

Errata

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OPERATING AND SERVICE MANUAL

MODEL 6428B

DC POWER SUPPLY

MANUFACTURING CODE 6D

January, 1966

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Table 1-1. Specifications

INPUT:	105-125 vac, 57 to 63 cps, single phase, 17 amperes, 1200 watts max.
RATED OUTPUT:	Constant Voltage: 0 to 18 vdc Constant Current: 0 to 45 amperes dc
LINE REGULATION:	Constant Voltage: Less than 18 mv for 105-125 vac input change. Constant Current: Less than 450 ma for 105-125 vac input change.
LOAD REGULATION:	Constant Voltage: Less than 36 mv for 0 to 45 ampere load change. Constant Current: Less than 450 ma for 0 to 18 vdc load change.
RIPPLE AND NOISE:	36 mvrms
OPERATING TEMPERATURE RANGE:	0°C to 50°C
STORAGE TEMPERATURE RANGE:	-20°C to 71°C
TEMPERATURE COEFFICIENT:	Constant Voltage: 0.05% plus 4 mv per degree centigrade. Constant Current: 135 ma per degree centigrade.
OUTPUT STABILITY: (after 30-minute warm-up)	Constant Voltage: 0.15% plus 12 mv for 8 hours at constant temperature. Constant Current: 450 ma for 8 hours at constant temperature.
REMOTE PROGRAMMING:	Constant Voltage: 200 ohms per volt $\pm 1\%$ Constant Current: 5 ohms per ampere $\pm 10\%$
TYPICAL OUTPUT IMPEDANCE:	Less than 0.002 ohm from dc to 0.5 cps Less than 0.2 ohm from 0.5 cps to 100 cps Less than 0.1 ohm from 100 cps to 1kc Less than 0.6 ohm from 1kc to 100 kc
OUTPUT INDUCTANCE:	1.0 microhenry

Table 1-1. Specifications (cont.)

TRANSIENT RECOVERY TIME:	<p>In constant voltage operation, less than 300 milliseconds is required for output voltage recovery to within 180 millivolts of the nominal output voltage following a load change equal to one half the maximum current rating of the power supply. Nominal output voltage is defined as the mean between the no-load and full-load voltages. The transient amplitude is less than 0.15 volt per ampere for any load change between 20% and 100% of rated output current. (Excluding the initial spike of approximately 100 microseconds duration which is significant only for load rise times faster than 0.5 ampere per microsecond.)</p>								
SIZE AND WEIGHT:	<table border="1"> <tr> <td data-bbox="873 948 1015 977">Height</td> <td data-bbox="1052 948 1138 977">Width</td> <td data-bbox="1224 948 1317 977">Depth</td> <td data-bbox="1398 948 1507 977">Weight</td> </tr> <tr> <td data-bbox="873 984 1015 1013">5-1/4 in.</td> <td data-bbox="1052 984 1138 1013">19 in.</td> <td data-bbox="1192 984 1349 1013">16-3/4 in.</td> <td data-bbox="1425 984 1507 1013">67 lb.</td> </tr> </table>	Height	Width	Depth	Weight	5-1/4 in.	19 in.	16-3/4 in.	67 lb.
Height	Width	Depth	Weight						
5-1/4 in.	19 in.	16-3/4 in.	67 lb.						
FINISH:	Light gray front panel with dark gray case.								

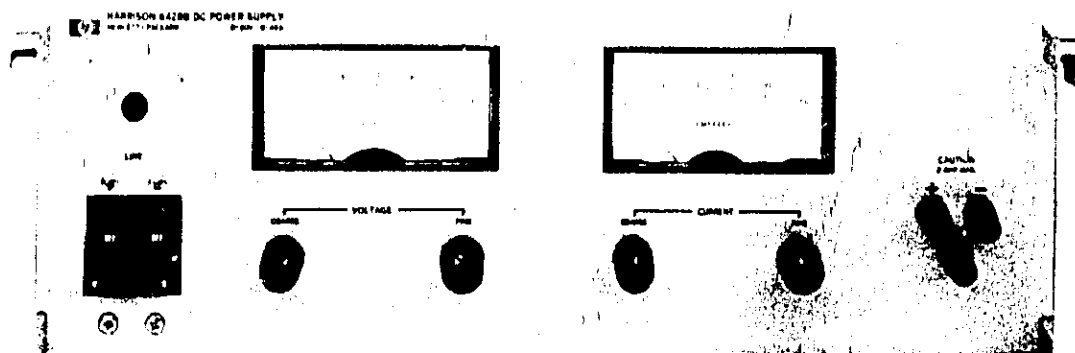


Figure 1-1. Model 6428B DC Power Supply.

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. GENERAL

1-3. The H-Lab Model 6428A DC Power Supply (fig. 1-1) is a completely solid-state, compact, well-regulated, constant voltage/constant current dc power supply suitable for either bench or relay rack operation. Input power is connected to a terminal strip at the rear of the power supply. The output is continuously variable between 0 and 18 vdc, and between 0 and 45 amperes. Detailed specifications are given in table 1-1.

1-4. OVERLOAD PROTECTION

1-5. A crossover feature protects both power supply and load in constant voltage operation. Automatic crossover circuitry switches the power supply from constant voltage to constant current operation if the output current exceeds a preset limit. This crossover circuitry also protects the load from overvoltage during constant current operation by automatically switching the power supply into constant voltage operation. The user can adjust the crossover point via the front panel controls (para. 3-8 and 3-9).

1-6. The power supply is protected from reverse voltage (positive voltage applied to negative terminal) by a diode that shunts current across the output terminals when this condition exists. The ac input components are protected by a dual circuit breaker in the ac input line. This circuit breaker is located on the front panel and serves as the on/off switch.

1-7. COOLING

1-8. A fan is used to blow air from left to right (facing front panel) through a compartment containing the major heat producing elements.

1-9. MONITORING

1-10. Two front-panel meters are provided for monitoring output voltage and current. The voltmeter has a 0 to 20 volt range and the ammeter has a 0 to 50 ampere range. Each meter has a 2% accuracy at full scale.

1-11. OUTPUT TERMINALS

1-12. Output power is available via a terminal strip on the rear panel. The rear panel terminal strip also enables the power supply to be connected for different modes of operation (para. 3-3). The output terminals are isolated from the chassis

and either the positive or the negative terminal may be connected to the chassis via a separate ground terminal located adjacent to the output terminals. The power supply is insulated to permit operation up to 300 vdc off ground.

1-13. INSTRUMENT IDENTIFICATION

1-14. Harrison Laboratories power supplies are identified by a three-part designation. The first part is the model number; the second part is the serial number; and the third part is the manufacturing code letter. This manual applies to all Model 6428A power supplies with the same manufacturing code letter given in the title page. Change sheets will be supplied with the manual to make it apply to Model 6428A power supplies with different manufacturing code letters.

SECTION II
INSTALLATION

2-1. INITIAL INSPECTION

2-2. GENERAL

2-3. Before shipment, the power supply was inspected and found free of mechanical and electrical defects. If damage to the shipping carton is evident, ask that the carrier's agent be present when the power supply is unpacked. As soon as the power supply is unpacked, inspect it for any damage that may have occurred in transit. Also check the cushioning material for signs of severe stress (may be indication of internal damage). Save all packing materials until the inspection is completed. If damage is found, proceed as instructed in the Claim for Damage in Shipment notice on the back of the front cover of this manual.

2-4. MECHANICAL CHECK

2-5. Check that there are no broken knobs or connectors, that the external surface is not scratched or dented, that the meter faces are not damaged, and that all controls move freely. Any external damage may be an indication of internal damage.

2-6. ELECTRICAL CHECK

2-7. Check that the straps on the terminal strip at the rear of the power supply are secure and that the strapping pattern is in accord with figure 3-2. Check the electrical performance of the power supply as soon as possible after receipt. A performance check that is suitable for incoming inspection is given in paragraphs 5-7 through 5-22.

2-8. INSTALLATION DATA

2-9. GENERAL

2-10. The power supply is shipped ready for bench or relay rack (19 inch) operation.

2-11. LOCATION

2-12. Because the power supply is forced-air (fan) cooled, the air intake and outlet vents on the sides of the chassis must not be obstructed. The power supply should be located in an area where the ambient temperature does not exceed 50°C.

2-13. POWER REQUIREMENTS

2-14. The power supply is operated from a 105 to 125 volt (115 volts nominal), 57 to 63 cps, single phase power source. At 115 volts, 60 cps, the full load requirement is 1200 watts at 16 amperes.

2-15. POWER CABLE

2-16. To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument should be used with a three-conductor power cable that has #12 AWG wire. The third conductor is the ground conductor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable three-prong connector is the ground connection.

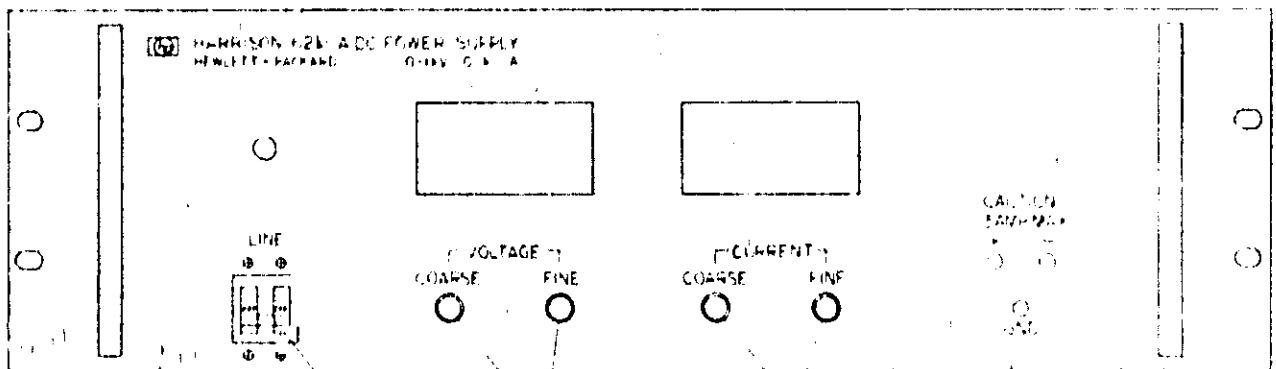
2-17. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adaptor and connect the green lead on the adaptor to ground.

2-18. REPACKAGING FOR SHIPMENT

2-19. To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your Hewlett-Packard field office for packing materials and information. A packing carton part number is included in the parts list.

2-20. Attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

OPERATION



1 TURN AC POWER ON

2 ADJUST COARSE AND FINE VOLTAGE CONTROLS
UNTIL THE VOLTAGE ON THE OUTPUT VOLTAGE
METER IS OF DESIRED VALUE

3 SHORT CIRCUIT THE OUTPUT TERMINALS
(AT REAR OF POWER SUPPLY)

4 ADJUST COARSE AND FINE CURRENT CONTROLS
UNTIL THE CURRENT ON THE OUTPUT CURRENT
METER IS OF DESIRED VALUE

5 REMOVE SHORT AND CONNECT LOAD

OPERATING PROCEDURE
FIG 3-1

SECTION III
OPERATING INSTRUCTIONS

3-1. CONTROLS AND INDICATORS

3-2. The controls and indicators are illustrated in figure 3-1.

3-3. OPERATION

3-4. GENERAL

3-5. The power supply is designed so that its mode of operation can be selected by making strapping connections between particular terminals on the terminal strip at the rear of the power supply. The terminal designations are stenciled in white on the power supply and are adjacent to their respective terminals. The strapping patterns illustrated in this section show neither terminal grounded. The operator can ground either terminal or operate the power supply up to 300 vdc off ground (floating). The ac input power is connected to the AC, ACC, and GND terminals at the rear of the power supply.

3-6. NORMAL

3-7. GENERAL. The power supply is normally shipped with its rear terminal strapping connections arranged for constant voltage/constant current, local sensing, local programming, single unit mode of operation. This strapping pattern is illustrated in figure 3-2. The operator selects either a constant voltage or a constant current output using the front panel controls (local programming, no strapping changes are necessary).

3-8. CONSTANT VOLTAGE. To select a constant voltage output, proceed as follows:

a. Turn-on power supply and adjust VOLTAGE controls for desired output voltage (output terminals open).

b. Short output terminals and adjust CURRENT controls for maximum output current allowable (current limit), as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically cross-over to constant current output at the preset current limit and the output voltage will drop proportionately. In setting the current limit, allowance must be made for high peak currents which can cause unwanted cross-over (refer to para. 3-40).

3-9. CONSTANT CURRENT. To select a constant current output, proceed as follows:

a. Short output terminals and adjust CURRENT controls for desired output current.

b. Open output terminals and adjust VOLTAGE controls for maximum output voltage allowable (voltage limit), as determined by load conditions. If a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage output at the preset voltage limit and the output current will drop proportionately. In setting the voltage limit, allowance must be made for high peak voltages which can cause unwanted crossover. (Refer to para. 3-40.)

3-10. CONNECTING LOAD

3-11. Two pairs of output terminals are provided on the terminal strip at the left rear side (facing rear) of the power supply. Either pair of terminals or both may be used. The terminals are marked + and -. A separate ground terminal is located adjacent to the output terminals. The positive or negative output terminal may be grounded, or neither grounded (floating operation; permitted to 300 vdc off ground).

3-12. Each load should be connected to the power supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If shield is used, connect one end to power supply ground terminal and leave the other end unconnected.)

3-13. If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (para. 3-14).

NOTE

It is recommended that the voltage drop in the connecting wires not exceed 2 volts. If a larger drop must be tolerated, please consult a Hewlett-Packard field representative.

3-14. REMOTE SENSING

3-15. Remote sensing is used to ameliorate the degradation of regulation which will occur at the load when the voltage drop in the connecting wires is appreciable. The use of remote distribution terminals (para. 3-13) is an example where remote sensing may be required. Due to the voltage drop in the load leads, it may be necessary to slightly increase the current limit in constant voltage operation.

CAUTION

Turn-off power supply before rearranging strapping pattern at the power supply rear terminal strip. If the -S terminal is opened while the power supply is on, the output voltage and current may exceed their maximum ratings and result in damage to the load. The power supply will not be damaged.

3-16. Proceed as follows:

a. Turn-off power supply and arrange rear terminal strapping pattern as shown in figure 3-3. The sensing wires will carry less than 10 ma and need not be as heavy as the load wires. It is recommended that sensing and load wires be twisted and shielded. (If shield is used, connect one end to power supply negative terminal and leave the other end unconnected.)

CAUTION

Observe polarity when connecting the sensing leads to the load.

b. In order to maintain low ac output impedance, a capacitor with a minimum rating of 20,000 μ fd and 25 vdcw should be connected across the load using short leads. This capacitor must have high-frequency characteristics as good or better than C17 has (see parts list).

c. Turn-on power supply.

3-17. REMOTE PROGRAMMING

3-18. GENERAL. The constant voltage and constant current outputs may be programmed (controlled) from a remote location. The front-panel controls are disabled in the following instructions. Changes in the rear terminal strapping arrangement are necessary. The wires connecting the programming terminals of the power supply to the remote programming device should be twisted or shielded to reduce noise pick-up. (If shield is used, connect one end to power supply ground terminal and leave the other end unconnected.) Remote sensing (para. 3-14) may be used simultaneously with remote programming. However, the strapping patterns shown in figures 3-4, 3-5, and 3-6 employ only local sensing and do not show the load connections.

CAUTION

Turn-off power supply before rearranging strapping pattern at the power supply rear terminal strip. If the current programming terminals are opened while the power supply is on, the output current will exceed its maximum rating and may result in damage to the load. The power supply will not be damaged. The constant voltage programming terminals have a zener diode connected internally across them to limit the programming voltage and thus prevent excessive output voltage.

3-19. **CONSTANT VOLTAGE.** In the constant voltage mode of operation, either a resistance or voltage source can be used for remote programming. For resistance programming, the programming coefficient (fixed by the programming current) is 200 ohms per volt (output voltage increases 1 volt for each 200 ohms in series with programming terminals). The programming current is adjusted to within 1% of 5 ma at the factory. If greater programming accuracy is required, change R39 (shunt). The programming resistance should be a stable, low noise, low-temperature (less than 30 ppm per °C) resistor with a power rating at least 10 times its actual dissipation.

3-20. The output voltage of the power supply should be 0 ± 20 mv, -100 mv when the programming resistance is zero ohms. This tolerance can be improved by changing R6. For further information on improving this tolerance, refer to paragraph 5-63 and to H-Lab Tech Letter #1.

3-21. If the resistance programming device is controlled by a switch, make-before-break contacts should be used in order to avoid momentary opening of the programming terminals. To connect the remote programming resistance, arrange rear terminal strapping pattern as shown in figure 3-4. The front-panel VOLTAGE controls are disabled when the strap between A6 and A7 is removed.

3-22. If a voltage source is used as the remote programming device, the output voltage of the power supply will vary in a 1 to 1 ratio with the programming voltage. The load on the voltage source will not exceed 25 microamperes. To connect the programming voltage, arrange rear terminal strapping pattern as shown in figure 3-5.

3-23. **CONSTANT CURRENT.** In constant current operation, resistance programming is used. The resistance programming coefficient (fixed by the programming current) is 5 ohms per ampere (output current increases 1 ampere for each 5 ohms in series with programming terminals). The programming current is adjusted to within approximately 10% of 2 ma at the factory. If greater programming accuracy is required, change R41 (shunt). The programming resistance should be a stable, low noise, low-temperature (less than 30 ppm per °C) resistor with a power rating at least 10 times its actual dissipation.

3-24. The output current of the power supply should be 0 +100 ma, -450 ma when the programming resistance is zero ohms. This tolerance can be improved by changing R20. For further information on improving this tolerance, refer to paragraph 5-67 and to H-Lab Tech Letter #1.

3-25. If the resistance programming device is controlled by a switch, make-before-break contacts should be used to avoid momentary opening of the programming terminals. To connect the remote programming resistance, arrange rear terminal strapping as shown in figure 3-6. The front-panel CURRENT controls are disabled when the strap between A1 and A2 is removed.

3-26. PARALLEL

3-27. GENERAL. Two or more power supplies can be connected in parallel to obtain a total output current greater than that available from one power supply. The total output current is the sum of the output currents of the individual power supplies. Each power supply can be turned-on or off separately. Remote sensing (para. 3-14) and programming (para. 3-17) can be used; however, the strapping patterns shown in figures 3-7 and 3-8 employ only local sensing and programming.

3-28. NORMAL. The strapping pattern for normal parallel operation of two power supplies is shown in figure 3-7. The output current controls of each power supply can be separately set. The output voltage controls of one power supply (master) should be set to the desired output voltage; the other power supply (slave) should be set for a slightly larger output voltage. The master will act as a constant voltage source; the slave will act as a constant current source, dropping its output voltage to equal the master's.

3-29. AUTO-PARALLEL. The strapping patterns for auto-parallel operation of two and three power supplies are shown in figures 3-8A and B, respectively. Auto-parallel operation permits equal current sharing under all load conditions, and allows complete control of output current from one master power supply. The output current of each slave is approximately equal to the master's. Because the output current controls of each slave is operative, they should be set to maximum to avoid having the slave revert to constant current operation; this would occur if the master output current setting exceeded the slave's.

3-30. SERIES

3-31. GENERAL. Two or more power supplies can be connected in series to obtain a total output voltage higher than that available from one power supply. The total output voltage is the sum of the output voltages of the individual power supplies. A single load can be connected across the series-connected power supplies or a separate load can be connected across each power supply. The power supply has a reverse polarity diode connected internally across the output terminals to protect the power supply against reverse polarity voltage if the load is short-circuited or if one power supply is turned off while its series partners are on.

3-32. The output current controls of each power supply are operative and the current limit is equal to the lowest control setting. If any output current controls are set too low with respect to the total output voltage, the series power supplies will automatically crossover to constant current operation and the output voltage will drop. Remote sensing (para. 3-14) and programming (para. 3-17) can be used; however, the strapping patterns shown in figures 3-9 and 3-10 employ only local sensing and programming.

3-33. NORMAL. The strapping pattern for normal series operation of two power supplies is shown in figure 3-9. The output voltage controls of each power supply must be adjusted to obtain the total output voltage.

3-34. AUTO-SERIES. The strapping patterns for auto-series operation of two and three power supplies are shown in figures 3-10A and B, respectively. Auto-series operation permits control of the output voltage of several power supplies (slaves) from one master power supply. The master must be the most negative power supply of the series. To obtain positive and negative voltages, the + terminal of the master may be grounded. For a given position of the slave output voltage controls, the total output voltage is determined by the master output voltage controls. The output voltage controls of a slave determines the percentage of the total output voltage that the slave will contribute. Turn-on and turn-off of the series is controlled by the master. In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors shown in figures 3-10A and B, should be stable, low-noise, low-temperature (less than 30 ppm per °C) resistors. The value of these resistors is determined by multiplying the output voltage of the applicable slave by the programming coefficient (200 ohms/volt).

3-35. AUTO-TRACKING

3-36. The strapping patterns for auto-tracking operation of two and three power supplies are shown in figures 3-11A and B, respectively. Automatic tracking operation permits the output voltages of two or more power supplies to be referenced to a common buss; one of the power supplies (master) controls the magnitude of the output voltage of the others (slaves) for a given position of the slave output voltage controls. The master must be the most negative power supply in the group. The output voltage of a slave is a percentage of the master output voltage. The output voltage controls of a slave determines this percentage. Turn-on and turn-off of the power supplies is controlled by the master. Remote sensing (para. 3-14) and programming (para. 3-17) can be used; however, the strapping patterns shown in figure 3-4 employ only local sensing and programming.

3-37. The value of the external resistors shown in figure 3-11 is determined by dividing the voltage difference between the master and the applicable slave by the programming current (nominally 5 ma; refer to para. 3-19). Finer adjustment of the slave output voltage can be accomplished using the slave output voltage controls. In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors should be stable, low-noise, low-temperature (less than 30 ppm per °C) resistors.

3-38. OPERATING CONSIDERATIONS

3-39. PULSE LOADING

3-40. The power supply will automatically cross over from constant voltage to constant current operation, or the reverse, in response to an increase (over the preset limit) in the output current or voltage, respectively. Although the preset limit may be set higher than the average output current or voltage, high peak currents or voltages (as occur in pulse loading) may exceed the preset limit and cause crossover to occur. To avoid this unwanted crossover, the preset limit must be set for the peak requirement and not the average.

3-41. OUTPUT CAPACITANCE

3-42. There are capacitors (internal) across the output terminals of the power supply. These capacitors help to supply high-current pulses of short duration during constant voltage operation. Any capacitance added externally will improve the pulse current capability, but will decrease the safety provided by the constant current circuit. A high-current pulse may damage load components before the average output current is large enough to cause the constant current circuit to operate.

3-43. The effects of the output capacitors during constant current operation are as follows:

- a. The output impedance of the power supply decreases with increasing frequency.
- b. The rise time of the output voltage is increased.
- c. A large surge current causing a high power dissipation in the load occurs when the load impedance is reduced rapidly.

3-44. NEGATIVE VOLTAGE LOADING

3-45. A diode is connected across the output terminals. Under normal operating conditions, the diode is reverse biased (anode connected to negative terminal). If a negative voltage is applied to the output terminals (positive voltage applied to negative terminal), the diode will conduct, shunting current across the output terminals and limiting the voltage to the forward voltage drop of the diode. This diode protects the filter and output electrolytic capacitors.

3-46. NEGATIVE CURRENT LOADING

3-47. Certain types of loads may cause current to flow into the power supply in the direction opposite to the output current. If the reverse current exceeds 0.6 ampere, preloading will be necessary. For example; if the load delivers 1 ampere to the power supply with the power supply output voltage at 18 vdc, a resistor equal to

18 ohms (18v/1a) should be connected across the output terminals. Thus, the 18 ohm resistor shunts the reverse current across the power supply. For more information on preloading, refer to paragraph C4 in the H-Lab Application Manual.

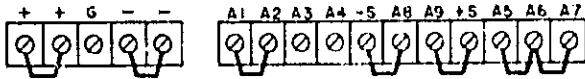


Figure 3-2.
Normal Strapping Pattern

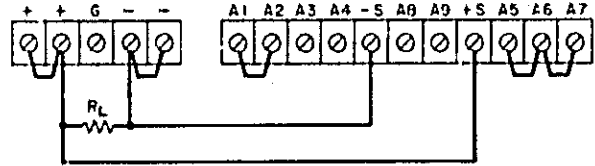


Figure 3-3.
Remote Sensing

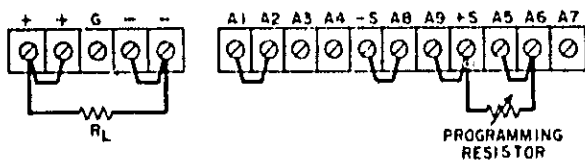


Figure 3-4.
Remote Resistance Programming
(Constant Voltage)

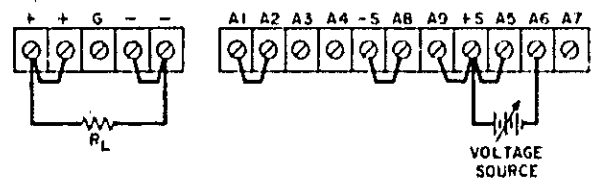


Figure 3-5.
Remote Voltage Programming
(Constant Current)

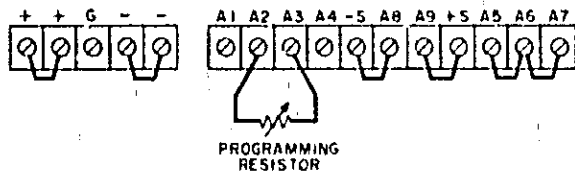


Figure 3-6.
Remote Resistance Programming
(Constant Current)

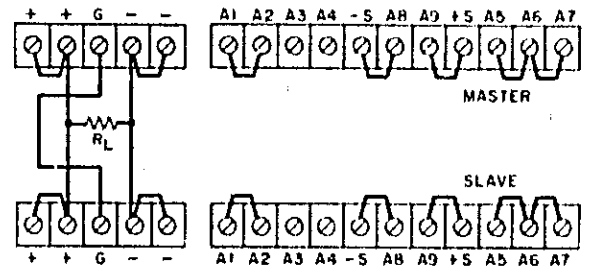


Figure 3-7.
Normal Parallel Operation

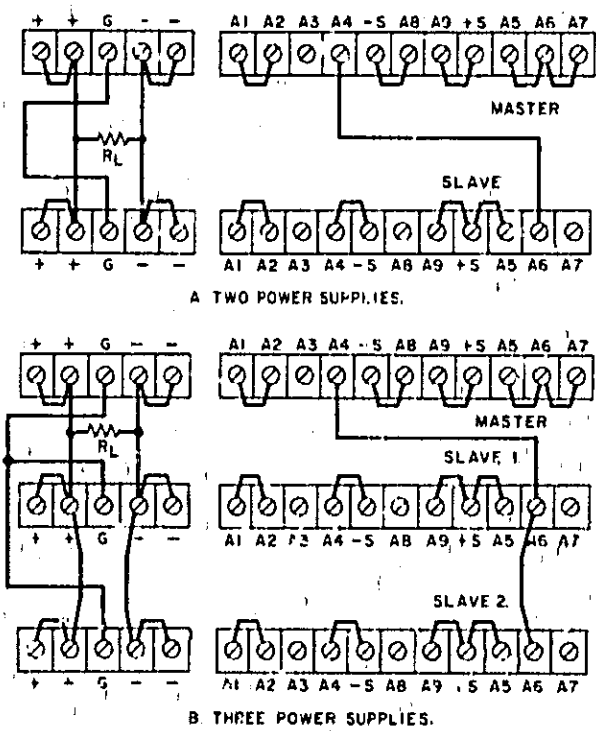


Figure 3-8.
Auto-Parallel Operation

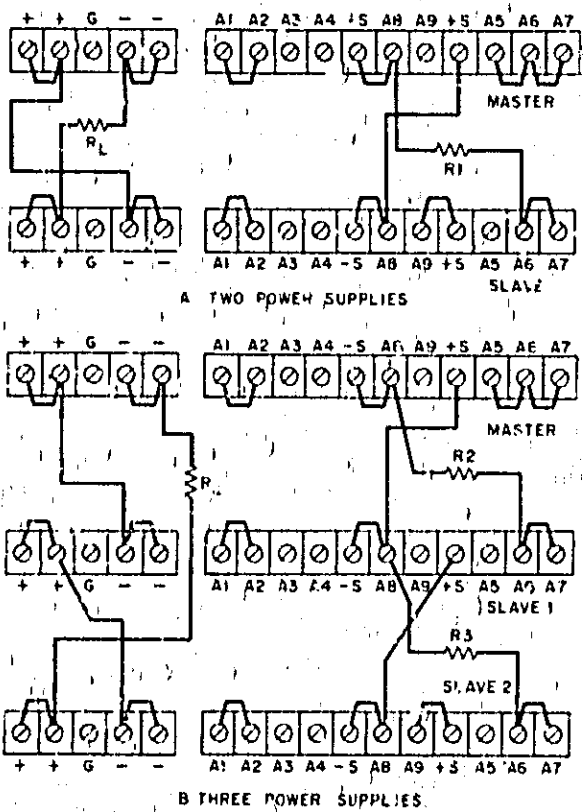


Figure 3-10.
Auto-Series Operation

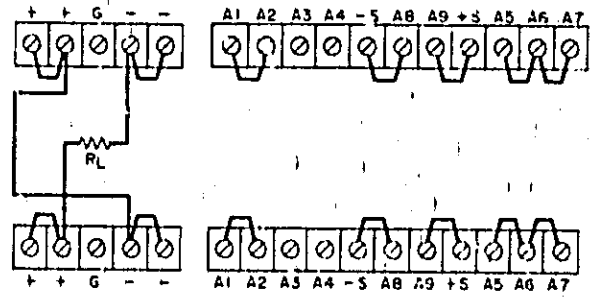


Figure 3-9.
Normal Series Operation

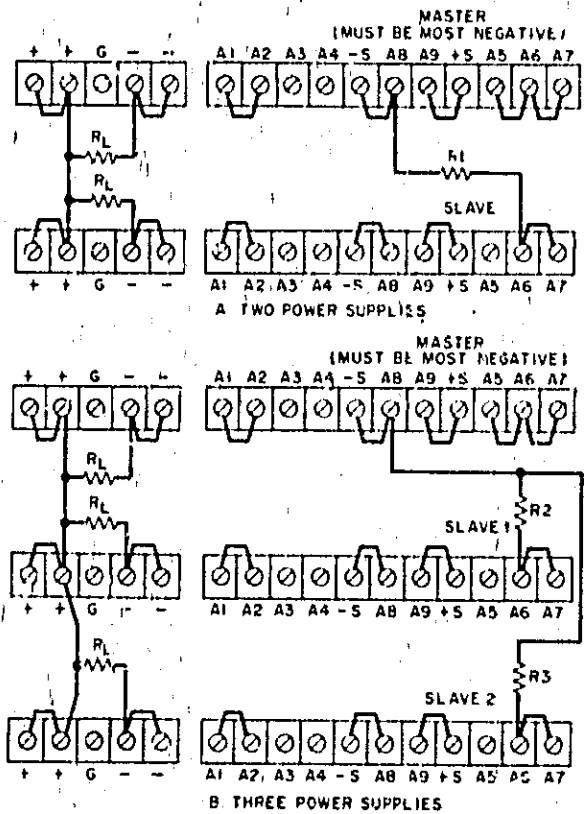


Figure 3-11.
Auto-Tracking Operation

THEORY

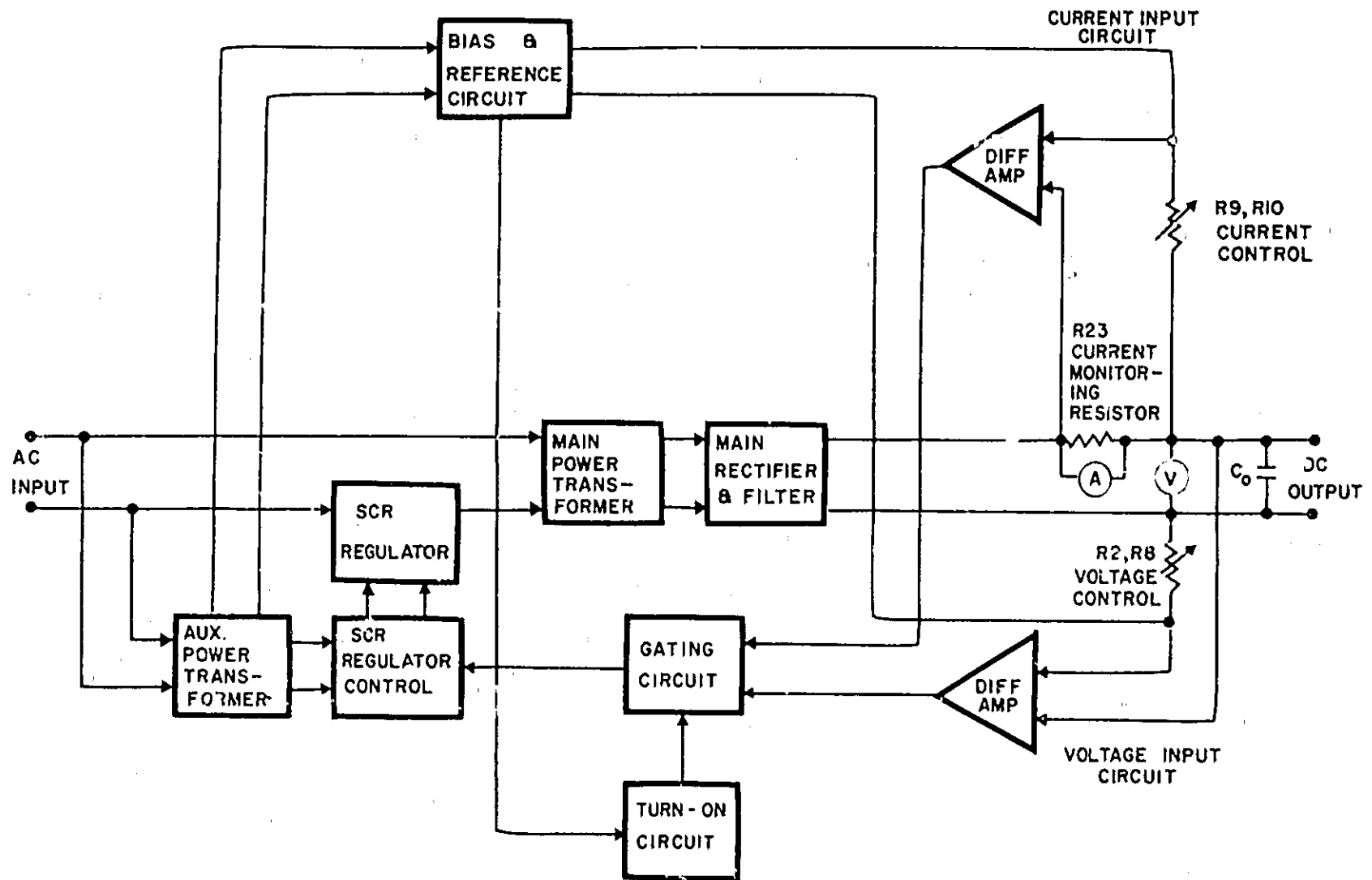


FIGURE 4-1. BLOCK DIAGRAM

SECTION IV

PRINCIPLES OF OPERATION

4-1. BLOCK DIAGRAM DESCRIPTION (See figure 4-1.)

4-2. The main power transformer isolates the ac input from the power supply and reduces it to the voltage level required. Rectification and filtering produces a smoothed dc output across the - and + terminals. A large capacitor (C_0) is connected across the - and + terminals for low ac output impedance and to help supply large pulse currents. An SCR regulator controls the ac input to provide good regulation of the dc output. The auxiliary power transformer powers the SCR regulator control circuit and the bias and reference circuit which produces dc bias and reference voltages for the power supply.

4-3. The SCR regulator is controlled by the SCR regulator control circuit which operates in response to signals developed by the voltage or current input circuit. A gating circuit assures that only one input circuit is used at a time.

4-4. The voltage and current input circuits operate in a similar manner. Each circuit has a differential amplifier that amplifies an error voltage that is proportional to the difference between the actual output and the programmed output. The programmed output is determined by the resistance of the programming resistors (voltage and current controls). Each programming resistor has a constant current through it which is maintained by the bias and reference circuit.

4-5. The voltage input circuit differential amplifier detects the error voltage that is proportional to the difference between the voltage across its programming resistors (R2-R8) and the dc output voltage. The error voltage is amplified and passed through the gating circuit to the SCR regulator control which triggers the SCR regulator. The SCR regulator increases or decreases the ac input voltage to the main power transformer as required to maintain a constant load voltage that is equal to the programmed voltage. In constant voltage operation, the gating circuit is biased to inhibit the input from the current input circuit.

4-6. The current input circuit differential amplifier detects the error voltage that is proportional to the difference between the voltage across its programming resistors (R9-R10) and the voltage across current monitoring resistor R23. The voltage across R23 is proportional to the load current. The SCR regulator responds to the amplified error voltage by increasing or decreasing the ac input current to the main power transformers as required to maintain a constant load current. In constant current operation, the gating circuit is biased to inhibit the input from the voltage input circuit.

4-7. To prevent overvoltage and excessive surge current when the power supply is turned-on, the turn-on circuit establishes initial conditions in the gating circuit. The turn-on circuit is activated by the bias and reference circuit when the power supply is turned-off.

4-8. A voltmeter is connected across the - and + terminals to monitor the output voltage. An ammeter is connected across current monitoring resistor R23 to monitor the output current (proportional to voltage across R23).

4-9. CIRCUIT DESCRIPTION (See figure 4-2 at back of manual.)

4-10. AC INPUT

4-11. The 105-125 vac, 57-63 cps, single phase input is applied through circuit breaker CB1 to transformer T2 and to the series combination of transformer T1 and SCR's CR17 and CR18 which are in parallel opposition. The SCR's are used to regulate the dc output by controlling the average value of the ac input to transformer T1. Capacitors C11 and C12 smooth transients to prevent the SCR's from being triggered by a rapidly changing voltage from anode to cathode. Resistor R21 damps oscillations that may occur due to resonance of C12 and the leakage inductance of T1. The leakage inductance of T1 limits the peak input current. The fan is also energized by the ac input.

4-12. DC OUTPUT

4-13. The output of the secondary of transformer T1 is full-wave rectified by bridge rectifier CR19 through CR22 and filtered by pi-section filter C13 through C17, and L1. Resistor R29 damps the parallel resonance of L1 and C17. The dc output is regulated to a constant value by the SCR's in the ac input line. Capacitor C17 is the output capacitor. Diode CR23 is connected across the filtered dc output to protect the power supply from reverse voltage applied to the output terminals. Resistor R23 is the current monitoring resistor; the full load current flows through it. Resistors R25 and R27 are used to calibrate the voltmeter and ammeter, respectively.

4-14. VOLTAGE INPUT

4-15. GENERAL. The voltage input circuit is basically a differential amplifier (Q1-Q2) that detects any voltage difference between the programmed output voltage and the actual output voltage. The differential amplifier output voltage varies in proportion to the power supply output voltage variation.

4-16. Q2 INPUT. Voltage divider R6-R47 maintains a slightly negative base bias to ensure that the output voltage can be programmed to zero. The output of Q2 is emitter-coupled (resistor R4) to Q1.

4-17. Q1 INPUT. There are three inputs to the base of Q1; one determined by the programmed voltage (voltage controls R2-R8), the second determined by the collector voltage of Q1 (negative feedback), and the third is from the positive side of the main rectifier. The collector current of Q1 is determined by the difference between its base and emitter inputs. This difference is an error voltage that is proportional to the difference between the programmed output voltage and the actual output voltage. The negative feedback from collector to base (C4, and R17-R18 in parallel) improves the stability of the voltage-regulating feedback loop.

4-18. The input from the positive side of the main rectifier (C1 and R1) improves loop stability by making the differential amplifier insensitive to output voltage variations of four cps or greater. Below four cps this input is negligible. This input is necessary because the phase shift of the pi-section output filter begins to become excessive over four cps. Resistors R1 and R5 are arranged so that the four cps input is isolated from the negative feedback input; and so that necessary impedance levels are obtained looking out from the base of Q1. The collector output of Q1 is coupled to the gating circuit.

4-19. CLAMPING. In order to protect the differential amplifier, the base of Q1 is clamped with respect to -S by diodes CR1 and CR2 to prevent excessive base voltage in either direction. Diode CR1 clamps the base to approximately -0.7 vdc; CR2 and the base-emitter junction of Q1 clamp the base to approximately +1.4 vdc. Zener diode VR1 clamps the programming terminals to prevent an excessive error signal that would cause excessive output voltage. This would occur, for example, if the programming terminals were opened accidentally. To prevent overshoot when the power supply switches from constant current to constant voltage, diodes CR9 and CR10 clamp the collector of Q1. Resistor R30 provides a small bleed current for CR10.

4-20. CURRENT INPUT

4-21. GENERAL. The current input circuit is basically a differential amplifier (Q8-Q9) that detects any current difference between the programmed output current (proportional to voltage across current controls) and the actual output current (proportional to voltage across current monitoring resistor R23). The differential amplifier output voltage varies in proportion to the output current variation.

4-22. Q8-Q9 INPUT. The input to the differential amplifier (across bases of Q8-Q9) is the voltage difference across current controls R9-R10 and current monitoring resistor R23. Because the programming current is constant in constant current operation, the voltage input to the differential amplifier varies as the load current through R23 (error voltage). Capacitors C6 and C24 and resistor R22 provide gain roll-off at high frequencies. Diode CR26 clamps the voltage (0.7 vdc) across the emitter-base junction of Q9 and R20. This clamping action prevents excessive reverse base voltage in Q9 when very large load current is drawn (output terminals shorted). To prevent overshoot when the power supply switches from constant voltage to constant current operation, diodes CR10 and CR12 clamp the collector of Q8.

4-23. Q8-Q9 OUTPUT. Resistor R13 is the collector load for Q8. The collector output of Q8 is coupled to the gating circuit. Voltage divider R20-R46 biases the base of Q9 and maintains a slightly negative base bias to ensure that the output current can be programmed to zero. Resistor R44 provides positive feedback to improve load regulation during constant current operation.

4-24. GATING CIRCUIT

4-25. Transistor Q4 draws current from the SCR control circuit (capacitor C25). The magnitude of this current is determined by either the voltage or current input circuit. For constant voltage operation, diode CR7 is forward biased to permit the voltage input circuit to drive Q4; diode CR8 is reverse biased to inhibit the input from the current input circuit. For constant current operation, the reverse occurs.

4-26. To prevent transients in the dc output when the power supply is turned-on, the turn-on of Q4 is delayed by capacitor C2 which charges through R12, R15 and CR5. When C2 charges sufficiently to reverse bias CR5, all the current through R15 flows to the base of Q4 to turn it on. This base current is controlled by the voltage or current input circuits via CR7 or CR8, respectively. For example, during constant voltage operation the collector voltage of Q1 (voltage input) forward biases CR7 (CR8 reverse biased by Q8), the current through CR7 will vary as Q1 collector voltage varies and thus vary Q4 base current; therefore, the collector current of Q4 is controlled by the voltage input. In a similar manner, the current input circuit controls the collector current of Q4 during constant current operation.

4-27. TURN-ON CIRCUIT

4-28. Transistor Q3 provides a path for rapidly discharging C2 (in gating circuit) when the power supply is turned-off. This assures that C2 is discharged if the power supply is turned-on shortly after turn-off. The purpose of having C2 discharged each time the power supply is turned-on is to maintain the same time delay in the turn-on of the gating circuit (refer to para. 4-26).

4-29. SCR REGULATOR CONTROL. (See waveshapes on figure 4-2.)

4-30. GENERAL. The SCR regulator control is basically a blocking oscillator (Q7 and T3) that applies pulses to the SCR regulator in response to error signals detected by the voltage or current input circuit. When transistor Q7 conducts, the pulse developed in winding 1-2 of transformer T3 is coupled to the base of Q7 (positive feedback) and to the SCR regulator (CR17 and CR18). Capacitor C27 charges in opposition to the feedback voltage and cuts off Q7. The charge time of C27 determines the pulse duration in the collector of Q7 (approximately 20 microseconds). The 35-vdc bias supplies current through R52, CR46, and CR44 to discharge C27 after Q7 stops conducting.

4-31. GATE INPUT. Throughout the operation of the blocking oscillator, capacitor C25 supplies most of the collector current for Q4 in the gating circuit (refer to para. 4-25). The amount of current pulled from C25 by Q4 is determined by the input (from the voltage or current input circuit) to the gating circuit. As a result of this current flow from C25, the voltage across C25 increases negatively with respect to the 6.0-vdc bias and has a waveshape that approximates a linear ramp. Thus, the slope of this ramp is determined by the voltage or current input circuit. Due to the time delay in the feedback loop, the slope of the ramp is constant for a half cycle of the ac input. The voltage on C25 is the emitter bias (forward bias when negative) for Q7 and therefore helps determine the point at which Q7 conducts.

4-32. AC INPUT. The ac input to transformer T2 is stepped-down and full-wave rectified by bridge rectifier CR39 through CR43. The output of the bridge rectifier is a negative-going pulsating dc (120 cps). Voltage divider R50-R51 supplies a portion of this pulsating dc through C27 to the base of Q7; thus, the base is reverse biased.

4-33. FIRING. A point is reached during each cycle of the 120-cps pulsating dc (each half cycle of the 60-cps ac input) when the reverse bias on the base and the forward bias (capacitor C25) on the emitter of Q7 are equal, and therefore Q7 has zero bias. As the ramp voltage across C25 goes more negative than the base voltage, the base-emitter junction of Q7 begins to become forward biased. When the emitter is more negative than the base by approximately 0.5 volts, Q7 conducts. The firing point of Q7 is therefore determined by both the dc output error and the line voltage change. Because Q7 saturates when it conducts, the collector voltage approximates a rectangular wave with a negative going pulse width of approximately 20 microseconds (determined by C27 and R51). The conduction of Q7 charges C25 in the positive direction (clamped by CR49). When Q7 stops conducting, the ramp across C25 begins again. However, Q7 is held cut-off by the charge on C27.

4-34. INITIAL CONDITIONS. At the beginning of each cycle of the 120-cps pulsating dc, certain initial conditions must be established on capacitors C25 and C27. When the negative-going pulsating dc is at the end of its cycle (C27 negatively charged earlier in the cycle by the feedback voltage), CR44 and CR45 become forward biased and current flows from the 35-vdc bias through R52, CR46, and CR44 to discharge C27 to approximately zero volts and through R52, CR46, and CR45 to charge C25 to approximately 0.7 volts (clamped by CR49). This discharge and charge occurs rapidly, so that it is completed before the next cycle begins and Q7 can conduct again. Diode CR47 provides another path for the current through CR44 so that the voltage to which C27 discharges remains predictable. As the negative-going pulsating dc increases in the next cycle, CR44 and CR45 become reverse biased.

4-35. BRIDGE RECTIFIER. At the zero cross-over region of the voltage waveform on secondary winding 3-4 of transformer T2, the voltage is insufficient to forward bias the rectifiers in the bridge. In order to maintain definition between the end of one cycle of the rectified output and the beginning of the next cycle, diode CR41 provides approximately 0.7 volts at the rectified output. The current for CR41 is supplied through CR46. As the voltage across the secondary winding moves away from the zero cross-over region, CR41 becomes reverse biased.

4-36. TRANSIENTS, DECOUPLING AND PROTECTION. Transients in the pulsating dc are reduced by R56 and C28. The base of Q7 is decoupled by C3. The voltage spike in the collector of Q7, induced by secondary winding 1-2 of transformer T3 when Q7 cuts-off, is clamped by CR48. The collector is decoupled by R53 and C26. To protect the power supply and load, thermostat TS1 opens the collector circuit of Q7 when the temperature of the SCR heat sinks exceeds 80°C.

4-37. SCR REGULATOR

4-38. GENERAL. The SCR regulator (CR17 and CR18) controls the ac input voltage and current to main power transformer T1 in response to the voltage and current error signals. In constant voltage operation, the ac input voltage to T1 is adjusted so that the output voltage remains constant with changing loads. In constant current operation, the ac input current to T1 is adjusted so that the output current remains constant with changing loads and the output voltage is allowed to vary.

4-39. GATING. Each half cycle of the ac input, either CR17 or CR18 is forward biased. The pulse induced in secondary windings 5-6 and 7-8 of T3 by the SCR control, turns on the SCR that is forward biased when the pulse occurs. The other SCR is not affected by the gate pulse because it is reverse biased. A gate pulse occurs each half cycle of the ac input, unless the output is open. The timing of the gate pulse with respect to the ac input is determined by the error in the dc output via the loop action.

4-40. AC INPUT CONTROL. When an SCR is gated on, it conducts until its anode-to-cathode voltage goes to approximately zero. Thus, the earlier an SCR is gated on, the greater the portion of the ac input that will be applied to T1. Because of the leakage inductance of T1, the conduction of an SCR may extend into the next half cycle. The conduction period may be shortened at high output by the voltage across capacitor C13 through C16 being reflected back into the primary. By controlling the ac input to T1 each half cycle, the average value of the voltage or current at the output of bridge rectifier CR19 through CR21 is adjusted so that dc output voltage or current is maintained constant.

4-41. PROTECTION. Diodes CR50 and CR51 prevent anode induced reverse gate currents from being fed back to the control circuit. Resistors R54 and R55 limit current in the SCR gates.

4-42. BIAS AND REFERENCE CIRCUIT

4-43. GENERAL. The bias and reference circuit supplies three voltages (+35, +6.0, and -19.5 vdc) for internal power supply operation, and maintains the programming currents constant. The +35 vdc is not regulated. The -19.5 vdc, +6.0 vdc, and the programming currents are regulated.

4-44. +35 AND +6.0 VDC. The output of secondary winding 5-6 of transformer T2 is full-wave rectified by CR30 and CR31. Capacitors C20 and C21 each charge to the peak rectified voltage (voltage doubling). The +6.0 vdc (with respect to -S) is maintained by diodes CR6 and CR14 and by zener diode VR4. The +35 vdc includes the +6.0 vdc and the voltage across C21. The +6.0 vdc and the negative voltage across C20 provide the unregulated input to the -19.5 vdc regulator.

4-45. -19.5 VDC. For the -19.5 vdc, transistor Q10 is the error detector/amplifier. Zener diode VR3 and diode CR27 provide a reference voltage at the emitter of Q10. Voltage divider R35-R36 supplies an error voltage to the base of

Q10 which amplifies and applies it to the base of series regulator Q11. The base drive of Q11 adjusts the voltage across Q11 as required to compensate for the error in the -19.5 vdc. Resistor R37 sets the optimum current through temperature-compensated zener diode VR3. Resistor R15 improves the line regulation. Resistor R56 reduces power dissipation in Q11. Capacitor C22 stabilizes the loop.

4-46. PROGRAMMING CURRENTS. Each programming current is held constant in a similar manner. The voltage across emitter resistors R38 and R40 is held constant by VR3, CR27, and the base-emitter drop of each transistor. Thus, the emitter current in each transistor is constant and therefore the collector currents are nearly constant. The collector currents of Q5 and Q6 are the constant voltage and constant current programming currents, respectively. Resistors R39 and R41 are used for trimming. Resistors R42 and R43 are collector loads. Diode CR28 clamps the collector of Q5 to protect against excessive positive voltage (breakdown) which might occur if the voltage controls are reduced to zero rapidly (positive dc output voltage would appear at collector).

MAINTENANCE

Table 5-1. Test Equipment

Type	Required Characteristics	Use	Recommended Model
Differential Voltmeter	Sensitivity: 1 mv full scale (min.) Input impedance: 10 megohms	Measure regulation and dc voltages; calibrate meters	HP 741A (See note 1)
AC Voltmeter	Accuracy: 2% Sensitivity: 1 mv full scale (min.)	Measure ac voltages and ripple	HP 403B
Variable Voltage Transformer	Range: 90-130 volts Equipped with voltmeter accurate within 1 volt	Vary and measure ac input voltage	-----
Oscilloscope	Sensitivity: 5mv/cm (min.) Differential input	Measure ripple and transient response	HP 130C
Battery	18 vdc	Measure transient response	-----
Switch	45-ampere capacity	Transient response; Constant current load regulation;	-----
Resistor	0.4 ohm, $\pm 5\%$, 1 kw	Load resistor	Rex Rheostat (See note 2)
Resistor	1 milliohm, 45 amperes 4 terminals	Current monitoring	Any 50 mv, 50 ampere meter shunt
Resistor	1,000 ohms, $\pm 1\%$, 2 w non-inductive	Measure impedance	-----
Resistor	100 ohms, $\pm 5\%$, 10 w	Measure impedance	-----
Capacitor	500 μ fd, 50 vdcw	Measure impedance	-----
Oscillator	Range: 1 cps to 100 kc Accuracy: 2% Output: 10 vrms	Measure impedance	HP 202C

Table 5-1. Test Equipment (cont.)

Type	Required Characteristics	Use	Recommended Model
Controlled-temperature oven	Range: 0-50°C	Measure temperature stability	-----
Resistance box	Range: 0-3,600 ohms Accuracy: 0.1% plus 1 ohm Make-before-break contacts	Measure programming coefficients	H-Lab 6931A

NOTE 1

A satisfactory substitute for a differential voltmeter is to arrange a reference voltage source and null detector as shown in figure 5-1. The reference voltage source is adjusted so that the voltage difference between the supply being measured and the reference voltage will have the required resolution for the measurement being made. The voltage difference will be a function of the null detector that is used. For measurements at the base of transistor Q4, a null detector with input impedance of 10 megohms or greater is required. Otherwise, satisfactory null detectors are: HP 405AR digital voltmeter, HP412A dc voltmeter, HP 419A null detector, a dc coupled oscilloscope utilizing differential input, or a 50 mv meter movement with a 100 division scale. A 2 mv change in voltage will result in a meter deflection of four divisions.

CAUTION

Care must be exercised when using an electronic null detector in which one input terminal is grounded to avoid ground loops and circulating currents.

8.

NOTE 2

To obtain 0.4 ohms, connect rheostat across output terminals, turn front-panel CURRENT controls fully clockwise (maximum), adjust front-panel VOLTAGE controls for 18 vdc and adjust rheostat until output current is 45 amperes. Use fan to cool rheostat.

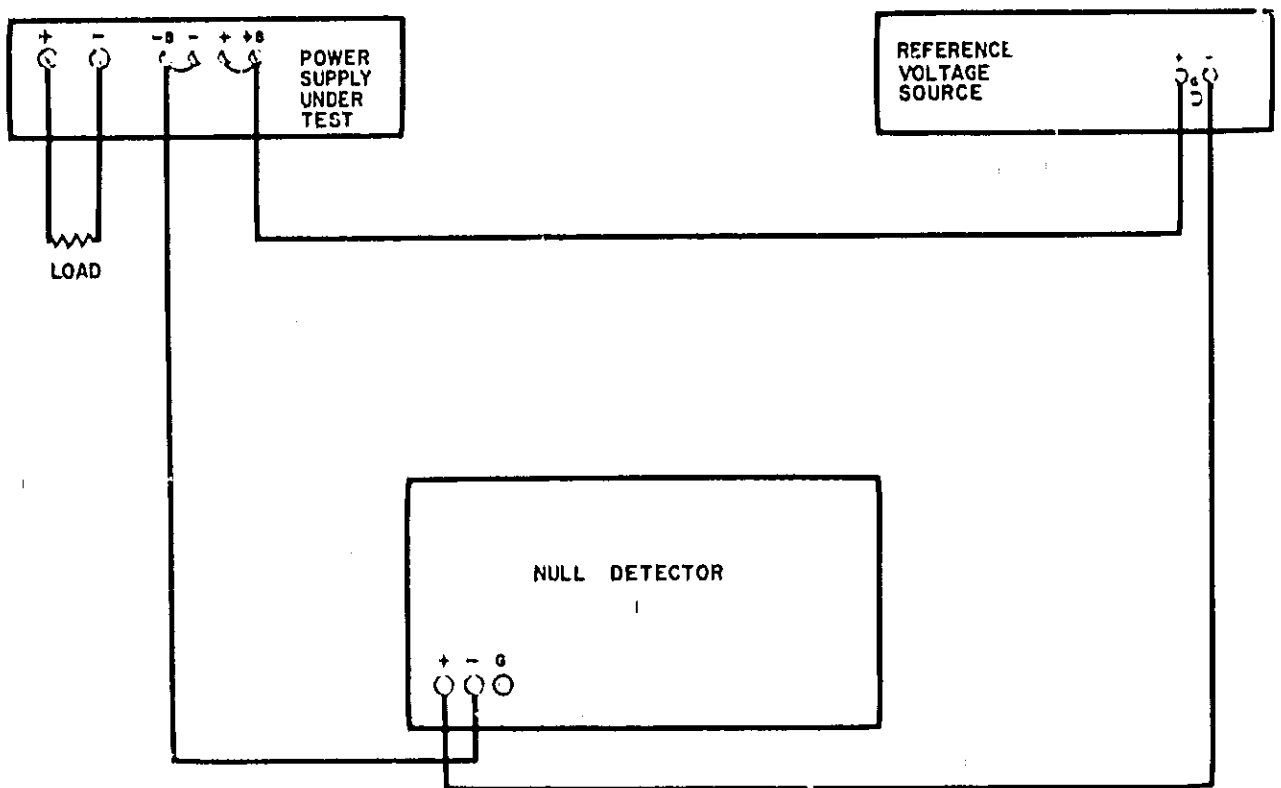


FIGURE 5-1 DIFFERENTIAL VOLTMETER SUBSTITUTE, TEST SETUP

SECTION V
MAINTENANCE

5-1. GENERAL

5-2. Table 5-1 lists the type of test equipment, its required characteristics, its use, and a recommended model for performing the instructions given in this section. Upon receipt of the power supply, the performance check (para. 5-7) should be made. This check is suitable for incoming inspection. Additional specification checks are given in paragraphs 5-24 through 5-36. If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (para. 5-39). After troubleshooting and repair (para. 5-50), perform any necessary adjustments and calibrations (para. 5-51). Before returning the power supply to normal operation, repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist. Before doing any maintenance checks, turn-on power supply, allow a half-hour warm-up, and read the measurement techniques (para. 5-3).

5-3. MEASUREMENT TECHNIQUES

5-4. A measurement made across the load includes the effect of the impedance of the leads connecting the load; these leads can have an impedance several orders of magnitude greater than the output impedance of the power supply. When measuring the output voltage of the power supply, use the -S and +S terminals.

5-5. For output current measurements, the current monitoring resistor should be a four-terminal resistor. The four terminals are connected as shown in figure 5-2.

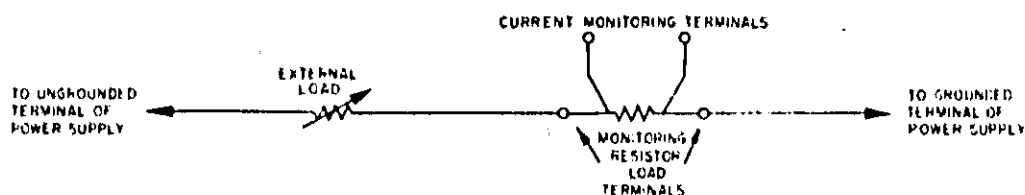


Figure 5-2. Output Current Measurement Technique

5-6. When using an oscilloscope, ground one terminal of the power supply and ground the case at the same ground point. Make certain that the case is not also grounded by some other means (power line). Connect both oscilloscope input leads to the power supply ground terminal and check that the oscilloscope is not exhibiting a ripple or transient due to ground loops, pick-up, or other means.

5-7. PERFORMANCE CHECK

5-8. GENERAL

5-9. The performance check is made using a 115-volt, 60-cps, single-phase input power source. The performance check is normally made at a constant ambient room temperature. The temperature range specification can be verified by doing the performance check at a controlled temperature of 0°C and at a controlled temperature of 50°C. If the correct result is not obtained for a particular check, do not adjust any controls; proceed to troubleshooting (para. 5-39).

5-10. RATED OUTPUT AND METER ACCURACY

5-11. CONSTANT VOLTAGE. Proceed as follows:

- a. Connect the 0.4-ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Turn front-panel VOLTAGE controls until front-panel voltmeter indicates 18.0 vdc.
- d. The differential voltmeter should indicate 18.0 ± 0.36 vdc.

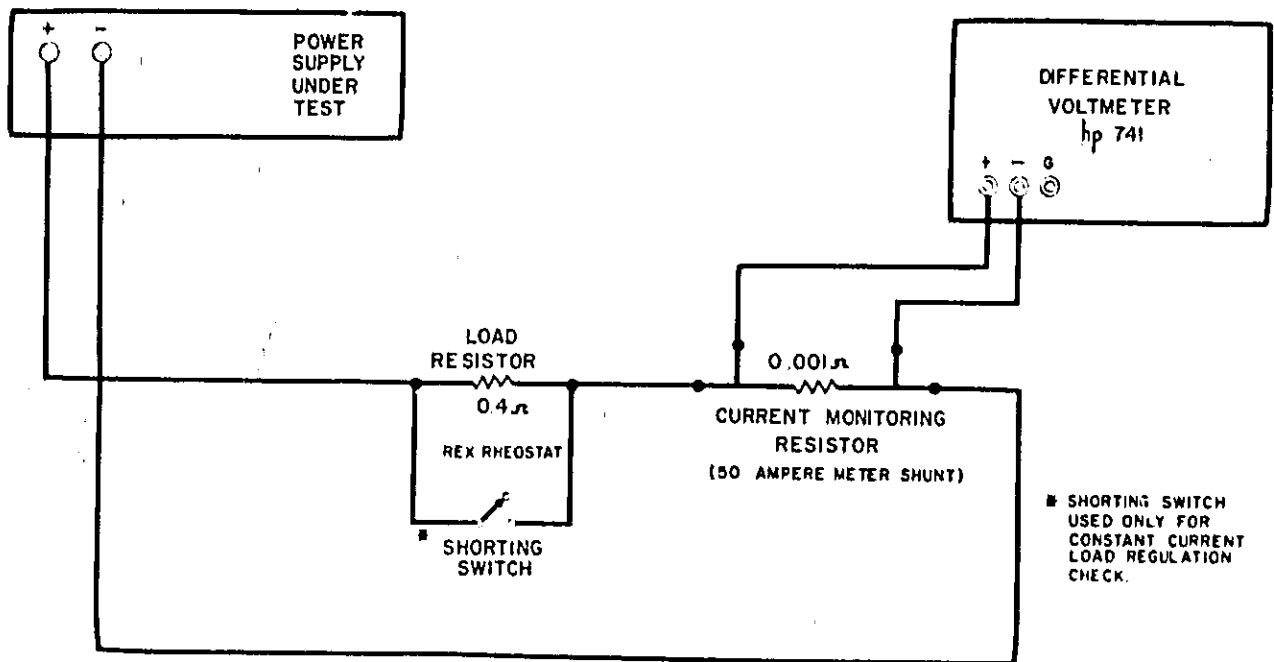


FIGURE 5-3 CONSTANT CURRENT TEST-SETUP

5-12. CONSTANT CURRENT. Proceed as follows:

- a. Connect test setup shown in figure 5-3.
- b. Turn front-panel VOLTAGE controls fully clockwise (maximum).
- c. Turn front-panel CURRENT controls until front-panel ammeter indicates 45.0 amperes.
- d. The differential voltmeter should indicate 45 ± 0.9 mvdc.

5-13. LINE REGULATION

5-14. CONSTANT VOLTAGE. Proceed as follows:

- a. Connect the 0.4-ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 105 vac.
- d. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 18.0 vdc.
- e. Adjust the variable voltage transformer to 125 vac.
- f. Differential voltmeter indication should change by less than 18 mvdc.

5-15. CONSTANT CURRENT. Proceed as follows:

- a. Connect test setup shown in figure 5-3.
- b. Turn front-panel VOLTAGE controls fully clockwise (maximum).
- c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 105 vac.
- d. Turn front-panel CURRENT controls until front-panel ammeter indicates 45 amperes.
- e. Record voltage indicated on differential voltmeter
- f. Adjust the variable voltage transformer to 125 vac.
- g. Differential voltmeter indication should change by less than 0.45 mvdc.

5-16. LOAD REGULATION

5-17. CONSTANT VOLTAGE. Proceed as follows:

- a. Connect the 0.4-ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Turn the front-panel VOLTAGE controls until front-panel ammeter indicates 45 amperes.
- d. Record voltage indicated on differential voltmeter.
- e. Disconnect load resistor.
- f. Differential voltmeter indication should change by less than 36 mvdc.

5-18. CONSTANT CURRENT. Proceed as follows:

- a. Connect test setup shown in figure 5-3.
- b. Turn front-panel VOLTAGE controls fully clockwise (maximum).
- c. Turn front-panel CURRENT controls until front-panel ammeter indicates 45 amperes.
- d. Record voltage indicated on differential voltmeter.
- e. Close the shorting switch.
- f. Differential voltmeter indication should change by less than 0.45 mvdc.

5-19. RIPPLE AND NOISE

5-20. Proceed as follows:

- a. Connect the 0.4-ohm load resistor across the output terminals and the ac voltmeter across the -S and +S terminals.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 125 vac.
- d. Turn front-panel VOLTAGE controls until front-panel ammeter indicates 45 amperes.
- e. The ac voltmeter should indicate less than 36 mvrms.

5-21. TRANSIENT RECOVERY TIME

5-22. Proceed as follows:

- a. Connect test setup shown in figure 5-4.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Turn front-panel VOLTAGE controls until front-panel ammeter indicates 45 amperes.
- d. Open and close the switch several times and observe the oscilloscope display.
- e. Oscilloscope display should be as shown in figure 5-5.

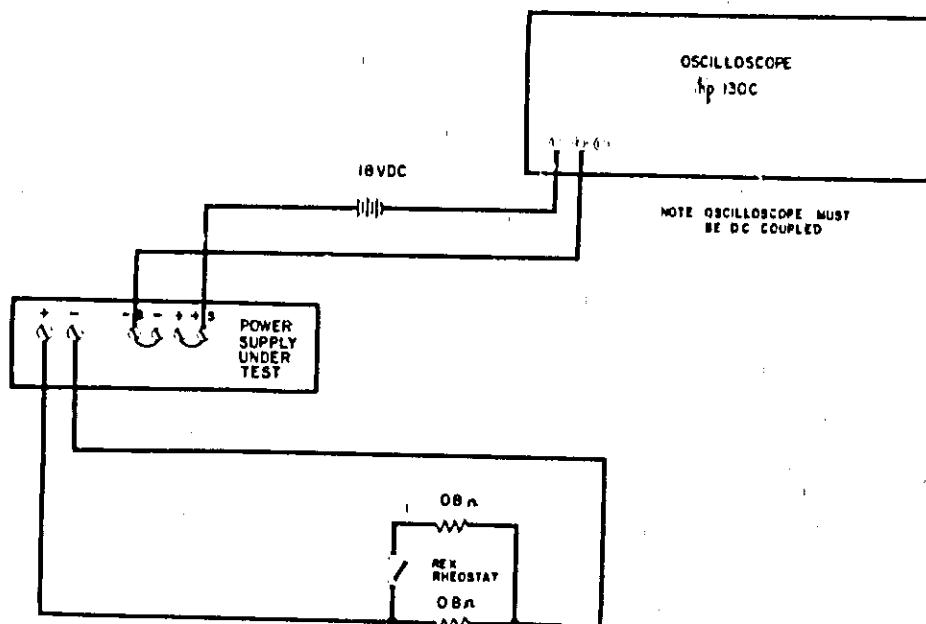


FIGURE 5-4 TRANSIENT RECOVERY TIME, TEST SETUP

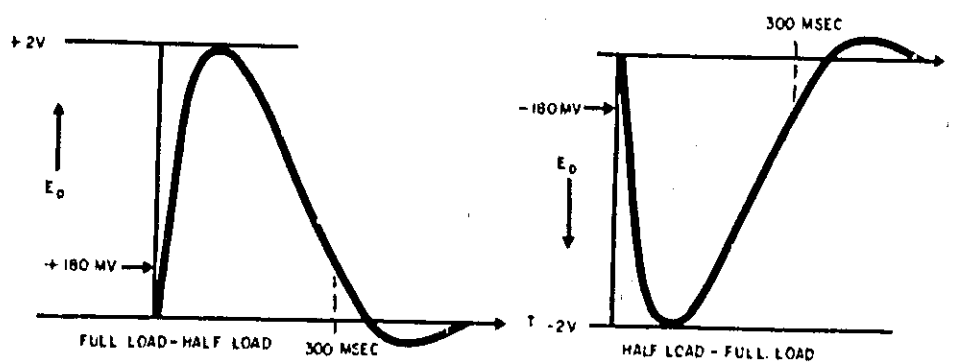


FIGURE 5-5 TRANSIENT RECOVERY TIME, WAVEFORM

5-23. ADDITIONAL SPECIFICATION CHECK

5-24. TEMPERATURE COEFFICIENT

5-25. CONSTANT VOLTAGE. Proceed as follows:

- a. Connect the 0.4-ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 18 vdc.
- d. Insert the power supply into the controlled-temperature oven (differential voltmeter and load remain outside oven). Set the temperature to 30°C and allow a half-hour warm-up.
- e. Record the differential voltmeter indication.
- f. Raise the temperature to 40°C and allow a half-hour warm-up.
- g. Differential voltmeter indication should change by less than 130 mvdc from indication recorded in step e.

5-26. CONSTANT CURRENT. Proceed as follows:

- a. Connect test setup shown in figure 5-3.
- b. Turn front-panel VOLTAGE controls fully clockwise (maximum).
- c. Turn front-panel CURRENT controls until the differential voltmeter indicates 45 mvdc.
- d. Insert the power supply into the controlled-temperature oven (differential voltmeter and load remain outside oven). Set the temperature to 30°C and allow a half-hour warm-up.
- e. Record the differential voltmeter indication.
- f. Raise the temperature to 40°C and allow a half-hour warm-up.
- g. Differential voltmeter indication should change by less than 1.35 mvdc from indication recorded in step e.

5-27. OUTPUT STABILITY

5-28. CONSTANT VOLTAGE. Proceed as follows:

- a. Connect the 0.4-ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 18 vdc.
- d. allow a half-hour warm-up and then record the differential voltmeter indication.
- e. After eight hours, the differential voltmeter indication should change by less than 39 mvdc from indication recorded in step d.

5-29. CONSTANT CURRENT. Proceed as follows:

- a. Connect test setup shown in figure 5-3.
- b. Turn front-panel VOLTAGE controls fully clockwise (maximum).
- c. Turn front-panel CURRENT controls until the differential voltmeter indicates 45 mvdc.
- d. Allow a half-hour warm-up and then record the differential voltmeter indication.
- e. After eight hours, the differential voltmeter indication should change by less than 0.45 mvdc.

5-30. REMOTE PROGRAMMING

5-31. CONSTANT VOLTAGE. Proceed as follows:

- a. Turn-off power supply and arrange rear terminal strapping pattern for constant voltage remote programming as shown in figure 3-4; use the resistance box (set to 1,000 ohms) for the remote programming resistance. (Refer to para. 3-17 through 3-21.)
- b. Connect the 0.4-ohm load resistor across the output terminals and the differential voltmeter across the -S and +S terminals.
- c. Turn front-panel CURRENT controls fully clockwise (maximum).
- d. Turn-on power supply, allow a half-hour warm-up and then record the differential voltmeter indication.
- e. Increase the remote programming resistance in 200-ohm steps to 1,800 ohms; record the differential voltmeter indication at each step. The voltage indication should increase 1.0 ± 0.01 vdc at each step.

f. Set the remote programming resistance to 2,800 ohms and repeat step e until the remote programming resistance reaches 3,600 ohms.

g. Turn-off power supply and reconnect normal strapping pattern (figure 3-2)

5-32. CONSTANT CURRENT. Proceed as follows:

a. Turn-off power supply and arrange rear terminal strapping pattern for constant current remote resistance programming as shown in figure 3-6: use the resistance box (set to 75 ohms) for the remote programming resistance. (Refer to para. 3-18 and 3-23 through 3-25.)

b. Connect test setup shown in figure 5-3.

c. Turn front-panel VOLTAGE controls fully clockwise (maximum).

d. Turn-on power supply, allow a half-hour warm-up and then record the differential voltmeter indication.

e. Increase the remote programming resistance in 5-ohm steps to 100 ohms; record the differential voltmeter indication at each step. The voltage indication should increase 1.0 ± 0.1 mvdc.

f. Set the remote programming resistance to 200 ohms and repeat step e until the remote programming resistance reaches 225 ohms.

g. Turn-off power supply and reconnect normal strapping pattern (figure 3-2)

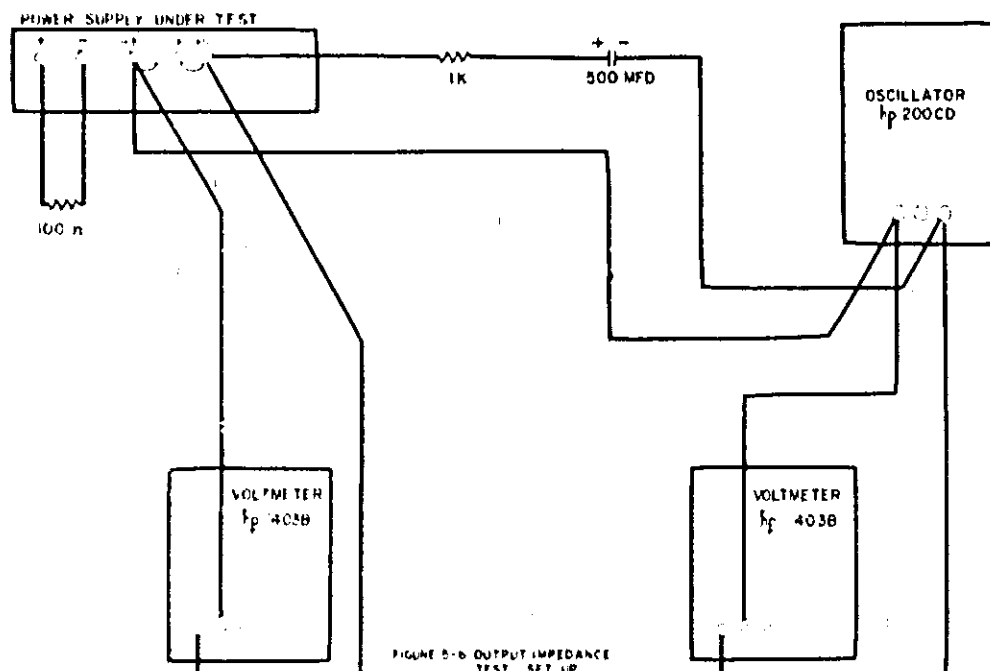


FIGURE 5-6 OUTPUT IMPEDANCE TEST SET UP

5-33. OUTPUT IMPEDANCE

5-34. Proceed as follows:

- a. Connect test setup shown in figure 5-6.
- b. Turn front-panel CURRENT controls fully clockwise (maximum).
- c. Turn front-panel VOLTAGE controls until front-panel voltmeter indicates 9 vdc.
- d. Adjust the oscillator for a 10-vrms (E_{in}), 0.5-cps output.
- e. Calculate and record the output impedance using the following formula:

$$Z_{out} = E_O R / (E_{in} - E_O)$$

$R = 1,000$ ohms; E_O measured across power supply -S and +S terminals using ac voltmeter; E_{in} measured across oscillator output terminals using the ac voltmeter.

f. Using the formula given in step e, calculate and record the output impedance for oscillator frequencies of 100 cps, 1 kc, and 100 kc.

g. The output impedance calculated and recorded in steps e and f should fall into the following ranges:

- (1) dc to 0.5 cps; less than 0.002 ohm
- (2) 0.5 cps to 100 cps; less than 0.2 ohm
- (3) 100 cps to 1 kc; less than 0.1 ohm
- (4) 1 kc to 100 kc; less than 0.6 ohm

5-35. OUTPUT INDUCTANCE

5-36. Proceed as follows:

- a. Repeat steps a through c of para. 5-24.
- b. Adjust the oscillator for a 10-vrms (E_{in}), 10-kc output.
- c. Calculate and record the output inductance using the following formula:

$$L = X_L / 2\pi f$$

X_1 is the output impedance (Z_{out}) calculated in steps e and f of paragraph 5-34; f is the frequency of the oscillator (determines which Z_{out} is used).

NOTE

The equation assumes that $X_1 \gg R_{out}$ and therefore $X_1 = Z_{out}$.

d. Using the formula given in step c, calculate and record the output inductance for oscillator frequencies of 50 kc and 100 kc at 10 vrms.

e. The output inductance calculated in steps c and d should not exceed 1.0 microhenry.

5-37. COVER REMOVAL

5-38. The top and bottom covers are removed by removing both sets of six attaching screws.

5-39. TROUBLESHOOTING

5-40. GENERAL

5-41. If a fault in the power supply is suspected, remove the covers (para. 5-38) and visually inspect for broken connections, burned components, etc. If the fault is not detected visually, proceed to trouble analysis (para. 5-42). If the fault is detected visually or via trouble analysis, correct it and then do the performance check (para. 5-7). If a part is replaced, refer to repair and replacement (para. 5-50) and to adjustments and calibrations (para. 5-51).

5-42. TROUBLE ANALYSIS

5-43. GENERAL. Before attempting trouble analysis, a good understanding of the principles of operation should be acquired by reading Section IV of this manual. Once the principles of operation are understood, logical application of this knowledge in conjunction with significant waveforms (on figure 4-2) and with normal voltage information (table 5-2) should suffice to isolate a fault to a part or small group of parts. As additional aids, the following are given:

a. Procedure for checking the bias and reference circuit. (Refer to para. 5-45.) Trouble in this circuit could show up in many ways because it supplies internal operating voltages for the power supply and the programming currents.

b. Procedures for checking the voltage feedback loop for the two most common troubles; high or low output voltage (para. 5-46 or 5-47, respectively).

c. Paragraph 5-48 which discusses common troubles.

5-44. A defective part should be replaced (refer to the parts list in Section VI). Test points called out in the procedures are identified on the schematic diagram (figure 4-2).

5-45. BIAS AND REFERENCE CIRCUIT. Proceed as follows:

- a. Make an ohmmeter check to be certain that neither the positive nor negative terminal is grounded.
- b. Turn front-panel VOLTAGE and CURRENT controls fully clockwise (maximum).
- c. Turn-on power supply (no load connected).
- d. Using the ac voltmeter, check voltage across secondary winding 5-6 of transformer T2. If voltage indication is not 23 ± 1.5 vrms, transformer T2 may be defective.
- e. Using the differential voltmeter, proceed as instructed in table 5-3.

5-46. HIGH OUTPUT VOLTAGE. Proceed as follows:

- a. Turn front-panel CURRENT controls fully clockwise (maximum).
- b. Turn front-panel VOLTAGE controls to mid-position.
- c. Turn-on power supply (no load connected).
- d. Using the ac voltmeter, check voltage across test points ACC and 45. If voltage indication is less than 1.0 vdc, CR17 or CR18 may be shorted.
- e. Using the differential voltmeter, check voltage across test points 33 and 36. If voltage is not 0.8 ± 0.12 vdc, check T2, CR39 through CR43, R50, and R51.
- f. Using the differential voltmeter, proceed as instructed in table 5-4.

5-47. LOW OUTPUT VOLTAGE. Proceed as follows:

- a. Turn front-panel CURRENT controls fully clockwise (maximum).
- b. Disconnect anode or cathode of diode CR8.
- c. Turn-on power supply (no load connected).
- d. Turn front-panel VOLTAGE controls clockwise and observe the front-panel voltmeter to see if the 18 vdc output can be obtained. If it can, the probable cause of the low output voltage is one or more of the following:

- (1) CR8 shorted.
- (2) Q8 shorted.
- (3) Q9 open.
- (4) Q6 open.
- (5) R40, R43 open.

e. If the 18 vdc output cannot be obtained in step d, reconnect diode CR8 and turn the front-panel VOLTAGE controls to mid-position.

f. Using the oscilloscope, check the following:

(1) Waveform across test points 31 (positive lead) and 33 (waveform on figure 4-2). If peak negative voltage is less than 15 volts, Q7, R53, CR48, C25, C26, or transformer T3 may be defective. It is also possible that thermostat TS1 has opened due to excessive heat.

(2) Ripple waveform across test points 18 (positive lead) and 48 (waveform shown on figure 4-2). If waveform is correct (except for amplitude), proceed to step (3). If waveform is incorrect, proceed as follows:

(a) If the ripple waveform is half-wave (60 cps) instead of full-wave (120 cps), either SCR (CR17 or CR18) may be open or the applicable gate circuit for the SCR may be defective. To check the gate circuit, disconnect R54 or R55 (as applicable) and make an ohmmeter check from the open end of the resistor to test point ACC or 45 (as applicable). If the resistance is greater than 55 ohms, the gate circuit is defective.

(b) If the ripple waveform indicates that neither SCR has fired, CR17 or CR18 may be shorted.

(c) If there is no ripple waveform, both CR17 and CR18 may be open or T1 may be defective.

g. Using the differential voltmeter, proceed as instructed in table 5-5.

5-48. COMMON TROUBLES. Table 5-6 gives the symptoms, checks, and probable causes for common troubles. The checks should be made using a 115-volt, 60-cps, single-phase power input and the test equipment listed in table 5-1.

5-49. REPAIR AND REPLACEMENT

5-50. Before servicing etched circuit boards, refer to figure 5-7. After replacing a semiconductor device, refer to table 5-7 for checks and adjustments that may be necessary. If a check indicates a trouble, refer to paragraph 5-39. If an adjustment is necessary, refer to paragraph 5-51.

SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

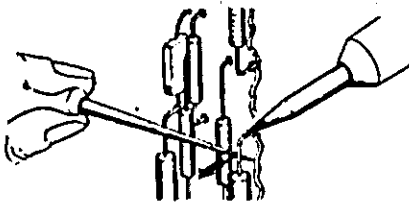
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

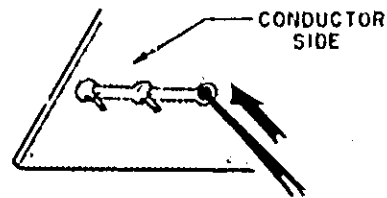
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

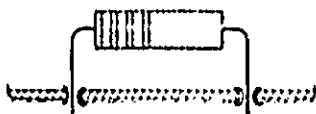
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



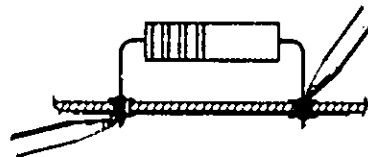
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.

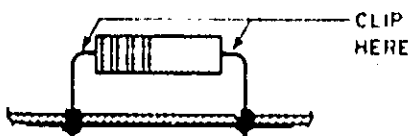


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

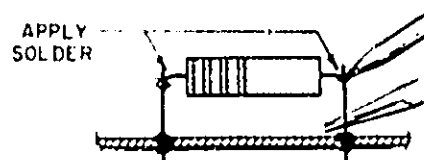


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-7. Servicing Etched Circuit Boards

5-51. ADJUSTMENTS AND CALIBRATIONS

5-52. GENERAL

5-53. Adjustments and calibrations may be required after performance testing (para. 5-7), additional specification testing (para. 5-2.), troubleshooting (para. 5-39), or repair and replacement (para. 5-50). Test points called out in the procedures are identified on the schematic diagram (figure 4-2). If an adjustment or calibration cannot be performed, troubleshooting is required. Table 5-8 summarizes the adjustments and calibrations. The adjustments and calibrations are performed using a 115-volt, 60-cps, single-phase power input to the power supply.

5-54. METER ZERO

5-55. Proceed as follows:

- a. Turn-off power supply and allow 2 minutes for all capacitors to discharge.
- b. Rotate voltmeter zero-set screw (figure 3-1) clockwise until the meter pointer is to the right of zero and moving to the left towards zero. Stop when pointer is on zero. If the pointer overshoots zero, continue rotating clockwise and repeat this step.
- c. When the pointer is exactly on zero, rotate the zero-set screw counter-clockwise approximately 15 degrees to free the screw from the meter suspension. If pointer moves, repeat steps a through c.
- d. Repeat steps a through c for the ammeter.

5-56. VOLTMETER TRACKING

5-57. Proceed as follows:

- a. Connect the differential voltmeter across the -S and +S terminals.
- b. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 18 vdc.
- c. Adjust R25 until the front-panel voltmeter indicates 18 vdc.

5-58. AMMETER TRACKING

5-59. Proceed as follows:

- a. Connect test setup shown in figure 5-3.
- b. Turn front-panel VOLTAGE controls fully clockwise (maximum).

c. Turn front-panel CURRENT controls until the differential voltmeter indicates 44 mvdc.

d. Adjust R27 until the front-panel ammeter indicates 44 amperes.

5-60. CONSTANT VOLTAGE PROGRAMMING CURRENT

5-61. Proceed as follows:

a. Connect a 3,600-ohm, 0.1%, 1/2 w resistor between terminals +S and A6 on the rear terminal strip of the power supply.

b. Disconnect the jumper between terminals A6 and A7.

c. Connect the resistance box in place of R39 (shunt).

d. Connect the differential voltmeter between the +S and -S terminals.

e. Adjust the resistance box until the differential voltmeter indicates 18 ± 0.09 vdc.

f. Choose resistor R39 (shunt) equal to the resistance required in step e.

5-62. ZERO VOLTAGE OUTPUT

5-63. Proceed as follows:

a. Connect a jumper between the +S and A7 terminals on the rear terminal strip of the power supply.

b. Connect the differential voltmeter between the +S and -S terminals.

c. Connect the resistance box in place of R6.

d. Adjust the resistance box so that the voltage indicated by the differential voltmeter is between zero and ± 10 mvdc.

e. Choose resistor R6 equal to the resistance value required in step d.

5-64. CONSTANT CURRENT PROGRAMMING CURRENT

5-65. Proceed as follows:

a. Connect test setup shown in figure 5-3.

b. Connect a 225-ohm, 0.1%, 1/2w resistor between terminals A2 and A3 on the rear terminal strip of the power supply.

c. Disconnect the jumper between terminals A1 and A2.

d. Connect the resistance box in place of R41 (shunt)

e. Adjust the resistance box until the differential voltmeter indicates 45 ± 4.5 mvdc.

f. Choose resistor R41 (shunt) equal to the resistance value required in step e.

5-66. ZERO CURRENT OUTPUT

5-67. Proceed as follows:

a. Connect test setup shown in figure 5-3.

b. Connect a jumper between the A1 and A3 terminals on the rear terminal strip of the power supply.

c. Connect the resistance box in place of R20.

d. Adjust the resistance box until the voltage indicated by the differential voltmeter is between zero and 0.1 mvdc.

e. Choose resistor R20 equal to the resistance value required in step d.

NOTE

If the resistance value required is less than 7,000 ohms or greater than 17,000 ohms, change R46. Replace the original R20.

5-68. BIAS AND REFERENCE LINE REGULATION

5-69. Proceed as follows:

a. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 105 vac.

b. Connect the differential voltmeter between the +S and -S terminals.

c. Connect the resistance box in place of R45.

d. Turn front-panel VOLTAGE controls until the differential voltmeter indicates 18 vdc.

e. Adjust the variable voltage transformer to 125 vac.

f. Adjust the resistance box until the voltage indicated by the differential voltmeter is within 18 mvdc of 18 vdc.

g. Choose resistor R45 equal to the resistance value required in step f.

NOTE

If the resistance value required is less than 20,000 ohms, troubleshooting is required. Replace the original R45.

5-70. LINE IMBALANCE

5-71. Proceed as follows:

a. Connect the 0.4-ohm load resistor across the output terminals.

b. Turn front-panel CURRENT controls fully clockwise (maximum).

c. Connect the variable voltage transformer between the input power source and the power supply power input. Adjust the variable voltage transformer to 125 vac.

d. Turn front-panel VOLTAGE controls until front-panel ammeter indicates 45 amperes.

e. Connect the oscilloscope across test points 18 and 48. Use internal sync.

f. Connect the resistance box in place of R17.

g. Adjust the resistance box until the oscilloscope display is similar to the waveform for test points 18-48 shown on figure 4-2.

h. Choose resistor R17 equal to the resistance value required in step f.

NOTE

If the resistance value required is less than 5,000 ohms, troubleshooting is required. Replace the original R17.

5-72. CONSTANT CURRENT LOAD REGULATION

5-73. Proceed as follows:

- a. Perform steps a through e of para. 5-18.
- b. Place a 10-megohm resistor in place of R44.
- c. Adjust the variable voltage transformer to 125 vac.
- d. Close the shorting switch.

e. Differential voltmeter indication should change by less than 0.45 mvdc. If voltage change is greater than 0.45 mvdc, reduce the 10-megohm resistor to 9 megohms, set the variable voltage transformer to 105 vac, open the shorting switch record the differential voltmeter indication, and repeat steps c and d. Repeat this process, reducing the 10-megohm resistor in 1-megohm steps until the voltmeter change is less than 0.45 mvdc. Changes smaller than 1-megohm may be required to obtain the optimum resistance value for R44. Choose resistor R44 equal to the optimum resistance value required.

NOTE

If the resistance value required is less than 1 megohm, troubleshooting is required. Replace the original R44.

Table 5-2. Normal Voltage

From (+) to (-)	Voltage	Typical Peak-to-Peak Values
-S 51	19.5 ±1.0 vdc	0.05 v
33 27	34.1 ±1.7 vdc	1.0 v
33 -S	6.0 ±0.3 vdc	0.1 v
40 33	33.0 ±1.7 vdc	0.6 v
24 51	10.3 ±0.6 vdc	---
22 51	9.7 ±0.5 vdc	---
21 51	9.7 ±0.5 vdc	---
23 22	7.1 ±0.7 vdc	---
20 21	3.1 ±0.3 vdc	---
39 38	0.81 ±0.1 vdc	---
51 27	6.6 ±2.0 vdc	1.0 v
33 12	6.0 ±0.6 vdc	---
26 27	0.59 ±0.1 vdc	---
-S 25	10.0 ±0.5 vdc	---
18 48	19.5 ±1.0 vdc	1.5 v
14 19	0.83 ±0.1 vdc	---
-S A6	0.04 ±0.1 vdc	---
-S 8	0.45 ±0.07 vdc	---
10 -S	0.06 ±0.1 vdc	---
19 -S	0.82 ±0.1 vdc	---
15 19	1.14 ±0.2 vdc	---
33 16	0.74 ±0.1 vdc	---
52 32	7.0 ±1.1 vdc	---
33 36	0.8 ±0.1 vdc	---
41 42	45.0 ±2.3 vpp	---
28 33	66.0 ±3.3 vpp	---
33 38	14.0 ±1.4 vdc	---

NOTE

These measurements were made with a 115-volt, 60-cps, single-phase power input; the front-panel CURRENT controls fully clockwise (maximum); the front-panel VOLTAGE controls set for 18 vdc output; and the 0.4-ohm load resistor across the output terminals (45 amperes). Differential voltmeter HP 741A was used for all measurements.

Table 5-3. Bias and Reference Circuit Troubleshooting

Step	Meter Common	Meter Positive	Normal Indication	If Indication is not Normal, Check the Following Parts
1	33	40	33 \pm 1.7 vdc	CR31, C21
2	-S	33	6.2 \pm 0.3 vdc	CR6, CR14, VR4
3	27	33	34.1 \pm 1.7 vdc	CR30, C20
4	51	-S	19.5 \pm 1.0 vdc	Q10, Q11
5	51	24	10.3 \pm 0.6 vdc	CR27, VR3
6	51	22	9.7 \pm 0.5 vdc	R40, R43, Q6
7	51	21	9.7 \pm 0.5 vdc	R38, R42, Q5

Table 5-4. High Output Voltage Troubleshooting

Step	Meter Common	Meter Positive	Response	Probable Cause
1	Emitter of Q4	29	<0.5 vdc	a. Q4 shorted b. R16 shorted c. R15 shorted
2	14	17	>0.85 vdc	CR7 open
3	14	33	<2 vdc	a. Q1 open b. Q2 shorted c. CR1 shorted d. R2-R8 open

Table 5-5. Low Output Voltage Troubleshooting

Step	Meter Common	Meter Positive	Response	Probable Cause
1	Emitter of Q4	29	>5 vdc	a. Q4 open b. R16 open c. R15 open
2	14	17	<0.4 vdc	CR7 shorted
3	14	33	>6 vdc	a. Q1 shorted b. Q2 open c. R2-R8 shorted

Table 5-6. Common Troubles

Symptom	Checks and Probable Causes
Circuit breaker CB1 trips when power supply is turned on.	Power supply has internal short. Disconnect Collector of Q7, turn-on power supply and check voltages (refer to table 5-2 or figure 4-2). If CB1 trips with Q7 disconnected, check CR17, CR18, and T3.
Poor line regulation (constant voltage)	<ul style="list-style-type: none"> a. Check bias and reference circuit (para. 5-45). Refer to paragraph 5-69 for adjustment. b. Check line input to SCR regulator control circuit (T2, CR39 through CR43, R50, R51).
Poor load regulation (constant voltage)	<ul style="list-style-type: none"> a. Check bias and reference circuit (para. 5-45). b. Power supply going into current limit. Check constant current input circuit. c. Constant voltage loop oscillates. Check adjustment of R17 (para. 5-71).
Poor line and load regulation (constant current)	<ul style="list-style-type: none"> a. Check bias and reference circuit (para. 5-45). Refer to paragraph 5-69 for adjustment. b. Power supply going into voltage limit. Check constant voltage input circuit. c. Constant current loop oscillates. Check adjustment of R44 (para. 5-73).
High ripple	<ul style="list-style-type: none"> a. Check operating setup for ground loops. b. If output is floating (ungrounded) connect 1-μf capacitor between output and ground (unless particular application prohibits this). c. Check pi-section output filter C13 through C17 and L1. d. Line imbalance. Check adjustment of R17 (para. 5-70).
Poor stability (constant voltage)	<ul style="list-style-type: none"> a. Check bias and reference circuit line regulation. (Refer to para. 5-69). b. Noisy programming resistors (R2-R8). c. CR1 or CR2 leaky. d. R1, R5, R40, R41, or R43 noisy or drifting. e. Q1 or Q2 defective.
Poor stability (constant current)	<ul style="list-style-type: none"> a. Check bias and reference circuit line regulation. (Refer to para. 5-69). b. Noisy programming resistors (R9-R10). c. R20, R23, R38, R39, or R42 noisy or drifting. d. Q8 defective.

Table 5-6. Common Troubles (cont.)

Symptom	Checks and Probable Causes
Oscillates (constant voltage)	Check R18, C1, C4, and adjustment of R17 (para. 5-71).
Oscillates (constant current)	Check C6, C24, R22, and adjustment of R20 (para. 5-66) and adjustment of R44 (para. 5-72).
Output voltage does not go to zero.	Check R6 and R47. (Refer to para. 5-63.)
Output current does not go to zero.	Check R20 and R46. (Refer to para. 5-67.)

Table 5-7. Checks and Adjustments after Replacement of Semiconductor Devices

Circuit Reference	Function	Check	Adjust
Q1, Q2	Constant voltage differential amplifier	Constant voltage line and load regulation; transient recovery time; zero voltage output	R6, R17
Q3	Turn-on circuit	Excessive transients at turn-on	-----
Q4	Gating Circuit	Constant voltage/constant current line and load regulation	-----
Q5	Constant voltage programming current regulator	Constant voltage programming coefficient	R38-R39
Q6	Constant Current programming current regulator	Constant current programming coefficient	R40-R41
Q7	SCR regulator control	Waveforms (shown in figure 4-2)	R51
Q8, Q9	Constant current differential amplifier	Constant current line and load regulation; zero current output	R20, R44
Q10	Bias and reference error detector/amplifier	Bias and reference circuit line regulation	R45
Q11	Bias and reference series regulator	Bias and reference circuit line regulation	R45
CR1, CR2, CR28	Constant voltage protection	Constant voltage load regulation	-----
CR6, CR9, CR10, CR11, CR12, CR14, CR27, CR46	Forward bias regulators	Voltage across each diode (0.6 to 0.85 vdc)	-----

Table 5-7. Checks and Adjustments after Replacement of Semiconductor Devices
(cont.)

Circuit Reference	Function	Check	Adjust
CR17, CR18	SCR regulator	Constant voltage load regulation	-----
CR19, CR20 CR21, CR22	Bridge rectifier	Voltage across bridge at full output (18 vdc)	-----
CR23	Output Protection	Output voltage	-----
CR26	Constant current protection	Constant current line and load regulation	-----
CR30, CR31	Full-wave rectifier	Rectifier output (67 vdc)	-----
CR39, CR40 CR41, CR42 CR43	Bridge rectifier	Voltage across bridge (20-25 peak, full wave)	-----
CR5, CR7, CR8, CR44, CR45, CR47, C 18, CR49, CR50, CR51,	Diode switches	-----	-----
VR1	Constant voltage programming protection	Full output voltage and zero output voltage obtainable via VOLTAGE controls; voltage regulation at 18 vdc output	-----
VR3	Voltage reference	Bias and reference circuit line regulation	R45
VR4	Voltage reference	6.0 vdc line regulation	-----

Table 5-8. Adjustment and Calibration Summary

Adjustment or Calibration	Paragraph Reference	Control Device
Meter Zero	5-55	Meter Spring
Voltmeter Tracking	5-57	R25
Ammeter Tracking	5-59	R27
Constant Voltage Programming Current	5-61	R39
Zero Voltage Output	5-63	R6
Constant Current Programming Current	5-65	R41
Zero Current Output	5-67	R20
Bias and Reference Line Regulation	5-69	R45
Line Imbalance	5-71	R17
Constant Current Load Regulation	5-73	R44

PARTS LIST

SECTION VI REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alpha-numeric order by reference designators and provides the following information:

- a. Reference Designators. Refer to Table 6-1.
- b. Description. Refer to Table 6-2 for abbreviations.
- c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.
- d. Manufacturer's Part Number or Type.
- e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.
- f. Hewlett-Packard Part Number.
- g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.
- h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor	VR	= zener diode
R	= resistor	X	= socket
S	= switch	Z	= integrated circuit or network
T	= transformer		
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
cd	= card	NP	= nickel-plated
coef	= coefficient	Ω	= ohm
comp	= composition	obd	= order by description
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
DPST	= double pole, single throw	p-p	= peak-to-peak
elect	= electrolytic	ppm	= parts per million
encap	= encapsulated	pvr	= peak reverse voltage
F	= farad	rect	= rectifier
°F	= degree Fahrenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry	SPST	= single pole, single throw
Hz	= Hertz	SS	= small signal
IC	= integrated circuit	T	= slow-blow
ID	= inside diameter	tan.	= tantalum
incnd	= incandescent	Ti	= titanium
k	= kilo = 10^3	V	= volt
m	= milli = 10^{-3}	var	= variable
M	= mega = 10^6	ww	= wirewound
μ	= micro = 10^{-6}	W	= Watt
met.	= metal		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS	CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N. Y.	07138	Westinghouse Electric Corp.	
00656	Aerovox Corp.	New Bedford, Mass.		Electronic Tube Div.	Elmira, N. Y.
00853	Sangamo Electric Co.		07263	Fairchild Camera and Instrument Corp.	Semiconductor Div.
	S. Carolina Div.	Pickens, S. C.			Mountain View, Calif.
01121	Allen-Bradley Co.	Milwaukee, Wis.	07387	Bircher Corp., The	Los Angeles, Calif.
01255	Litton Industries, Inc.	Beverly Hills, Calif.	07397	Sylvania Electric Prod., Inc.	
				Sylvania Electronic Systems	
01281	TRW Semiconductors, Inc.	Lawndale, Calif.		Western Div.	Mountain View, Calif.
01295	Texas Instruments, Inc.		07716	IRC Div. of TRW Inc.	Burlington Plant
	Semiconductor-Components Div.				Burlington, Iowa
		Dallas, Texas	07910	Continental Device Corp.	
01686	RCL Electronics, Inc.	Manchester, N. H.			Hawthorne, Calif.
01930	Amerock Corp.	Rockford, Ill.	07933	Raytheon Co. Components Div.	
02107	Sparta Mfg. Co.	Dover, Ohio		Semiconductor Operation	
02114	Ferroxcube Corp.	Saugerties, N. Y.			Mountain View, Calif.
02606	Fenwal Laboratories	Morton Grove, Ill.	08484	Breeze Corporations, Inc.	Union, N. J.
02660	Amphenol Corp.	Broadview, Ill.	08530	Reliance Mica Corp.	Brooklyn, N. Y.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N. J.	08717	Sloan Company, The	Sun Valley, Calif.
03508	G. E. Semiconductor Products Dept.	Syracuse, N. Y.	08730	Vemaline Products Co., Inc.	Wyckoff, N. J.
03797	Eldema Corp.	Compton, Calif.	08806	General Elect. Co.	Miniature Lamp Dept.
03877	Transitron Electronic Corp.	Wakefield, Mass.			Cleveland, Ohio
			08863	Nylomatic Corp.	Norrisville, Pa.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N. J.	08919	RCH Supply Co.	Vernon, Calif.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.	09021	Airco Speer Electronic Components	
04072	ADC Electronics, Inc.	Harbor City, Calif.			Bradford, Pa.
04213	Caddell & Burns Mfg. Co., Inc.	Mineola, N. Y.	09182	*Hewlett-Packard Co.	New Jersey Div.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.			Berkeley Heights, N. J.
04713	Motorola Semiconductor Prod., Inc.	Phoenix, Arizona	09213	General Elect. Co.	Semiconductor Prod. Dept.
05277	Westinghouse Electric Corp.				Buffalo, N. Y.
	Semiconductor Dept.	Youngwood, Pa.	09214	General Elect. Co.	Semiconductor Prod. Dept.
05347	Ultronix, Inc.	Grand Junction, Colo.			Auburn, N. Y.
05820	Wakefield Engr. Inc.	Wakefield, Mass.	09353	C & K Components Inc.	Newton, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S. C.	09922	Burndy Corp.	Norwalk, Conn.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.	11115	Wagner Electric Corp.	
06486	IRC Div. of TRW Inc.			Tung-Sol Div.	Bloomfield, N. J.
	Semiconductor Plant	Lynn, Mass.	11236	CTS of Berne, Inc.	Berne, Ind.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N. Y.	11237	Chicago Telephone of Cal., Inc.	
06555	Beede Electrical Instrument Co.	Penacook, N. H.			So. Pasadena, Calif.
06666	General Devices Co., Inc.	Indianapolis, Ind.	11502	IRC Div. of TRW Inc.	Boone Plant
06751	Semcor Div. Components, Inc.	Phoenix, Arizona			Boone, N. C.
06776	Robinson Nugent, Inc.	New Albany, Ind.	11711	General Instrument Corp	
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.		Rectifier Div.	Newark, N. J.
07137	Transister Electronics Corp.	Minneapolis, Minn.	12136	Philadelphia Handle Co., Inc.	
					Camden, N. J.
			12615	U. S. Terminals, Inc.	Cincinnati, Ohio
			12617	Hamlin Inc.	Lake Mills, Wisconsin
			12697	Claroostat Mfg. Co., Inc.	Dover, N. H.
			13103	Thermalloy Co.	Dallas, Texas
			14493	*Hewlett-Packard Co.	Loveland Div.
					Loveland, Colo.
			14655	Cornell-Dubilier Electronics Div.	
				Federal Pacific Electric Co.	Newark, N. J.
			14936	General Instrument Corp.	Semiconductor Prod. Group
					Hicksville, N. Y.
			15801	Fenwal Elect.	Framingham, Mass.
			16299	Corning Glass Works, Electronic Components Div.	Raleigh, N. C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atiantic Semiconductors, Inc.	Asbury Park, N. J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div, Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N. J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N. J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N. Y.
24455	General Electric Co. Lamp Div. of Con- sumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV ElectroSystems Inc Memcor/Com- ponents Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc. Saugerties, N. Y.	Saugerties, N. Y.
27014	National Semiconductor Corp.	Santa Clara, Calif
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N. J.
28875	IMC Magnetics Corp.	New Hampshire Div. Rochester, N. H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G. E. Co. Tube Dept.	Owensboro, Ky.
35434	Leetrohm, Inc.	Chicago, Ill.
37942	P. R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div.	General Motors Corp. Sandusky, Ohio
44655	Ohmite Manufacturing C	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55025	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntro Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N. Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N. Y.

CODE NO.	MANUFACTURER	ADDRESS
70563	Amperite Co. Inc.	Union City, N. J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I. T. I. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R. I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N. Y.
72699	General Instrument Corp.	Newark, N. J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N. J.
72982	Erie Technological Products Inc.	Eric, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N. Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N. J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N. Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N. Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N. J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J. W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS	CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.	83508	Grant Pulley and Hardware Co.	West Nyack, N. Y.
76854	Oak Mfg. Co. Div. of Oak		83594	Burroughs Corp. Electronic Components Div.	Plainfield, N. J.
77068	Electro/Netics Corp.	Crystal Lake, Ill.	83835	U. S. Radiant Corp.	Morristown, N. J.
	Bendix Corp., Electrodynamics Div.		83877	Yardeny Laboratories, Inc.	New York, N. Y.
		No. Hollywood, Calif.	84171	Arco Electronics, Inc.	Great Neck, N. Y.
77122	Palnut Co.	Mountainside, N. J.	84411	TRW Capacitor Div.	Ogallala, Neb.
77147	Patton-MacGuyver Co.	Providence, R. I.	86664	RCA Corp. Electronic Components	Harrison, N. J.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.	86838	Rummel Fibre Co.	Newark, N. J.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.	87034	Marco & Oak Industries a Div. of Oak	Anaheim, Calif.
77342	American Machine and Foundry Co.		87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
	Potter and Brumfield Div.	Princeton, Ind.	87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
77630	TRW Electronic Components Div.	Camden, N. J.	87929	Tower-Olschan Corp.	Bridgeport, Conn.
77764	Resistance Products Co.	Harrisburg, Pa.	88140	Cutler-Hammer Inc. Power Distribution and Control Div.	Lincoln Plant Lincoln, Ill.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.	88245	Litton Precision Products Inc. USECO	Van Nuys, Calif.
		Chicago, Ill.	90634	Gulton Industries Inc.	Metuchen, N. J.
78452	Everlock Chicago, Inc.	Chicago, Ill.	90763	United-Car Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.	91345	Miller Dial and Nameplate Co.	El Monte, Calif.
78526	Stanwyck Winding Div. San Fernando		91418	Radio Materials Co.	Chicago, Ill.
	Electric Mfg. Co. Inc.	Newburgh, N. Y.	91506	Augat, Inc.	Attleboro, Mass.
78553	Thinnerman Products, Inc.	Cleveland, Ohio	91637	Dale Electronics, Inc.	Columbus, Neb.
78584	Stewart Stamping Corp.	Yonkers, N. Y.	91662	Elco Corp.	Willow Grove, Pa.
79136	Waldes Kohinoor, Inc.	L. I. C., N. Y.	91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
79307	Whitehead Metals Inc.	New York, N. Y.	92825	Whitso, Inc.	Schiller Pk., Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.	93332	Sylvania Electric Prod. Inc. Semi-conductor Prod. Div.	Woburn, Mass.
79963	Zierick Mfg. Co.	Mt. Kisco, N. Y.	93410	Essex Wire Corp. Stomco	Mansfield, Ohio
80031	Mepco Div. of Sessions Clock Co.	Morristown, N. J.	93144	Raytheon Co. Components Div.	Quincy, Mass.
80294	Bourns, Inc.	Riverside, Calif.	94154	Wagner Electric Corp.	Livingston, N. J.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.	94222	Southco Inc.	Lester, Pa.
		La Grange, Ill.	95263	Leecraft Mfg. Co. Inc.	L. I. C., N. Y.
81073	Grayhill, Inc.	La Grange, Ill.	95354	Methode Mfg. Co.	Rolling Meadows, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.	95712	Bendix Corp. Microwave	Franklin, Ind.
		El Segundo, Calif.	95987	Wechsner Co. Inc.	Chicago, Ill.
81751	Columbus Electronics Corp.	Yonkers, N. Y.	96791	Amphenol Corp. Amphenol	Janesville, Wis.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N. Y.	97464	Industrial Retaining Ring Co.	Irvington, N. J.
82142	Airco Speer Electronic Components	Du Bois, Pa.	97702	IMC Magnetics Corp. Eastern Div.	Westbury, N. Y.
82219	Sylvania Electric Products Inc.		98291	Seaelectro Corp.	Mamaroneck, N. Y.
	Electronic Tube Div. Receiving		98416	ETC Inc.	Cleveland, Ohio
	Tube Operations	Emporium, Pa.	98978	International Electronic Research Corp.	Burbank, Calif.
82389	Switchcraft, Inc.	Chicago, Ill.	99934	Renbrandt, Inc.	Boston, Mass.
82647	Metals and Controls Inc. Control				
	Products Group	Attleboro, Mass.			
82866	Research Products Corp.	Madison, Wis.			
82877	Rotron Inc.	Woodstock, N. Y.			
82893	Vector Electronic Co.	Glendale, Calif.			
83058	Carr Fastener Co.	Cambridge, Mass.			
83186	Victory Engineering Corp.	Springfield, N. J.			
83298	Bendix Corp. Electric Power Div.	Eatontown, N. J.			
		Brooklyn, N. Y.			
83330	Herman H. Smith, Inc.	Brooklyn, N. Y.			
83385	Central Screw Co.	Chicago, Ill.			
83501	Gavitt Wire and Cable Div. of				
	Amerace Esna Corp.	Brookfield, Mass.			

Table 6-4. Replaceable Parts

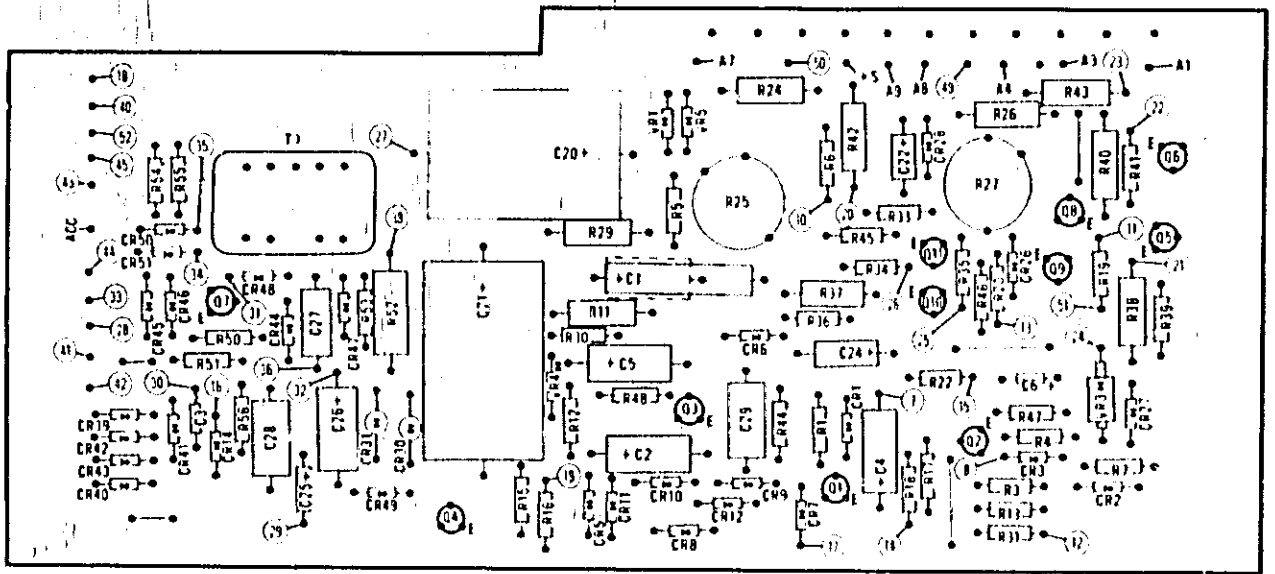
REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	PART NO.	RS
B1	Fan Motor, Shaded Pole	1		09182	3140-0010	1
C1	fxd, elect 5 μ f 65Vdc	3	D33689	09182	0180-1836	1
C2	fxd, elect 100 μ f 6Vdc	1	30D107G006DB4	56289	0180-1734	1
C3	fxd, film .0022 μ f 200Vdc	1	192P22292	56289	0160-0154	1
C4-6	fxd, elect 5 μ f 65Vdc		D33689	09182	0180-1836	
C7,18,19,23	NOT ASSIGNED	-	-	-	-	-
C8	fxd, film .01 μ f 200Vdc	1	192P10392	56289	0160-0161	1
C9,10	fxd, paper .047 μ f 600Vdc	4	160P47396	56289	0160-0005	1
C11	fxd, paper .47 μ f 600Vdc	1	161P47406	56289	0160-2464	1
C12	fxd, paper 0, 1 μ f 400Vdc	1	160P10494	56289	0160-0013	1
C13-17	fxd, elect 71000 μ f 25Vdc	5	36D713G025DF6B	56289	0180-1843	1
C20,21	fxd, elect 300 μ f 40Vdc	2	34D307C40GJ4	56289	0180-1805	1
C22	fxd, elect 1 μ f 35Vdc	2	150D105X9036A2	56289	0180-0291	1
C24	fxd, elect 10 μ f 25Vdc	1	30D106G025BB2	56289	0180-0059	1
C25	fxd, elect 1 μ f 35Vdc		150D105X9036A2	56289	0180-0291	
C26,27	fxd, film .082 μ f 200Vdc	2	192P82392	56289	0160-0167	1
C28	fxd, film .22 μ f 80Vdc	1	192P2249R8	56289	0160-2453	1
C29	NOT USED	-	-	-	-	-
CB1	Circuit Breaker 20 Amp 250Vac Max	1	AM33 Curve 4 obd	74193	2110-0212	1
CR1	Diode, si. 200PRV 250mW	15	1N485B	93332	1901-0033	7
CR2-4,13,15, 16,24,25, 29,32-38	NOT ASSIGNED	-	-	-	-	-
CR5	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR6	Rect. si. 200mA 15PRV	11	1N4828	03508	1901-0461	7
CR7,8	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR9,10	Rect. si. 200mA 15PRV		1N4828	03508	1901-0461	
CR11	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR12	Rect. si. 200mA 15PRV		1N4828	03508	1901-0461	
CR14	Rect. si. 200mA 15PRV		1N4828	03508	1901-0461	
CR17,18	SCR 25A 200PRV	2	C30B obd	03508	1884-0017	2
CR19,20	Rect. si. 40A 50PRV	2	1N1183A	16758	1901-0315	2
CR21,22	Rect. si. 40A 50PRV	2	1N1183AR	16758	1901-0316	2
CR23	Rect. si. 20A 100PRV	1	A41A	03508	1901-0324	1
CR26	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR27	Rect. si. 200mA 15PRV		1N4828	03508	1901-0461	
CR28	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR30,31	Rect. si. 500mA 200PRV	2	1N3253	02735	1901-0389	2
CR39-45	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR46,47	Rect. si. 200mA 15PRV		1N4828	03508	1901-0461	
CR4	Diode, si. 200PRV 250mW		1N485B	93332	1901-0033	
CR49-51	Rect. si. 200mA 15PRV		1N4828	03508	1901-0461	
DS1	Indicator Light, Neon	1	599-124	72765	1450-0048	1
L1	Choke, Filter	1		09182	9100-1872	1
L2	Inductor, Filter	1		09182	9100-2169	1
M1	Voltmeter Assy., 3 $\frac{1}{2}$ ", 0-24 Volts	1		09182	1120-1171	1
M2	Ammeter Assy., 3 $\frac{1}{2}$ ", 0-50 Amps	1		09182	1120-1180	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
Q1-4	SS NPN si.	7	2N3391	03508	1854-0371	6
Q5	SS NPN S. C.	1	2N3390	03508	1854-0202	1
Q6	SS NPN si.		2N3391	03508	1854-0371	
Q7	SS NPN si.	2	2N3417	03508	1854-0087	2
Q8	SS NPN si.		2N3391	03508	1854-0371	
Q9	SS NPN si.		2N3391	03508	1854-0371	
Q10	SS PNP si.	1	MPS 6517 obd	04713	1853-0065	1
Q11	SS NPN si.		2N3417	03508	1854-0087	
R1	fxd, met, film 20K Ω \pm 1% 1/8W	2	Type CEA T-O obd	07716	0757-0449	1
R2	var, ww 4.5K Ω \pm 5%	1		09182	2100-1852	1
R3	fxd, met, film 43K Ω \pm 1% 1/8W	2	Type CEA T-O obd	07716	0698-5090	1
R4	fxd, met, film 100K Ω \pm 1% 1/8W	2	Type CEA T-O obd	07716	0757-0465	1
R5	fxd, met, film 12K Ω \pm 1% 1/8W	2	Type CEA T-O obd	07716	0698-5088	1
R6	fxd, met, film 3K Ω \pm 1% 1/8W	3	Type CEA T-O obd	07716	0757-1093	1
R7	fxd, comp 22 Ω \pm 5% 1/2W	1		01121	0686-2205	1
R8	var, ww 200 Ω \pm 5%	1		09182	2100-1856	1
R9	var, ww 10 Ω \pm 5%	1		09182	2100-1857	1
R10	var, ww 300 Ω \pm 5%	1		09182	2100-1848	1
R11	fxd, comp 3K Ω \pm 5% 1W	1	GB-3025	01121	0689-3025	1
R12	fxd, comp 680K Ω \pm 5% 1/2W	2	EB-6845	01121	0686-6845	1
R13	fxd, met, film 43K Ω \pm 1% 1/8W		Type CEA T-O obd	07716	0698-5090	
R14,32,49,57	NOT ASSIGNED	-	-	-	-	-
R15	fxd, comp 680K Ω \pm 5% 1/2W		EB-6845	01121	0686-6845	
R16	fxd, comp 1K Ω \pm 5% 1/2W	2	EB-1025	01121	0686-1025	1
R17	fxd, comp SELECTED \pm 5% 1/2W	4	Type EB obd	01121		
R18	fxd, comp 10K Ω \pm 5% 1/2W	3	EB-1035	01121	0686-1035	1
R19	fxd, met, film 100K Ω \pm 1% 1/8W		Type CEA T-O obd	07716	0757-0465	
R20	fxd, met, film 12K Ω \pm 1% 1/8W		Type CEA T-O obd	07716	0698-5088	
R21	fxd, ww 10 Ω \pm 5% 1W	1	GB-1005	01121	0689-1005	1
R22	fxd, comp 20K Ω \pm 5% 1/2W	1		01121	0686-2035	1
R23	fxd, ww .01 Ω Special 20ppm	1		09182	5080-7106	1
R24	fxd, met, film 20K Ω \pm 1% 1/8W		Type CEA T-O obd	07716	0757-0449	
R25	var, ww 5K Ω (Modify)	1	Type 110-F4 obd	11236	2100-1824	1
R26	fxd, met, film 365 Ω \pm 1% 1/2W	1	Type CEB T-O obd	07716	0757-0723	1
R27	var, ww 250 Ω (Modify)	1	Type 110-F4 obd	11236	2100-0439	1
R28	fxd, ww 40 Ω \pm 5% 40W	1	40S/817 MTC obd	63743	0811-1965	1
R29	fxd, ww 1 Ω \pm 5%	1	Type BWH obd	07716	0811-1666	1
R30	fxd, comp 3K Ω \pm 5% 1/2W	2	EB-3025	01121	0686-3025	1
R31	fxd, comp 33K Ω \pm 5% 1/2W	2	EB-3335	01121	0686-3335	1
R33	fxd, comp 1K Ω \pm 5% 1/2W		EB-1025	01121	0686-1025	
R34	fxd, comp 10K Ω \pm 5% 1/2W		EB-1035	01121	0686-1035	
R35,36	fxd, met, film 3K Ω \pm 1% 1/8W		Type CEA T-O obd	07716	0757-1093	
R37	fxd, met, film 1K Ω \pm 1% 1/2W	2	Type CEB T-O obd	07716	0757-0338	1
R38	fxd, met, film 2K Ω \pm 1% 1/2W	1	Type CEB T-O obd	07716	0757-0739	1
R39	fxd, comp SELECTED \pm 5% 1/2W		Type EB obd	01121		
R40	fxd, met, film 6.2K Ω \pm 1% 1/2W	1	Type CEB T-O obd	07716	0698-5149	1
R41	fxd, comp SELECTED \pm 5% 1/2W		Type EB obd	01121		
R42	fxd, met, film 1.33K Ω \pm 1% 1/2W	1	Type CEB T-O obd	07716	0698-3134	1
R43	fxd, met, film 1K Ω \pm 1% 1/2W		Type CEB T-O obd	07716	0757-0338	
R44	fxd, comp SELECTED \pm 5% 1/2W		Type EB obd	01121		
R45	fxd, comp 51K Ω \pm 5% 1/2W	1	EB-5135	01121	0686-5135	1
R46	fxd, comp 15M Ω \pm 5% 1/2W	1	EB-1565	01121	0686-1565	1
R47	fxd, comp 1M Ω \pm 5% 1/2W	1	EB-1055	01121	0686-1055	1
R48	fxd, comp 43K Ω \pm 5% 1/2W	1	EB-4335	01121	0686-4335	1
R50	fxd, comp 3K Ω \pm 5% 1/2W		EB-3025	01121	0686-3025	

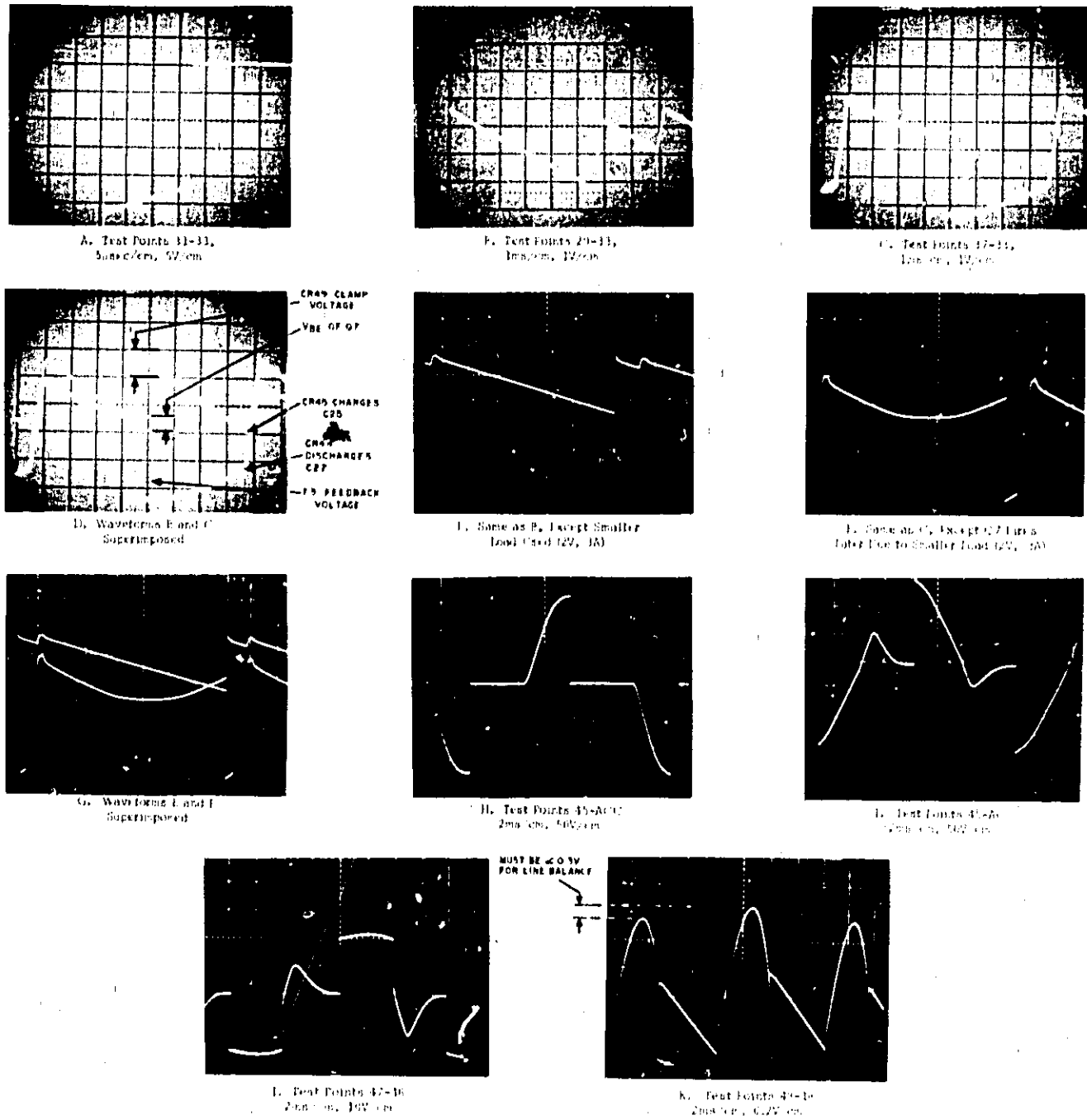
6428B

6-6

REF. DESIG.	DESCRIPTION	QTY	MFR. PART NO.	MFR. CODE	f _p PART NO.	RS.
R51	fxd, comp 180 Ω \pm 5% $\frac{1}{2}$ W	1	EB-1815	01121	0686-1815	1
R52	fxd, met. ox 3K Ω \pm 5% 2W	1	Type C42S cbd	16299	0698-3642	1
R53	fxd, comp 10K Ω \pm 5% $\frac{1}{2}$ W	1	EB-1035	01121	0686-1035	1
R54,55	fxd, comp 47 Ω \pm 5% $\frac{1}{2}$ W	2	EB-4705	01121	0686-4705	1
R56	fxd, comp 39 Ω \pm 5% $\frac{1}{2}$ W	1	EB-3905	01121	0686-3905	1
R58	fxd, comp 33K Ω \pm 5% $\frac{1}{2}$ W	1	EB-3335	01121	0686-3335	1
T1	Power Transformer	1		09182	9100-1871	1
T2	Bias Transformer	1		09182	9100-1876	1
T3	Pulse Transformer	1		09182	9100-1875	1
TS1	Thermal Switch	1		09182	0440-0042	1
VR1	Zener 23.7V \pm 5% 400mW	1	1N970	04713	1902-3256	1
VR2	NOT ASSIGNED	-	-	-	-	-
VR3	Zener 9.4V \pm 5% 500mW	1	1N2163A	06751	1902-0763	1
VR4	Zener 4.22V \pm 5% 400mW	1	1N749	04713	1902-3070	1
VR5	STRAP	1				
MISCELLANEOUS PARTS						
	Chassis, Main, Welded Assy.	1		09182	5060-6114	
	Chassis, Rear, Welded Assy.	1		09182	06428-60001	
	Cover, Top and Bottom	2		09182	5000-6009	
	Front Panel Assy.	1		09182	06428-60002	
	Rubber Bumper, Chassis Connection	4	3066	87585	0403-0085	
	P. C. Board (Includes Components)	1		09182	06428-60020	
	P. C. Board (Blank)	1		09182	5020-5521	
	Bracket, P. C. Board	1		09182	5000-6012	
	Bracket, P. C. Board	1		09182	5000-6014	
	Clamp (C13-C17)	4		09182	5000-6017	
	Bracket, LI	2		09182	06428-00002	
	Buss Bar, C13-C16	2		09182	06428-00003	
	Heat Sink, SCR's CR17, CR18	1		09182	5020-5501	
	Insulator Wafer, SCR's	1	H4021	61637	0340-0175	
	Heat Sink, CR19-CR22	2		09182	5020-5502	
	Handle, Carrying, 5 $\frac{1}{4}$ "	2		09182	5020-5512	
	Barrier Strip, AC Input	1		09182	0360-1213	
	Barrier Strip, P. C. Board	1		09182	0360-1238	
	Barrier Strip, Output Terminals	1		09182	0360-1220	
	Cover, AC Input Barrier Strip	1		09182	5020-5513	
	Cover, Output Term. Barrier Strip	1		09182	06428-20001	
	Jumper, Output Barrier Strip	2	602J	75382	0360-1280	1
	Jumper, P. C. B. Barrier Strip	5	422-13-11-013	71785	0360-1143	1
	Bezel, Meter, $\frac{1}{4}$ MOD	2		09182	4040-0296	1
	Spring, Meter	8		09182	1460-0256	2
	Fastener, DSI	1	C17373-012-24B	78553	0510-0123	
	Binding Post, Maroon, Front Panel	1	DF21Mn	09182	1510-0040	1
	Binding Post, Black, Front Panel	2	DF21BC	58474	1510-0039	1
	Rubber Bumpers, Rear Chassis	4	Type 2097W	87585	0403-0089	1
	Knob, Voltage and Current	4		09182	0370-0034	1
	Fan Housing, B1	1		09182	5243A-20A	1
	Fan Blade, B1	1		09182	3160-0034	1
	Insulator, SCR and Rect. Heat Sinks	8		09182	0340-0172	2
	Standoff, Insulator, C12-R21 Tiepoint	1	17A1-Ae	92825		



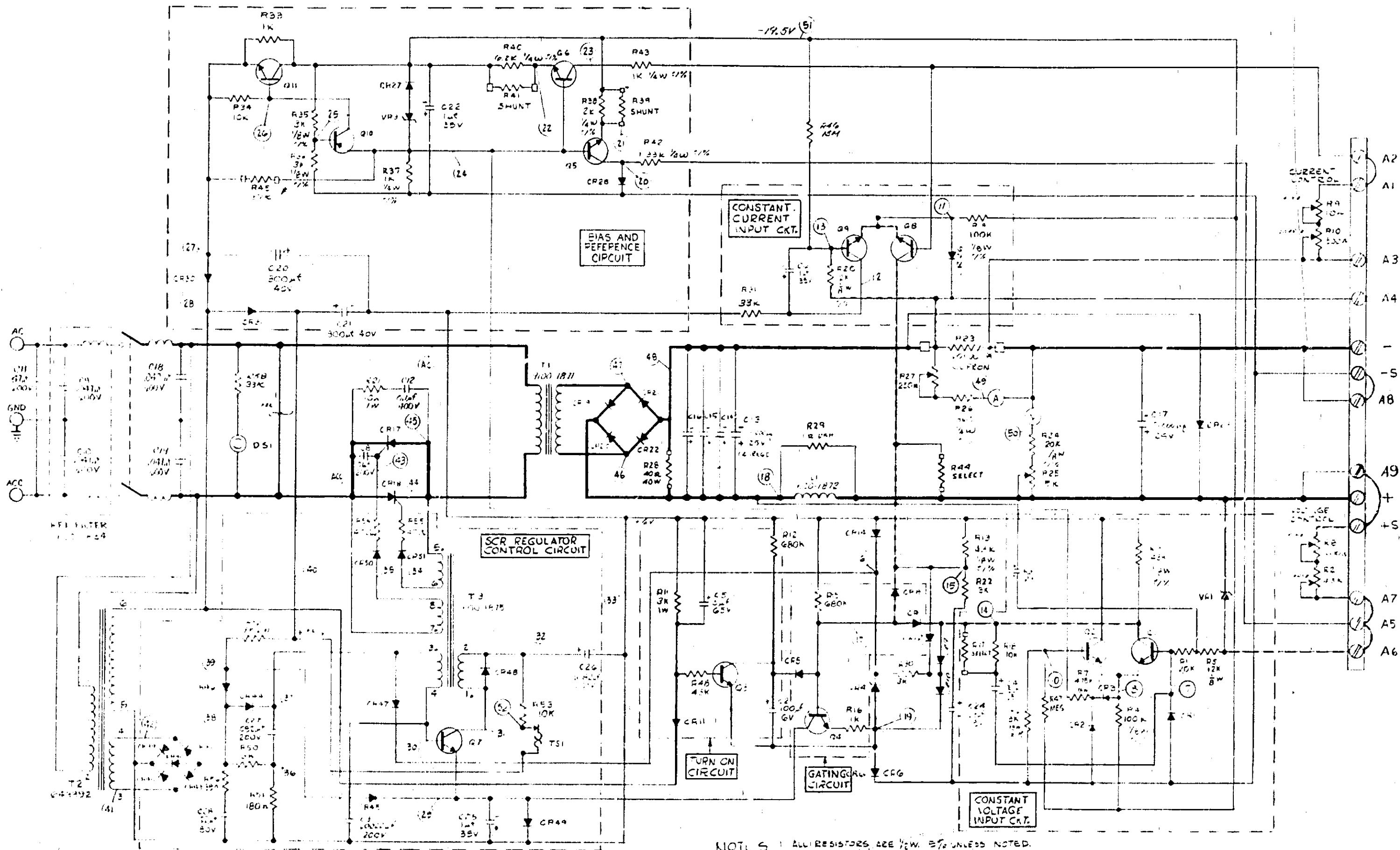
Model 6128a Component Location Diagram



All waveforms were taken with 115 Volt, 60Hz, single-phase input and 18Vdc, 45 Ampere load (except E and F as indicated). Waveforms H and I require the oscilloscope to be ungrounded. If it is not desirable to unground the oscilloscope, use a 2-kva isolation transformer between the input power source and the power supply power input.

WARNING

If the oscilloscope is ungrounded, injury can occur if personnel touch the oscilloscope case and other equipment simultaneously.



PATENT APPLIED FOR ON THIS CIRCUIT. LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HARRISON LABORATORIES, DIV. OF HEWLETT PACKARD

- NOTES
- 1 ALL RESISTORS ARE 1/2W, 5% UNLESS NOTED.
 - 2 # DENOTES 20 PPM WIRE TEMP COEFF.
 - 3 REAR TERMINALS SHOWN IN NORMAL STEPPING.
 - 4 INPUT VOLTAGES MEASURED AT 100V NO LOAD.
 - 5 --- DENOTES VOLTAGE SIGNAL.
 - 6 - - - DENOTES CURRENT SIGNAL.

MANUAL CHANGES

MANUAL CHANGES

Model 6428B DC Power Supply
Manual HP Part No. 06428-90001

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
ALL	-	Errata
6F	0151 - 0350	1
6F	0351 - 1102	1, 2
9E	1103 - 1252	1, 2, 3
9E	1253 - 1282	1, 2, 3, 4
9E	1283 - 1312	1 through 5
0H	1313 - 1379	1 through 6
0H	1380 - 1504	1 through 7
1147A	1505 - 1524	1 through 8
1147A	1525 - 1624	1 through 9
1147A	1625 - 2069	1 through 10
1621A	2070 - 2129	1 through 11
1648A	2130 - 2144	1 through 12
1715A	2150 - 2169	1 through 13
1721A	2170-2289	1 through 14
1824A	2290-2349	1 through 15
1834A	2350-2369	1-16
1836A	2370-2479	1-17
1909A	2480-2754	1-18
2036A	2755-2824	1-19
2127A	2825-up	1-20

ERRATA:

Throughout the manual, change Model from "6428A" to "6428B" and Rated Output from "18" to "20Vdc."

In Table 1-1 and in applicable portions of the specification checks in Section V, make the following changes:

LINE REGULATION: Change "Less than 18mV" to "Less than 20mV."

LOAD REGULATION: Change from "Less than 36mV" to "Less than 40mV" and "0 to 18Vdc" to "0 to 20Vdc."

RIPPLE AND NOISE: Change from "36mVrms" to "40mVrms."

TEMP. COEFFICIENT: Change from "4mV" to "5mV."

OUTPUT STABILITY: Change from "12mV" to "15mV."

Add to Paragraphs 1-12 and 3-11 "The +, -, and GND front-panel banana jacks may be used for loads less than 3 amps and for applications not requiring remote programming, remote sensing, auto-parallel, auto-series, and auto-tracking."

In Paragraph 1-10, change voltmeter range from "0 to 20" to "0 to 24." Change Paragraph 1-14 to read "Hewlett-Packard power supplies are identified by a three-part designation. The first part is the model number, the second part is the manufacturing number/letter code, and the third part is the serial number. This manual applies to all Model 6428B power supplies with the same manufacturing code given in the title page. Change sheets are included in the manual to update it to Model 6428B power supplies with different manufacturing codes."

In Figures 3-2 through 3-11, change the - and + terminals, located next to the -S and +S terminals, to A8 and A9, respectively.

On Figure 3-3, remove the lead attached to (+) terminal (on the larger barrier strip) and attach it to +S terminal.

Q10: Change to S PNP Si., 2N2907A, 56289, HP Part No. 1853-0099.

Table 1-1. Remote Programming. Constant Current: Change 5 ohms per ampere $\pm 10\%$ to 6 ohms per ampere $\pm 20\%$.

Paragraph 3-23: Change 5 ohms per ampere to 6 ohms per ampere (2 places).

Page 5-15, Paragraph 5-65 should read:

- a. Connect test setup as shown in Figure 5-3.
- b. Connect a 300 Ω , 0.1%, $\frac{1}{2}$ W resistor between terminals A2 and A3 on the rear terminal strip of the power supply.
- c. Disconnect the jumper between terminals A1 and A1.
- d. Connect the resistance box in place of R41 (shunt).
- e. Adjust the resistance box until the differential voltmeter indicates 50 \pm 5mVdc.
- f. Choose resistor R41 (shunt) equal to the resistance value determined in Step e.
- g. If an 0.001 Ω , 50 ampere resistor is not available, the front panel meter may be used to indicate 50 amperes output current $\pm 2\%$ when performing Step e.

In replaceable parts table, make the following change:

CR17, 18: Change to HP Part No. 1884-0058.

CHANGE 1:

On the title page, change manufacturing code from "6D" to "6F."

In the replaceable parts table and on the schematic (where applicable) make the following changes:

C6: Should be fxd, elect 1 μ F 35Vdc, 150D105X9036A2, 56289, HP Part No. 0180-0291.

C18, 19: Add new capacitors C18 and C19. These capacitors are same as existing capacitors C9 and C10, fxd, paper .047 μ F 600Vdc, 160P47396, 56289, HP Part No. 0160-0005.

C24: Should be fxd, elect 68 μ F 15Vdc, 150D686X0015R2, 56289, HP Part No. 0180-1835.

CR2, 3: Add diodes CR2, CR3, Rect, Si, 200mA, 15prv, 09182, HP Part No. 1901-0461.

R7: Change to fxd, met. film 4.75K Ω $\pm 1\%$ 1/8W, CEA T-O, IRC, HP Part No. 0757-0437.

R22: Change to fxd, comp 3K $\pm 5\%$ $\frac{1}{2}$ W, EB-3025,

A. B., HP Part No. 0686-3025.

CHANGE 2:

In the replaceable parts table, make the following changes:

- CR9, 10, 12: Change to type 1N485B, HP Part No. 1901-0033.
- L2: Change line choke (RFI filter) to HP Part No. 9100-2169.

CHANGE 3:

In replaceable parts table and on schematic, make the following changes:

- R21: Change to 100 Ω , $\pm 5\%$, 2W, HP Part No. 0698-3620.
- Fan Motor: Change to HP Part No. 3140-0052.

CHANGE 4:

In the replaceable parts table and on the schematic diagram, make the following change:

- R17: Change from selected value to 8.2k Ω , $\frac{1}{2}$ W, $\pm 5\%$, HP Part No. 0686-8225.

CHANGE 5:

In the replaceable parts table, make the following change:

- Handle: Add, HP Part No. 5020-5715, qty. 2.
- Machine Screw, handles: Add, HP Part No. 2680-0173, Qty. 4.

CHANGE 6:

The serial number prefix of the instrument has been changed from "9E" to "0H."

In the replaceable parts table, make the following change:

- L2, Line Choke: Change to HP Part No. 5080-7151.

CHANGE 7:

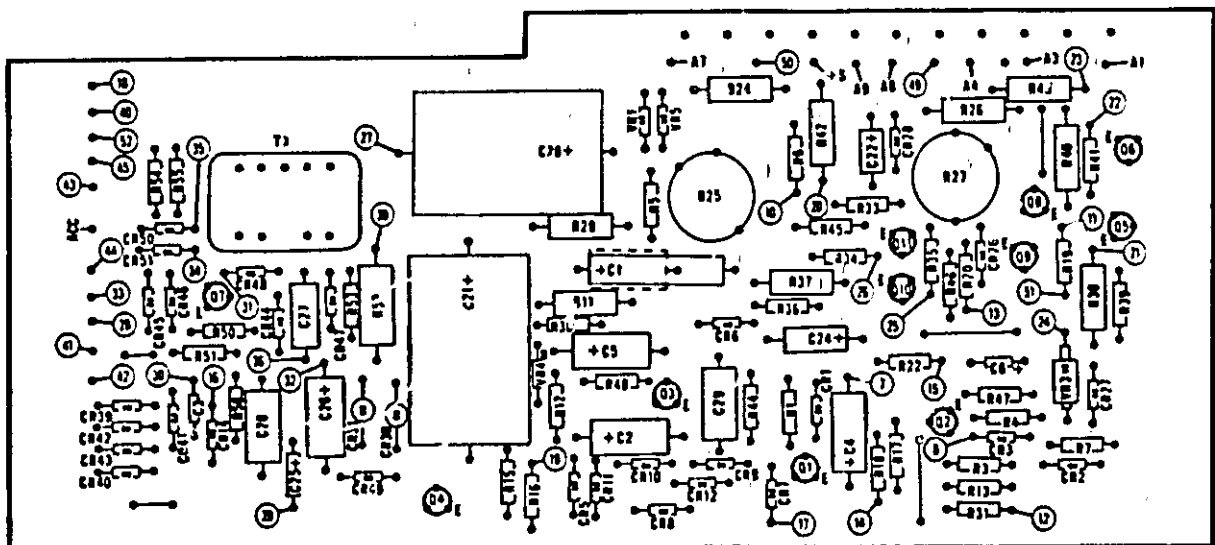
The main P. C. board, HP Part No. 5020-5521, has been converted to a double sided board. Although there are no circuit changes, some of the component designations have not been included on the board. As a convenience for the service technician, a component location diagram of this board is shown below.

In the replaceable parts table under Miscellaneous Parts, change Bezel, Meter $\frac{1}{2}$ mod. to HP Part No. 4040-0293.

The following changes are made to allow the power supply to operate with Option 27 (208Vac input) or Option 28 (230Vac input).

In the replaceable parts table and on the schematic, make the following changes:

- C7: Add C7, 1 μ F, 35V, HP Part No. 0180-0291.
- C12: Change to .047 μ F, 600V, HP Part No. 0160-0005.
- C26: Change to .22 μ F, 80V, HP Part No. 0160-2453.
- CR24: Add CR24, Diode, Si, 200prv 200mW, HP Part No. 1901-0033.
- R3 and R13: Change to 47.5k $\pm 1\%$, 1/8W, HP Part No. 0757-0457.
- R15: Change to 150k $\pm 5\%$, 1/2W, HP Part No. 0686-1545.
- R21: Change to 390 Ω $\pm 5\%$, 2W, HP Part No. 0698-3633.
- R32: Add R32, 12k, $\pm 5\%$, 1/2W, HP Part No. 0686-1235.
- R49: Add R49, 2k, $\pm 5\%$, 1/2W, HP Part No. 0686-2025.
- R56: Change to 270 Ω $\pm 5\%$, 1/2W, HP Part No. 0686-2715.
- T1: Change to HP Part No. 06428-80092.
- C28: Change to 1 μ F, 200V, HP Part No. 0160-2465.



T2: Change to HP Part No. 9100-2195.
 T3: Change to HP Part No. 5080-7176.

On the schematic diagram, the wiring of T1 and T2 and associated parts has been changed as shown on diagram.

On the schematic diagram, make the following changes:

In the SCR Regulator Control Circuit: Remove R56 (connected between C28 at the junction of R50, CR41-CR43) and replace with a short circuit. Reconnect new R56 (changed to 27Ω) in series with the junction of CR41-43 (anodes) and the junction of C28, R50, CR44, and CR46.

In the Constant Voltage Input Circuit: Add C7 (1μF, 35V) in parallel with R18.

In the Constant Current Input Circuit: (1) Remove jumper and add R49 (2k) between C6 and R31; (2) Remove jumper and add R32 (12k) between base of Q8 and R43-A2 junction; (3) add CR24 between base of Q8 (cathode side) and A4.

208Vac (Option 27) and 230Vac (Option 28) operation.

If Option 27 or 28 is installed, change all references in the manual from 115Vac operation to the appropriate line voltage input.

In Chapter 2, add the following paragraph 2-21. CONNECTIONS FOR 208/230 VOLT OPERATION (Options 27 and 28, respectively).

T1 is rewired as follows:

- Connection between terminals 1 and 3 is removed.
- Connection between terminals 2 and 5 is removed.
- Terminal 2 is connected to terminal 3.

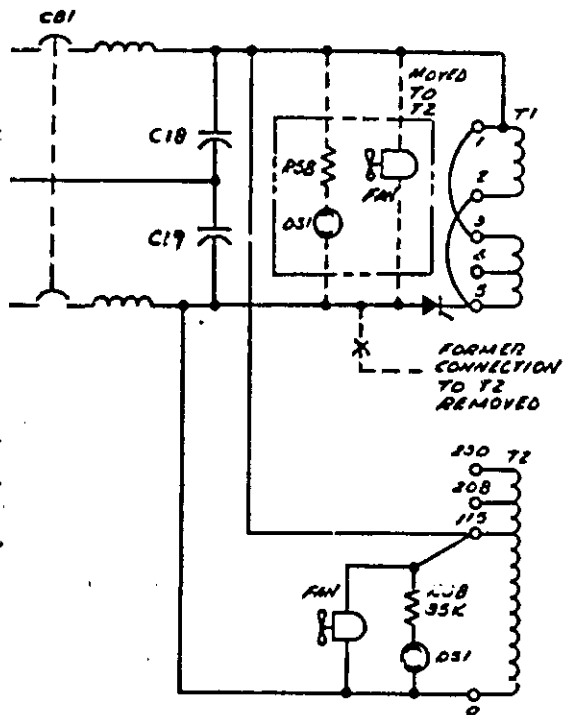
For 208V (Option 27) only, the AC input connection to terminal 5 is removed and connected to terminal 4. Ensure that C18 (+) is connected to terminal 4, also.

T2 is rewired:

- The AC input connection to the "115V" terminal is removed and connected to the "208V" or "230V" terminal as applicable.

ERRATA:

In Table 1-1, substitute the following paragraph for the entire Transient Recovery Time Specificatic :
 TRANSIENT RECOVERY TIME: Less than 200 milliseconds is required for output voltage recovery to



within 200 millivolts of the nominal output voltage following a load change from full load to half load. Excluding the initial spike of approximately 100μsec (significant only with load rise times faster than 0.1 amp/μsec), the transient amplitude will be less than 0.15 volts/amp for any load change between 20% and 100% of rated output current.

Delete the entire NOTE at the bottom of Page 5-17.

CHANGE 8:

The Serial Prefix of this unit has been changed to 1147A. This is the only change.

CHANGE 9:

In the replaceable parts table, change resistor R46 to 10MΩ ±5%, 1/4W, HP Part No. 0686-1065.

On Page 5-16, in Paragraph 5-67, Step 4 and the

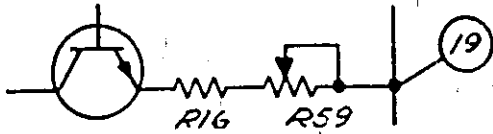
NOTE:

Change the reference to R20 to read "R6."

The standard colors for this instrument are now mint gray (for front and rear panels) and olive gray (for all top, bottom, side, and other external surfaces). Option X95 designates use of the former color scheme of light gray and blue gray. Option A85 designates use of a light gray front panel with olive gray used for all other external surfaces. New part numbers are shown at bottom.

CHANGE 10:

In the replaceable parts table and on the schematic, make the following changes:
 R16: Change to 910 Ω \pm 5%, 1/2W, HP Part No. 0686-9115.
 R59: Add R59 var ww 500 Ω \pm 5%, HP Part No. 2100-0898.
 R59 is added to the Gating Circuit as shown below to allow the clamp voltage to be adjusted to prevent half-cycle operation.



R59 is adjusted in the factory as follows: Measure voltage drop across CR9 with supply set for maximum current and full rated voltage output at low line. Adjust R59 for a forward bias drop across CR9 of 150 to 200mV.

ERRATA:

In Table 1-1 and paragraph 5-33, change the Output Impedance specification to read as follows:
OUTPUT IMPEDANCE (TYPICAL): Approximated by a 2 milliohm resistance in series with a 1 microhenry inductance.

In parts list and on schematic, change value of R17 to "factory selected for optimum performance". In parts list make the following HP Part No. changes:

- CB1: Change to 3105-0035
- CR19, 20: Change to 1901-0317
- CR21, 22: Change to 1901-0318

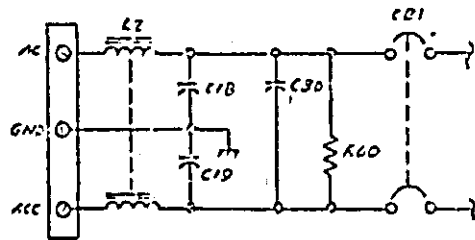
In Chapter 2, add the following paragraph 2-22.
 50Hz AC INPUT (Option 5). For 50Hz operation R17 is factory selected as described in paragraph 5-70 and R59 is factory adjusted as follows: with supply set for full output voltage and current rating at low line, adjust R59 for a forward bias across CR9 of 150mV to 200mV.

In the replaceable parts table, change the HP Part No. of pilot lamp DS1 to 1450-0566. The new pilot lamp is more reliable because its leads are crimped instead of being spot welded.

Add the following to the "Ordering Additional Manuals" paragraph in Section I: "Effective December 1975, extra manuals may be obtained by specifying Option 910 when ordering your instrument. The number of extra manuals depends upon the quantity of Option 910s ordered."

CHANGE 11:

Make the following changes to the parts list: Delete C9, C10, and C11. Change C18 and C19 to 0.015 μ F, 250Vac, HP Part No. 0160-3969. Add C30, 0.22 μ F, 250Vac, HP Part No. 0160-4259. Add C31 and C32, 0.0047 μ F, 4kV, HP Part No. 0160-0543. Add resistor R60, 1M Ω , 5%, 1/2W, HP Part No. 0686-1055. Capacitors C18, C19, and C30 and resistor R60 are physically located on the RFI filter assembly. Electrically, they are connected as shown in the revised schematic of the ac input wiring shown below. Capacitors C31 and C32 are mounted on the output barrier strip and are connected from the positive output terminal to ground and from negative output terminal to ground, respectively. Make these changes to the schematic in the manual. These new capacitors reduce the line leakage current for better safety and improve the RFI filtering.



CHANGE 12:

The front panel binding posts have been changed to a type with better designed insulation. Delete the two types of posts listed on page 6-7 and add: black binding post, HP Part No. 1510-0107 (qty 1); and red binding post, HP Part No. 1510-0091 (qty 2)

DESCRIPTION	HP PART NO.		
	STANDARD	OPTION A85	OPTION X95
Front Panel, Assembly	06428-60004	06428-60002	←
Chassis, Main Assembly	5060-7970	←	5060-6114
Cover, Top and Bottom (2)	5000-9804	←	5000-6009
Chassis Rear Assembly	06428-60005	←	06428-60001

CHANGE 13:

The three capacitors and one resistor in the revised RFI filter circuit shown in Change 11 have been re-located to a new RFI Assembly circuit board. The new circuit board assembly replaces the circuit board that was formerly part of the inductor-filter assembly. The capacitors have also been re-designated: C18 is now C101, C19 is now C102, and C30 is now C103. With these designations changed, the ac input wiring schematic accompanying Change 11 is correct.

In the parts list and on the schematic, change C12 in the SCR snubber circuit to 0.047 μ F, 250Vac, HP Part No 0160-4323 Also change the part number of the C12/R21 Insulated standoff to 0380-0849, (qty 2).

ERRATA:

Add three 3/8 32 nylon hex nuts, HP Part No 2950-0144, to the parts list These hex nuts mount the new binding posts added by Change 12
 Change the part number of R59 (added to the gating circuit by Change 10) to 2100-1772 The resistor has not been changed; just its part number has.
 Add this note to the end of paragraph 2-17:

NOTE

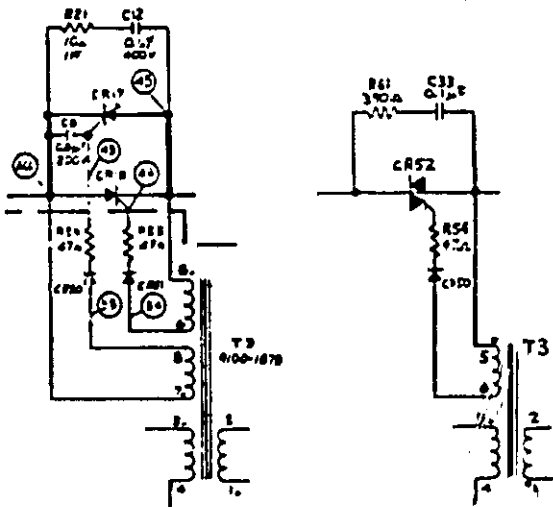
No line cord is provided with this power supply

CHANGE 14:

This change replaces SCR's CR17 and CR18 with a new type, HP Part No. 1884-0218, and adds a MOV varistor designated RV1 across the load side of the line switch The part number of the varistor is 0837-0117

CHANGE 15:

In the replaceable parts list and on the schematic: replace CR17, CR18, R55, CR51, and C8 with triac CR52, HP Part No. 1884-0218; change C12 to C33, HP Part No. 0160-4323; change R21 to R61, 390 Ω , 0.5W, HP Part No. 0686-3915; change T51 to HP Part No. 0440-0079; change T3 to HP Part No. 5080-1914. Replace the section of schematic shown below on left with the drawing on right.



CHANGE 16:

Only the serial number has changed.

CHANGE 17:

Delete cover barrier strip, HP Part No. 5020-5513. Add strain relief, HP Part No. 5060-2791. Change zener diode VR3 to 9V, HP Part No. 1902 0785. Change resistor R35 to 2.87K Ω , 1%, HP Part No. 0698-3151. Change resistor R37 to 1.3K 1/4W, HP Part No. 0757-0735.

CHANGE 18:

On page 6-7, change the HP Part Number for Barrier Strip Output Terminals to 0360-1259.

CHANGE 19:

In the replaceable parts list and on the schematic: change R16 to 820 Ω , 5%, HP Part No. 0686-8215; change R59 (added in Change 10) to 1k Ω , 10% HP Part No. 2100-3211; replace Fan Motor and Blade with Fan, tube axial, HP Part No. 3160-0056.

CHANGE 20:

In the replaceable parts list, page 6-5 add C34 .22 μ F 250V HP Part No. 0160-4259.
 On the schematic insert C34 on the inboard side of circuit breaker CB1, between AC and ACC.

ERRATA:

In the replaceable parts list, change fan (added in Change 19) to fan ball bearing HP Part No. 3160-0369.

► ERRATA

On page 3-8, Figure 3-5 delete the connection between A5 and +5.
 1-18-82