FLUKE ®

Instruction Manual

Model

332B

DC Voltage Standard

P/N 293936

JANUARY 1972

Rev. 1 3/75

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within one year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or the nearest Service facility, giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

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

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC. will be happy to answer all application or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, ATTEN: Sales Dept. For European Customers: Fluke (Nederland) B.V., Zevenheuvelenweg 53, Tilburg, The Netherlands.

* For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., • P.O. Box 43210 • Mountlake Terrace, Washington 98043

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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 332B DC Voltage Standard provides dc voltages from 0 to 1111 volts with an accuracy of ±0.0020%. Output current is rated at 0 to 50 milliamperes. The output voltage is set by seven in-line decade switches. Separate terminals are provided for sensing the output voltage directly at the load, thereby eliminating errors due to voltage drop in connecting wires between the instrument and load.

1-3. Protection against possible equipment failures or operator errors, which might damage expensive instruments, are incorporated. The VOLTAGE TRIP and VERNIER controls provide a means of limiting the output voltage within the selected 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.

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 may cause error.

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.

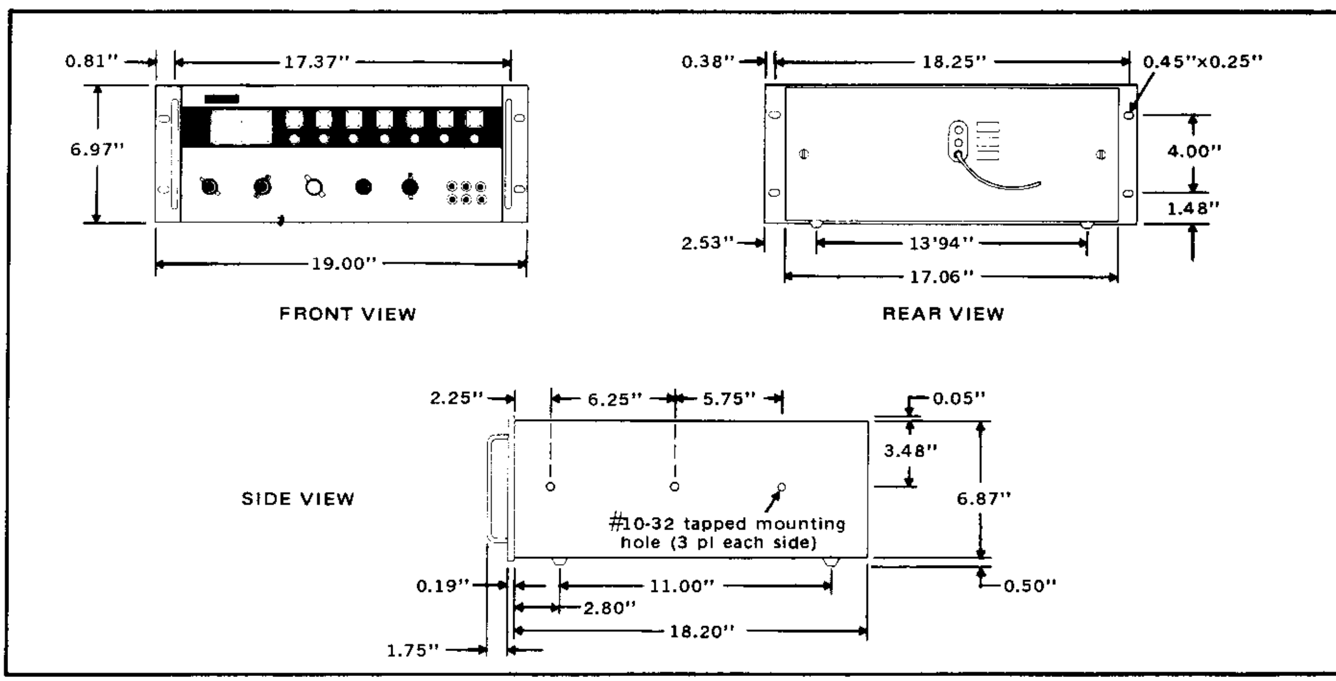


Figure 1-1. MODEL 332B OUTLINE DRAWING

1-6. SPECIFICATIONS

OUTPUT VOLTAGE: 0 to 1111.1110 VDC.

VOLTAGE RANGES: 10, 100, and 1000V ranges with outputs as follows:
0 to 11.111110 (1 uv steps)
0 to 111.11110 (10 uv steps)
0 to 1111.1110 (100 uv steps)

RESOLUTION: 0.1 ppm of range (1 uv maximum).

ACCURACY OF OUTPUT: (For 90 days)
10V range - ±(0.002% of setting + 10 uv)
100V range - ±(0.002% of setting + 0.00002% of range)
1000V range - ±(0.002% of setting + 0.00002% of range)

NOTE: The above 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.

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

STABILITY OF OUTPUT: (At standard reference conditions described under ACCURACY OF OUTPUT).

10V range
±(0.001% of setting + 10 uv) per month
±(0.002% of setting + 20 uv) per year

100V and 1000V ranges
±(0.001% of setting + 20 uv) per month
±(0.002% of setting + 40 uv) per year

OUTPUT CURRENT: 0 to 50 milliamperes at any output voltage.

OVERCURRENT PROTECTION: Automatically limits output current at any preset level between 1 ma and 60 ma via continuously variable front panel control. Panel lamp illuminates during limiting. Normal operation restored upon removal of overload.

OVERVOLTAGE PROTECTION: Automatically disables output voltage if level exceeds setting of front panel control. Continuously variable from 10% to 110% of each range. Manual reset.

DESIGN: All solid-state throughout (no vacuum tubes).

RIPPLE AND NOISE (to 30 kHz)
10V range - less than 20 uv RMS
100V range - less than 30 uv RMS
1000V range - less than 40 uv RMS

OUTPUT RESISTANCE: Less than 0.0005 ohms or ($0.0001E_O$) ohms (whichever is greater) at DC.

SETTLING TIME: Typically, 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 140 db from DC to 400 Hz, up to 700V RMS or 1000 VDC. (Output voltage changes less than 10^{-7} of the applied common mode voltage.)

ISOLATION: Either output terminal may be floated up to 1000 VDC from chassis ground.

TERMINAL CONFIGURATION:

Voltage output	- 2 terminals
Remote sense	- 2 terminals
Guard	- 1 terminal
Chassis	- 1 terminal

REMOTE SENSE: Separate terminals are provided for sensing the output voltage directly at the load, reducing errors due to voltage drop in connecting wires between the instrument and load.

METER (switch selectable): 0 - 1200 VDC
0 - 60 ma

OPERATING TEMPERATURE RANGE: 0°C to 50°C (see ACCURACY OF OUTPUT and TEMPERATURE COEFFICIENT OF OUTPUT).

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

RELATIVE HUMIDITY: 0 to 70%.

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

VIBRATION: Meets all test requirements of Mil-T-945A, rigidly mounted or rack-mounted with slides.

ALTITUDE: 10,000 ft. operating; 50,000 ft. non-operating.

FUNGUS NUTRIENTS: None.

MERCURIC COMPONENTS: None.

FUSES: One power line fuse, one high voltage fuse.

INPUT POWER: 115/230 VAC ±10%, 50 - 60 Hz, single phase. Approximately 130 VA fully loaded.

SIZE: 7" high x 19" wide x 18" behind panel.

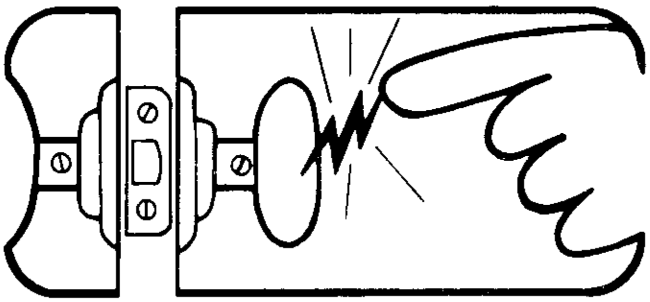
WEIGHT: 60 lbs.

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

static awareness

A Message From

John Fluke Mfg. Co., Inc.



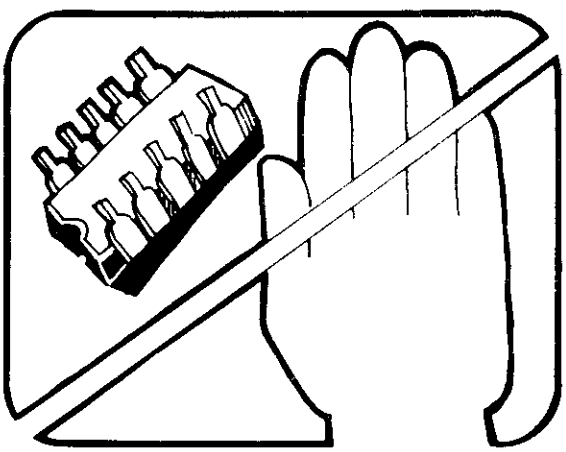
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

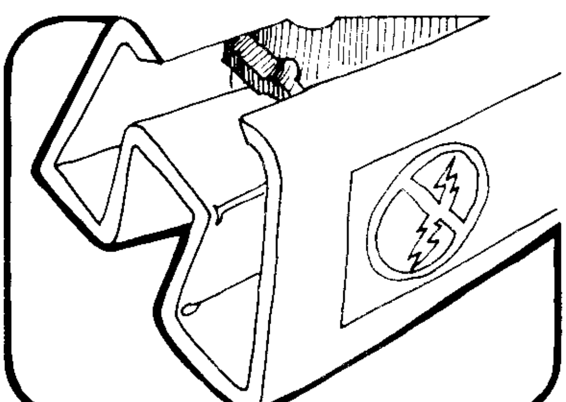
The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol

"⊗"

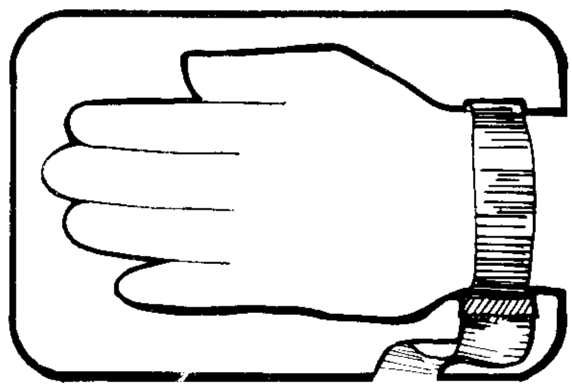
The following practices should be followed to minimize damage to S.S. devices.



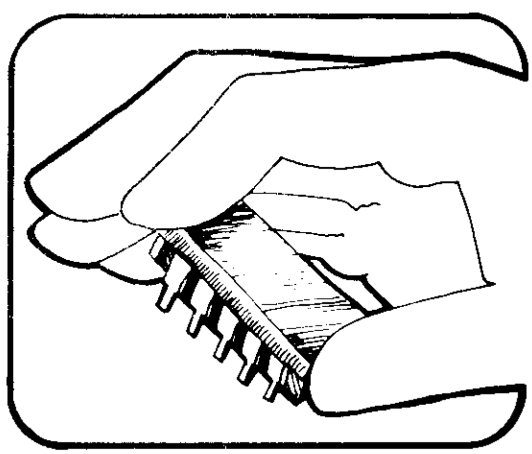
1. MINIMIZE HANDLING



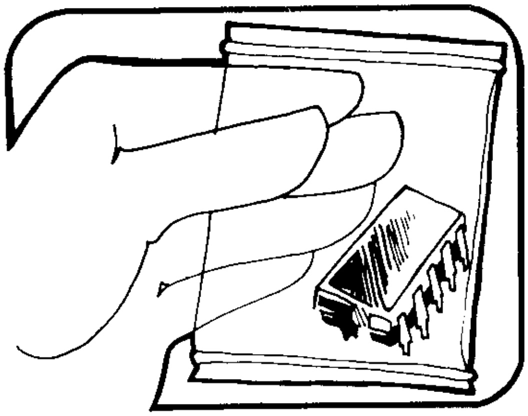
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



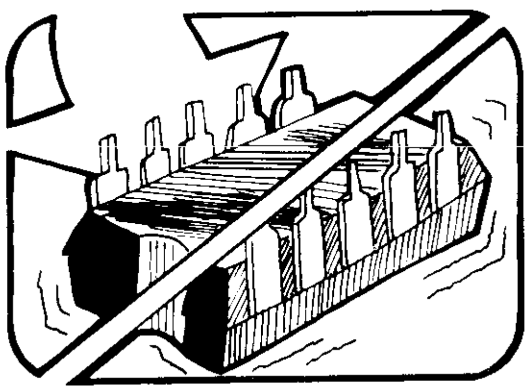
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



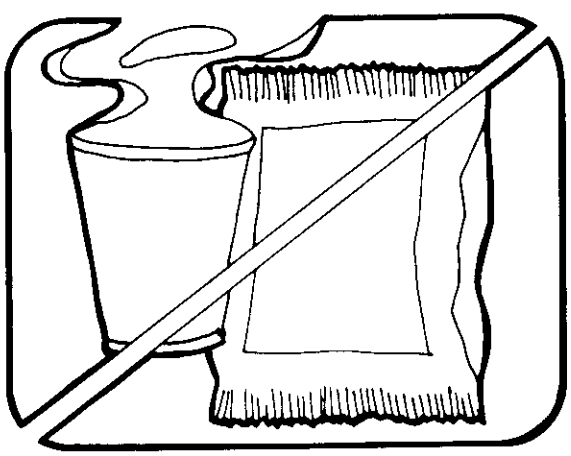
4. HANDLE S.S. DEVICES BY THE BODY



5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

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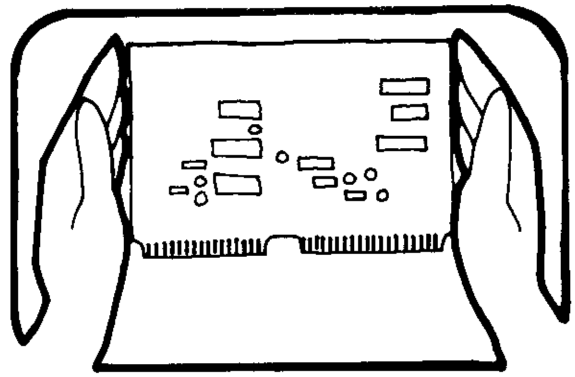
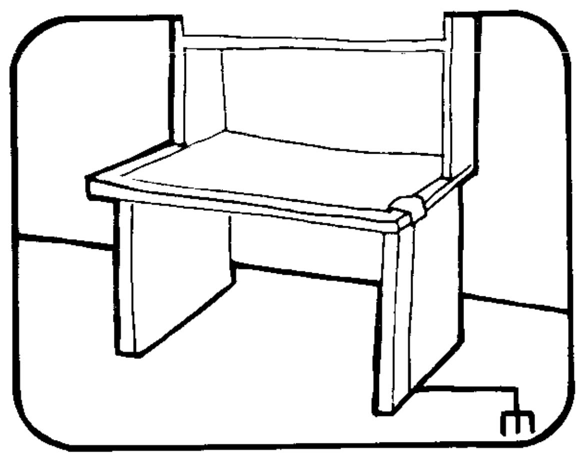
AND GENERAL DYNAMICS, POMONA DIV.

® Dow Chemical



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Description
453522	6" X 8" Bag
453530	8" X 12" Bag
453548	16" X 24" Bag
454025	12" X 15" Bag
Pink Poly Sheet 30"x60"x60 Mil P/N RC-AS-1200 $20.00	Wrist Strap P/N TL6-60 $7.00

J0089B-07U7810/SE EN Litho in U.S.A.

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section of the manual contains information essential to the correct operation and performance of the Model 332B DC Voltage Standard. It is recommended that the contents of this section be thoroughly read and understood before attempting to operate the instrument. Should any difficulties be encountered during the operation of your instrument, please feel free to contact the nearest John Fluke Sales Representative or the John Fluke Mfg. Co., Inc., Box 43210, Mountlake Terrace, WA 98043. A complete list of Sales Representatives is located in Section 7.

2-3. CLAIM FOR DAMAGE IN SHIPMENT

2-4. The Instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to the John Fluke representative. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

2-5. SHIPPING INSTRUCTIONS

2-6. All John Fluke Mfg. Co., Inc. instruments should be shipped prepaid in the original packing carton. Upon request, a new carton can be obtained from the John Fluke Mfg. Co., Inc. Please include the instrument model number when requesting a new container.

2-7. INPUT POWER

2-8. The power transformer 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 paragraph 4-18 in Section 4.

2-9. RACK MOUNTING PROCEDURES

2-10. The Model 332B is supplied with rubber nonskid feet. A rack-slide kit (FLUKE MEE-8088) is available for installation of the instrument in a standard 19-inch rack. In order to rack mount the instrument refer to figure 2-1 and perform the following steps:

a. Attach the chassis section (A) to the side panels with the screws (B) provided in the kit.

b. Install the cabinet sections (D) and center sections (C) into equipment rack. The extension angle

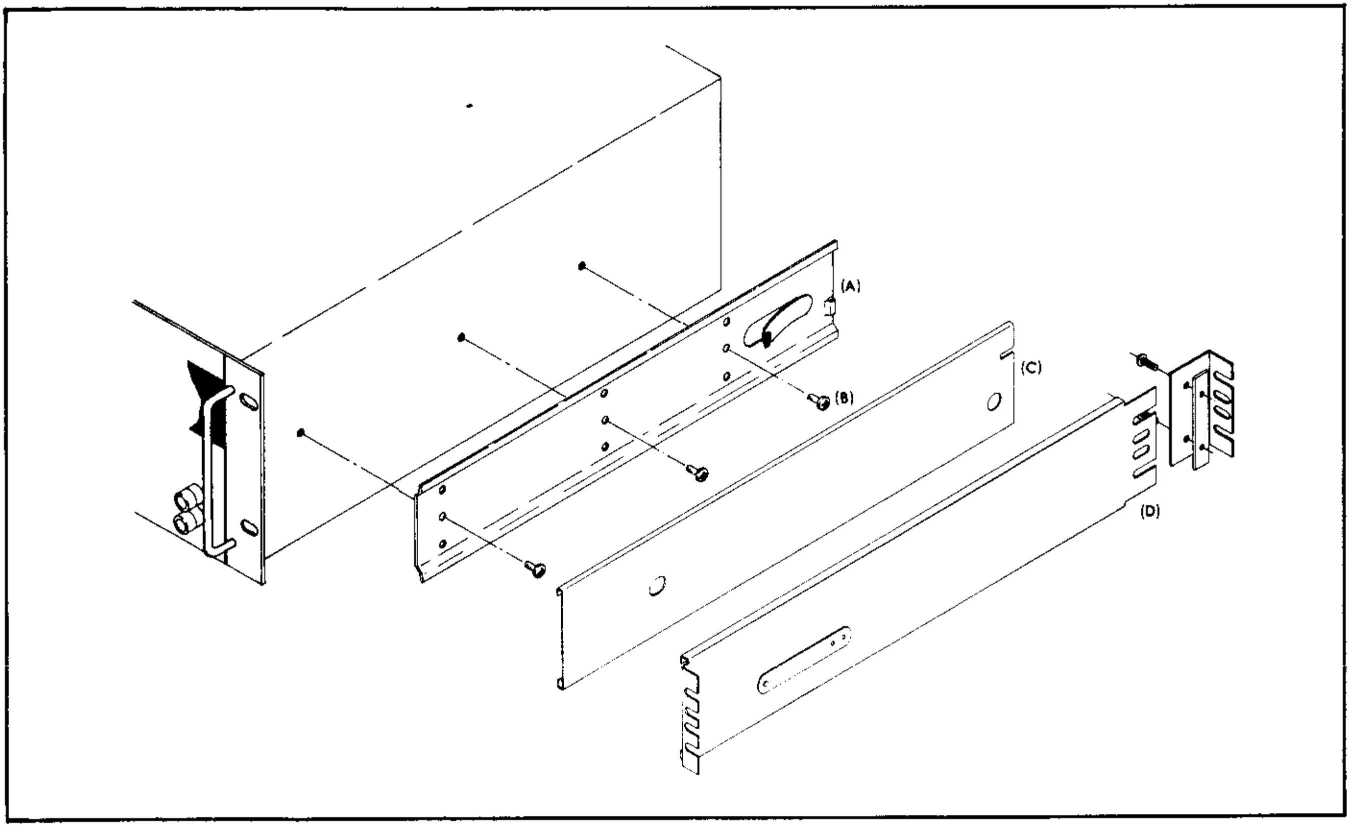


Figure 2-1. CHASSIS SLIDE INSTALLATION

brackets, which are part of section (D), are mounted at the rear of the cabinet.

c. Slide the center sections (C) toward the front of the cabinet until they lock in place.

d. Depress the spring locks on the chassis sections (A) and insert the instrument between the extended center sections (C) on the cabinet.

e. Slide the instrument completely into the equipment rack and secure it in place with fasteners through the front panel.

2-11. CONTROLS, TERMINALS AND INDICATORS

2-12. The name and function of the front and rear panel controls, terminals, and indicators are illustrated and described in Figure 2-2. The numbers at the tails of the arrow callouts correspond to the reference numbers in the chart.

2-13. INITIAL OPERATION

2-14. General

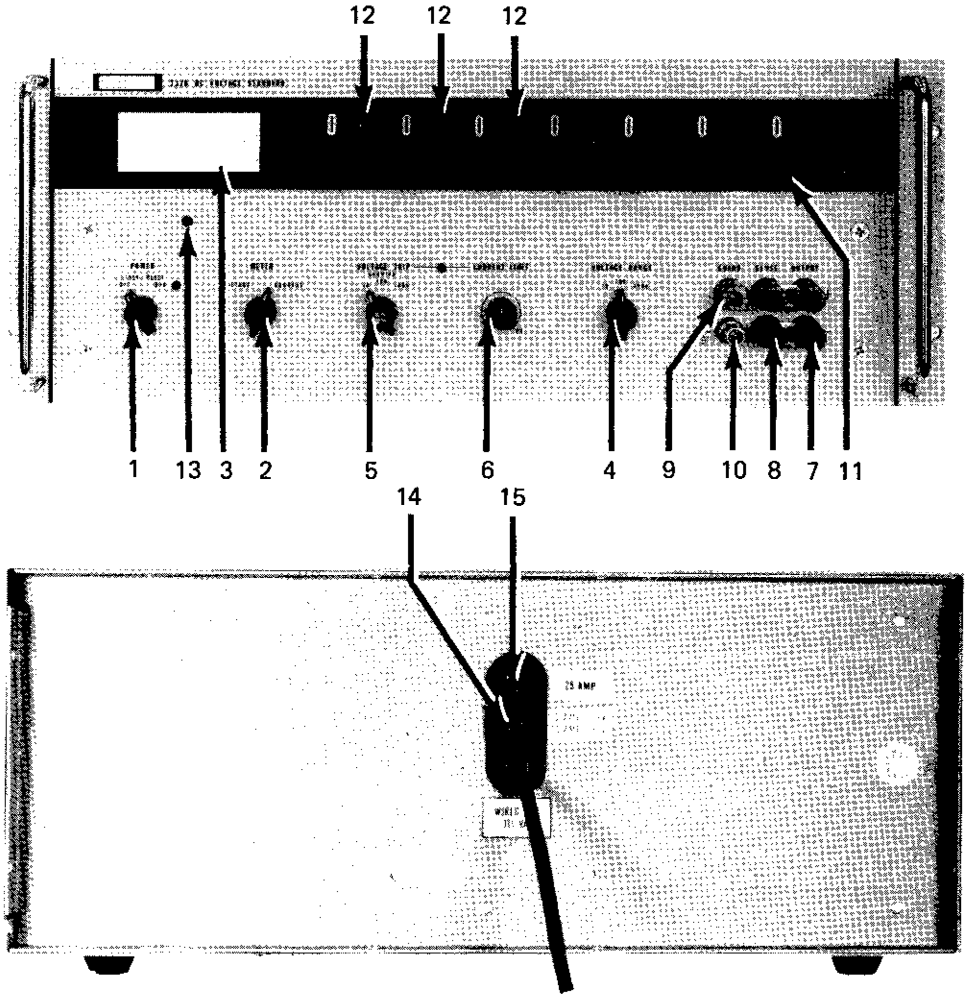
2-15. Before operating the instrument, some preliminary settings and connections should be considered. The use of these settings and connections depends upon the degree of equipment safety and accuracy required. The following paragraphs discuss the merits and procedures for each of the settings and connections.

2-16. Voltage Trip Setting

2-17. The VOLTAGE 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 VOLTAGE TRIP switch. Refinement of the value of the voltage to be limited is accomplished with the VERNIER control. If no degree of limiting is required within the ranges of the instrument, set the VOLTAGE TRIP switch to 1000 and the VERNIER fully clockwise. Should some degree of limiting be desirable, proceed as follows:

a. Without any 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
VOLTAGE TRIP	To the lowest range that overlaps the desired trip voltage



REF. NO.	NAME	FUNCTION
1	POWER switch	Applies line power to the auxiliary power supplies within the instrument, when in the STDBY/RESET postion. The instrument is completely energized when the POWER switch is in the OPR position and the red indicator lamp near the switch is illuminated.
2	METER Switch	Selects meter indication of either output voltage or output current.
3	Meter	Indicates either output voltage or output current depending on the position of the METER switch. The meter voltage range depends on the setting of the VOLTAGE RANGE switch. The current range is 0 to 60 milliamperes.
4	VOLTAGE RANGE Switch	Selects the output voltage range of 10, 100, or 1000 volts, and changes the meter to a corresponding range.

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

REF. NO.	NAME	FUNCTION
5	VOLTAGE TRIP Switch and VERNIER Control	The VOLTAGE TRIP switch provides a means of limiting the output voltage in three ranges (10, 100, and 1000 volts) independent of the VOLTAGE RANGE switch. The VERNIER control varies the amount of limiting within the ranges of the VOLTAGE TRIP switch. When an over-voltage condition exists, the red indicator lamp near the VOLTAGE TRIP switch illuminates and the red lamp near the POWER switch is extinguished.
6	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.
7	OUTPUT Terminals	Provides a convenient means of connecting the load to the output circuit.
8	SENSE Terminals	Allows the regulating circuitry to be connected to the OUTPUT terminals (7) or directly to the load for optimum regulation.
9	GUARD Terminal	When properly connected, provides a means of eliminating circulating ground currents through the load.
10		Power line ground.
11	Readout Dials	Select and indicate the output voltage. The recessed numbers directly above each dial provide in-line readout of the output voltage. 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.
12	Decimal Lamps	These lamps indicate the proper decimal point setting when illuminated and are controlled by the RANGE switch.
13	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.
14	Fuse, line	A 3 ampere slow-blow fuse for 115 volt power line operation. Use a 1½ ampere slow-blow fuse for instruments converted to 230 volt power line operation.
15	Fuse, high voltage	A ¼ ampere slow-blow fuse electrically located at the output of the high voltage rectifier circuit.

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

VERNIER	Fully cw
CURRENT LIMIT	As desired
METER	Voltage
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 VOLTAGE 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.

2-18. Current Limit Setting

2-19. 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
VOLTAGE TRIP and VERNIER	As desired
VOLTAGE CURRENT LIMIT	Fully clockwise
METER	Current
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.

2-20. Sense Connections

2-21. When a load is connected, there may be an appreciable voltage drop between the instrument and the load, depending on the length and gauge of the connecting leads. The nomograph of Figure 2-3 can be used to determine the approximate voltage across the connecting wire leads.

2-22. 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 No. 28 wires, each 3 feet long, are used to connect a load, requiring 50 milliamperes, to the Model 332B. With a straight edge, connect the known current on scale 1 (50 ma) and the wire size on scale 2 (No. 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 at 1000 volts output. To compensate for this, the instrument is equipped with remote sensing, which maintains regulation at the load. Consequently, the voltage across the connecting wires will have no effect. Determine if the wire leads used to connect the instrument to the load, will cause a voltage drop in excess of the load regulation specifications. If this voltage drop is excessive, remote sensing should be used. To prepare the instrument for remote sensing, proceed as follows:

a. With the POWER switch set to OFF, or to STDBY/RESET, remove the front-panel shorting links between the SENSE and OUTPUT terminals.

b. Using a twisted pair of insulated wires, connect the +SENSE terminal to the positive side of the load, and connect the -SENSE terminal to the negative side of the load.

CAUTION

Ensure 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.

2-23. Guard Connection

2-24. 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 the two instruments.

This potential difference can cause circulating ground currents, which could cause errors in the output voltage. To prevent these errors from occurring, the instrument is equipped with a guard. This guard, when properly connected to the load, will provide a separate path for the circulating ground currents, thus eliminating possible errors in the output voltage. For proper connection, connect the GUARD terminal directly to the grounded side of the load, at the load. Figure 2-4 illustrates the correct GUARD terminal connection and the re-routed circulating ground current path.

2-25. OPERATION

2-26. Operate the instrument in accordance with the following procedure:

a. Set the METER switch to VOLTAGE.

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.

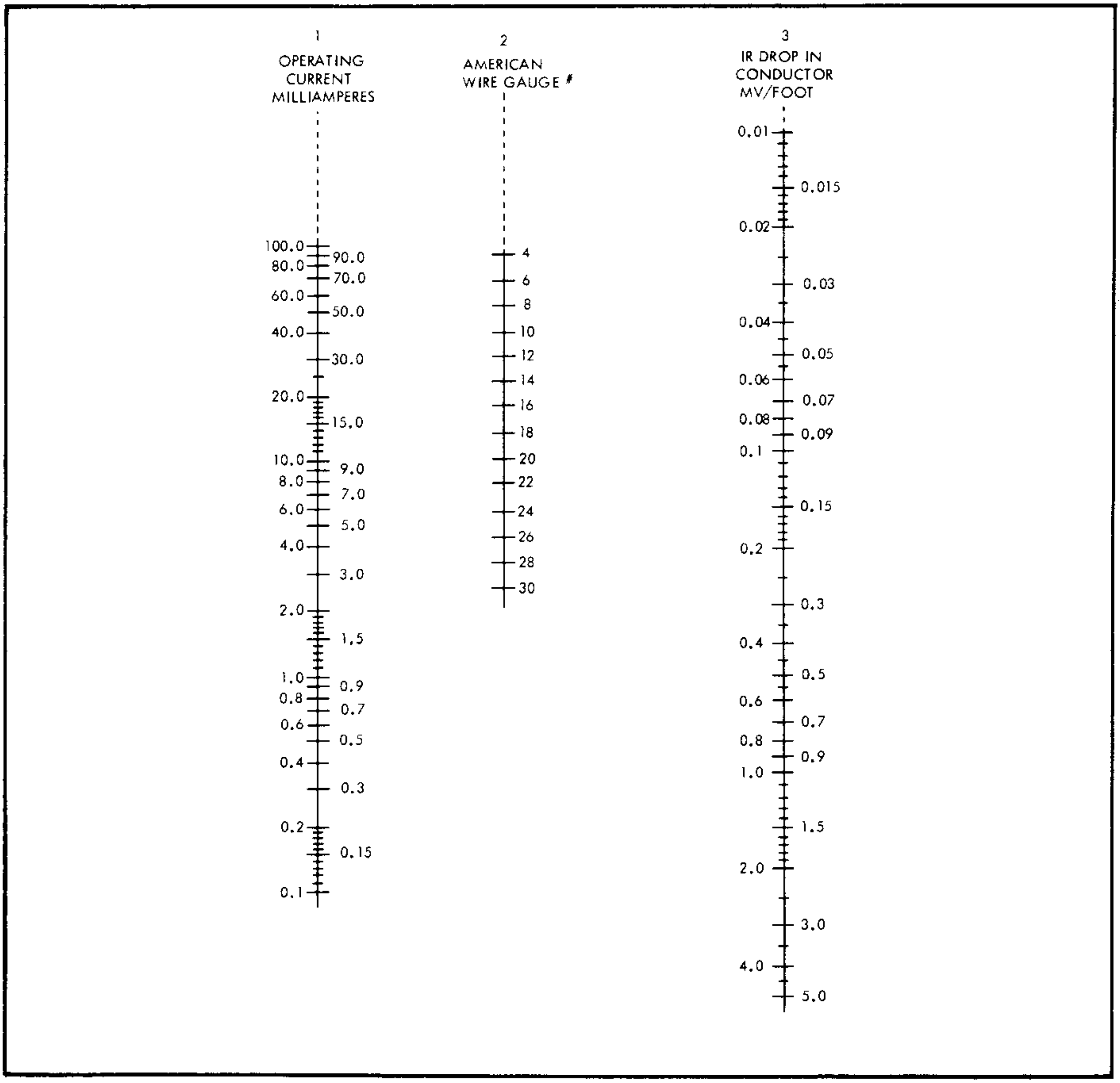


Figure 2-3. NOMOGRAPH OF VOLTAGE DROP ACROSS LOAD WIRES

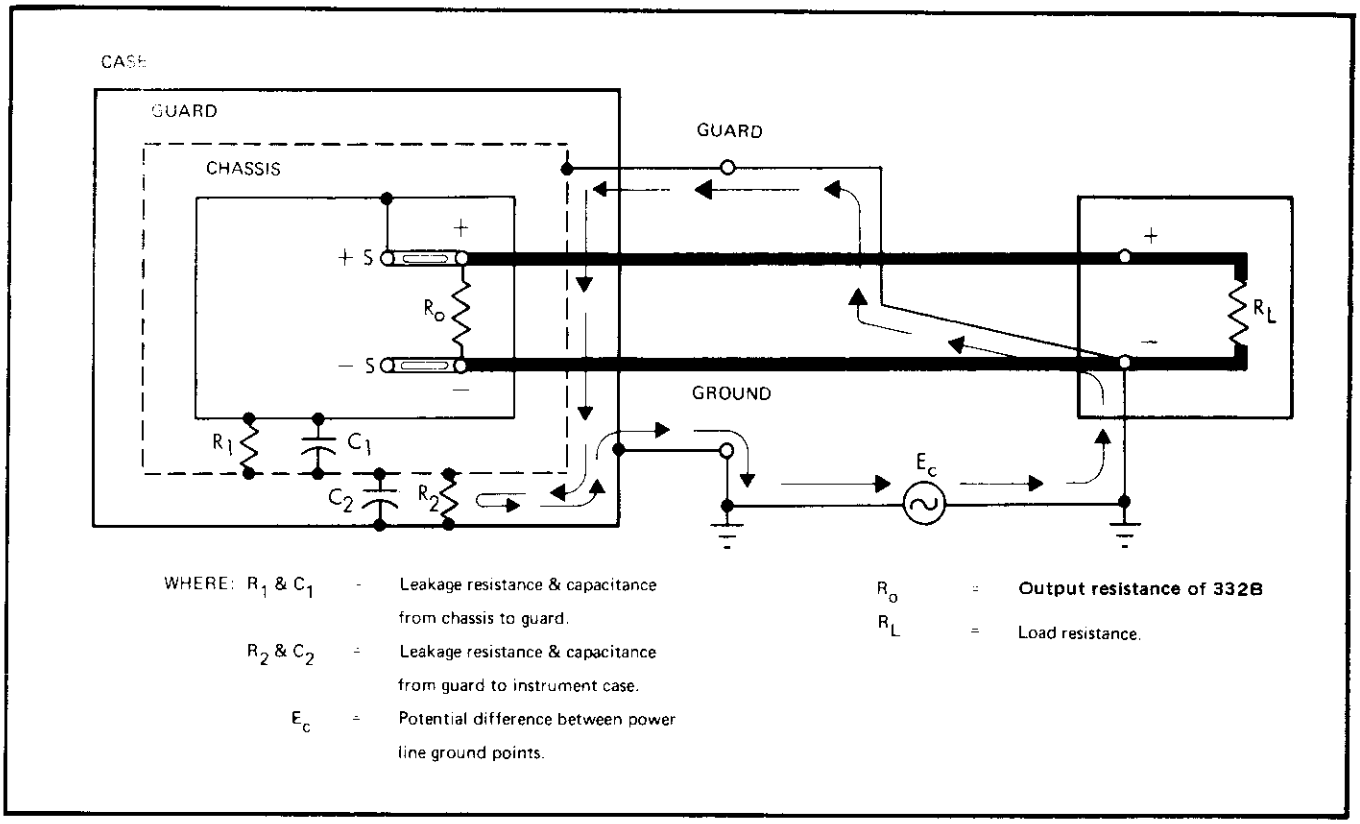


Figure 2-4. GUARD CONNECTION

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 2-20.

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 2-18.

g. Set the readout dials to the value of the output voltage desired.

h. If desired, connect the GUARD terminal to the grounded side of the load in accordance with paragraph 2-25. 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 2-22.

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 current, place the METER switch in the CURRENT position.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section describes the theory of operation of the Model 332B. In conjunction with the text, refer to the functional schematic diagrams located in the rear of the manual. Before attempting to trouble shoot the unit in detail, one should be thoroughly familiar with circuit operation.

3-3. FUNCTIONAL DESCRIPTION

3-4. This voltage standard is a series regulated power supply basically consisting of the voltage control circuitry, preregulation 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. The error amplifier and series pass element, illustrated in the shaded portion, together 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 ($E_{REFERENCE}$), 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 (332B-1500), at the back of the manual. In this diagram, the chopper amplifier, differential amplifier, and series pass driver constitute the error amplifier of Figure 3-1.

3-5. 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. In this instrument, a unijunction oscillator circuit monitors the voltage across the series pass element and provides a voltage level information to a pre-regulation circuit. The pre-regulation circuit utilizes this information to provide full-wave 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.

3-6. Circuitry, for protection of personnel as well as external equipment, is provided. The instrument contains an interlock system to de-energize the high voltage circuits within the instrument when the covers are removed. 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.

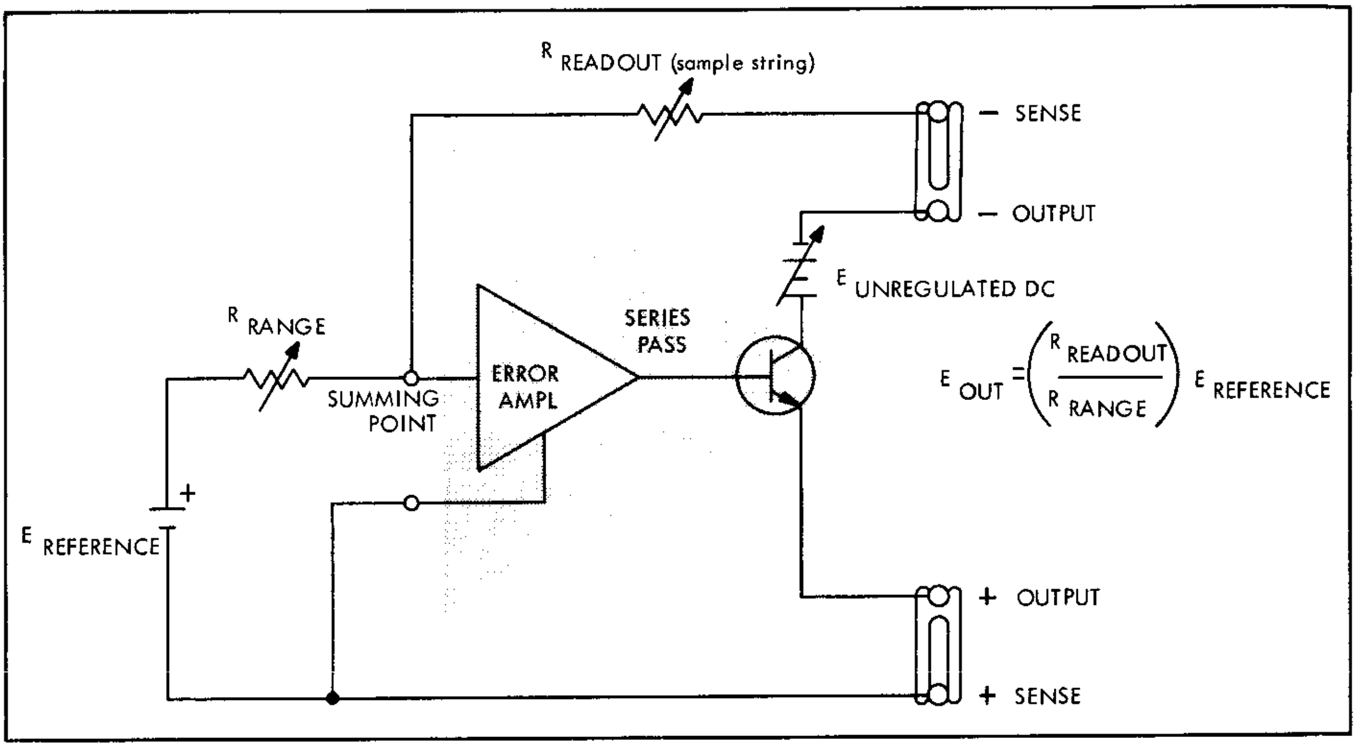


Figure 3-1. VOLTAGE CONTROL CIRCUITRY

3-7. CIRCUIT DESCRIPTIONS

3-8. Voltage Control Circuitry

3-9. REFERENCE SUPPLY. The master reference voltage for the instrument is produced in the A5A1 Reference Supply (332B-1083). This assembly consists of a +15V dc reference supply, an oven temperature regulator for the reference supply, and divider networks for compensation of offset voltages when the output is set to zero.

3-10. The Reference supply is composed of differential amplifier A2 and zener reference amplifier A3. The reference amplifier is enclosed in an oven which maintains a constant temperature for environmental stability. Selection of the values of R7A and R7B scales the output of the Reference Supply to +15V dc. Variable resistor R9 allows adjustment of the resulting V_{REF} output. Temperature coefficient of the base/emitter voltage for A3 is accurately matched to the zener element through selection of R13. The resulting stable reference at the collector of A3 is applied to the non-inverting input of A2. The other input to A2 receives an equivalent voltage from the divider composed of R14 and R15. Any change in V_{REF} is sensed at the base of A3 and the resulting amplified change applied to the non-inverting input of A2. This change then alters the conduction of A2 such that V_{REF} is maintained at +15V dc.

3-11. Constant operating temperature for the reference amplifier A3 is provided by the Oven Temperature Regulator Q1 and A1. The series-pass regulator composed of Q1 and A1 establishes a constant voltage across the heater element of A3. Any variation in heater voltage is sensed by A1 and amplified. The resulting output of A1 then alters the conduction of Q1 to eliminate the voltage variation across the heater element. The heater element consists of a semiconductor material which has moderate conductivity at temperatures below a specific stabilization point and a marked decrease in conductivity as the temperature approaches the stabilization point. Application of a constant voltage to the heater provides a fast warm-up and a much more stable operating temperature.

3-12. The divider network composed of R1 through R6 provide a bias voltage to one input of the A5A4 Chopper Amplifier. Potentiometers R2, R4, and R6 are adjusted to compensate for offsets in the 10V, 100V, and 1000V ranges when the output is set to zero.

3-13. RANGE RESISTORS. The A4 Range Cal (332B-1052) provides three separate adjustable range resistors. These resistors together with the A2 Sample String form a resistive divider which determines the output voltage of the instrument.

3-14. SAMPLE STRING. The A2 Sample String (332B-1051) together with the selected range resistor in the A4 Range Cal forms a resistive divider, the ratio of which is controlled by the front panel decade dials. The output voltage of the sample string is proportional to the reference voltage multiplied by the ratio of the sample string resistance to the A4 range resistance.

3-15. CHOPPER AMPLIFIER. The A5A4 Chopper Amplifier (332B-1058) compares low frequency and dc control signals from the A2 Sample String output to the +SENSE terminal voltage and amplifies any difference. The circuitry consists of an input filter, a MOSFET chopper, an operational amplifier, a synchronous demodulator, an output filter, and a multivibrator.

3-16. Low frequency and dc control signals at terminal 6 are passed through the input filter C2, R1, C3 to reject frequencies above 30 Hz. The MOSFET chopper Q1 modulates the signal appearing at the junction of C4 and output signal at Q2 is then amplified by the operational amplifier IC1, which has a gain of approximately 420. The paraphase amplifier Q3 amplifies the output of IC1 and provides two equal amplitude, but 180° out-of-phase signals. The collector signal of Q3 is coupled by C16 to the shunt demodulator Q4. The resulting demodulated signal appearing at the junction of C17 and R24 is filtered by R24, R26 and C18, leaving only the amplified dc and low frequency signals. The emitter signal of Q3 is applied through C14, R21, C15, R25, R23, and C22 to C18, where it is used to cancel any chopper ripple at 270 Hz.

3-17. The 270 Hz multivibrator is formed by Q6, Q7 and associated timing networks, in addition to a driver Q5. Variable resistor R43 adjusts the level of the signal applied to the driver Q5, and subsequently the output signal applied to the gate of Q1. The collector signal of Q5 is applied to Q1 across C5 to compensate for spikes coupled through Q1. Variable resistor R34 provides adjustment of the compensation signal. An output signal at the collector of Q7 is applied to the base of Q4, which synchronously demodulates the Chopper Amplifier output.

3-18. DIFFERENTIAL AMPLIFIER. Error signals in the form of ac changes are applied to the A5A3 Differential Amplifier (332B-1057). These signals are coupled 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.

3-19. 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.

3-20. SERIES PASS. The A7A1 Series Pass (332B-1061) contains the series-pass transistors which control the output voltage. It also contains a voltage controlled oscillator (VCO) and control amplifiers which are part of the preregulator, a power supply, and an automatic "crowbar" driver.

3-21. The power supply composed essentially of CR1 through CR4 produces the required operating voltages for the series pass circuitry. AC voltage at terminals 8 and 9 is rectified by CR1 through CR4 to provide an unfiltered positive voltage. This voltage is isolated by CR5 and filtered by C2 to provide a +150V dc operating voltage for the series-pass transistors. The voltage divider of R1 through R3 and zener CR6 produces a clipped, full-wave rectified 16V synchronizing signal for the VCO.

3-22. Output voltage of the instrument is established and maintained by the series-pass transistors, Q1 through Q8. The transistors Q1 through Q7 are normally saturated and Q8 is absorbing the total voltage required to maintain the output of the instrument. However, when the output level or load current is changed and the voltage across Q8 exceeds 150V, Q1 through Q7 absorb the additional voltage. The preregulator circuitry then reduces the output of the A7 H.V. Mother Board until the voltage across Q8 is less than 150V. When this condition is reached, Q1 through Q7 again saturate and Q8 absorbs the total regulation voltage.

3-23. The automatic "crowbar" consisting of Q10 monitors the total voltage drop across the series-pass transistors. Load or output changes that cause the voltage across the series-pass to exceed 225V will cause Q10 to conduct. Its conduction energizes K2 on the A7 H.V. Motor Board and places a load across the high voltage rectifier, thus limiting the voltage across the series-pass transistors.

3-24. Unijunction transistor Q9 and C3, L3, R37, CR18, R35, and CR19 form a VCO which furnishes turn off pulses to the preregulator circuitry. This VCO is synchronized to the ac line zero crossing through amplifiers Q11 and Q12.

3-25. A clipped 16V pulse is rectified by CR32 and C5 to provide operating voltage for the base of the VCO, Q9. This voltage is clamped to zero during the ac line zero interval by amplifiers Q11 and Q12. The divider composed of R36 and R42 provides a sample of the clipped 16V pulse at the base of Q12. When the pulse is at 0V, Q12 produces an amplified positive pulse at its collector. This pulse is differentiated by C4 and R41 and the resulting positive spike momentarily turns on Q11. Conduction of Q11 clamps the output of rectifier CR32, C5 to zero, thus synchronizing the output of Q9 to the ac line zero crossing. The output pulses from Q9 are dependent upon the voltage charge on C3. The voltage is sensed across Q8 through the divider consisting of L3, R37, R35, CR18, and CR19. If this voltage increases. Q9 will produce a preregulator turn off pulse earlier in the ac line cycle, thus reducing the ac power available to the A7 H.V. Mother Board. Conversely, should the voltage across Q8 decrease, the ac power to the A7 H.V. Mother Board is increased.

3-26. POWER SUPPLIES. Operating voltages for the temperature regulating circuit, zener reference circuit, chopper amplifier, and differential amplifier are provided by the A5A5 Auxiliary Power Supply P/C Assembly (332B-1059). 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.

3-27. 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.

3-28. 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.

3-29. The ±35 volt operating voltages for the series pass driver circuitry on the A5A2 Series Pass Driver P/C is provided by a power supply located on the A5A6 Current Limiter P/C Assembly (332B-1060). 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.

3-30. Pre-Regulation Circuitry

3-31. OSCILLATOR. A unijunction oscillator, consisting of Q9 and associated circuitry, is located on the A7A1 Series Pass Element P/C Assembly (332B-1060). Applied to base two 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 two 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 pre-regulator is switched off earlier in each half cycle. This in turn reduces the series pass element voltage of Q8 to its equilibrium value.

3-32. 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.

3-33. PREREGULATOR. The A7A2 Preregulator (332B-1082) controls the ac power supplied to the instrument by passing only enough power to the A7 H. V. Mother Board to meet the output load requirement. It consists of a ±V supply, a relay power supply, preregulator control drivers, a preregulator bridge, and a current limiter.

3-34. ±V and +10V dc operating voltages are produced for the A7A2 Preregulator by the rectifier CR1 through CR4 and associated components. A 10V ac input is applied to CR1 through CR4. The dc output at the junction of CR2 and CR4 is filtered by C3 to provide a −V operating voltage. The dc voltage at the junction of CR3 and CR1 is heavily loaded by R1 to provide an unfiltered +V operating voltage. This voltage is also isolated through CR5 and filtered by C4 to provide a +10V dc operating voltage.

3-35. Operating voltage for relay K1, which supplies ac voltage to the preregulator bridge, is produced by bridge rectifier CR6 through CR9 and K2. AC return for the bridge rectifier is provided through the contacts of K2. This relay is energized only in the OPR mode by a control voltage from the A5A2 Series Pass Driver. The A5A2 Series Pass Driver automatically removes the control voltage from K2 should a VOLTAGE TRIP occur, thus removing ac power to the preregulator bridge and establishing a STDBY condition.

3-36. The circuitry consisting of Q2 through Q9 controls the conduction of the preregulator bridge attenuator, Q1. Input pulses from the VCO in the A7A1 Series Pass are supplied to the base of Q7 via terminal 14. The first pulse turns on Q7 and Q6, which through regenerative action, saturate. This condition turns off Q5 and causes Q4 and Q8 to also turn off. Q9 is subsequently turned on by the −V collector voltage of Q8 and provides a negative voltage at the base of Q2. This condition turns off Q2 and also Q1, thus causing the preregulator bridge of CR10 through CR13 and Q1 to provide maximum attenuation to the ac voltage applied to the A7 H.V. Motherboard. When the ac line passes through zero, the 0V, +V condition at the emitter of Q6 causes it to turn off and also turns off Q7. This condition reverses the previously described state of each transistor and the preregulator bridge again passes the ac line voltage to the A7 H.V. Motherboard.

3-37. AC line voltage applied to T2 and subsequently the A7 H.V. Motherboard is controlled through the pre-regulator bridge consisting of CR10 through CR13 and Q1. The previously described circuitry of Q2 through A9 controls conduction of Q1. Diodes CR10 through CR13 provide a unidirectional current through Q1. Positive alterations are passed by CR10 and CR13. CR12 and CR11 pass negative alternations. Should Q1 be cut off, C6 and R5 provide a dynamic load for the bridge. Overload current protection for Q1 is provided through divider R2, R8, and R9 and Q3. Should the current through Q1 exceed 17 amperes, the voltage at the base of Q3 turns it on and causes Q6 to saturate. This condition causes Q1 to be cut off, thus limiting the current through the preregulator bridge.

3-38. Protection Circuitry

3-39. **Trip.** The purpose of the trip circuit is to remove ac power from the primary of the high voltage transformer and to open the negative output path, if an overvoltage or catastrophic overcurrent condition exists. The trip circuitry is located on the A5A2 Series Pass Driver P/C Assembly (335A-1056). Transistor Q3 is a constant current source for relays A7K1 and A7A2K2. With A7A2K2 (on the Pre-Regulator P/C Assembly) closed, current is provided to A7A2K1 which completes the primary circuit for the high voltage transformer. With relay A7K1 (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 after 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.

3-40. The overvoltage trip element is Q1. The base of Q1 is connected to R15 and the appropriate resistor selected by the VOLTAGE 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.

3-41. CURRENT LIMIT. The current limit circuitry, located on the A5A6 Current Limiter P/C Assembly (332B-1060), provides a means of varying the limiting point of the output current. Current sensing resistor R22 on the A5A2 Series Pass Driver P/C Assembly 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 A5 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.

3-42. INTERLOCKS. The Model 332B is equipped with an interlock circuit for personnel safety (332B-1000). When either the top or bottom inner covers or printed circuit assemblies A7A2, A7, A7A1, A5A1, A5A3, A5A4, A5A5, or A5A6 are removed, the ground return for the A7K1 and A7A2K2 relays is opened. This results in removal of the input power to the high voltage transformer (T2) and opens the negative output side of the instrument.

3-43. TIME DELAY. The purpose of the time delay circuit, located on the A6 Time Delay P/C Assembly (332B-1020), is to provide a short interval for the auxiliary voltages to rise to nominal value. This ensures that the control amplifiers are operating before the high voltage is available. The time delay circuit momentarily holds open relays A7K1 and A7A2K2, which prevent the closure of A7A2K1. The time delay is approximately 3 seconds. Diodes 2001 and 2002 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 A7K1 and A7A2K2, and these relays are allowed to actuate.

3-44. Miscellaneous Circuitry

3-45. OUTPUT CIRCUIT CURRENT SOURCE. In addition to the main high voltage bridge rectifier, CR1 through CR10 on the A7 High Voltage Mother Board P/C Assembly Schematic (332B-1056), there 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. 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 setting time.

3-46. CAPACITOR SWITCH. The capacitor switch circuitry is located on the A3 Capacitor Switch P/C Assembly Schematic (332B-1092). When down ranging from 1000 volts, capacitor C4 (on the chassis) will tend to charge to a voltage level proportional to the difference between the charge on C5 and the parallel combination of the output capacitors C1 and C2. If this difference is too great, C4 will receive a charge of sufficient magnitude to cause a dielectric absorption problem, thus excessive settling time will result. (Dielectric absorption is the tendency of the dielectric material of the capacitor to absorb and retain a small charge). To prevent this occurrence, C5 is discharged through R7 (on A3) when the RANGE switch is down ranged from 1000 volts to 10 or 100 volts. In doing so the decay rate of C5 and the parallel combination of C1 and C2 will be equal, thus C4 does not receive an over charge. After C5 has discharged sufficiently (several seconds), the K1A contacts (on A3) close and parallel the low resistance of R6 with R7. This essentially shorts C5 and returns the loop gain to the required amount. The capacitor switch circuitry is responsible for allowing a time delay before closing the K1A contacts. When down ranging from 1000 volts, C1 is charged by the +35 volt supply through R2 and R1. After several seconds, C1 accumulates a sufficient charge to cause Q1 to conduct. Conduction of Q1 energizes relay K1 which closes the K1A contacts.

3-47. CROWBAR CIRCUIT. If the output voltage were suddenly turned to zero with a load connected to the instrument, the voltage across the filter capacitors C1, C2, and C3 (located on the A7 High Voltage Mother Board P/C) 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 A7A1 Series Pass Element P/C. It also includes relay K2 on the A7 High Voltage Mother Board P/C. When the voltage across the series pass element reaches approximately 225 volts, transistor A10 conducts. Since relay K2 is in the collector circuit of Q10, the relay is energized and closes the contacts. With the K2A contacts closed, a discharge path through R15 is provided for the filter capacitors.

3-48. METER CIRCUIT. The front panel meter indicates the output voltage or output current, depending on the position of the METER switch. When the METER switch is in the VOLTAGE position, resistors R3 through R6, on the Series Pass Driver P/C Assembly, and the resistors selected by the RANGE switch S2f provide the meter with a current which is proportional to the output voltage. When the METER switch is in the CURRENT position, resistors R1 and R2, on the Series Pass Driver P/C Assembly, provide the meter with a current which is proportional to the output current.

Section 4
Maintenance

4-1. INTRODUCTION

4-2. Maintenance and calibration of the Model 332B is covered 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 problem areas, should any of these checks fail, is covered under paragraph 4-20, PERFORMANCE TESTS. Paragraph 4-36, PERFORMANCE TESTS. Paragraph 4-36, 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 this 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

WARNING

The inner chassis is at +OUTPUT potential! Hazardous voltages exist between inner chassis and front panel.

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".

4-9. Located on the left side of the instrument, behind bulkhead, is an extender card A8. This board is used as an extender for the plug-in circuit board assemblies to provide access to adjustments and test points.

CAUTION!

Remove all power from the instrument before removing or inserting plug-in circuit boards.

Remove the plug-in circuit board assembly to be investigated, insert the extender card in its place, and plug the circuit board assembly in the extender card.

4-10. Unique Maintenance Procedures

4-11. CLEANING OF 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 Sample String P/C Assembly (A2), and Capacitor P/C Assembly (A1). When components are replaced on these assemblies that require soldering, the land pattern side of the board should be cleaned as described in paragraph 4-12. Should contamination be suspected on the component side of the circuit board, use Freon TF Degreaser (Miller-Stephenson Chemical Co.).

4-12. CIRCUIT BOARD SEALANT. The land pattern side of all printed circuit boards have been coated with epocast (a polyurethane resin) to inhibit fungus growth and moisture absorption. When soldering to a printed circuit land, the heat from the soldering iron decomposes the epocast resin, leaving a charred residue. Upon completion of soldering, the residue should be removed with a solvent such as toluol.

4-13. After removal of the epocast residue, the affected area should be recoated with a sealant. A spray can of Circuit Coat (Furane Plastic Inc., 4516 Brazil Street, Los California or 16 Spielman Road, Fairfield, New Jersey) may be used for recoating.

4-14. Fuse Replacement

4-15. 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	¼A, slow blow
F2	Line	3A, slow blow, 115V conn.
		1½A, slow blow, 230V conn.

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

4-16. Lamp Replacement

4-17. The indicator lamps are located immediately behind the front panel. The instrument must 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.

4-18. 115/230V Conversion

4-19. 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 the instrument 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 4-14.

4-20. PERFORMANCE TESTS

4-21. Introduction

4-22. The following tests are intended for checking performance of the instrument. These tests may be used for incoming inspection, periodic inspections and precalibration checks. It is recommended that these tests be performance prior to calibration.

4-23. Each performance test includes an introductory paragraph which states the purpose of the test and describes the circuitry involved. An understanding of the purpose of each test and the circuitry involved should aid a technician in analyzing a malfunction.

4-24. 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. Table 4-1 lists the equipment needed for testing and calibrating.

4-25. The load, line and ripple checks do not rely on any calibration adjustments; any major or minor 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.

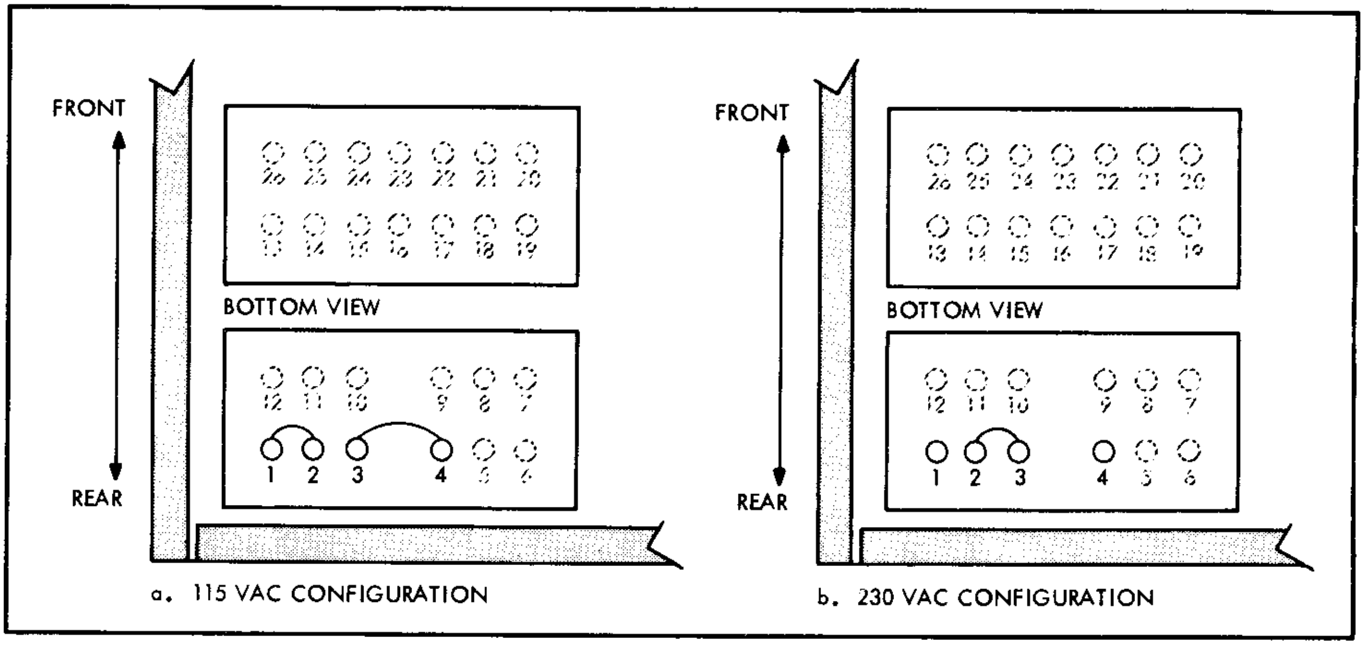


Figure 4-1. 115/230 VAC CONVERSION

EQUIPMENT REQUIRED	SPECIFICATIONS REQUIRED
Volt/Ohmmeter - RCA VoltOhmyst or equivalent	DC Accuracy of ± 3% and input impedance of 10 M Ω
Metered Autotransformer - General Radio Variac W5MT3A or equivalent	Output of 0 to 130 vac at 3 amperes.
DC Differential Voltmeter - Fluke Model 895A or equivalent (quantity of 2 required)	DC Accuracy of ±0.0025% with 100 uv null detector
RMS Voltmeter - Fluke Model 931B or equivalent	Accuracy of ±(0.05% of input +0.005% of range) from 30 Hz to 50 kHz.
Preamplifier	Gain of 1000 and bandpass of 20 Hz to 30 kHz
Oscilloscope - Tektronix Type 541 or equivalent Preamplifier - Tektronix Type D	General purpose 1 mv / cm sensitivity
General Purpose Power Supply	Provide 5.5 volts
DC Milliammeter	0 to 100 milliamperes ±5%
Load Resistor Box - Clarostat 240-C	Resistance range of 20 to 20,000Ω at ±5%. Capable of handling up to 80 watts
Resistor, Composition	100k Ω ±5%, ½w

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

EQUIPMENT REQUIRED	SPECIFICATIONS REQUIRED
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: Voltage Standard, Model 332B/332D Null Detector, Model 845AR Voltage Divider, Model 750A Kelvin-Varley Voltage Divider, Model 720A	Capable of measuring 0.1 to 1100 vdc with 5 ppm accuracy

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

4-26. 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.

4-27. DC Output

4-28. 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 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
METER	CURRENT
RANGE	10
READOUT	All Zero
VOLTAGE TRIP	1000
VERNIER	Clockwise
CURRENT LIMIT	Clockwise (60)

c. Connect the Model 895A to the SENSE terminals and set to plus polarity. Connect the 240-C Load Resistor Box to the OUTPUT terminals of the Model 332B.

d. Set the RANGE switch, readout dials, and load box to the values indicated in the first group of settings in Table 4-2. Set the POWER switch to the OPR position. Note the voltage indicated on the Model 895A. Set the autotransformer to low line (103V). The output voltage change, indicated on the Model 895A, should not exceed the specification listed in Table 4-2. Adjust the autotransformer setting to nominal line (115V). Note the voltage indication on the Model 895A. Set the autotransformer to high line (127V). The voltage change, indicated on the Model 895A, should not exceed the 20 microvolt specification. Repeat this procedure for each group of settings in Table 4-2.

4-29. 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
METER	CURRENT
RANGE	10
Readout	All Zero
VOLTAGE TRIP	1000
VERNIER	Clockwise
CURRENT LIMIT	Clockwise (60)

c. Connect the Model 895A to the SENSE terminals.

d. Set the RANGE switch and Readout Dials to the values indicated in the first group of settings listed in the Table 4-3. Set the POWER switch to the OPR position. Note the voltage indicated on the Model 895A. Connect the 20-ohm load to the OUTPUT terminals and note output voltage change on the Model 895A. The change should not exceed the specification listed in the table. Repeat step d. for each group of settings.

e. Repeat step d. for low line (103V) and high line (127V).

4-30. RIPPLE. The ripple test determines if an ac component superimposed 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
METER	CURRENT
RANGE	10
Readout	All Zero
VOLTAGE TRIP	1000
VERNIER	Clockwise
CURRENT LIMIT	Clockwise (60)

c. With the autotransformer set to nominal line voltage (115 vac), set the POWER switch to OPR. The ripple output should not exceed 20 microvolts.

NOTE!

Ripple indication is via 1000X preamplifier.

d. Set the readout dials to 10 volts. The ripple output should not exceed 20 microvolts rms.

e. Connect the 200-ohm load resistor to the OUTPUT terminals. The ripple output 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 output should not exceed 30 microvolts rms.

g. Set the readout dials to 100 volts. The ripple output should not exceed 30 microvolts rms.

h. Connect the 2,000-ohm load resistor to the OUTPUT terminals. The ripple output 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 output should not exceed 40 microvolts rms.

RANGE	READOUT	LOAD (50 ma)	SPEC.
10	1.000000	20Ω	10 uv
10	10.000000	200Ω	20 uv
100	10.00000	200Ω	20 uv
100	100.00000	2000Ω	200uv
1000	100.0000	2000Ω	200uv
1000	1000.0000	20,000Ω	2.0 mv

Table 4-2. CONTROL SETTINGS, LOAD REQUIREMENTS, AND LIMITS FOR LINE REGULATION

RANGE	READOUT	LOAD(50 ma)	SPEC.
10	1.000000	20Ω	10 uv
10	10.000000	200Ω	20 uv
100	10.00000	200Ω	20 uv
100	100.00000	2000Ω	200 uv
1000	100.0000	2000Ω	200 uv
1000	1000.0000	20,000Ω	2.0 mv

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

j. Set the readout dials to 1000 volts. The ripple output should not exceed 40 microvolts rms.

k. Connect the 20,000-ohm load resistor to the OUTPUT terminals. The ripple output should not exceed 40 microvolts rms. Disconnect the load resistor.

4-31. 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 specifications. These checks should be accomplished after the unit has warmed up for 1 hour at standard reference conditions of 23°C ±1°, up to 70% relative humidity, and constant line voltage. One method of checking the instrument accuracy is by comparing the voltages to a saturated standard cell by means of a reference divider. Use the equipment and connections shown in Figure 4-4 and the procedure of paragraph 4-53, steps l. through t.

4-32. Meter and Protection Circuits

4-33. V-I MONITOR. This procedure checks the output voltage and current monitor circuitry associated with the front panel meter.

a. With the METER switch in the VOLTAGE 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, Table 4-4. All meter indications should be within ±3% of full scale.

RANGE	READOUT
10	1.000000
100	10.00000
1000	100.0000
10	10.000000
1000	1000.0000

Table 4-4. 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 METER switch to CURRENT.

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 of the Model 332B should 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 0.5 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 0.5 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 VOLTAGE TRIP, and readout dials to the values indicated in Table 4-5. 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	VOLTAGE TRIP	READOUT DIALS
10	10	10.X00000
100	100	10X.00000
1000	1000	10XX.X00

Table 4-5. CONTROL SETTINGS FOR VOLTAGE TRIP CHECK

b. Set the output of the instrument for 4 volts on the 10 volt range. Set the VOLTAGE 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 VOLTAGE 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 VOLTAGE TRIP switch to the 1000 volt position and the VERNIER maximum clockwise. Re-set 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. CALIBRATION

4-37. Introduction

4-38. The following procedures are intended for calibration. The equipment required is listed in Table 4-1. During the first portion of the calibration procedure, the chassis will have to be removed from the case and the top inner cover removed from the chassis. However, upon removal of the top inner cover it will be necessary to "cheat" the interlock located at the top right-hand edge of the instrument chassis.

4-39. Meter Mechanical Zero

4-40. 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 zero position.

4-41. Auxiliary Circuits

4-42. AUXILIARY POWER SUPPLY. With the POWER switch in the OFF position, connect the instrument 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 895A to pin 10 on the Auxiliary Power Supply P/C Assembly.

b. Referring to Figure 4-2, adjust A5A5 R9 until the Model 895A indicates 25 volts, ±10 millivolts.

c. While varying the line voltage from 100 to 130 volts ac, the Model 895A indication should not change more than 40 millivolts.

d. Set the POWER switch on OFF and disconnect the Model 895A. Replace the Auxiliary Power Supply P/C Assembly. Return the POWER switch to the STDBY/RESET position.

4-43. CURRENT LIMIT. Proceed as follows:

a. Set the front panel controls as follows:

POWER	STDBY/RESET
RANGE	10
Readout Dials	5.000000
VOLTAGE 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 4-2, adjust R23 for a 60 milliampere indication on the external meter.

d. Rotate the CURRENT LIMIT control maximum counter-clockwise. Adjust R24 for a 0.5 milliampere indication on the external meter.

e. If necessary, re-adjust R23 and R24 until the range of the CURRENT LIMIT control is from 0.5 to 60 milliamperes.

f. Set the POWER switch to STDBY/RESET and install the top inner cover.

4-44. OUTPUT CURRENT MONITOR. Proceed as follows:

a. Set the METER switch to CURRENT and POWER switch to OPR.

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

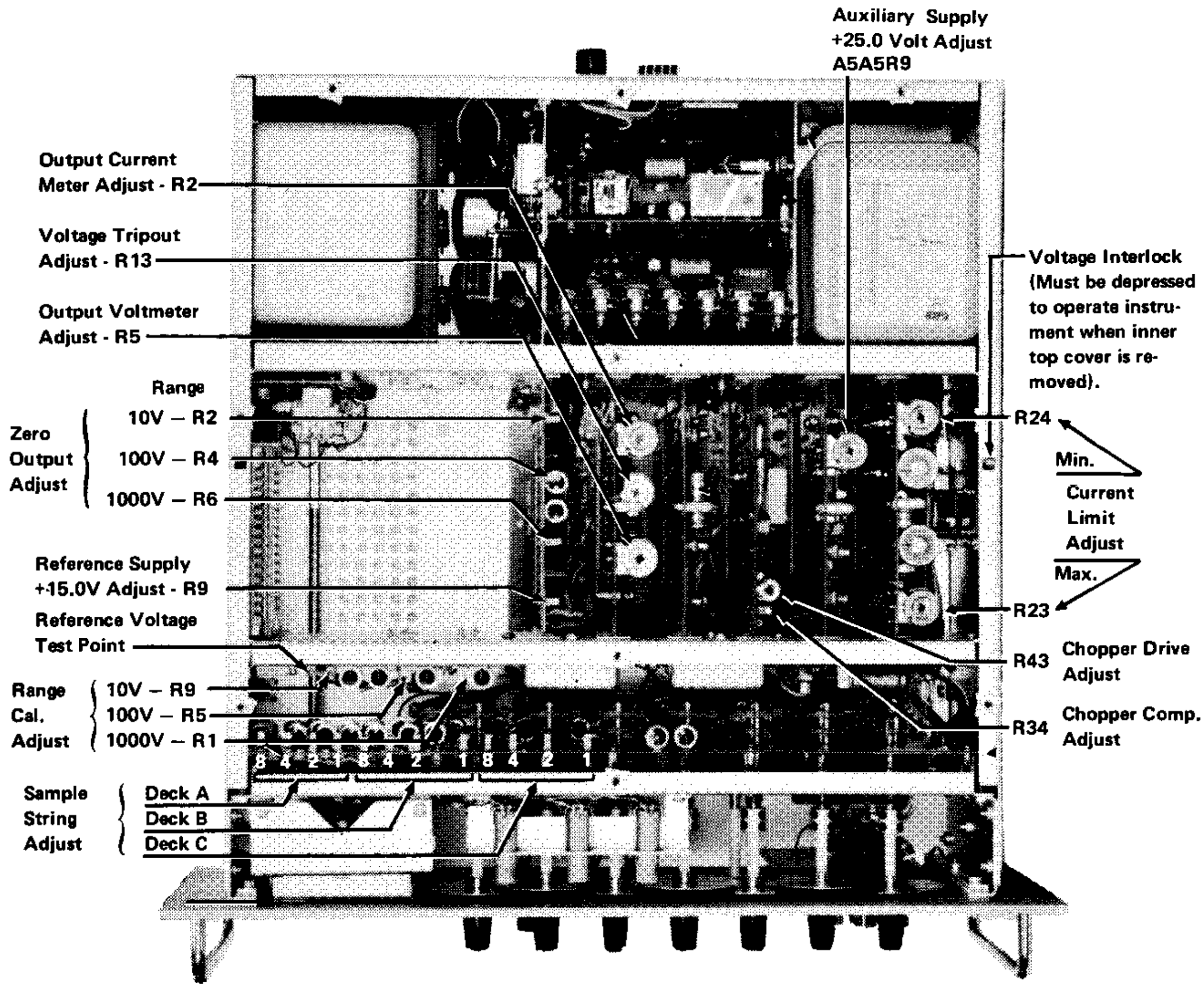


Figure 4-2. LOCATION OF ADJUSTMENTS

c. Rotate the adjustment labeled 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 and remove the external meter connections.

4-45. OUTPUT VOLTAGE MONITOR. Proceed as follows:

a. Set the front panel controls as follows:

METER	VOLTAGE
RANGE	100
Readout Dials	100.00000

b. Rotate the adjustment labeled 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 Table 4-6. All meter indications should be within ±3% of full scale.

RANGE	READOUT DIALS
10	1.000000
100	10.00000
1000	100.0000
10	10.000000
1000	1000.0000

Table 4-6. CONTROL SETTINGS FOR VOLTAGE MONITOR LINEARITY CHECK

4-46. VOLTAGE TRIP. Proceed as follows:

a. Set the front panel controls as follows:

RANGE	100
Readout Dials	10X.00000
VOLTAGE TRIPOUT ADJUST (topcover)	maximum counter-clockwise
VOLTAGE TRIP	100
VERNIER	30° from maximum

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 Table 4-7. Check the trip action on each range by rotating the VERNIER control counter-clockwise. The trip point should occur in each RANGE switch position when the VERNIER control is approximately 30° from the maximum clockwise position.

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

Table 4-7. CONTROL SETTINGS FOR TRIP RANGE CHECK

4-47. MASTER REFERENCE. Proceed as follows:

a. Set the front panel controls as follows:

POWER	ON
RANGE	1000
Readout Dials	00X.0000
VOLTAGE TRIP	1000
VERNIER	Maximum clockwise
CURRENT LIMIT	Maximum clockwise

b. Connect a Model 895A to the MASTER REFERENCE test points through the top inner cover.

c. Adjust CAL 1000V, CAL 100V and CAL 10V mechanically to mid-point of travel.

d. Rotate the REF VOLTAGE ADJUST to obtain an indication of 1500 volts (±10 uV) on the Model 895A.

e. Set the POWER switch to STDBY/RESET.

4-48. Voltage Standard Output

4-49. 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 the 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 with each other.

4-50. This procedure is divided into sections, initial and final. Both procedures are to be performed if any servicing has been done. The Final calibration need only be done if the instrument is operating normally and requires certification.

4-51. **INITIAL CALIBRATION**. The following adjustments should be performed whenever repairs have been made to the Model 332B. After completion, however, the adjustments given under Final Calibration must also be done.

4-52. The instrument should be warmed up for at least four hours at standard reference conditions of 23°C ±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.

a. Set the Model 332B controls as follows:

POWER	ON
RANGE	1000
Readout Dials	00X.0000
VOLTAGE TRIP	1000
VERNIER	Maximum Clockwise
CURRENT LIMIT	Maximum Clockwise

b. Connect a Model 895A to the MASTER REFERENCE test points through the top inner cover.

c. Rotate the REF VOLTAGE ADJUST to obtain an indication of 15.0 volts (±10 uV) on the Model 895A.

d. Connect a Model 845AR null detector across the OUTPUT terminals. Set the voltage standard dial readout to all zeros and the POWER switch to OPR.

e. At each RANGE switch position, vary the corresponding ZERO OUTPUT ADJUST (10V, 100V, 1000V) for a null indication (±2 microvolt) on the null detector.

f. Connect the 895A to the OUTPUT terminals of the 332B with the voltmeter common connected to the positive (+) output.

g. Set RANGE switch and decades on the 332B as listed in Table 4-8. Null the 895A reading or adjust the specified Sample String adjustment potentiometer.

h. Leave the 895A connected as in step f.

i. Set the RANGE and decades on the 332B as listed in Table 4-9. Adjust the 895A to the 10.0 00 00 volts. Adjust the range calibration pots (CAL) shown in Figure 4-2 as required.

j. Set the Model 332B controls as follows:

POWER	STDBY/RESET
RANGE	10
Readout Dials	5.000000
VOLTAGE TRIP	1000
VERNIER	Maximum Clockwise
CURRENT LIMIT	Maximum Clockwise

Range	Dial Setting	Adjust 895A to:	Adjust *	
1000	00 0X 00 0	Null Reading	- -	C Decade
1000	00 10 00 0	-------	1	
1000	00 1X 00 0	Null Reading	- -	
1000	00 20 00 0	-------	2	
1000	00 3X 00 0	Null Reading	- -	
1000	00 40 00 0	-------	4	
1000	00 7X 00 0	Null Reading	- -	
1000	00 80 00 0	-------	8	
1000	00 X0 00 0	Null Reading	- -	B Decade
1000	01 00 00 0	-------	1	
100	01 X0 00 0	Null Reading	- -	
100	02 00 00 0	-------	2	
100	03 X0 00 0	Null Reading	- -	
100	04 00 00 0	-------	4	
100	07 X0 00 0	Null Reading	- -	
100	08 00 00 0	-------	8	
100	0X 00 00 0	Null Reading	- -	A Decade
100	10 00 00 0	-------	1	
10V	1X 00 00 0	Null Reading	- -	
10V	20 00 00 0	-------	2	
10V	3X 00 00 0	Null Reading	- -	
10V	40 00 00 0	-------	4	
10V	7X 00 00 0	Null Reading	- -	
10V	80 00 00 0	-------	8	

* Adjust the specified Sample String potentiometers to within ±2μ volts of the previous null reading.

Table 4-8. SAMPLE STRING PRE-LINEARIZATION

332B Range	332B Dial Setting	Adjust 895A To:	Adjust
10V	100 00 00 0	10 0 00 00	10V CAL to null
100V	10 00 00 0	10 0 00 00	100V CAL to null
1000V	01 00 00 0	10 0 00 00	1000V CAL to null

Table 4-9. PRELIMINARY RANGE CALIBRATION

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

l. Referring to Figure 4-2, adjust R23 for a 60 milliampere indication on the external meter.

m. Rotate the CURRENT LIMIT control maximum counter-clockwise. Adjust R24 for approximately 0.5 milliampere indication on the external meter.

n. If necessary, re-adjust R23 and R24 until the range of the CURRENT LIMIT control is from 0.5 to 60 milliamperes.

o. Set the POWER switch to STDBY/RESET. Replace the top inner cover on the Model 332B.

p. Set the METER switch to CURRENT and POWER switch to OPR.

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

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

s. 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.

t. Set the POWER switch to STDBY/RESET. Remove the external meter connections from Model 332B.

u. Set the Model 332B front panel controls as follows:

POWER	OPR
METER	VOLTAGE
RANGE	100
Readout Dials	100.00000

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

w. Meter linearity may be checked at the cardinal points listed in Table 4-10. All meter indications should be within ±3% of full scale.

RANGE	READOUT DIALS
10	1.000000
100	10.00000
1000	100.0000
10	10.000000
1000	1000.0000

Table 4-10. CONTROL, SETTINGS FOR VOLTAGE MONITOR LINEARITY CHECK

x. Set the Model 332B controls as follows:

RANGE	1000V
Readout Dials	125.0000
VOLTAGE TRIPOUT ADJUST (top cover)	Maximum Counter-clockwise
VOLTAGE TRIP	100
VERNIER	Fully Clockwise

y. 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.

z. Set RANGE to 10 and reset the instrument.

aa. Set the POWER switch to OPR. Set the RANGE switch, TRIP switch, and readout dials as listed in Table 4-11. Check the trip action on each range by rotating the VERNIER control counter-clockwise. The trip point should occur in each RANGE switch position when the VERNIER control is approximately 30° from the maximum clockwise position.

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

Table 4-11. CONTROL SETTINGS FOR TRIP RANGE CHECK

ab. Set the output of the instrument for 4 volts on the 10 volt range. Set the VOLTAGE TRIP switch to the 10 volt position and the VERNIER control to the 12 o'clock position.

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

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

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

af. Set the VOLTAGE TRIP switch to the 1000 volt position and the VERNIER maximum clockwise. Re-set the instrument.

ag. Set the RANGE switch to 100 volts then to 10 volts. The trip circuit should not actuate in either position.

4-53. FINAL CALIBRATION. The following procedure should be performed to accomplish the final linearization of the Sample String and the Range Calibration on the 332B.

a. Connect a Model 845AR null detector across the OUTPUT terminals. Set the voltage standard dial readout to all zeros and the POWER switch to OPR.

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

c. Self-calibrate the 720A using the procedure contained in its instruction manual.

d. Using the 7101B DC Voltage Calibration System make the equipment connections shown in Figure 4-3.

e. Set the readout dials of the 720A to the standard cell voltage (e.g., ".1018000").

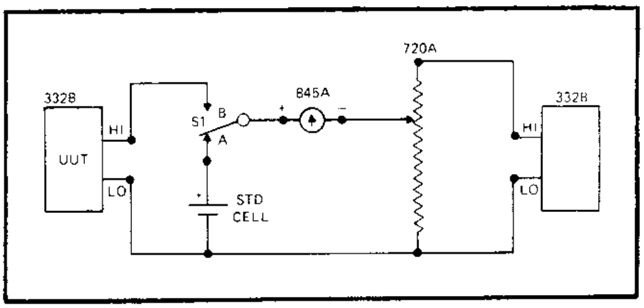


Figure 4-3. CONNECTIONS FOR SAMPLE STRING LINEARIZATION

f. Set switch S1 to position A.

g. Adjust the output of the 332B (approximately 11V) for a null indication (±1 microvolt) on the 845AR.

h. Set OPERATE switch on 845AR to zero. Set switch S1 to position B.

i. Set the RANGE and readout dials to the values listed in Table 4-12 and adjust the RANGE CAL or SAMPLE STRING ADJUST potentiometers as indicated.

STEP	720 SETTING	332B RANGE	332B DIAL SETTING	NULL ADJUSTMENT	845AR NULL
1	0000000	1000V	000.0000	(1) 845AR	±1 uV
2	.1000000	1000V	000.X000	1000V CAL	±1 uV
3	.1000000	1000V	001.0000	DECK C – 1	±1 uV
4	.2000000	1000V	002.0000	DECK C – 2	±1 uV
5	.4000000	1000V	004.0000	DECK C – 4	±2 uV
6	.8000000	1000V	008.0000	DECK C – 8	±4 uV
7	1.0000000	1000V	00X.0000	(2) 720A	±5 uV
8	Step 7 null	1000V	010.0000	DECK B – 1	±5 uV
9	0000000	100V	00.00000	(1) 845AR	±1 uV
10	.1000000	100V	01.00000	100V CAL	±1 uV
11	.2000000	100V	02.00000	DECK B – 2	±1 uV
12	.4000000	100V	04.00000	DECK B – 4	±2 uV
13	.8000000	100V	08.00000	DECK B – 8	±4 uV
14	1.0000000	100V	0X.00000	(2) 720A	±5 uV
15	Step 14 null	100V	10.00000	DECK A – 1	±5 uV
16	0000000	10V	0.000000	(1) 845AR	±1 uV
17	.1000000	10V	1.000000	10V CAL	±1 uV
18	.2000000	10V	2.000000	DECK A – 2	±1 uV
19	.4000000	10V	4.000000	DECK A – 4	±2 uV
20	.8000000	10V	8.000000	DECK A – 8	±4 uV

(1) Adjust the 845AR ZERO ADJ to obtain a system zero.

(2) Adjust the 720A readout dials for a null on the 845AR. Retain this setting for the next step.

Table 4-12. FINAL LINEARIZATION OF DECK C, B AND A

j. Repeat steps a. through h., paragraph 4-53.

k. Set the RANGE and readout dials to the values listed in Table 4-13 and adjust the RANGE CAL potentiometers as indicated.

NOTE!

The calibration of the 332B should now be checked to ensure that it meets the accuracy specifications.

l. Using the 7101B DC Voltage Calibration System make the equipment connections shown in Figure 4-4.

m. Set the Standard cell voltage on the standard cell readout dials of the 750A.

n. Set the instruments to the settings shown in step 1 of Table 4-14.

o. Connect the 845AR across the output terminals of the 332B. The 845AR should read zero volts and be within the tolerance specified in Table 4-14.

p. Connect the 845AR to test points A shown in Figure 4-4.

q. Set the instruments to the settings shown in step 2 of Table 4-14.

r. Switch in the null indicator with the switch on the 750A and adjust the output of the 332B for a null indication (±1 microvolt) on the 845AR. The 332B should read ≈ 1100 volts.

s. Connect the 845AR to test points B shown in Figure 4-4. The null indicator should read within the tolerance specified for this step in Table 4-14.

t. Perform the remaining checks in Table 4-14 by setting the instruments as specified in each step and checking the specified tolerance against the 845AR null indicator. The steps that are marked with a flag should be performed as in instruction o. of this paragraph.

WARNING!

During this procedure high voltage is present at the terminals of all test instruments except the standard cell. When relocating the null indicator the output of the 332B should be set to zero volts.

720A SETTING	332B RANGE	332B DIAL SETTING	NULL ADJUSTMENT	845AR NULL
1.0000000	1000V	010.0000	1000V CAL	±5 uV
1.0000000	100V	10.00000	100V CAL	±5 uV
1.0000000	10V	10.000000	10V CAL	±5 uV

Table 4-13. FINAL RANGE CALIBRATION

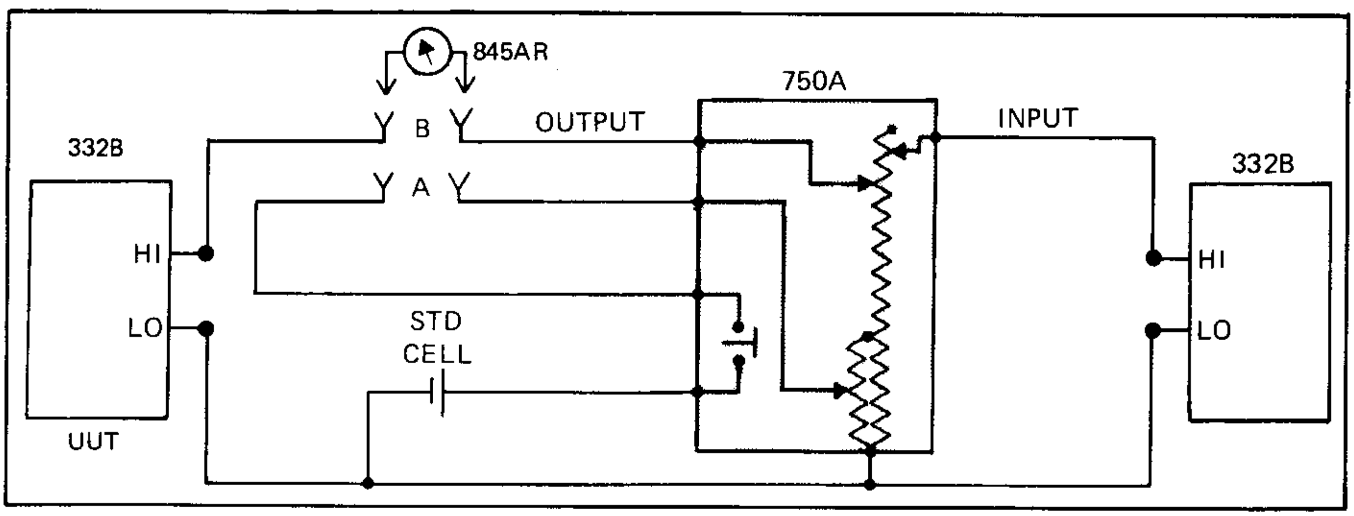


Figure 4-4. CONNECTIONS FOR RANGE CALIBRATION CHECKS

STEP	750A SETTING INPUT	OUTPUT	332B RANGE	DIAL SETTING	TOLERANCE
[1] 1	- - -	- - -	10V	0.000000	±10 uV
2	1100	5	10V	5.000000	±110 uV
3	1100	10	10V	10.000000	±210 uV
[1] 4	- - -	- - -	100V	00.00000	±20 uV
5	1100	5	100V	05.00000	±120 uV
6	1100	10	100V	10.00000	±220 uV
7	1100	50	100V	50.00000	±1020 uV
8	1100	100	100V	100.00000	±2020 uV
[1] 9	- - -	- - -	1000V	000.0000	±200 uV
10	1100	5	1000V	005.0000	±300 uV
11	1100	10	1000V	010.0000	±400 uV
12	1100	50	1000V	050.0000	±1.2 mV
13	1100	100	1000V	100.0000	±2.2 mV
14	1100	500	1000V	500.0000	±10.2 mV
15	1100	1000	1000V	1000.000	±20.2 mV
16	1100	1100	1000V	10X0.0000	±22.2 mV
17	1100	1100	1000V	1099.999X	±22.2 mV

[1] Perform this test as described in step o., paragraph 4-53.

Table 4-14. CONTROL SETTINGS AND TOLERANCES FOR CALIBRATION CHECK

4-54. TROUBLESHOOTING

4-55. A thorough understanding of the principles of operation is necessary to efficiently troubleshoot the instrument. It is recommended that Section 3 be reviewed before attempting to troubleshoot the unit.

4-56. 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 the Standby Power Check, Paragraphs 4-57 and 4-59 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.

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 controlling power to the High Voltage Rectifier, the POWER switch may be set to the OPR position and the Series Pass Element checked.

WARNING !

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

4-57. Resistance Measurements

4-58. These checks verify correct output resistance of auxiliary voltage supplies. A check of the sample string may reveal an open resistor, which is sometimes a cause of loss of regulation. An ohmmeter (RCA VoltOhmyst or equivalent) is required for this test.

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 front panel controls as follows:

POWER	OFF
METER	V
VOLTAGE RANGE	100V
VOLTAGE TRIP	1000V
VERNIER	Fully Clockwise (CW)
CURRENT LIMIT	Fully Clockwise (CW)
Decade Dials	50.00000

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	8.4 kilohms
Auxiliary Power Supply	10	2.1 kilohms
Current Limiter	1	6.0 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 negative 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.

4-59. Standby Power

4-60. This check measures power consumption in the STDBY/RESET mode. It reveals possible gross faults such as wiring errors or 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 come on and the time delay relay (A6-K2001) should operate. The wattmeter should indicate 30 to 40 watts power drain.

4-61. Auxiliary Supply Voltages

4-62. This procedure checks out the bias voltages, master reference voltage and the series pass element voltage.

a. Using the Model 895A differential voltmeter, measure the voltage between the test points listed in Table 4-15 and the +SENSE terminal, which is common.

b. Where indicated, perform the adjustment to determine that it can be made. These should be re-checked 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
Range Cal	Test Points	14.9 to 15.1 [2]
Reference Supply	Collector Q1	26 to 35 [3]
Series Pass	Collector Q8	Approx. 140
Rear bulkhead power resistor, 100 kilohms	Yellow lead	650 to 725

[1] Adjustable to 25 volts ±10 mv with R9
[2] Adjustable to 15.0 volts ±10 uV with R9 on Reference Supply pcb
[3] Approximately 1 volt at turn-on, rising to 26 to 35 volts after 10 minute warm up.

Table 4-15. REFERENCE AND AUXILIARY VOLTAGES

4-63. Unijunction Oscillator and Chopper Amplifier

4-64. UNIJUNCTION OSCILLATOR. 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 is 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 1 milliseconds/cm and vertical sensitivity to 1 volt/cm.

b. Set the POWER switch to STDBY/RESET. Positive going pulses of 1.0 to 2.0 volts peak-to-peak should be observed.

4-65. CHOPPER AMPLIFIER. This procedure checks the alignment and response of the Chopper Amplifier in the 332B. An oscilloscope and a general purpose supply are required for this test. To check alignment:

a. Install the Chopper Amplifier assembly on the extender card. Connect an oscilloscope to the base of Q3 on the Chopper Amplifier Board. The scope common should be connected to Pin 13 of the card connector. Connect a clip lead between Pin 6 and Pin 12 of the input connector.

b. Turn the POWER switch to STDBY/RESET. Turn the CHOPPER DRIVE ADJUST (R43) to maximum clockwise. Turn CHOPPER COMPENSATION ADJUST to maximum clockwise.

c. Adjust R34, CHOPPER COMPENSATION ADJUST for minimum pulse amplitude. The total adjustment range of R34 should provide a positive and negative pulse swing. If this is not satisfied, cut the jumper across R33 and again adjust R34. When correctly adjusted, R34 will reduce the positive spike at the transition point to zero.

d. Alternately adjust R43 counter-clockwise and R34 as necessary to obtain maximum squareness of the chopper waveform without a spike at the transition point. When correctly adjusted, waveform should appear as shown in Figure 4-5.

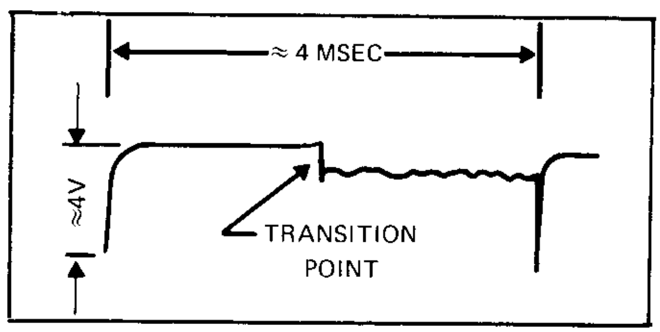


Figure 4-5. CHOPPER WAVEFORM

e. Replace the chopper board in the instrument.

4-66. To check amplifier response:

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 1 milliseconds/cm and vertical sensitivity to 1 volt/cm.

b. Set the POWER switch to STDBY/RESET. Positive going pulses of 1.0 to 2.0 volts peak-to-peak should be observed.

c. Set POWER switch to OPR position. The pulses observed in step b. should disappear.

d. Set the output of a laboratory power supply to 5.5V dc.

e. With 332B POWER switch in OPR position, connect the lab supply to the corresponding OUTPUT terminals of the 332B.

f. Set 332B controls as follows and observe unijunction pulses:

Range	Dialed Voltage	Unijunction Pulses
10V	5.000000	Should appear
10V	6.000000	Should disappear
100V	05.00000	Should appear
100V	06.00000	Should disappear
1000V	005.0000	Should appear
1000V	006.0000	Should disappear

4-67. Pre-Regulator

4-68. This check verifies operation of the Pre-Regulator circuitry Q1 through Q8. An oscilloscope and 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 instrument 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 1 millisecond/cm and the vertical sensitivity to 0.5 volt/cm.

e. Set the readout dials to 50.0000 and the POWER switch to STDBY/RESET. The oscilloscope waveform should appear as shown in Figure 4-6.

f. Set the POWER switch to OPR. The oscilloscope waveform should appear as shown in Figure 4-7.

g. Set POWER switch to STDBY/RESET and remove oscilloscope connections. Short out the interlocks using nylon blocks. Set POWER switch to OPR. Voltmeter of 332B should indicate 50±10 volts.

h. Set RANGE switch to 10 volt range. Voltmeter should indicate 5 ±1 volt.

i. Set RANGE switch to 1000 volt range. Voltmeter should indicate 500 ±100 volts. Set POWER switch to OFF.

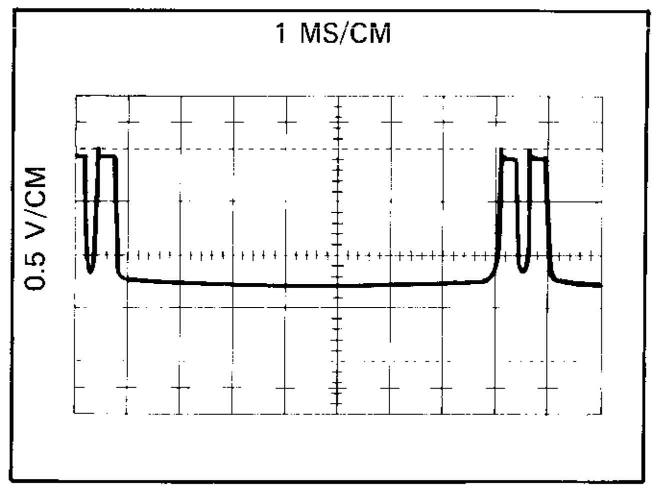


Figure 4-6. PRE-REGULATOR Q1, WAVEFORM ON STDBY/RESET

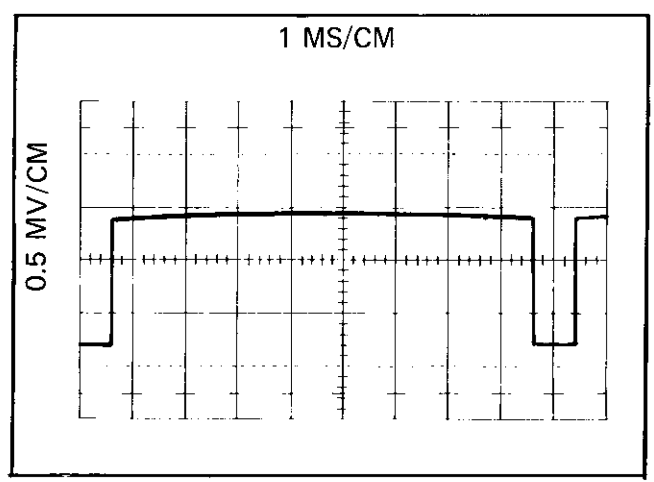


Figure 4-7. PRE-REGULATOR Q1, WAVEFORM ON OPR

j. Connect the oscilloscope across the 50 watt zener diode on the pre-regulator assembly. Connect oscilloscope "positive" input to cathode; connect "negative" input to the anode; use a 10X probe. Connect output to load box.

k. Set decades for 1100 volt output and set CURRENT LIMIT to 60 mA. Set POWER switch to OPR and apply full load, 60 mA.

l. Set oscilloscope sensitivity to 50V/cm and sweep speed to 2 ms/cm.

m. Set line voltage to 115V ac, 60 Hz. The waveform observed on the oscilloscope should appear as in Figure 4-8A and should not exceed 150 volts peak.

n. Set line voltage to 100V ac, 60 Hz. The waveform observed on the oscilloscope should appear as in Figure 4-8B and should not exceed 150 volts peak.

o. Set line voltage to 130V ac, 60 Hz. The waveform observed on the oscilloscope should appear as in Figure 4-8C and should not exceed 150 volts peak.

p. Remove oscilloscope connections.

4-69. Series Pass Element

4-70. If the procedure has been completed satisfactorily thus far, the main parts of the voltage control circuitry have been checked out excluding the Series Pass P/C Assembly. A differential voltmeter and a load resistor box are required for this test.

a. Set the line voltage to 100V ac and set readout dials to all zeros on 10 volt range. Connect a voltmeter between the collector of Q1 and the emitter of Q8 on the Pass Element Assembly. This voltage should read less than 82V dc.

b. Set the line voltage and 332B controls as in Table 4-16 and measure the voltage between the collector and emitter of Q8. The voltages should be within the specified limits.

c. Connect the voltmeter across the OUTPUT terminals of the 332B. Set the 332B for the following outputs on the 1000 volt range and short the OUTPUT terminals at each setting. The output should return to normal upon removal of the short.

OUTPUTS: 100, 300, 600, 900, 1100 volts.

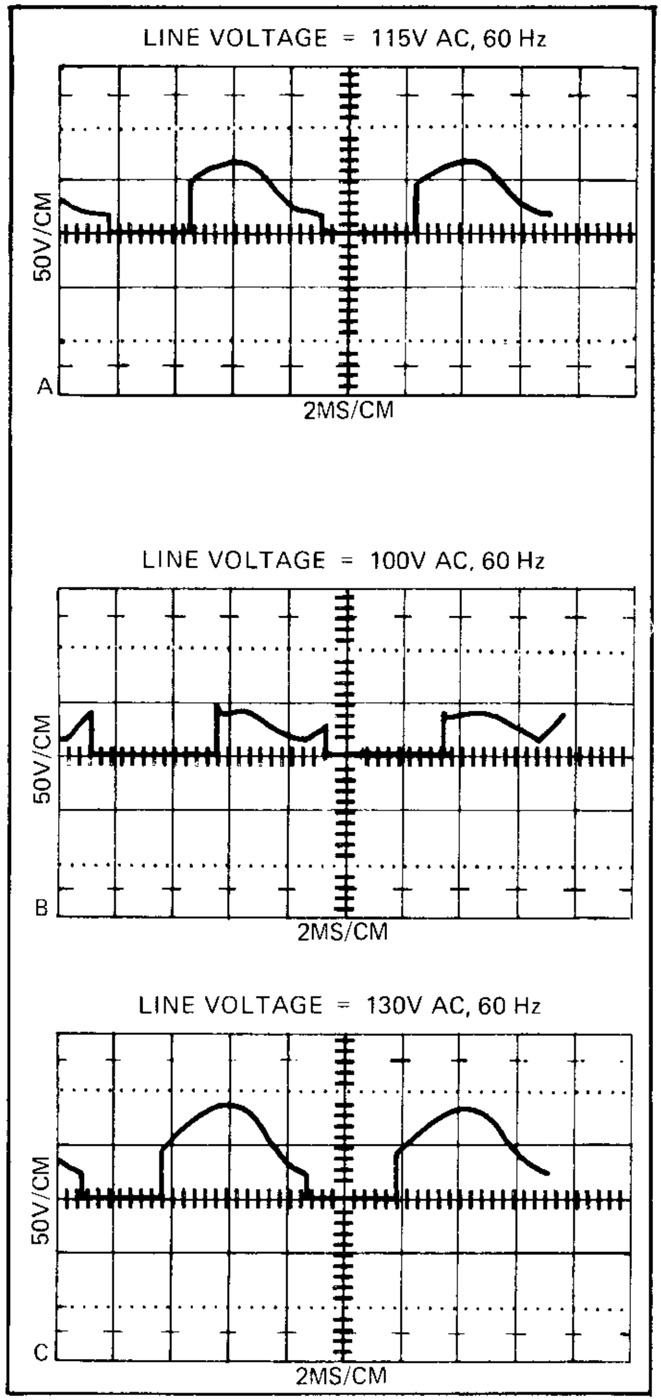


Figure 4-8. WAVEFORMS ACROSS ZENER DIODE

Range	Output	Load	Line Voltage	Voltage Limits Across Q8	
				Min.	Max.
10	0	0	100	45	100
10	0	0	130	45	90
1000	1100	60 mA	100	42	55
1000	1100	60 mA	130	42	55

Table 4-16. SERIES PASS ELEMENT VOLTAGE CHECKS

Section 5

Lists of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alpha-numerically by assembly. Electrical components are listed by reference designation and mechanical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

a. Reference Designation or Item Number.

b. Description of each part

c. Fluke Stock Number.

d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)

e. Manufacturer's part Number or Type.

f. Total Quantity per assembly or component.

g. Recommended Quantity: This entry indicates 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 in each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.

h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK 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. To ensure prompt and efficient handling of your order, include the following information.

a. Quantity

b. FLUKE Stock Number

c. Description

d. Reference Designation or Item Number

e. Printed Circuit Board Part Number

f. Instrument model and Serial number

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	DC VOLTAGE STANDARD **Figure 5-1**	332B					
A1	Capacitor P/C Assembly (See Figure 5-2)	239343 (332B-4055)	89536	239343	1		
A2	Sample String P/C Assembly (See Figure 5-3)	314849 (332B/AF-4051)	89536	314849	1 1		
A3	Capacitor Switch P/C Assembly (See Figure 5-4)	227603 (335A-4092)	89536	227603	1		
A4	Range Calibration P/C Assembly (See Figure 5-5)	314856 (332B/AF-4052)	89536	314856	1		
A5	Main Mother Board P/C Assembly (See Figure 5-6)	219238 (335A-4064)	89536	219238	1		
A5A1	Reference Supply P/C Assembly (See Figure 5-7)	314864 (332B/AF-4083)	89536	314864	1		
A5A2	Series Pass Driver P/C Assembly (See Figure 5-8)	219154 (335A-4056)	89536	219154	1		
A5A3	Differential Amplifier P/C Assembly (See Figure 5-9)	219162 (335A-4057)	89536	219162	1		
A5A4	Chopper Amplifier P/C Assembly (See Figure 5-10)	251918 (333A-4004)	89536	251918	1		
A5A5	Auxiliary Power Supply P/C Assembly (See Figure 5-11)	219188 (335A-4059)	89536	219188	1		
A5A6	Current Limiter P/C Assembly (See Figure 5-12)	219196 (335A-4060)	89536	219196	1		
A6	Time Delay P/C Assembly (See Figure 5-13)	192260 (332A-420)	89536	192260	1		
A7	High Voltage Mother Board P/C Assembly (See Figure 5-14)	239350 (332B-4056)	89536	239350	1		
A7A1	Series Pass Element P/C Assembly (See Figure 5-15)	314823 (332B/AF-4061)	89536	314823	1		
A7A2	Preregulator P/C Assembly (See Figure 5-16)	314815 (332B/AF-4082)	89536	314815	1		
A8	Extender P/C Board	187344 (332A-415)	89536	187344	1		
C1	Cap, oil, 4 uf ± 10%, 1,200V	183541	01884	CMLE405K12	1		
C2	Cap, cer, 0.01 uf, gmv, 1,600V (located on C1)	106930	71590	DD16-103	2		

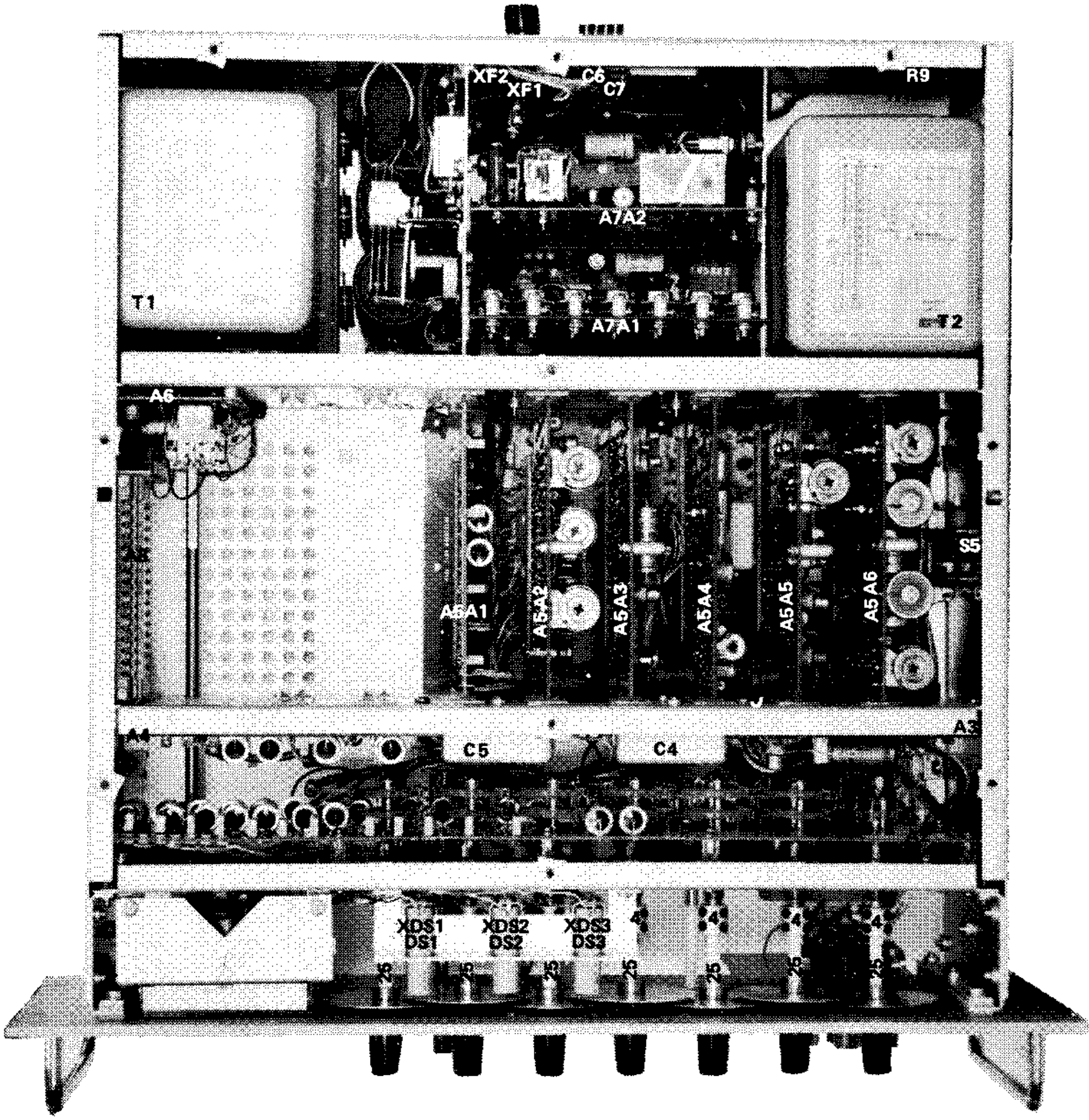


Figure 5-1. DC VOLTAGE STANDARD (Sheet 1 of 3)

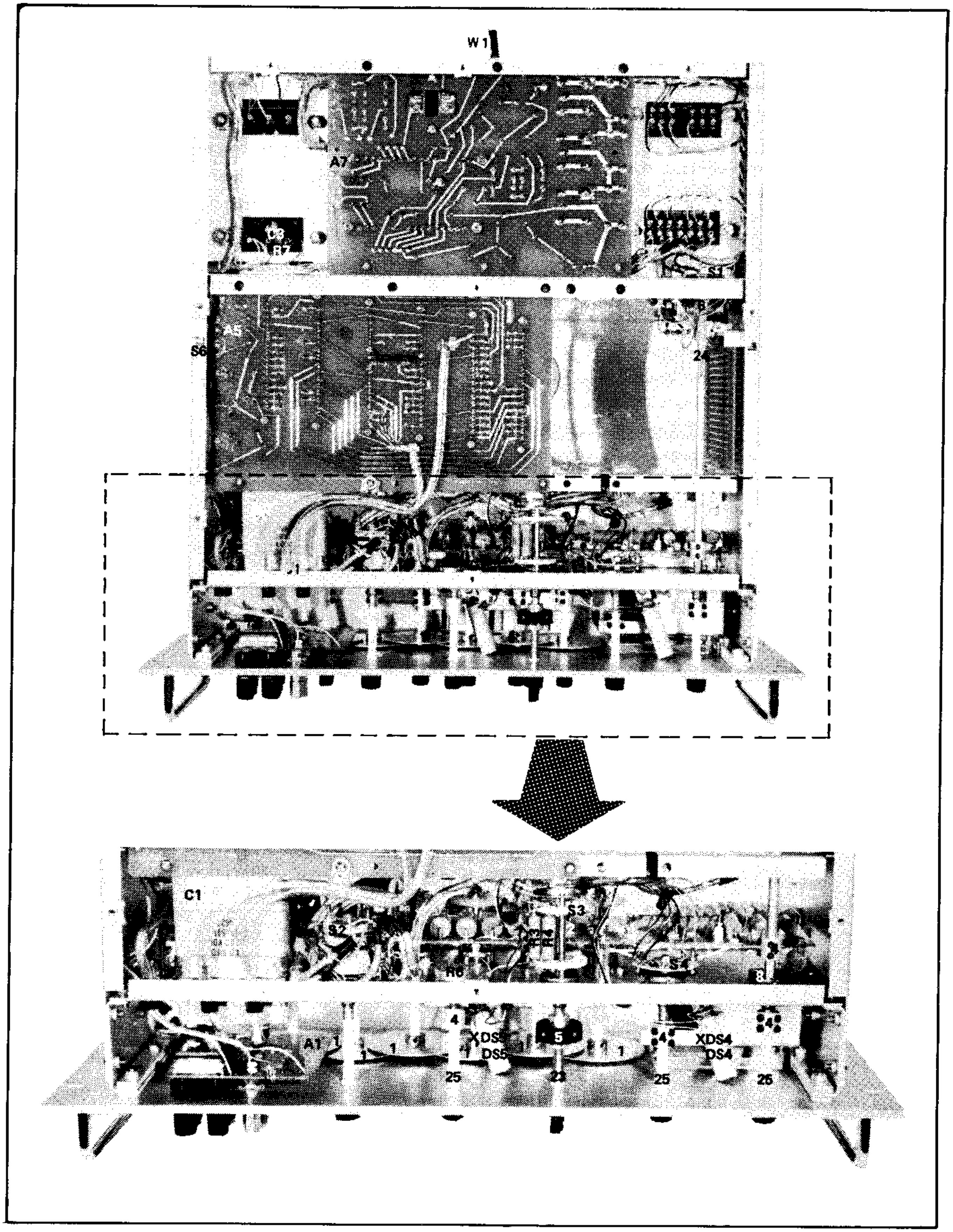
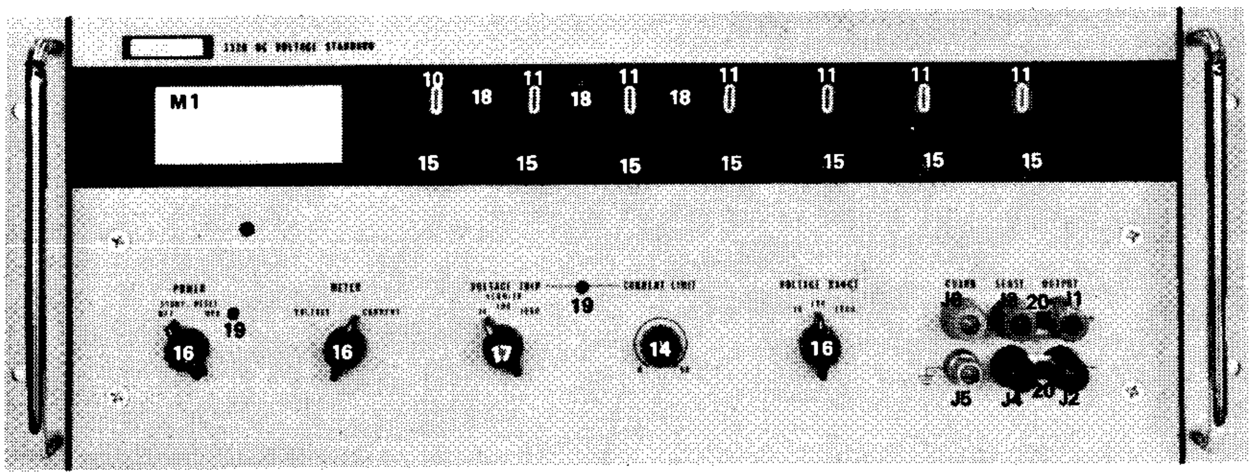


Figure 5-1. DC VOLTAGE STANDARD (Sheet 2 of 3)



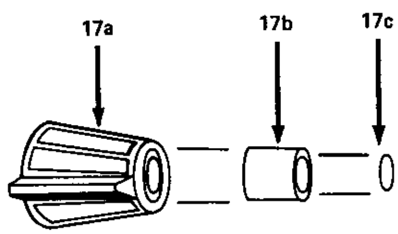


Figure 5-1. DC VOLTAGE STANDARD (Sheet 3 of 3)

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C3	Cap, cer, 0.005 uf ±20%, 3,000V	188003	71590	DD30-502	1		
C4,C5	Cap, plstc, 0.1 uf ±10%, 1,500V	234260	96733	C-60232A	2		
C6, C7	Cap, poly, .10 uf ±10%, 400V	289744	73445	C280CFA100K	2		
CR1	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	51	5	
CR2, CR3	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	48	5	
CR4 thru CR8	Diode, light-emitting	309617	71318	FLV102	5		
F1	Fuse, Type MDL, slow blow, 1/4 amp, 250V	166306	71400	Type MDL	1	5	
F2	Fuse, Type MDA, slow blow, 3 amp, 250V (For 115V operation)	109280	71400	Type MDA	1	5	
F2	Fuse, Type MDX, slow blow, 1-1/2 amp, 250V (For 230V operation)	109231	71400	Type MDX	1	5	
J1	Binding post, red, OUTPUT	149856	58474	BHB10208G22	2		
J2	Binding post, black, OUTPUT	149864	58474	BHB10208G21	2		
J3	Binding post, red, SENSE	149856	58474	BHB10208G22	REF		
J4	Binding post, black, SENSE	149864	58474	BHB10208G21	REF		
J5	Binding post, GROUND	155911	58474	GP30NC	1		
J6	Binding post, blue, GUARD	233833	58474	DF31BLC	1		
K1	Relay, armature, 115 vac, dpdt	148940	73949	060713-00	1		
M1	Meter, 0-100 ua, 325Ω	225490	89536	225490	1		
R1	Res, met flm, 100k ±1%, 1/2w (mounted on S3)	151316	75042	Type CEC-TO	2		
R2	Res, met flm, 1M ±1%, 1/2w (mounted on S3)	161075	75042	Type CEC-TO	1		
R3, R4	Res, car flm, 5M ±1%, 1w	107458	75042	Type C13	2		
R5	Res, var, ww, 5k ±10%, 5w (mounted on S3)	219758	71450	Type AW	1		
R6	Res, var, ww, 300Ω ±10%, 5w	219741	71450	Type AW	1		
R7	Res, comp, 1k ±10%, 1/2w	108563	01121	EB1021	4		
R8	Res, ww, 500Ω ±5%, 25w	183533	14193	Type MC250	1		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R9, R10	Res, ww, 100k ±1%, 10w	177121	14193	Type SP1127	2		
S1	Switch, POWER, STDBY/RESET wafer Switch, POWER, OPR wafer	187864 187872	76854 76854	Type HC 248214HC	1 1		
S2	Switch, VOLTAGE RANGE, rotary	237305	89536	237205	1		
S3	Switch, VOLTAGE TRIP, rotary	240739	89536	240739	1		
S4	Switch, METER, rotary	187146	89536	187146	1		
S5, S6	Switch, interlock	187708	91929	V3L-78	2		
T1	Transformer, power	222315	89536	222315	1		
T2	Transformer, high voltage	222307	89536	222307	1		
W1	Line cord	102822	89536	102822	1		
XF1, XF2	Holder, fuse	160846	75915	342004	2		
1	Coupler, dial	130252	89536	130252	7		
2	Coupler, R5 to S3	193557	89536	193557	1		
3	Coupler, Digit Switches to detents	226779	89536	226779	7		
4	Coupler, Digit Switches, S1, S4, R6	104505	89536	104505	11		
5	Coupler, S3	246058	89536	246058	1		
6	Coupler, S1 shaft to S1 wafer	200592	89536	200592	1		
7	Cover (not illustrated)	228809	89536	228809	1		
8	Detent, S1	240895	89536	240895	1		
9	Detent, Digit Switches	240887	89536	240887	7		
10	Dial, 0-10	226993	89536	226993	1		
11	Dial, 0-X	226985	89536	226985	6		
12	Foot, rubber (not illustrated)	103309	77969	9102W	4		
13	Handle, chrome plated brass	101717	05704	807	2		
14	Knob, CURRENT LIMIT	190249	89536	190249	1		
15	Knob, DIGITS 1-7	158949	89536	158949	7		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
16	Knob, METER, POWER, VOLTAGE RANGE	158956	89536	158956	3		
17	Knob, VOLTAGE TRIP						
17a	Concentric	162347	89536	162347	1		
17b	vernier	241018	89536	241018	1		
17c	trim disc	236950	89536	236950	1		
18	Lens, decimal, clear	222596	89536	222596	3		
19	Lens, decimal, red	228056	89536	228056	2		
20	Link, shorting, copper	190728	24655	938LG	2		
21	Panel, front	228775	89536	228775	1		
22	Shaft, S3 (not illustrated)	227272	89536	227272	1		
23	Shaft, S3 to front panel	240879	89536	240879	1		
24	Shaft, S1	239392	89536	239392	1		
25	Shaft, Digit Switches, S1, S4, R6	226928	89536	226928	10		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1	**CAPACITOR P/C ASSEMBLY Figure 5-2**	239343 (332B-4055)	89536	239343	REF		
C1, C2	Cap, plstc, 1 uf ±20%, 250V	190330	73445	C280AE/PIM	2		
CR1, CR2	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		

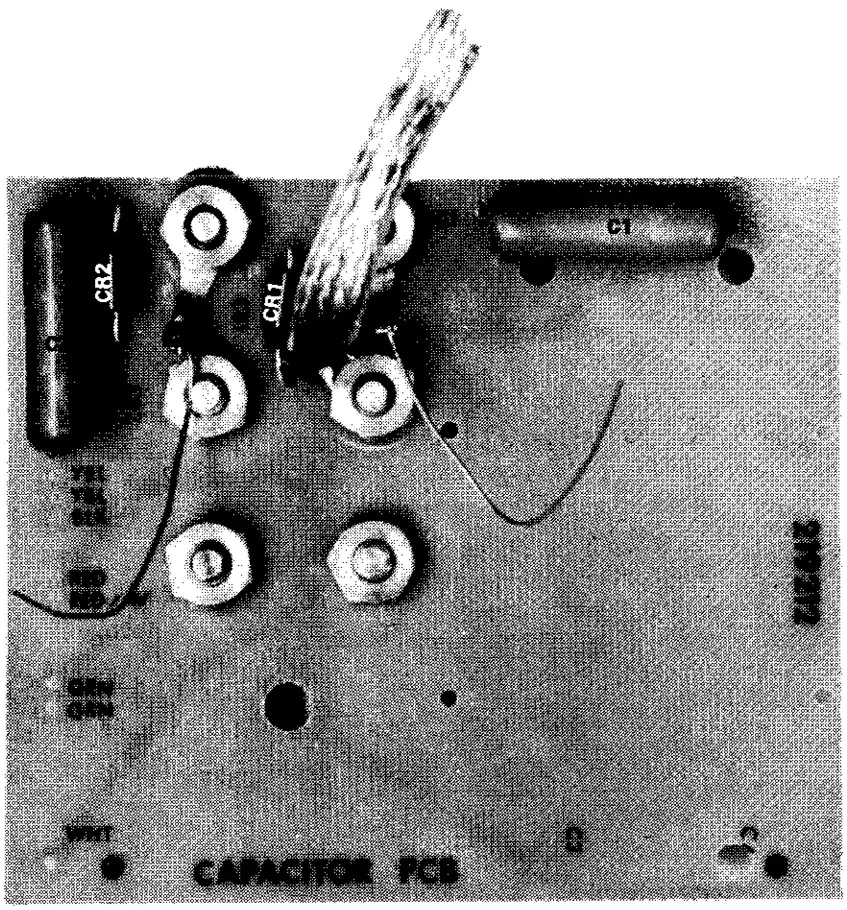


Figure 5-2. CAPACITOR PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2	**SAMPLE STRING P/C ASSEMBLY** **Figure 5-3**	314849 (332B/AF-4051)	89536	314849	REF		
R1, R2	Res, met flm, 34Ω ±1%, 1/8w	296699	91637	TYPE MFF1/8	2		
R3, R4	Res, met flm, 20Ω ±1%, 1/8w	236844	91637	TYPE MFF1/8	2		
R5, R6	Res, var, cer met 50Ω ±20%, 1/2w	267815	71450	190PC500B	2		
R7, R8, R9, R10, R11, R12	Res, var, cer met 20Ω ±20%, 1/2w	261180	71450	190PC200B	6		
R13 thru R24	Res, met flm, 10Ω ±1%, 1/8w	268789	91637	TYPE MFF1/8	12		
R25	Res, 997.5Ω, matched set	▷1	89536	▷1	1		
R26	Res, 1996.5Ω, matched set	▷1		▷1	1		
R27, R28	Res, 3.995k, matched set	▷1	89536	▷1	2		
R29 thru R35	Res, 19.985k, matched set	▷1	89536	▷1	7		
R36 thru R46	Res, 99.925k, matched set	▷1	89536	▷1	11		
R47	Res, var, cer met, 100Ω ±20%, 1/2w	267823	71450	190PC101B	1		
R48	Res, var, cer met, 200Ω ±20%, 1/2w	284711	71450	190PC201B	1		
R49, R50	Res, var, cer met, 500Ω ±20%, 1/2w	267849	71450	190PC501B	2		
R51	Res, met flm, 100Ω ±1%, 1/8w	168195	91637	TYPE MFF1/8	1		
R52	Res, met flm, 200Ω ±1%, 1/8w	245340	91637	TYPE MFF1/8	1		
R53, R54	Res, met flm, 348Ω ±1%, 1/8w	236778	91637	TYPE MFF1/8	2		
R55	Res, ww, 2Ω ±0.2%, 1/10w	131870	89536	131870	1		
R56	Res, ww, 1Ω ±2%, 1/10w	131888	89536	131888	1		
R57, R58	Res, ww, 4Ω +.015%, 1/4w	313809	89536	313809	2		
R59	Res, ww, 10Ω ±9%, 1/2w	155879	89536	155879	1		
R60	Res, ww, 20Ω +5%, 1/2w	155887	89536	155887	1		
R61, R62	Res, ww, 40Ω, 1/2w	158022	89536	158022	2		
R63	Res, ww, 100Ω +0.15%, 1/2w	155846	89536	155846	1		
R64	Res, ww, 200Ω +0.15%, 1w	131656	89536	131656	1		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R65, R66	Res, ww, 400Ω ±0.25%, 1/2w	131698	89536	131698	2		
S1 thru S6	Switch, rotary, sample string	313023	76854	249	6		
S7	Switch, assembly, seventh decade (R67 thru R76 included)	291021	89536	291021	1		

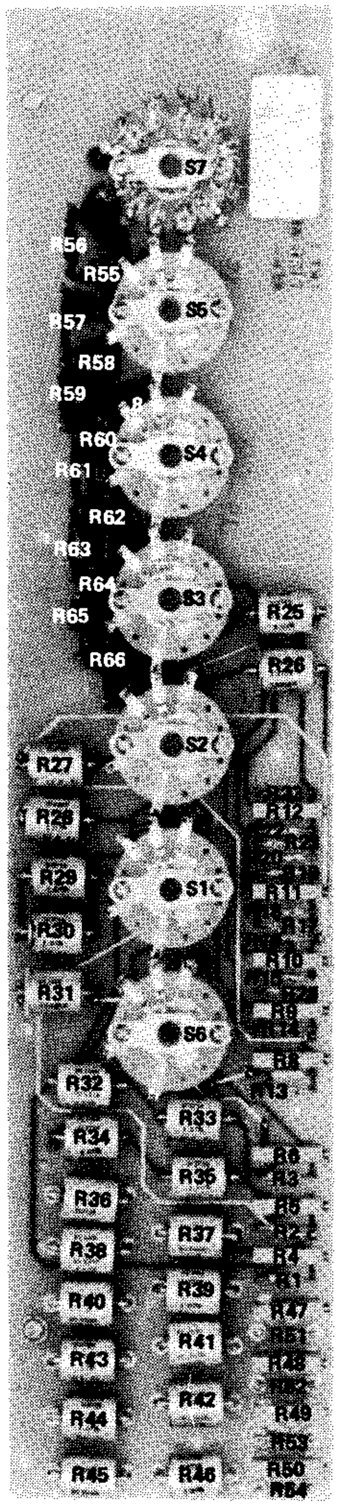


Figure 5-3. SAMPLE STRING PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A3	**CAPACITOR SWITCH P/C ASSEMBLY Figure 5-4**	227603 (335A-4092)	89536	227603	REF		
C1	Cap, elect, 400 uf +50/-10%, 25V	168153	73445	C437ARF400	1	1	
CR1	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
K1	Relay, reed, 1,000V	233916	12617	Type DRR-5	1		
	Coil, reed relay, 24V	186155	71707	SP-24-P	4		
Q1	Tstr, silicon, NPN	203489	07910	CDQ10656	17	5	
R1, R6	Res, comp, 100Ω ±10%, 1/2w	108100	01121	EB1011	2		
R2	Res, comp, 15k ±10%, 1/2w	108530	01121	EB1531	2		
R3	Res, comp, 470Ω ±10%, 1/2w	108415	01121	EB4711	2		
R4	Res, comp, 10k ±10%, 1/2w	108118	01121	EB1031	4		
R5	Res, comp, 1k ±10%, 1/2w	108563	01121	EB1021	REF		
R7	Res, comp, 39k ±5%, 1w	236729	01121	GB3935	1		

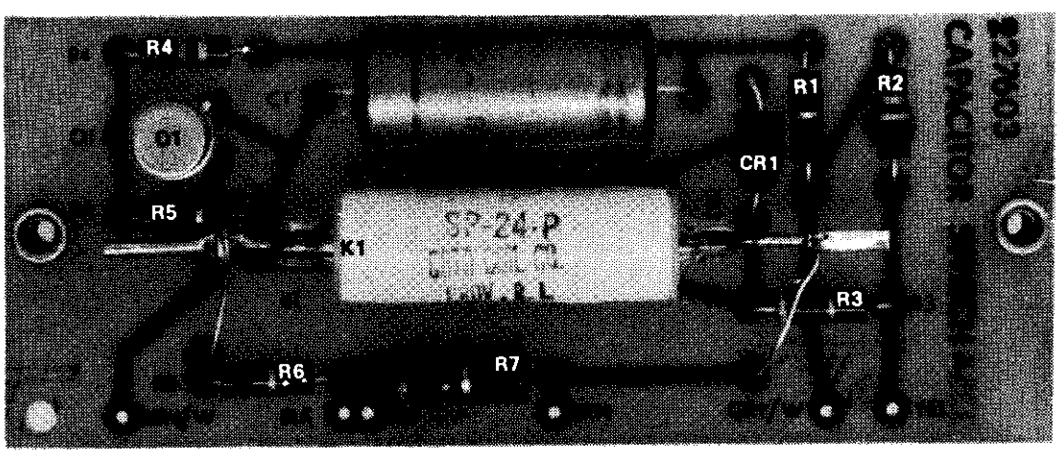


Figure 5-4. CAPACITOR SWITCH PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A4	**RANGE CALIBRATION P/C ASSEMBLY Figure 5-5**	314856 (332B/AF-4052)	89536	314856	REF		
R1	Res, var, cer met, 20Ω ±20%, 1/2w	261180	71450	190PC200B	1		
R2, R3	Res, ww, 7.492k, matched set	▷1	89536	▷1	2		
R4	Res, met flm, 20Ω ±1%, 1/2w	296350	91637	TYPE MFF1/8	1		
R5	Res, var, cer met 200Ω ±20%, 1/2w	284711	71450	190PC201B	1		
R6, R7	Res, ww, 74.925k, matched set	▷1	89536	▷1	2		
R8	Res, met flm, 200Ω ±1%, 1/2w	151480	91637	TYPE MFF1/8	1		
R9	Res, var, cer met, 2k ±20%, 1/2w	267864	71450	190PC202B	1		
R10, R11	Res, ww, 749.25k, matched set	▷1	89536	▷1	2		
R12	Res, met flm, 2k ±1%, 1/2w	151266	91637	TYPE MFF1/2	1		
T1	Test point, red	170480	74970	105-752	1		
T2	Test point, black	149112	74970	105-0753	1		

▷1 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 regarding obtaining parts.

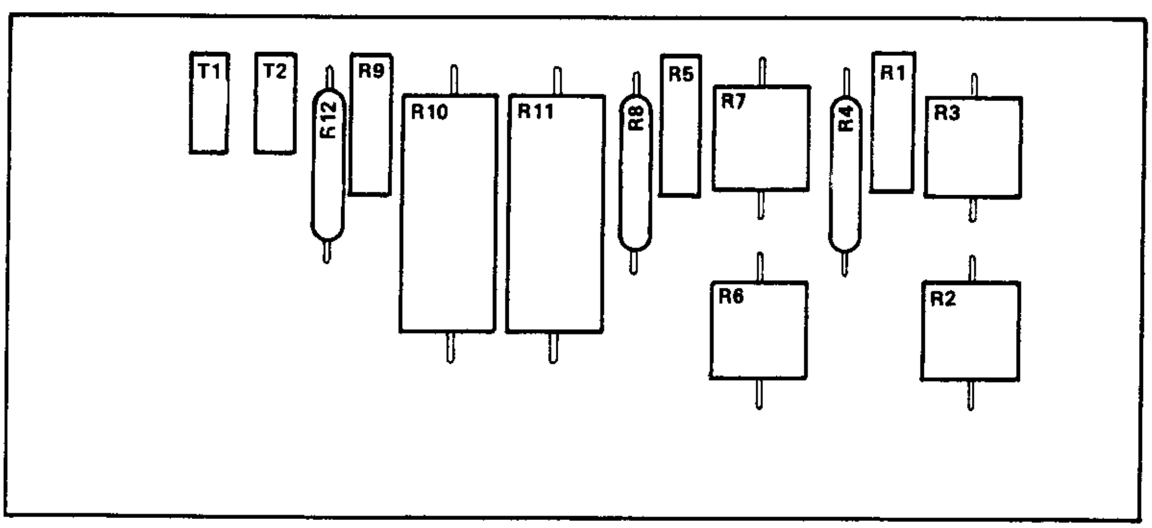


Figure 5-5. RANGE CALIBRATION PRINTED CIRCUIT ASSEMBLY

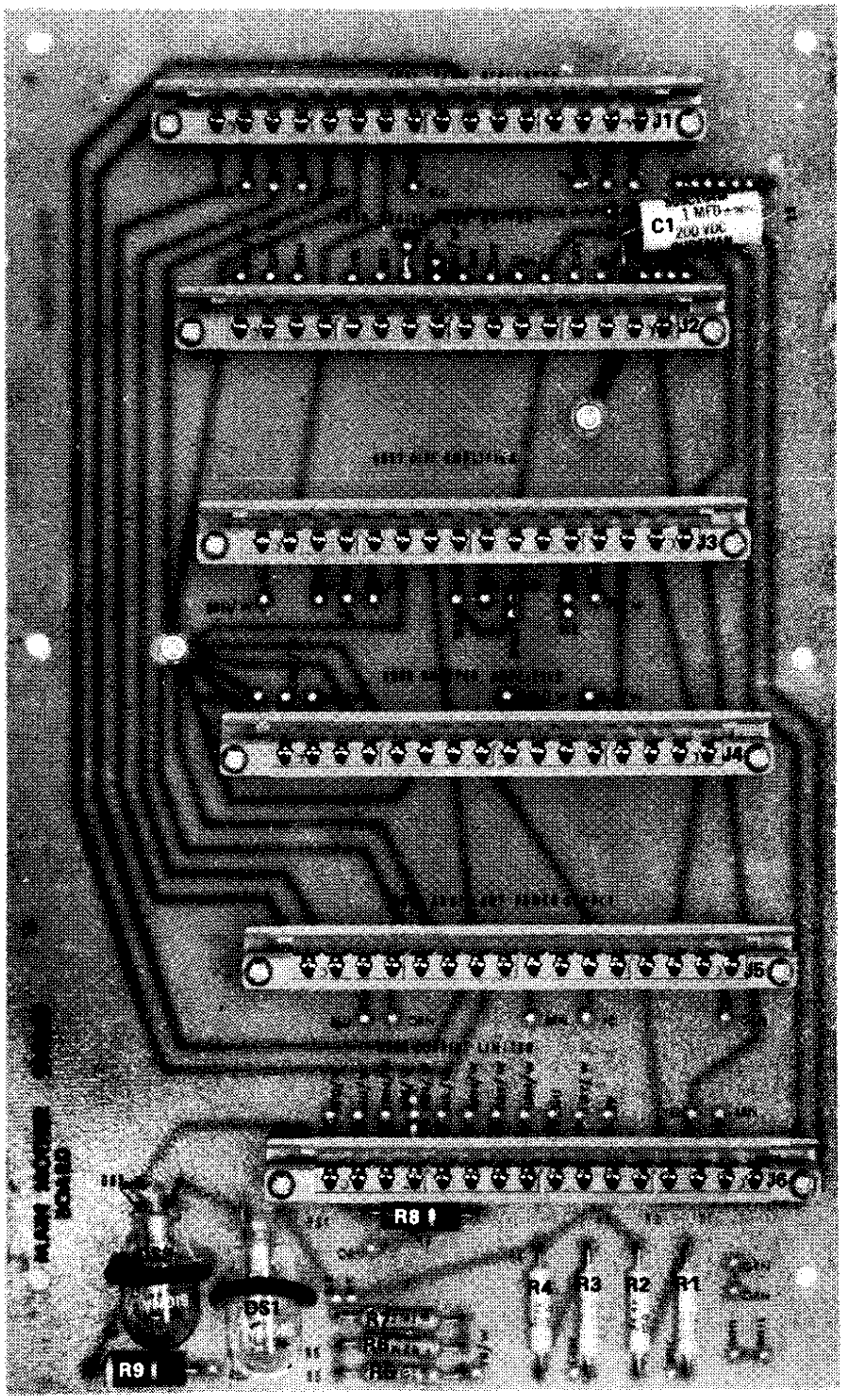


Figure 5-6. MAIN MOTHER BOARD PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5	**MAIN MOTHER BOARD P/C ASSEMBLY - Figure 5-6**	219238 (335A-4064)	89536	219238	REF		
C1	Cap, plstc, 0.1 uf ±20%, 200V	106435	56289	192P10402	3		
DS1, DS2	Lamp, neon	185017	74276	NE-7	2	5	
R1	Res, met flm, 23.7k ±1%, 1/2w	169383	75042	Type CEC-TO	2		
R2	Res, met flm, 25.5k ±1%, 1/2w	219006	75042	Type CEC-TO	1		
R3	Res, met flm, 267k ±1%, 1/2w	218990	75042	Type CEC-TO	1		
R4	Res, met flm, 274k ±1%, 1/2w	218982	75042	Type CEC-TO	1		
R5 thru R7	Res, car flm, 1.82M ±1%, 1/2w	219089	75042	Type C12	3		
R8	Res, comp, 1k ±10%, 1w	109371	01121	GB1021	1		
R9	Res, comp, 470Ω ±10%, 1w	109710	01121	GB4711	1		
J1 thru J6	Connector, female, 16 contact	187732	91662	00-5009-016-153-001	8		

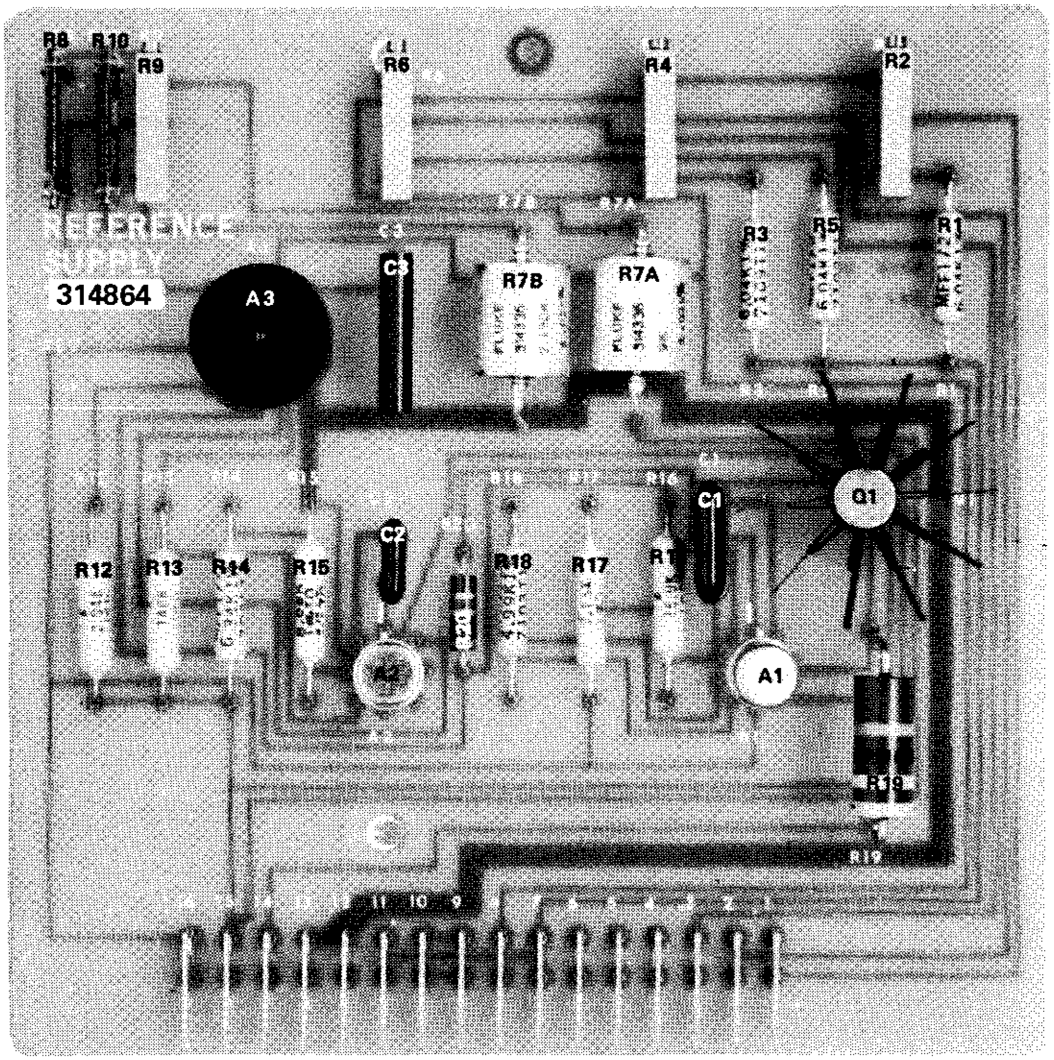


Figure 5-7. REFERENCE SUPPLY PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A1	**REFERENCE SUPPLY P/C ASSEMBLY Figure 5-7**	314864 (332B/AF-4083)	89536	314864	REF		
A1	IC, Operational amplifier	313106	MOTOROLA	MC1723CG	1		
A2	IC, Operational amplifier	271502	12040	LM301A	1		
A3	Ref amp with oven	248914	01295	4ST1-2	1		
C1	Cap, mica, 510 pf ±5%, 500V	148411	14655	CD19F511J	1		
C2	Cap, mica, 27 pf ±5%, 500V	177998	14655	CD15F221J	1		
C3	Cap, plstc, 0.1 uf ±10%, 50V	271866	06001	75F2R5A104	1		
Q1	Tstr, NPN	203489	07910	CDQ10656	1		
R2, R4, R6	Res, var, cer met, 10k ±20%, 1/2w	267880	71450	190PC103B	3		
R7A, R7B, R13	Res, ref amp, matched set (R7A is always 9k res)	314971	89536	314971	1		
R8, R10	Res, ww, 50Ω ±.06%, 1/2w	238493	89536	238493	2		
R9	Res, var, cer met 50Ω ±20%, 1/2w	267815	71450	190PC500B	1		
R11	Not used						
R12	Res, met flm, 2.94k ±1%, 1/2w	247528	91637	TYPE MFF1/2	1		
R14	Res, met flm, 6.34k ±1%, 1/2w	218636	91637	TYPE MFF1/2	1		
R15	Res, met flm, 8.66k ±1%, 1/2w	247957	91637	TYPE MFF1/2	1		
R16	Res, met flm, 16.9k ±1%, 1/2w	198275	91637	TYPE MFF1/2	1		
R17	Res, met flm, 7.15k ± 1%, ½w	186072	91637	TYPE MFF 1/2	1		
R18	Res, met flm, 4.99k ±1%, 1/2w	148890	74970	105-0753	1		
R19	Res, comp, 33Ω ±5%, 2w	161497	01121	HB3305	1		
R20	Res, comp, 1.5Ω ±5%, 1/2w	246793	01121	EB15G5	1		

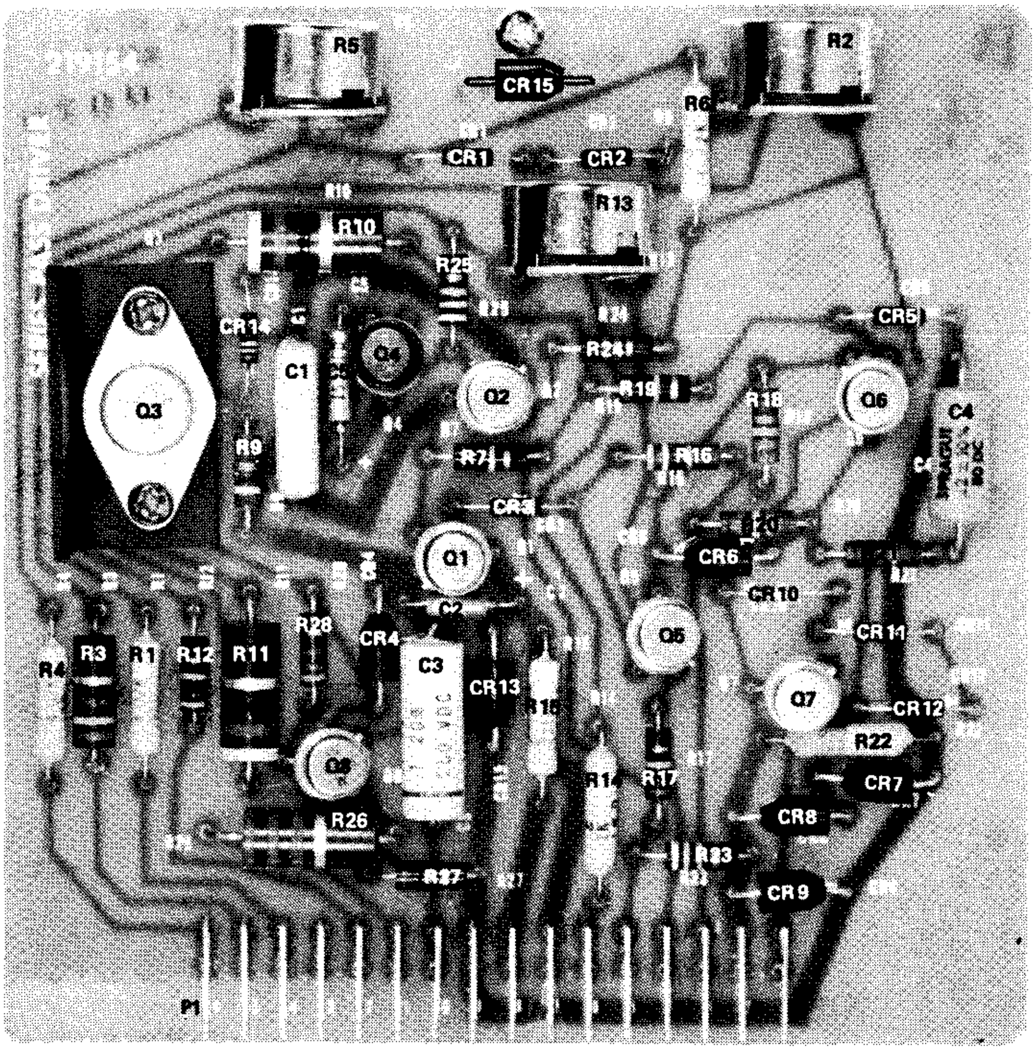


Figure 5-8. SERIES PASS DRIVER PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A2	**SERIES PASS DRIVER P/C ASSEMBLY - Figure 5-8**	219154 (335A-4056)	89536	219154	REF		
C1	Cap, plstc, 0.47 uf ±20%, 250V	184366	73445	C280AE/P470	1		
C2	Cap, Ta, 2.2 uf ±10%, 20V	160226	05397	K2R2C20K	1		
C3	Cap, plstc, 0.1 uf ±20%, 200V	106435	56289	192P10402	REF		
C4	Cap, plstc, 0.22 uf ±10%, 80V	159392	56289	192P2249R8	1		
C5	Cap, Ta, 15 uf ±10%, 20V	153056	05397	K15C20K	2		
CR1, CR2, CR4, CR6 thru CR9, CR13, CR15	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR3, CR5	Diode, zener, 10v	113324	07910	1N961A	2	1	
CR10, CR11, CR12	Diode, silicon, 150 ma, 6 piv	113308	07910	CD13161	3		
CR14	Diode, zener, 4.3V	180455	07910	1N749A	1	1	
P1	Connector, male, 16 contact	187724	91662	02-016-013-5-200	REF		
Q1, Q4 Q6, Q8	Tstr, tested, silicon, PNP	159491	89536	159491	11	2	
Q2, Q5, Q7	Tstr, silicon, NPN	203489	07910	CDQ10656	REF		
Q3	Tstr, silicon, NPN	183004	95303	40250	1		
R1, R4	Res, met flm, 4.02k ±1%, 1/2w	167478	75042	Type CEC-TO	2		
R2	Res, var, ww, 2k ±10%, 1-1/4w	198416	71450	Type 110	1		
R3	Res, comp, 2.7k ±10%, 1w	109496	01121	GB2721	1		
R5, R13	Res, var, ww, 3k ±20%, 1-1/4w	149781	71450	Type 110	2		
R6	Res, met flm, 5.62k ±1%, 1/2w	219014	75042	Type CEC-TO	1		
R7	Res, comp, 100k ±10%, 1/2w	108126	01121	EB1041	3		
R9	Res, comp, 2.4k ±5%, 1/2w	108902	01121	EB2425	1		
R10, R11	Res, comp, 47Ω ±10%, 2w	144352	01121	HB4701	2		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R12	Res, comp, 36k ±5%, 1/2w	185991	01121	EB3635	4		
R14	Res, met flm, 1k ±1%, 1/2w	151324	75042	Type CEC-TO	1		
R15	Res, met flm, 221k ±1%, 1/2w	182527	75042	Type CEC-TO	3		
R16	Res, comp, 3.9k ±10%, 1/2w	161406	01121	EB3921	1		
R17	Res, comp, 20k ±5%, 1/2w	109041	01121	EB2035	3		
R18	Res, comp, 16k ±5%, 1/2w	159632	01121	EB1635	3		
R19	Res, comp, 10k ±10%, 1/2w	108118	01121	EB1031	REF		
R20	Res, comp, 27k ±5%, 1/2w	186023	01121	EB2735	1		
R21	Res, comp, 220Ω ±5%, 1/2w	186031	01121	EB2215	1		
R22	Res, met flm, 10Ω ±1%, 1/2w	151043	75042	Type CEC-TO	1		
R23, R25	Res, comp, 47k ±5%, 1/2w	108738	01121	EB4735	2		
R24	Res, comp, 620Ω ±5%, 1/2w	108704	01121	EB6215	2		
R26	Res, comp, 180Ω ±10%, 2w	155457	01121	HB1811	1		
R27	Res, comp, 2k ±5%, 1/2w	169854	01121	EB2025	2		
R28	Res, comp, 8.2k ±5%, 1/2w	147777	01121	EB8225	2		
	Heat sink	186759	89536	186759	1		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A3	**DIFFERENTIAL AMPLIFIER P/C ASSEMBLY - Figure 5-9**	219162 (335A-4057)	89536	219162	REF		
C1	Cap, plstc, 0.1 uf ±10%, 50V	150318	56289	194P1049R5	1		
C2	Cap, mica, 510 pf ±5%, 500V	148411	88419	CD19F511J	2		
C3	Cap, Ta, 15 uf ±10%, 20V	153056	05397	K15C20K	REF		
C4	Cap, elect, 250 uf +50/-10%, 40V	178616	73445	C437ARG250	1	1	
C5	Cap, mica, 27 pf ±5%, 500V	177998	88419	CD15E270J	1		
CR1 thru CR 13	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR14	Diode, zener, 10V	113324	07910	1N961A	REF		
CR15	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
P1	Connector, male, 16 contact	187724	91662	02-016-013-5-200	REF		
Q1	Tstr, silicon, NPN	177105	07263	2N3565	5		
Q2	Tstr, FET, silicon N-channel	166223	15818	U-1249	2		
Q3	Tstr, silicon, PNP	190389	04713	SM4144	REF		
Q4	Tstr, tested, silicon, NPN	198812	89536	4805-198812	2	1	
Q5, Q7	Tstr, silicon, PNP	190389	04713	SM4144	2		
Q6	Tstr, tested, silicon, NPN	198812	89536	198812	1		
Q8	Tstr, silicon, NPN	203489	07910	CDQ10656	REF		
Q9, Q10 Q11, Q12	Tstr, silicon, PNP	183558	04713	2N3250	3	1	
R1	Res, comp, 22k ±5%, 1/2w	186064	01121	EB2235	3		
R2, R3 R5, R6	Res, comp, 100Ω ±5%, 1/2w	188508	01121	EB1015	6		
R4	Res, ww, 10k ±0.2%, 1/4w	112177	89536	112177	1		
R7, R30	Res, comp, 1k ±5%, 1/2w	108597	01121	EB1025	10		
R8	Res, comp, 3.3k ±5%, 1/2w	165761	01121	EB3325	4		
R9	Res, comp, 3k ±5%, 1/2w	109090	01121	EB3025	2		

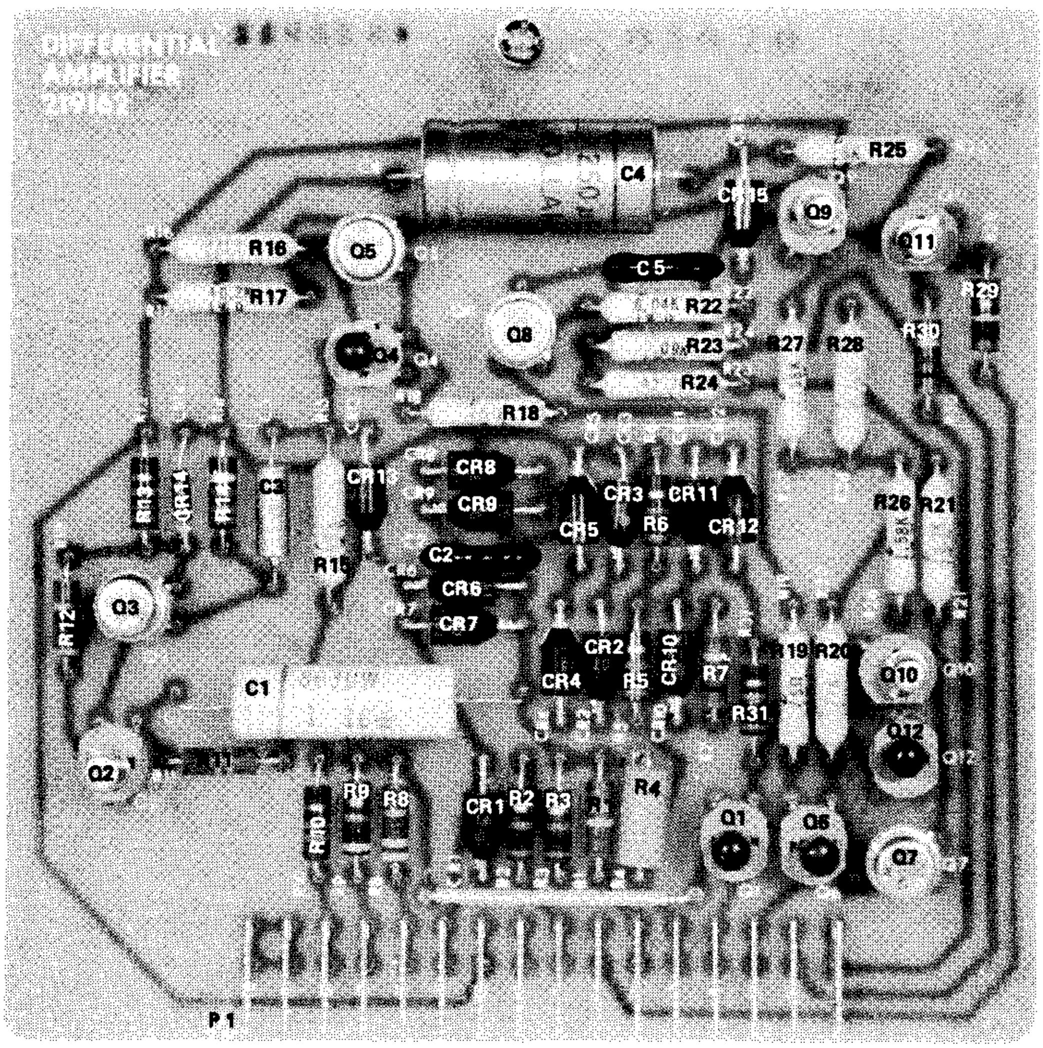


Figure 5-9. DIFFERENTIAL AMPLIFIER PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R10	Res, comp, 510Ω ±5%, 1/2w	108951	01121	EB5115	1		
R11	Res, comp, 22M ±10%, 1/2w	108233	01121	EB2261	1		
R12	Res, comp, 6.2k ±5%, 1/2w	108621	01121	EB6225	3		
R13	Res, comp, 2.2k ±5%, 1/2w	108506	01121	EB2225	2		
R14	Res, comp, 1.2k ±10%, 1/2w	108803	01121	EB1221	1		
R15	Res, met flm, 100k ±1%, 1/2w	151316	75042	Type CEC-TO	REF		
R16, R20	Res, met flm, 221k ±1%, 1/2w	182527	75042	Type CEC-TO	REF		
R17, R21	Res, met flm, 40.2k ±1%, 1/2w	161059	75042	Type CEC-TO	2		
R18, R19	Res, met flm, 75Ω ±1%, 1/2w	150870	75042	Type CEC-TO	2		
R22	Res, met flm, 6.04k ±1%, 1/2w	162586	75042	Type CEC-TO	REF		
R23	Res, met flm, 42.2k ±1%, 1/2w	182501	75042	Type CEC-TO	1		
R24	Res, met flm, 9.09k ±1%, 1/2w	151258	75042	Type CEC-TO	1		
R25	Res, met flm, 15k ±1%, 1/2w	151498	75042	Type CEC-TO	1		
R26 R27	Res, met flm, 1.58k ±1%, 1/2w	182543	75042	Type CEC-TO	2		
R28	Res, met flm, 9.76k ±1%, 1/2w	182485	75042	Type CEC-TO	3		
R29	Res, comp, 10k ±5%, 1/2w	109165	01121	EB1035	2		
R31	Res, comp, 2k ±5%, 1/2w	169854	01121	EB2025	REF		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A4	**CHOPPER AMPLIFIER ASSEMBLY Figure 5-10**	251918 (333A-4004)	89536	251918			
C1	Cap, plstc, 0.1 uf ±10%, 250V	161992	73445	C280AE/A100K	1		
C2, C3	Cap, plstc, 0.0068 uf ±20%, 200V	106070	56289	192P68202	2		
C4	Cap, plstc, 0.047 uf ±10%, 250V	162008	73445	C280AE/A47K	1		
C5	Cap, mica, 4 pf ±5%, 500V	190397	14655	CD15C040K	1		
C6	Cap, mica, 640 pf ±5%, 500V	215251	14655	CD19F6405	1		
C7, C13	Cap, elect, 5 uf +75/−10%, 25V	152009	56289	30D505G025 BA4	2		
C8, C21	Cap, elect, 50 uf +50/−10%, 25V	168823	73445	C426ARF50	2		
C9, C23	Cap, elect, 100 uf +75/−10%, 3V	106534	56289	30D107G003 CB4	2		
C10	Cap, mica, 220 pf ±5%, 500V	170423	14655	CD15F221J	1		
C11	Cap, cer, 100 pf ±10%, 1 kV	105593	71590	DD-101	1		
C12	Cap, mica, 5 pf ±10%, 500V	148577	14655	CD15C050K	1		
C14, C16	Cap, Ta, 33 uf ±10%, 10V	182832	56289	150D336X90 10B2	2		
C15, C17	Cap, elect, 15 uf +75/−10%, 6V	105700	56289	30D156G006 BA4	2		
C18	Cap, Ta, 100 uf ±10%, 10V	170456	05397	K100C10K	1		
C19, C20	Cap, plstc, 0.015 uf ±2%, 100V	233577	02799	1PC-153-G	2		
C22	Cap, Ta, 0.47 uf ±20%, 35V	161349	56289	196D474X00 35	1		
CR1	Diode, zener, silicon	266601	07910	1N965B	1		
CR2 thru CR9	Diode, silicon, 150 mA	203323	03508	DHD1105	8		
IC1	IC, operational amplifier	246603	07263	U5B770939X	1		
Q1	Tstr, MOS FET, P-channel	226043	07263	FT704	1		
Q2	Tstr, FET, N-channel	271924	07910	CFE13041	1		
Q3	Tstr, silicon, PNP	195974	04713	2N3906	1		
Q4	Tstr, silicon, PNP	288761	49956	RS2048	1		
Q5 thru Q7	Tstr, silicon, NPN	218396	04713	2N3904	3		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R1	Res, comp, 51k ±5%, 1/4w	193334	01121	CB5135	1		
R2, R21, R22	Res, comp, 100k ±5%, 1/4w	148189	01121	CB1045	3		
R3	Res, met flm, 604k ±1%, 1/2w	182493	91637	TYPE MFF1/2	1		
R4	Res, comp, 10Ω ±5%, 1/4w	147868	01121	CB1005	1		
R5	Res, met flm, 604K ±1%, 1/2w	182493	91637	TYPE MFF1/2	1		
R6	Res, comp, 3.3M ±5%, 1/4w	208389	01121	CB3355	1		
R7	Res, comp, 13k ±5%, 1/4w	221598	01121	CB1335	1		
R8, R41, R42	Res, comp, 200Ω ±5%, 1/4w	193482	01121	CB2015	3		
R9, R32, R37, R39, R40	Res, comp, 22k ±5%, 1/4w	148130	01121	CB2235	5		
R10, R12	Res, met flm, 34k ±1%, 1/2w	151241	91637	TYPE MFF1/2	2		
R11	Res, comp, 10M ±5%, 1/4w	194944	01121	CB1065	1		
R13	Res, comp, 1.5k ±5%, 1/4w	148031	01121	CB1525	1		
R14	Res, met flm, 301 ±1%, 1/2w	167494	91637	TYPE MFF1/2	1		
R15	Res, met flm, 8.06k ±1%, 1/2w	159467	91637	TYPE MFF1/2	1		
R16	Res, met flm, 68.1k ±1%, 1/2w	161083	91637	TYPE MFF1/2	1		
R17	Res, comp, 68k ±5%, 1/4w	148171	01121	CB6835	1		
R18	Res, comp, 24k ±5%, 1/4w	193425	01121	CB2435	1		
R19, R20	Res, met flm, 10k ±1%, 1/2w	151274	91637	TYPE MFF1/2	2		
R23	Res, comp, 33k ±5%, 1/4w	148155	01121	CB3335	1		
R24	Res, comp, 10k ±5%, 1/4w	148106	01121	CB1035	1		
R25	Res, comp, 36k ±5%, 1/4w	221929	01121	CB3635	1		
R26	Res, comp, 18k ±5%, 1/4w	148122	01121	CB1835	1		
R27	Res, comp, 560Ω ±5%, 1/4w	147991	01121	CB5615	1		
R28	Res, comp, 47k ±5%, 1/4w	148163	01121	CB4735	1		
R29	Res, comp, 180k ±5%, 1/4w	193441	01121	CB1845	1		
R30	Res, comp, 8.2k ±5%, 1/4w	160796	01121	CB8225	1		
R31	Res, comp, 15k ±5%, 1/4w	148114	01121	CB1535	1		
R33	Res, met flm, 4.22k ±1%, 1/2w	223396	91637	TYPE MFF1/2	1		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R34	Res, var cer met, 5k ±20%, 3/4w	159905	73138	78PR5K	1		
R35	Res, met flm, 24.3k ±1%, 1/2w	217430	91637	TYPE MFF1/2	1		
R36, R38	Res, met flm, 187k ±1%, 1/8w	289462	91637	TYPE MFF1/2	2		
R43	Res, var, comp, 10k ±30%, 1/4w	223131	37942	TYPE MTC	1		
	Connector, male, 16 contact	187724	91662	02-106-013-5-200	1		
	Cover, chopper	251751	89536	251751	1		

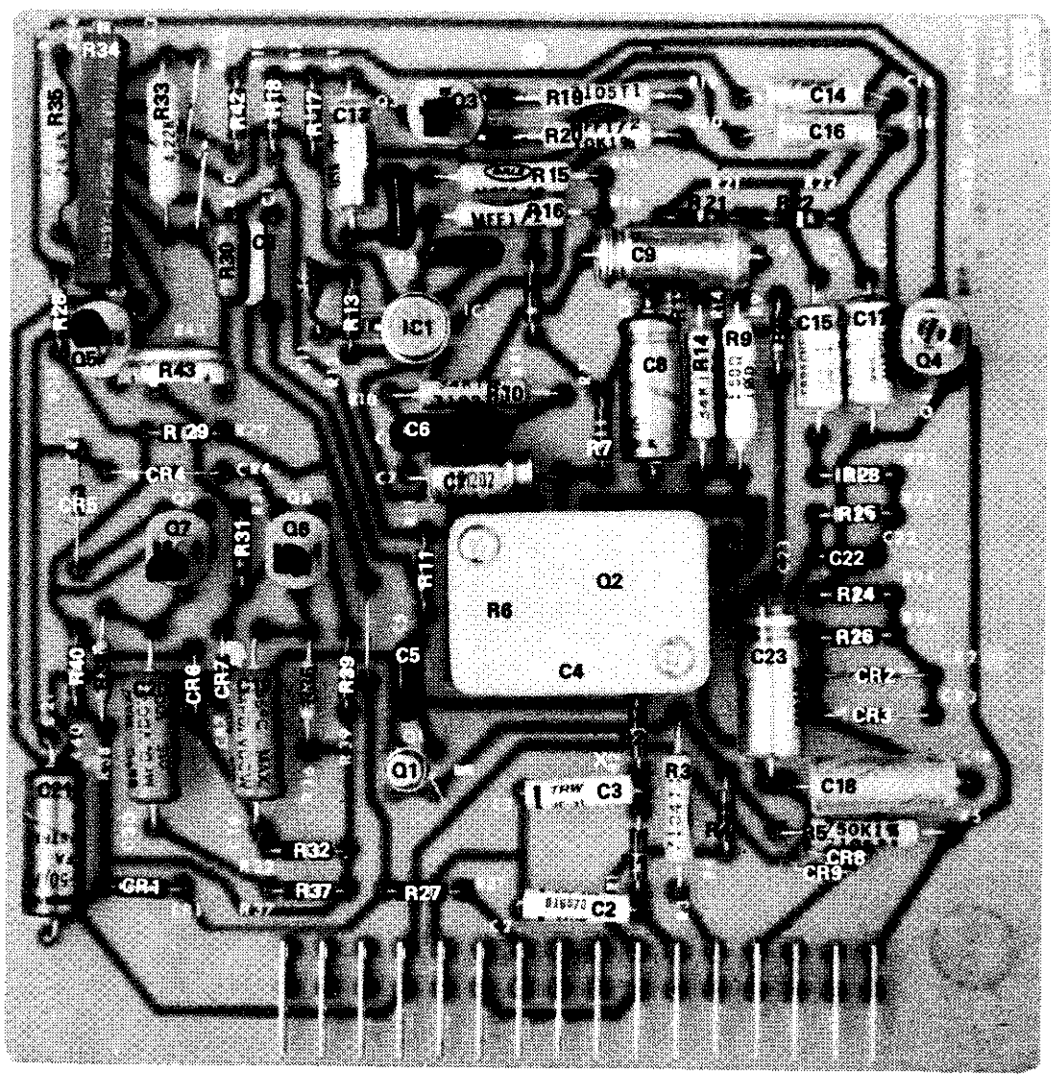


Figure 5-10. CHOPPER AMPLIFIER PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A5	**AUXILIARY POWER SUPPLY P/C ASSEMBLY - Figure 5-11**	219188 (335A-4059)	89536	219188	REF		
C1	Cap, Ta, 68 uf ±10%, 15V	182824	05397	K68C15K	1		
C2	Cap, elect, 250 uf +50/-10%, 64V	185850	73445	C437ARH250	4	1	
C3, C8	Cap, elect, 50 uf +75/-10%, 50V	105122	80183	TE1307	3	1	
C4	Cap, cer, 220 pf ±10%, 500V	105528	72982	315-024X5UD 221K	1		
C5, C10	Cap, plstc, 2 uf ±20%, 100V	106963	84411	Type X663FR	2		
C6	Cap, plstc, 0.1 uf ±20%, 200V	106435	56289	192P10402	REF		
C7, C11	Cap, elect, 20 uf +75/-10%, 50V	106229	80183	TE1305	REF		
C9	Cap, plstc, 0.0012 uf ±10%, 200V	106088	56289	192P12292	1		
CR1, CR2, CR3, CR4, CR7 thru CR10	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR5	Diode, zener, 3.9V	113316	07910	1N748	2	1	
CR6	Diode, zener, 6.3V	172148	03877	1N3496	1	1	
P1	Connector, male, 16 contact	187724	91662	02-016-013-5-200	REF		
Q1	Silicon controlled rectifier, 1.6 amp, 50V	192567	03508	C-6F	2	1	
Q2	Tstr, selected, silicon, PNP	159491	89536	159491	REF		
Q3, Q5, Q6, Q8, Q9	Tstr, silicon, NPN	203489	07910	CDQ10656	REF		
Q4, Q7	Tstr, silicon, NPN	183004	95303	40250	REF		
R1	Res, comp, 10k ±5%, 1/2w	109165	01121	EB1035	REF		
R2	Res, comp, 390Ω ±5%, 1/2w	109082	01121	EB3915	1		
R3	Res, comp, 5.6k ±5%, 1/2q	187880	01121	EB5625	1		
R4	Res, comp, 15Ω ±10%, 2w	155549	01121	HB1505	1		
R5	Res, comp, 15k ±10%, 1/2w	108530	01121	EB1531	REF		

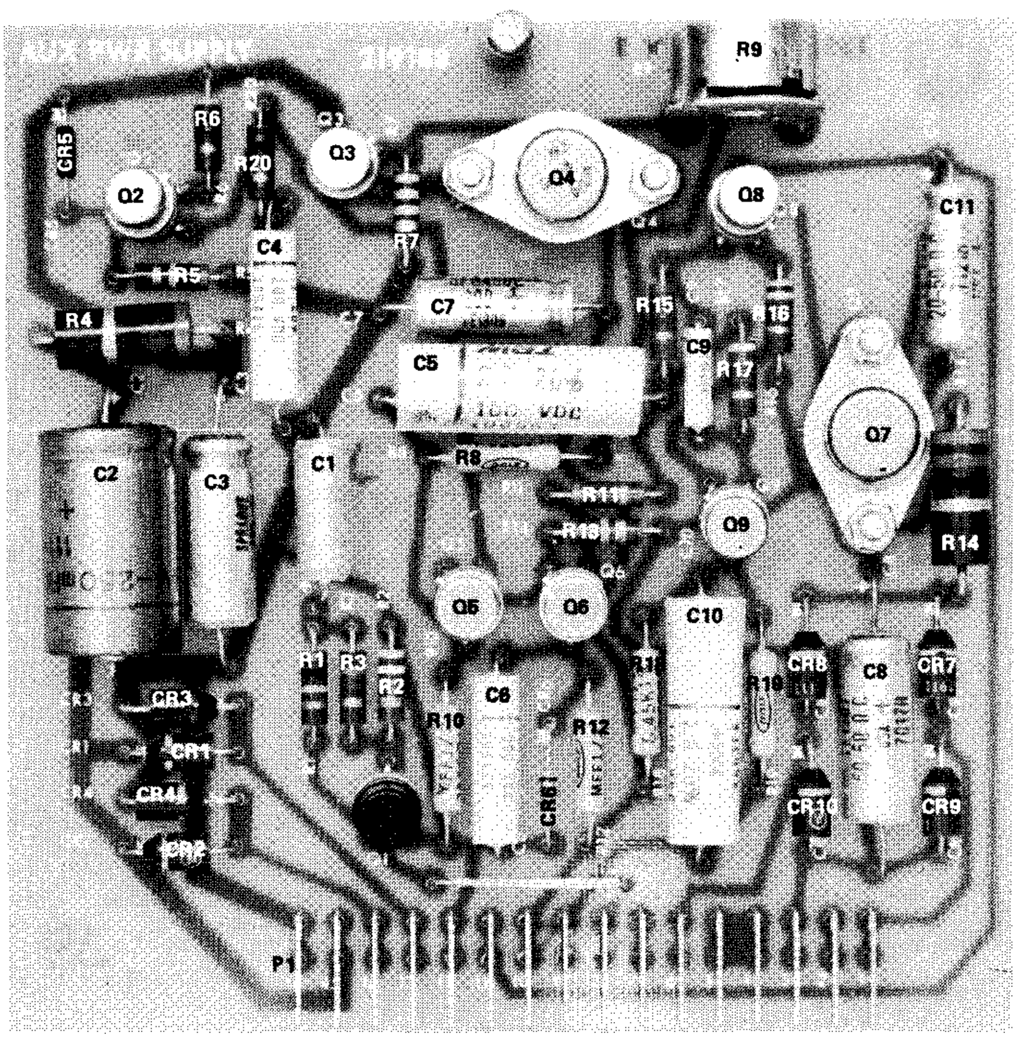


Figure 5-11. AUXILIARY POWER SUPPLY PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R6	Res, comp, 3k ±5%, 1/2w	109090	01121	EB3025	REF		
R7	Res, comp, 33k ±10%, 1/2w	178541	01121	EB3331	REF		
R8	Res, met flm, 7.15k ±1%, 1/2w	186072	75042	Type CEC-TO	1		
R9	Res, var, ww, 1k ±20%, 1-1/4w	113266	71450	Type 110	1		
R10	Res, met flm, 2.55k ±1%, 1/2w	176362	75042	Type CEC-TO	1		
R11	Res, comp, 6.2k ±5%, 1/2w	108621	01121	EB6225	REF		
R12	Res, met flm, 2.37k ±1%, 1/2w	182519	75042	Type CEC-TO	1		
R13	Res, comp, 12k ±10%, 1/2w	108977	01121	EB1231	1		
R14	Res, comp, 82Ω ±10%, 2w	110239	01121	HB8201	1		
R15	Res, comp, 8.2k ±5%, 1/2w	147777	01121	EB8225	REF		
R16	Res, comp, 3.3k ±10%, 1/2w	108373	01121	EB3321	1		
R17	Res, comp, 4.7k ±10%, 1/2w	108381	01121	EB4721	2		
R18	Res, met flm, 8.45k ±1%, 1/2w	159475	75042	Type CEC-TO	1		
R19	Res, met flm, 4.99k ±1%, 1/2w	148890	75042	Type CEC-TO	1		
R20	Res, comp, 2.0k ±5%, 1/2w	169854	01121	EB2025	REF		

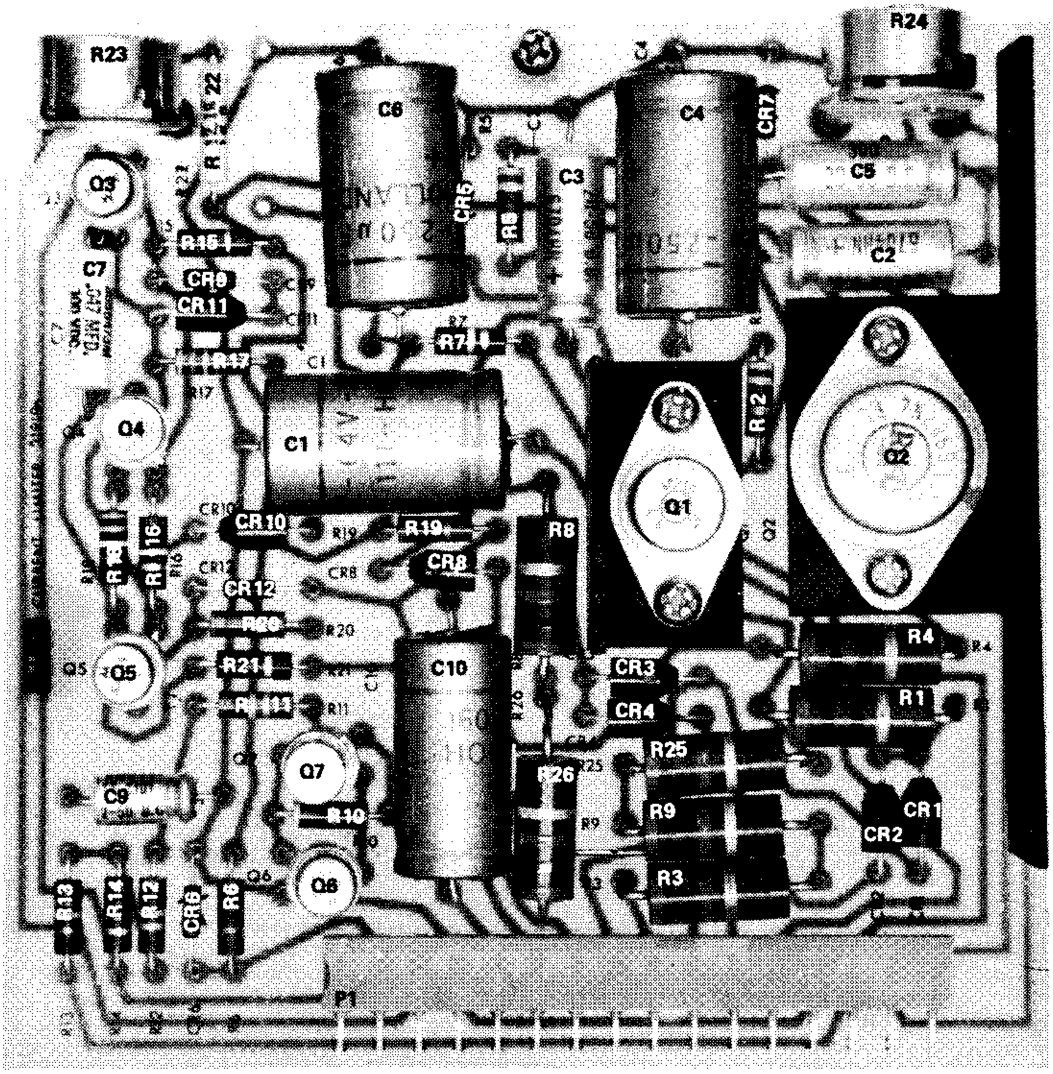


Figure 5-12. CURRENT LIMITER PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A5A6	**CURRENT LIMITER P/C ASSEMBLY - Figure 5-12**	219196 (335A-4060)	89536	219196	REF		
C1	Cap, elect, 350 uF +75/–10%, 75V	292862	73445	C437ARH250	3		
C2	Cap, elect, 20 uf +75/-10%, 50V	106229	80183	TE1305	REF		
C3	Cap, elect, 20 uf +75/-10%, 50V	106229	80183	TE1305	REF		
C4	Cap, elect, 350 uF +75/–10%, 75V	292862	73445	C437ARH250	REF		
C5	Cap, elect, 20 uf +75/-10%, 50V	106229	80183	TE1305	REF		
C6	Cap, elect, 350 uF +75/–10%, 75V	292862	73445	C437ARH250	REF		
C7	Cap, plstc, 0.047 uf ±20%, 100V	106096	72928	335B473M	1		
C9	Cap, elect, 2 uf +75/-10%, 50V	105197	80183	TE1301	1	1	
C10	Cap, elect, 160 uf +50/-10%, 64V	170274	73445	C437ARH160	1	1	
CR1, CR2, CR3, CR4, CR8	Diode, silicon, 1 amp, 600 piv	112382	05277	1N4822	REF		
CR5	Diode, zener, 36V	186163	07910	1N974B	2	1	
CR6	Diode, zener, 3.9V	113316	07910	1N748	REF		
CR7	Diode, zener, 36V	237354	04713	1N3033A	1	1	
CR9	Diode, zener, 12V	159780	07910	1N759	1	1	
CR10, CR11	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR12	Diode, silicon, 150 ma, 6 piv	113308	07910	CD13161	REF		
P1	Connector, male, 16 contact	187724	91662	02-016-013-5-200	REF		
Q1	Tstr, silicon, NPN	183004	95303	40250	REF		
Q2	Tstr, germanium, PNP	152868	95303	2N2869	1	1	
Q3	Tstr, selected, silicon, PNP	159491	89536	159491	REF		
Q4, Q7	Tstr, silicon, NPN	203489	07910	CDQ10656	REF		
Q5, Q6	Tstr, selected, silicon, PNP	159491	89536	159491	REF		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R1, R4	Res, comp, 10Ω ±10%, 2w	110163	01121	HB1001	4		
R2, R5	Res, comp, 3.3k ±5%, 1/2w	165761	01121	EB3325	REF		
R3,R26	Res. comp, 2.4k ±5%, 2w	218834	01121	HB2425	2		
R6, R19 R20	Res, comp, 7.5k ±5%, 1/2w	108910	01121	EB7525	3		
R7, R16	Res, comp, 100k ±10%, 1/2w	108126	01121	EB1041	REF		
R8, R9 R25	Res, comp, 120Ω ±10%, 2w	155531	01121	HB1211	3		
R10	Res, comp, 4.7k ±10%, 1/2w	108381	01121	EB4721	REF		
R11, R12	Res, comp, 10k ±10%, 1/2w	108118	01121	EB1031	REF		
R13	Res, comp, 16k ±5%, 1/2w	159632	01121	EB1635	REF		
R14, R21	Res, comp, 1k ±10%, 1/2w	108563	01121	EB1021	REF		
R15	Res, comp, 2.2k ±10%, 1/2w	108605	01121	EB2221	1		
R17	Res, comp, 36k ±5%, 1/2w	185991	01121	EB3635	REF		
R18	Res, comp, 330k ±5%, 1/2w	150201	01121	EB3345	1		
R22	Res, met flm, 12.1k ±1%, 1/2w	182535	75042	Type CEC-TO	1		
R23	Res, var, ww, 10k ±10%, 1-1/4w	162115	71450	Type 110	1		
R24	Res, var, ww, 150Ω ±10%, 1-1/4w	113092	71450	Type 110	1		
	Heat sink	186759	89536	186759	REF		
	Heat sink	186742	89536	186742	1		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A6	**TIME DELAY P/C ASSEMBLY Figure 5-13**	192260 (332A-420)	89536	192269	REF		
C2001	Cap, elect, 400 uf +50/-10%, 40V	185868	73445	C437ARG400	1		
CR2001 CR2002 CR2003	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
K2001	Relay, armature, 12 vdc, dpdt	176347	80089	62-760	1		
Q2001	Silicon controlled rectifier, 1.6 amp, 50V	192567	03508	C-6F	REF		
R2001	Res, comp, 2.2k ±10%, 2w	109967	01121	HB2221	2		
R2002	Res, comp, 5.6k ±10%, 1/2w	108324	01121	EB5621	1		
R2003	Res, comp, 390Ω ±10%, 1/2w	108365	01121	EB3911	1		
R2004	Res, comp, 10k ±10%, 1/2w	108118	01121	EB1031	REF		

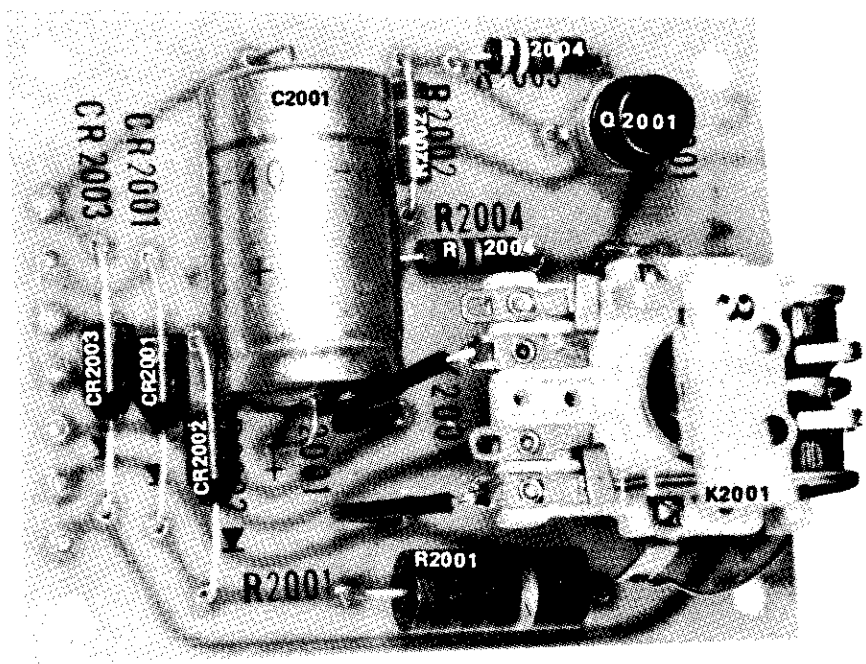


Figure 5-13. TIME DELAY PRINTED CIRCUIT ASSEMBLY

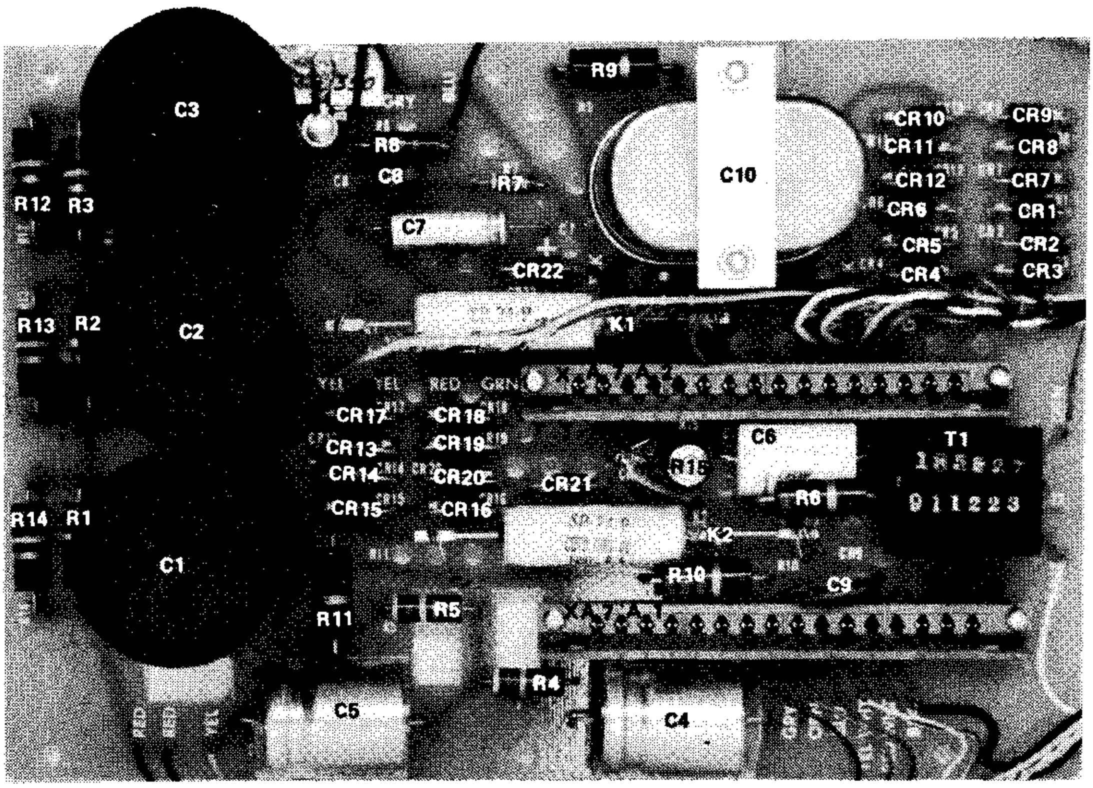


Figure 5-14. HIGH VOLTAGE MOTHER BOARD PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7	**HIGH VOLTAGE MOTHER BOARD P/C ASSEMBLY - Figure 5-14**	239350 (332B-4056)	89536	239250	REF		
A7A1	Series Pass Element P/C Assembly (See Figure 5-15)	314823 (332B-4064)	89536	314823	REF		
A7A2	Preregulator P/C Assembly (See Figure 5-16)	314815 (332B-4082)	89536	314815	REF		
C1, C2, C3	Cap, elect, 125 uf +50/-10%, 450V	106336	56289	Type 66D	3	1	
C4, C5	Cap, elect, 8 uf +50/-10%, 450V	194068	56289	39D805F-450HE4	2		
C6, C10	Cap, plstc, 1 uf ±20%, 200V	106450	84411	Type X663F	2		
C7	Cap, elect, 50 uf +75/-10%, 50V	105122	80183	TE1307	1		
C8	Cap, cer, 0.001 uf ±20%, 3 kv	105635	80183	29C300	1		
C9	Cap, cer, 0.01 uf, gmv, 1600V	106930	71590	DD16-103	REF		
CR1 thru CR19	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		
CR21, CR22	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
K1	Relay, reed, 5,000V	184440	12617	DRVT-1	2		
	Coil, reed relay, 24V	186155	71707	SP-24-P	REF		
K2	Relay, reed, 5,000V	184440	12617	DRVT-1	REF		
	Coil, reed relay, 24V	186155	71707	SP-24-P	REF		
R1, R2 R12, thru R14	Res, comp, 220k ±10%, 2w	110197	01121	HB2241	6		
R4, R5	Res, comp, 470k ±5%, 1w	809819	01121	GB4745	2		
R6, R9	Res, comp, 10Ω ±10%, 2w	110163	01121	HB1001	REF		
R7	Res, comp, 470Ω ±10%, 1/2w	108415	01121	EB4711	REF		
R8	Res, comp, 5.1Ω ±5%, 1w	219071	01121	GB51G5	1		
R10	Res, comp, 270Ω ±10%, 2w	110189	01121	HB2711	1		
R11	Res, comp, 2.2k ±10%, 2w	109967	01121	HB2221	REF		
R15	Res, ww, 2k ±5%, 10w	155416	06136	Type 10F	1		
T1	Transformer, pulse	185827	89536	185827	1		
J1, J2	Connector, female, 16 contact	285015	91662	00-5009-016 153-001	REF		

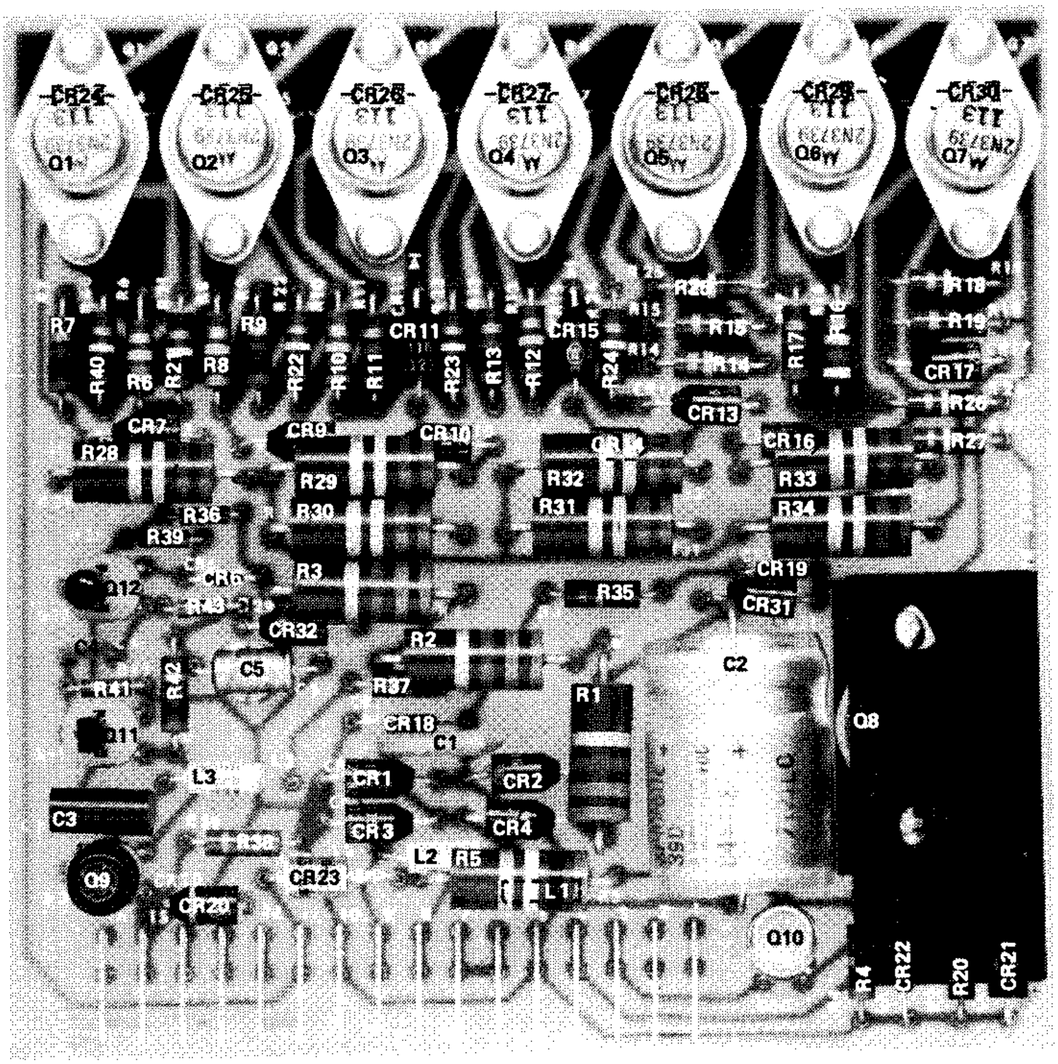


Figure 5-15. SERIES PASS ELEMENT PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7A1	**SERIES PASS ELEMENT P/C ASSEMBLY - Figure 5-15**	314823 (332B-4061)	89536	14823	REF		
C1	Cap, cer, 0.05 uf +80/-10%, 500V	105676	56289	33C58B	4		
C2	Cap, elect, 8 uf +50/-10%, 450V	194068	56289	39D805F450-HE4	REF		
C3	Cap, mylar, .0022 uf ±10%, 50V	313239	06001	75F1R5A224	1		
C4	Cap, cer, 0.005 uf ±20%, 100V	175232	56289	C023B101E-802M	1		
C5	Cap, elect, 20 uf +50/-10%, 16V	241356	73445	C426ARE20	1		
CR1 thru CR5, CR7 thru CR17, CR31	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	17		
CR6	Diode, zener, ±5%, 16V	313221	12969	UZ8716	1	1	
CR18	Diode, zener, 20V	113340	07910	1N968A	1	1	
CR19	Diode, zener, 36V	186163	07910	1N974B	REF		
CR20, CR21, CR32	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR22	Diode, zener, 6.2V	180497	07910	1N753	1	1	
CR23 thru CR30	Diode, zener, 200V	217422	04713	1N3051A	8	1	
P1	Connector, male, 16 contact	187724	91662	02-016-013 5-200	REF		
Q1 thru Q8	Tstr, silicon, NPN	190710	04713	2N3739	8	8	
Q9	Tstr, silicon, unijunction	117176	03508	2N1671A	1	1	
Q10	Tstr, silicon, NPN	203489	07910	CDQ10656	REF		
R1 thru R3	Res, comp, 1.8k ±10%, 2w	185983	01121	HB1821	3		
R4, R8	Res, comp, 62k ±5%, 1/2w	108522	01121	EB6235	2		

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R5	Res, comp, 100k ±10%, 2w	158659	01121	HB1041	1		
R6	Res, comp, 56k ±5%, 1/2w	219048	01121	EB5635	1		
R7, R9 R11	Res, comp, 1k ±5%, 1/2w	108597	01121	EB1025	REF		
R10	Res, comp, 68k ±5%, 1/2w	159624	01121	EB6835	1		
R12, R35	Res, comp, 75k ±5%, 1/2w	108928	01121	EB7535	REF		
R13, R15, R17, R19, R42	Res, comp, 1k ±5%, 1/2w	108597	01121	EB1025	REF		
R14	Res, comp, 82k ±5%, 1/2w	195966	01121	EB8235	1		
R16	Res, comp, 91k ±5%, 1/2w	219030	01121	EB9135	1		
R18, R21 thru R27, R40	Res, comp, 100k ±5%, 1/2	168054	01121	EB1045	9		
R20	Res, comp, 1.1Ω ±5%, 1/2w	163717	01121	EB11G5	1		
R28, R29 thru R34	Res, comp, 22k ±10%, 2w	109975	01121	HB2231	7		
R36, R43	Res, comp, 5.1k ±5%, 1/4w	193342	01121	CB5125	REF		
R37	Res, comp, 36k ±5%, 1/2w	185991	01121	EB3635	REF		
R38	Res, comp, 180Ω ±5%, 1/2w	108944	01121	EB1815	1		
R39	Res, comp, 1.1k ±5%, 1/4w	267336	01121	CB1125	1		
R41	Res, comp, 5.1k ±5%, 1/4w	193342	01121	CB5125	2		
	Heat sink	192245	89536	192245	1		
L1, L2	Inductance, 2.2 MH	147801	72259	WEE-2,200	2		
L3	Inductance, 220 uh	147835	72259	WEE-220	1		
Q11	Tstr, silicon NPN	218396	04713	2N3904			
Q12	Tstr, silicon NPN	177105	07263	2N3565			

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7A2	**PREREGULATOR P/C ASSEMBLY Figure 5-16**	314815 (332B-4082)	89536	314815	REF		
C1, C2 C6, C8	Cap, cer, 0.05 uf +80/-10%, 500V	105676	56289	33C58B	REF		
C3, C4	Cap, elect, 250 uf +50/-10%, 16V	187765	73445	C437ARE250			
C5	Cap, mylar, 1.0 uf ±20%, 200V	106450	72928	364	1		
C7	Cap, mylar, .001 uf ±10%, 200V	159582	56289	192P10292	1		
CR1 thru CR5, CR15 thru CR17	Diode, silicon, 1 amp, 100 piv	116111	05277	1N4817	REF		
CR6 thru CR9	Diode, silicon, 1 amp, 600 piv	112383	05277	1N4822	REF		
CR10 thru CR13	Diode, silicon, 3 amp, 200 piv	187716	04713	MR1032B	4		
CR14	Diode, zener, 200V	187617	04713	1N3350RA	1	1	
K1	Relay, armature, 115 vac, dpdt	106864	16332	100-5ADPDT	1		
K2	Relay, reed, 500V	136630	12617	Type DRG-1	1		
	Coil, reed relay, 24V	186155	71707	SP-24-P	REF		
P1	Connector, male, 16 contact	187724	91662	02-016-013-5-200	REF		
Q1	Tstr, silicon, NPN	193953	05277	320C034H31	1	1	
Q2	Tstr, silicon, NPN	261347	16758	Type DTS410	1		
Q3	Tstr, tested, silicon, NPN	203489	07910	CDQ10656	REF		
Q4, Q6	Tstr, tested, silicon, PNP	159491	89536	4805-159491	REF		
Q5, Q7	Tstr, silicon, NPN	203489	07910	CDQ10656	REF		
Q8, Q9	Tstr, silicon, PNP	159491	89536	159491	REF		
R1	Res, comp, 68Ω ±10%, 2w	110205	01121	HB6801	1		
R2	Res, ww, 0.192Ω ±1%, 3w	238741	89536	238741	1	1	
R4	Res, ww, 1k ±5%, 5w	113282	63743	Type 5F1000	1		

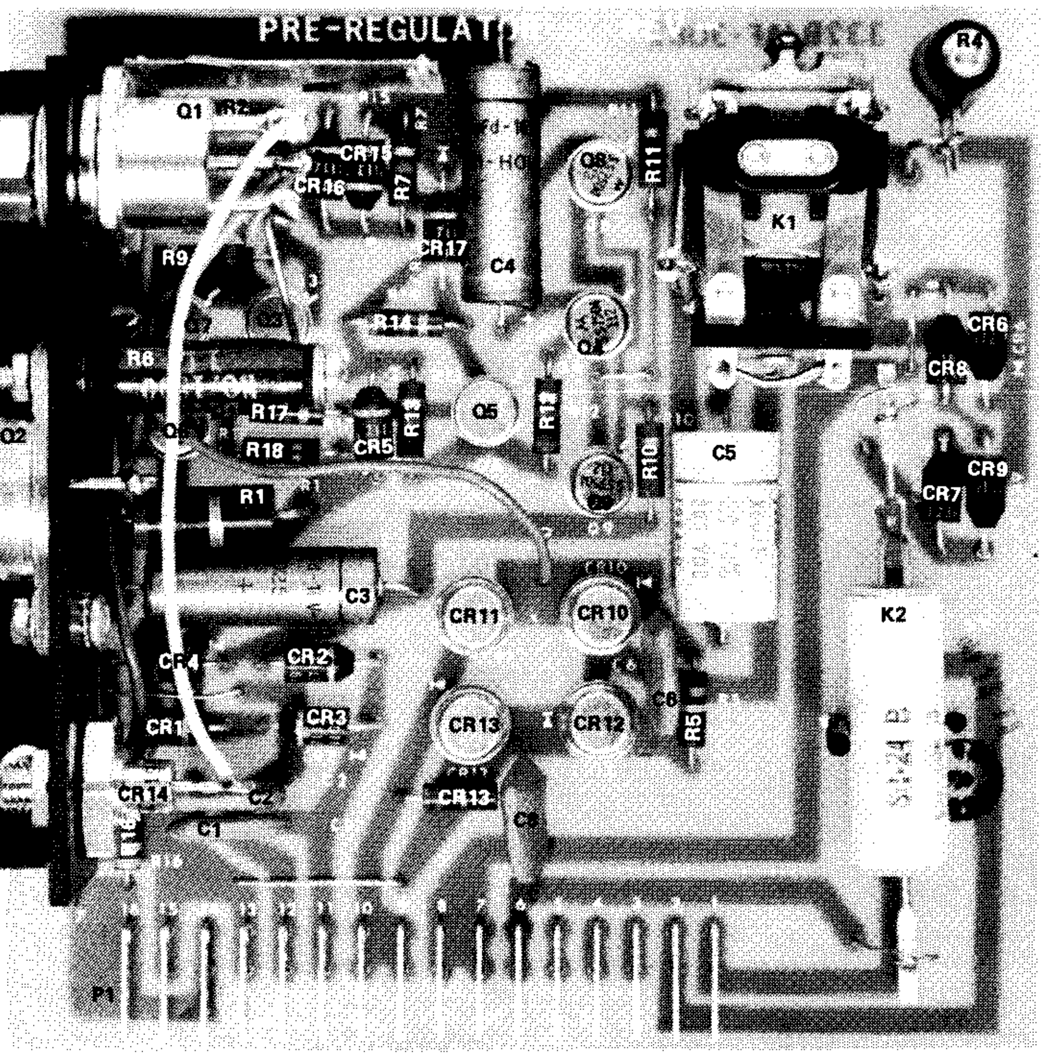


Figure 5-16. PREREGULATOR PRINTED CIRCUIT ASSEMBLY

REF DESIG	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R5	Res, comp, 22k ±5%, 1/2w	186064	01121	EB2235	REF		
R6	Res, ww, 1Ω ±10%, 5w	112425	44655	1K48F	1		
R7	Res, comp, 220Ω ±10%, 1/2w	108191	01121	EB2211	1		
R8	Res, comp, 430Ω ±5%, 1/2w	109058	01121	EB4315	1		
R9	Res, comp, 100Ω ±5%, 1/2w	188508	01121	EB1015	REF		
R10	Res, comp, 2.2k ±5%, 1/2w	108506	01121	EB2035	REF		
R11	Res, comp, 100Ω ±5%, 1/2w	188508	01121	EB1015	REF		
R12	Res, comp, 1k ±5%, 1/2w	108597	01121	EB1025	REF		
R13, R14, R17	Res, comp, 1k ±5%, 1/2w	108597	01121	EB1025	3		
R15	Res, comp, 4.7k ±5%, 1/2w	108886	01121	EB4725	1		
R16	Res, comp, 3.3k ±5%, 1/2w	165761	01121	EB3325	REF		
R18	Res, comp, 560Ω ±5%, 1/2w	109124	01121	EB5615	1		
R19	Res, comp, 68Ω ±5%, 1/2w	178384	01121	EB6805	1		
	Heat sink	314807	89536	314807	1		

Section 6

Option & Accessory Information

There are no options or accessories available for use with the Model 332D DC Voltage Standard, other than the rack mounting kits described earlier in section 2 of this manual.

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5. The following information is presented in this section:

List of Abbreviations

Federal Supply Codes for Manufacturers

Fluke Technical Service Centers - U.S. and Canada

Fluke Technical Service Centers - International

Sales Representatives - U.S. and Canada

Sales Representatives - International

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(-) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmable read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co.
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div.
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc.
Freeport, New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co.
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Div.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts, Div. of
Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

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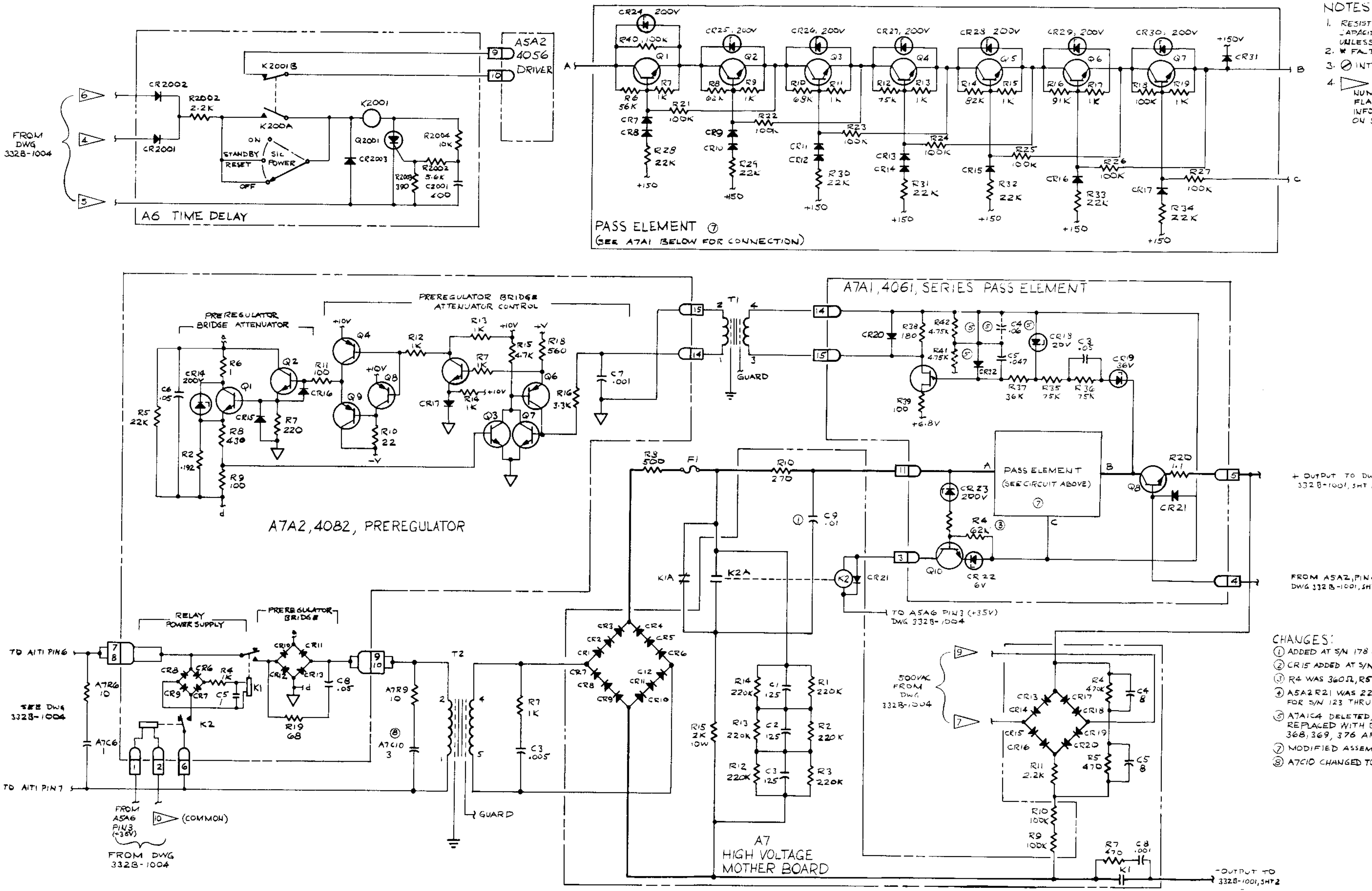
Section 8
Schematic Diagrams



NOTES:

1. RESISTANCE IN OHMS AND CAPACITANCE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. * FACTORY SELECTED COMPONENT.
3. ⊘ INTERNAL ADJUSTMENT
4. ▷ FLAG NOTES WITH SAME NUMBERS ARE CONNECTED. FLAGS WITHOUT TO OR FROM INFORMATION ARE LOCATED ON SAME SHEET.

CHANGES:

① ADDED AT S/N 178 AND ON.
② CR15 ADDED AT S/N 179 AND ON.
③ R4 WAS 360Ω, R5 WAS 270K, S/N 123 THRU 187.
④ A5A2 R21 WAS 220Ω, A7A2R8 WAS 430Ω FOR S/N 123 THRU 355.
⑤ A7A1C4 DELETED, A7A1R4 DELETED, A7A1R42 REPLACED WITH BUSS WIRE, S/N 356, 358, 368, 369, 376 AND ON.
⑦ MODIFIED ASSEMBLY ON 332B/AF.
⑧ A7C10 CHANGED TO 1µF ON 33B/AF.

FIGURE 8-1. (1 of 3) DC VOLTAGE STANDARD (332B-1001)

NOTES:
SEE SHT.

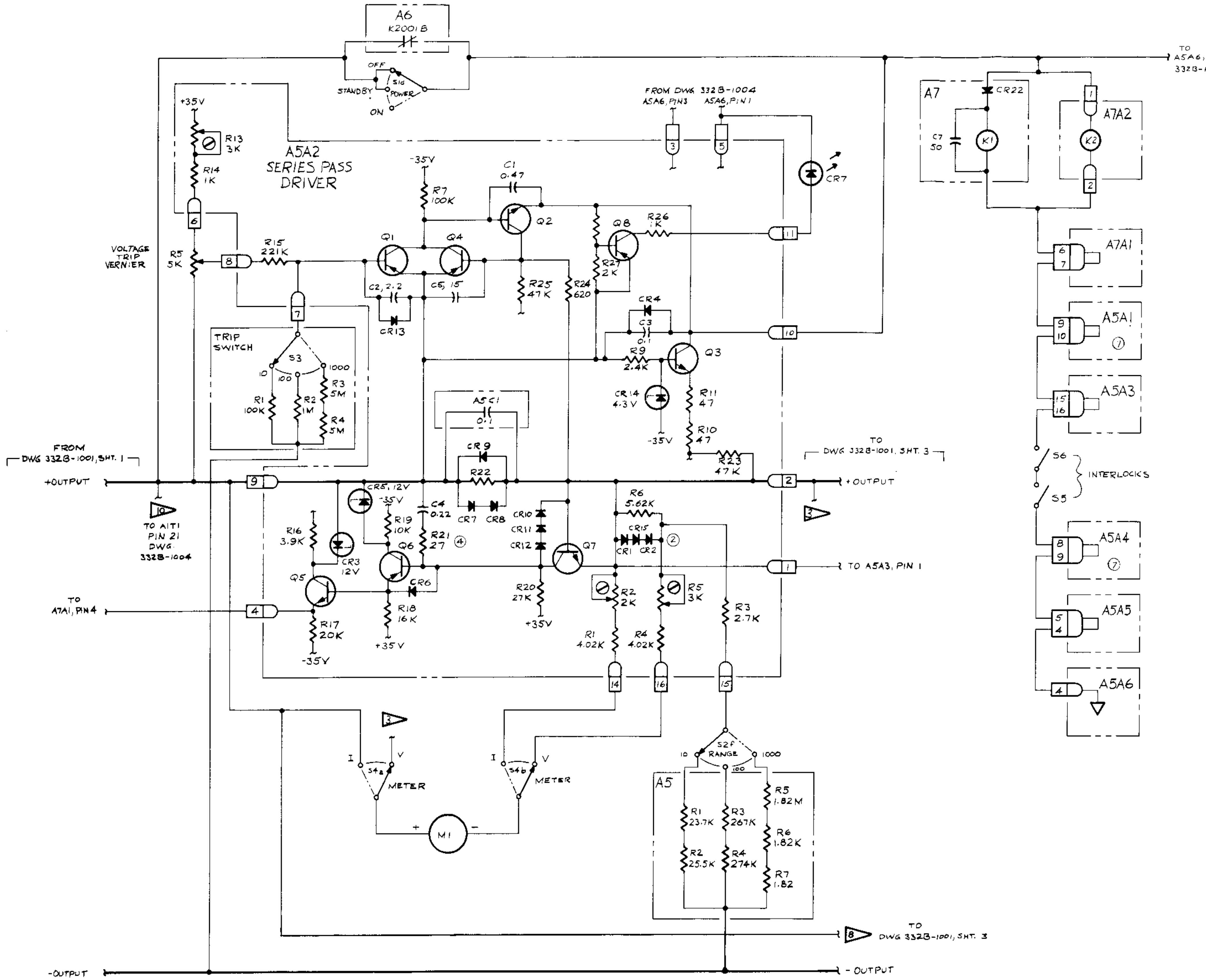


FIGURE 8-1. (2 of 3) DC VOLTAGE STANDARD
(332B-1001)

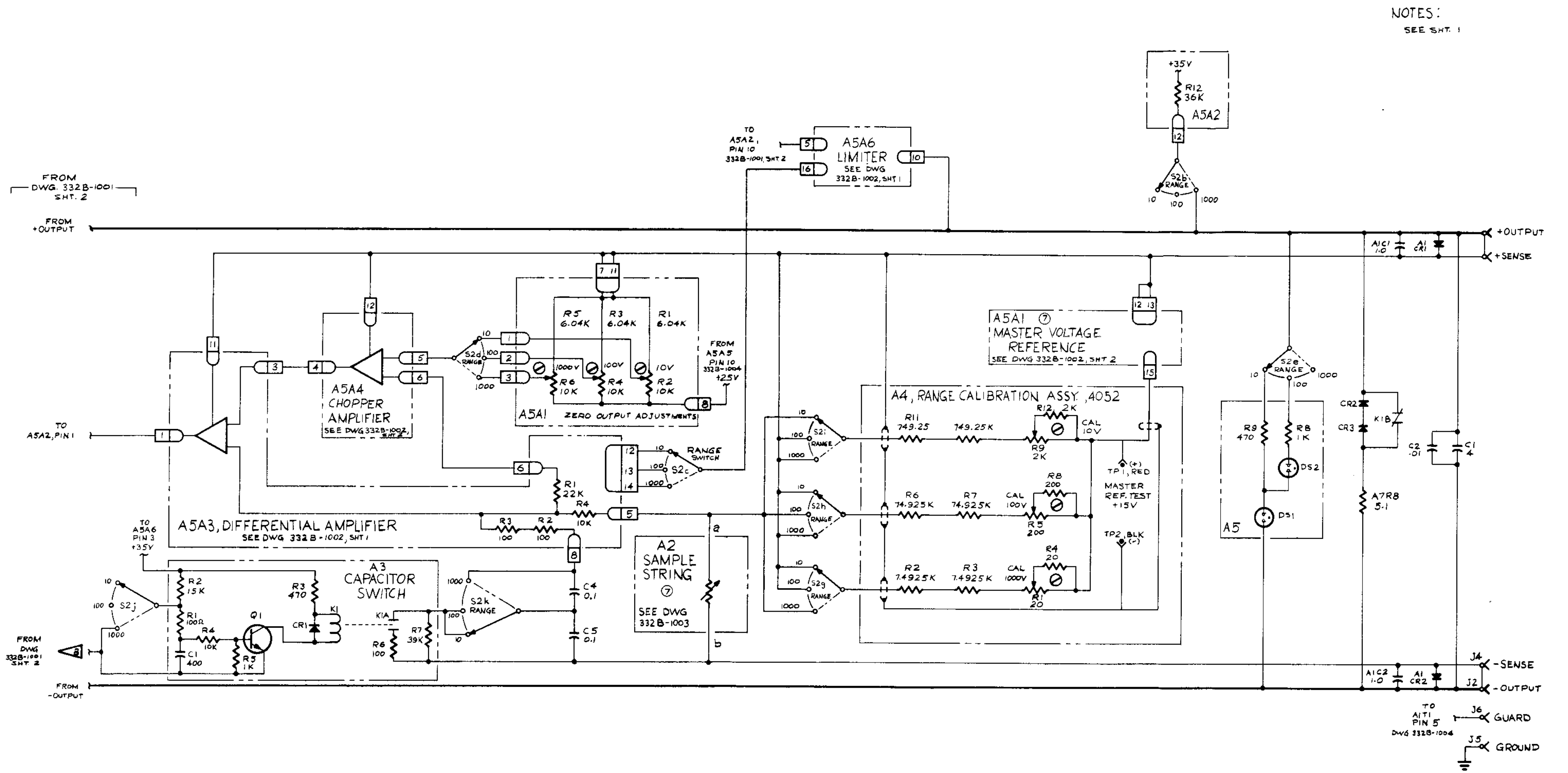
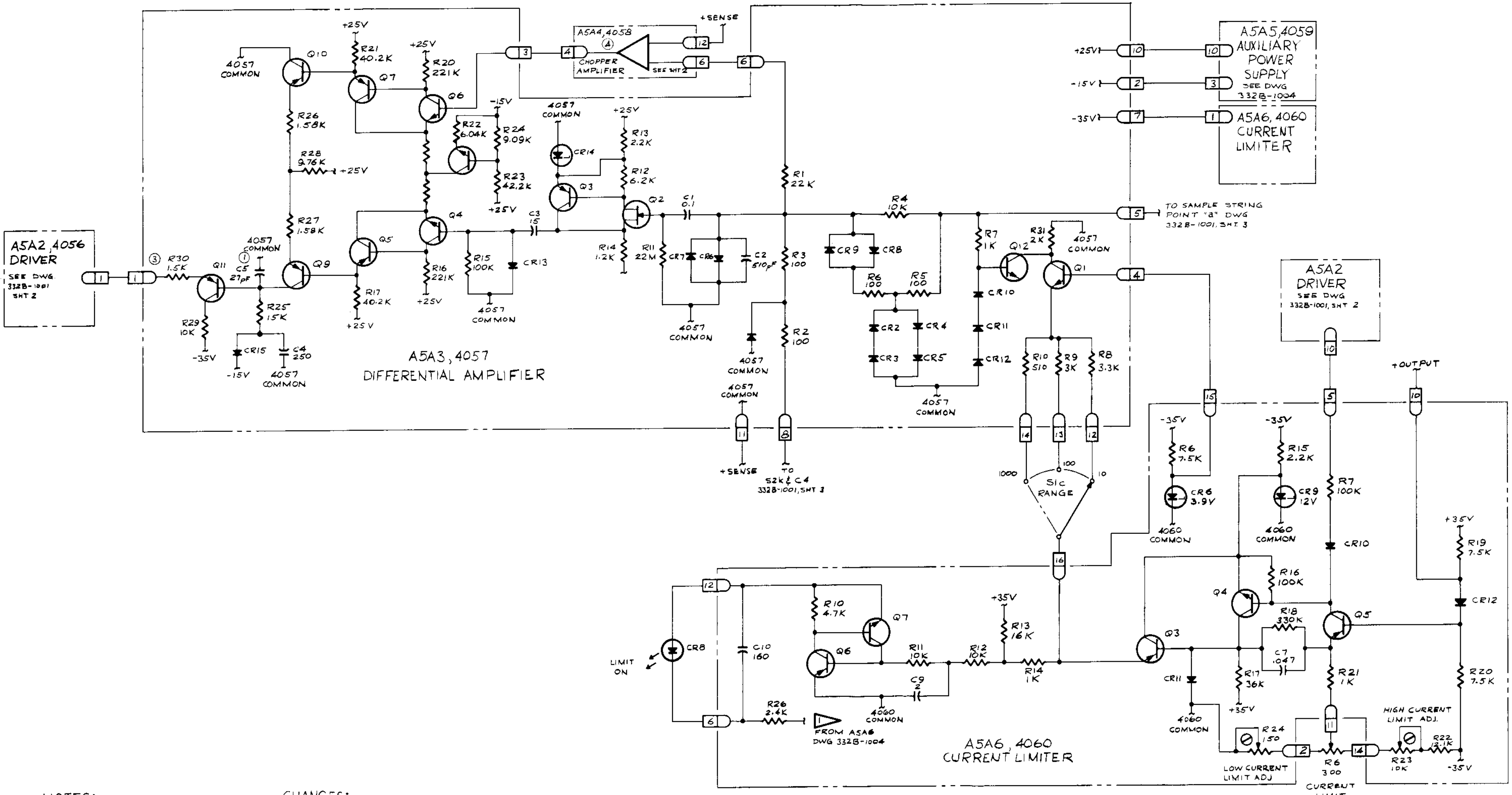


FIGURE 8-1. (3 of 3) DC VOLTAGE STANDARD (332B-1001)



NOTES:

1. RESISTANCE IN OHMS AND CAPACITANCE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ▷ FLAGS WITH SAME NUMBER ARE CONNECTED.
3. * FACTORY SELECTED COMPONENT.
4. ⊘ INTERNAL ADJUSTMENT

CHANGES:

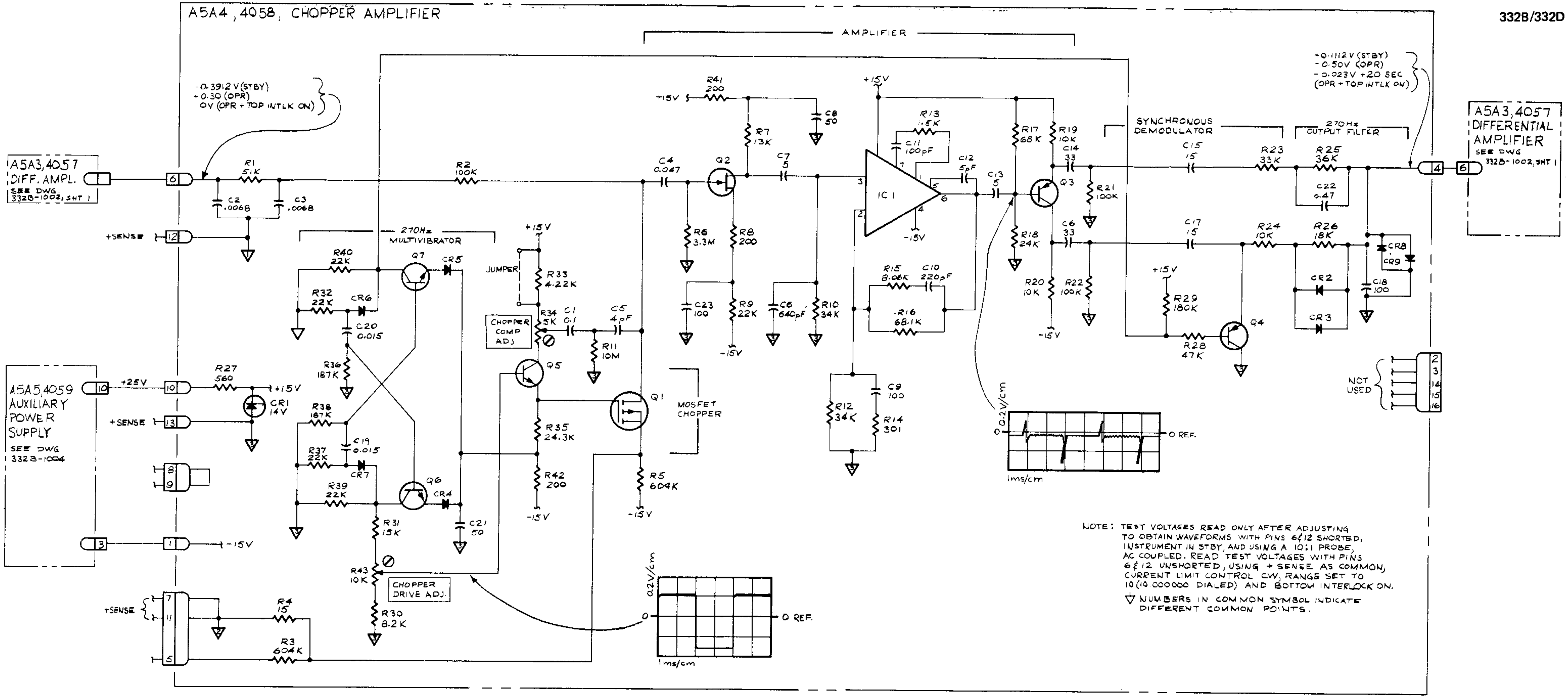
① A5A3 C5 INCLUDED IN S/N 188 THRU 307, 309, 311, 314, 316, 317, 319, 320, 322, 324, 330, 331, & 335.

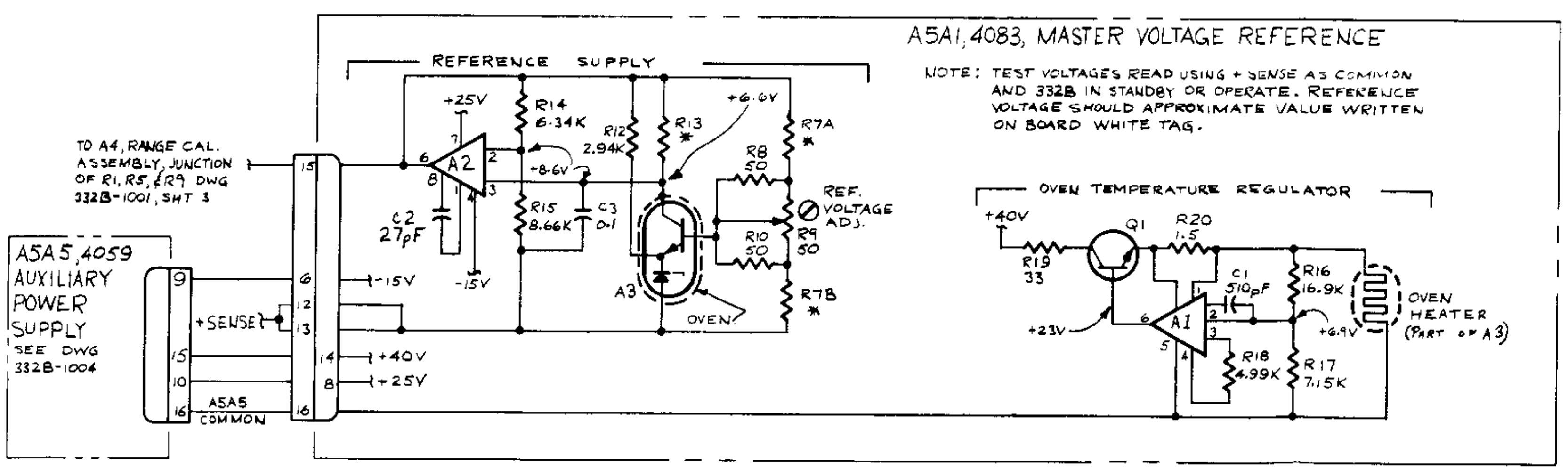
② A5A1C1 ADDED TO S/N 270, 273, 283, 284, 287-296, 298, 300-302, 305, 306 & ON.

③ A5A3R30 CHANGED FROM 1K TO 1.5K AT S/N 366 & ON.

④ MODIFIED ASSEMBLY ON 332B/AF.

FIGURE 8-2. (1 of 2) SUPPORT MODULE ASSEMBLIES (332B-1002)

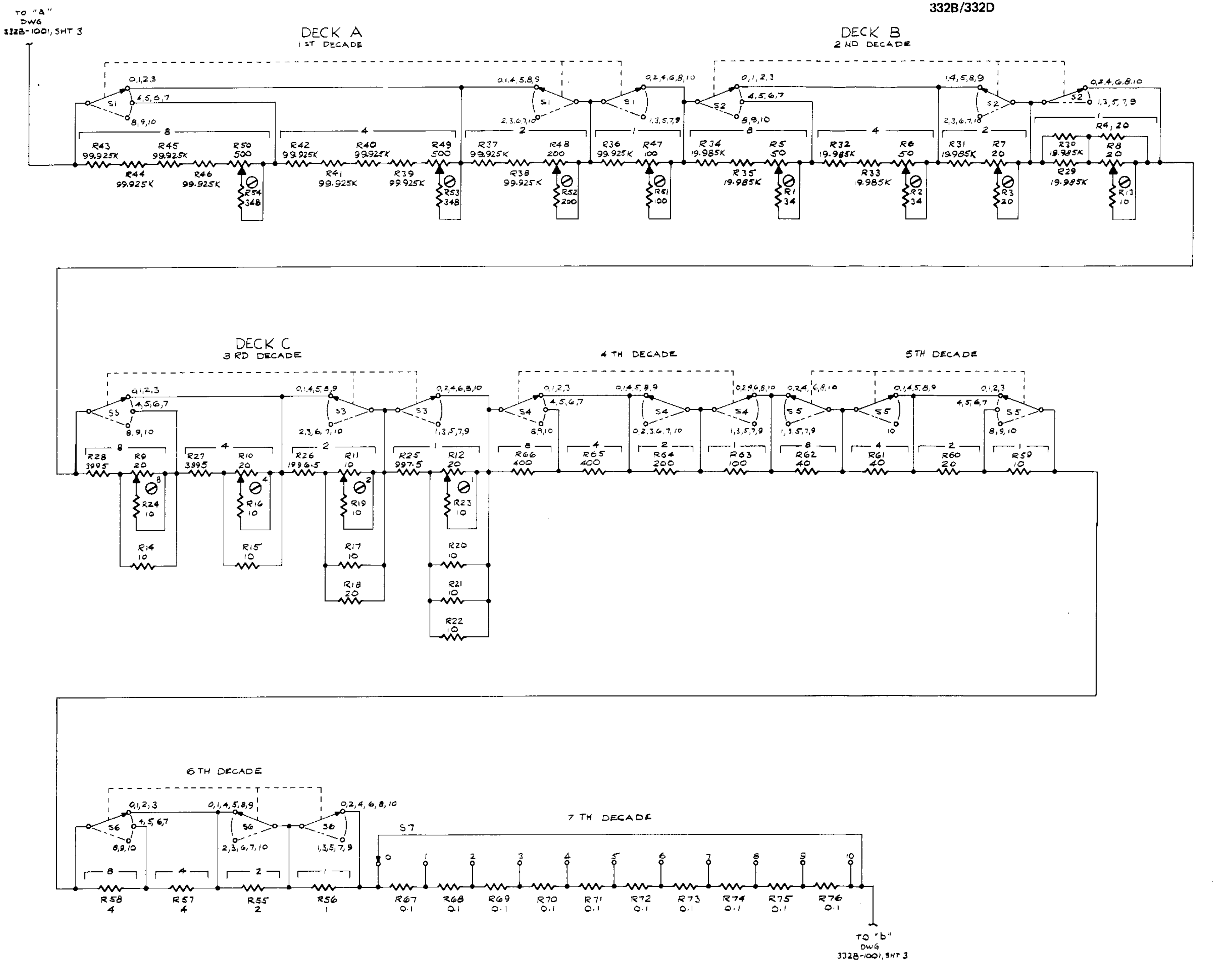




NOTES:

SEE SHEET 1 FOR NOTES AND CHANGES.

FIGURE 8-2. (2 of 2) SUPPORT MODULE ASSEMBLIES (332B-1002)



NOTES:
1. RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED.
2. ⊘ INTERNAL ADJUSTMENT.

FIGURE 8-3. A2 SAMPLE STRING (332B-1003)

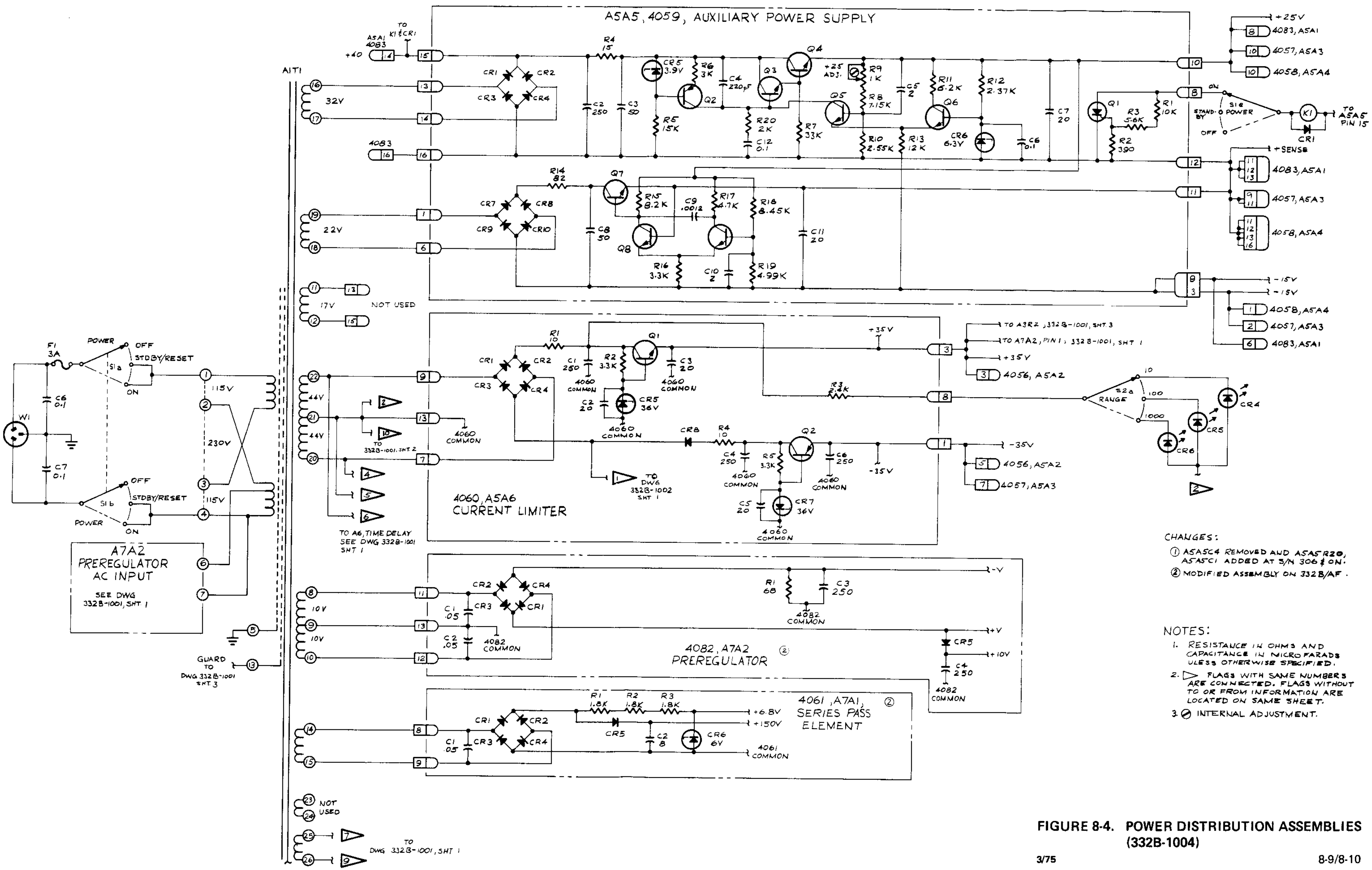


FIGURE 8-4. POWER DISTRIBUTION ASSEMBLIES (332B-1004)