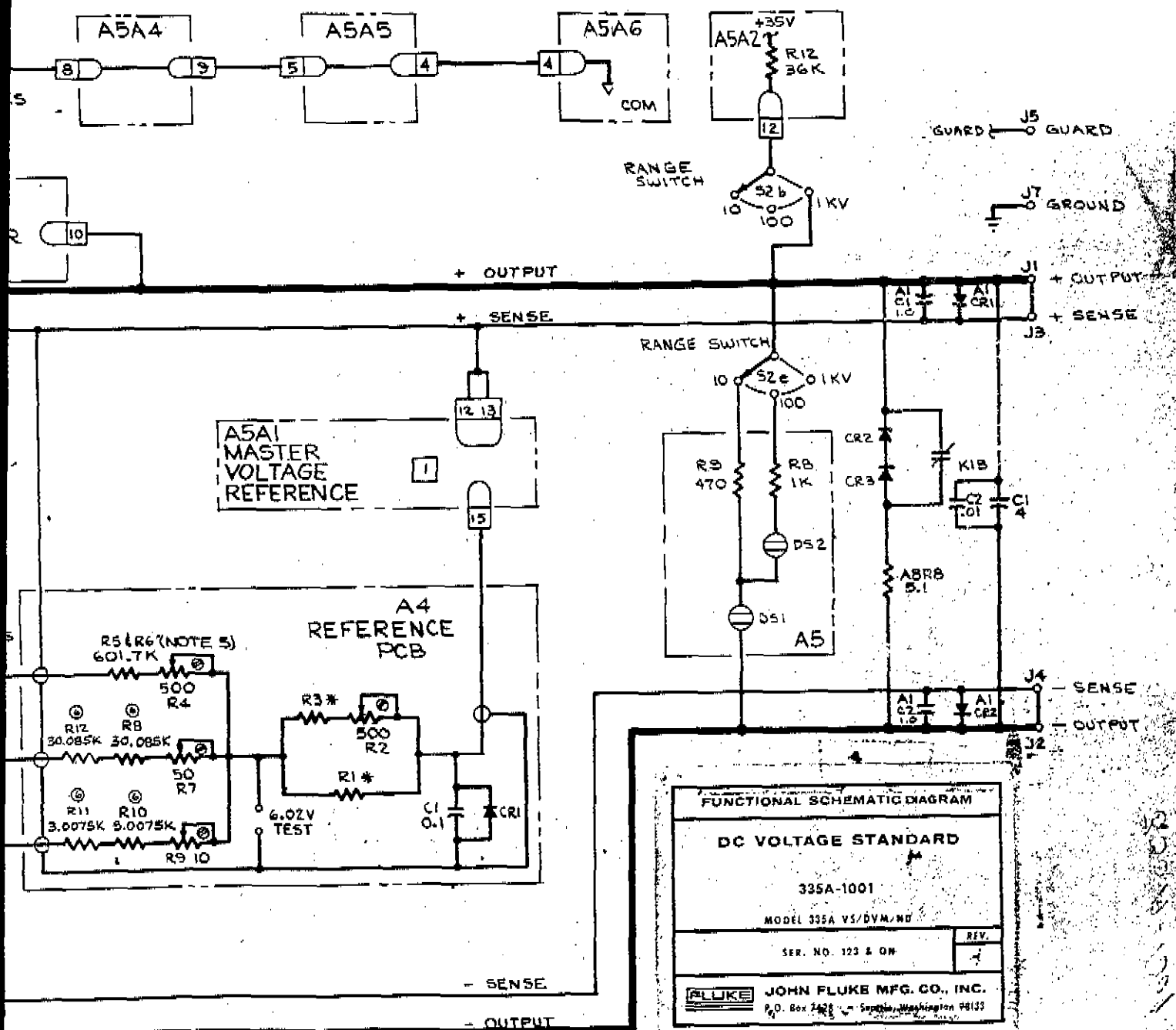




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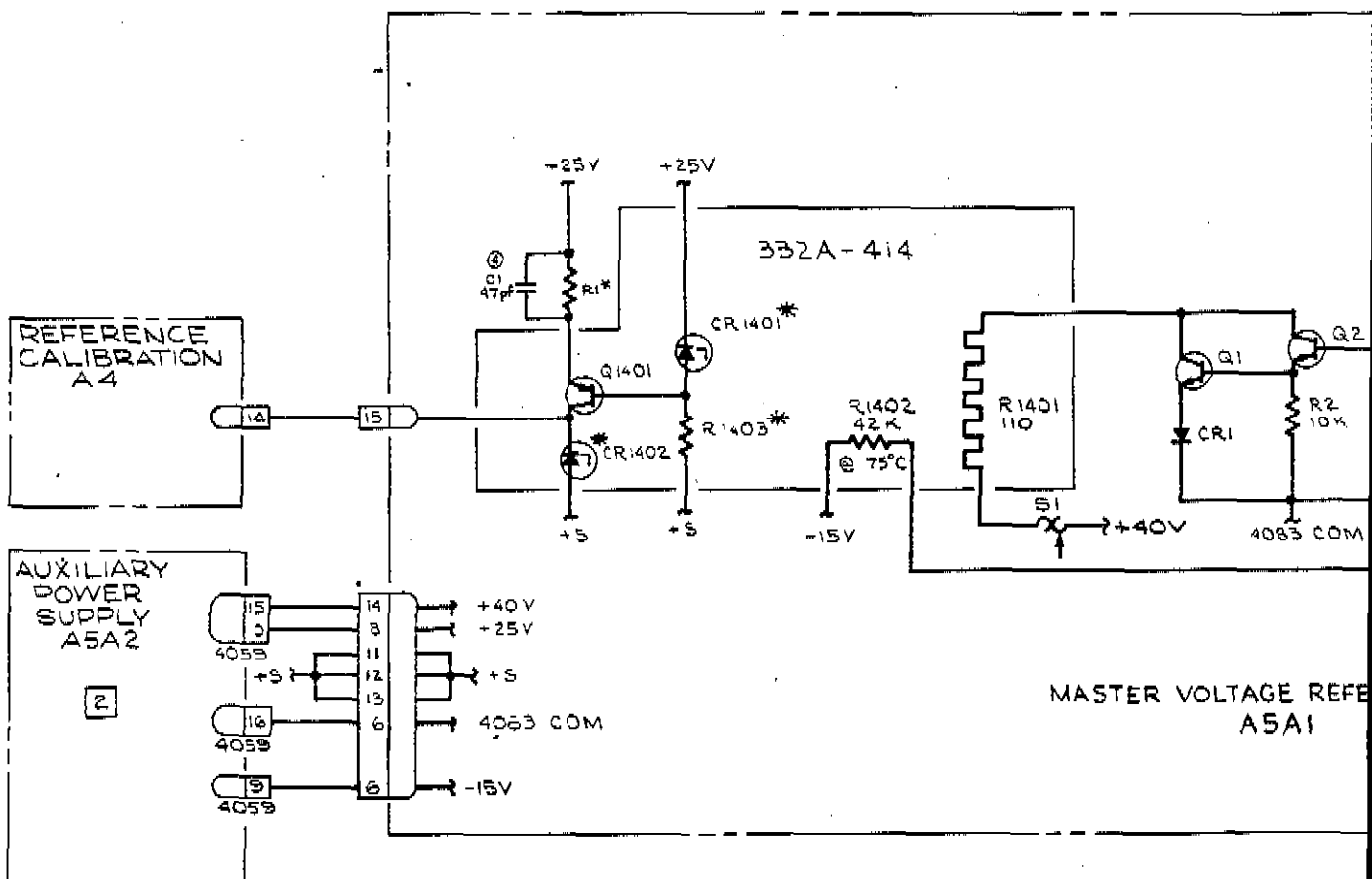
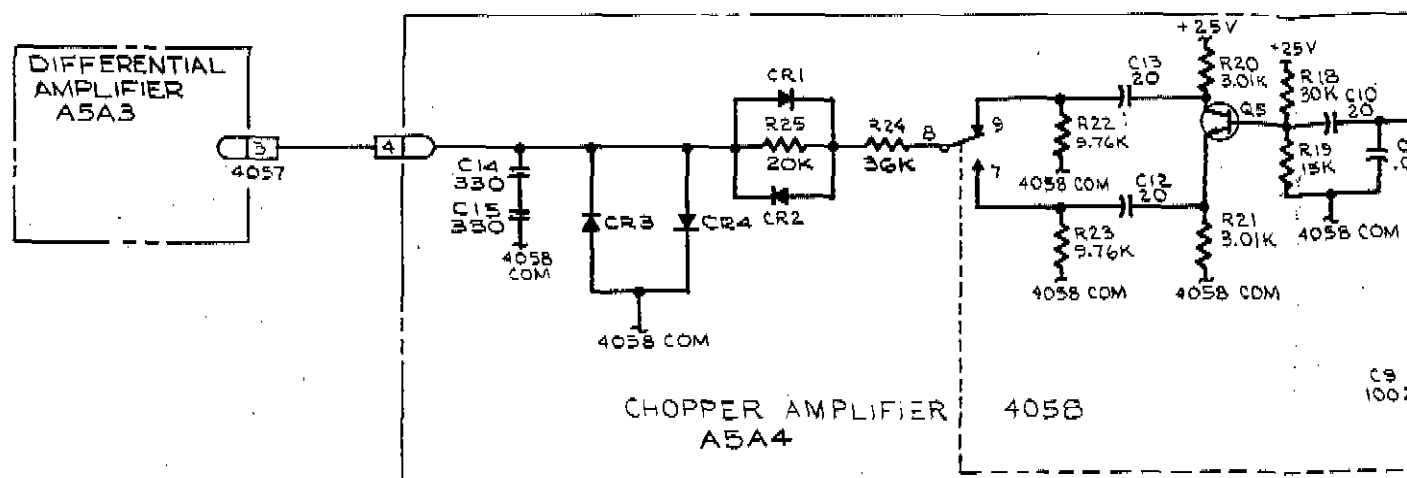
OR DESIGNATED RESERVOIR IS
LY TWO RESISTORS IN SERIES
DUCE 601.7 K-OHMS.

- ① ADDED AT S/N 148 AND ON
- ② CR15 ADDED AT S/N 399 AND ON
- ③ ABAIR WAS 360Ω AND ABAIR5 WAS 270K FOR S/N 27 THRU 309.
- ④ FOR S/N 123 THRU 376:
ASA2R1 WAS 220Ω; ASA2R6 WAS 430Ω
- ⑤ FOR S/N 600 AND 621 AND ON:
ABAI4 & ABAIR41 DELETED
ABAI42 REPLACED WITH BUSS WIRE
- ⑥ FOR S/N 630 AND 761 THRU 776:
A4R6 CHANGED FROM 60.175K TO 30.085K
A4R10 CHANGED FROM 6.015K TO 3.0075K
A4R11 & A4R12 ADDED



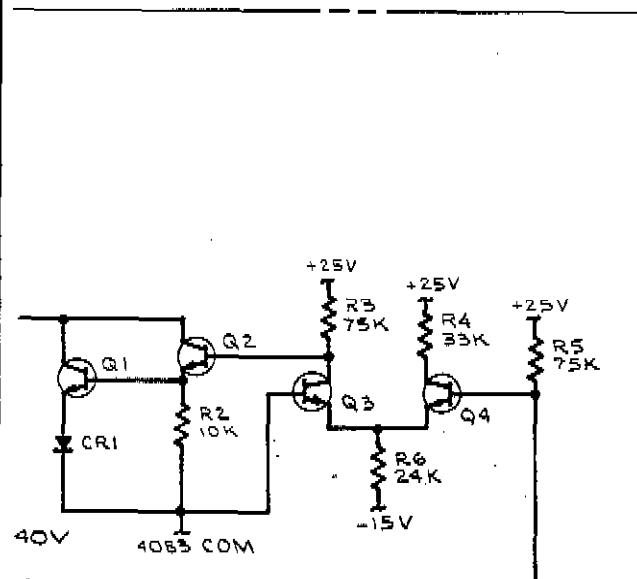
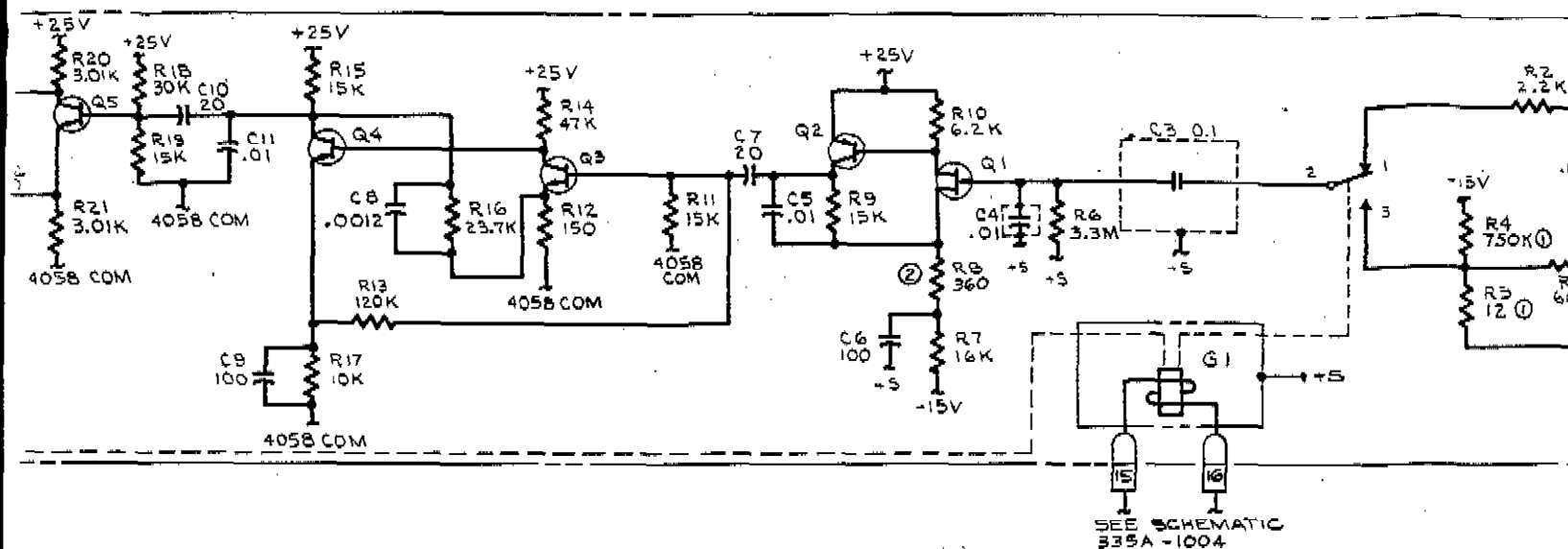
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SHT. 1 OF 6

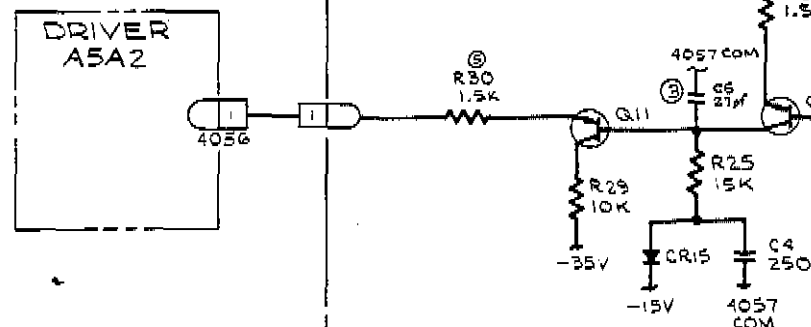


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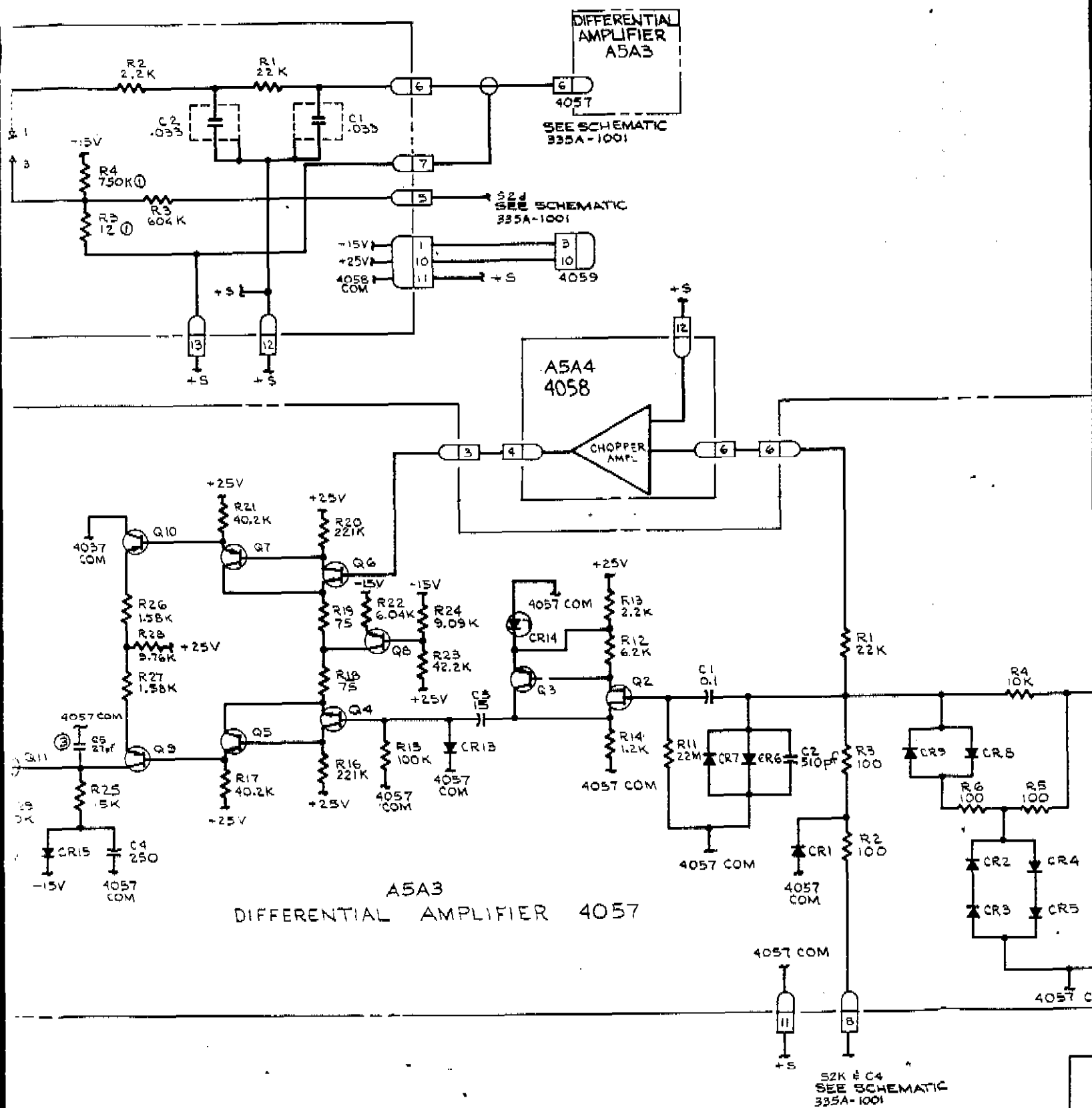
SHT. 2 OF 6



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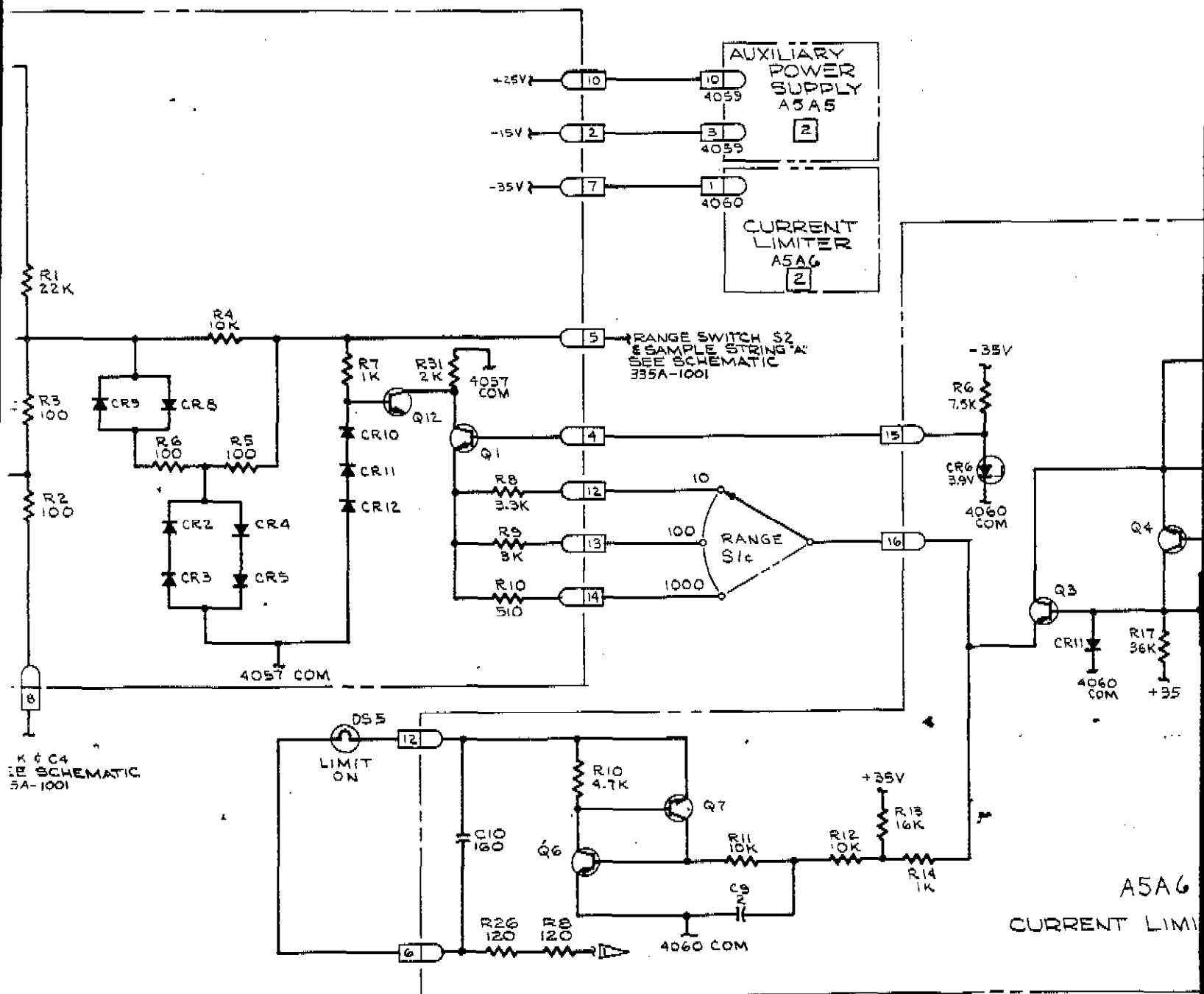


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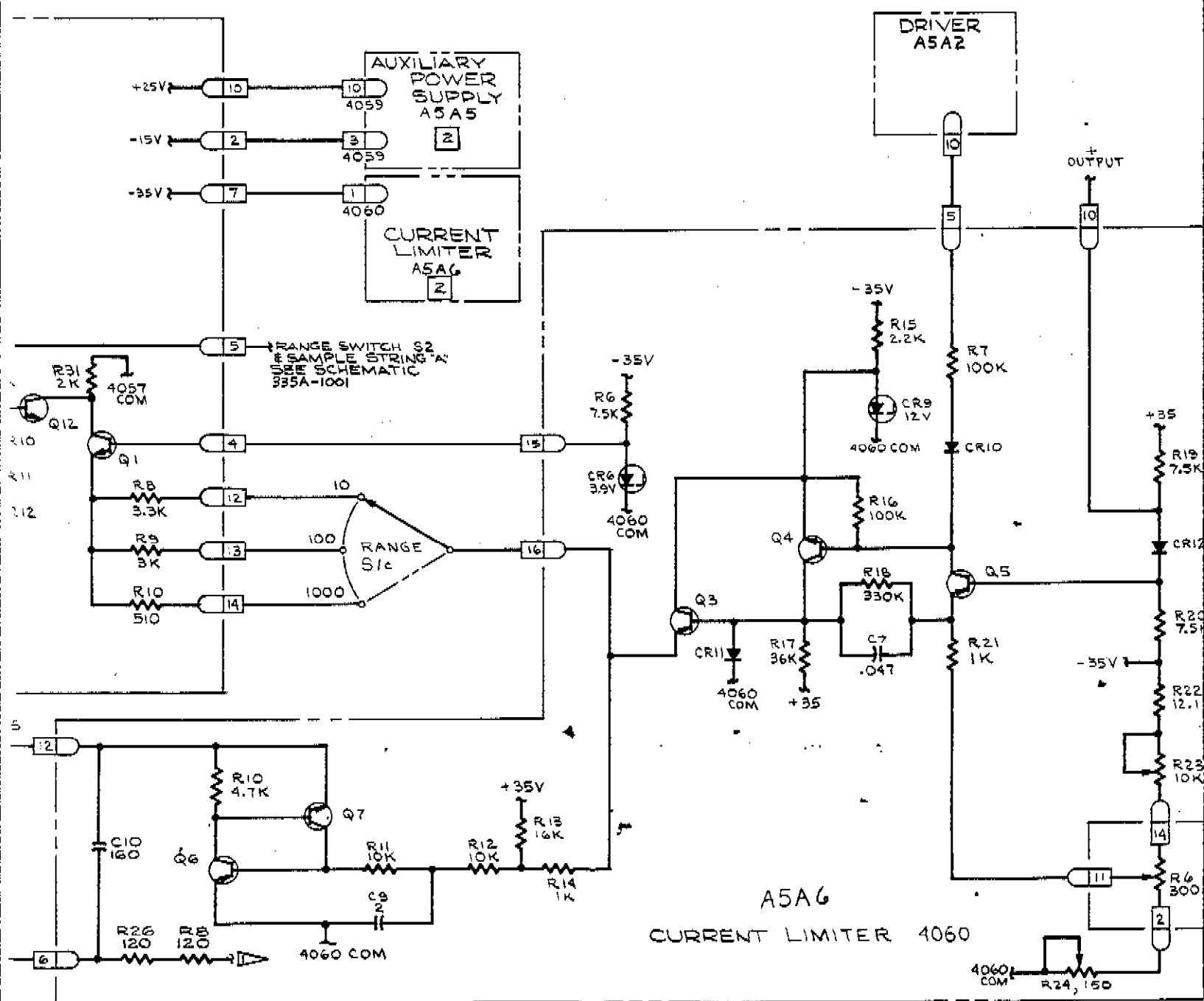
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SHT: 4 OF 6



DWG. 335A-1002

SHT. 5 OF 6

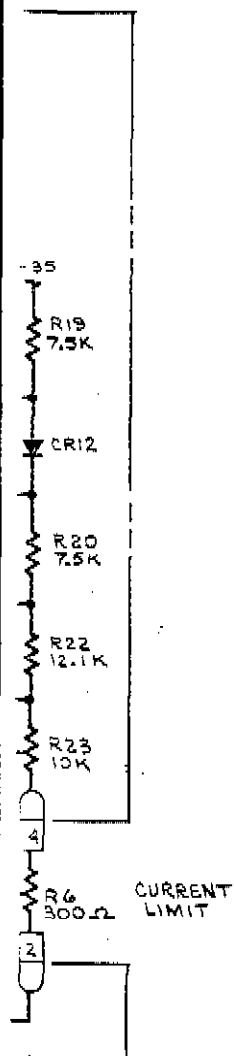


DWG. 335A-1002

SHT. 6 OF 6

CHANGES:

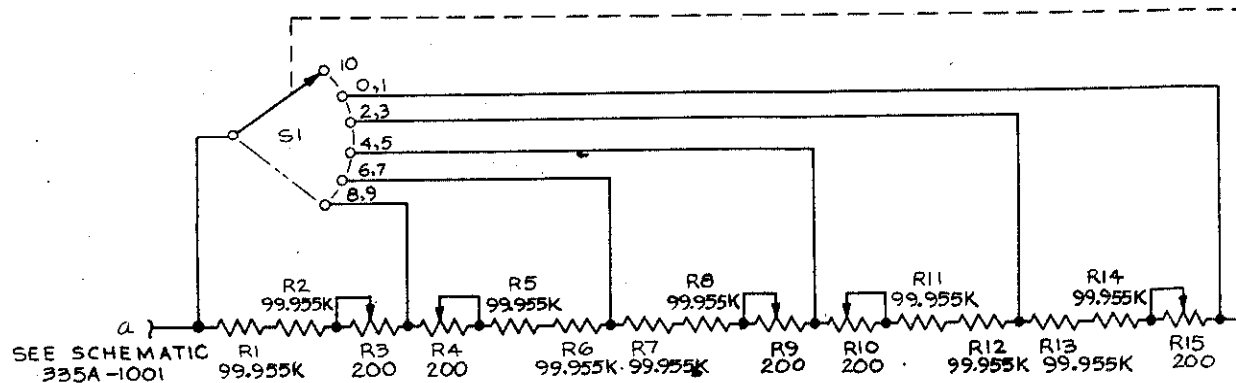
- ① A5A4R4 WAS 604K AND A5A4R5 WAS 10 Ω FROM S/N 123 THRU 220
- ② A5A4R8 WAS CHANGED FROM 200 Ω TO 360 Ω AT S/N 152, 170, 177, 179, 181, 185, 186, 188, 189, 198 AND ON.
- ③ A5A3C5 27 pF ADDED AT S/N 210 AND ON.
- ④ A5A1C1 470 pF ADDED AT S/N 444, 454, 458, 467, 470, 480 AND ON.
- ⑤ FOR S/N 123 THRU 576: A5A3R30 WAS 1K



FUNCTIONAL SCHEMATIC DIAGRAM	
DC VOLTAGE STANDARD SUPPORT MODULES 335A-1002 MODEL 335A VS/DVM/ND	
SER. NO. 123 & ON	REV. C
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	

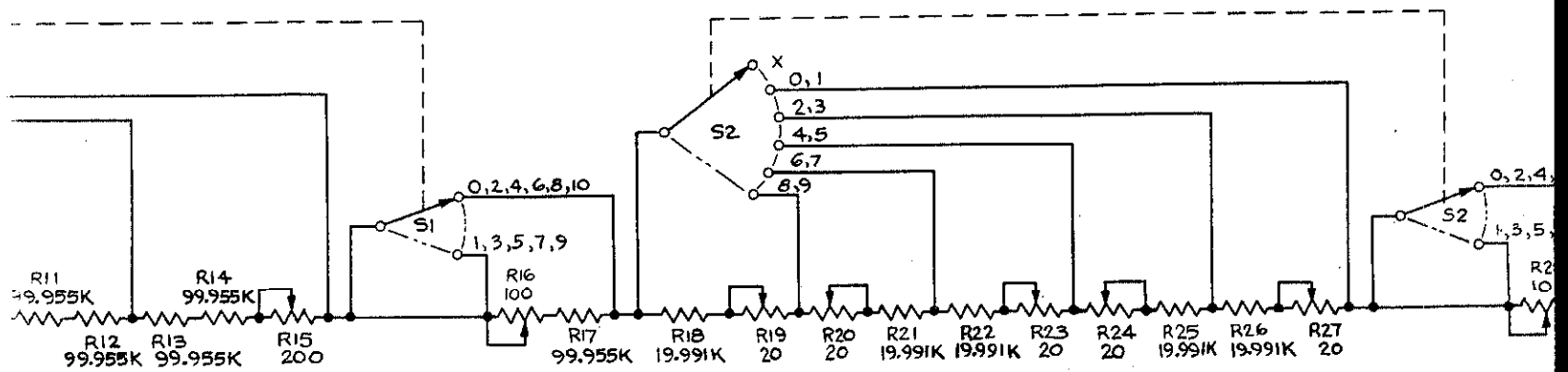
DWG. 335A-1003

SHT. 1 OF 6



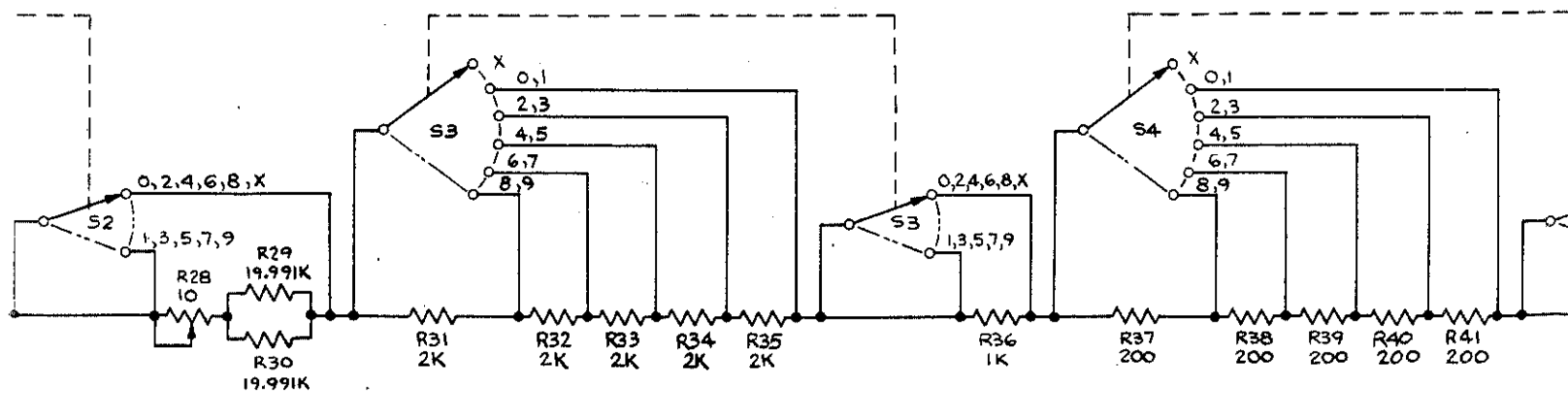
DWG. 335A-1003

SHT. 2 OF 6



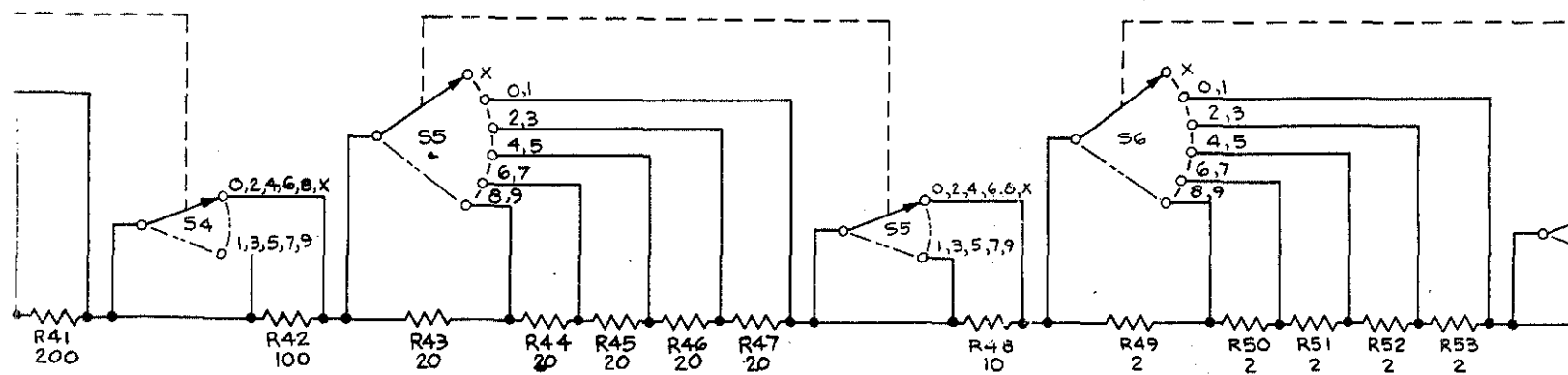
DWG. 335A-1003

SHT. 3 OF 6



DWG. 335A-1003

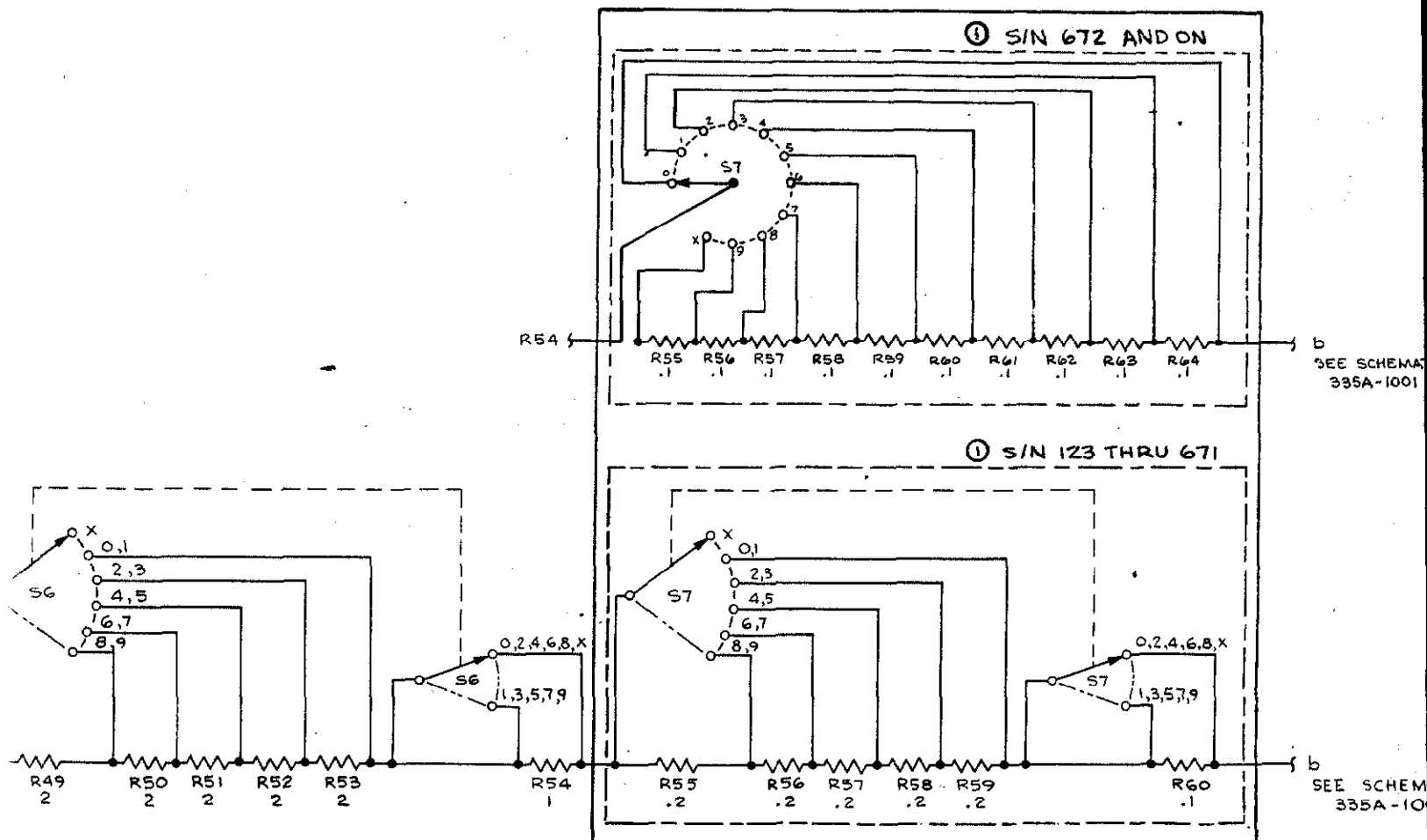
SHT. 4 OF 6



DWG. 335A-1003

SHT. 5 OF 6

DETAIL I



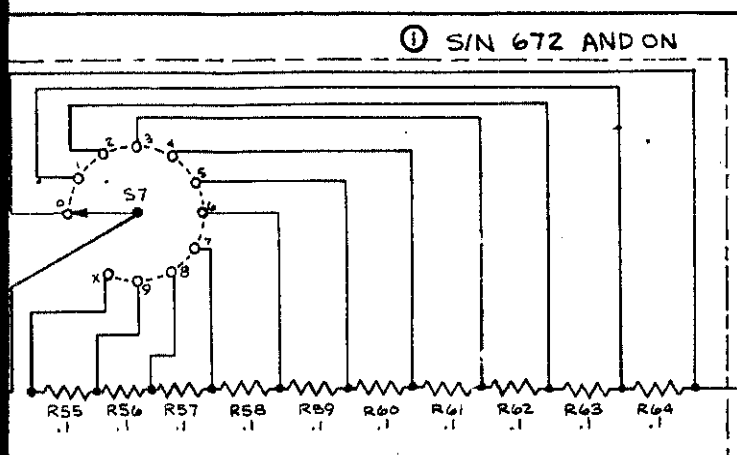
CHANGES:

- ① FOR S/N 672 AND ON:
S7 CONFIGURATION CHANGED.
R55 THRU R60 WW CARD RESISTOR
CHANGED TO R55 THRU R64
RESISTANCE WIRE.

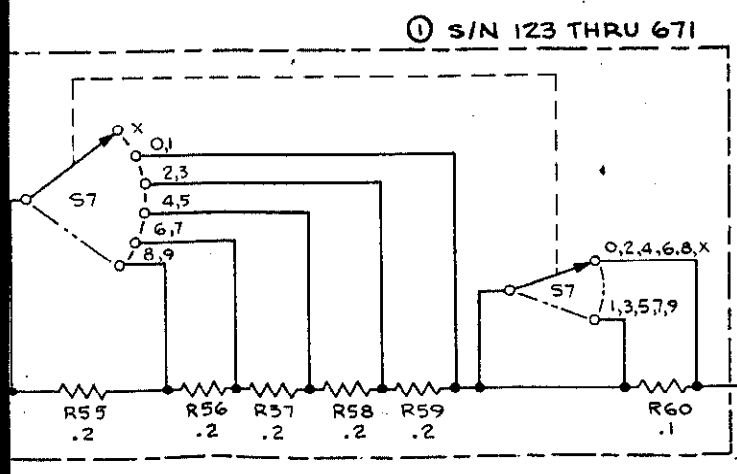
DWG. 335A-1003

SHT. 6 OF 6

DETAIL I



SEE SCHEMATIC
335A-1001



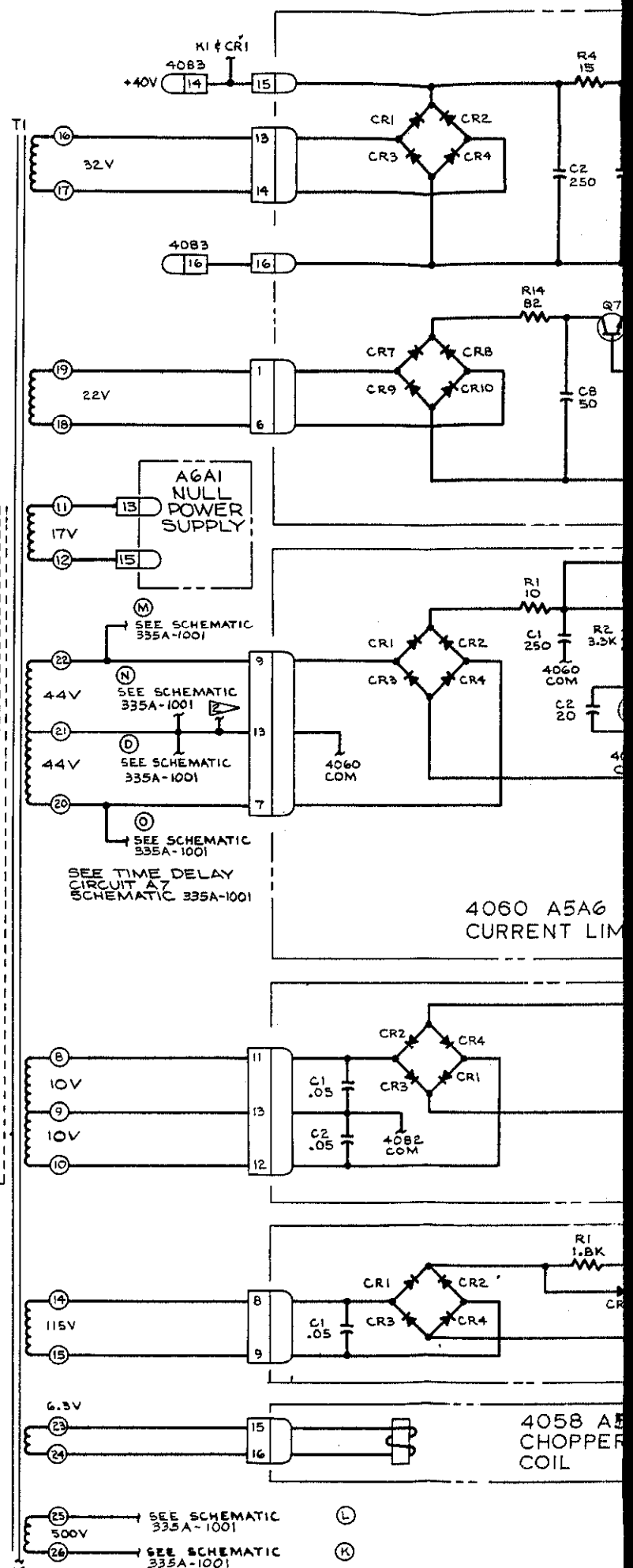
SEE SCHEMATIC
335A-1001

CHANGES:

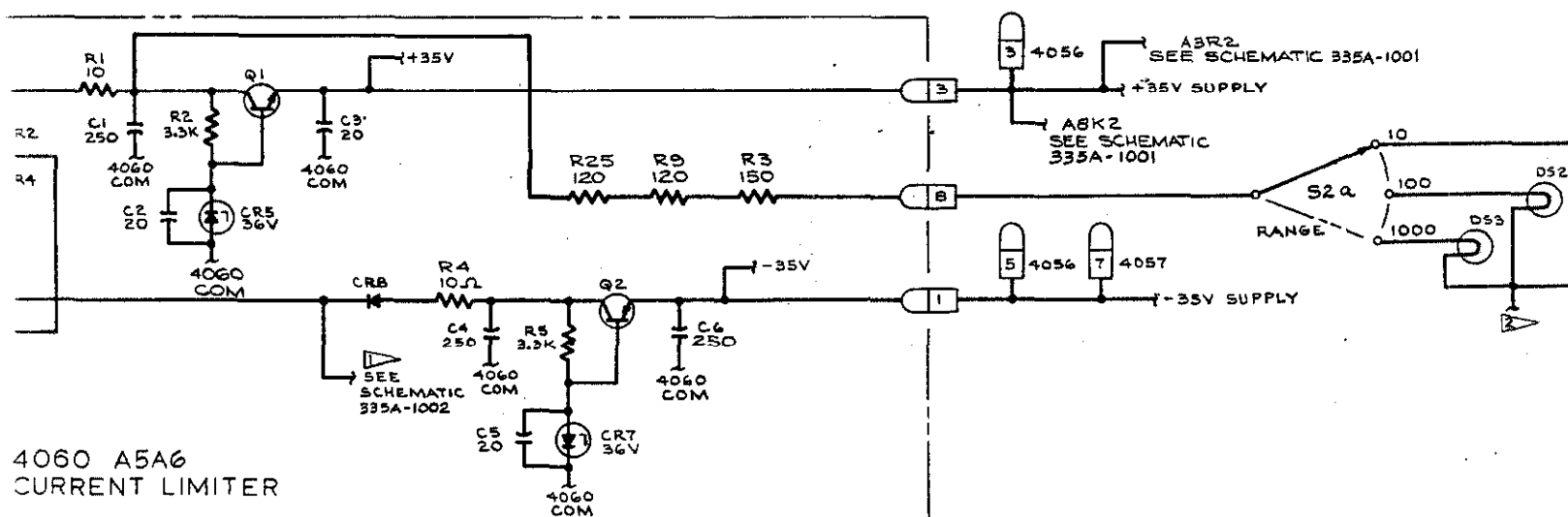
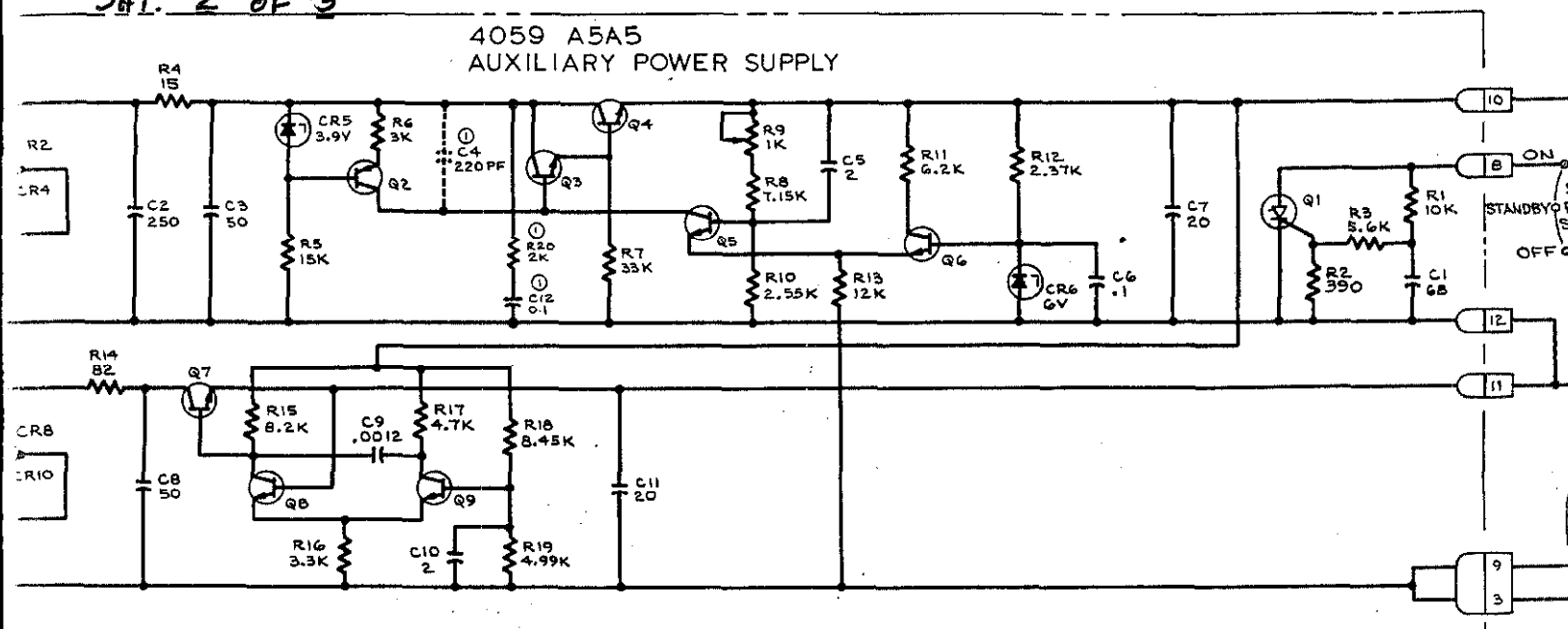
- ① FOR S/N 672 AND ON:
S7 CONFIGURATION CHANGED.
R55 THRU R60 WW CARD RESISTORS
CHANGED TO R55 THRU R64
RESISTANCE WIRE.

FUNCTIONAL SCHEMATIC DIAGRAM	
SAMPLE STRING	
335A-1003	
MODEL 335A VS/DVM/NO	
SER. NO. 123 & ON	REV. b
JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	

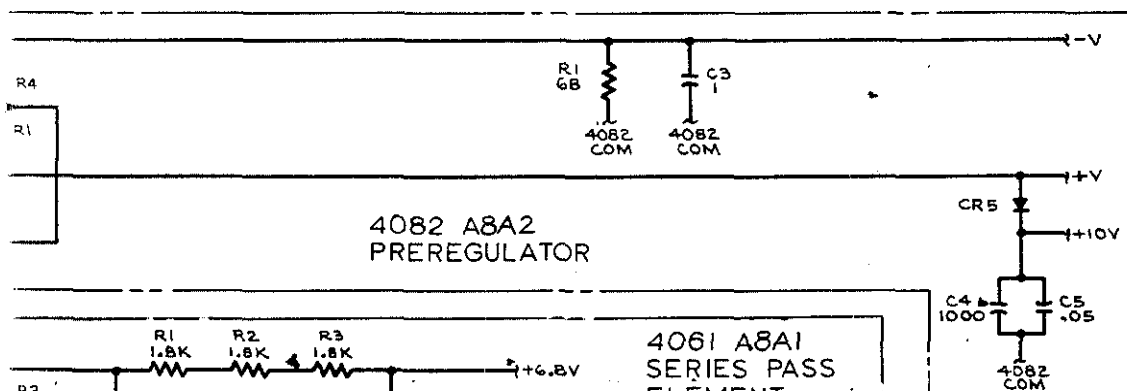
SHT. 1 OF 3



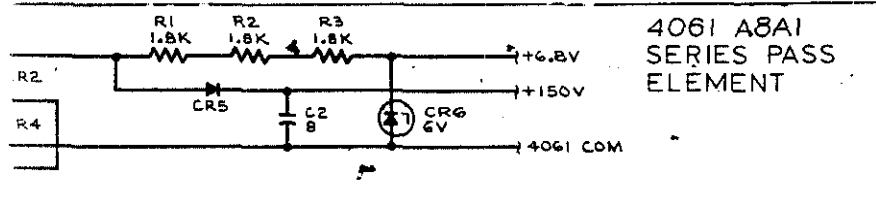
4059 A5A5
AUXILIARY POWER SUPPLY



4082 A8A2
PREREGULATOR



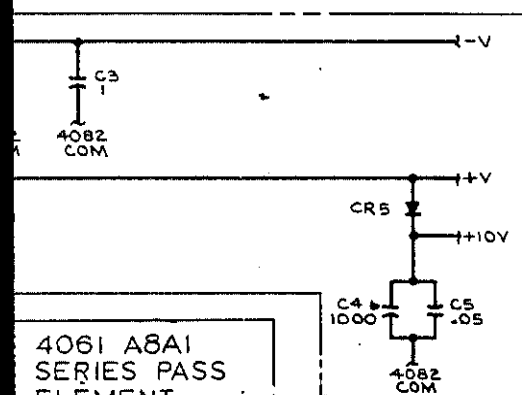
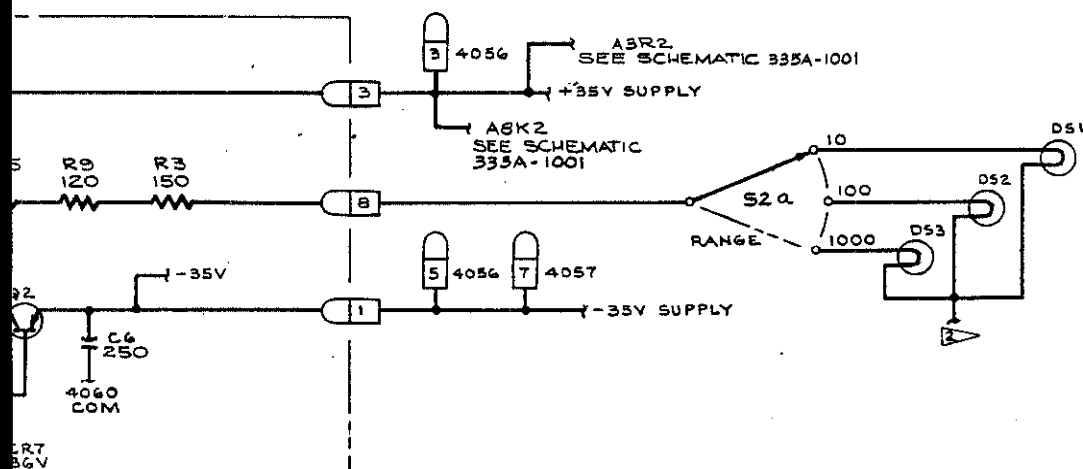
4061 A8A1
SERIES PASS
ELEMENT



4058 A5A4
CHOPPER
COIL

CHANGES:

- ① FOR S/N 487 AND ON:
A5A5C4 220pf DELETED
A5A5C12 0.1 uf ADDED
A5A5R20 2K ADDED

[illegible]

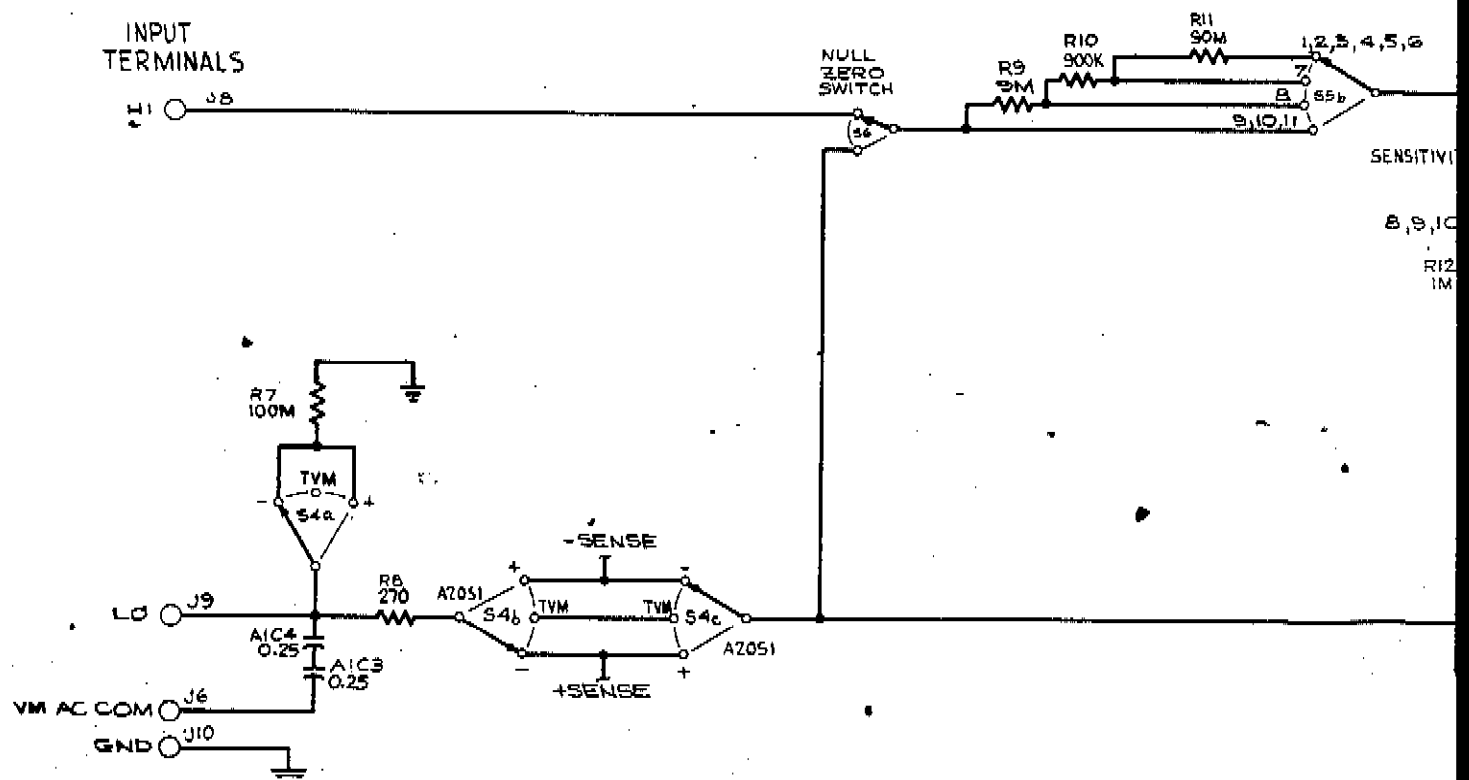
CHANGES:

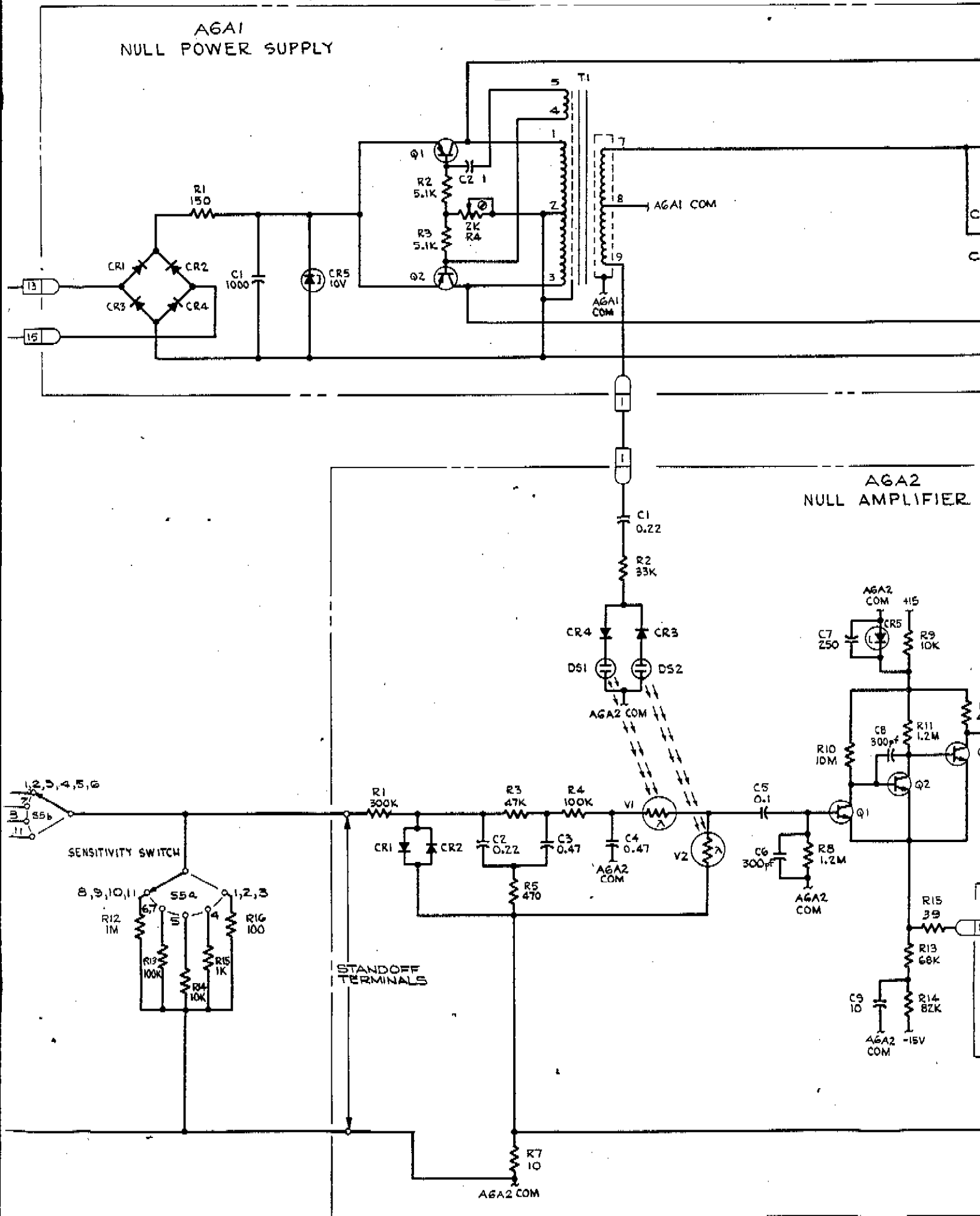
- ① FOR S/N 487 AND ON :
A5A5C4 220pf DELETED
A5A5C12 0.1 uf ADDED
A5A5R20 2K ADDED

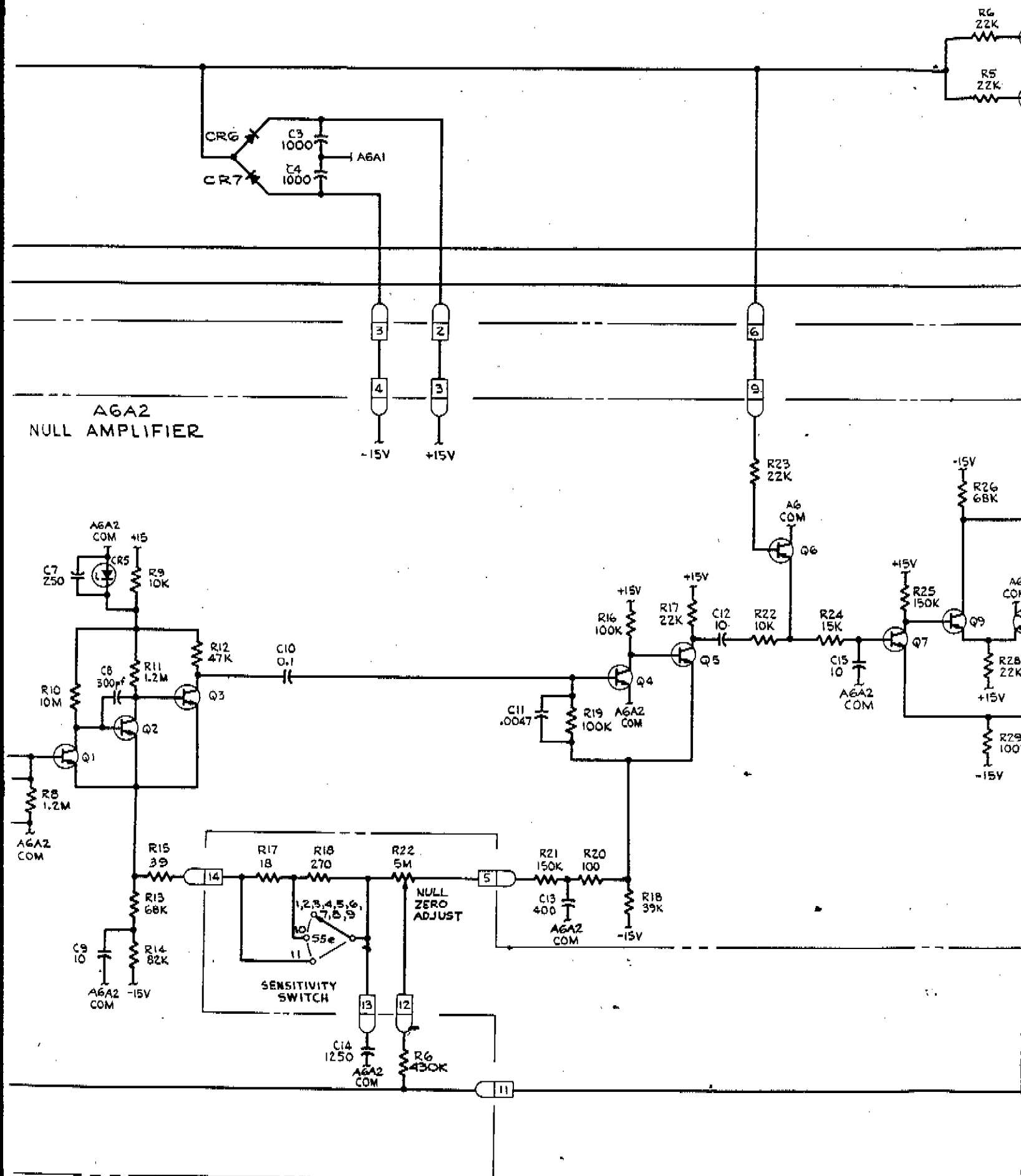
FUNCTIONAL SCHEMATIC DIAGRAM	
POWER DISTRIBUTION	
335A-1004	
MODEL 335A VS/DVM/ND	
SER. NO. 123 & ON	REV. 5
	JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133

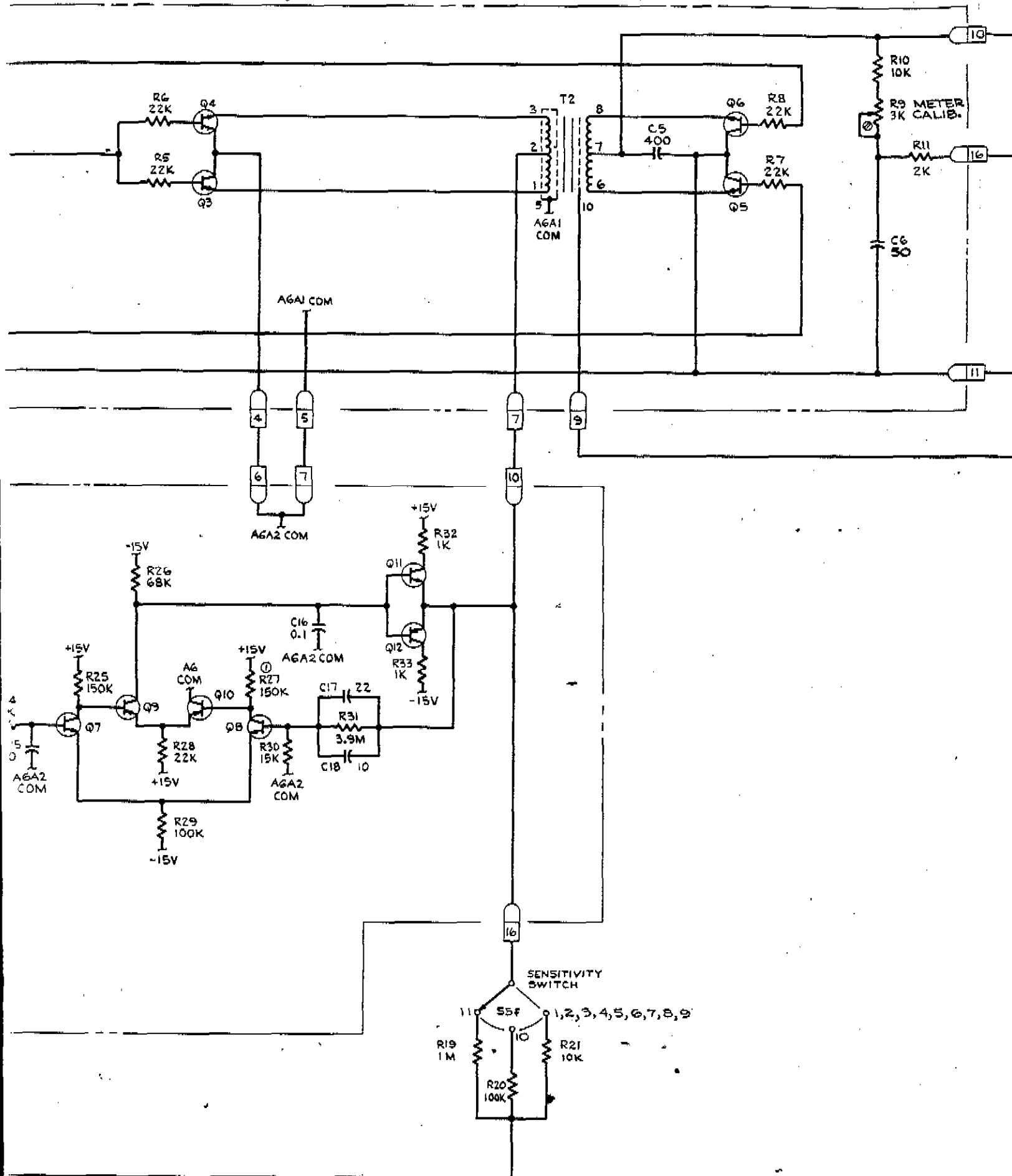
SAT. 1 OF 5

T1-11) —
1C 17V
T1-12) —

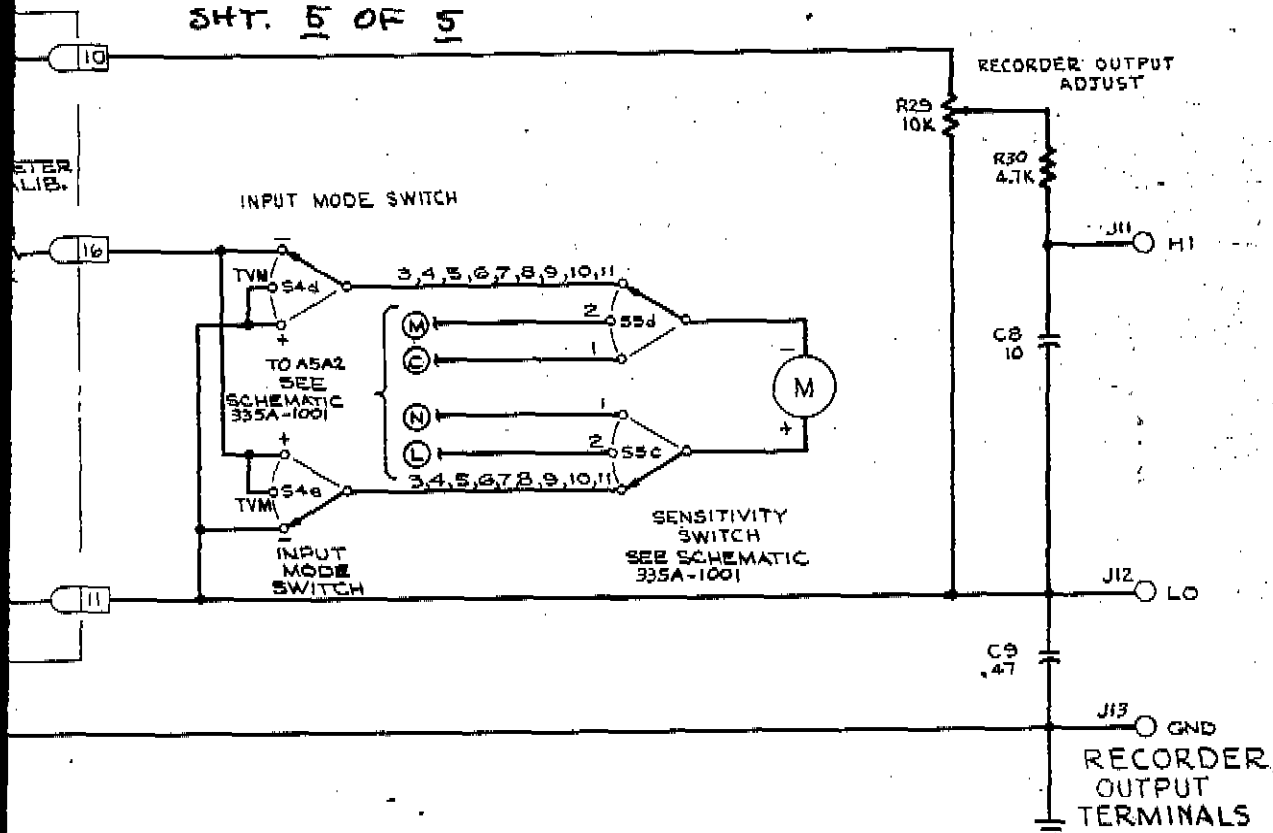








DWG. 335A-1005
 SHT. 5 OF 5



CHANGES:

- ① FOR S/N 123 THRU 486:
 R27 WAS 15K

FUNCTIONAL SCHEMATIC DIAGRAM	
NULL DETECTOR	
335A-1005	
MODEL 335A VS/DVM/ND	
SER. NO. 123 & ON	REV. b
FLUKE JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133	