FLUKE - 335A/335D

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

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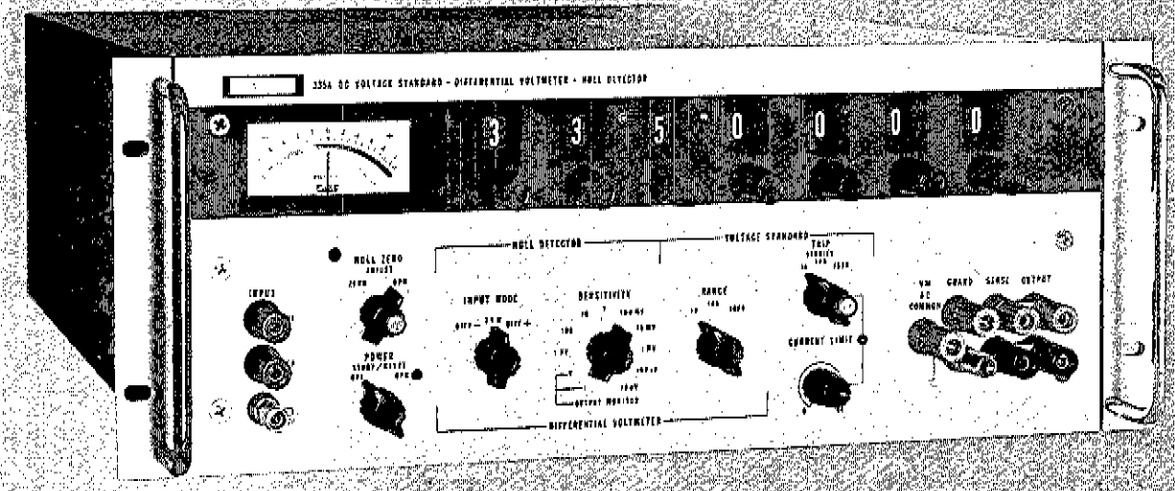



**MODEL 335A & 335D DC VOLTAGE STANDARD-**

**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°C ±1°C and up to 70% relative humidity.

| Range (volts) | ACCURACY 335A (90 Days) | 335D (60 Days) |
|---|---|---|
| 10 | ±(0.002% of setting + 10 uv) | ±(0.001% of setting + 10 uv) |
| 100 | ±(0.002% of setting + 0.00002% of range) | ±(0.001% of setting + 0.00002% of range) |
| 1000 | ±(0.002% of setting + 0.00002% of range) | ±(0.0015% of setting + 0.00002% of range) |

TEMPERATURE COEFFICIENT OF OUTPUT
Less than (0.0002% of setting + 1 uv) per °C from 0° to +50° C.

STABILITY OF OUTPUT

| Range (volts) | 335A | 335D |
|---|---|---|
| 10 | ±(0.001% of setting + 10 uv) per month<br>±(0.002% of setting + 20 uv) per year | ±(5 ppm of setting + 7 uv) per month |
| 100, 1000 | ±(0.001% of setting + 20 uv) per month<br>±(0.002% of setting + 40 uv) per year | ±(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 ($0.0001E_O$) 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(±1)° C.

| Range (volts) | Accuracy |
|---|---|
| 10 | ±(0.002% of setting +10 uv) |
| 100 | ±(0.002% of setting +20 uv) |
| 1000 | ±(0.002% of setting +40 uv) |

TEMPERATURE COEFFICIENT OF ACCURACY
Less than ±0.0002% setting +1 uv/° C from 0 to 50° C.

INPUT RANGES

| Range (volts) | Input (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) |

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 uf 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.

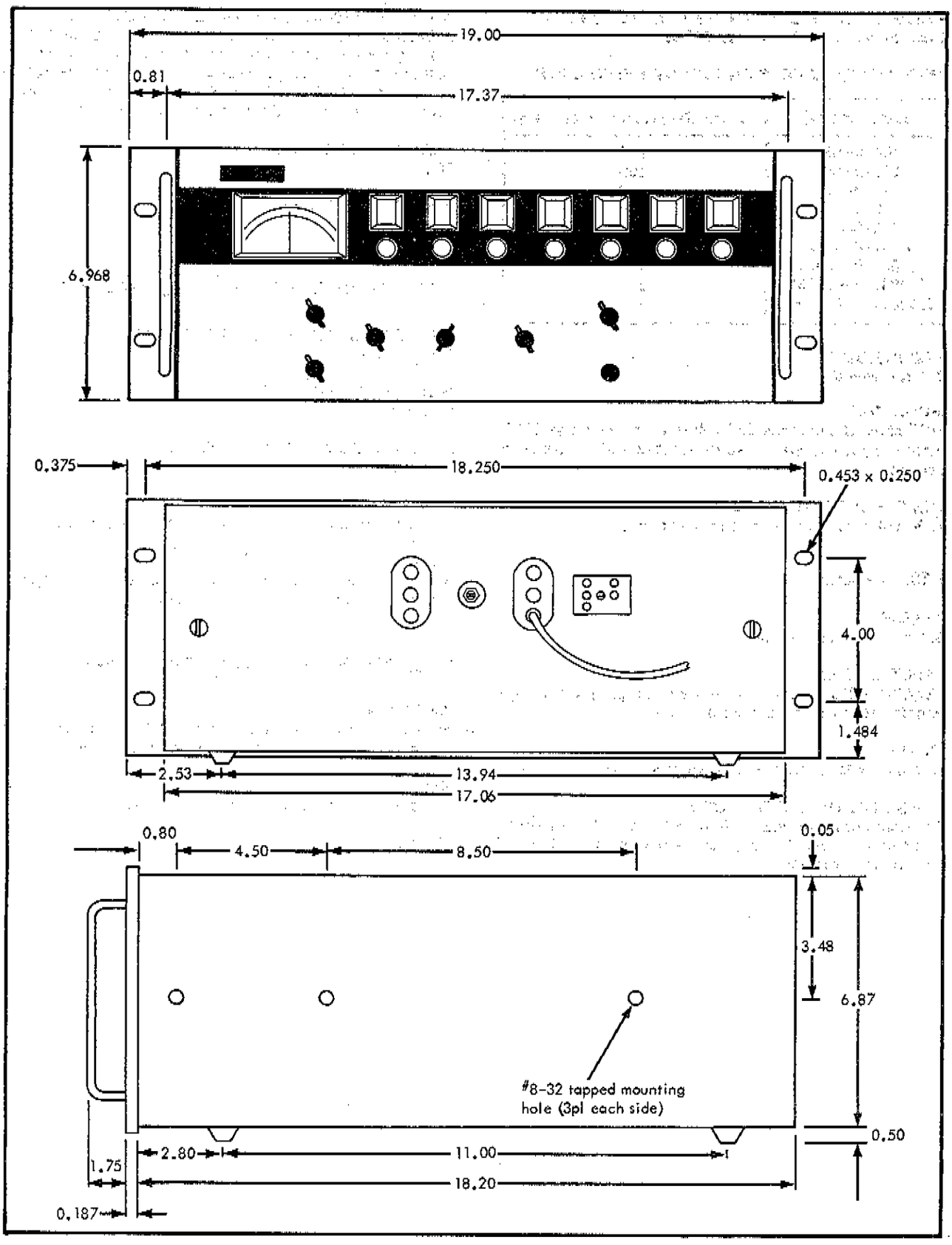



Figure 1-1. OUTLINE DRAWING

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
$10^{12}$ 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 ±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 ±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.

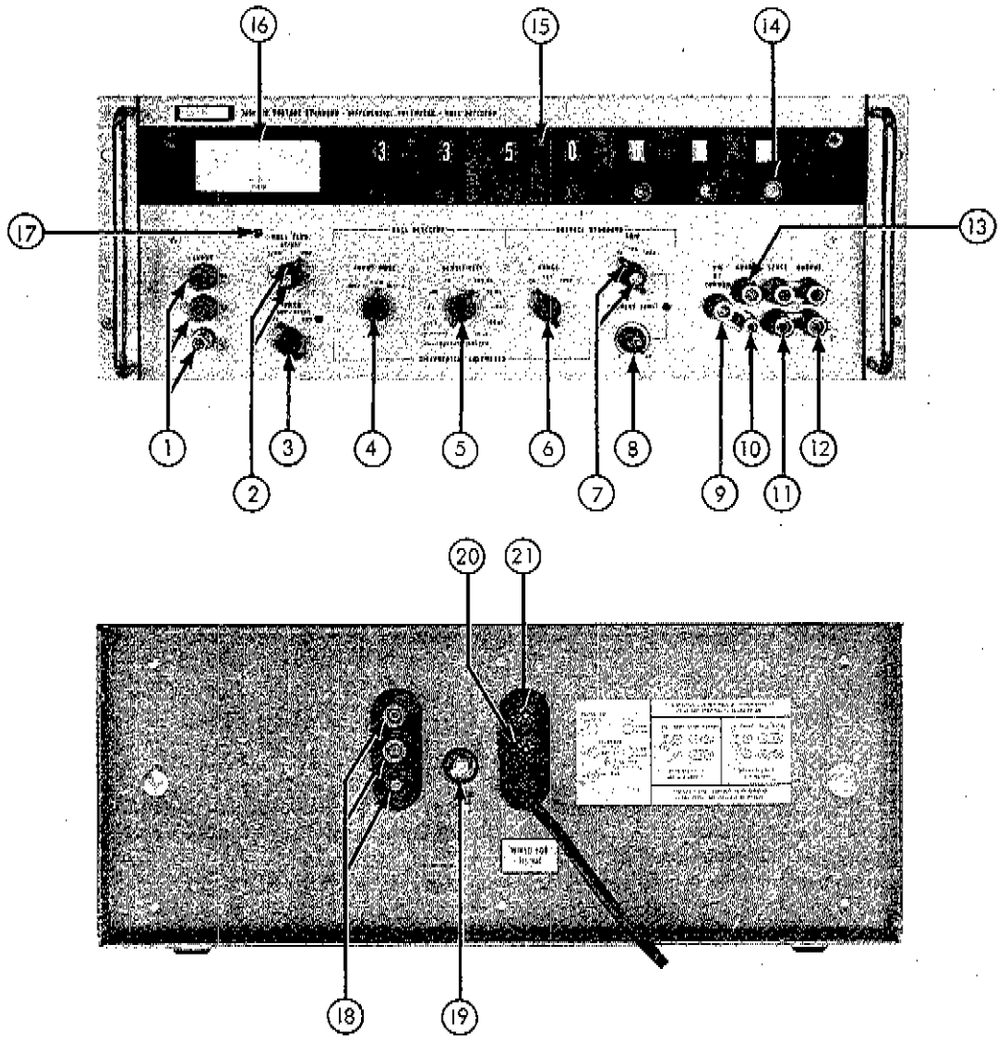
## 2-8. PRELIMINARY OPERATION

### 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 ÷ (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 ÷ 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 11.111110 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

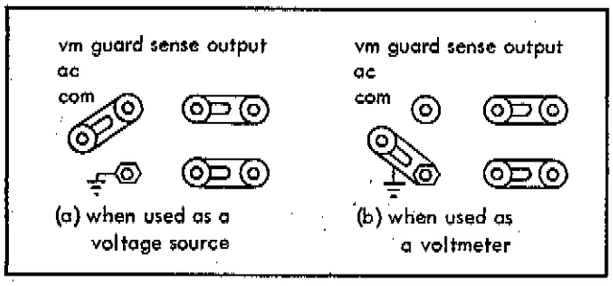



Figure 2-2. VM AC COMMON CONNECTIONS

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 x 3ft x 3.2 mv/ft = 19.2 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 foltage 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 respective 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 occuring, 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.

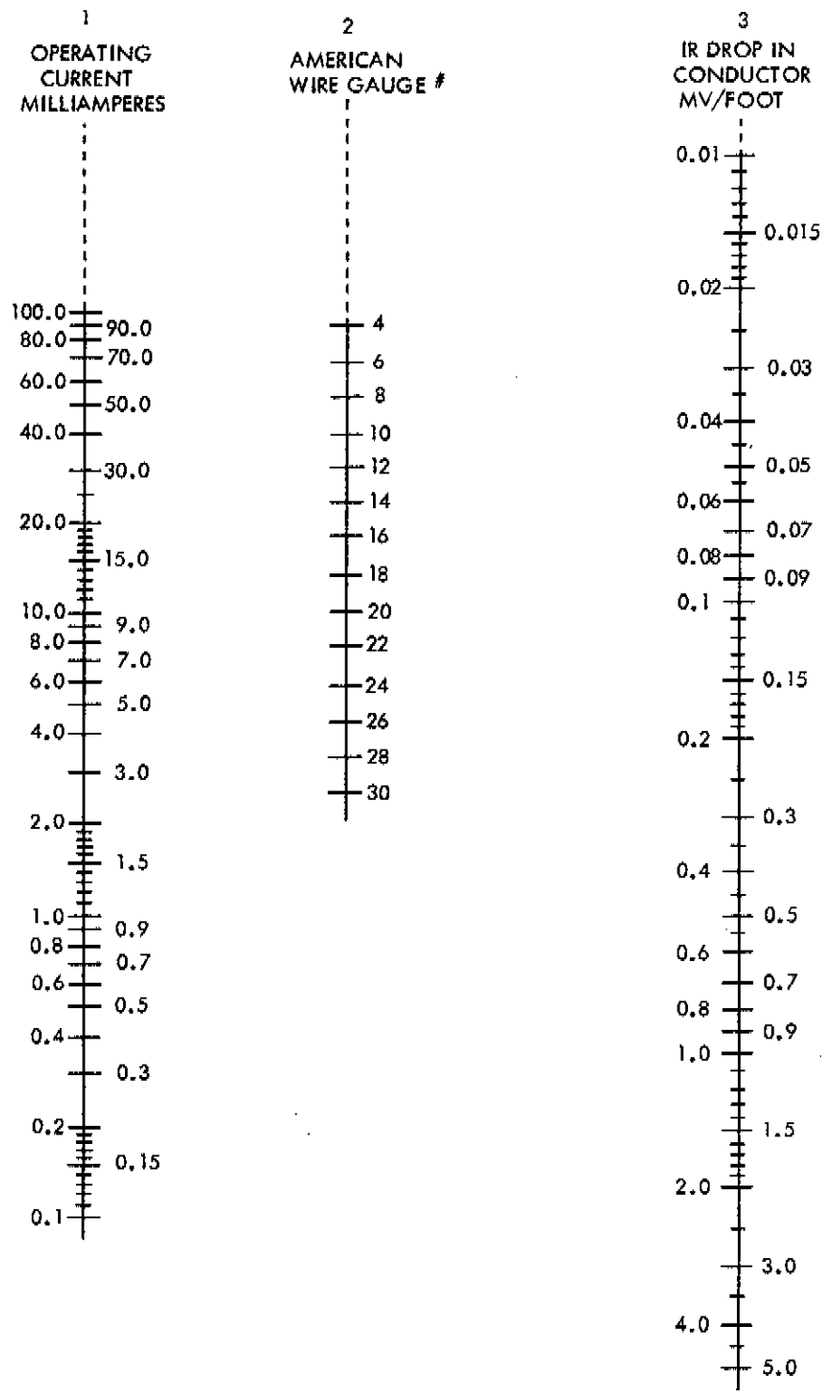



Figure 2-3. NOMOGRAPH OF VOLTAGE DROP ACROSS LOAD WIRES

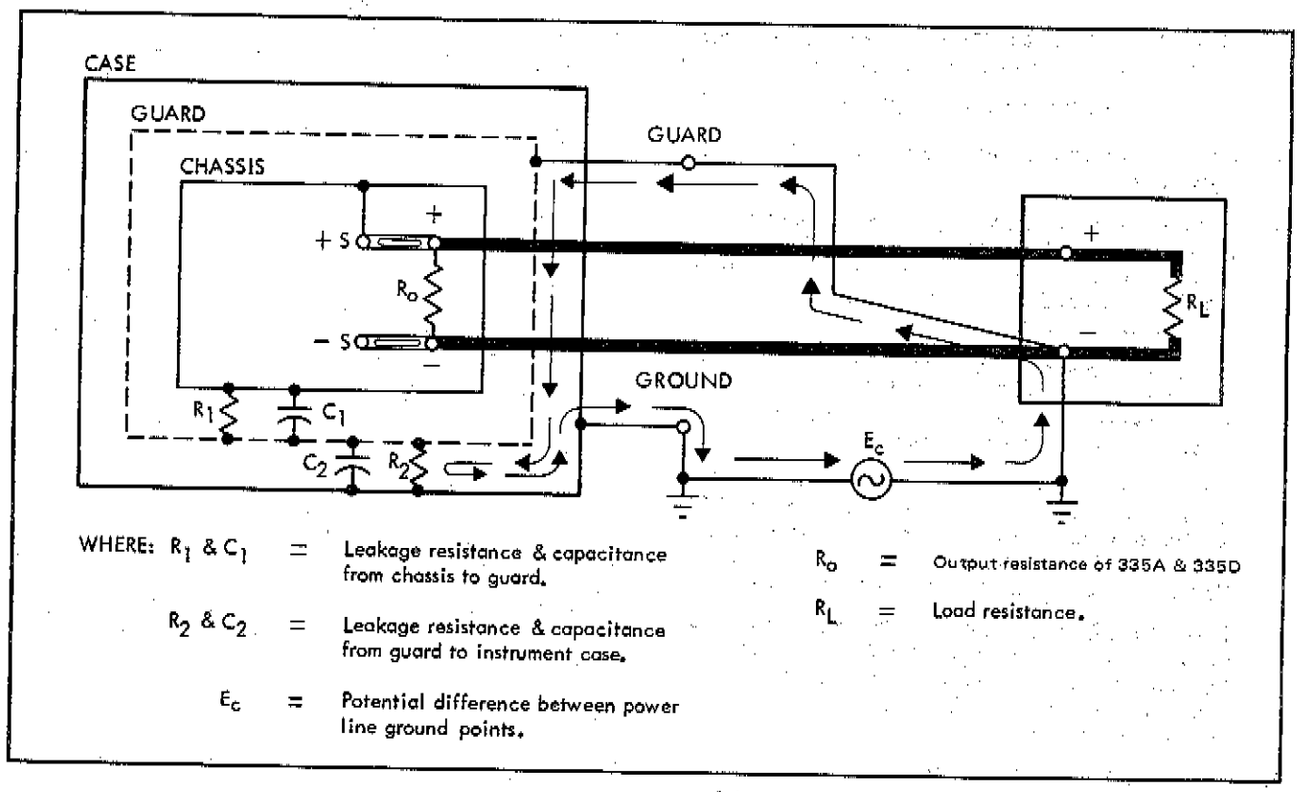



Figure 2-4. GUARD CONNECTION

## 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 conter-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.

f. 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, readjust 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 Connections | See Figure 2-2 (b) |

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.

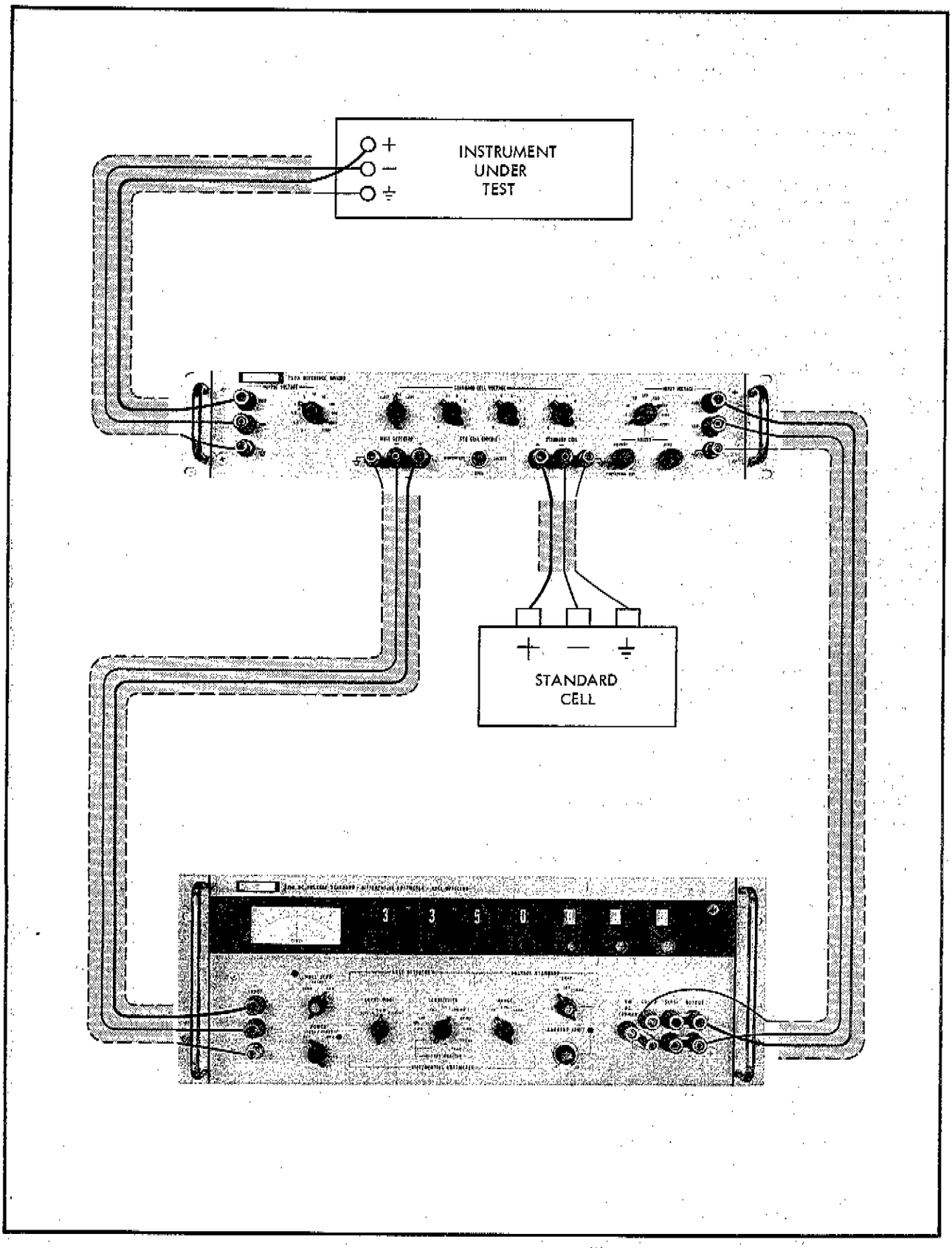



Figure 2-5. OPERATION WITH A REFERENCE DIVIDER

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:

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

$$E_X = E_S + \triangle E \quad (2)$$

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 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%.

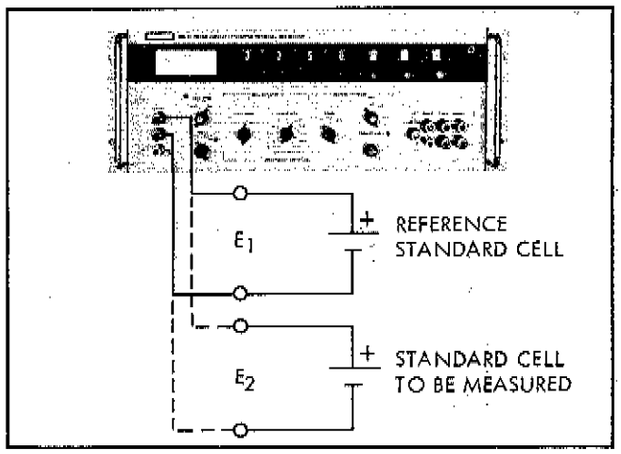



Figure 2-6. STANDARD CELL COMPARISON

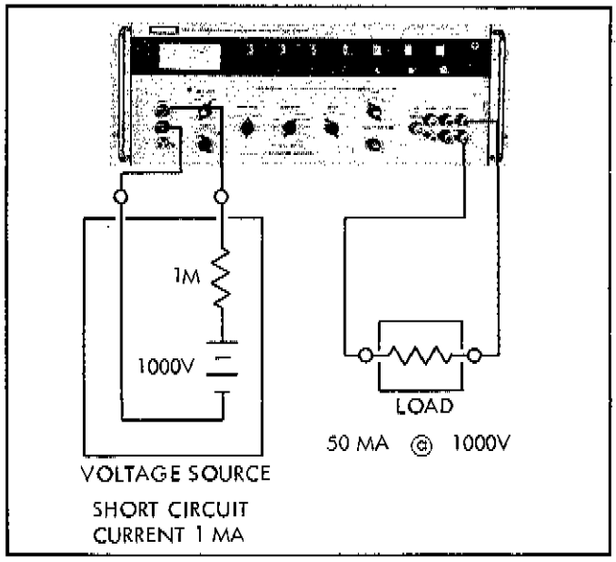



Figure 2-7. POWER TRANSFER

## 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 ($E_{REFERENCE}$), as illustrated in Figure 3-1. The constant reference voltage ($E_{REFERENCE}$), 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 milliampere current for the 1000 volt range. Resistors R7 and R8 provide a 0.1 milliampere current for the 100 volt range. Resistors R4, R5, and R6 provide a 0.01 milliampere 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.

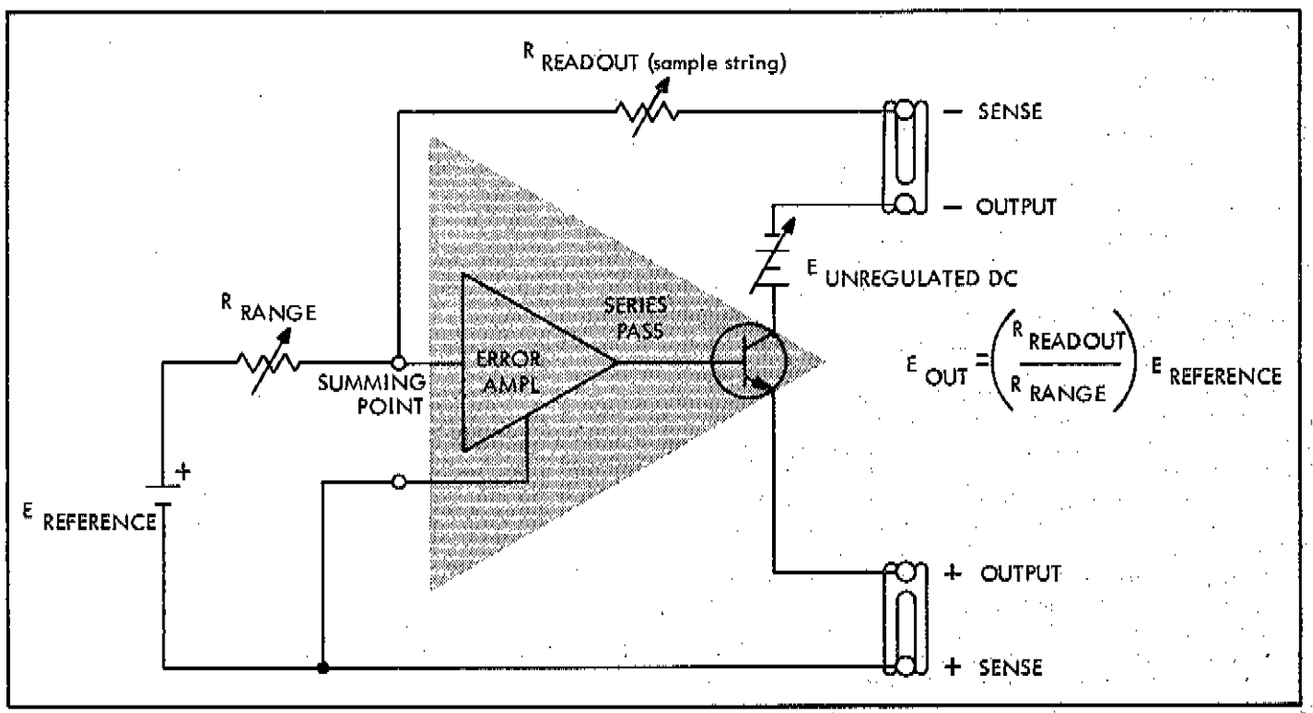



Figure 3-1. VOLTAGE CONTROL CIRCUITRY

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 absorbtion 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 ± 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

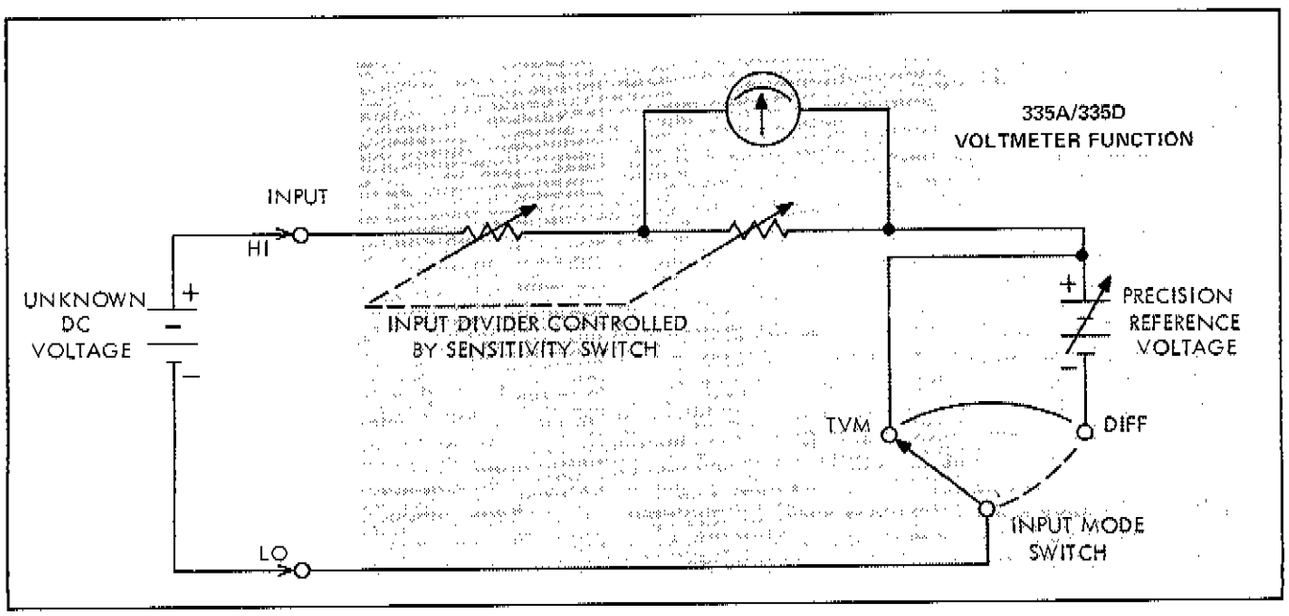



Figure 3-2. BASIC VOLTMETER OPERATION

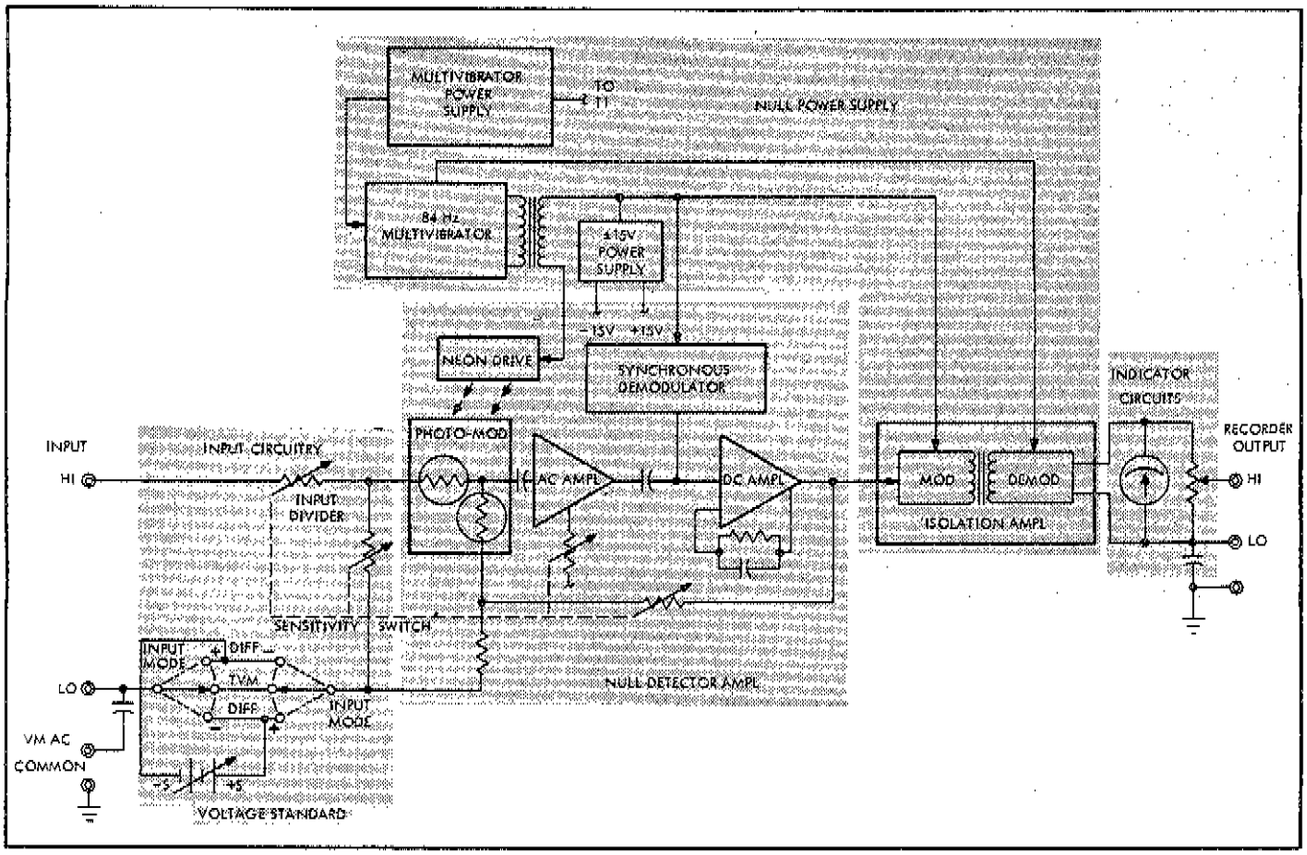



Figure 3-3. VOLTMETER FUNCTIONAL BLOCK DIAGRAM

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 voltmeter 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 becleaned 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 deionized 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 capacitors(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 SEALENT. 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 absorbtion. 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 sealent. 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.<br>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:

a. Disconnect the line cord from the power line.

b. Remove the instrument from the case and place upside down on a suitable work space.

c. Orient the instrument and perform the appropriate electrical connections as illustrated in Figure 4-1.

d. 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.

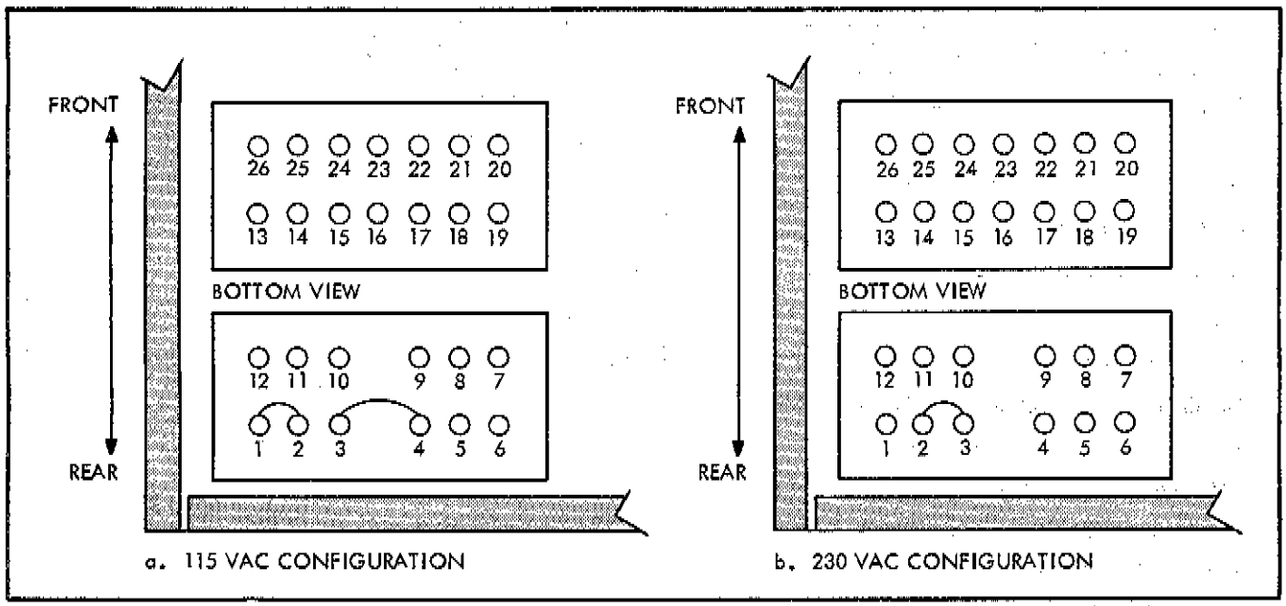



Figure 4-1. 115/230 VAC CONVERSION

| EQUIPMENT REQUIRED | SPECIFICATIONS REQUIRED |
|---|---|
| Volt/Ohmmeter - RCA Voltohmyst or equivalent | DC Accuracy of ±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 ±0.0025% with 100 uv null detector. |
| RMS Voltmeter - Fluke Model 931B or equivalent.<br>Preamplifier | Accuracy of 1% from 50 Hz to 30 kHz.<br>Gain of 1000 and bandpass of 10 Hz to 10 kHz. |
| Oscilloscope - Tektronix Type 541 or equivalent.<br>Preamplifier - Tektronix Type L | General purpose.<br>5 mv/cm sensitivity. |
| General Purpose Power Supply | Provide 5.5 volts. |
| DC Milliammeter | 0 to 100 milliamperes ±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 20,000Ω at ±5%. Capable of handling up to 80 watts. |
| Resistor, Composition | 100kkΩ ±5%, 1/2w |
| Lead Set | Low-leakage; low-thermal emf |
| Standard Cell Enclosure - Guildline Model 9152 | Accuracy of ±0.0003%. |
| DC Voltage Calibration System - Fluke Model 7101B consisting of the following equipment, or an equivalent system:<br>Voltage Standard, Model 332B<br>Null Detector, Model 845AR<br>Voltage Divider, Model 750A<br>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.

a. Connect the line cord through an auto-transformer connected to an ac power line. Set the autotransformer to 115 volts ac.

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) |
| Terminal Connections | See Figure 2-2(a) |

c. Connect the Model 885A to the SENSE terminals and the 240-C Load Resistor Box to the OUTPUT terminals.

d. 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.

a. Connect the line cord to an autotransformer connected to an ac power line. Set the autotransformer to 115 volts ac.

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) |
| Terminal Connections | See Figure 2-2(a) |

| RANGE | READOUT | LOAD (50 ma) | SPEC. |
|---|---|---|---|
| 10 | 1 | 20Ω | 10 uv |
| 10 | 10 | 200Ω | 20 uv |
| 100 | 10 | 200Ω | 20 uv |
| 100 | 100 | 2000Ω | 200 uv |
| 1000 | 100 | 2000Ω | 200 uv |
| 1000 | 1000 | 20,000Ω | 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.

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) |
| Terminal Connections | See Figure 2-2(a) |

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.

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.

| RANGE | READOUT | LOAD (50 ma) | SPEC |
|---|---|---|---|
| 10 | 1 | 20Ω | 10 uv |
| 10 | 10 | 200Ω | 20 uv |
| 100 | 10 | 200Ω | 20 uv |
| 100 | 100 | 2000Ω | 200 uv |
| 1000 | 100 | 2000Ω | 200 uv |
| 1000 | 1000 | 20,000Ω | 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 ±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.

a. With the SENSITIVITY switch in the "V" position, set the RANGE switch and readout dials for 100 volts output.

b. The front-panel meter should indicate 100 volts ±3.0 volts.

c. Check the meter linearity at the following cardinal points, Figure 4-5. All meter indications should be within ±3% of full scale.

| RANGE | READOUT |
|---|---|
| 10 | 1.0 0 0 0 0 0 |
| 100 | 1 0.0 0 0 0 0 |
| 1000 | 1 0 0.0 0 0 0 |
| 10 | 10.0 0 0 0 0 0 |
| 1000 | 10 0 0.0 0 0 0 |

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

d. 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".

e. Connect a 0 to 100 dc milliammeter across the OUTPUT terminals.

f. 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.

g. 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.

a. 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.

b. Connect a 0 to 100 dc milliammeter across the output terminals.

c. Set the POWER switch to OPR. The external meter should indicate 60 milliamperes.

d. 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.

a. 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

b. 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.

c. Set the RANGE switch to 100 volts. The trip circuit should actuate.

d. Set the TRIP switch to the 100 volt position and reset the instrument.

e. Set the RANGE switch to the 1000 volt position. The trip circuit should actuate.

f. Set the TRIP switch to the 1000 volt position and the VERNIER control maximum clockwise. Reset the instrument.

g. 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.

a. 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.

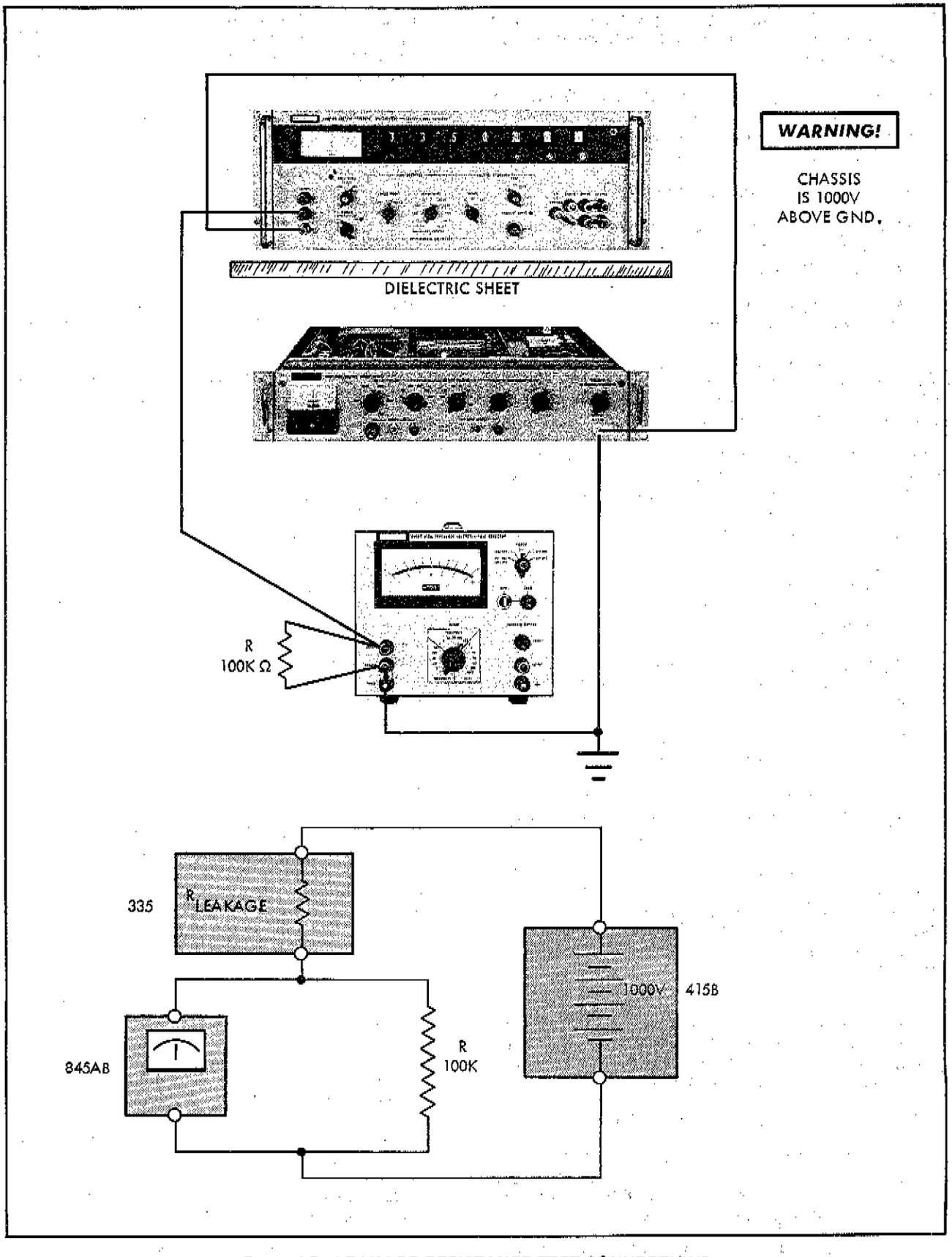



Figure 4-7. LEAKAGE RESISTANCE TEST CONNECTIONS

b. Connect a 100 kilo-ohm (±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 ±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± 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 ⏚ (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:

a. Adjust the meter electrical zero. Set the INPUT MODE switch to TVM and the SENSITIVITY switch to the 1 millivolt position.

b. Apply +1 millivolt to the INPUT terminals.

c. Refer to Figure 4-8 and adjust R9 for a full scale meter deflection (1.0) ±1/2 a small division.

d. Apply -1 millivolt to the INPUT terminals. The meter pointer should deflect full scale to the left of zero ±1/2 a small division.

e. 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:

a. Using the +SENSE terminal as common, connect a Model 885A to pin 10 on the Auxiliary Power Supply P/C Assembly.

b. Referring to Figure 4-8, adjust R9 until the Model 885A indicates 25 volts, ±10 millivolts.

c. While varying the line voltage from 100 to 130 volts ac, the Model 885A indication should not change more than 20 millivolts.

d. 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:

a. 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 |

b. Connect a 0 to 100 dc milliammeter across the OUTPUT terminals. Set the POWER switch to OPR.

c. Referring to Figure 4-8, adjust R23 for a 60 milliampere indication on the external meter.

d. Rotate the CURRENT LIMIT control maximum counter-clockwise. Referring to Figure 4-8, adjust R24 for a 2 milliampere indication on the external meter.

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

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

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

a. Set the SENSITIVITY switch to "I".

b. Adjust the CURRENT LIMIT control to obtain a 50 milliampere indication on the external meter.

c. Rotate the adjustment labelled OUTPUT CURRENT METER ADJUST until the front-panel meter pointer indicates 50 milliamperes on the red scale.

d. 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.

e. Set the POWER switch to STDBY/RESET. Remove the external meter connections from the instrument.

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

a. Set the front panel controls as follows:

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

b. Rotate the adjustment labelled OUTPUT VOLTMETER ADJUST until the front-panel meter indicates 100 volts ±0.5 volts.

c. Meter linearity may be checked at the cardinal points listed in Figure 4-9. All meter indications should be within ±3% of the readout dial settings.

4-57. VOLTAGE TRIP. Proceed as follows:

a. Set the controls as follows:

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

b. Rotate the VOLTAGE TRIPOUT ADJUST until the output is de-energized, as indicated by the illumination of the red indicator lamp and the audible "click" of relays.

c. Set the POWER switch to STDBY/RESET. Rotate the VERNIER control to the maximum clockwise position.

d. 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

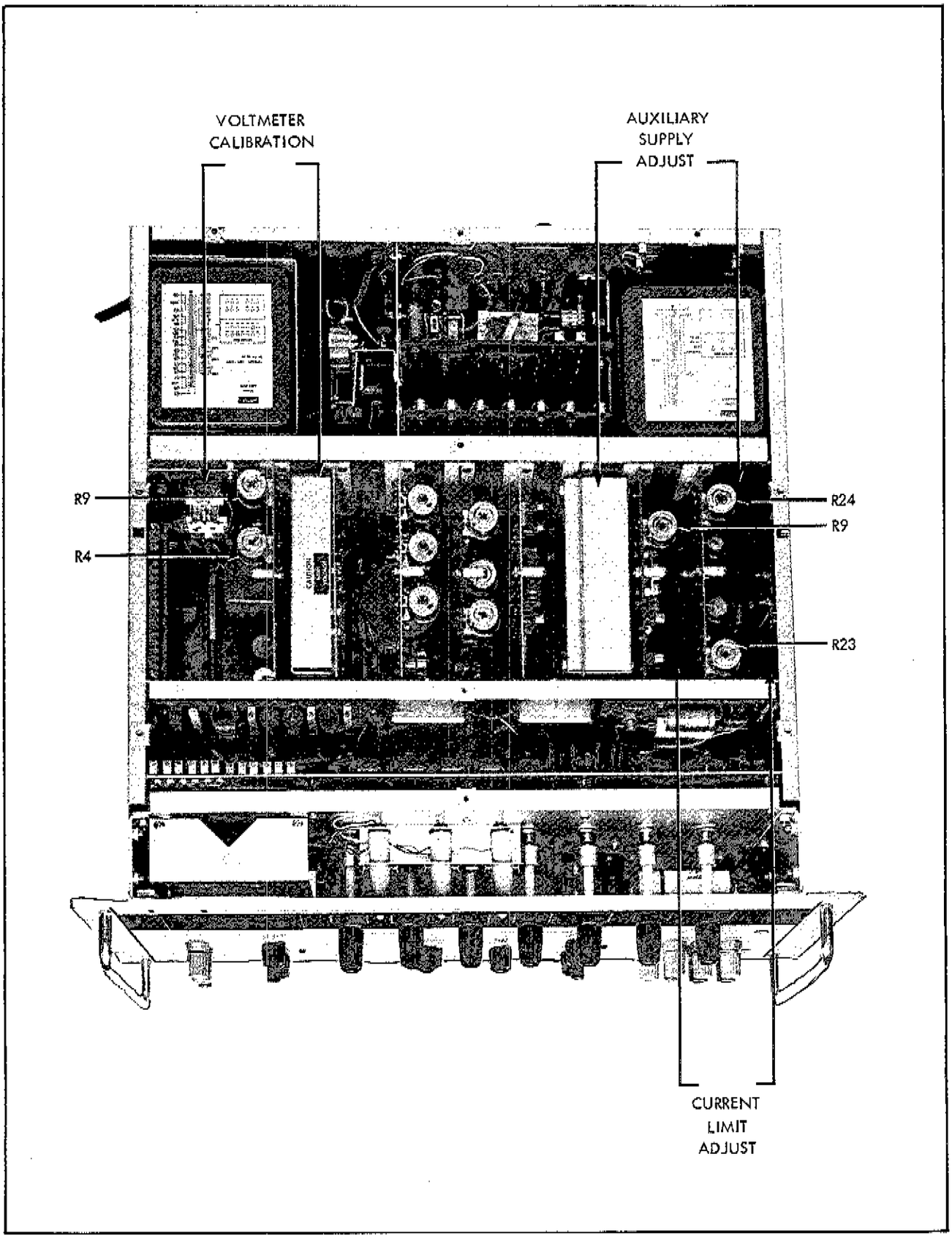



Figure 4-8. LOCATION OF ADJUSTMENTS

| RANGE | READOUT DIALS |
|---|---|
| 10 | 1.000000 |
| 100 | 10.00000 |
| 1000 | 100.0000 |
| 10 | 10.000000 |
| 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 | 10XXX000 |

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:

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

b. 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.

c. At each RANGE switch position, vary the corresponding ZERO OUTPUT adjustments (10V, 100V, 1000V) for a null indication (±1 microvolt) on the voltmeter.

d. 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:

a. Connect the equipment as shown in Figure 4-11.

b. Self-calibrate the Model 720A according to its instruction manual.

c. Turn on the reference voltage source (Model 332B) and allow to stabilize at equllibrium 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.

d. Set the voltage reference source for 10 volts output. Set the Model 720A to .1000000.

e. 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.

f. Set the Model 750A INPUT VOLTAGE switch to 100 and the OUTPUT VOLTAGE switch to 10.

g. Set the POWER switch to OPR, set the RANGE switch to 1000 and the dial readout to 00X.0000.

h. Rotate the CAL 1000V adjustment to obtain a null (±.5 uv) on the null detector.

i. Set the Model 845AR to ZERO mode. Set the instrument dial readout to 010.0000.

j. Set the Model 845AR to OPR mode. Rotate adjustment 1 of DECK B for a null (±.5 uv) indication.

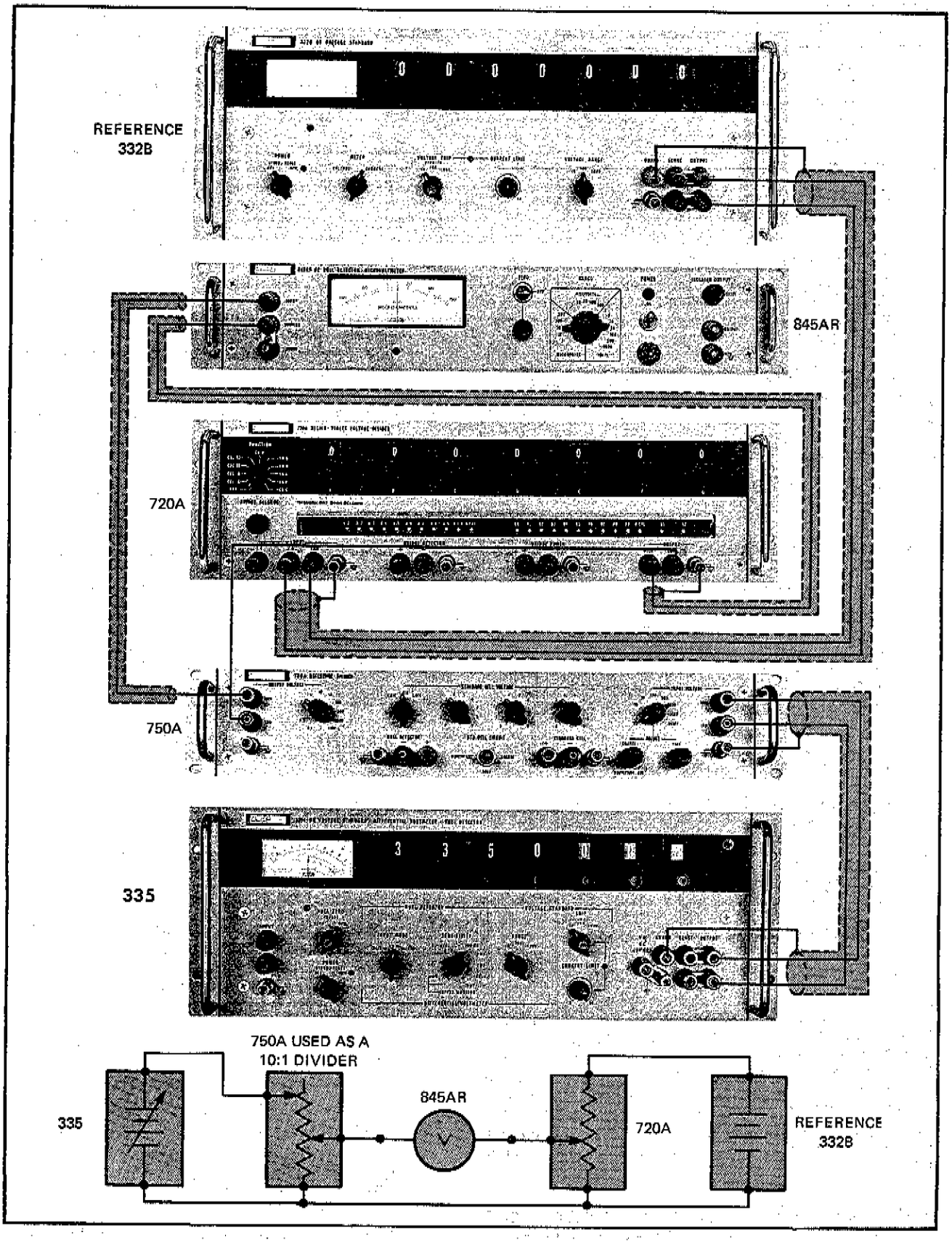



Figure 4-11. CONNECTIONS FOR LINEARIZATION ADJUSTMENT

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 (⏚) terminal.

c. Set the front panel controls as follows:

| | |
|---|---|
| NULL ZERO | OPR |
| INPUT MODE | TVM |
| SENSITIVITY | V |
| RANGE | 10 |
| TRIP | 1000 |
| TRIP VERNIER | Maximum clockwise |
| CURRENT LIMIT | Approx. 10° from maximum counterclockwise |
| 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

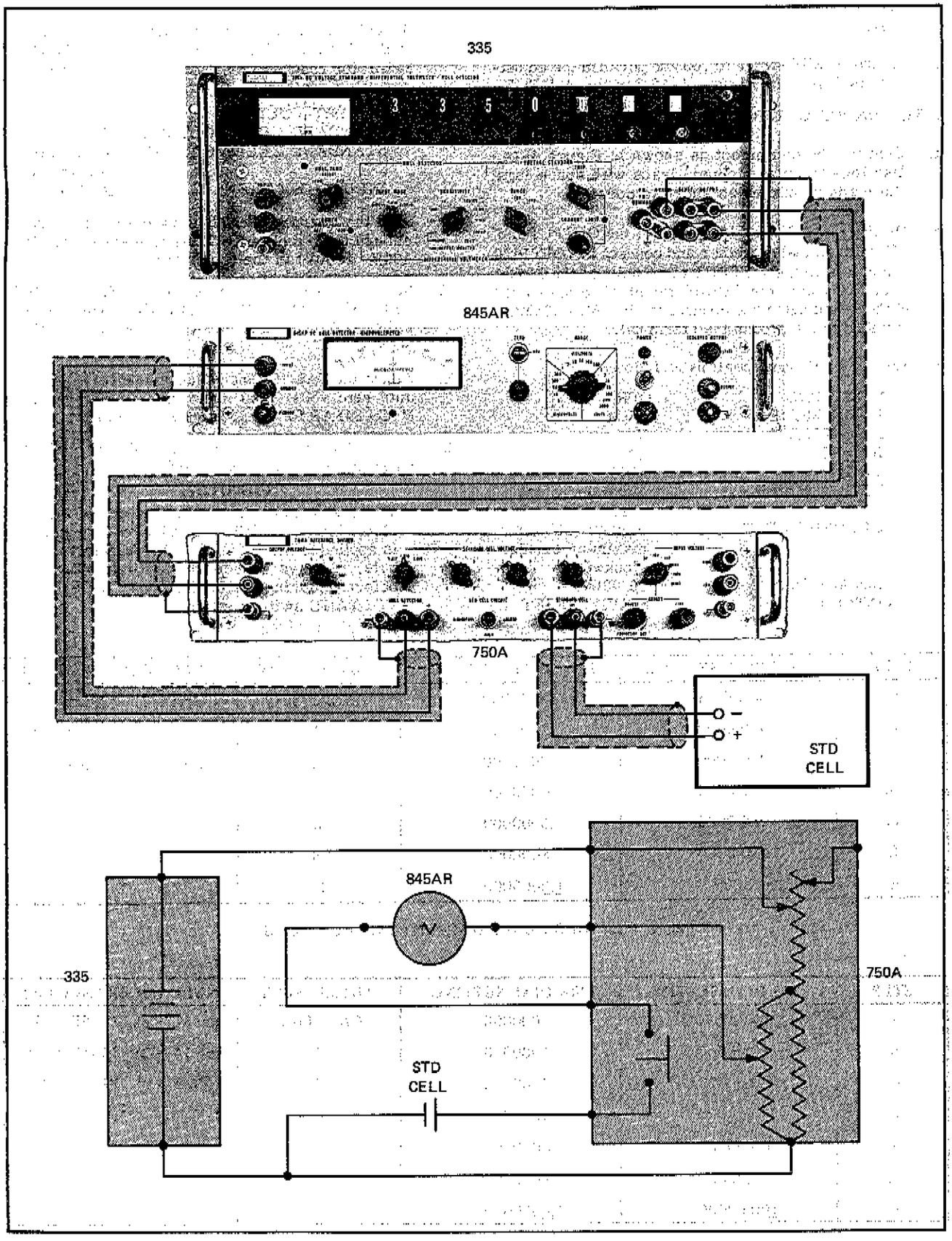



Figure 4-14. CONNECTIONS FOR RANGE CALIBRATION

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.

a. Remove the Pre-Regulator P/C Assembly.

b. Check all auxiliary supplies and the reference voltage.

| | 335 | | ADJ. | 750A | 845AR NULL |
|---|---|---|---|---|---|
| | RANGE | READOUT | | OUTPUT | TOLERANCE (uv) |
| Adjustments | 1000 | 1000.0000 | CAL 1000V | 1000 | (335A ±1.0) (335D ±.5) |
| | 100 | 100.00000 | CAL 100V | 100 | (335A ±1.0) (335D ±.5) |
| | 10 | 10.000000 | CAL 10V | 10 | (335A ±1.0) (335D ±.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

c. Check the Control Amplifier to ensure that it operates properly when provided with an error signal.

d. 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 conrolling 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 Voltohymst or equivalent) is required for this test.

a. 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.

b. Remove the Pre-Regulator P/C Assembly. Set the instrument POWER switch to OFF and set the readout dials to all zeros.

c. 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 |

d. 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 [1] |
| 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 [2] |
| Master Reference | Collector Q1 | 26 to 35 [3] |
| Series Pass | Collector Q8 | Approx. 140 |
| Rear bulkhead power resistor, 100 kilohms | Yellow lead | 650 |

[1] Adjustable to 25 ±10 volts with R9

[2] Adjustable to 6.02 ±10 volts with R2

[3] 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 | 05.00000 | should appear |
| 100 | 06.00000 | 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.

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

b. Set the front panel controls as follows:

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

c. 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.

d. 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.

e. Set the POWER switch to STDBY/RESET. The oscilloscope waveform should appear as shown in Figure 4-17.

f. 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

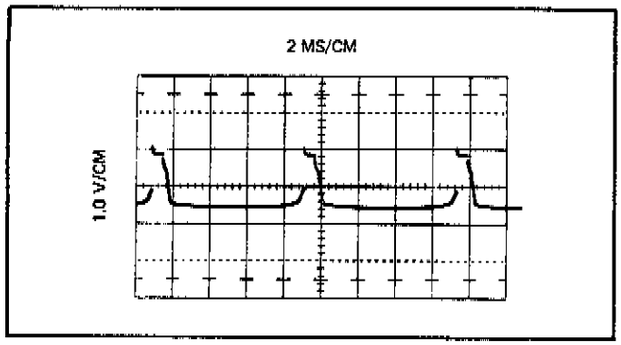



Figure 4-17. PRE-REGULATOR Q1, WAVEFORM ON STDBY/RESET

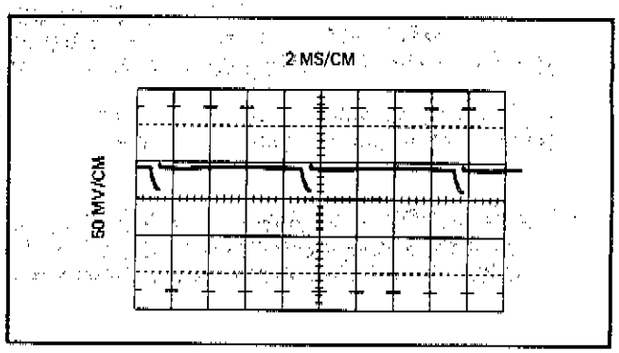



Figure 4-18. PRE-REGULATOR Q1, WAVEFORM ON OPR

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.

a. 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 |

b. 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 preceeding check.

c. 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.

d. 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 |

e. 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 ±10%, 1,200v | 1505-183541 | 01884 | CMLE405K12 | 1 | | |
| C2 | | Cap, cer, 0.01 uf, gmv, 1,600v (located on C1) | 1501-106930 | 71590 | DD16-103 | 2 | | |
| C3 | | Cap, cer, 0.005 uf ±20%, 3,000v | 1501-188003 | 71590 | DD30-502 | 1 | | |
| C4 | | Cap, plstc, 0.1 uf ±10%, 1,500v | 1507-234260 | 96733 | C-60232A | 2 | | |
| C5 | | Cap, plstc, 0.1 uf ±10%, 1,500v | 1507-234260 | 96733 | C-60232A | REF | | |
| C6 | | Cap, cer, 0.1 uf +80/-20%, 500v | 1501-105684 | 56289 | 41C92 | 2 | | |
| C7 | | Cap, cer, 0.1 uf +80/-20%, 500v | 1501-105684 | 56289 | 41C92 | REF | | |
| C8 | | Cap, Ta, 10 uf ±10%, 20v | 1508-160259 | 05397 | K10C20K | 5 | | |
| C9 | | Cap, plstc, 0.47 uf ±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 OUTPUT HI | 2811-149856 | 58474 | BHB10208G22 | REF | | |
| J12 | | Binding post, red, RECORDER OUTPUT 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, 325Ω | 2901-218925 | 89536 | 2901-218925 | 1 | | |
| R1 | | Res, met flm, 100k ±1%, 1/2w | 4705-151316 | 75042 | Type CEC-TO | 2 | | |
| R2 | | Res, met flm, 1M ±1%, 1/2w | 4705-161075 | 75042 | Type CEC-TO | 1 | | |
| R3 | | Res, car flm, 5M ±1%, 1w | 4703-107458 | 75042 | Type C13 | 2 | | |
| R4 | | Res, car flm, 5M ±1%, 1w | 4703-107458 | 75042 | Type C13 | REF | | |
| R5 | | Res, var, ww, 5k ±10%, 5w | 4702-219758 | 71450 | Type AW | 1 | | |
| R6 | | Res, var, ww, 300Ω ±10%, 5w | 4702-219741 | 71450 | Type AW | 1 | | |
| R7 | | Res, comp, 100M ±10%, 1/2w | 4704-190520 | 01121 | EB1071 | 1 | | |
| R8 | | Res, comp, 270Ω ±10%, 2w | 4704-110189 | 01121 | HB2711 | 2 | | |
| R9 | | Res, car flm, 9M, matched | 1 | | | | | |
| R10 | | Res, car flm, 900k ±1/2%, 1/2w | 4703-107391 | 75042 | Type C12 | 1 | | |
| R11 | | Res, car flm, 90M, matched | 1 | | | | | |
| R12 | | Res, car flm, 1M, matched | 1 | | | | | |
| R13 | | Res, car flm, 100k, matched | 1 | | | | | |
| R14 | | Res, car flm, 10k, matched | 1 | | | | | |
| R15 | | Res, car flm, 1k, matched | 1 | | | | | |
| R16 | | Res, car flm, 100Ω, matched | 1 | | | | | |
| R17 | | Res, comp, 18Ω ±5%, 1/4w | 4704-219022 | 01121 | CB1805 | 1 | | |
| R18 | | Res, comp, 270Ω ±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 ±20%, 0.2w | 4701-219733 | 71450 | Type 70 | 1 | | |
| R25 | | Res, comp, 1k ±10%, 1/2w | 4704-108563 | 01121 | EB1021 | 5 | | |
| R26 | | Res, ww, 500Ω ±5%, 25w | 4706-183533 | 14193 | Type MC250 | 1 | | |
| R27 | | Res, ww, 100k ±1%, 10w | 4706-177121 | 14193 | Type SP1127 | 2 | | |
| R28 | | Res, ww, 100k ±1%, 10w | 4706-177121 | 14193 | Type SP1127 | REF | | |
| R29 | | Res, var, car, 10k ±20%, 1/2w | 4703-162800 | 12697 | Series 37 | 1 | | |
| R30 | | Res, comp, 4.7k ±10%, 1/2w | 4704-108381 | 01121 | EB4721 | 3 | | |
| S1 | | Switch, POWER, STDBY/RESET wafer<br>Switch, POWER, OPR wafer | 5107-187864<br>5107-187872 | 76854<br>76854 | Type HC<br>248214HC | 1<br>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 | 2402-226787 | 89536 | 2402-226787 | 1 | | |
| 4 | | Coupler, Digit Switches to detents (not illustrated) | 3153-226779 | 89536 | 3153-226779 | 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 | | |

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

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.

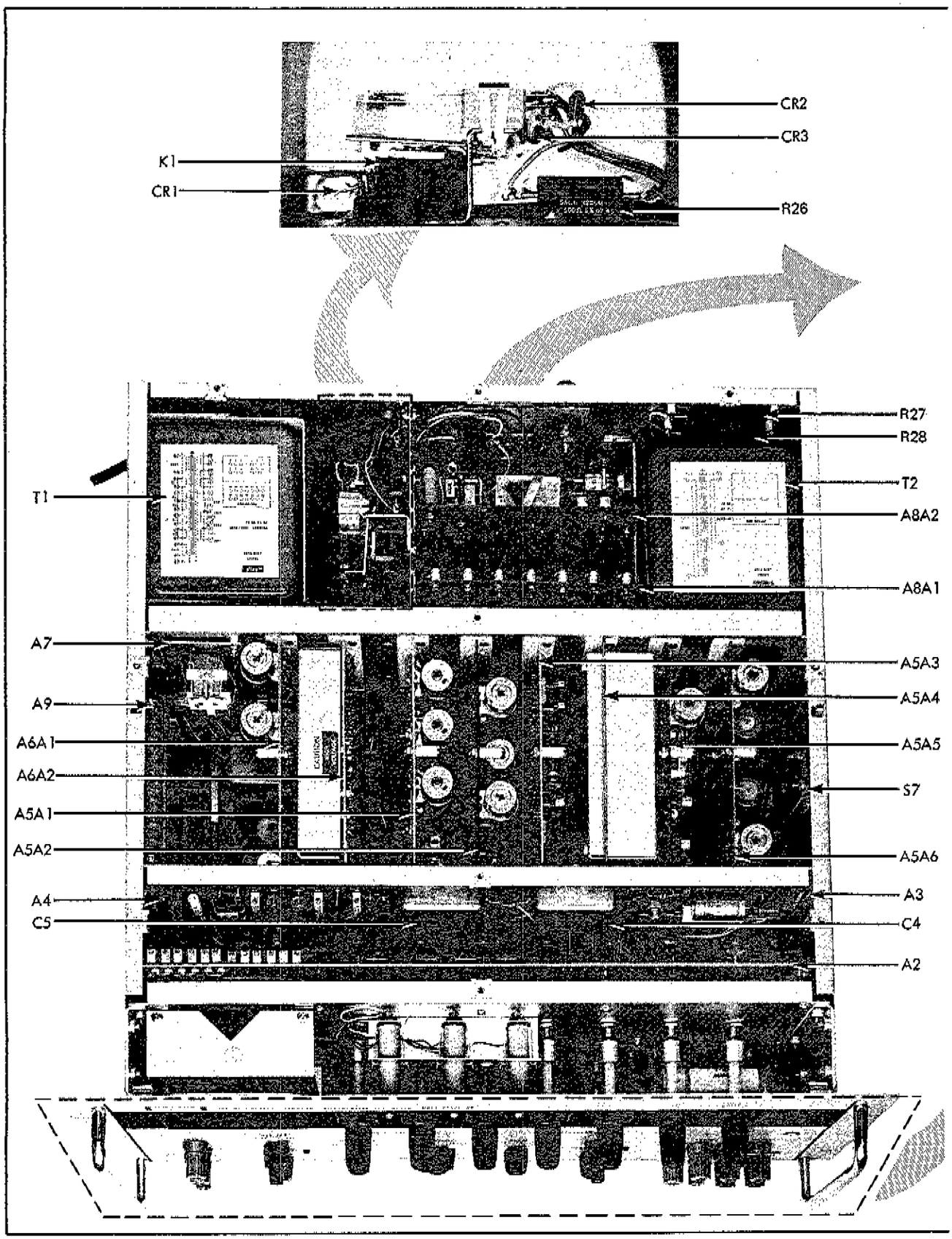
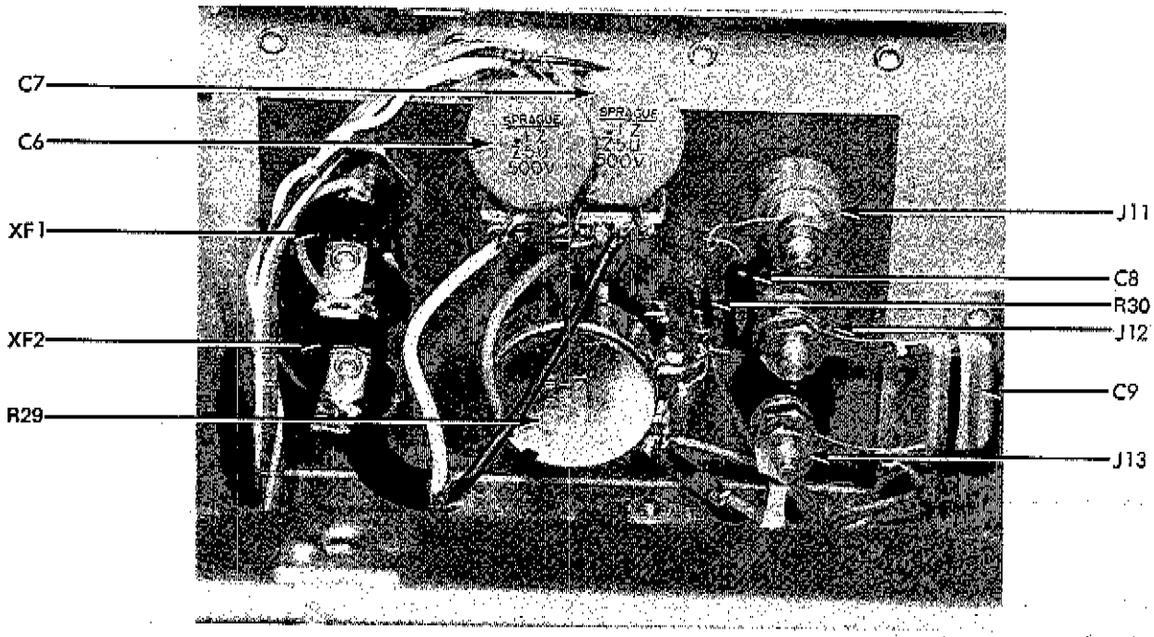
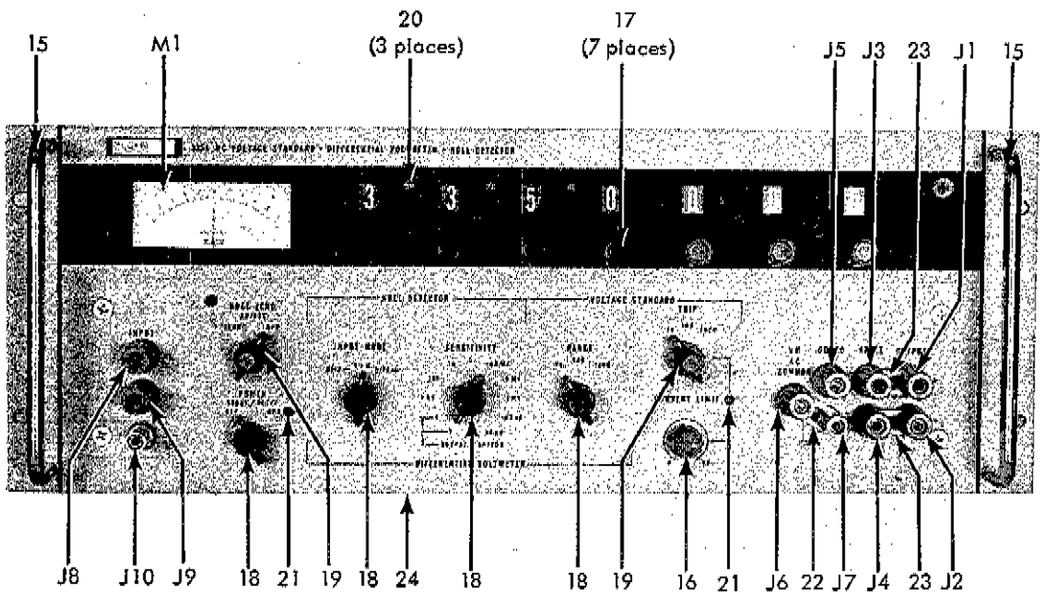



Figure 5-1. DC VOLTAGE STANDARD -DIFFERENTIAL VOLTMETER-NULL DETECTOR (Sheet 1 of 5)



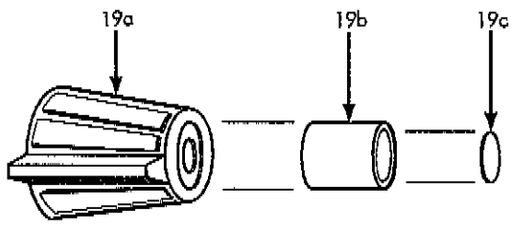




Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NULL DETECTOR (Sheet 2 of 5)

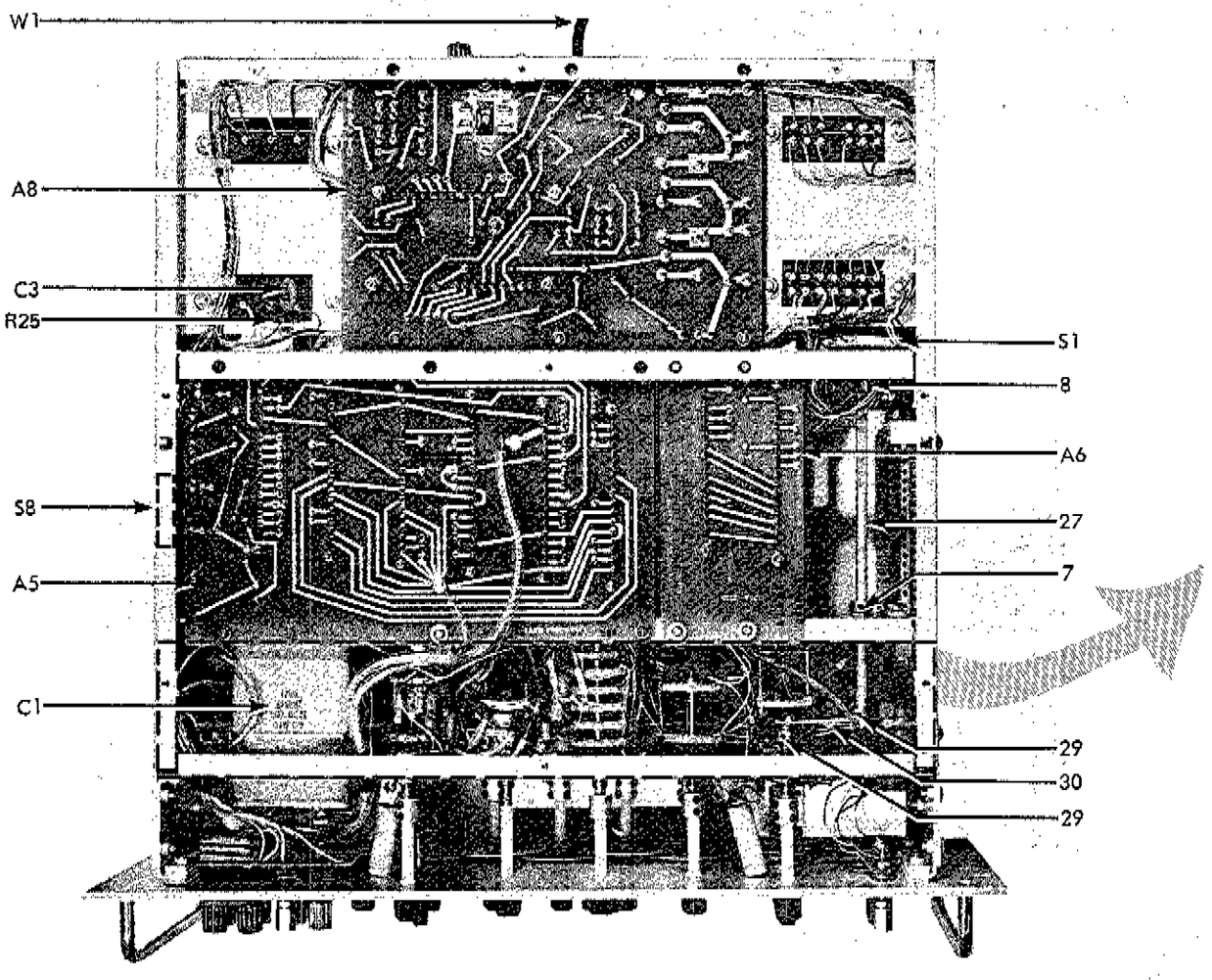
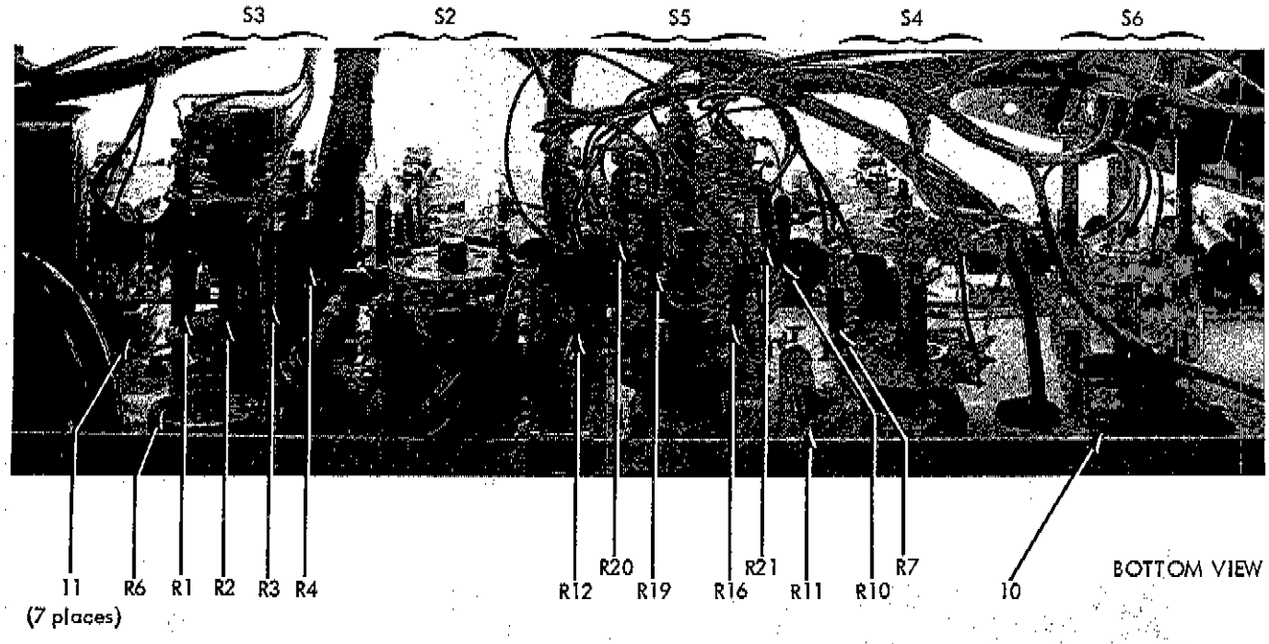



Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NULL DETECTOR (Sheet 3 of 5)



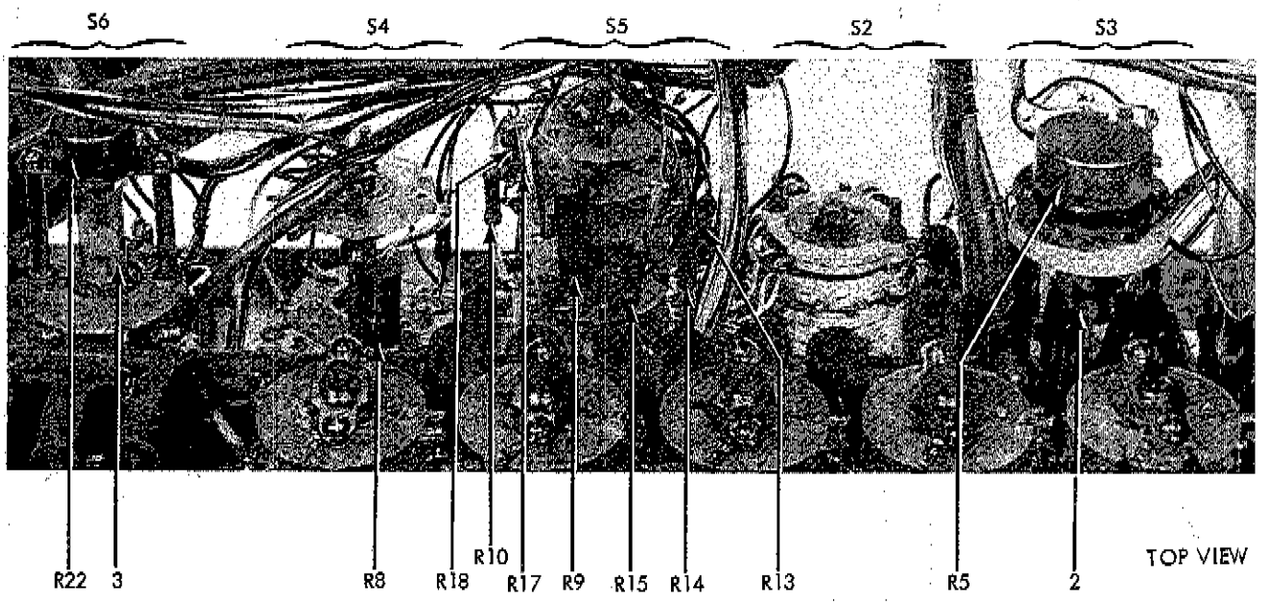




Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NULL DETECTOR (Sheet 4 of 5)

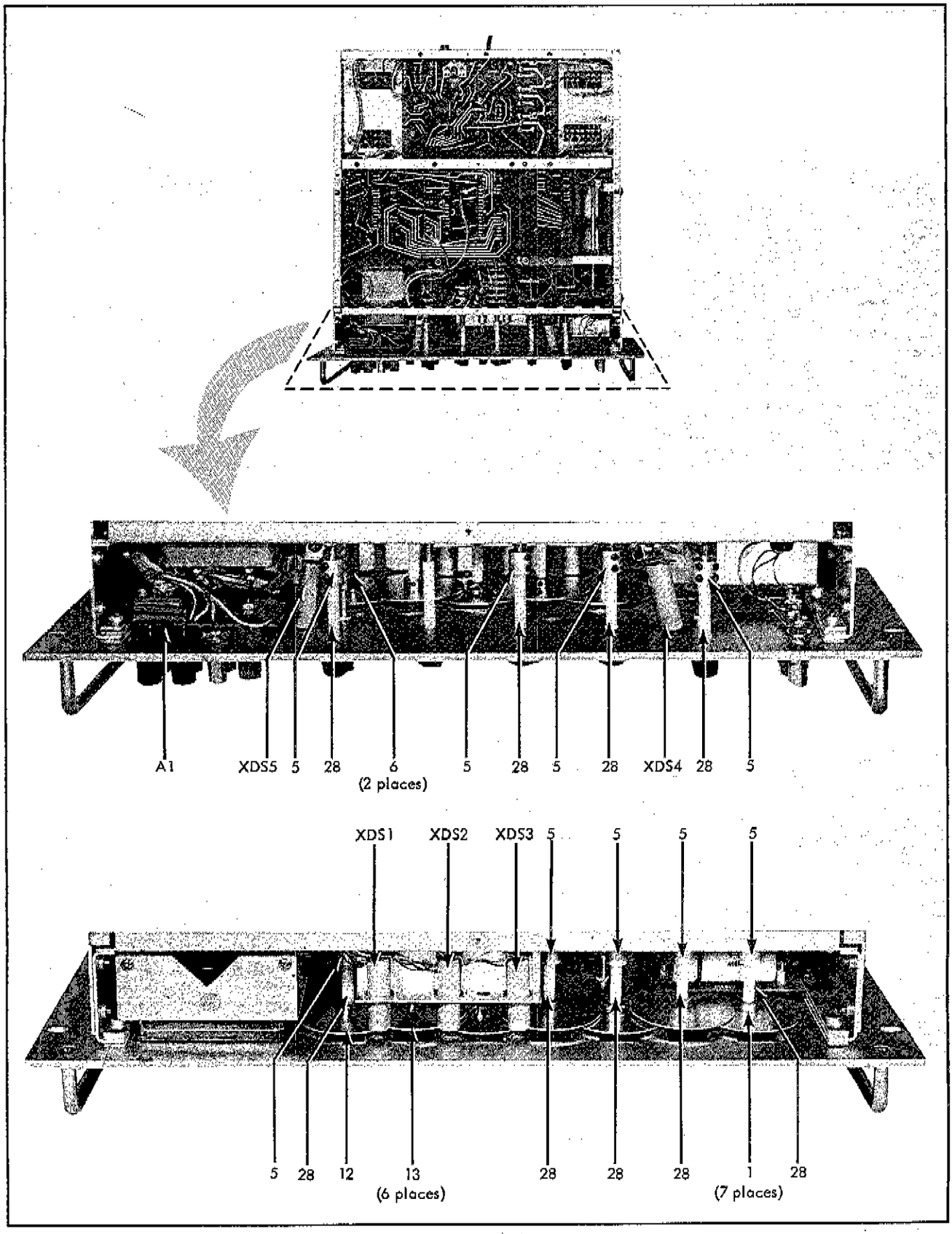



Figure 5-1. DC VOLTAGE STANDARD-DIFFERENTIAL VOLTMETER-NULL DETECTOR (Sheet 5 of 5)

| 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 ±20%, 250v | 1507-190330 | 73445 | C280AE/P1M | 3 | | |
| C2 | E1-H4 | Cap, plstc, 1 uf ±20%, 250v | 1507-190330 | 73445 | C280AE/P1M | REF | | |
| C3 | D1-K5 | Cap, plstc, 0.25 uf ±10%, 1200v | 1507-183616 | 84411 | JF6 | 2 | | |
| C4 | D1-M2 | Cap, plstc, 0.25 uf ±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 | | |

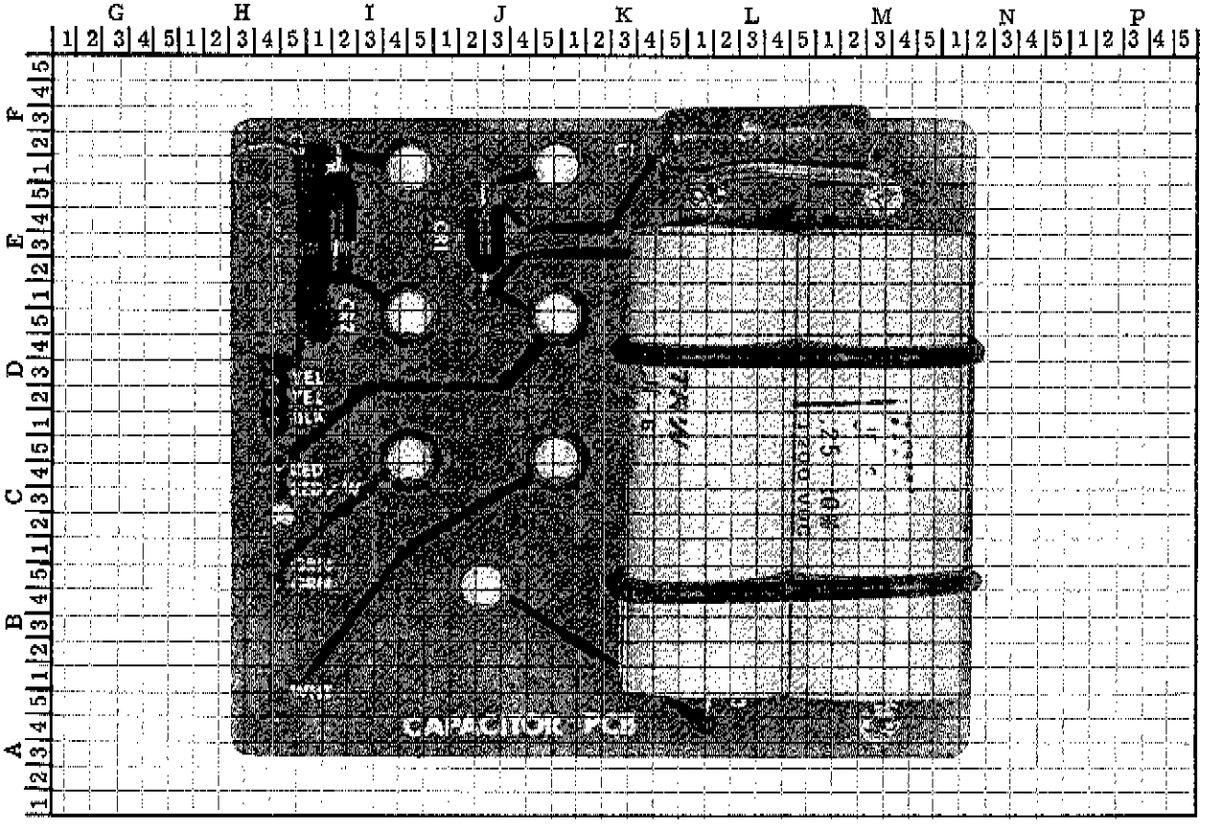



Figure 5-2. CAPACITOR P/C ASSEMBLY

| 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 | 3 | | | | | |
| R2 | B1-P3 | Res, ww, 99.955k, matched | 3 | | | | | |
| 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 | 3 | | | | | |
| R6 | B4-N5 | Res, ww, 99.955k, matched | 3 | | | | | |
| R7 | C1-N5 | Res, ww, 99.955k, matched | 3 | | | | | |
| R8 | B5-P3 | Res, ww, 99.955k, matched | 3 | | | | | |
| 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 | 3 | | | | | |
| R12 | C4-N5 | Res, ww, 99.955k, matched | 3 | | | | | |
| R13 | D2-N5 | Res, ww, 99.955k, matched | 3 | | | | | |
| R14 | C4-P3 | Res, ww, 99.955k, matched | 3 | | | | | |
| 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 | 3 | | | | | |
| R18 | E4-N5 | Res, ww, 19.991k, matched | 3 | | | | | |
| 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 | 3 | | | | | |
| R22 | F3-N5 | Res, ww, 19.991k, matched | 3 | | | | | |
| 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 | 3 | | | | | |
| R26 | E3-Q3 | Res, ww, 19.991k, matched | 3 | | | | | |
| 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 | 3 | | | | | |

| 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, 200Ω, matched | 3 | | | | | |
| R38 | H1-N5 | Res, ww, 200Ω, matched | 3 | | | | | |
| R39 | H2-N5 | Res, ww, 200Ω, matched | 3 | | | | | |
| R40 | H4-Q2 | Res, ww, 200Ω, matched | 3 | | | | | |
| R41 | H3-Q2 | Res, ww, 200Ω, matched | 3 | | | | | |
| R42 | H3-Q2 | Res, ww, 100Ω, matched | 3 | | | | | |
| R43 | H5-N5 | Res, ww, 20Ω, matched | 3 | | | | | |
| R44 | H4-N5 | Res, ww, 20Ω, matched | 3 | | | | | |
| R45 | I1-N5 | Res, ww, 20Ω, matched | 3 | | | | | |
| R46 | I2-Q2 | Res, ww, 20Ω, matched | 3 | | | | | |
| R47 | I1-Q2 | Res, ww, 20Ω, matched | 3 | | | | | |
| R48 | I3-Q2 | Res, ww, 10Ω, matched | 3 | | | | | |
| R49 | I2-N5 | Res, ww, 2Ω, matched | 3 | | | | | |
| R50 | I3-N4 | Res, ww, 2Ω, matched | 3 | | | | | |
| R51 | I4-N4 | Res, ww, 2Ω, matched | 3 | | | | | |
| R52 | I5-N4 | Res, ww, 2Ω, matched | 3 | | | | | |
| R53 | I4-Q2 | Res, ww, 2Ω, matched | 3 | | | | | |
| R54 | I4-Q2 | Res, ww, 1Ω, matched | 3 | | | | | |
| R55 | J3-T3 | Res, ww, 0.2Ω, matched | 3 | | | | | V |
| R55 | | Resistance wire, 0.1Ω (See S7) | | | | | | W |
| R56 | J3-T2 | Res, ww, 0.2Ω, matched | 3 | | | | | V |
| R56 | | Resistance wire, 0.1Ω (See S7) | | | | | | W |
| R57 | J3-T3 | Res, ww, 0.2Ω, matched | 3 | | | | | V |
| R57 | | Resistance wire, 0.1Ω (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, 0.2Ω, matched | ③ | | | | | V |
| R58 | | Resistance wire, 0.1Ω (See S7) | | | | | | W |
| R59 | J3-U1 | Res, ww, 0.2Ω, matched | ③ | | | | | V |
| R59 | | Resistance wire, 0.1Ω (See S7) | | | | | | W |
| R60 | J3-T5 | Res, ww, 0.1Ω, matched | ③ | | | | | V |
| R60 | | Resistance wire, 0.1Ω (See S7) | | | | | | W |
| R61 thru R64 | | Resistance wire, 0.1Ω (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, 0.1Ω resistance wire. For replacement of resistance wire, order a new S7 digit switch.) | 5110-291021 | 89536 | 5110-291021 | 1 | | W |

③ 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.

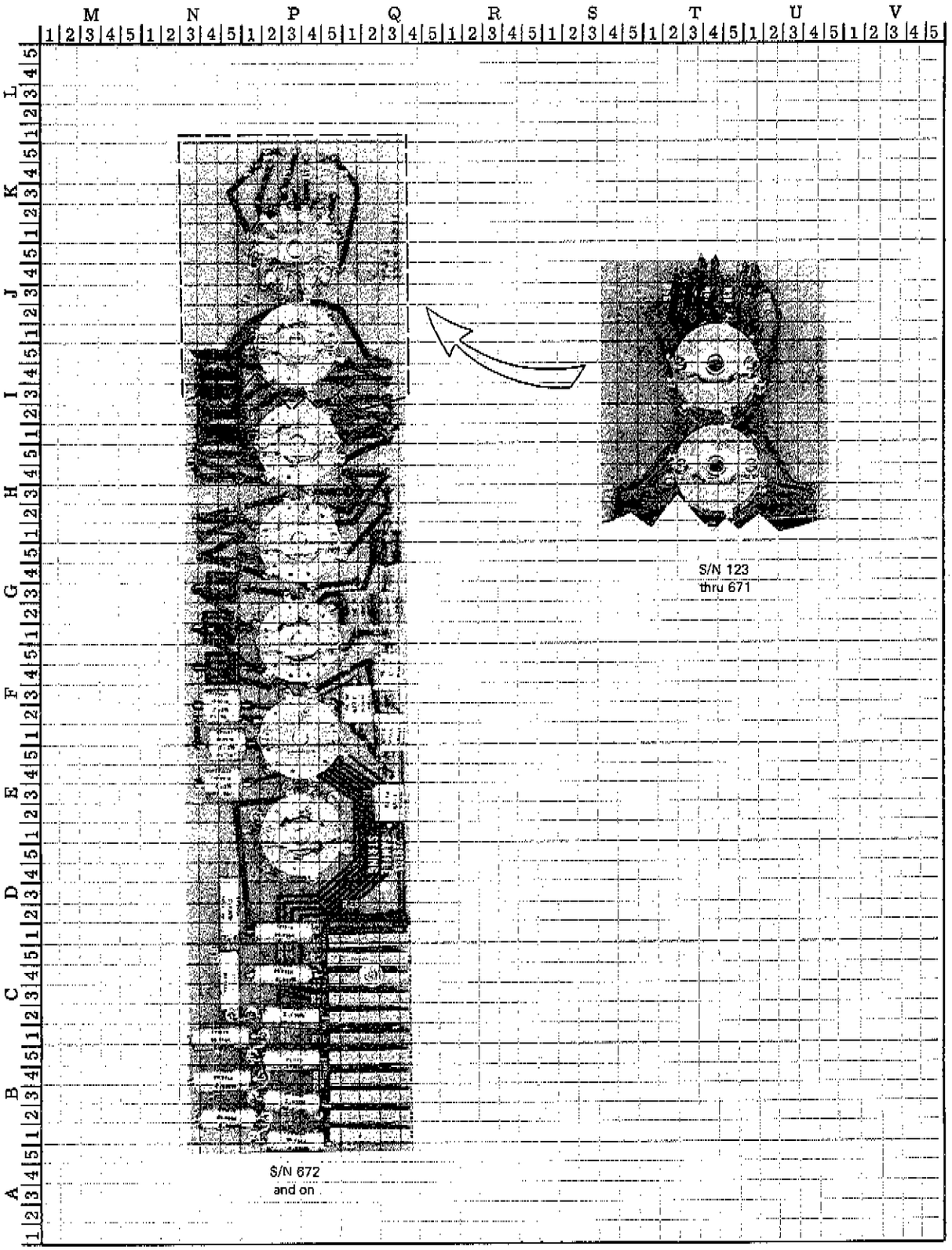



Figure 5-3. SAMPLE STRING P/C ASSEMBLY

| 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 | Relay, reed, 1,000v | 5103-233916 | 12617 | Type DRR-5 | 1 | | |
| | C5-J5 | Coil, reed relay, 24v | 1802-186155 | 71707 | SP-24-P | 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 | | |

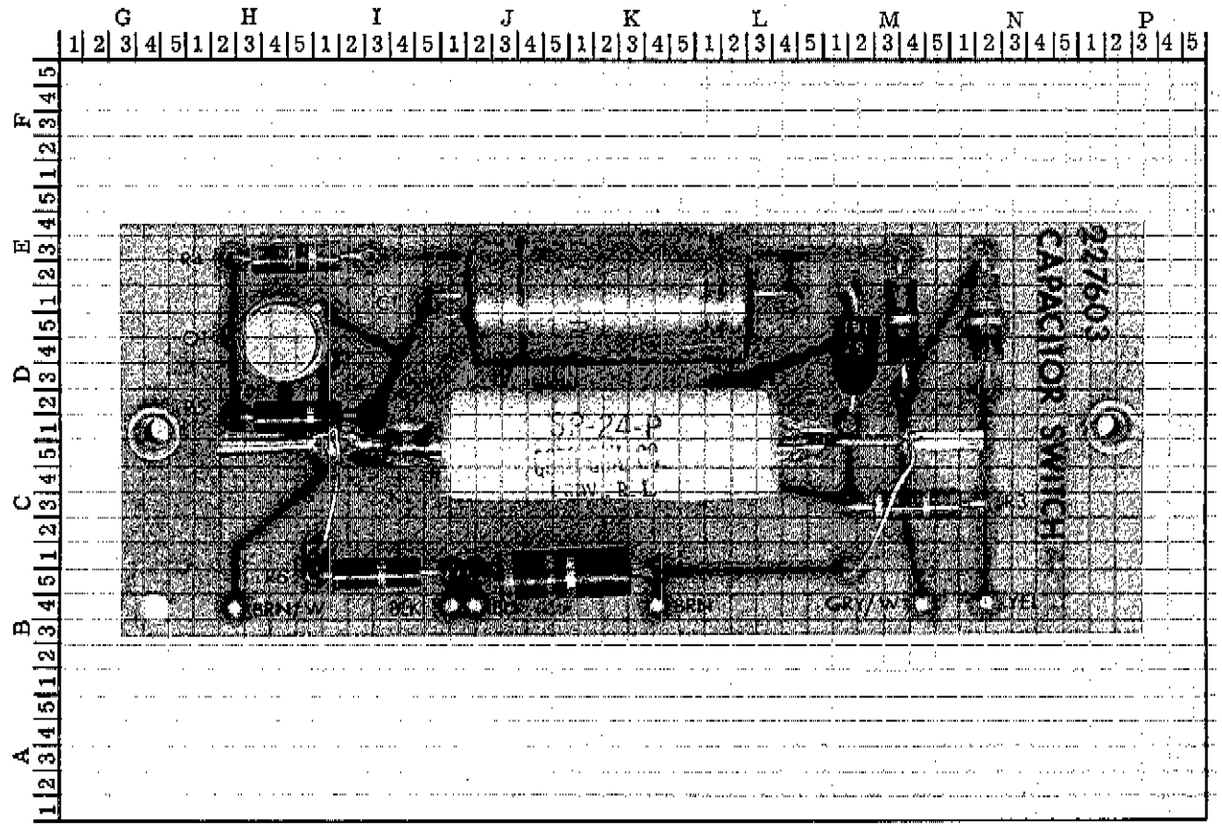



Figure 5-4. CAPACITOR SWITCH P/C ASSEMBLY

| 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 ±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 | Res, var, ww, 500Ω ±5%, ¾w | 4702-187740 | 12697 | Type 76JA-3 | 1 | | |
| R3 | C5-J1 | Res, ww, factory selected | ④ | | | | | |
| R4 | D1-K1 | Res, var, met flm, 500Ω ±20%, ¾w | 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, 50Ω ±20%, ¾w | 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, 10Ω ±30%, ¾w | 4701-186205 | 73138 | 78PR10 | REF | | |
| R10 | D2-N4 | Res, ww, 6.015k, matched | ③ | | | | | X |
| R10 | D2-N4 | Res, ww, 3.0075k, matched | | | | | | 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 | | |

④ 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.

③ 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.

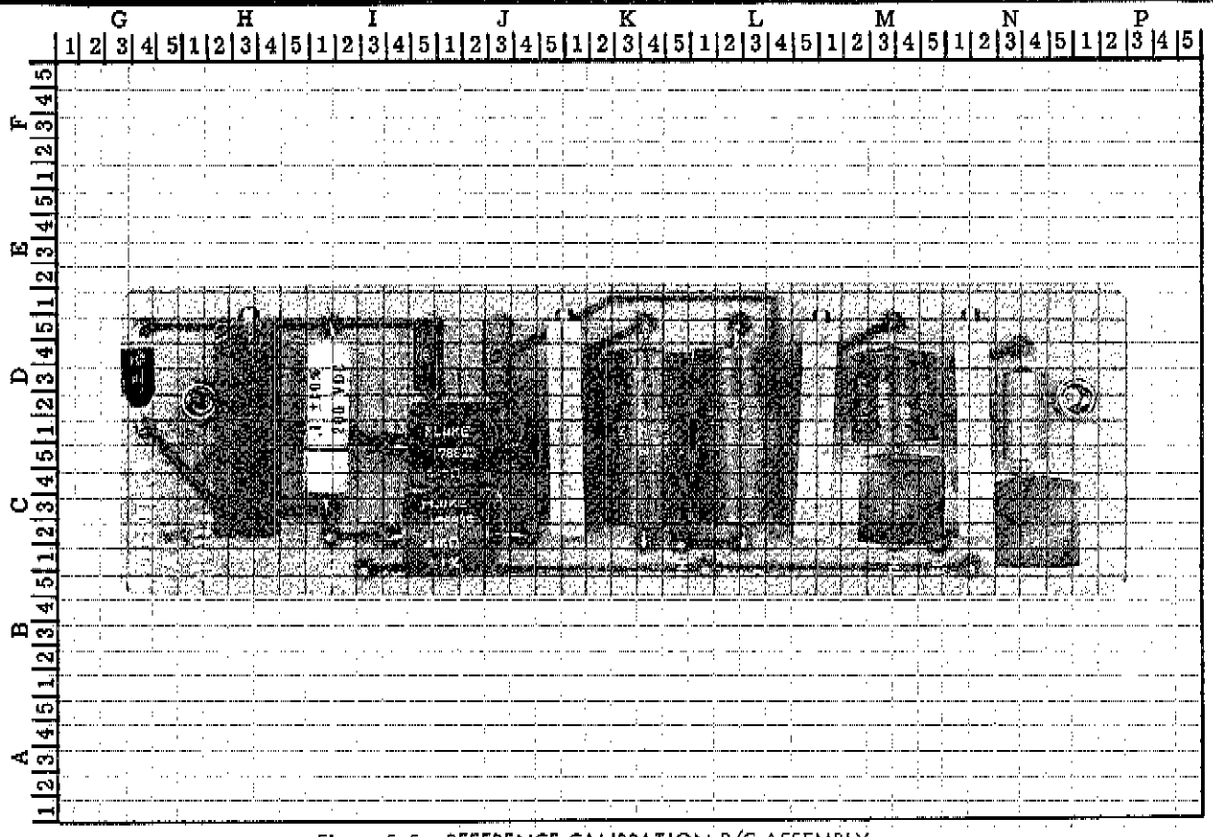



Figure 5-5. REFERENCE CALIBRATION P/C ASSEMBLY

| 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, plstc, 0.1 uf ±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 ±1%, 1/2w | 4705-169383 | 75042 | Type CEC-TO | 2 | | |
| R2 | B2-T1 | Res, met flm, 25.5k ±1%, 1/2w | 4705-219006 | 75042 | Type CEC-TO | 1 | | |
| R3 | B2-S4 | Res, met flm, 267k ±1%, 1/2w | 4705-218990 | 75042 | Type CEC-TO | 1 | | |
| R4 | B2-S3 | Res, met flm, 274k ±1%, 1/2w | 4705-218982 | 75042 | Type CEC-TO | 1 | | |
| R5 | A5-R2 | Res, car flm, 1.82M ±1%, 1/2w | 4703-219089 | 75042 | Type C12 | 3 | | |
| R6 | B1-R2 | Res, car flm, 1.82M ±1%, 1/2w | 4703-219089 | 75042 | Type C12 | REF | | |
| R7 | B2-R2 | Res, car flm, 1.82M ±1%, 1/2w | 4703-219089 | 75042 | Type C12 | REF | | |
| R8 | C1-R3 | Res, comp, 1k ±10%, 1w | 4704-109371 | 01121 | GB1021 | 1 | | |
| R9 | A5-P2 | Res, comp, 470Ω ±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 | | |

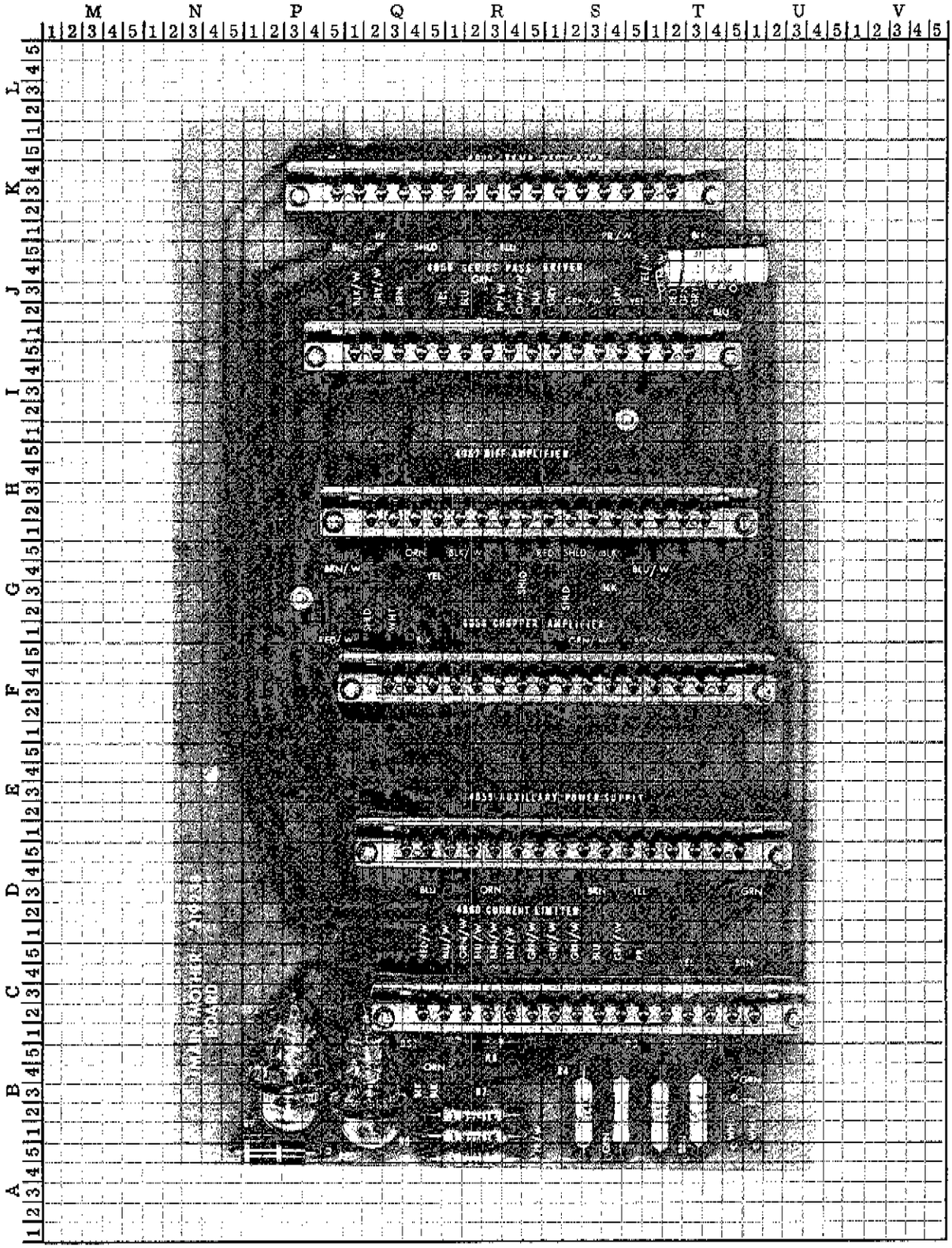



Figure 5-6. MAIN MOTHER BOARD P/C ASSEMBLY

| 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 ±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 | 91662 | 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 | ⟨4⟩ | | | | | |
| R2 | E3-P3 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |
| R3 | G2-P3 | Res, comp, 75k ±5%, 1/2w | 4704-108928 | 01121 | EB7535 | 4 | | |
| R4 | G2-P4 | Res, comp, 33k ±10%, 1/2w | 4704-178541 | 01121 | EB3331 | 2 | | |
| R5 | F5-P5 | Res, met film, 75k ±1%, 1/2w | 4705-193961 | 75042 | Type CEC-TO | 1 | | |
| R6 | G2-P2 | Res, comp, 24k ±5%, 1/2w | 4704-108654 | 01121 | EB2435 | 1 | | |
| R7 | G3-Q3 | Res, var, ww, 10k ±10%, 1-1/4w | 4702-195164 | 71450 | Type 115 special | 3 | | |
| R8 | F4-Q4 | Res, met film, 6.04k ±1%, 1/2w | 4705-162586 | 75042 | Type CEC-TO | REF | | |
| R9 | G3-S2 | Res, var, ww, 10k ±10%, 1-1/4w | 4702-195164 | 71450 | Type 115 special | REF | | |
| R10 | F4-S3 | Res, met film, 6.04k ±1%, 1/2w | 4705-162586 | 75042 | Type CEC-TO | REF | | |
| R11 | G3-T3 | Res, var, ww, 10k ±10%, 1-1/4w | 4702-195164 | 71450 | Type 115 special | REF | | |
| R12 | F4-T4 | Res, met film, 6.04k ±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 | ⟨5⟩ | | | | | |
| CR1402 | I5-S1 | Diode, zener, matched | ⟨5⟩ | | | | | |
| Q1401 | J4-Q5 | Tstr, silicon, PNP | 4805-190389 | 04713 | SM4144 | 4 | 1 | |
| R1401 | J2-S3 | Res, ww, 110Ω ±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 film, selected | ⟨4⟩ | | | | | |

⟨4⟩ 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.

⟨5⟩ 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.

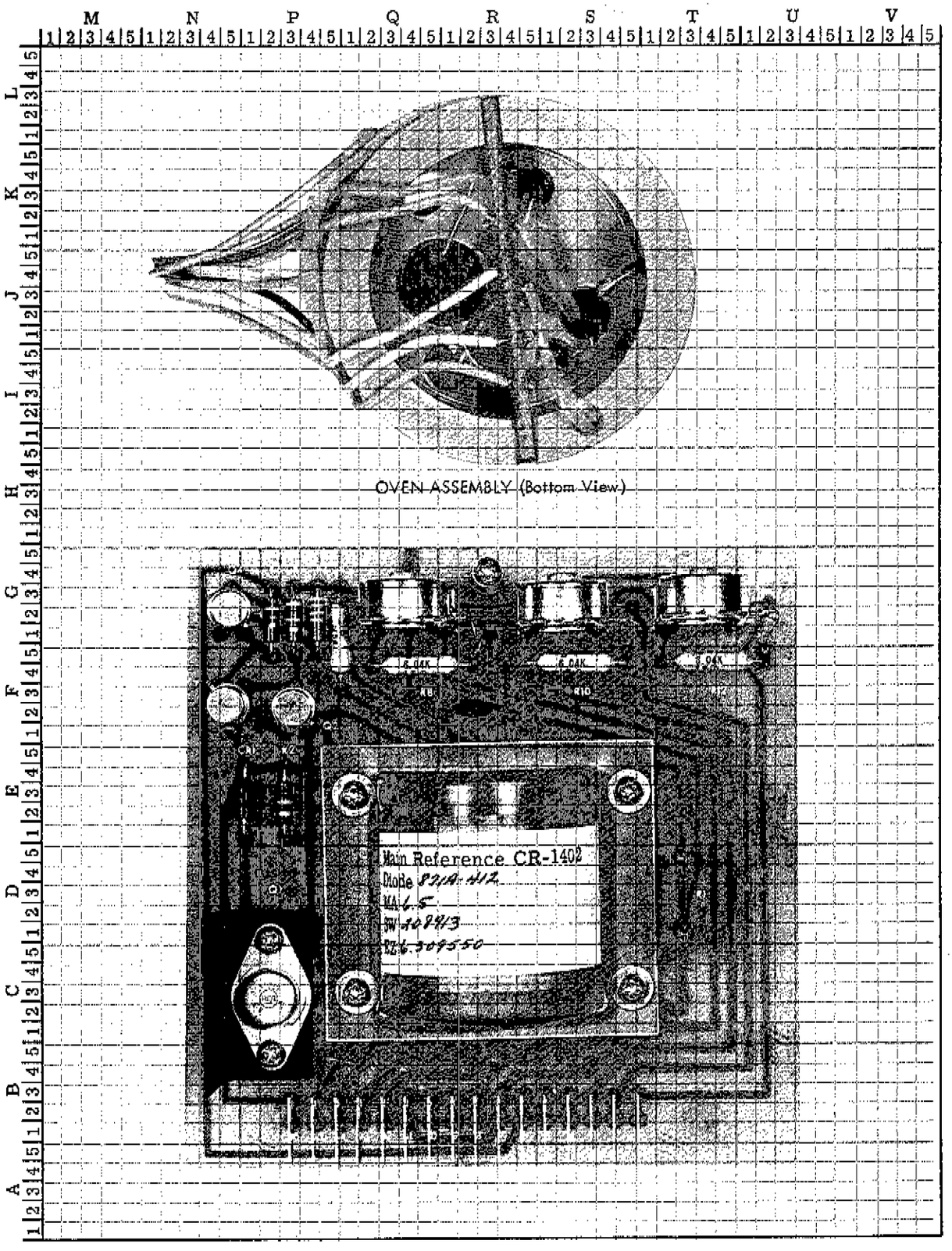



Figure 5-7. MASTER VOLTAGE REFERENCE P/C ASSEMBLY

| 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 ±20%, 250v | 1507-184366 | 73445 | C280AE/P470K | REF | | |
| C2 | F2-Q5 | Cap, Ta, 2.2 uf ±10%, 20v | 1508-160226 | 05397 | K2R2C20K | 1 | | |
| C3 | E2-Q5 | Cap, plstc, 0.1 uf ±20%, 200v | 1507-106435 | 56289 | 192P10402 | REF | | |
| C4 | G2-U5 | Cap, plstc, 0.22 uf ±10%, 80v | 1507-159392 | 56289 | 192P2249R8 | 1 | | |
| C5 | H1-Q1 | Cap, Ta, 15 uf ±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 ±1%, 1/2w | 4705-167478 | 75042 | Type CEC-TO | 2 | | |
| R2 | J3-T3 | Res, var, ww, 2k ±10%, 1-1/4w | 4702-198416 | 71450 | Type 110 | 2 | | |
| R3 | E3-N1 | Res, comp, 2.7k ±10%, 1w | 4704-109496 | 01121 | GB2721 | 1 | | |
| R4 | E3-M5 | Res, met flm, 4.02k ±1%, 1/2w | 4705-167478 | 75042 | Type CEC-TO | REF | | |
| R5 | J3-P4 | Res, var, ww, 3k ±20%, 1-1/4w | 4702-149781 | 71450 | Type 110 | 3 | | |
| R6 | I5-S5 | Res, met flm, 5.62k ±1%, 1/2w | 4705-219014 | 75042 | Type CEC-TO | 1 | | |
| R7 | G2-R2 | Res, comp, 100k ±10%, 1/2w | 4704-108126 | 01121 | EB1041 | 3 | | |
| R9 | G1-P2 | Res, comp, 2.4k ±5%, 1/2w | 4704-108902 | 01121 | EB2425 | 1 | | |
| R10 | I1-P5 | Res, comp, 47Ω ±10%, 2w | 4704-144352 | 01121 | HB4701 | 2 | | |
| R11 | E2-P2 | Res, comp, 47Ω ±10%, 2w | 4704-144352 | 01121 | HB4701 | REF | | |
| R12 | E3-N5 | Res, comp, 36k ±5%, 1/2w | 4704-185991 | 01121 | EB3635 | 4 | | |
| R13 | I1-R5 | Res, var, ww, 3k ±20%, 1-1/4w | 4702-149781 | 71450 | Type 110 | REF | | |
| R14 | D3-S1 | Res, met flm, 1k ±1%, 1/2w | 4705-151324 | 75042 | Type CEC-TO | 1 | | |
| R15 | E2-R4 | Res, met flm, 221k ±1%, 1/2w | 4705-182527 | 75042 | Type CEC-TO | 3 | | |
| R16 | G2-S4 | Res, comp, 3.9k ±10%, 1/2w | 4704-161406 | 01121 | EB3921 | 1 | | |
| R17 | E1-S3 | Res, comp, 20k ±5%, 1/2w | 4704-109041 | 01121 | EB2035 | 3 | | |
| R18 | G3-T3 | Res, comp, 16k ±5%, 1/2w | 4704-159632 | 01121 | EB1635 | 3 | | |
| R19 | G5-S3 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |
| R20 | F5-T2 | Res, comp, 27k ±5%, 1/2w | 4704-186023 | 01121 | EB2735 | 1 | | |
| R21 | F4-U2 | Res, comp, 220Ω ±5%, 1/2w | 4704-186031 | 01121 | EB2215 | 1 | | Q |
| R21 | F4-U2 | Res, comp, 27Ω ±5%, ½w | 4704-260984 | 01121 | EB2705 | 1 | | R |
| R22 | E1-U2 | Res, met flm, 10Ω ±1%, 1/2w | 4705-151043 | 75042 | Type CEC-TO | 1 | | |
| R23 | D2-S5 | Res, comp, 47k ±5%, 1/2w | 4704-108738 | 01121 | EB4735 | 2 | | |
| R24 | H2-S2 | Res, comp, 620Ω ±5%, 1/2w | 4704-108704 | 01121 | EB6215 | 2 | | |
| R25 | H4-Q5 | Res, comp, 47k ±5%, 1/2w | 4704-108738 | 01121 | EB4735 | REF | | |
| R26 | D3-P5 | Res, comp, 180Ω ±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 ±5%, 1/2w | 4704-169854 | 01121 | EB2025 | 3 | | |
| R28 | E5-P5 | Res, comp, 8.2k ±5%, 1/2w | 4704-147777 | 01121 | EB8225 | 2 | | |
| | G1-N1 | Heat sink | 4806-186759 | 89536 | 4806-186759 | REF | | |

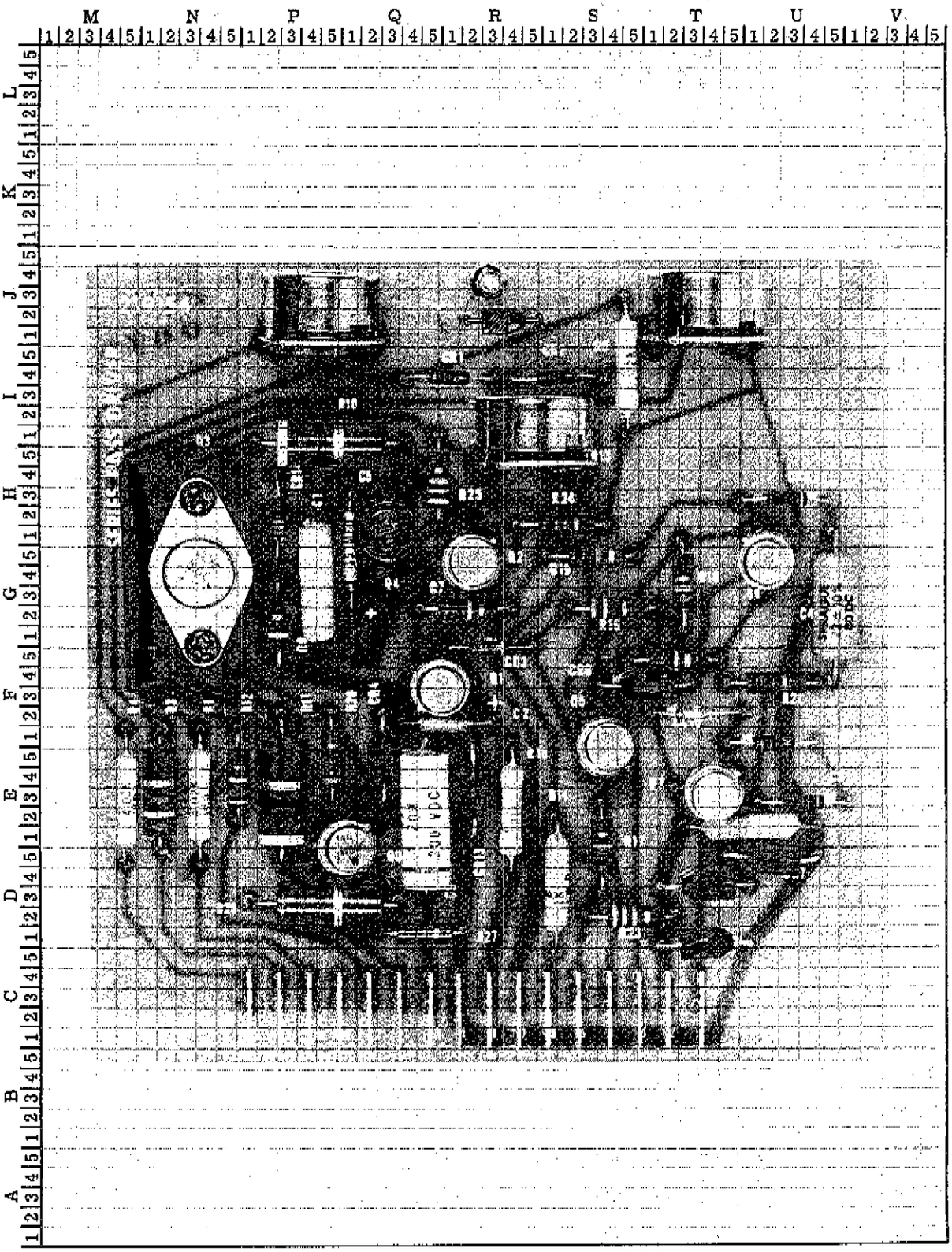


Figure 5-8. SERIES PASS DRIVER P/C ASSEMBLY

| 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 ±10%, 50v | 1507-150318 | 56289 | 194P1049R5 | 1 | | |
| C2 | F4-Q5 | Cap, mica, 510 pf ±5%, 500v | 1504-148411 | 88419 | CD19F511J | 2 | | |
| C3 | G1-P3 | Cap, Ta, 15 uf ±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 ±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-T5 | 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 ±5%, 1/2w | 4704-186064 | 01121 | EB2235 | 7 | | |
| R2 | D3-R3 | Res, comp, 100Ω ±5%, 1/2w | 4704-188508 | 01121 | EB1015 | 6 | | |
| R3 | D3-R5 | Res, comp, 100Ω ±5%, 1/2w | 4704-188508 | 01121 | EB1015 | REF | | |
| R4 | D3-S3 | Res, ww, 10k ±0.2%, 1/4w | 4707-112177 | 89536 | 4707-112177 | 1 | | |
| R5 | E5-S3 | Res, comp, 100Ω ±5%, 1/2w | 4704-188508 | 01121 | EB1015 | REF | | |
| R6 | F5-S3 | Res, comp, 100Ω ±5%, 1/2w | 4704-188508 | 01121 | EB1015 | REF | | |
| R7 | E4-T1 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | 9 | | |
| R8 | D3-Q3 | Res, comp, 3.3k ±5%, 1/2w | 4704-165761 | 01121 | EB3325 | 4 | | |
| R9 | D3-Q2 | Res, comp, 3k ±5%, 1/2w | 4704-109090 | 01121 | EB3025 | 2 | | |
| R10 | D3-P5 | Res, comp, 510Ω ±5%, 1/2w | 4704-108951 | 01121 | EB5115 | 1 | | |
| R11 | E1-P1 | Res, comp, 22M ±10%, 1/2w | 4704-108233 | 01121 | EB2261 | 1 | | |
| R12 | F1-M5 | Res, comp, 6.2k ±5%, 1/2w | 4704-108621 | 01121 | EB6225 | 3 | | |
| R13 | G1-N3 | Res, comp, 2.2k ±5%, 1/2w | 4704-108506 | 01121 | EB2225 | 2 | | |
| R14 | G1-P1 | Res, comp, 1.2k ±10%, 1/2w | 4704-108803 | 01121 | EB1221 | 1 | | |
| R15 | F5-P5 | Res, met flm, 100k ±1%, 1/2w | 4705-151316 | 75042 | Type CEC-TO | REF | | |
| R16 | I1-P1 | Res, met flm, 221k ±1%, 1/2w | 4705-182527 | 75042 | Type CEC-TO | REF | | |
| R17 | H4-P1 | Res, met flm, 40.2k ±1%, 1/2w | 4705-161059 | 75042 | Type CEC-TO | 2 | | |
| R18 | G4-R1 | Res, met flm, 75Ω ±1%, 1/2w | 4705-150870 | 75042 | Type CEC-TO | 2 | | |
| R19 | E4-T4 | Res, met flm, 75Ω ±1%, 1/2w | 4705-150870 | 75042 | Type CEC-TO | REF | | |
| R20 | E4-T5 | Res, met flm, 221k ±1%, 1/2w | 4705-182527 | 75042 | Type CEC-TO | REF | | |
| R21 | F4-U4 | Res, met flm, 40.2k ±1%, 1/2w | 4705-161059 | 75042 | Type CEC-TO | REF | | |
| R22 | H4-S3 | Res, met flm, 6.04k ±1%, 1/2w | 4705-162586 | 75042 | Type CEC-TO | REF | | |
| R23 | H1-S5 | Res, met flm, 42.2k ±1%, 1/2w | 4705-182501 | 75042 | Type CEC-TO | 1 | | |
| R24 | H2-S5 | Res, met flm, 9.09k ±1%, 1/2w | 4705-151258 | 75042 | Type CEC-TO | 1 | | |
| R25 | I5-T5 | Res, met flm, 15k ±1%, 1/2w | 4705-151498 | 75042 | Type CEC-TO | 1 | | |
| R26 | F4-U3 | Res, met flm, 1.58k ±1%, 1/2w | 4705-182543 | 75042 | Type CEC-TO | 2 | | |
| R27 | G5-T4 | Res, met flm, 1.58k ±1%, 1/2w | 4705-182543 | 75042 | Type CEC-TO | REF | | |
| R28 | G5-U1 | Res, met flm, 9.76k ±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 ±5%, 1/2w | 4704-109165 | 01121 | EB1035 | 2 | | |
| R30 | H2-U4 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | Q |
| R30 | H2-U4 | Res, comp, 1.5k ±10%, 1/2w | 4704-108159 | 01121 | EB1521 | 1 | | R |
| R31 | E3-T2 | Res, comp, 2k ±5%, 1/2w | 4704-169854 | 01121 | EB2025 | REF | | |

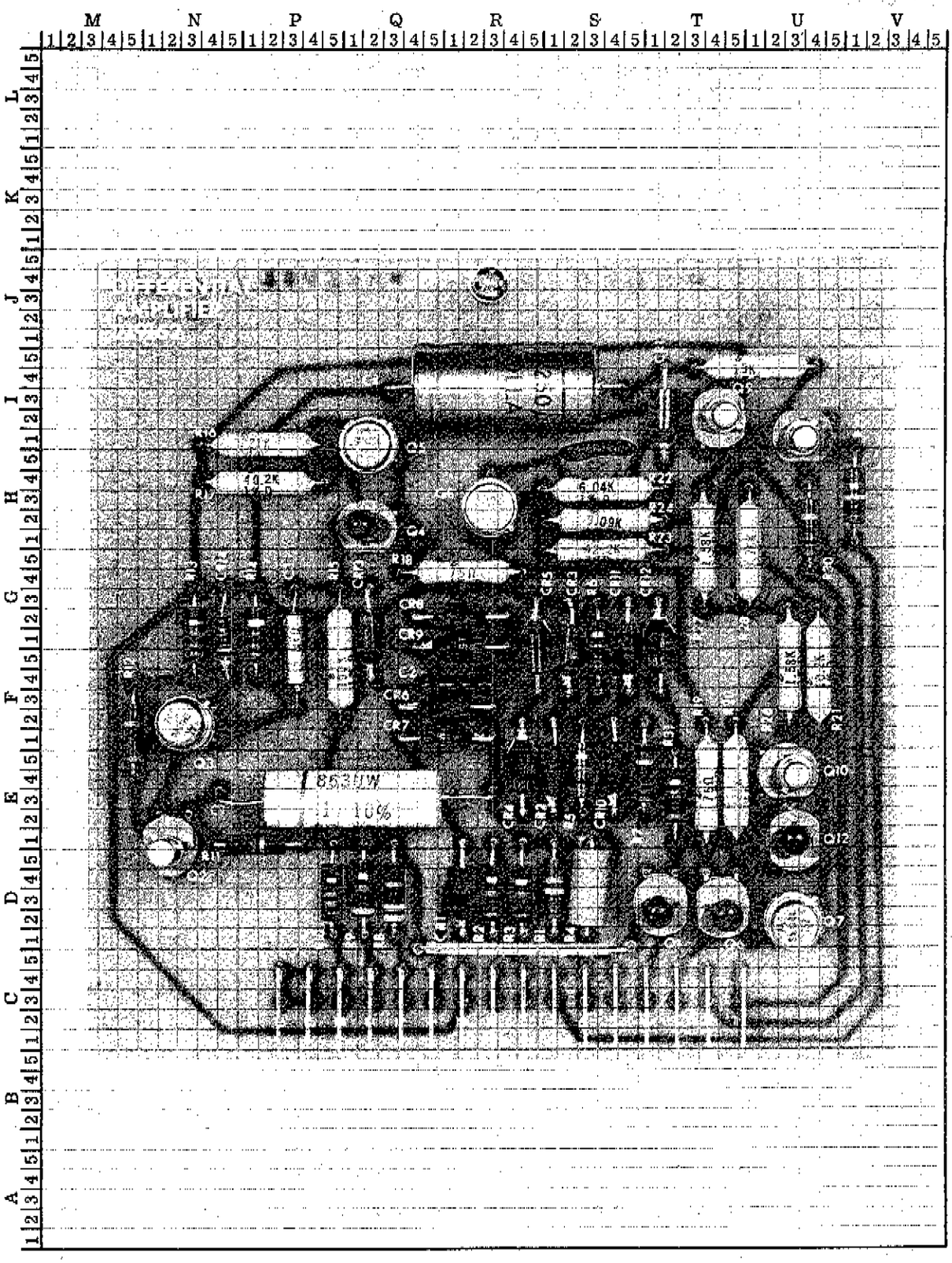



Figure 5-9. DIFFERENTIAL AMPLIFIER P/C ASSEMBLY

| 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 ±10%, 200v ⑥ | 1507-106062 | 56289 | 192P33392 | 2 | | |
| C2 | E5-T3 | Cap, plstc, 0.033 uf ±10%, 200v ⑥ | 1507-106062 | 56289 | 192P33392 | REF | | |
| C3 | E1-T3 | Cap, plstc, 0.1 uf ±20%, 200v ⑥ | 1507-106435 | 56289 | 192P10402 | REF | | |
| C4 | F3-T1 | Cap, plstc, 0.01 uf ±20%, 100v ⑥ | 1507-235390 | 84411 | Type 663UW | 1 | | |
| C5 | G2-T4 | Cap, cer, 0.01 uf ±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 ±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 ±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 ±10%, 6v | 1508-193011 | 05397 | K330J6K | 2 | | |
| C15 | E3-N3 | Cap, Ta, 330 uf ±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 ±5%, 1/2w | 4704-186064 | 01121 | EB2235 | REF | | |
| R2 | F1-S1 | Res, comp, 2.2k ±5%, 1/2w | 4704-108506 | 01121 | EB2225 | REF | | |
| R3 | D3-T1 | Res, met flm, 604k ±1%, 1/2w | 4705-182493 | 75042 | Type CEC-TO | 1 | | |
| R4 | D1-T1 | Res, met flm, 604k ±1%, 1/2w | 4705-182493 | 75042 | Type CEC-TO | REF | | H |
| R4 | D1-T1 | Res, met flm, 750k ±1%, 1/2w | 4705-155192 | 75042 | Type CEC-TO | 1 | | I |
| R5 | D1-R5 | Res, comp, 10Ω ±10%, 1/2w | 4704-108092 | 01121 | EB1001 | 1 | | H |
| R5 | D1-R5 | Res, comp, 12Ω ±10%, 1/2w | 4704-187831 | 01121 | EB1201 | 1 | | I |
| R6 | F2-T2 | Res, comp, 3.3M ±10%, 1/2w | 4704-108282 | 01121 | EB3351 | 1 | | |
| R7 | D2-U4 | Res, comp, 16k ±5%, 1/2w | 4704-159632 | 01121 | EB1635 | REF | | |
| R8 | F3-U2 | Res, comp, 200Ω ±5%, 1/2w | 4704-169839 | 01121 | EB2015 | 1 | | C |
| R8 | F3-U2 | Res, comp, 360Ω ±5%, 1/2w | 4704-192559 | 01121 | EB3615 | 2 | | D |
| R9 | F5-U1 | Res, comp, 15k ±10%, 1/2w | 4704-108530 | 01121 | EB1531 | REF | | |
| R10 | G3-T1 | Res, comp, 6.2k ±5%, 1/2w | 4704-108621 | 01121 | EB6215 | REF | | |
| R11 | H5-T5 | Res, comp, 15k ±10%, 1/2w | 4704-108530 | 01121 | EB1531 | REF | | |
| R12 | H5-U4 | Res, met flm, 150Ω ±1%, 1/2w | 4705-182550 | 75042 | Type CEC-TO | 1 | | |
| R13 | H4-T2 | Res, comp, 120k ±10%, 1/2w | 4704-108779 | 01121 | EB1241 | 1 | | |
| R14 | H4-T3 | Res, comp, 47k ±10%, 1/2w | 4704-108480 | 01121 | EB4731 | 1 | | |
| R15 | I3-P5 | Res, comp, 15k ±10%, 1/2w | 4704-108530 | 01121 | EB1531 | REF | | |
| R16 | J1-S4 | Res, met flm, 23.7k ±1%, 1/2w | 4705-169383 | 75042 | Type CEC-TO | REF | | |
| R17 | G2-S1 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |
| R18 | I5-N4 | Res, comp, 30k ±5%, 1/2w | 4704-186015 | 01121 | EB3035 | 1 | | |
| R19 | H4-Q1 | Res, comp, 15k ±10%, 1/2w | 4704-108530 | 01121 | EB1531 | REF | | |
| R20 | H2-N5 | Res, met flm, 3.01k ±1%, 1/2w | 4705-196709 | 75042 | Type CEC-T2 | 2 | | |
| R21 | H2-P4 | Res, met flm, 3.01k ±1%, 1/2w | 4705-196709 | 75042 | Type CEC-T2 | REF | | |
| R22 | F4-P3 | Res, met flm. 9.76k ±1%, 1/2w | 4705-182485 | 75042 | Type CEC-TO | REF | | |
| R23 | F4-P4 | Res, met flm, 9.76k ±1%, 1/2w | 4705-182485 | 75042 | Type CEC-TO | REF | | |
| R24 | D3-Q2 | Res, comp, 36k ±5%, 1/2w | 4704-185991 | 01121 | EB3635 | REF | | |
| R25 | E2-P2 | Res, comp, 20k ±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 | | |

6 See Section 4-13 for replacement instructions.

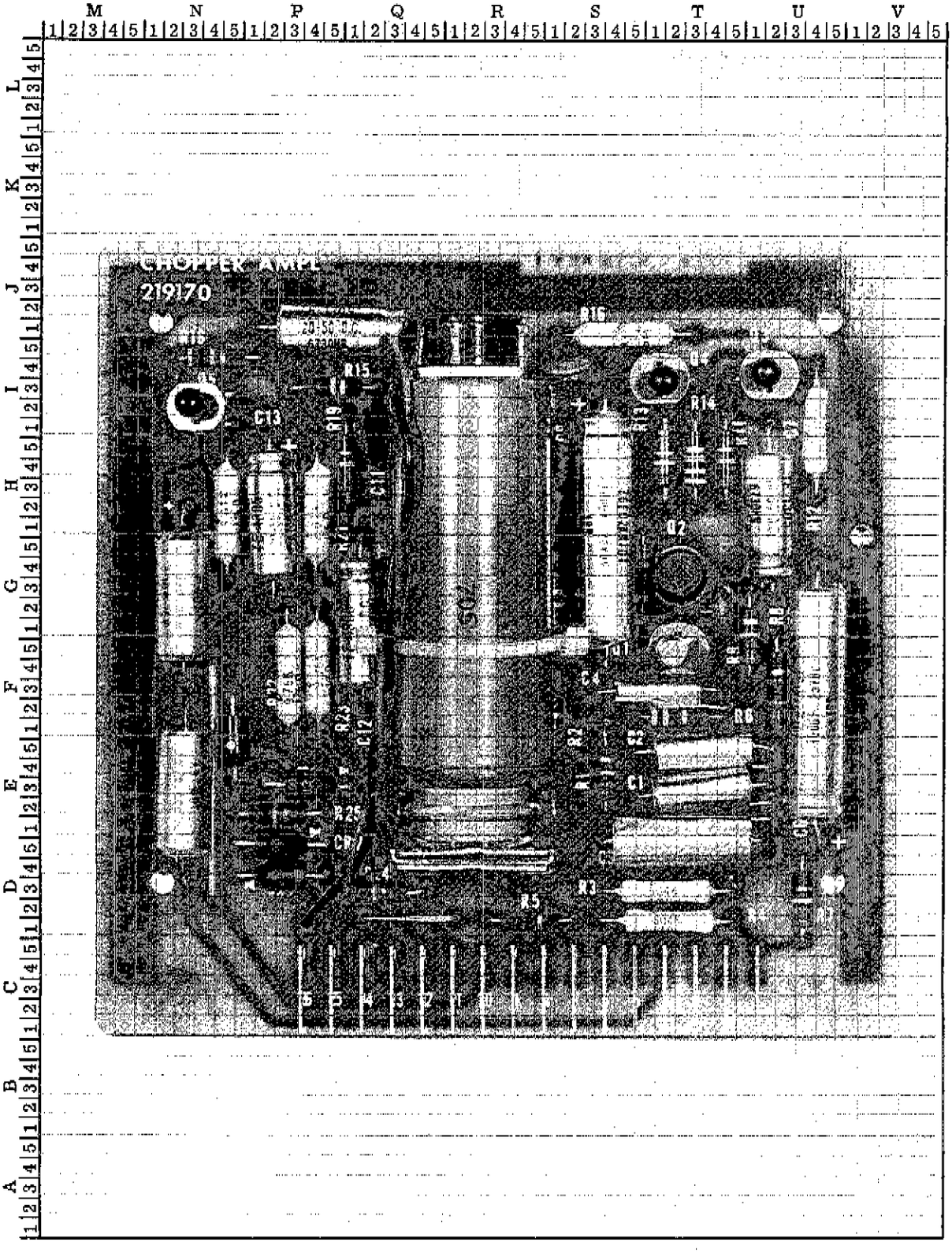



Figure 5-10. CHOPPER AMPLIFIER P/C ASSEMBLY

| 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 ±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 ±10%, 500v | 1501-105528 | 72982 | 315-024X5UD-221K | 1 | | O |
| C5 | H1-R3 | Cap, plstc, 2 uf ±20%, 100v | 1507-106963 | 84411 | Type X663FR | 2 | | |
| C6 | E2-R3 | Cap, plstc, 0.1 uf ±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 ±10%, 200v | 1507-106088 | 56289 | 192P12292 | 1 | | |
| C10 | E2-T1 | Cap, plstc, 2 uf ±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 ±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 ±5%, 1/2w | 4704-109165 | 01121 | EB1035 | REF | | |
| R2 | E5-Q3 | Res, comp, 390Ω ±5%, 1/2w | 4704-109082 | 01121 | EB3915 | 1 | | |
| R3 | E5-Q2 | Res, comp, 5.6k ±5%, 1/2w | 4704-187880 | 01121 | EB5625 | 1 | | |
| R4 | H3-N3 | Res, comp, 15Ω ±10%, 2w | 4704-155549 | 01121 | HB1501 | 1 | | |
| R5 | I1-N5 | Res, comp, 15k ±10%, 1/2w | 4704-108530 | 01121 | EB1531 | REF | | |
| R6 | J1-P1 | Res, comp, 3k ±5%, 1/2w | 4704-109090 | 01121 | EB3025 | REF | | |
| R7 | I4-Q4 | Res, comp, 33k ±10%, 1/2w | 4704-178541 | 01121 | EB3331 | REF | | |
| R8 | G4-R3 | Res, met flm, 7.15k ±1%, 1/2w | 4705-186072 | 75042 | Type CEC-TO | 1 | | |
| R9 | J4-T2 | Res, var, ww, 1k ±20%, 1-1/4w | 4702-113266 | 71450 | Type 110 | 1 | | |
| R10 | E2-R1 | Res, met flm, 2.55k ±1%, 1/2w | 4705-176362 | 75042 | Type CEC-TO | 1 | | |
| R11 | G3-S2 | Res, comp, 6.2k ±5%, 1/2w | 4704-108621 | 01121 | EB6225 | REF | | |
| R12 | E2-S1 | Res, met flm, 2.37k ±1%, 1/2w | 4705-182519 | 75042 | Type CEC-TO | 1 | | |
| R13 | G1-S2 | Res, comp, 12k ±10%, 1/2w | 4705-108977 | 01121 | EB1231 | 1 | | |
| R14 | G2-V1 | Res, comp, 82Ω ±10%, 2w | 4704-110239 | 01121 | HB8201 | 1 | | |
| R15 | H4-S4 | Res, comp, 8.2k ±5%, 1/2w | 4704-147777 | 01121 | EB8225 | REF | | |
| R16 | H4-T4 | Res, comp, 3.3k ±10%, 1/2w | 4704-108373 | 01121 | EB3321 | 1 | | |
| R17 | H2-T2 | Res, comp, 4.7k ±10%, 1/2w | 4704-108381 | 01121 | EB4721 | REF | | |
| R18 | E4-S4 | Res, met flm, 8.45k ±1%, 1/2w | 4705-159475 | 75042 | Type CEC-TO | 1 | | |
| R19 | E4-T3 | Res, met flm, 4.99k ±1%, 1/2w | 4705-148890 | 75042 | Type CEC-TO | 1 | | |
| R20 | J1-P3 | Res, comp, 2k ±5%, ½w | 4704-169854 | 01121 | EB2025 | REF | | P |

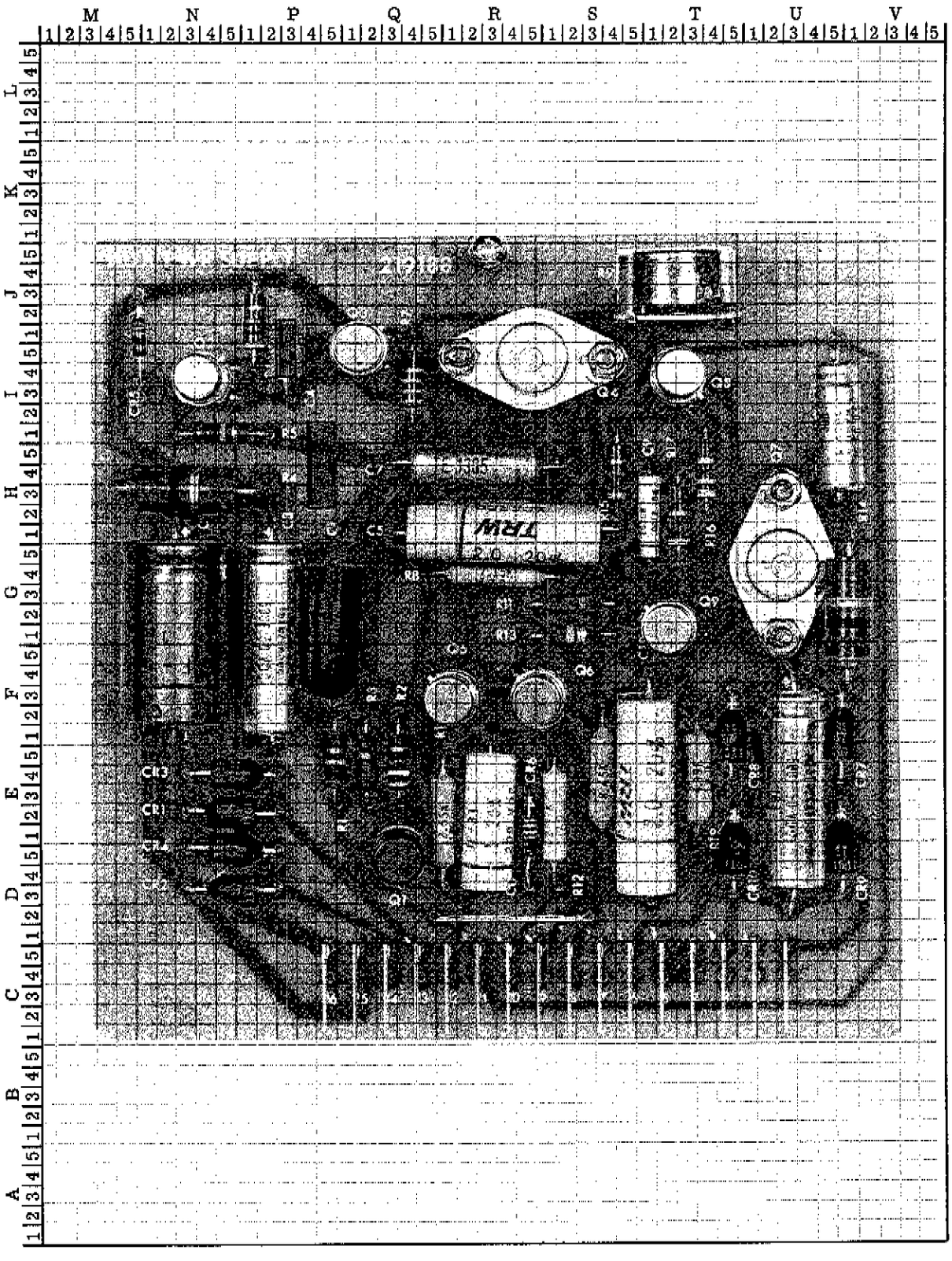


Figure 5-11. AUXILIARY POWER SUPPLY P/C ASSEMBLY

| 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, 10Ω ±10%, 2w | 4704-110163 | 01121 | HB1001 | 4 | | |
| R2 | H2-T3 | Res, comp, 3.3k ±5%, 1/2w | 4704-165761 | 01121 | EB3325 | REF | | |
| R3 | D3-T1 | Res, comp, 150Ω ±5%, 2w | 4704-235192 | 01121 | HB1515 | 1 | | |
| R4 | F3-U2 | Res, comp, 10Ω ±10%, 2w | 4704-110163 | 01121 | HB1001 | REF | | |
| R5 | I5-R3 | Res, comp, 3.3k ±5%, 1/2w | 4704-165761 | 01121 | EB3325 | REF | | |
| R6 | D3-P2 | Res, comp, 7.5k ±5%, 1/2w | 4704-108910 | 01121 | EB7525 | 3 | | |
| R7 | H5-R1 | Res, comp, 100k ±10%, 1/2w | 4704-108126 | 01121 | EB1041 | REF | | |
| R8 | F5-R4 | Res, comp, 120Ω ±10%, 2w | 4704-155531 | 01121 | HB1211 | 4 | | |
| R9 | E1-T1 | Res, comp, 120Ω ±10%, 2w | 4704-155531 | 01121 | HB1211 | REF | | |
| R10 | E2-Q1 | Res, comp, 4.7k ±10%, 1/2w | 4704-108381 | 01121 | EB4721 | REF | | |
| R11 | F1-P3 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |
| R12 | D3-N4 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |
| R13 | D3-N1 | Res, comp, 16k ±5%, 1/2w | 4704-159632 | 01121 | EB1635 | REF | | |
| R14 | D3-N2 | Res, comp, 1k ±10%, 1/2w | 4704-108563 | 01121 | EB1021 | REF | | |
| R15 | I3-P1 | Res, comp, 2.2k ±10%, 1/2w | 4704-108605 | 01121 | EB2221 | 1 | | |
| R16 | G2-N4 | Res, comp, 100k ±10%, 1/2w | 4704-108126 | 01121 | EB1041 | REF | | |
| R17 | H4-P1 | Res, comp, 36k ±5%, 1/2w | 4704-185991 | 01121 | EB3635 | REF | | |
| R18 | G2-N3 | Res, comp, 330k ±5%, 1/2w | 4704-150201 | 01121 | EB3345 | 1 | | |
| R19 | G2-Q5 | Res, comp, 7.5k ±5%, 1/2w | 4704-108910 | 01121 | EB7525 | REF | | |
| R20 | F4-P3 | Res, comp, 7.5k ±5%, 1/2w | 4704-108910 | 01121 | EB7525 | REF | | |
| R21 | F2-P3 | Res, comp, 1k ±10%, 1/2w | 4704-108563 | 01121 | EB1021 | REF | | |
| R22 | J3-P1 | Res, met flm, 12.1k ±1%, 1/2w | 4705-182535 | 75042 | Type CEC-TO | 1 | | |
| R23 | J5-N2 | Res, var, ww, 10k ±10%, 1-1/4w | 4702-162115 | 71450 | Type 110 | 1 | | |
| R24 | J4-U3 | Res, var, ww, 150Ω ±10%, 1-1/4w | 4702-113092 | 71450 | Type 110 | 1 | | |
| R25 | E3-T2 | Res, comp, 120Ω ±10%, 2w | 4704-155531 | 01121 | HB1211 | REF | | |
| R26 | E2-R4 | Res, comp, 120Ω ±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 | | |

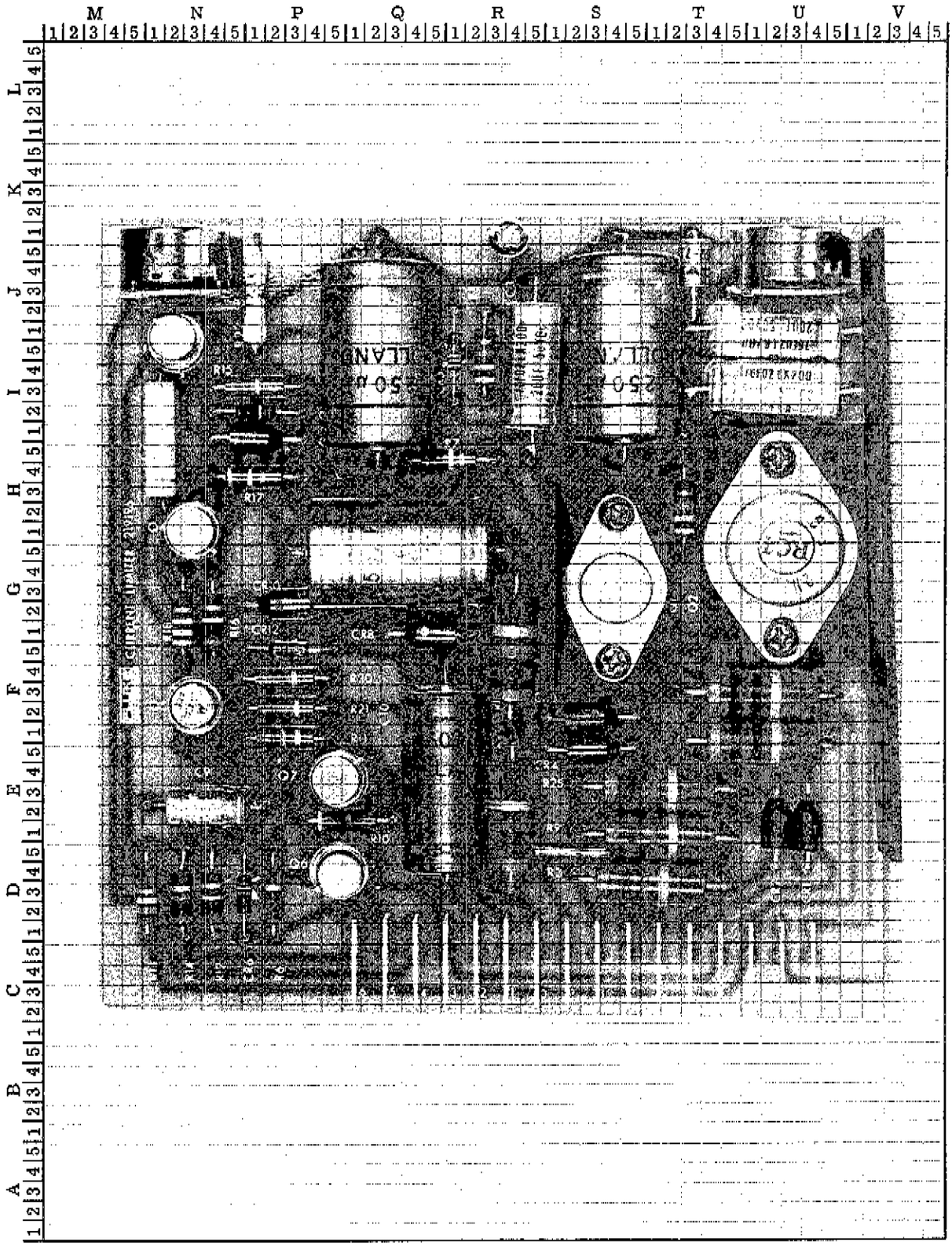


Figure 5-12. CURRENT LIMITER P/C ASSEMBLY

| 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 | | |

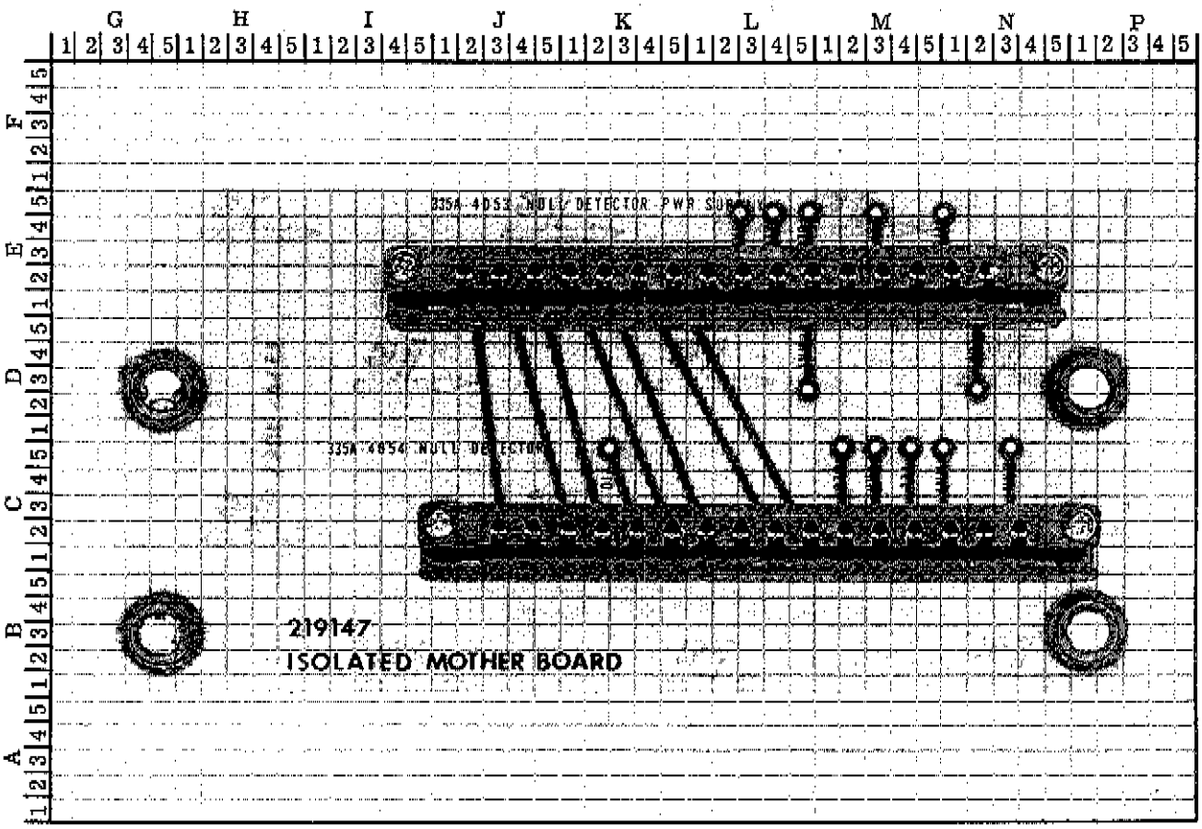



Figure 5-13. ISOLATED MOTHER BOARD P/C ASSEMBLY

| 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 ±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, 150Ω ±5%, 1/2w | 4704-186056 | 01121 | EB1515 | 1 | | |
| R2 | I1-N3 | Res, comp, 5.1k ±5%, 1/2w | 4704-109108 | 01121 | EB5125 | 2 | | |
| R3 | I1-P5 | Res, comp, 5.1k ±5%, 1/2w | 4704-109108 | 01121 | EB5125 | REF | | |
| R4 | J3-Q2 | Res, var, ww, 2k ±10%, 1-1/4w | 4702-198416 | 71450 | Type 110 | REF | | |
| R5 | E5-T2 | Res, comp, 22k ±5%, 1/2w | 4704-186064 | 01121 | EB2235 | REF | | |
| R6 | F1-S5 | Res, comp, 22k ±5%, 1/2w | 4704-186064 | 01121 | EB2235 | REF | | |
| R7 | G1-Q1 | Res, comp, 22k ±5%, 1/2w | 4704-186064 | 01121 | EB2235 | REF | | |
| R8 | G1-N3 | Res, comp, 22k ±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 ±20%, 1-1/4w | 4702-149781 | 71450 | Type 110 | REF | | |
| R10 | I5-Q1 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |
| R11 | F5-M5 | Res, comp, 1k ±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 | | |

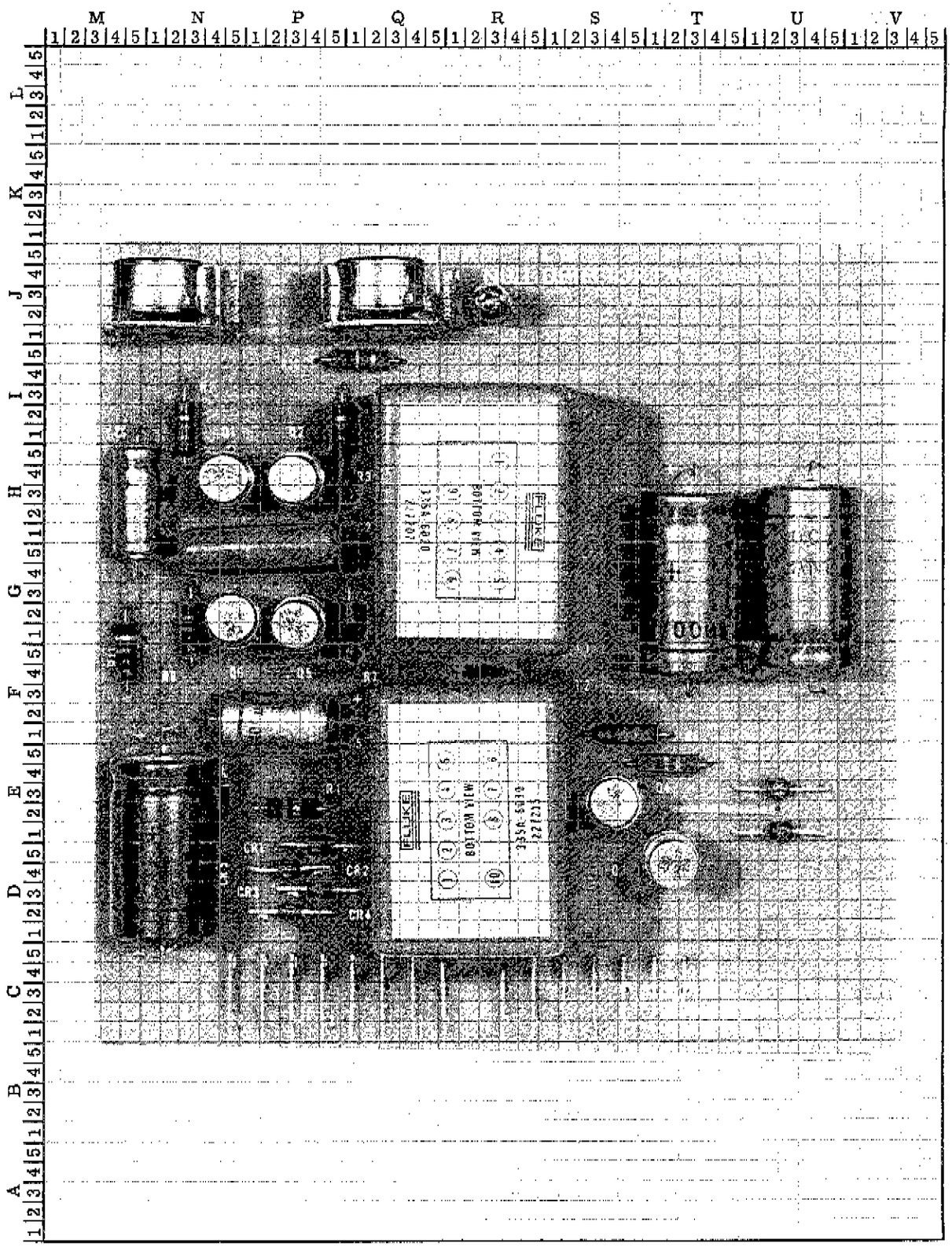



Figure 5-14. NULL DETECTOR POWER SUPPLY P/C ASSEMBLY

| 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 ±20%, 250v | 1507-194803 | 73445 | C280AE/ P220K | 1 | | |
| C2 | G5-P1 | Cap, plstc, 0.22 uf ±20%, 120v | 1507-167452 | 84411 | JF39 | 1 | | |
| C3 | H5-P1 | Cap, plstc, 0.47 uf ±20%, 120v | 1507-190553 | 84411 | JF36 | 2 | | |
| C4 | J1-P1 | Cap, plstc, 0.47 uf ±20%, 120v | 1507-190553 | 84411 | JF36 | REF | | |
| C5 | J3-T2 | Cap, plstc, 0.1 uf ±20%, 250v | 1507-161992 | 73445 | C280AE/P100K | 3 | | |
| C6 | I4-S3 | Cap, cer, 300 pf ±10%, 500v | 1501-105734 | 71590 | SB60301KW7W | 2 | | |
| C7 | I2-R5 | Cap, elect, 250 uf +50/-10%, 16v | 1502-187765 | 73445 | C437ARE250 | 1 | 1 | |
| C8 | I3-S4 | Cap, cer, 300 pf ±10%, 500v | 1501-105734 | 71590 | SB60301KW7W | REF | | |
| C9 | I2-T3 | Cap, Ta, 10 uf ±10%, 20v | 1508-160259 | 05397 | K10C20K | REF | | |
| C10 | E2-S1 | Cap, plstc, 0.1 uf ±20%, 250v | 1507-161992 | 73445 | C280AE/P100K | REF | | |
| C11 | E3-T2 | Cap, plstc, 0.0047 uf ±20%, 200v | 1507-106054 | 56289 | 192P47202 | 1 | | |
| C12 | G5-T5 | Cap, Ta, 10 uf ±10%, 20v | 1508-160259 | 05397 | K10C20K | REF | | |
| C13 | D2-S1 | Cap, elect, 400 uf +50/-10%, 4v | 1502-187773 | 73445 | C426ARB400 | REF | | |
| C14 | D4-P4 | Cap, elect, 1250 uf +50/-10%, 4v | 1502-166330 | 73445 | C437ARB1250 | 1 | 1 | |
| C15 | G2-N5 | Cap, Ta, 10 uf ±10%, 20v | 1508-160259 | 05397 | K10C20K | REF | | |
| C16 | F4-Q1 | Cap, plstc, 0.1 uf ±20%, 250v | 1507-161992 | 73445 | C280AE/P100K | REF | | |
| C17 | D1-N1 | Cap, Ta, 22 uf ±10%, 15v | 1508-182816 | 05397 | K22C15K | 1 | | |
| C18 | E2-P2 | Cap, Ta, 10 uf ±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 ±1%, 2w | 4703-107425 | 91637 | Type C14 | 1 | | |
| R2 | C3-U3 | Res, comp, 33k ±5%, 1/2w | 4704-108761 | 01121 | EB3335 | 1 | | |
| R3 | H3-R1 | Res, comp, 47k ±5%, 1/4w | 4704-148163 | 01121 | CB4735 | 2 | | |
| R4 | I3-R1 | Res, comp, 100k ±5%, 1/4w | 4704-148189 | 01121 | CB1045 | 4 | | |
| R5 | H3-Q2 | Res, comp, 470Ω ±5%, 1/4w | 4704-147983 | 01121 | CB4715 | 1 | | |
| R6 | D2-Q2 | Res, comp, 430k ±5%, 1/4w | 4704-226381 | 01121 | CB4345 | 1 | | |
| R7 | H2-R2 | Res, ww, 10Ω ±1%, 1/2w | 4707-193946 | 89536 | 4707-193946 | 1 | 1 | |
| R8 | J3-S3 | Res, comp, 1.2M ±10%, 1/2w | 4704-108407 | 01121 | EB1251 | 1 | | |
| R9 | I2-R2 | Res, comp, 10k ±5%, 1/4w | 4704-148106 | 01121 | CB1035 | 2 | | |
| R10 | I2-S2 | Res, comp, 10M ±10%, 1/2w | 4704-108142 | 01121 | EB1061 | 1 | | |
| R11 | H2-S3 | Res, comp, 1.2M ±5%, 1/4w | 4704-188425 | 01121 | CB1255 | 1 | | |
| R12 | H2-S4 | Res, comp, 47k ±5%, 1/4w | 4704-148163 | 01121 | CB4735 | REF | | |
| R13 | H2-T1 | Res, comp, 68k ±5%, 1/4w | 4704-148171 | 01121 | CB6835 | 2 | | |
| R14 | H2-T3 | Res, comp, 82k ±5%, 1/4w | 4704-188458 | 01121 | CB8235 | 1 | | |
| R15 | H2-T2 | Res, comp, 39Ω ±5%, 1/4w | 4704-193391 | 01121 | CB3905 | 1 | | |
| R16 | F1-T3 | Res, comp, 100k ±5%, 1/4w | 4704-148189 | 01121 | CB1045 | REF | | |
| R17 | F4-U1 | Res, comp, 22k ±5%, 1/4w | 4704-148130 | 01121 | CB2235 | 3 | | |
| R18 | D5-T1 | Res, comp, 39k ±5%, 1/4w | 4704-188466 | 01121 | CB3935 | 1 | | |
| R19 | E2-T1 | Res, comp, 100k ±5%, 1/4w | 4704-148189 | 01121 | CB1045 | REF | | |
| R20 | D4-T1 | Res, comp, 100Ω ±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 ±5%, 1/4w | 4704-182212 | 01121 | CB1545 | 3 | | |
| R22 | G2-S4 | Res, comp, 10k ±5%, 1/4w | 4704-148106 | 01121 | CB1035 | REF | | |
| R23 | E5-Q3 | Res, comp, 22k ±5%, 1/4w | 4704-148130 | 01121 | CB2235 | REF | | |
| R24 | G2-Q2 | Res, comp, 15k ±5%, 1/4w | 4704-148114 | 01121 | CB1535 | 2 | | |
| R25 | G1-P1 | Res, comp, 150k ±5%, 1/4w | 4704-182212 | 01121 | CB1545 | REF | | |
| R26 | F4-Q3 | Res, comp, 68k ±5%, 1/4w | 4704-148171 | 01121 | CB6835 | REF | | |
| R27 | F1-P3 | Res, comp, 15k ±5%, 1/4w | 4704-148114 | 01121 | CB1535 | REF | | O |
| R27 | F1-P3 | Res, comp, 150k ±5%, ¼w | 4704-182212 | 01121 | CB1545 | REF | | P |
| R28 | F5-P4 | Res, comp, 22k ±5%, 1/4w | 4704-148130 | 01121 | CB2235 | REF | | |
| R29 | F1-N2 | Res, comp, 100k ±5%, 1/4w | 4704-148189 | 01121 | CB1045 | REF | | |
| R30 | D4-N2 | Res, comp, 15k ±5%, 1/4w | 4704-148114 | 01121 | CB1535 | REF | | |
| R31 | C4-N2 | Res, comp, 3.9M ±5%, 1/4w | 4704-188417 | 01121 | CB3955 | 1 | | |
| R32 | F4-S3 | Res, comp, 1k ±5%, 1/4w | 4704-148023 | 01121 | CB1025 | 2 | | |
| R33 | E5-Q3 | Res, comp, 1k ±5%, 1/4w | 4704-148023 | 01121 | CB1025 | REF | | |
| V1<br>V2 | I5-U2<br>I5-U5 | Photocell assembly | 3700-194449 | 89536 | 3700-194449 | 1 | 1 | |
| | 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 | | |

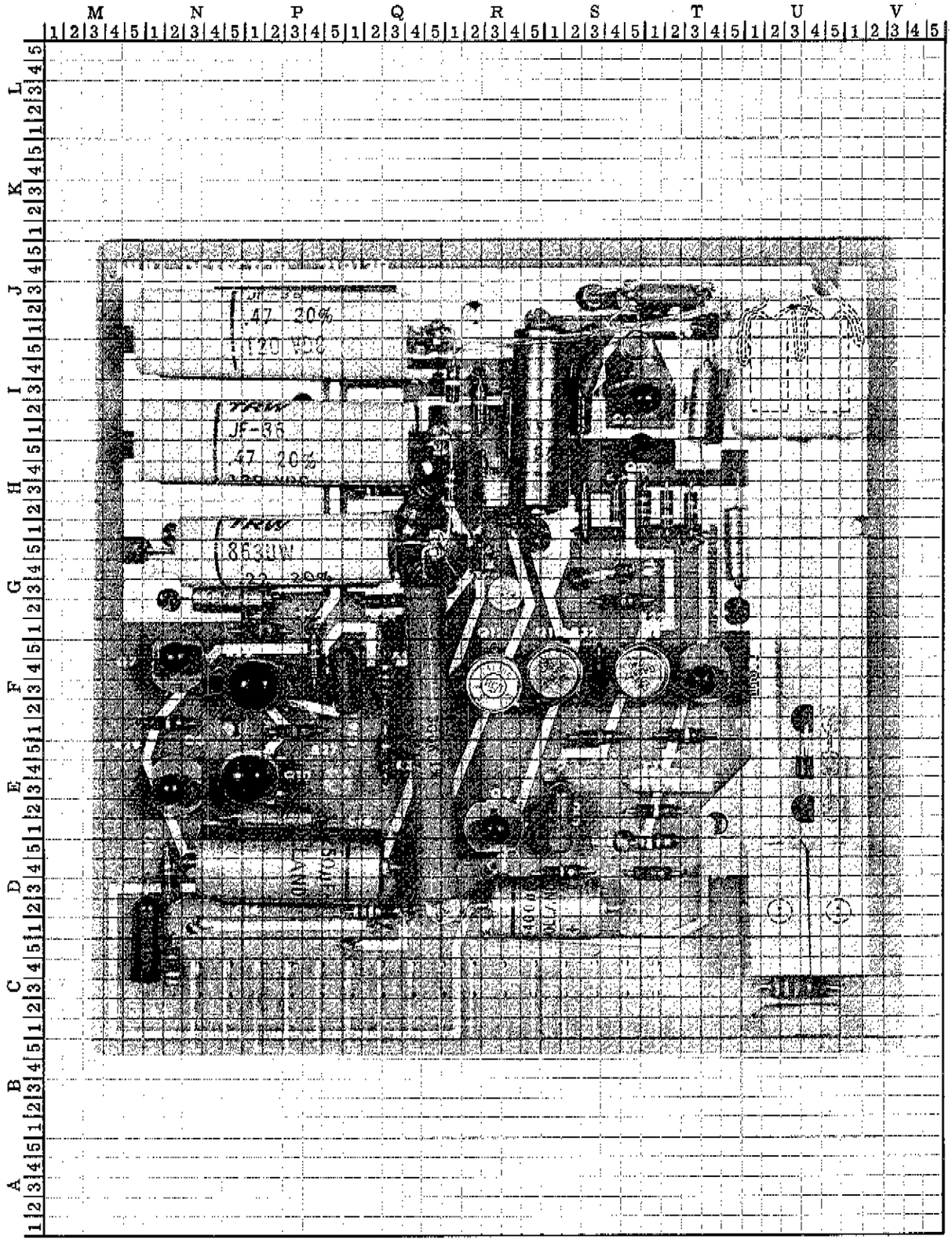


Figure 5-15. NULL DETECTOR AMPLIFIER P/C ASSEMBLY

| 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 ±10%, 2w | 4704-109967 | 01121 | HB2221 | 2 | | |
| R2002 | E3-K3 | Res, comp, 5.6k ±10%, 1/2w | 4704-108324 | 01121 | EB5621 | 1 | | |
| R2003 | F2-L3 | Res, comp, 390Ω ±10%, 1/2w | 4704-108365 | 01121 | EB3911 | 1 | | |
| R2004 | D4-K5 | Res, comp, 10k ±10%, 1/2w | 4704-108118 | 01121 | EB1031 | REF | | |

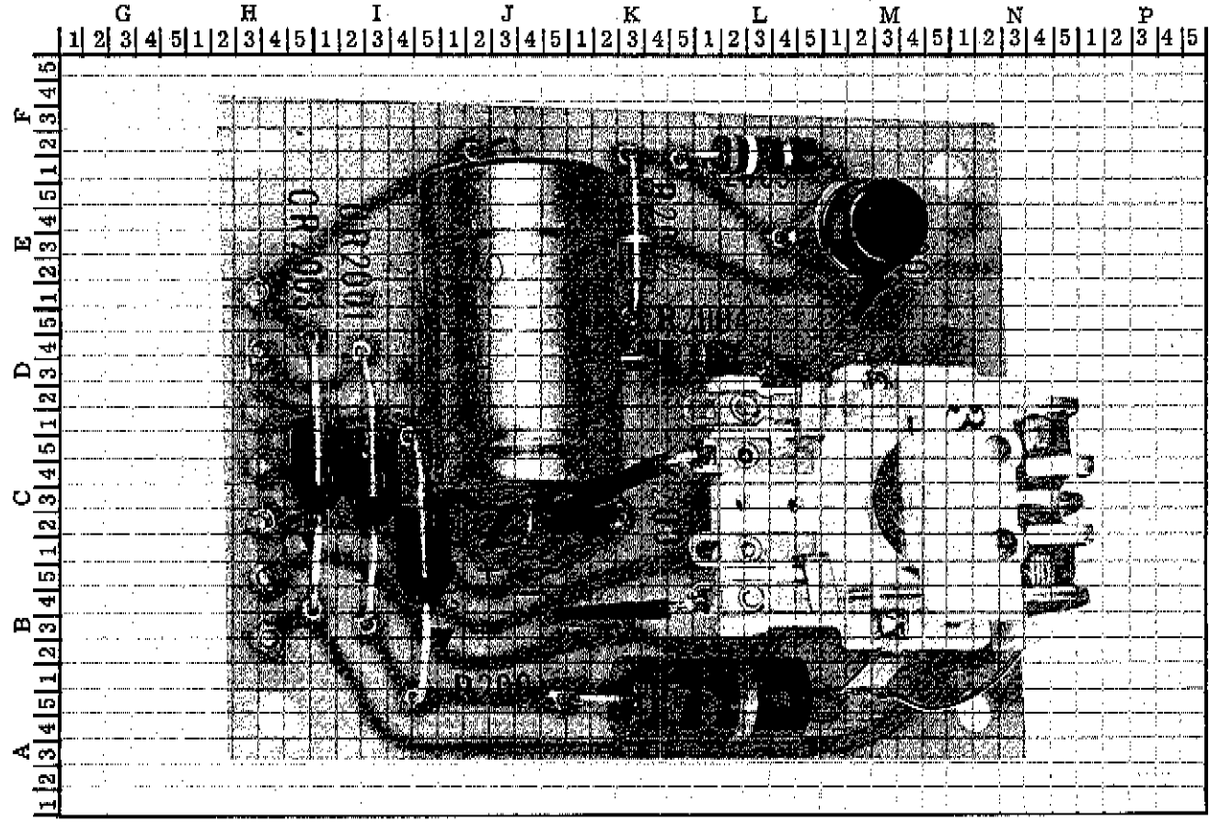



Figure 5-16. TIME DELAY P/C ASSEMBLY

| 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 ±10%, 2w | 4704-110197 | 01121 | HB2241 | 6 | | |
| R2 | G4-N1 | Res, comp, 220k ±10%, 2w | 4704-110197 | 01121 | HB2241 | REF | | |
| R3 | H5-N1 | Res, comp, 220k ±10%, 2w | 4704-110197 | 01121 | HB2241 | REF | | |
| R4 | E3-R3 | Res, comp, 470k ±5%, 1w | 4704-109819 | 01121 | GB4745 | 2 | | |
| R5 | E5-Q4 | Res, comp, 470k ±5%, 1w | 4704-109819 | 01121 | GB4745 | REF | | |
| R6 | G1-T3 | Res, comp, 10Ω ±10%, 2w | 4704-110163 | 01121 | HB1001 | REF | | |
| R7 | I1-R2 | Res, comp, 470Ω ±10%, 1/2w | 4704-108415 | 01121 | EB4711 | REF | | |
| R8 | I3-Q2 | Res, comp, 5.1Ω ±5%, 1w | 4704-219071 | 01121 | GB51G5 | 1 | | |
| R9 | I5-S1 | Res, comp, 10Ω ±10%, 2w | 4704-110163 | 01121 | HB1001 | REF | | |
| R10 | F1-S4 | Res, comp, 270Ω ±10%, 2w | 4704-110189 | 01121 | HB2711 | REF | | |
| R11 | F1-Q1 | Res, comp, 2.2k ±10%, 2w | 4704-109967 | 01121 | HB2221 | REF | | |
| R12 | H5-M4 | Res, comp, 220k ±10%, 2w | 4704-110197 | 01121 | HB2241 | REF | | |
| R13 | G5-M4 | Res, comp, 220k ±10%, 2w | 4704-110197 | 01121 | HB2241 | REF | | |
| R14 | F3-M4 | Res, comp, 220k ±10%, 2w | 4704-110197 | 01121 | HB2241 | REF | | |
| R15 | G1-S4 | Res, ww, 2k ±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 | | |

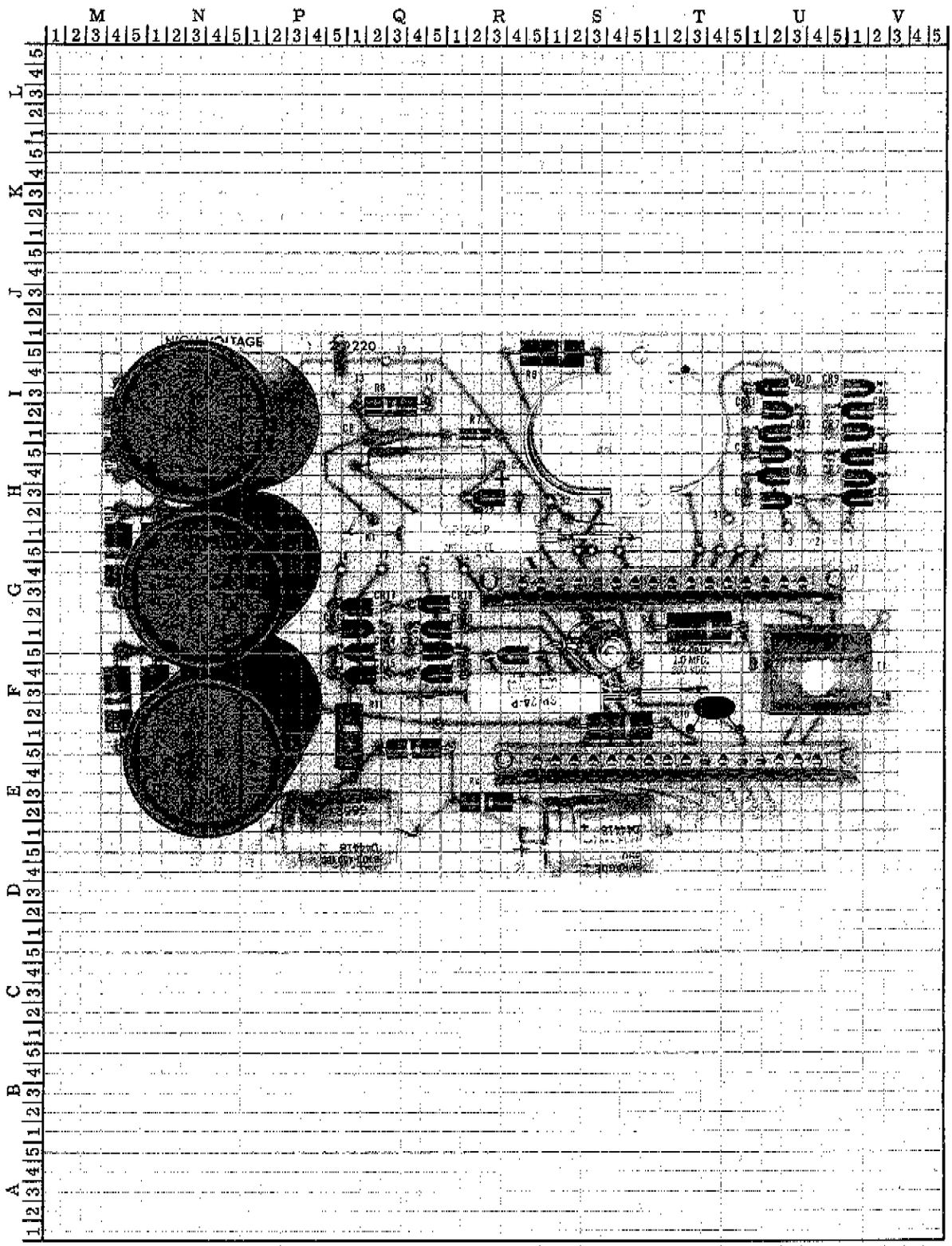


Figure 5-17. HIGH VOLTAGE MOTHER BOARD P/C ASSEMBLY

| 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 ±10%, 2w | 4704-185983 | 01121 | HB1821 | 3 | | |
| R2 | F3-N4 | Res, comp, 1.8k ±10%, 2w | 4704-185983 | 01121 | HB1821 | REF | | |
| R3 | E5-N4 | Res, comp, 1.8k ±10%, 2w | 4704-185983 | 01121 | HB1821 | REF | | |
| R4 | C4-U2 | Res, comp, 360Ω ±5%, 1/2w | 4704-192559 | 01121 | EB3615 | REF | | L |
| R4 | C4-U2 | Res, comp, 62k ±5%, 1/2w | 4704-108522 | 01121 | EB6235 | 2 | | M |
| R5 | F1-R5 | Res, comp, 270k ±10%, 2w | 4704-110023 | 01121 | HB2741 | 1 | | L |
| R5 | F1-R5 | Res, comp, 100k ±10%, 2w | 4704-158659 | 01121 | HB1041 | 1 | | M |
| R6 | H2-N3 | Res, comp, 56k ±5%, 1/2w | 4704-219048 | 01121 | EB5635 | 1 | | |
| R7 | H2-M5 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R8 | H2-P1 | Res, comp, 62k ±5%, 1/2w | 4704-108522 | 01121 | EB6235 | REF | | |
| R9 | H2-P3 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R10 | H2-Q1 | Res, comp, 68k ±5%, 1/2w | 4704-159624 | 01121 | EB6835 | 1 | | |
| R11 | H2-Q2 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| R12 | H2-R4 | Res, comp, 75k ±5%, 1/2w | 4704-108928 | 01121 | EB7535 | REF | | |
| R13 | H2-R2 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R14 | H2-S5 | Res, comp, 82k ±5%, 1/2w | 4704-195966 | 01121 | EB8235 | 1 | | |
| R15 | H3-S5 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R16 | H2-T5 | Res, comp, 91k ±5%, 1/2w | 4704-219030 | 01121 | EB9135 | 1 | | |
| R17 | H2-T3 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R18 | H5-U4 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | 9 | | |
| R19 | H3-U4 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R20 | C4-U5 | Res, comp, 1.1Ω ±5%, 1/2w | 4704-163717 | 01121 | EB11G5 | 1 | | |
| R21 | H2-N5 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R22 | H2-P4 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R23 | H2-Q5 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R24 | H2-S2 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R25 | H5-S5 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R26 | G5-U4 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R27 | H2-U4 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R28 | G1-P3 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | 7 | | |
| R29 | G4-Q3 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | REF | | |
| R30 | F5-Q3 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | REF | | |
| R31 | G2-S5 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | REF | | |
| R32 | F5-S5 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | REF | | |
| R33 | F4-U3 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | REF | | |
| R34 | G1-U3 | Res, comp, 22k ±10%, 2w | 4704-109975 | 01121 | HB2231 | REF | | |
| R35 | F3-Q5 | Res, comp, 75k ±5%, 1/2w | 4704-108928 | 01121 | EB7535 | REF | | |
| R36 | F5-R3 | Res, comp, 75k ±5%, 1/2w | 4704-108928 | 01121 | EB7535 | REF | | |
| R37 | E1-N2 | Res, comp, 36k ±5%, 1/2w | 4704-185991 | 01121 | EB3635 | REF | | |
| R38 | D4-P5 | Res, comp, 180Ω ±5%, 1/2w | 4704-108944 | 01121 | EB1815 | 2 | | |
| R39 | E1-M5 | Res, comp, 100Ω ±5%, 1/2w | 4704-188508 | 01121 | EB1015 | REF | | |
| R40 | H2-N2 | Res, comp, 100k ±5%, 1/2w | 4704-168054 | 01121 | EB1045 | REF | | |
| R41 | E3-N5 | Res, met flm, 4.75k ±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 ±1%, 1/2w | 4705-192500 | 75042 | Type CEC-TO | REF | | S |
| | E1-V1 | Heat sink | 4806-192245 | 89536 | 4806-192245 | 1 | | |

7 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.

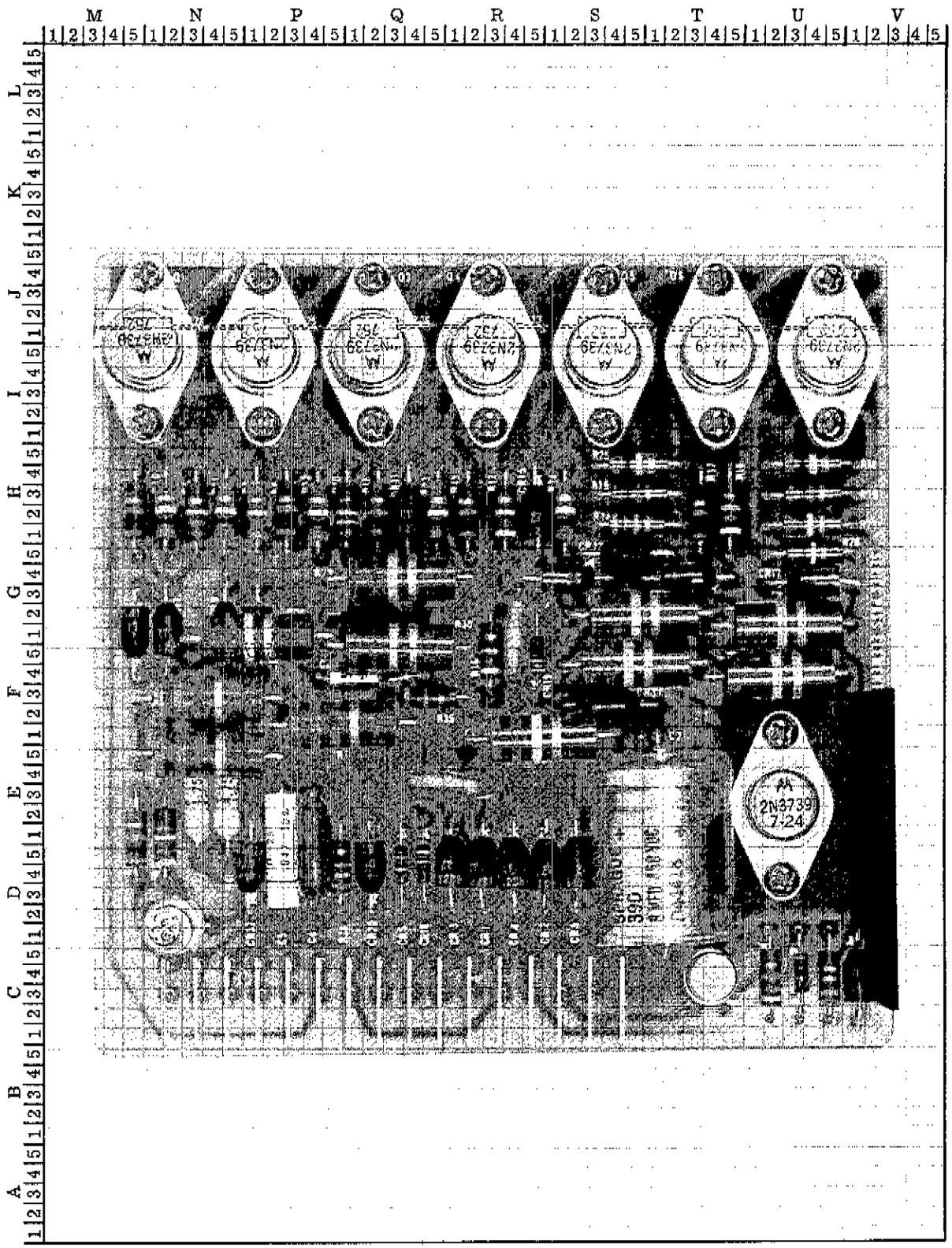



Figure 5-18. SERIES PASS ELEMENT P/C ASSEMBLY

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT 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 ±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 ±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 | 91662 | 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, 68Ω ±10%, 2w | 4704-110205 | 01121 | HB6801 | 1 | | |
| R2 | J1-R1 | Res, ww, 0.192Ω ±1%, 3w | 4707-238741 | 89536 | 4707-238741 | 1 | 1 | |
| R4 | J3-V1 | Res, ww, 2k ±5%, 5w | 4706-113506 | 06136 | Type 5F | 1 | | |
| R5 | I4-P4 | Res, comp, 22k ±5%, 1/2w | 4704-186064 | 01121 | EB2235 | REF | | |
| R6 | E1-U1 | Res, ww, 10Ω ±10%, 5w | 4706-112300 | 06136 | Type 10F | 2 | | |
| R7 | D1-U1 | Res, ww, 10Ω ±10%, 5w | 4706-112300 | 06136 | Type 10F | REF | | |
| R8 | I2-Q3 | Res, comp, 430Ω ±5%, 1/2w | 4704-109058 | 01121 | EB4315 | 1 | | Q |
| R8 | I2-Q3 | Res, comp, 560Ω ±5%, ½w | 4704-109124 | 01121 | EB5615 | 1 | | R |
| R9 | I1-Q1 | Res, comp, 360Ω ±5%, 1/2w | 4704-192559 | 01121 | EB3615 | REF | | |
| R10 | F5-N5 | Res, comp, 20k ±5%, 1/2w | 4704-109041 | 01121 | EB2035 | REF | | |
| R11 | I2-S1 | Res, comp, 100Ω ±5%, 1/2w | 4704-188508 | 01121 | EB1015 | REF | | |
| R12 | H2-T1 | Res, comp, 1k ±5%, 1/2w | 4704-108597 | 01121 | EB1025 | REF | | |
| R13 | H5-S2 | Res, comp, 270Ω ±5%, 1/2w | 4704-159616 | 01121 | EB2715 | 2 | | |
| R14 | G1-P3 | Res, comp, 180Ω ±5%, 1/2w | 4704-108944 | 01121 | EB1815 | REF | | |
| R15 | G1-S1 | Res, comp, 4.7k ±5%, 1/2w | 4704-108886 | 01121 | EB4725 | 1 | | |
| R16 | E5-N5 | Res, comp, 3.3k ±5%, 1/2w | 4704-165761 | 01121 | EB3325 | REF | | |
| R17 | G3-R5 | Res, comp, 270Ω ±5%, 1/2w | 4704-159616 | 01121 | EB2715 | REF | | |
| R18 | H2-S1 | Res, comp, 620Ω ±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 | | |

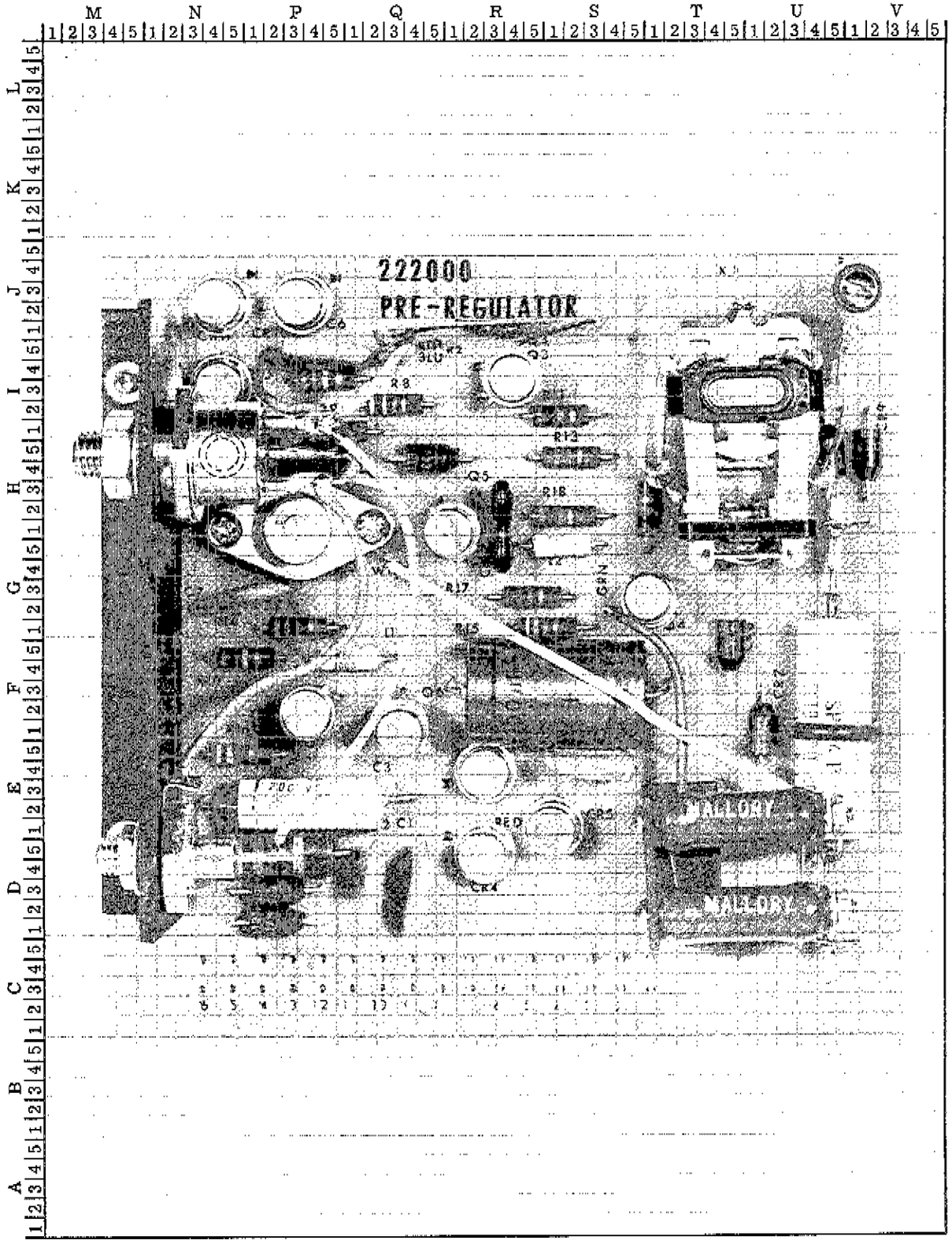


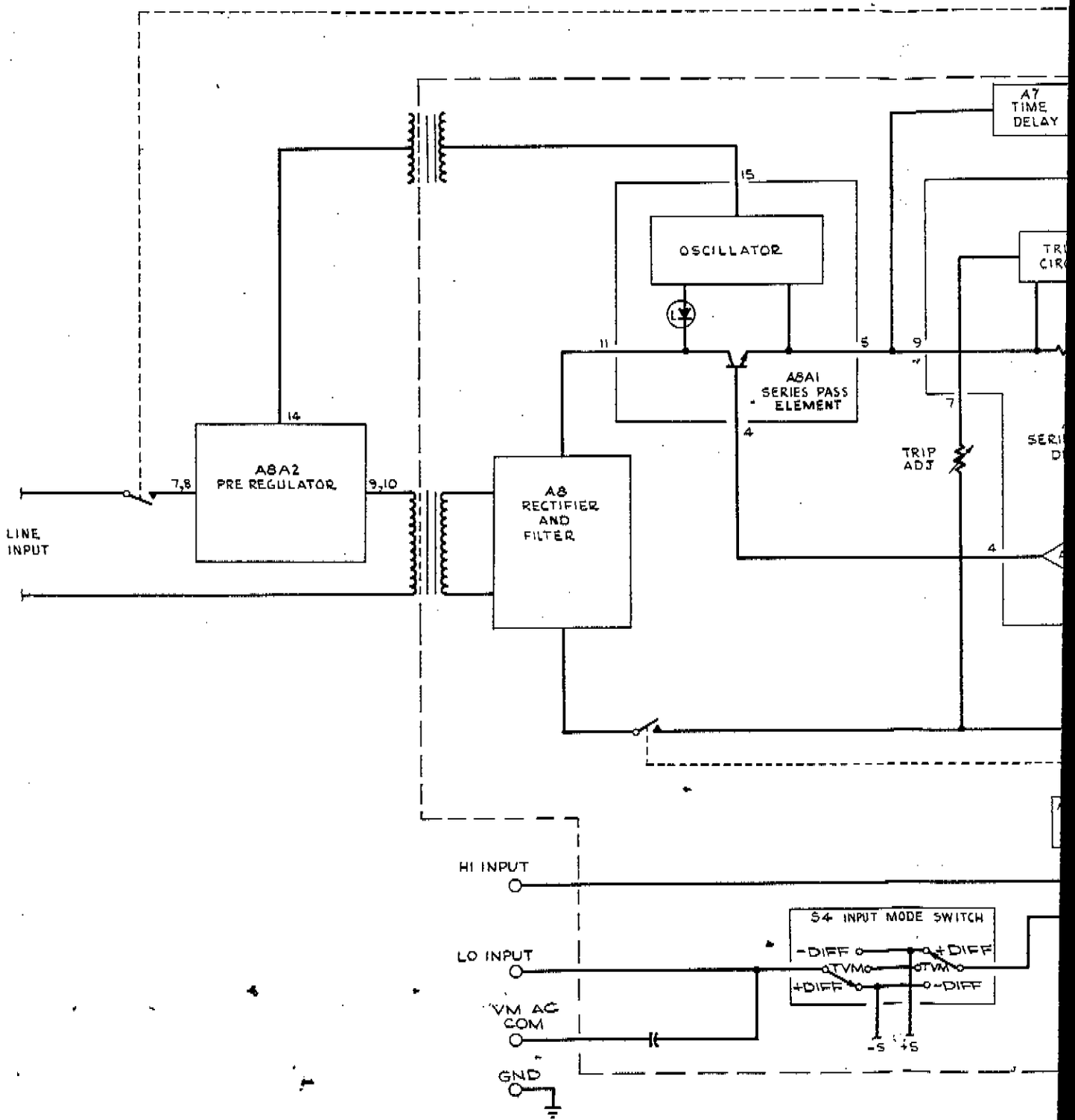

Figure 5-19. PREREGULATOR P/C ASSEMBLY

Appendix B

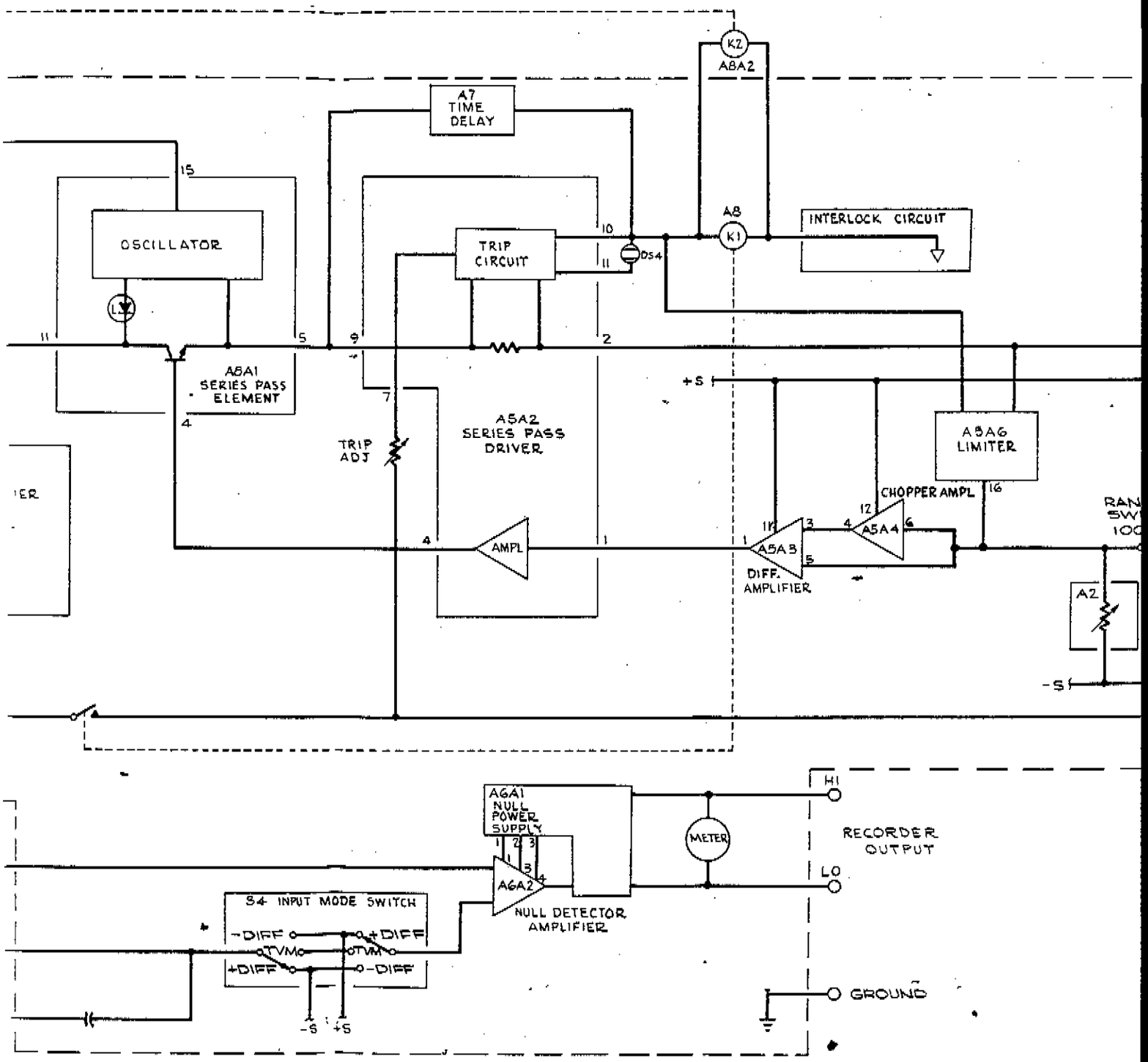
# List of Abbreviations

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

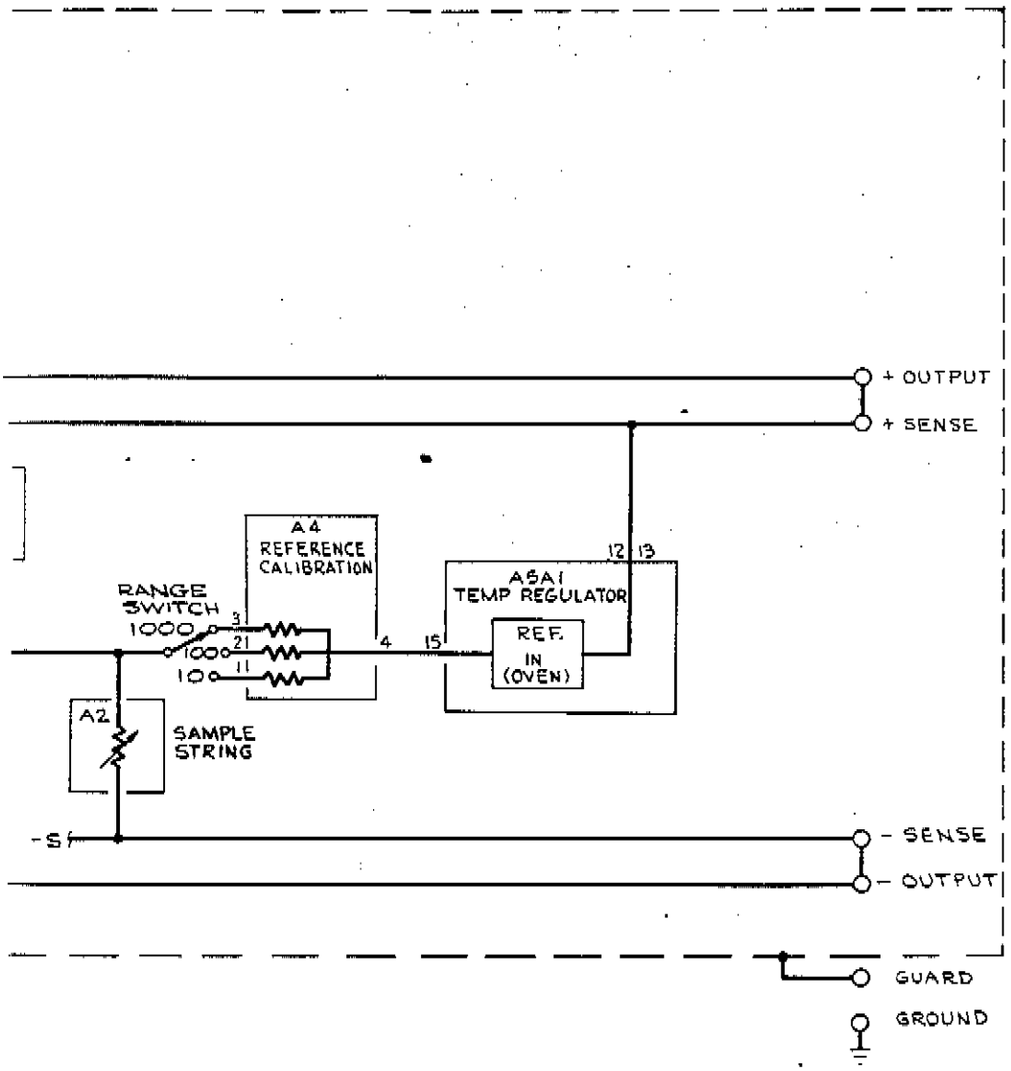
DWG. 335A-1000
SHT. 1 OF 3



DWG. 335A-1000
SHT. 2 OF 3



DWG. 335A-1000
SHT. 3 OF 3




FUNCTIONAL BLOCK DIAGRAM

MODEL 335A

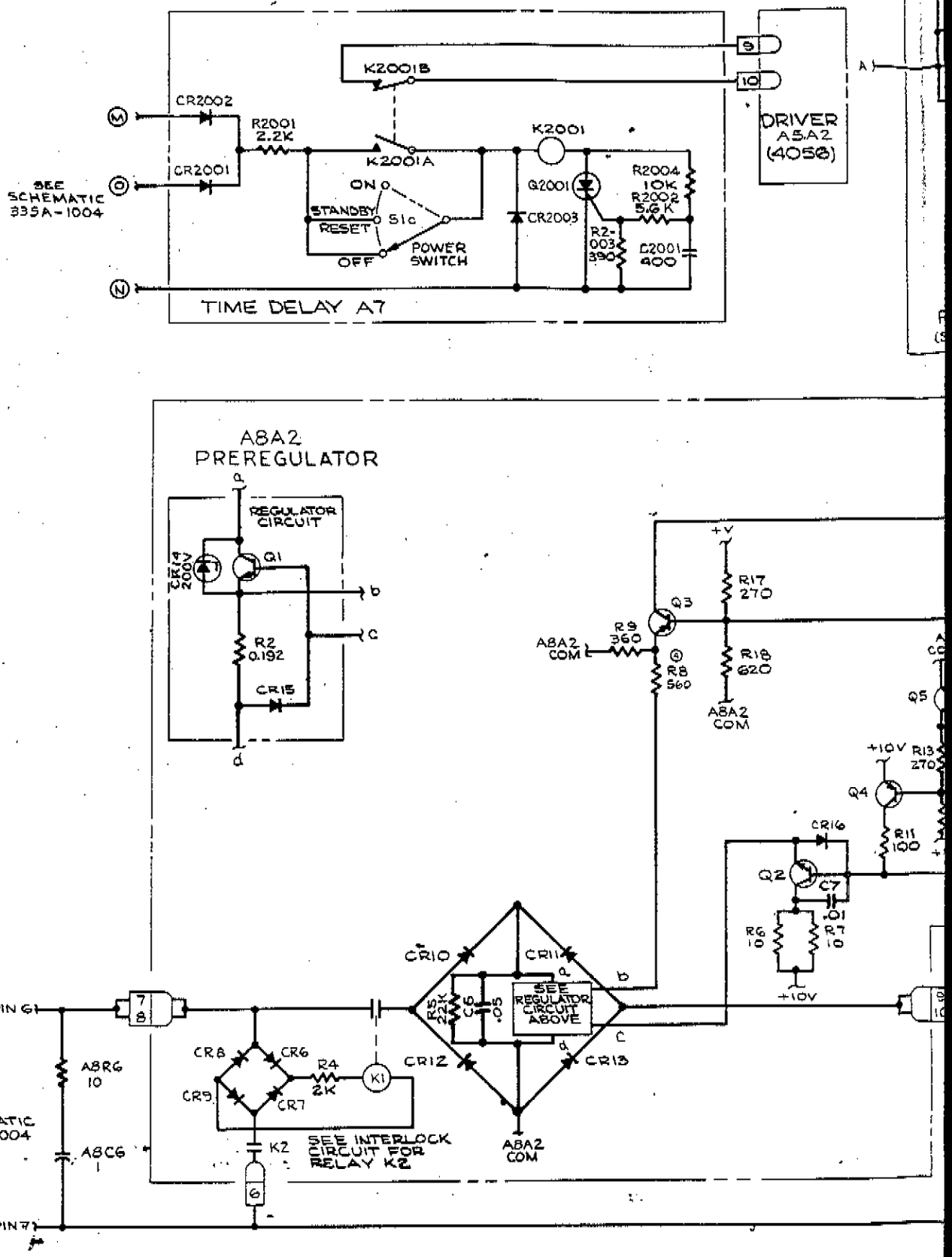
DC VOLTAGE STANDARD/
DIFFERENTIAL VOLTMETER/
NULL DETECTOR

335A-1000

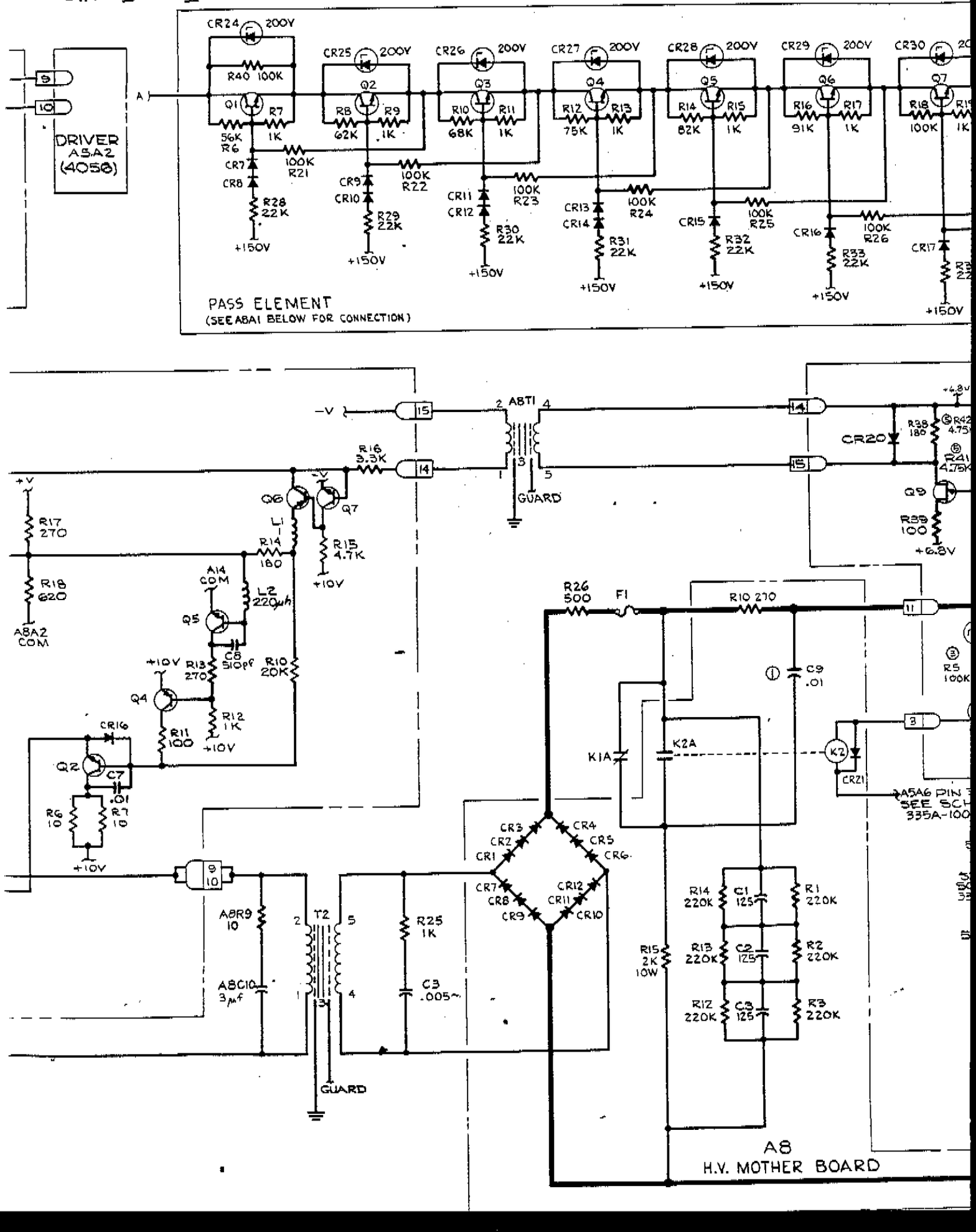
SER. NO. 123.& ON | REV. a

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133

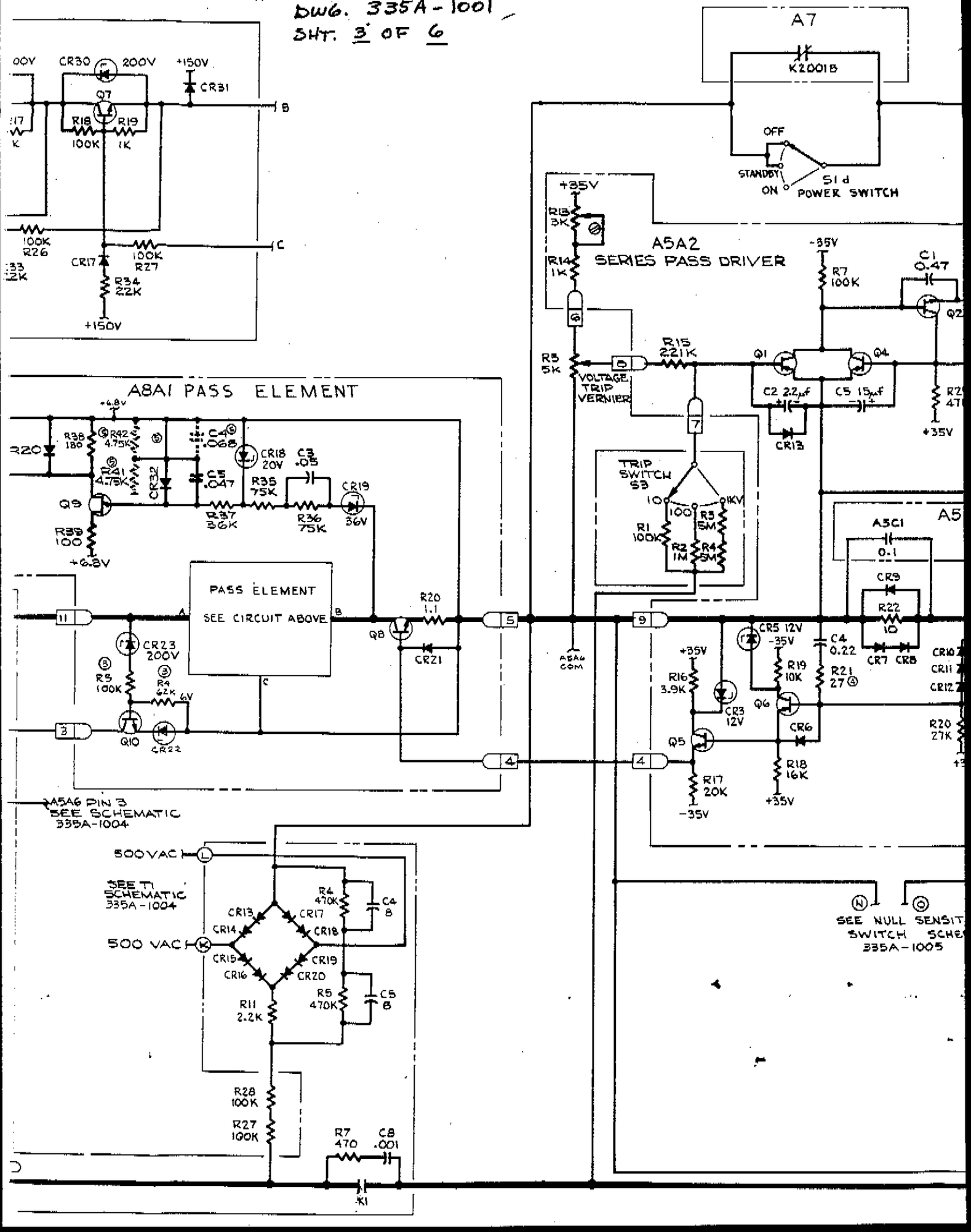
DWG. 335A-1001
SHT. 1 OF 6



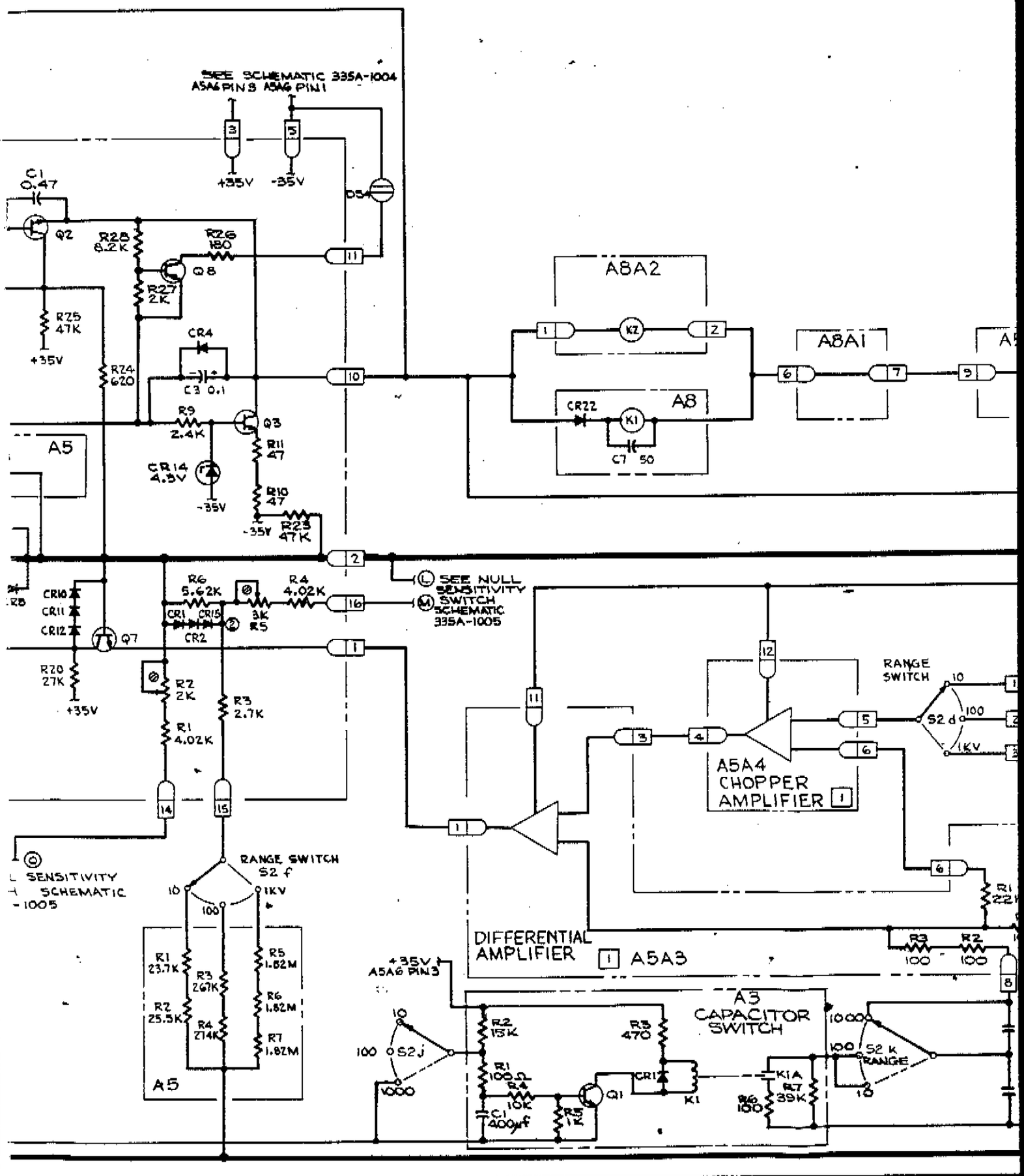
DWG. 335A-1001
SHT. 2 OF 6



DWG. 335A-1001
SHT. 3 OF 6



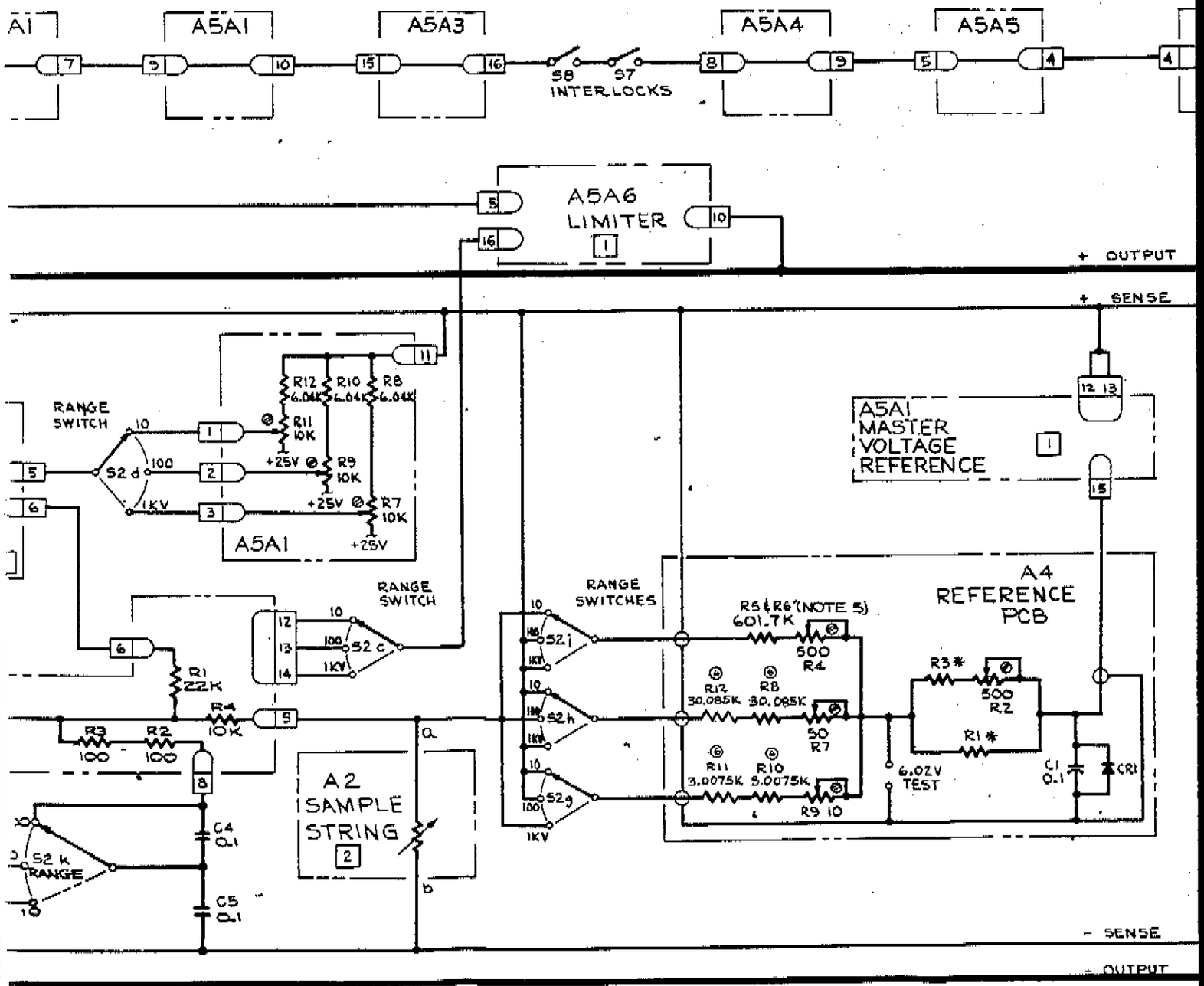
DWG. 335A-1001
SHT. 4 OF 6



Dwg.
335A-1001
SHT. 5 OF 6

NOTES:

1. ▷ FLAG NOTES WITH THE SAME NUMBERS ARE CONNECTED
2. * INDICATES FACTORY SELECTED COMPONENT
3. ⊘ INDICATES INTERNAL ADJUSTMENT
4. ALL RESISTANCES ARE IN OHMS, ALL CAPACITANCES IN MICROFARADS, AND ALL INDUCTANCES ARE IN MILLI-HENRIES UNLESS OTHERWISE SPECIFIED
5. RESISTOR DESIGNATED R5 & R6 IS ACTUALLY TWO RESISTORS IN SERIES TO PRODUCE 601.7 K-OHMS.



DWG. 335A-1001
SHT. 6 OF 6

...G NOTES WITH THE SAME
...BERS ARE CONNECTED

...TES FACTORY SELECTED
...ENT

...TES INTERNAL ADJUSTMENT

...STANCES ARE IN OHMS, ALL
...NCES IN MICROFARADS, AND
...CTANCES ARE IN MILLI-
... UNLESS OTHERWISE SPECIFIED

...OR DESIGNATED R5 & R6 IS
...Y TWO RESISTORS IN SERIES
...DUCE 601.7 K-OHMS.

SCHEMATIC DETAIL REFERENCE:

[1] REFER TO SCHEMATIC 335A-1002

[2] REFER TO SCHEMATIC 335A-1003

CHANGES:

(1) ADDED AT S/N 148 AND ON

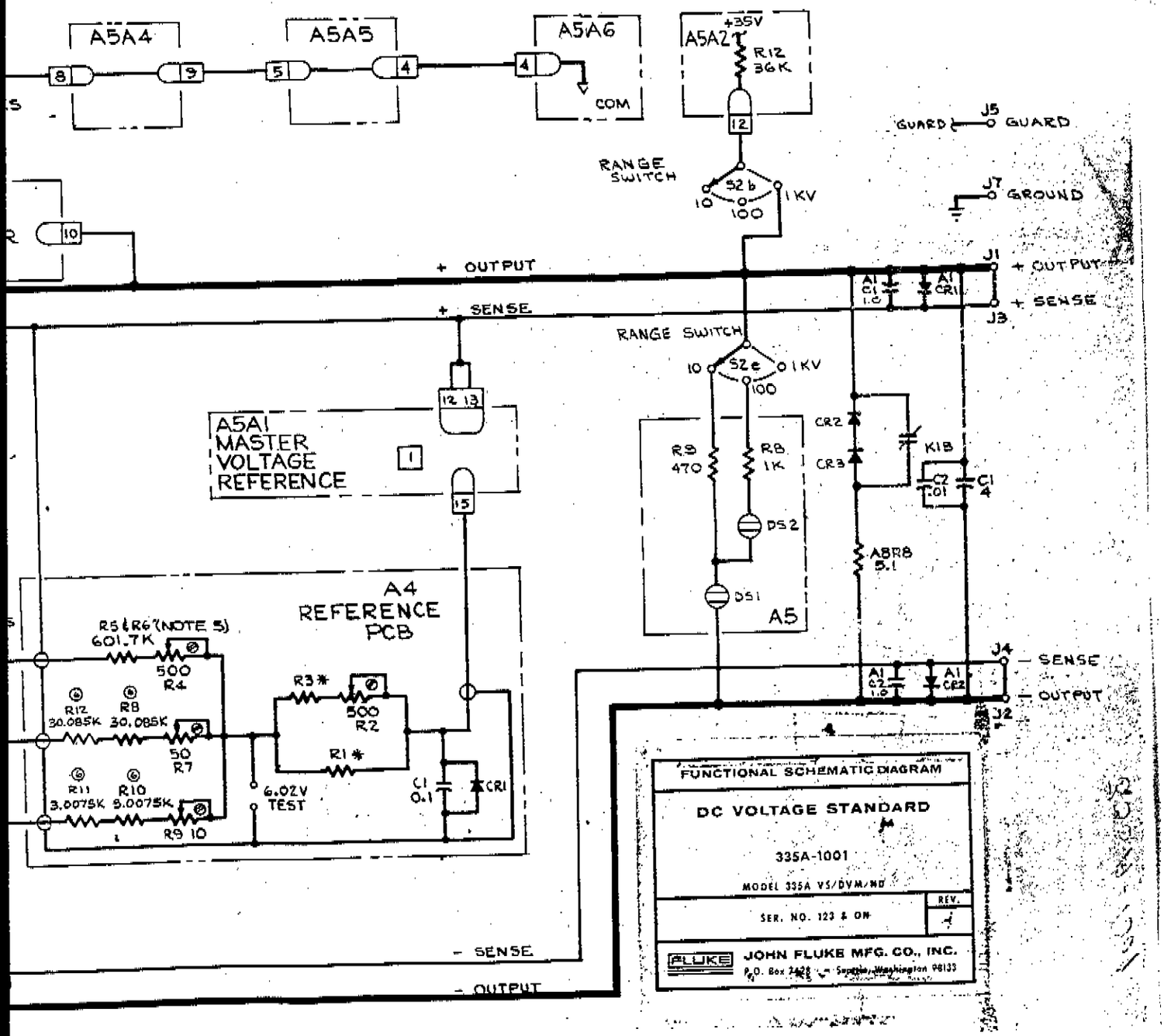
(2) CR15 ADDED AT S/N 399 AND ON

(3) A8A1R1 WAS 360Ω AND A8A1R5 WAS 270K [illegible] 209.

(4) FOR S/N 125 THRU 576:
A5A2R1 WAS 220Ω; A8A2R8 WAS 430Ω

(5) FOR S/N 600 AND 621 AND ON:
A8A1C4 & A8A1R41 DELETED
A8A1R42 REPLACED WITH BUSS WIRE

(6) FOR S/N 630 AND 761 THRU 776:
A4R8 CHANGED FROM 60.175K TO 30.085K
A4R10 CHANGED FROM 6.015K TO 3.0075K
A4R11 & A4R12 ADDED




FUNCTIONAL SCHEMATIC DIAGRAM

DC VOLTAGE STANDARD

335A-1001

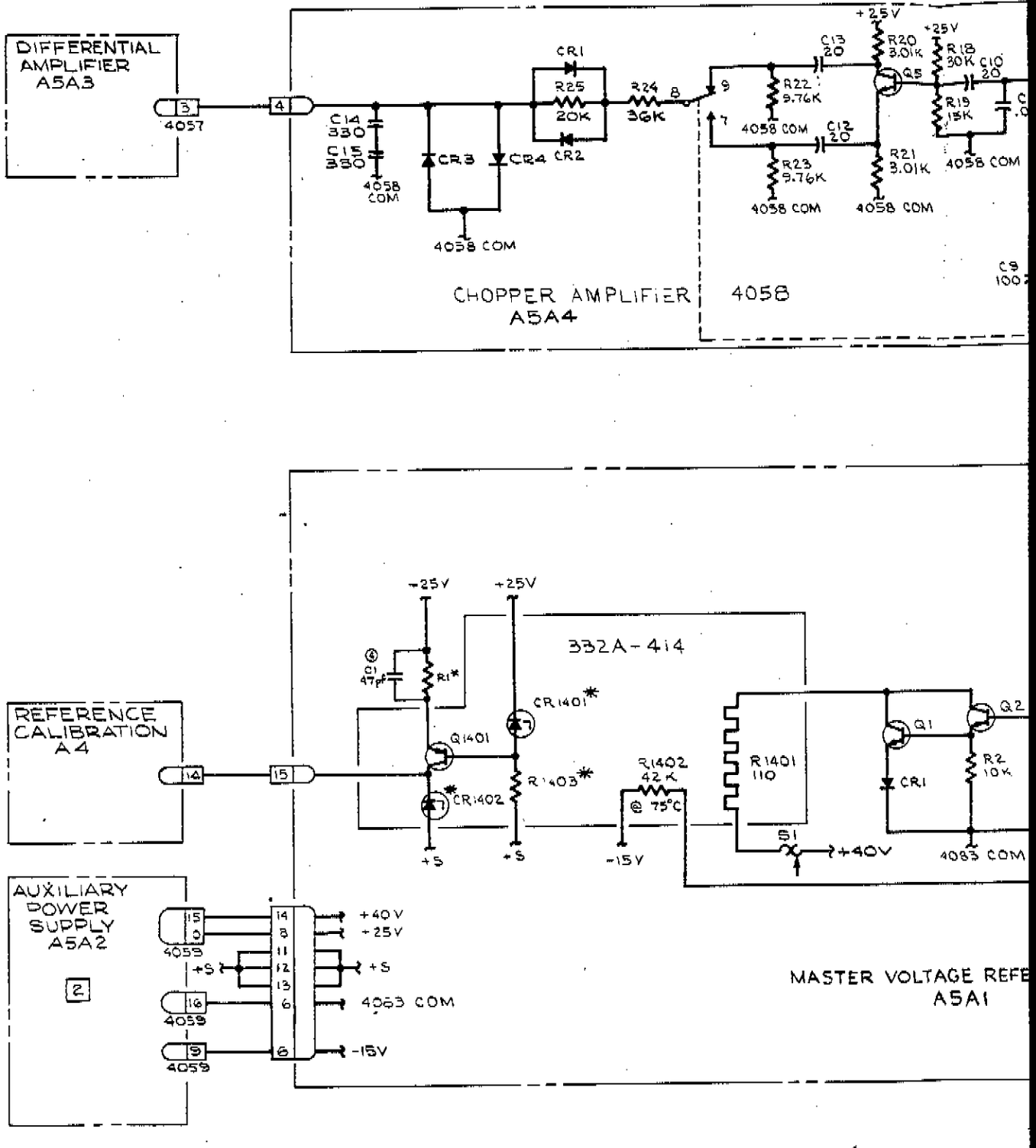
MODEL 335A VS/DVM/ND

SER. NO. 123 & ON

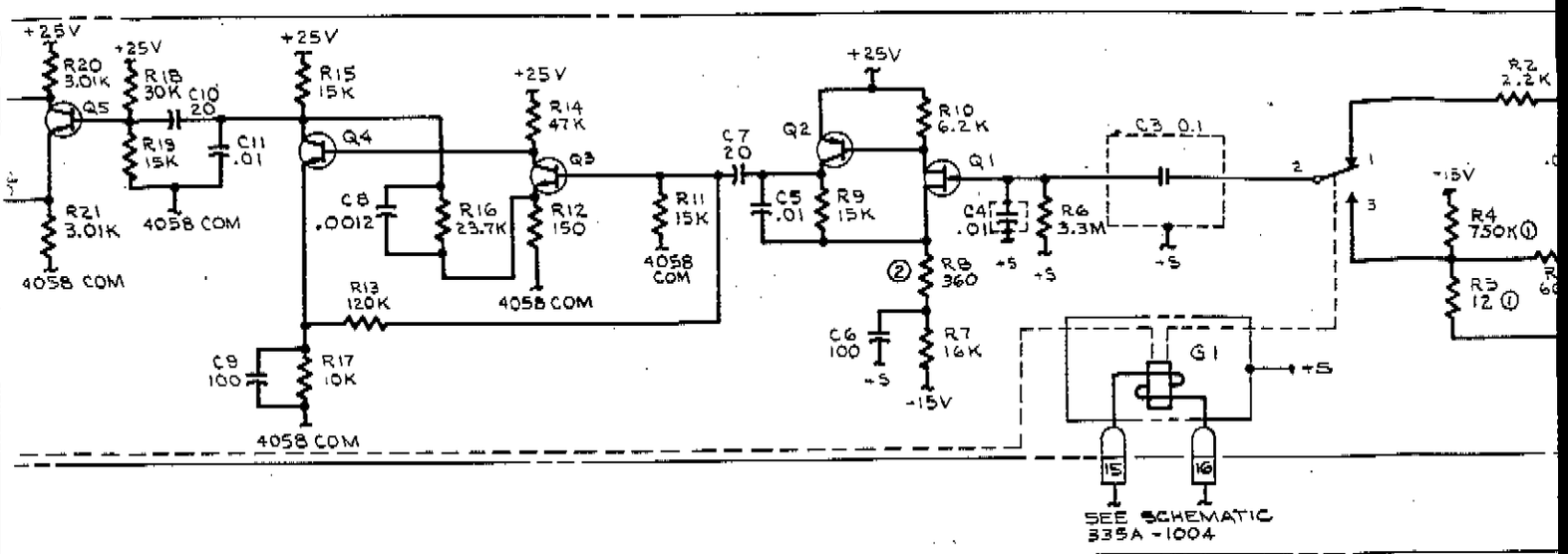
REV. 4

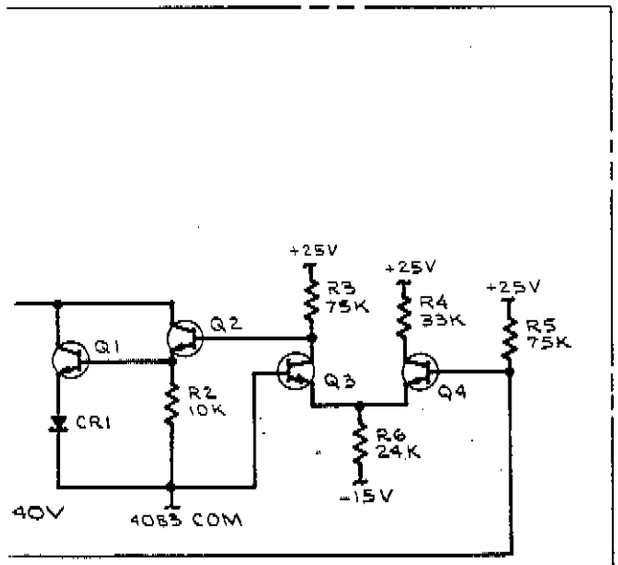
FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 2428 — Seattle, Washington 98133

DWG. 335A-1002
SHT. 1 OF 6

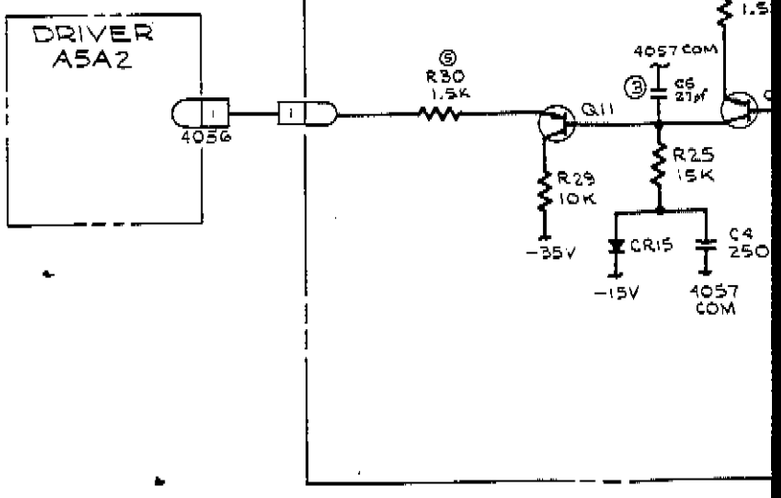


DWG. 335A -1002
SHT. 2 OF 6



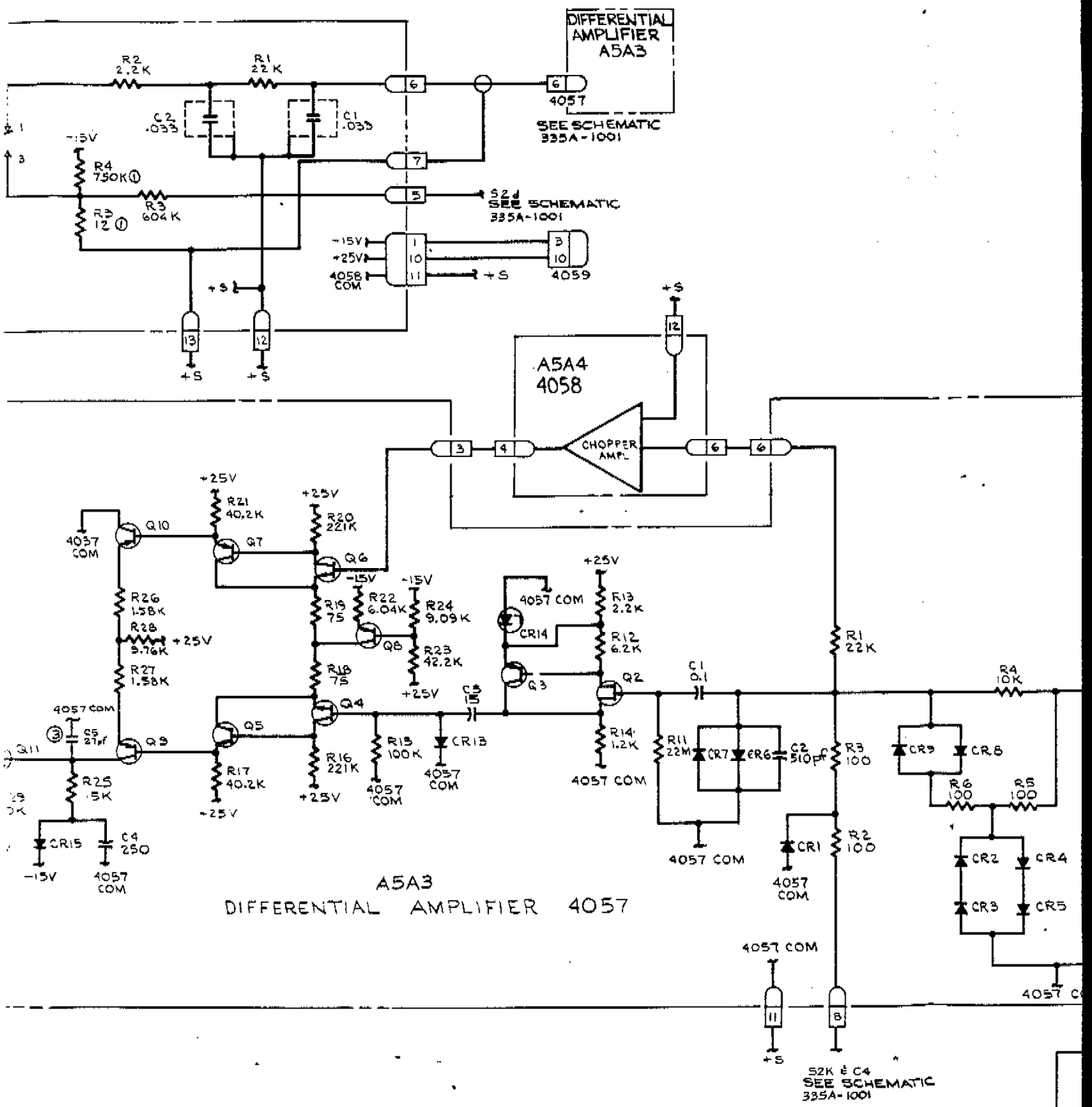




ER VOLTAGE REFERENCE
A5A1



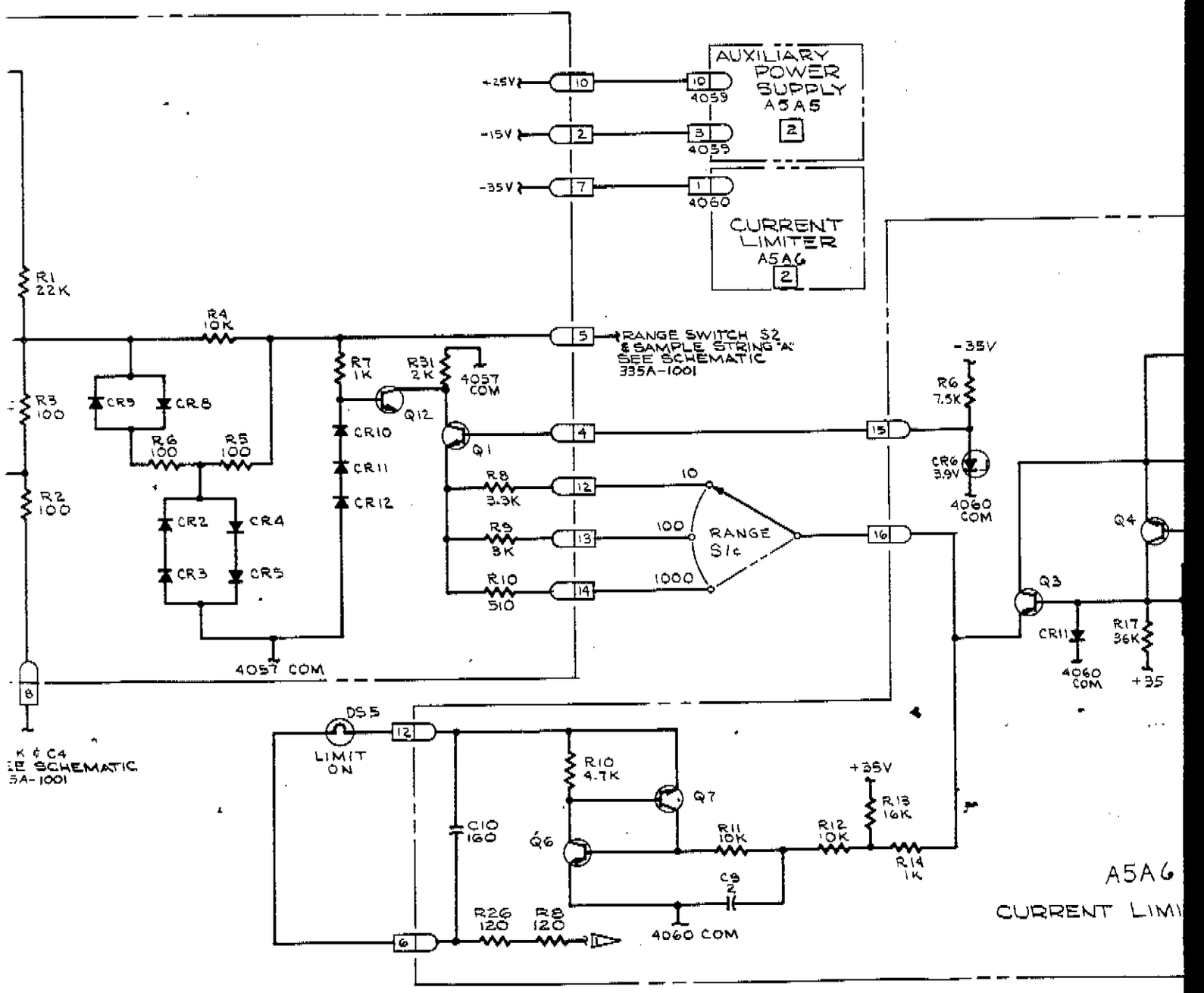
DWG. 335A-1002

SHT. 3 OF 6

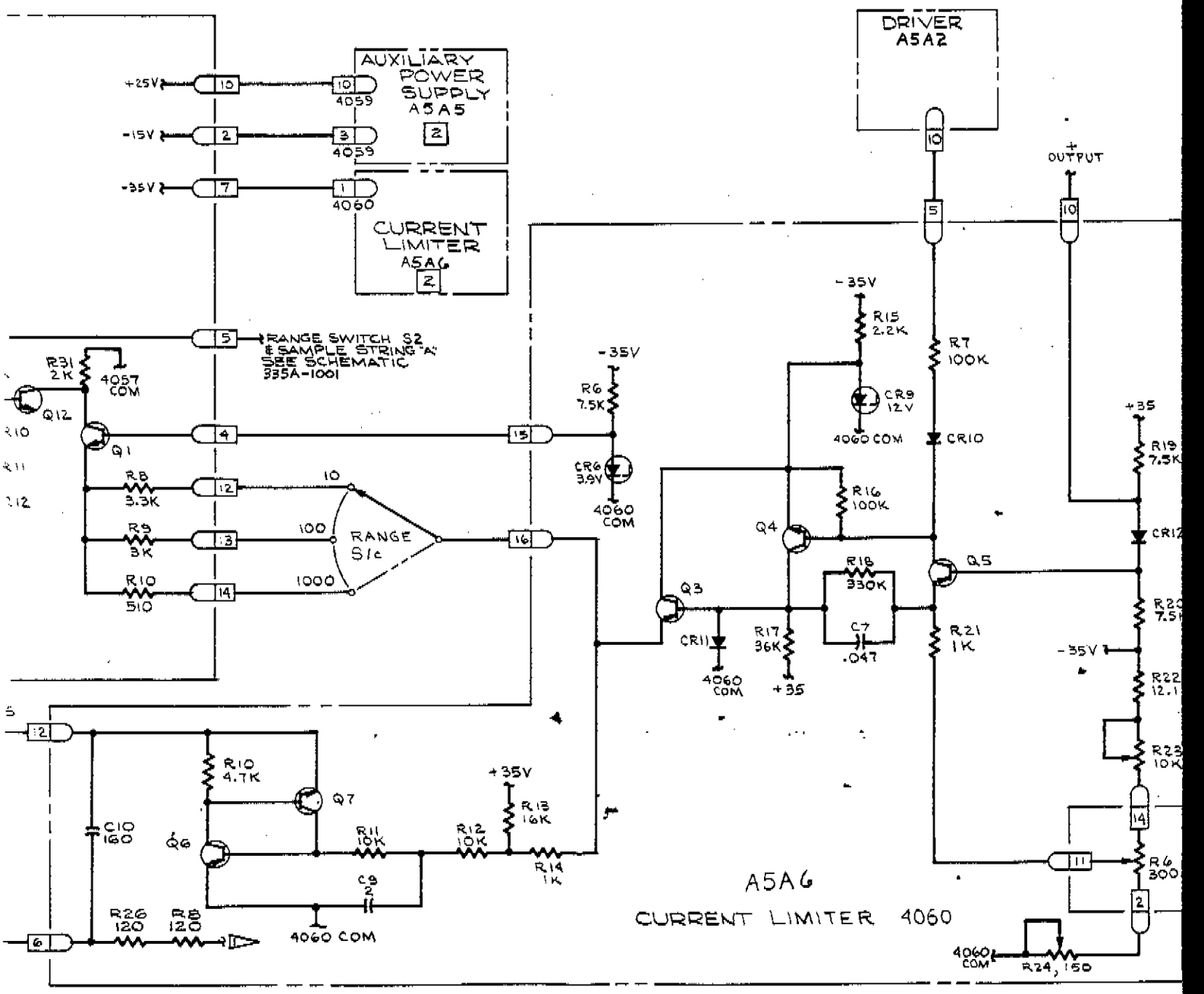


DWG. 335A-1002

SHT: 1 OF 6



DWG. 335A-1002
SHT. 5 OF 6



DWG. 335A-1002
SHT. 6 OF 6

CHANGES:

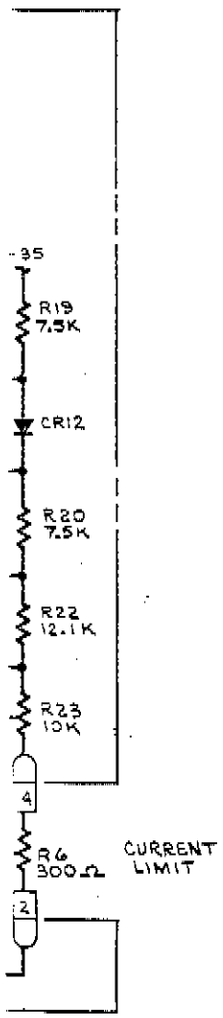
① A5A4R4 WAS 604K AND A5A4R5 WAS 10Ω FROM S/N 123 THRU 220

② A5A4R8 WAS CHANGED FROM 200Ω TO 360Ω 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

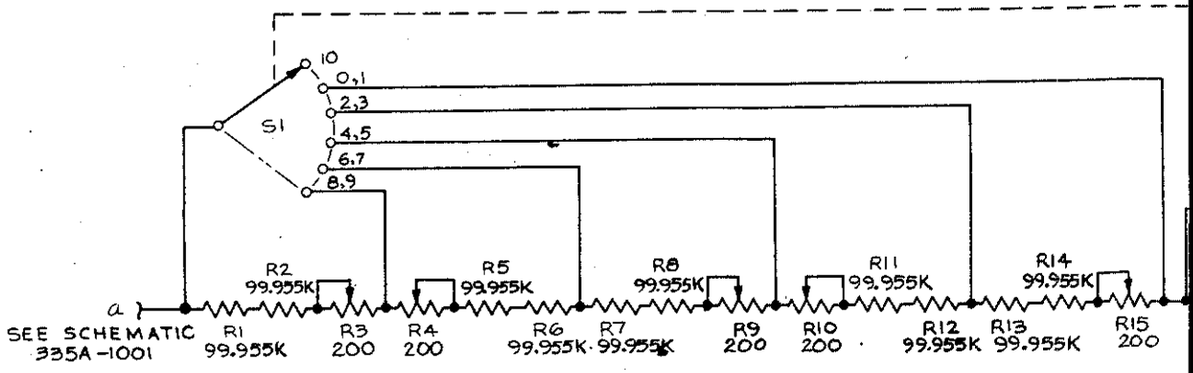
MODEL 335A V5/DVM/ND

SER. NO. 123 & ON

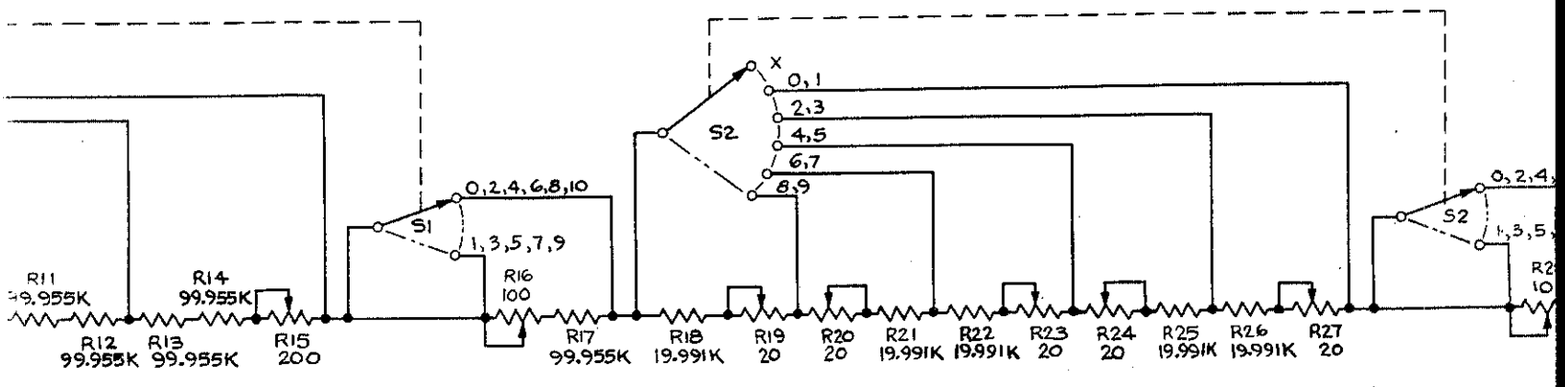
REV. C

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133

DWG. 335A-1003
SHT. 1 OF 6

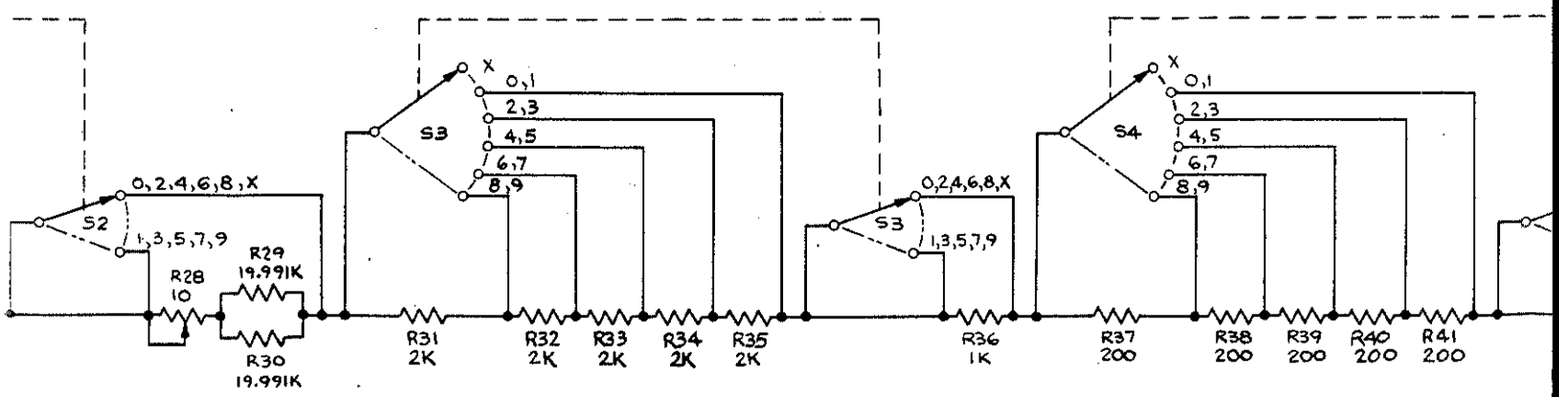


DWG. 335A-1003
SHT. 2 OF 6



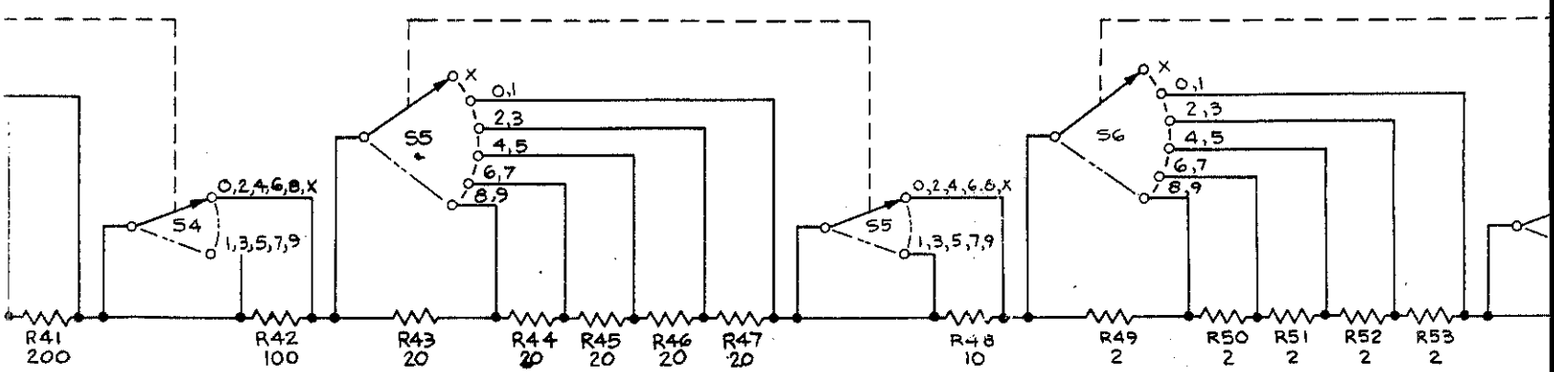
DWG. 335A-1003

SHT. 3 OF 6

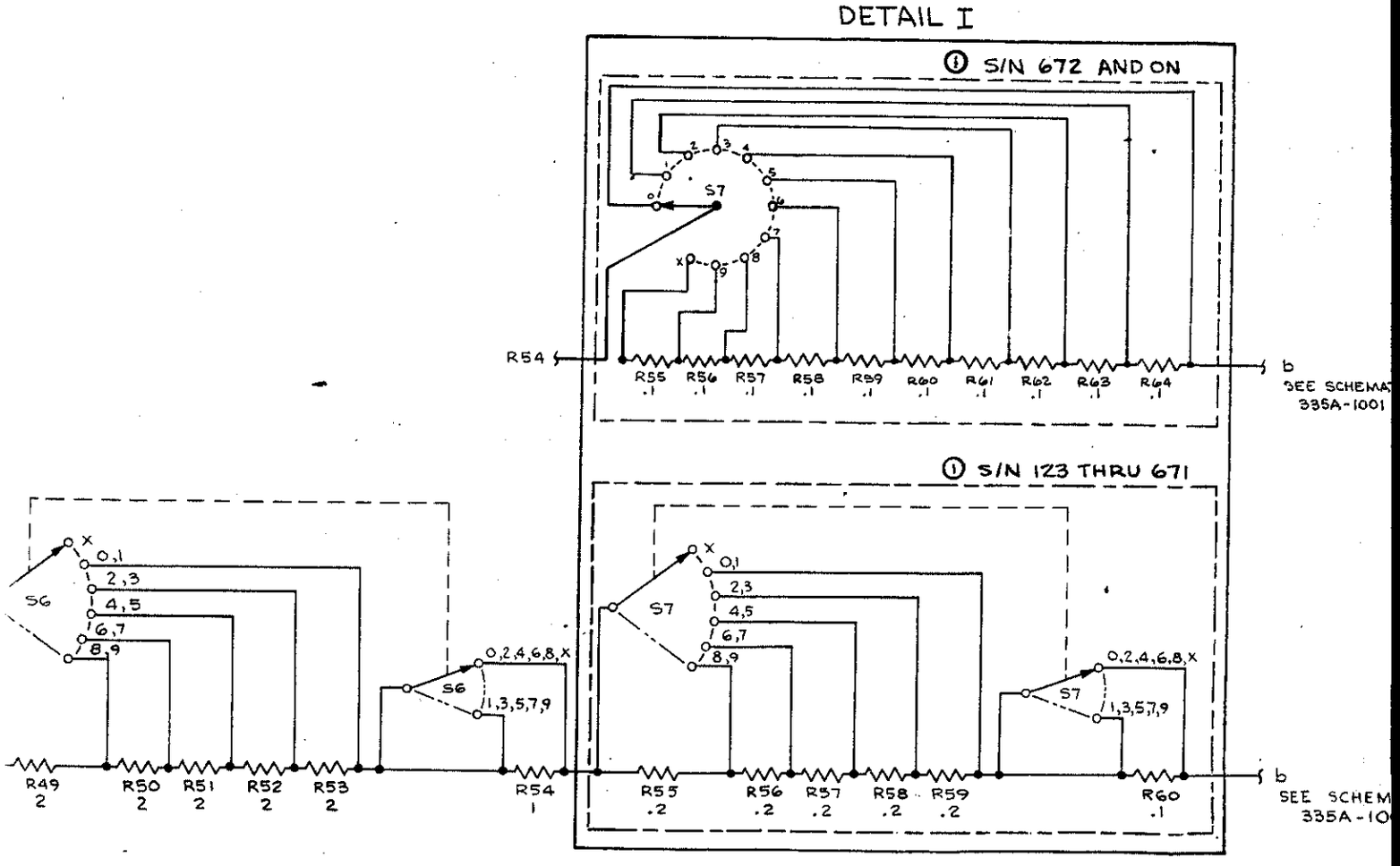


DWG. 3351-1003

SHT. 4 OF 6



DWG. 335A-1003
SHT. 5 OF 6

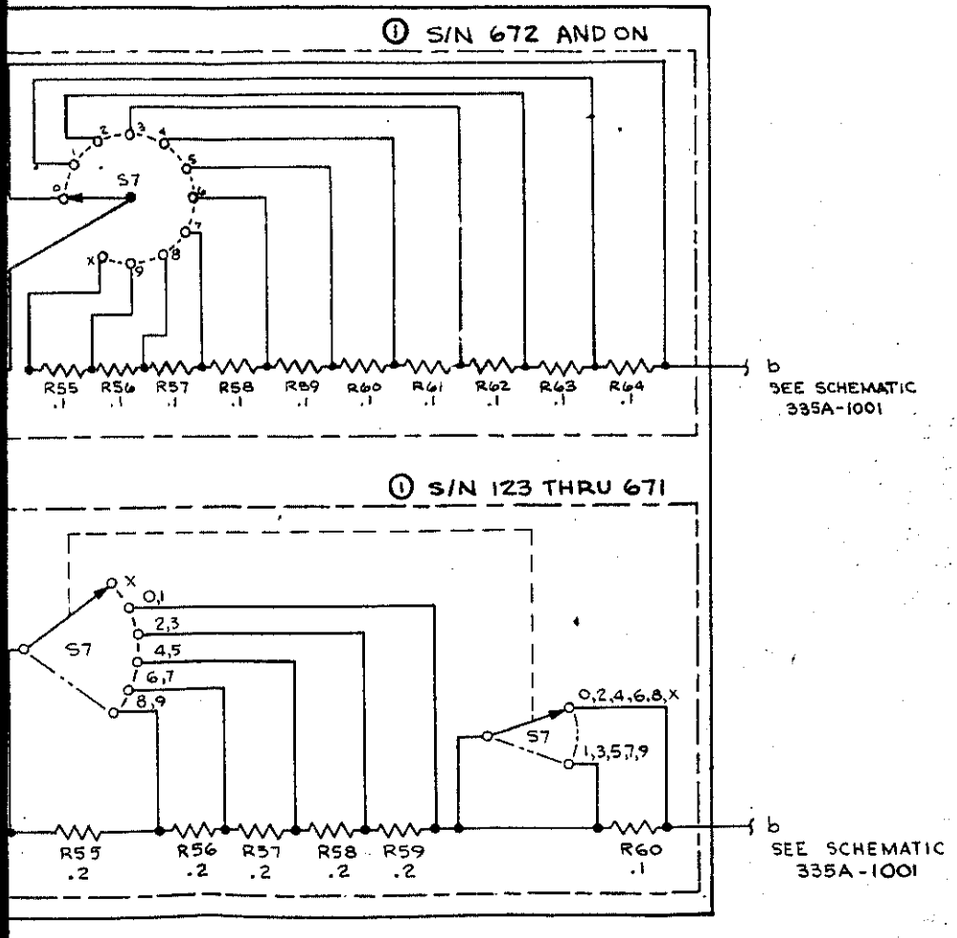



CHANGES:

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

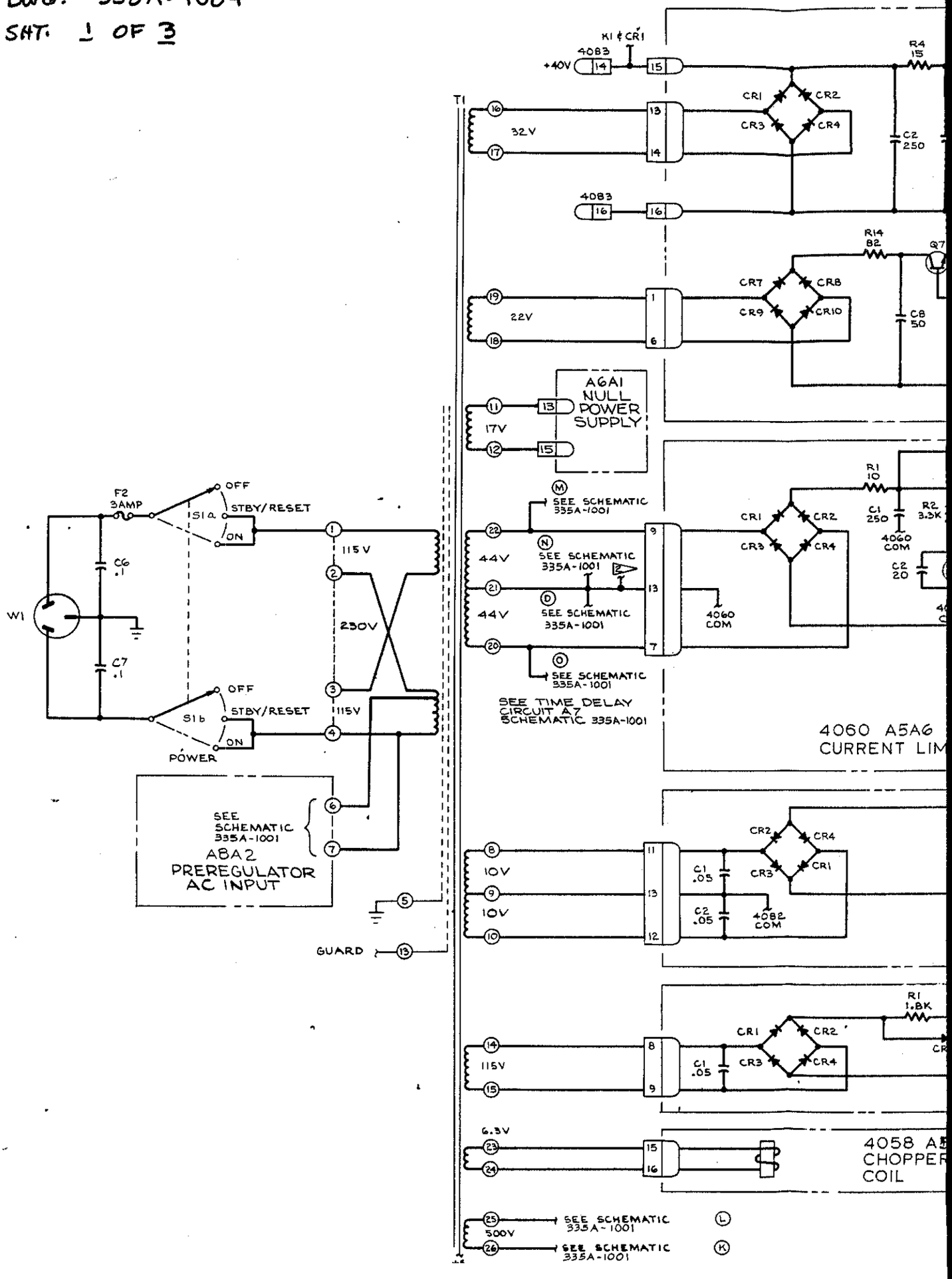
DETAIL I



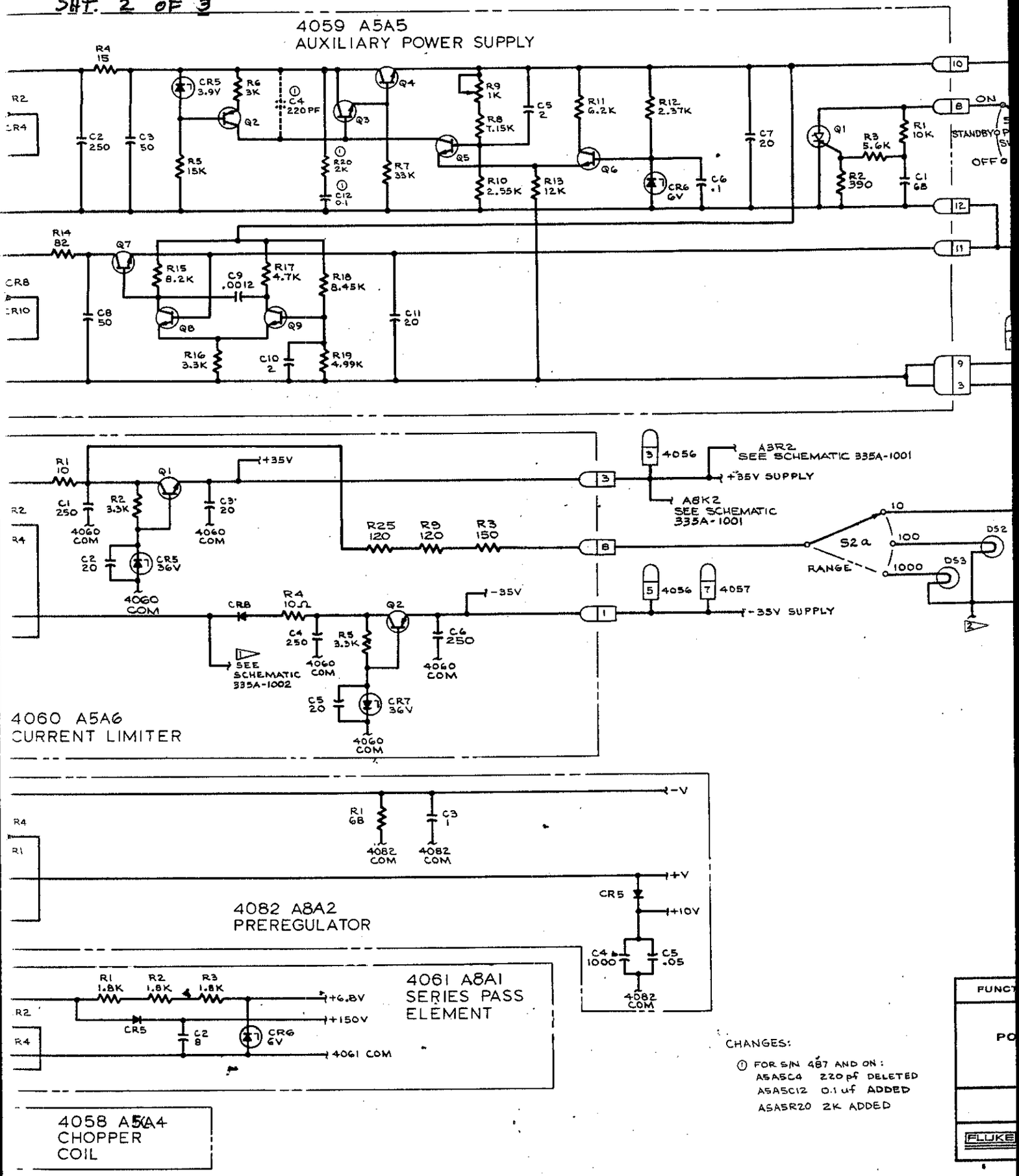

CHANGES:
① FOR S/N 672 AND ON:
S7 CONFIGURATION CHANGED.
R55 THRU R60 WW CARD RESISTORS CHANGED TO R55 THRU R64 RESISTANCE WIRE.

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

DWG. 335A-1004
SHT. 1 OF 3



DWG. 335A-1004
SHT. 2 OF 3

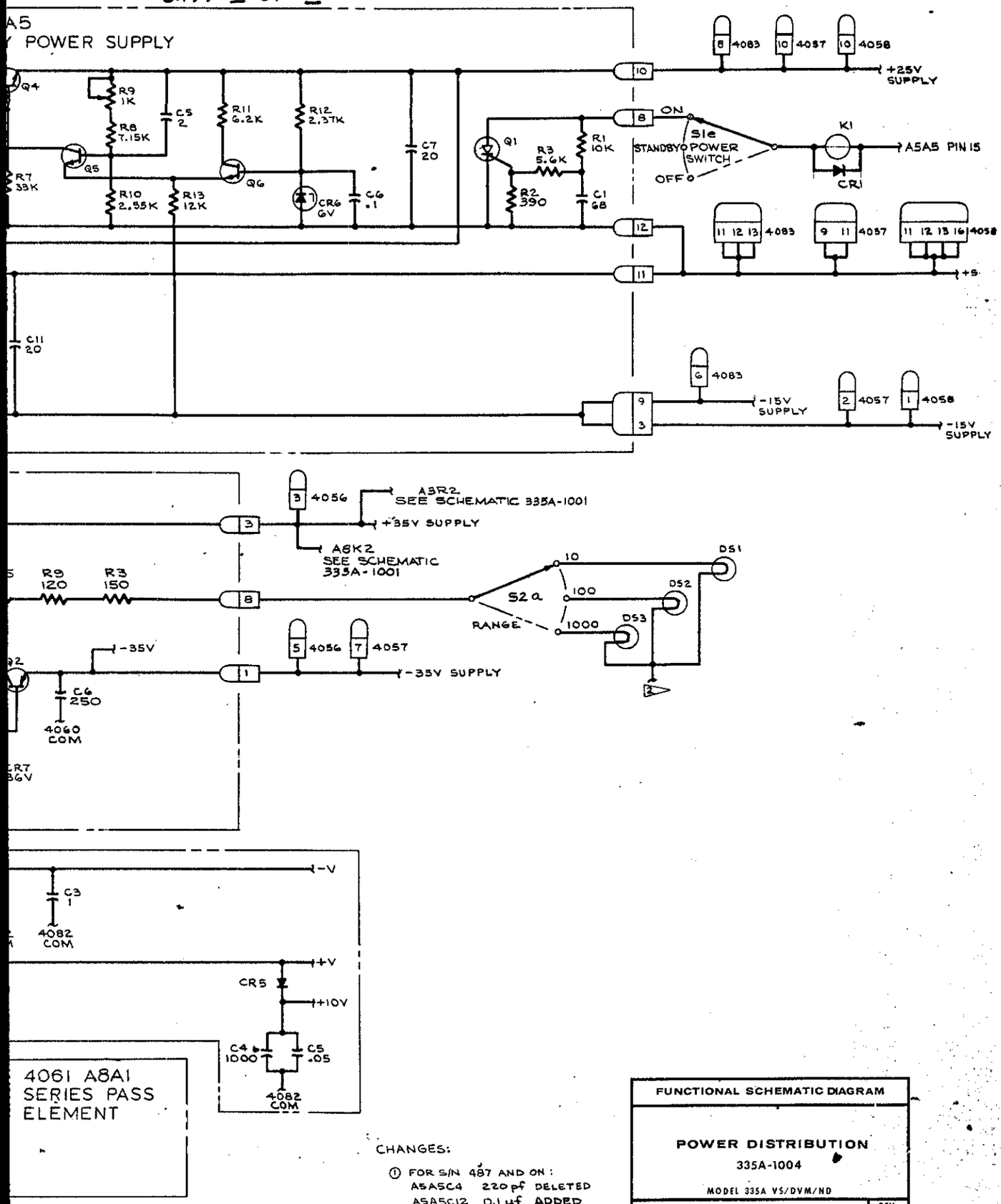



CHANGES:

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

FUNCT
PO
FLUKE

DWG. 335A-1004
SHT. 3 OF 3



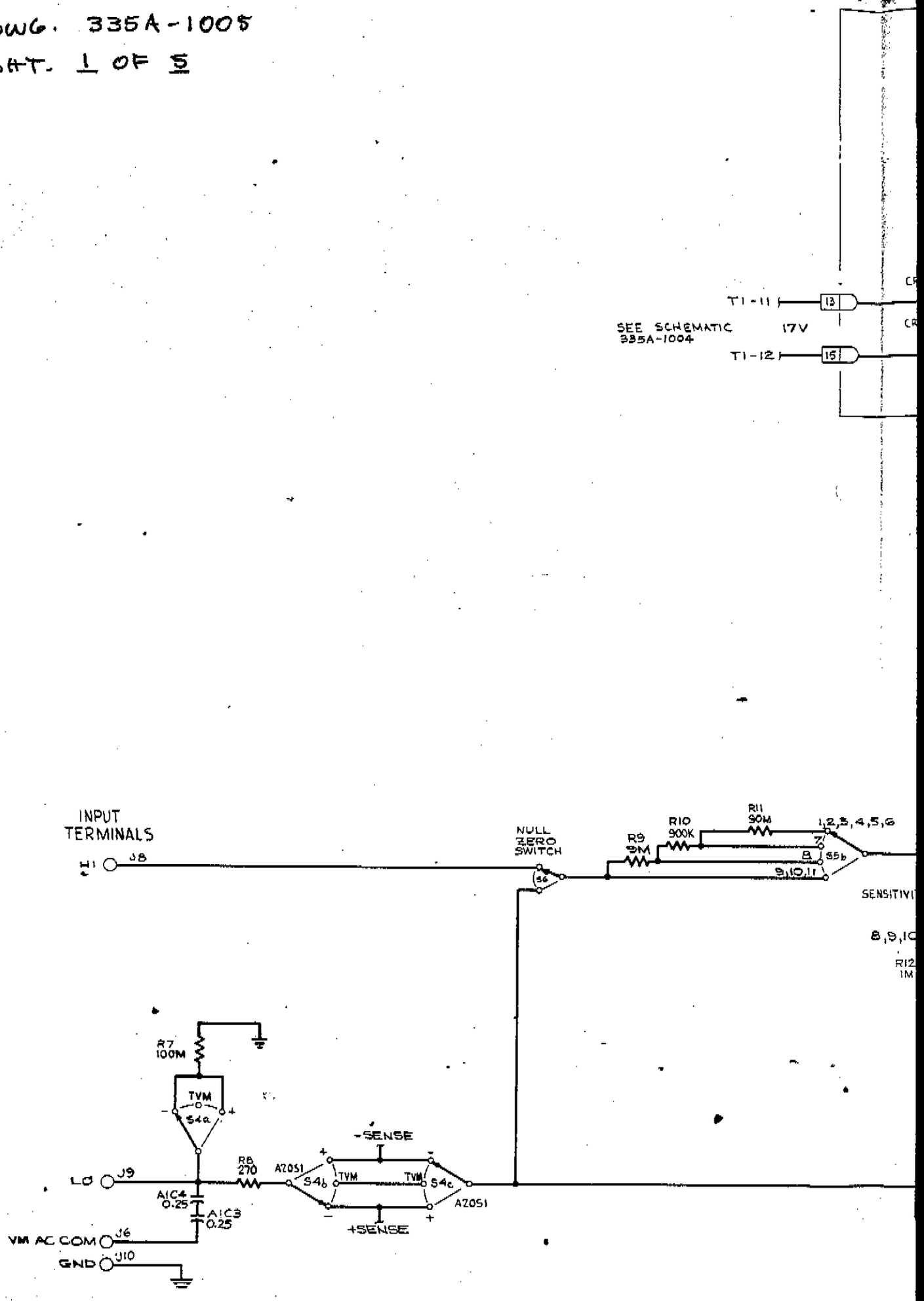

CHANGES:

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

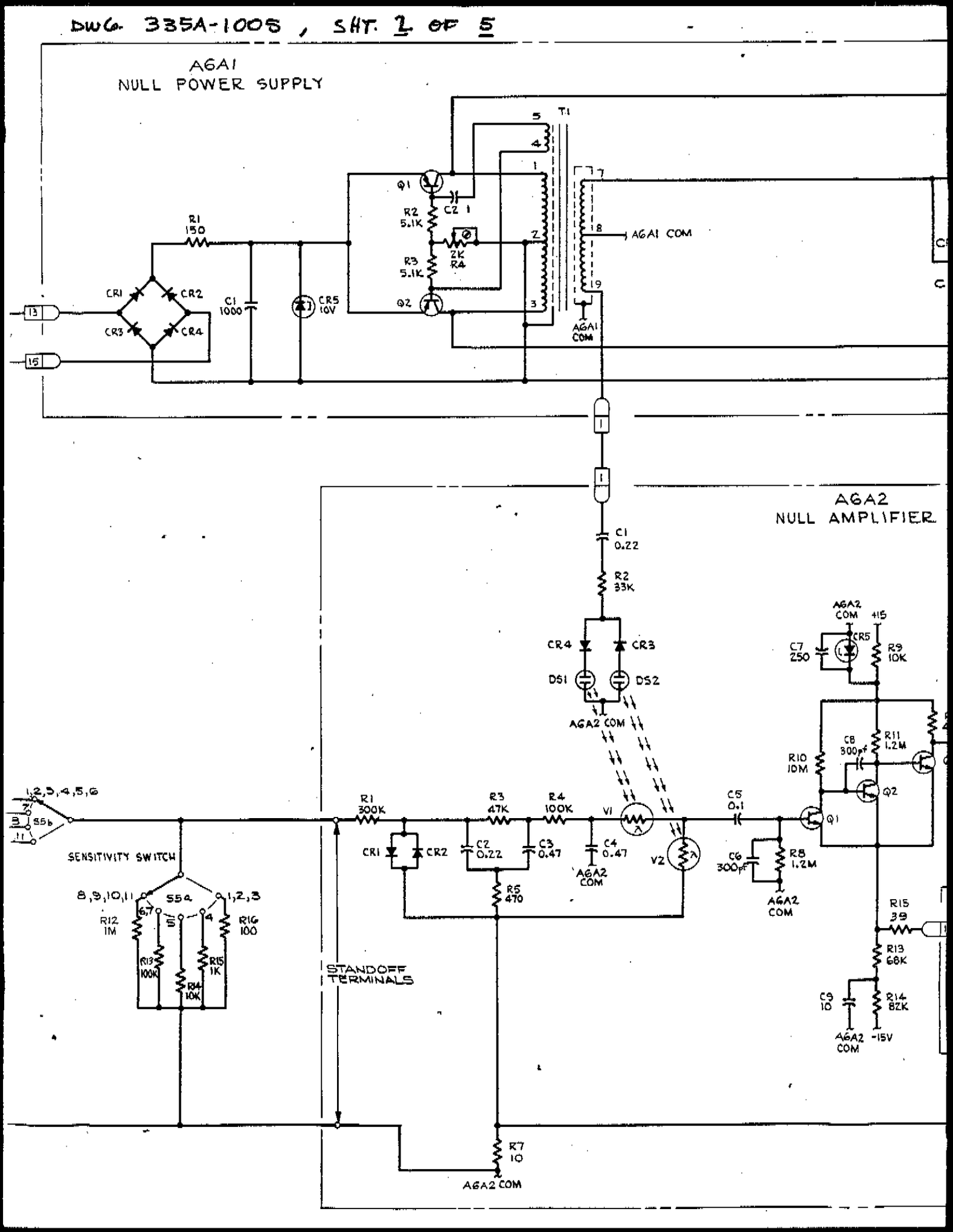
| FUNCTIONAL SCHEMATIC DIAGRAM | |
|---|---|
| POWER DISTRIBUTION<br>335A-1004<br>MODEL 335A VS/DVM/ND | |
| SER. NO. 123 & ON | REV. b |
| FLUKE JOHN FLUKE MFG. CO., INC.<br>P.O. Box 7428 Seattle, Washington 98133 | |

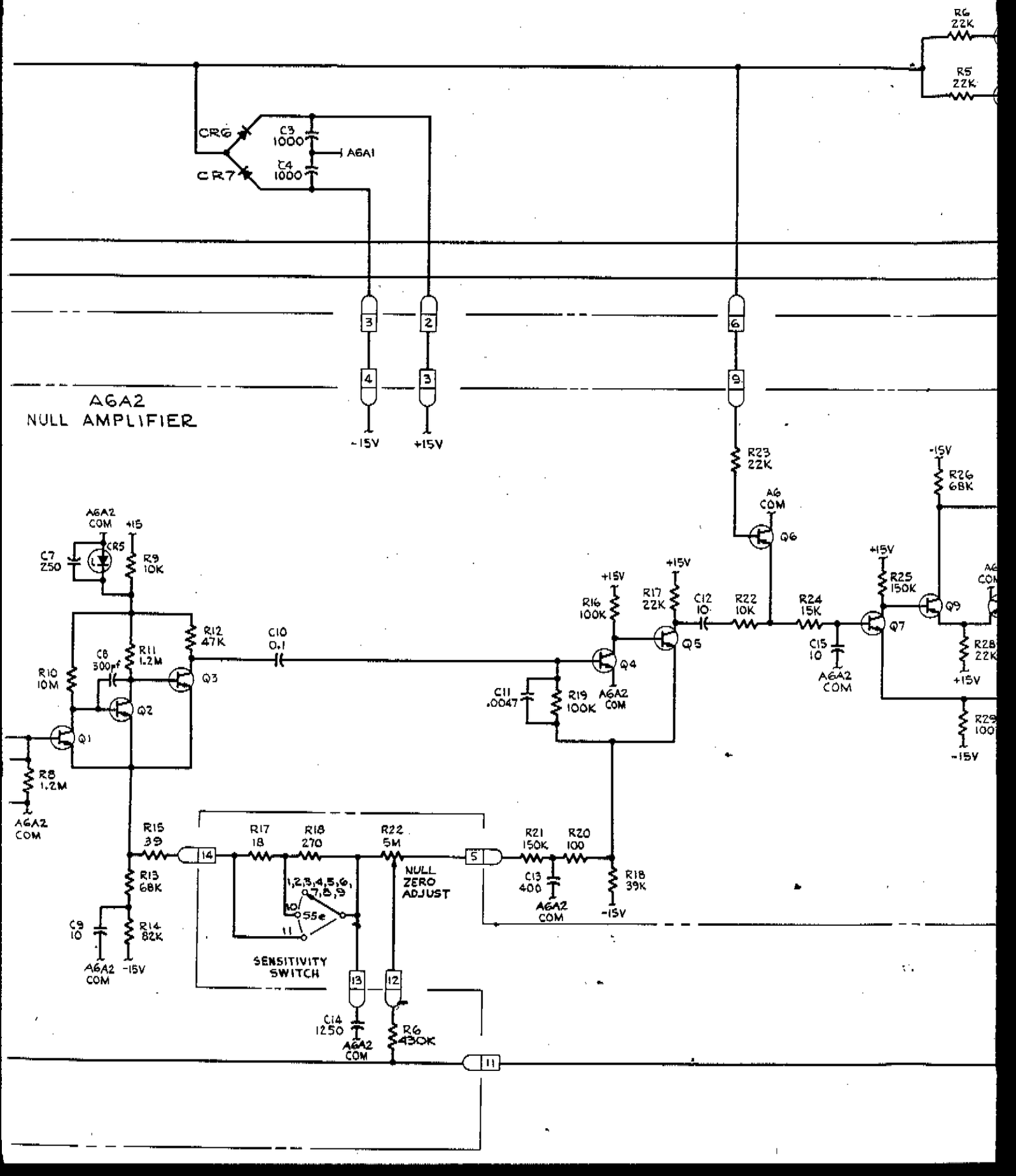
DWG. 335A-1005

SHT. 1 OF 5

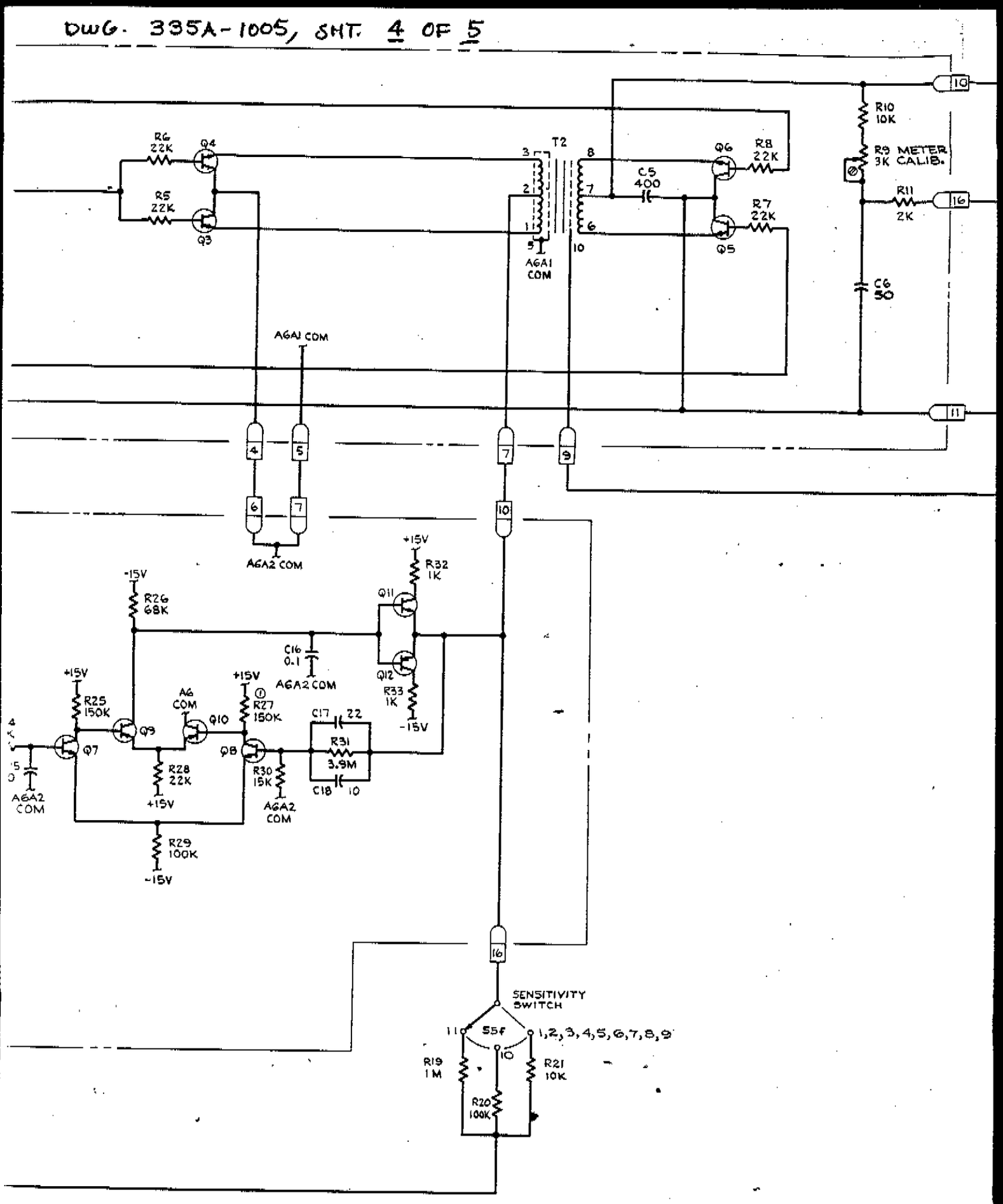


DWG. 335A-1005, SHT. 2 OF 5

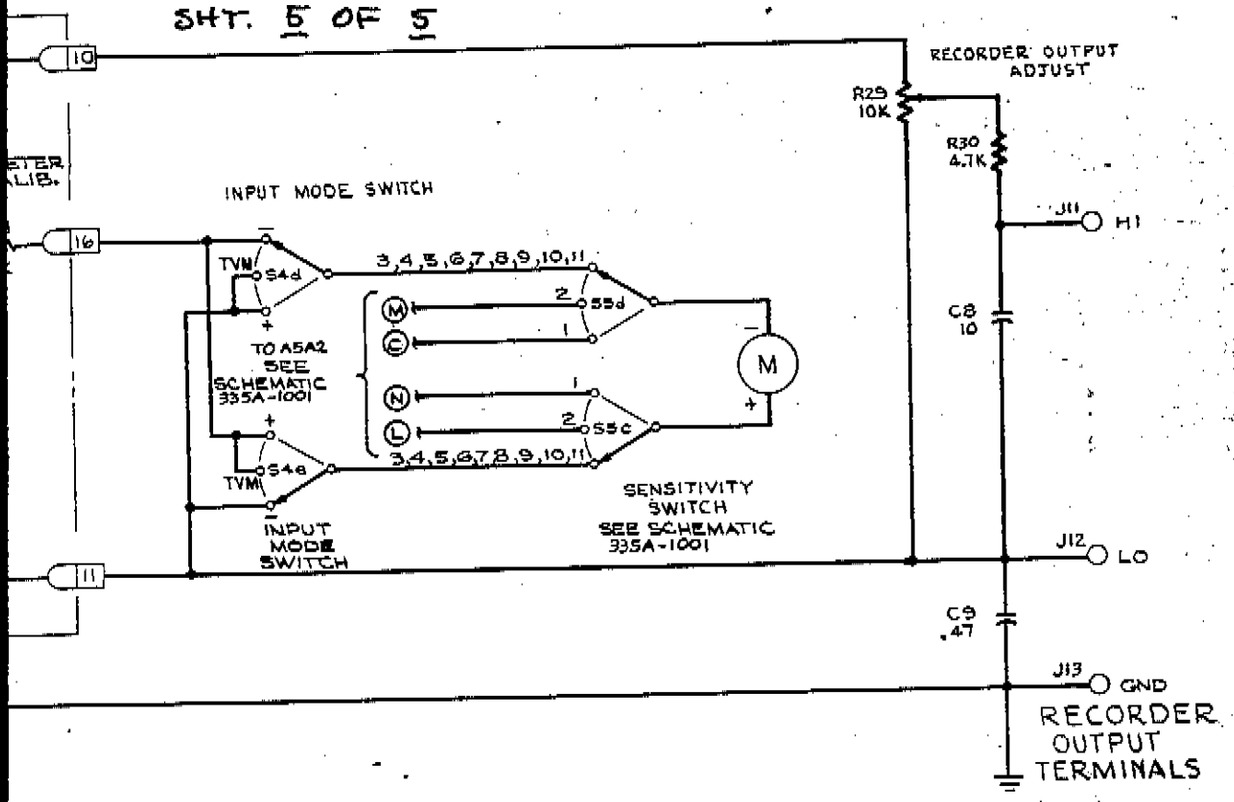



A6A2
NULL AMPLIFIER
CR6
CR7
C3 1000
C4 1000
A6A1
R6 22K
R5 22K
-15V
+15V
A6A2 COM
C7 250
CR5
R9 10K
R10 10M
C8 300pf
R11 1.2M
R12 47K
C10 0.1
Q1
Q2
Q3
R8 1.2M
R15 39
R13 68K
C9 10
R14 82K
R17 18
R18 270
R22 5M
NULL ZERO ADJUST
1,2,3,4,5,6,7,8,9
10
55e
11
SENSITIVITY SWITCH
C14 1250
R6 430K
R16 100K
R17 22K
C12 10
R22 10K
R24 15K
C15 10
Q4
Q5
Q6
Q7
Q9
C11 .0047
R19 100K
R21 150K
R20 100
C13 400
R18 39K
R23 22K
A6 COM
R25 150K
R26 68K
R28 22K
R29 100
+15
-15V

DWG. 335A-1005, SHT. 4 OF 5



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 | |