

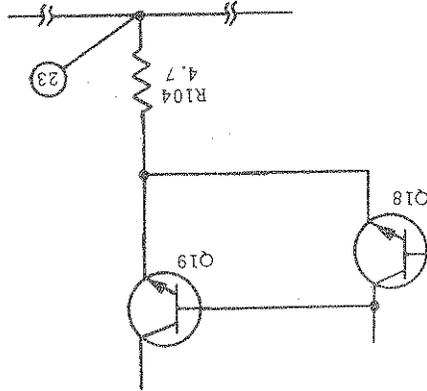
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SERIAL NUMBER PREFIX 6J

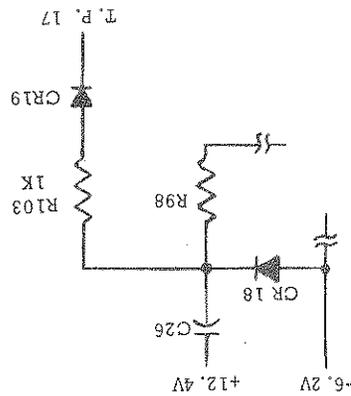
LAB SERIES, MODEL 6207B

DC POWER SUPPLY





R104: Add new resistor, R104, in series with emitters of Q18, Q19 as shown below. Resistor is 4.7 ohms,  $\frac{1}{2}$ W,  $\Phi$  Stock No. 0698-0001.



C25: Delete C25 from parts list and schematic. Base of Q18 and T2-1 are no longer connected in any way.  
 CR21: Add new diode (CR21, 200mA, 180prv,  $\Phi$  Stock No. 1901-0033) across secondary of pulse transformer T2 (anode to term. 4 and cathode to term. 3).  
 CR28, 29: Change  $\Phi$  Stock No. to 1901-0388.  
 CR19, R103: Add new components CR19 and R103 as shown in the sketch below. CR19 is 200mA, 180prv,  $\Phi$  Stock No. 1901-0033. R103 is 1K,  $\frac{1}{2}$ W,  $\Phi$  Stock No. 0686-1025.

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

CHANGE 1: On the title page, change Serial Number Prefix from "6J" to "7E".

| MAKE    | SERIAL |           |
|---------|--------|-----------|
|         | Prefix | Number    |
| CHANGES | 7E     | 1026 - up |
|         |        | 1, 2, 3   |

| MAKE    | SERIAL |             |
|---------|--------|-------------|
|         | Prefix | Number      |
| CHANGES | 7E     | 0476 - 0625 |
|         | 7E     | 0626 - 1025 |
|         |        | Errata      |
|         |        | 1, 2        |

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.

Manual Serial Number Prefix 6J

Model 6207B

DC POWER SUPPLY

MANUAL CHANGES

11-19-68

C1: Change to 0.47 $\mu$ f, 400V, Sprague, 220P47494B,  $\text{\textcircled{P}}$  Part No. 0160-3356.  
 R49: Change to 15K $\Omega$ , 10W, Axial lead,  $\text{\textcircled{P}}$  Part No. 0815-0045.  
 R89: Change to 220 $\Omega$ , fxd ww, 2W,  $\text{\textcircled{P}}$  Part No. 0811-1763.

CHANGE 3: In the replaceable parts table, make the following changes:

ERRATA: Q3, 4, 8, 10, 12, 14, 15: Change to 2N2907A, Sprague, 56289,  $\text{\textcircled{P}}$  Part No. 1853-0099.

Q6: Change to  $\text{\textcircled{P}}$  Part No. 1854-0225.  
 R40: Delete resistor R40.  
 R62: Change to 750 $\Omega$ , 1/8w,  $\text{\textcircled{P}}$  Part No. 0757-0420.  
 R63: Change to 5K $\Omega$  potentiometer  $\text{\textcircled{P}}$  Part No. 2100-1824.  
 R64: Change to 12K $\Omega$ , 1/8w,  $\text{\textcircled{P}}$  Part No. 0698-5088  
 VR6: Add new Zener diode, (VR6 4.22V,  $\text{\textcircled{P}}$  Part No. 1902-3070). In the meter circuit on the schematic, delete R40 and connect VR6 in its place. Cathode of VR6 to +12.4V and anode to base of Q15.

CHANGE 2: In the replaceable parts table, make the following changes:

SECTION I  
GENERAL INFORMATION

c. Series and Auto-Series Operation

Power supplies may be used in series when a higher output voltage is required in the voltage mode of operation or when greater voltage compliance is required in the constant current mode of operation. Auto-Series operation permits one knob control of the total output voltage from a "master" supply.

d. Parallel and Auto-Parallel Operation

The power supply may be operated in parallel with a similar unit when greater output current capability is required. Auto-Parallel operation permits one knob control of the total output current from a "master" supply.

e. Auto-Tracking

The power supply may be used as a "master" supply, having control over one (or more) "slave" supplies that furnish various voltages for a system.

1-6 SPECIFICATIONS

1-7 Detailed specifications for the power supply are given in Table 1-1.

1-8 OPTIONS

1-9 Options are factory modifications of a standard instrument that are requested by the customer. The following options are available for the instrument covered by this manual. Where necessary, detailed coverage of the options is included throughout the manual.

| Option No. | Description |
|------------|-------------|
|------------|-------------|

50 Hz Regulator Realignment:

Standard instruments will operate satisfactorily at both 60 and 50 Hz without adjustment. However Operation 05 factory realignment results in more efficient operation at 50 Hz, and is recommended for all applications when continuous operation from a 50 Hz ac input is intended.

1-1 DESCRIPTION

1-2 This power supply, Figure 1-1, is complete-

ly transistorized and suitable for either bench or relay rack operation. It is a compact, well-regulated, Constant Voltage / Constant Current supply that will furnish full rated output voltage at the maximum rated output current or can be continuously adjusted throughout the output range. The front panel CURRENT controls can be used to establish the output current limit (overload or short circuit) when the supply is used as a constant voltage source and the VOLTAGE control can be used to establish the voltage limit (ceiling) when the supply is used as a constant current source. The supply will automatically crossover from constant voltage to constant current operation and vice versa if the output current or voltage exceeds these preset limits.

1-3 The power supply has both front and rear terminals. Either the positive or negative output terminal may be grounded or the power supply can be operated floating at up to a maximum of 300 volts off ground.

1-4 A single meter is used to measure either output voltage or output current in one of two ranges. The voltage or current ranges are selected by a METER switch on the front panel.

1-5 Barrier strip terminals located at the rear of the unit allow ease in adapting to the many operational capabilities of the power supply. A brief description of these capabilities is given below:

a. Remote Programming

The power supply may be programmed from a remote location by means of an external voltage source or resistance.

b. Remote Sensing

The degradation in regulation which would occur at the load because of the voltage drop in the load leads can be reduced by using the power supply in the remote sensing mode of operation.

1-16 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and the stock number provided on the title page.

1-15 ORDERING ADDITIONAL MANUALS

1-14 If the serial number prefix on your power supply does not agree with the prefix on the title page of this manual, change sheets are included to update the manual. Where applicable, back-dating information is given in an appendix at the rear of the manual.

1-13 Hewlett-Packard power supplies are identified by a three-part serial number tag. The first part is the power supply model number. The second part is the serial number prefix, which consists of a number-letter combination that denotes the date of a significant design change. The number designates the year, and the letter A through L designates the month, January through December respectively. The third part is the power supply serial number.

1-12 INSTRUMENT IDENTIFICATION

C05 8" Black Handle that can be attached to side of supply.

14513A Rack Kit for mounting one 3 1/2" high supply. (Refer to Section II for details.)

14523A Rack Kit for mounting two 3 1/2" high supplies. (Refer to Section II for details.)

1-10 ACCESSORIES

1-11 The accessories listed in the following chart may be ordered with the power supply or separately from your local Hewlett-Packard field sales office (refer to list at rear of manual for addresses).

(28) of reconnecting the input transformer for 230 Vac operation.

28 Rewire For 230V AC Input: Supply as normally shipped is wired for 115 Vac input. Option 28 consists

14 Three Digit Graduated Decadal Current Control: Control that re-places coarse and fine current controls permitting accurate resettability.

13 Three Digit Graduated Decadal Voltage Control: Control that re-places 10-turn voltage control permitting accurate resettability.

08 Current 10-Turn Pot: A single control that replaces both coarse and fine current controls and improves output stability.

Detailed coverage of Option 06 is included in an addendum at the rear of manuals that support power supplies containing Option 06.

NOTE

Weight: Add 2 lbs. net.

Size: Add 5 inches to power supply depth dimension.

Power Requirement: 15ma continuous drain from power supply being protected.

Overvoltage Margin: 1 to 4 volts, screwdriver adjustable.

supply at the factory.

is attached to the rear of the power requested by the customer the device exceeded. When Option 06 is re-

supply failure or operator error. This independent device monitors the output voltage and within 10µsec imposes a virtual short-circuit (crowbar) across the power supply output if the preset overvoltage margin is exceeded.

Option No. Description

Option No. Description

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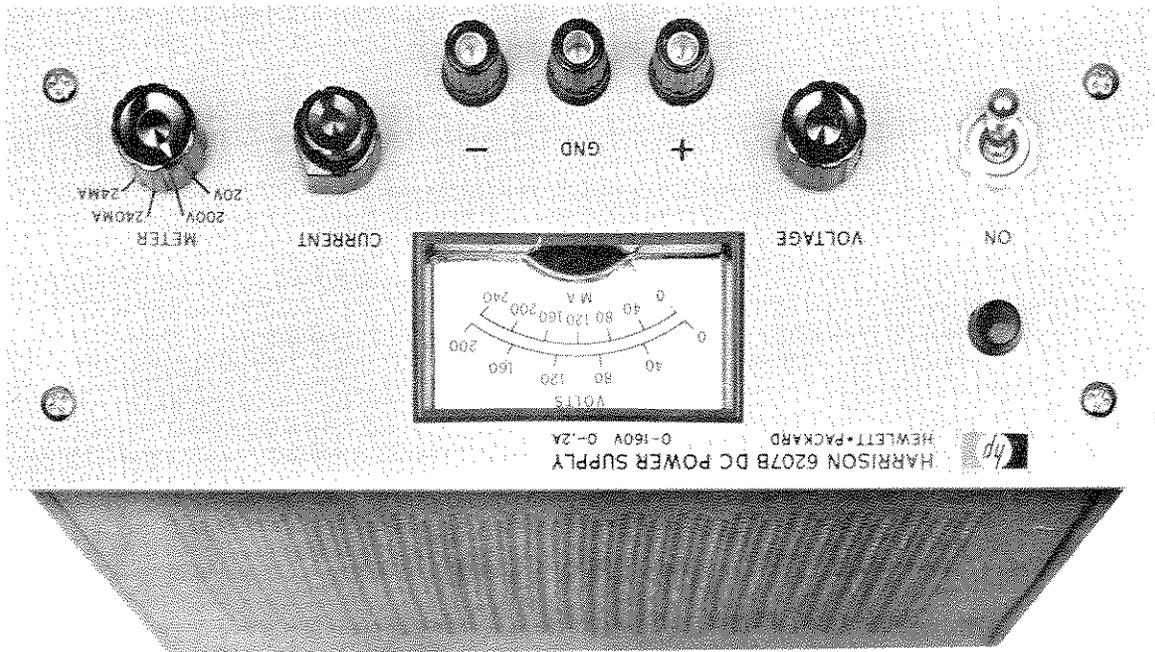
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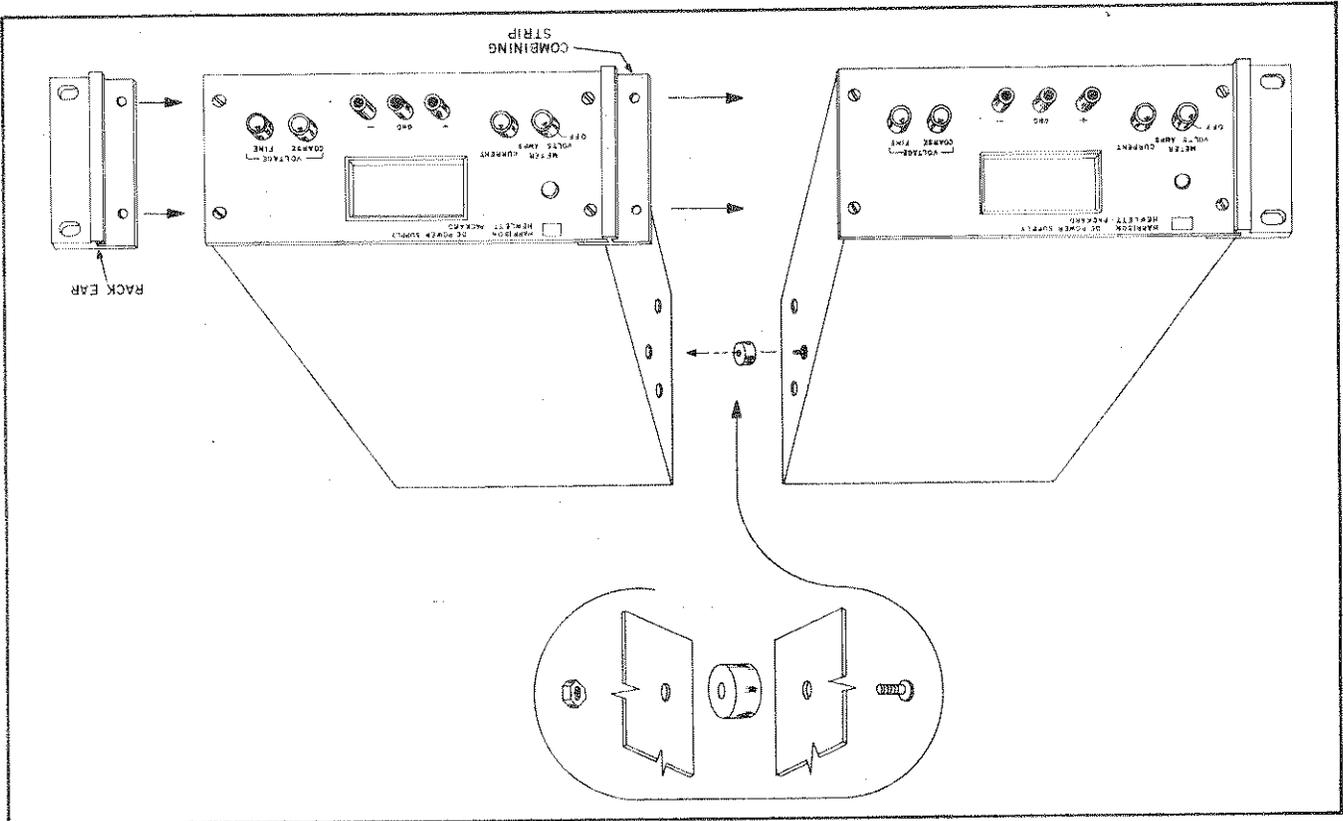
Figure 1-1. DC Power Supply, Model 6207B



|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>INPUT:</b> 105-125/210-250Vac, single phase, 48-63Hz.</p> <p><b>OUTPUT:</b> 0-160 volts @ 0-0.2 amps.</p> <p><b>LOAD REGULATION:</b> Constant Voltage -- Less than 0.02% plus 2mV for a full load to no load change in output current.</p> <p><b>LINE REGULATION:</b> Constant Current -- Less than 200µA for a 2mV for any line voltage change within the input rating.</p> <p><b>TEMPERATURE COEFFICIENT:</b> Constant Voltage -- Less than 0.02% plus 1mV per degree Centigrade.</p> <p><b>TEMPERATURE RANGES:</b> Operating: 0 to 50°C. Storage: -40 to +85°C.</p> <p><b>TEMPERATURE COEFFICIENT:</b> Constant Current -- Less than 0.02% plus 150µA per degree Centigrade.</p> <p><b>STABILITY:</b> Constant Voltage -- Less than 0.10% plus 5mV total drift for 8 hours after an initial warmup time of 30 minutes at constant ambient, constant line voltage, and constant load.</p> <p><b>INTERNAL IMPEDANCE AS A CONSTANT VOLTAGE SOURCE:</b> Less than 0.02<math>\Omega</math> from DC to 1kHz. Less than 0.5<math>\Omega</math> from 1kHz to 100kHz. Less than 3.0<math>\Omega</math> from 100kHz to 1MHz.</p> <p><b>TRANSIENT RECOVERY TIME:</b> Less than 50µsec for output recovery to within 10mV following a full load current change in the output.</p> <p><b>OVERLOAD PROTECTION:</b> A continuously acting constant current circuit protects the power supply for all overloads including a direct short placed across the terminals with each unit.</p> | <p><b>IN CONSTANT VOLTAGE OPERATION:</b> The constant voltage circuit limits the output voltage in the constant current mode of operation.</p> <p><b>METER:</b> The front panel meter can be used as either a 0-20 or 0-200 volt voltmeter or as a 0-24 or 0-240mA ammeter.</p> <p><b>OUTPUT CONTROLS:</b> Ten-turn voltage control and coarse and fine current controls are provided on the front panel.</p> <p><b>OUTPUT TERMINALS:</b> Three "five-way" output posts are provided on the front panel and an output terminal strip is located on the rear of the chassis. All power supply output terminals are isolated from the chassis and either the positive or negative terminal may be connected to the chassis through a separate ground terminal located on the output terminal strip.</p> <p><b>ERROR SENSING:</b> Error sensing is normally accomplished at the front terminals if the load is attached to the front or at the rear terminals if the load is attached to the rear terminal strip for remote sensing.</p> <p><b>REMOTE PROGRAMMING:</b> Remote programming of the supply output at approximately 300 ohms per volt in constant voltage is made available at the rear terminals. In constant current mode of operation, the current can be remotely programmed at approximately 75K ohms per ampere.</p> <p><b>COOLING:</b> Convection cooling is employed. The supply has no moving parts.</p> <p><b>SIZE:</b> 3-1/2" H x 12-5/8" D x 8-1/2"W. Two of the units can be mounted side by side in a standard 19" rack panel.</p> <p><b>WEIGHT:</b> 13 lbs. net, 18 lbs. shipping.</p> <p><b>FINISH:</b> Light gray front panel with dark gray case.</p> <p><b>POWER CORD:</b> A three-wire, five-foot power cord is provided with each unit.</p> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Table 1-1. Specifications

Figure 2-1. Rack Mounting, Two Units



2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, proceed as described in the Claim for Damage in Shipment section of the warranty page at the rear of this manual.

2-3 MECHANICAL CHECK

2-4 This check should confirm that there are no broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches, and that the meter is not scratched or cracked.

2-5 ELECTRICAL CHECK

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. It is necessary only to connect the in-

SECTION II  
INSTALLATION

2-9 LOCATION

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the sides and rear of the instrument when it is in operation. It should be used in an area where the ambient temperature does not exceed 50°C.

2-11 RACK MOUNTING

2-12 This instrument may be rack mounted in a standard 19 inch rack panel either alongside a similar unit or by itself. Figures 2-1 and 2-2 show how both types of installations are accomplished.

2-13 To mount two units side-by-side, proceed as follows:

a. Remove the four screws from the front panels of both units.

b. Slide rack mounting ears between the front panel and case of each unit.

c. Slide combining strip between the front panels and cases of the two units.

d. After fastening rear portions of units together using the bolt, nut, and spacer, replace panels screws.

2-16 This power supply may be operated from either a nominal 115 volt or 230 volt 48-63 cycle power source. The unit, as shipped from the factory, is wired for 115 volt operation. The input power required when operated from a 115 volt 60 cycle power source at full load is 60 watts and 1.0 ampere.

2-17 CONNECTIONS FOR 230 VOLT OPERATION (Figure 2-3)

2-18 Normally, the two primary windings of the input transformer are connected in parallel for operation from 115 volt source. To convert the power supply to operation from a 230 volt source, the power transformer windings are connected in series as follows:

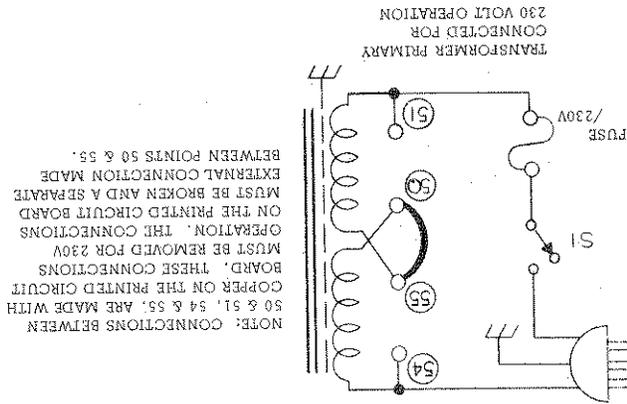
2-15 INPUT POWER REQUIREMENTS

2-14 To mount a single unit in the rack panel, proceed as follows:

- Bolt rack mounting ears, combining straps, and angle brackets to each side of center spacing panels. Angle brackets are placed behind combining straps as shown in Figure 2-2.
- Remove four screws from front panel of unit.
- Slide combining strips between front panel and case of unit.
- Bolt angle brackets to front sides of case and replace front panel screws.

c. Add strap between 50 and 55.  
 d. Replace existing fuse with 1 ampere, 230 volt fuse. Return unit to case and operate normally.

Figure 2-3. Primary Connections



NOTE: CONNECTIONS BETWEEN 50 & 51, 54 & 55, ARE MADE WITH COPPER ON THE PRINTED CIRCUIT BOARD. THESE CONNECTIONS MUST BE REMOVED FOR 230V OPERATION. THE CONNECTIONS ON THE PRINTED CIRCUIT BOARD MUST BE BROKEN AND A SEPARATE EXTERNAL CONNECTION MADE BETWEEN POINTS 50 & 55.

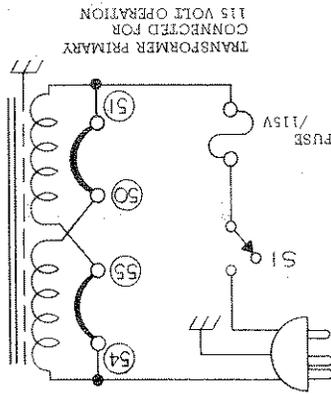
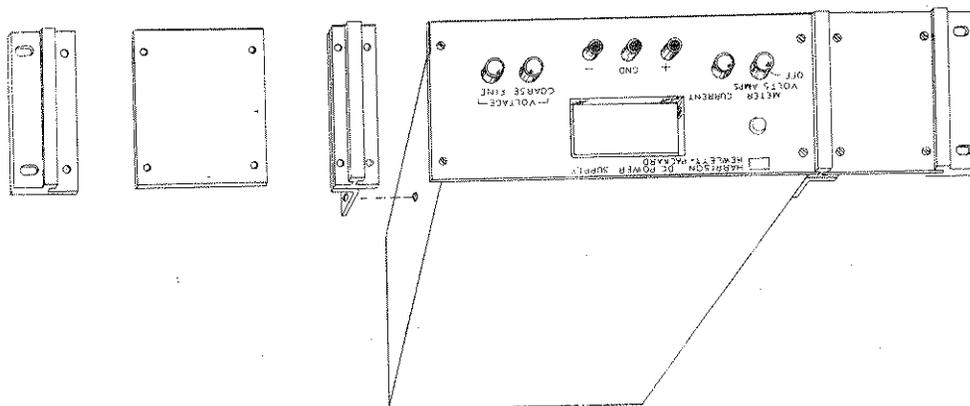


Figure 2-2. Rack Mounting, One Unit



2-19 POWER CABLE

2-20 To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three conductor power cable. 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.

2-21 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to ground.

2-22 REPACKAGING FOR SHIPMENT

2-23 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 local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to 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.

SECTION III  
OPERATING INSTRUCTIONS

3-1 OPERATING CONTROLS AND INDICATORS

3-2 The front panel controls and indicators, together with the normal turn-on sequence, are shown in Figure 3-1.

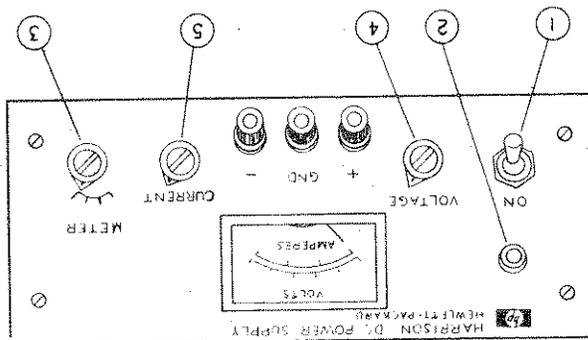


Figure 3-1. Front Panel Controls and Indicators

3-3 OPERATING MODES

3-4 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 above their respective terminals. Although the strapping patterns illustrated in this section show the positive terminal grounded, the operator can ground either terminal or operate the power supply up to 300 vdc off ground (floating). The following paragraphs describe the procedures for utilizing the various operational capabilities of the power supply. A more theoretical description is contained in a power supply Application Manual and in various Tech. Letters published by the Harrison Division. Copies of these can be obtained from your local Hewlett-Packard field office.

3-5 NORMAL OPERATING MODE

3-6 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).

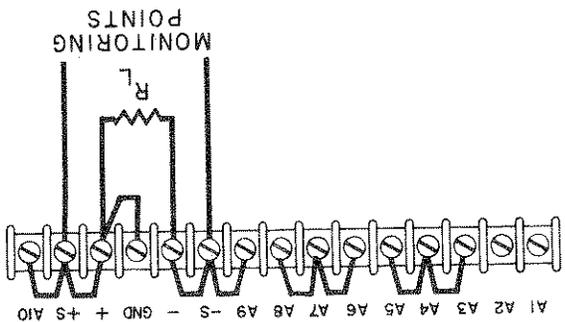


Figure 3-2. Normal Strapping Pattern

3-7 CONSTANT VOLTAGE

3-8 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 allowable (current limit), as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically crossover 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 current which can cause unwanted cross-over. (Refer to Paragraph 3-44.)

3-9 CONSTANT CURRENT

3-10 To select a constant current output, proceed as follows:  
a. Short output terminals and adjust CURRENT controls for desired output current.

3-21 The impedance ( $R_X$ ) looking into the external programming voltage source should be approximately 1000 ohms if the temperature and stability specifications of the power supply are to be maintained.

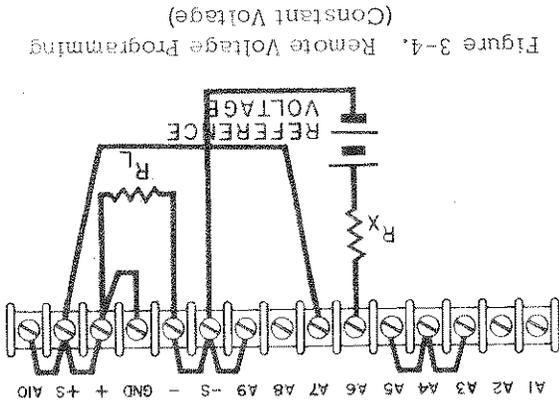


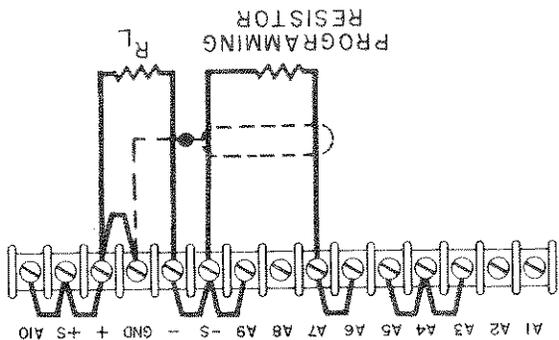
Figure 3-4. Remote Voltage Programming (Constant Voltage)

3-20 Voltage Programming (Figure 3-4). Employ the strapping pattern shown on Figure 3-4 for voltage programming. In this mode, the output voltage will vary in a 1 to 1 ratio with the programming voltage (reference voltage) and the load on the programming voltage source will not exceed 25 microamperes.

3-19 To maintain the stability and temperature coefficient of the power supply, use programming resistors that have stable, low noise, and low temperature (less than 30 ppm per degree Centigrade) characteristics. A switch can be used in conjunction with various resistance values in order to obtain discrete output voltages. The switch should have make-before-break contacts to avoid momentarily opening the programming terminals during the switching interval.

3-18 The output voltage of the power supply should be zero volts  $\pm 20$  millivolts when zero ohms is connected across the programming terminals. It may be achieved by changing resistor  $R_6$  or  $R_8$  as described in Paragraph 5-49.

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



3-17 Resistance Programming (Figure 3-3). In this mode, the output voltage will vary at a rate determined by the programming coefficient -- 300 ohms per volt (i.e., the output voltage will increase 1 volt for each 300 ohms added in series with programming terminals). The programming coefficient is determined by the programming current. This current is adjusted to within 2% of 3.3mA at the factory. If greater programming accuracy is required, it may be achieved by changing resistor  $R_{13}$ .

3-16 The constant voltage output of the power supply can be programmed (controlled) from a remote location if required. Either a resistance or voltage source can be used for the programming device. The wires connecting the programming terminals of the supply to the remote programming device should be twisted or shielded to reduce noise pick-up. The VOLTAGE controls on the front panel are disabled according to the following procedures.

3-15 REMOTE PROGRAMMING, CONSTANT VOLTAGE

3-14 OPTIONAL OPERATING MODES

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 (Paragraph 3-28).

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.)

3-11 CONNECTING LOAD

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 Paragraph 3-44).

3-22 REMOTE PROGRAMMING, CONSTANT CURRENT

3-23 Either a resistance or a voltage source can be used to control the constant current output of the supply. The CURRENT controls on the front panel are disabled according to the following procedures.

3-24 Resistance Programming (Figure 3-5). In

this mode, the output current varies at a rate determined by the programming coefficient -- 75K ohms per ampere for Model 6207B, and 150K ohms per ampere for Model 6209B. The programming coefficient is determined by the programming current. This current is factory adjusted to within 10% of 0.1mA. If greater programming accuracy is required, it may be achieved by changing resistors for R19.

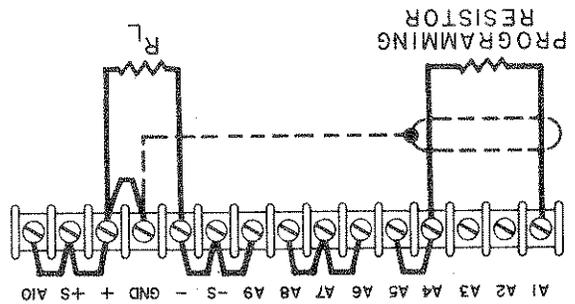


Figure 3-5. Remote Resistance Programming (Constant Current)

3-25 Use stable, low noise, low temperature coefficient (less than 30 ppm / °C) programming resistors to maintain the power supply temperature coefficient and stability specifications. A switch may be used to set discrete values of output current. A make-before-break type of switch should be used since the output current will exceed the maximum rating of the power supply if the switch contacts open during the switching interval.

CAUTION

If the programming terminals (A1 and A4) should open at any time during this mode, the output current will rise to a value that may damage the power supply and/or the load. To avoid this possibility, connect a 15K resistor across the programming terminals and in parallel with a remote programming resistor. Like the programming resistor, the 15K resistor should be of the low noise, low temperature coefficient type.

3-26 Voltage Programming (Figure 3-6). In this mode, the output current will vary linearly with changes in the programming voltage. The programming voltage should not exceed 1.5 volts. Voltage

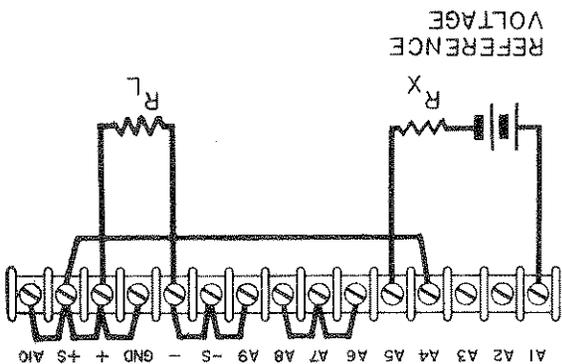


Figure 3-6. Remote Voltage Programming (Constant Current)

In excess of 1.5 volts will result in excessive power dissipation in the instrument and possible damage.

3-27 The output current for Model 6207B supplies

will be the programming voltage divided by 7.5 ohms. For Model 6209B supplies, it will be the programming voltage divided by 15 ohms. The current required from the voltage source will be less than 25 microamperes. The impedance (RX) as seen looking into the programming voltage source should be approximately 500 ohms if the temperature coefficient and stability specifications of the power supply are to be maintained.

3-28 REMOTE SENSING (See Figure 3-7)

3-29 Remote sensing is used to maintain good regulation at the load and reduce the degradation of regulation which would occur due to the voltage drop in the leads between the power supply and the load. Remote sensing is accomplished by utilizing the strapping pattern shown in Figure 3-7. The power supply should be turned off before changing strapping patterns. The leads from the +S terminals to the load will carry less than 10 milliamperes of current, and it is not required that these leads be as heavy as the load leads. However, they must be twisted or shielded to minimize noise pick-up.

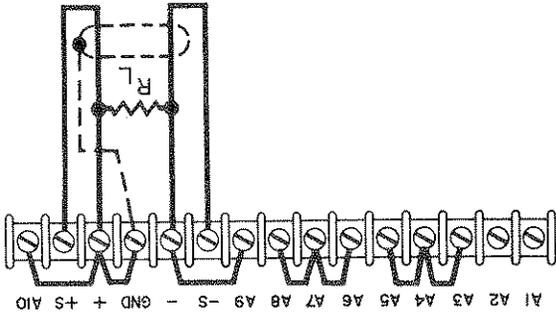


Figure 3-7. Remote Sensing

Figure 3-9. AUTO-Series, Two and Three Units

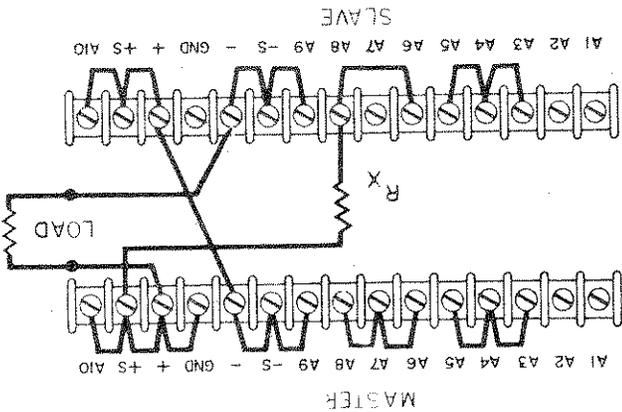
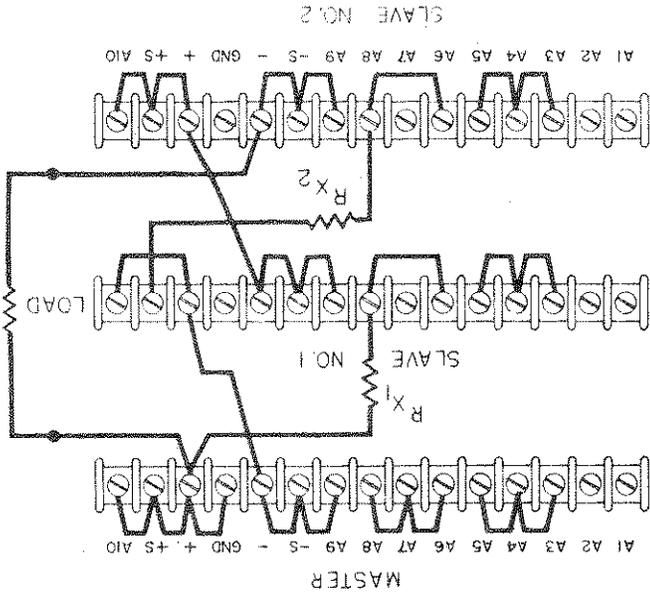
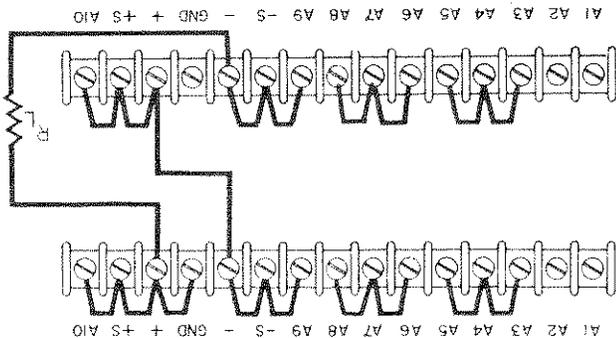


Figure 3-8. Normal Series



3-34 Normal Series Connections (Figure 3-8). Two or more power supplies can be operated in series to obtain a higher voltage than that available from a single supply. When this connection is used, the output voltage is the sum of the voltages of the individual supplies. Each of the individual supplies must be adjusted in order to obtain the total output voltage. The power supply contains a protective diode connected internally across the output which protects the supply if one power supply is turned off while its series partner(s) is on. 3-35 Auto-Series Connections (Figure 3-9). The Auto-Series configuration is used when it is desirable to have the output voltage of each of the series connected supplies vary in accordance with the setting of a control unit. The control unit is called the master; the controlled units are called slaves. At maximum output voltage, the voltage of the slaves is determined by the setting of the front panel VOLTAGE control on the master. The

3-33 SERIES OPERATION

It is necessary to readjust the current limit when the instrument is operated in the remote sensing mode.

NOTE

Although the strapping patterns shown in Figures 3-3 through 3-6 employ local sensing, note that it is possible to operate a power supply simultaneously in the remote sensing and Constant Voltage / Constant Current remote programming modes. 3-32 Although the strapping patterns shown in Figures 3-3 through 3-6 employ local sensing, note that it is possible to operate a power supply simultaneously in the remote sensing and Constant Voltage / Constant Current remote programming modes.

3-31 The procedure just described will result in a low DC output impedance at the load. If a low AC impedance is required, it is recommended that the following precautions be taken:  
 a. Disconnect output capacitor C20, by disconnecting the strap between A10 and +S.  
 b. Connect a capacitor having similar characteristics (approximately same capacitance, same voltage rating or greater, and having good high frequency characteristics) across the load using short leads.

3-30 Note that it is desirable to minimize the drop in the load leads and it is recommended that the drop not exceed 1 volt per lead if the power supply is to meet its DC specifications. If a larger drop must be tolerated, please consult a Hewlett-Packard field representative.

CAUTION

Observe polarity when connecting the sensing leads to the load.

3-39 Auto-Parallel. The Strapping Patterns for Auto-Parallel operation of two and three supplies are shown in Figure 3-11. 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 are 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.

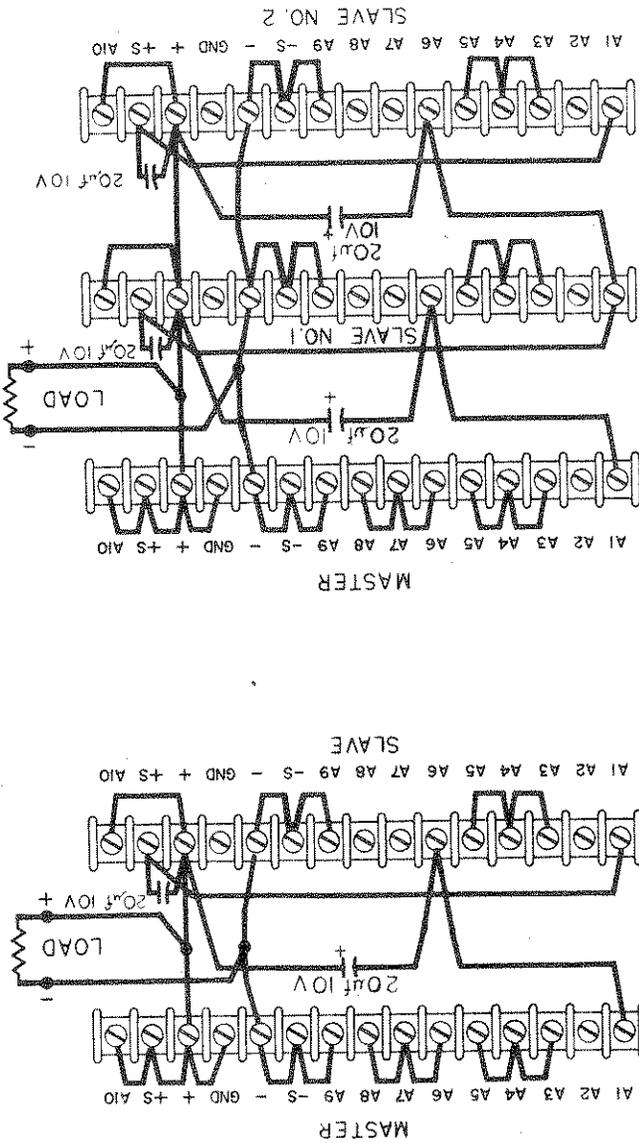


Figure 3-11. Auto-Parallel, Two and Three Units

master supply must be the most positive supply of the series. The output CURRENT controls of all series units are operative and the current limit is equal to the lowest control setting. If any output CURRENT controls are set too low, automatic crossover to constant current operation will occur and the output voltage will drop. Remote sensing and programming can be used; however, the strapping arrangements shown in the applicable figures show local sensing and programming.

3-36 In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors ( $R_x$ ) shown in Figure 3-9 should be stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) resistors. The value of each resistor is dependant on the maximum voltage rating of the "master" supply. The value of  $R_x$  is this voltage divided by the voltage programming current of the slave supply ( $1/K_p$  where  $K_p$  is the voltage programming coefficient). The voltage contribution of the slave is determined by its voltage control setting.

3-37 PARALLEL OPERATION

3-38 Normal Parallel Connections (Figure 3-10). 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. The output CURRENT controls of each power supply can be separately set. The output voltage controls of one power supply should be set to the desired output voltage; the other power supply should be set for a slightly larger output voltage. The supply set to the lower output voltage will act as a constant voltage source; the supply set to the higher output will act as a constant current source, dropping its output voltage until it equals that of the other supply.

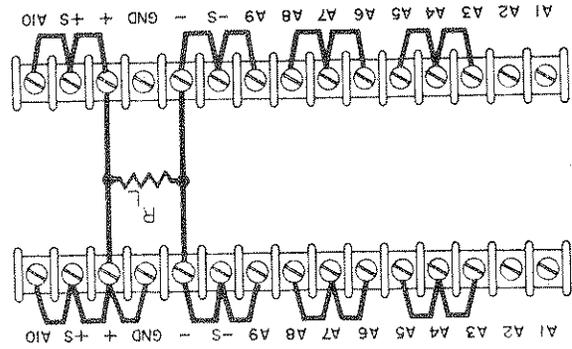


Figure 3-10. Normal Parallel

3-40 AUTO-TRACKING OPERATION (See Figure 3-12)

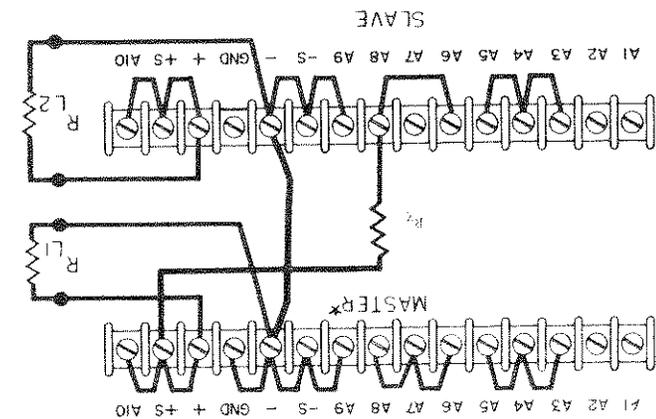
3-41 The Auto-Tracking configuration is used when it is necessary that several different voltages referred to a common bus, vary in proportion to the setting of a particular instrument (the control or master). A fraction of the master's output voltage is fed to the comparison amplifier of the slave supply, thus controlling the slave's output. The master must have the largest output voltage of any power supply in the group (must be the most positive supply in the example shown on Figure 3-12).

3-42 The output voltage of the slave is a percentage of the master's output voltage, and is determined by the voltage divider consisting of  $R_X$  (or  $R_Y$  and  $R_Z$ ) and the voltage control of the slave supply,  $R_P$  where:  $E_S = R_P / (R_X + R_P)$ . Turn-on and turn-off of the power supplies is controlled by the master. Remote sensing and programming can be used; although the strapping patterns for these modes show only local sensing and programming. 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 30ppm per°C) resistors.

3-43 SPECIAL OPERATING CONSIDERATIONS

3-44 PULSE LOADING

3-45 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. If this crossover limiting is not desired, set the preset limit for the peak requirement and not the average.



\* MASTER UNIT IN POSITIVE SUPPLY

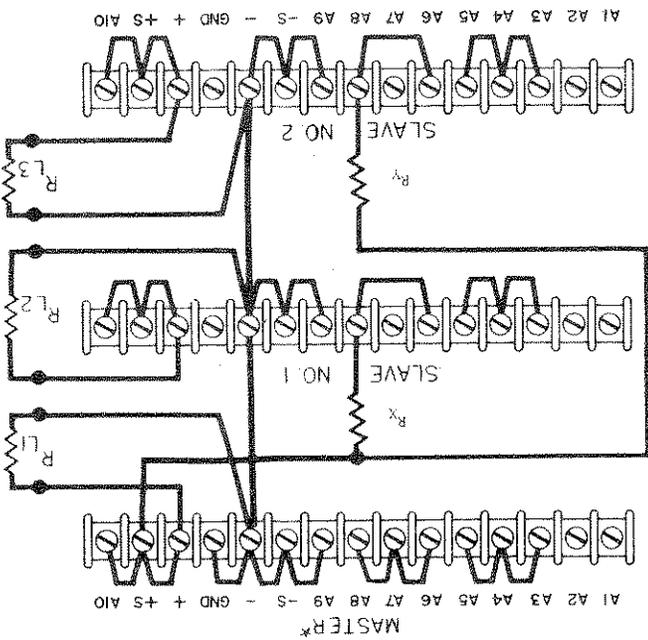


Figure 3-12. Auto-Tracking, Two and Three Units

## 3-46 OUTPUT CAPACITANCE

3-47 There is a capacitor (internal) across the output terminals of the power supply. This capacitor helps 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.

3-48 The effects of the output capacitor during

constant current operation are as follows:

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

## 3-49 REVERSE VOLTAGE LOADING

3-50 A diode is connected across the output terminals. Under normal operating conditions, the diode is reverse biased (anode connected to negative terminal). If a reverse 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 series transistors and the output electrolytic capacitors.

## 3-51 REVERSE CURRENT LOADING

3-52 Active loads connected to the power supply may actually deliver a reverse current to the power supply during a portion of its operating cycle. An external source cannot be allowed to pump current into the supply without loss of regulation and possible damage to the output capacitor. To avoid these effects, it is necessary to preload the supply with a dummy load resistor so that the power supply delivers current through the entire operating cycle of the load device.

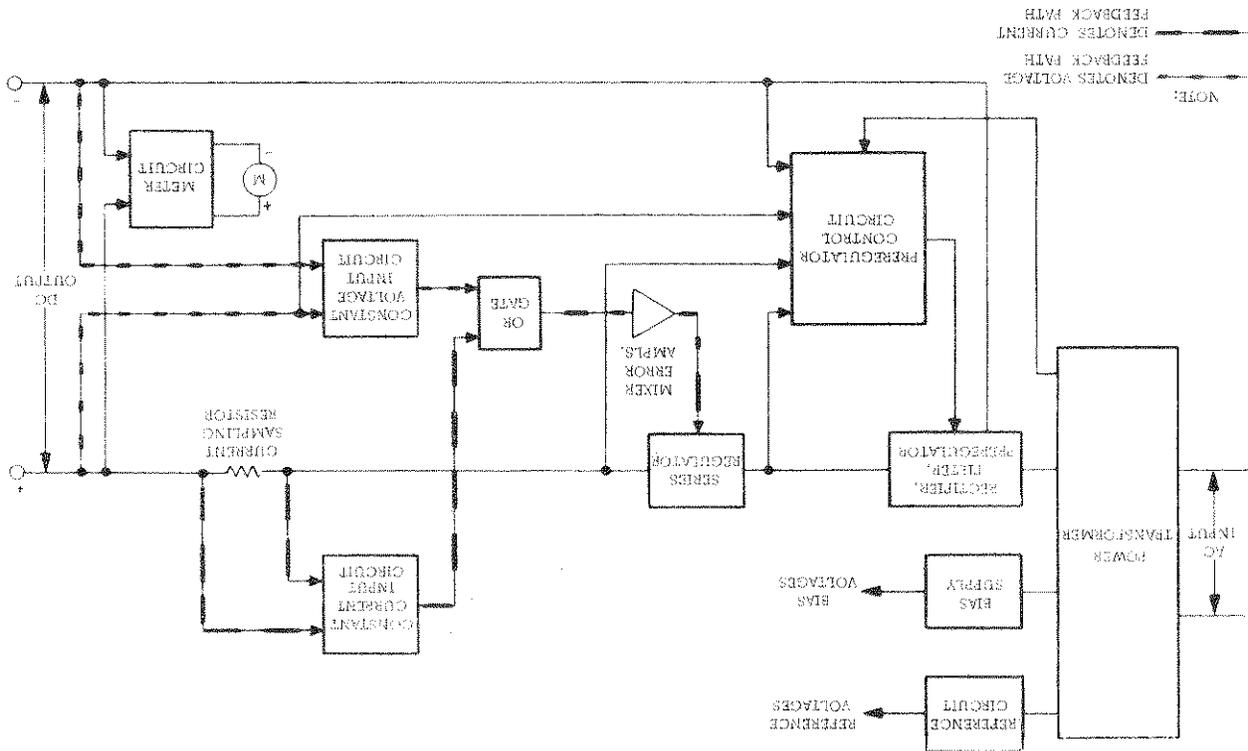
4-2 The power supply, as shown on the overall block diagram on Figure 4-1, consists of a power transformer, a rectifier-preregulator-filter, pre-regulator control circuit, series regulator, the mixer and error amplifiers, an "OR" gate, a constant voltage input circuit, a constant current input circuit, a reference circuit, bias supply, and a meter circuit.

4-3 The input line voltage passes through the power transformer to the rectifier diodes where it receives full wave rectification. The rectified ac is applied to the preregulator which consists of an SCR operating in conjunction with a control circuit. The SCR minimizes the power dissipated by the series regulator by keeping the voltage drop across the regulator at a low and constant level. The SCR control circuit accomplishes this by issuing a firing pulse to the SCR once during each half cycle

4-1 OVERALL BLOCK DIAGRAM DISCUSSION

of the input ac. The control circuit continuously samples the output voltage, the input line voltage, the load current and the voltage across the series regulator and, on the basis of these inputs, determines at what time during each cycle that the firing pulse will be generated. By adjusting the voltage applied to regulator is varied thus maintaining a constant voltage drop across the regulator. The series regulator, part of another feedback loop, is made to alter its conduction to maintain a constant output voltage or current. Its conduction varies in accordance with feedback control signals obtained from the error amplifier. Notice that the series regulator provides fine and "fast" regulation of the output, while the preregulator handles large relative "slow" regulation demands. The dc current from the series regulator passes through a current sampling resistor before reaching the positive output terminal.

Figure 4-1. Overall Block Diagram



SECTION IV  
PRINCIPLES OF OPERATION



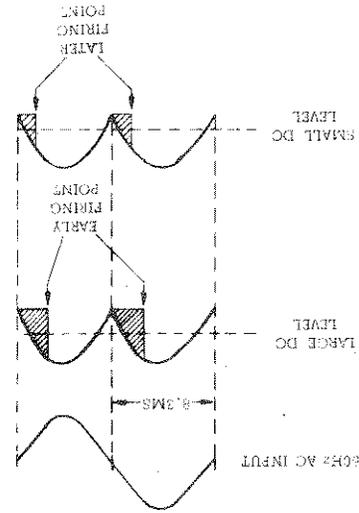
4-12 The inputs to the control circuit are algebraically summed across capacitor C22. All inputs contribute to the time required to charge C22. The input line voltage is rectified by CR9 and CR12, attenuated by voltage divider R100 and R101, and applied to the summing point at TP 66 via capacitor C22. Capacitor C23 is used for smoothing purposes. Resistor R82, connected between the minus output terminals and the summing point, furnishes a voltage drop which is proportional to the output voltage. Resistors R91 and R92 sample the voltage across the series transistor, Q6. Resistor R93 and capacitor C24 stabilize the control circuit feedback loop. Resistors R97 and R99 are the source of an offset current which varies with the output current. This offset current sustains a negative charging current to the summing capacitor ensuring that the SCR will fire at low output voltages.

4-13 The summation of the input signals results in the generation of a voltage waveform similar to that shown on Figure 4-4. The linear ramp portion of the waveform starts at zero volts (with no load connected and at full rated output voltage) and, when a certain negative threshold voltage is reached, the forward biases diodes CR16 and CR17. The negative voltage then is coupled to the base of transistor Q18. Transistors Q18 and Q19 form a squaring circuit similar to a Schmitt trigger configuration. Q18 is conducting, prior to firing time, due to the positive bias connected to its base through R94. Transistor Q19 is cutoff at this time because its base is connected directly to the collector of conducting transistor Q18. When the negative threshold voltage is reached, transistor Q18 is driven towards cutoff and transistor Q19 begins to conduct. This action is accelerated by speed-up capacitor C25 which couples a portion of the negative going collector voltage of Q19 back to the base of Q18. Thus the collector voltage of Q19 decays very rapidly as shown on Figure 4-4. The conduction of Q19 allows capacitor C17 to discharge rapidly through pulse transformer T2 resulting in the SCR firing pulse shown on the diagram. The firing pulse is relatively narrow (about 10µsec) because when Q19 reaches saturation the magnetic field surrounding T2 collapses driving the voltage in a negative direction.

4-14 Reset of the control circuit occurs once every 8.33 milliseconds when the rectified ac voltage at test point 65 recedes to a level at which diode CR15 becomes forward biased. Summing capacitor C22 is then allowed to completely discharge through CR15. Diodes CR16 and CR17 become reverse biased at reset and transistor Q18 reverts

4-10 The preregulator minimizes changes in the power dissipated by the series regulator due to output voltage, load current or input line voltage changes. Preregulation is accomplished by means of a phase control circuit utilizing an SCR (CR35) as the switching element. The SCR is fired once during each half-cycle (8.33 milliseconds) of the rectified ac (see Figure 4-3). Notice that when the SCR is fired at an early point during the half-cycle the dc level applied to the series regulator is fairly high. When the SCR is fired later during the cycle, the dc level is relative low.

Figure 4-3. SCR Phase Control Over DC Input Level



4-11 The SCR control circuit samples the input line voltage, the output voltage, and the voltage across the series transistor. It generates a firing pulse, at the time required, to fire the SCR so that the voltage across input capacitor C14 will be maintained at the desired level.

4-9 PREREGULATOR AND CONTROL CIRCUIT

4-8 DETAILED CIRCUIT ANALYSIS (Refer to Schematic at Rear of Manual).

the meter circuit block on Figure 4-2, allows the meter to read output voltage or current in one of two ranges. Figure 4-2 also shows the internal sources of bias and reference voltages and their nominal magnitudes with an input of 115 Vac and no load connected. Diode CR34, connected across the output terminals of the power supply, is a protective device which prevents internal damage that might occur if a reverse voltage were applied across the output terminals. Output capacitor, C20, stabilizes the feedback loop when the normal strapping pattern shown in Figure 4-2 is employed. Note that this capacitor can be removed if an increase in the programming speed is desired. Under these conditions, capacitor C19 serves to insure loop stability.

4-18 CONSTANT VOLTAGE INPUT CIRCUIT

4-19 The circuit consists of the programming resistor (R10) and a differential amplifier stage (Q1) and associated components). Transistor Q1 consists of two silicon transistors housed in a single package. The transistors have matched characteristics minimizing differential voltages due to mismatched stages. Moreover, drift due to thermal differentials is minimized, since both transistors operate at essentially the same temperature.

4-20 The constant voltage input circuit continuously compares a fixed reference voltage with a portion of the output voltage and, if a difference exists, produces an error voltage whose amplitude and phase is proportional to the difference. The error output is fed back to the series regulator, through OR gate diode CR3 and the mixer/error amplifiers. The error voltage changes the conduction of the series regulator which, in turn, alters the output voltage so that the difference between the two input voltages applied to the differential amplifier is reduced to zero. This action maintains the output voltage constant.

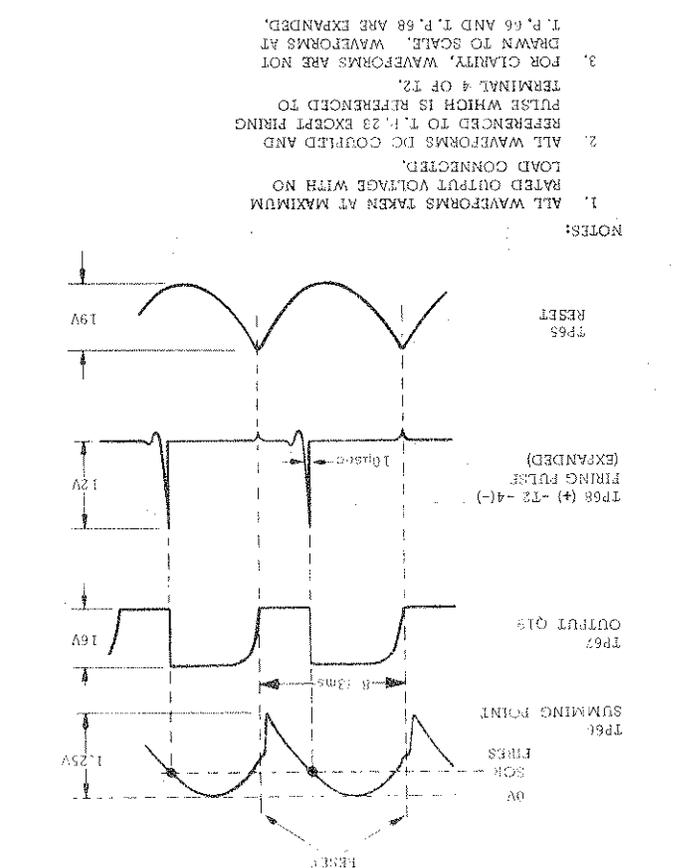
4-21 Stage Q1B of the differential amplifier is connected to a common (+S) potential through impedance equalizing resistor R5. Resistor R6 and R8 are used to zero bias the input stage, offsetting minor base to emitter voltage differences in Q1. The base of Q1A is connected to a summing point (A6) at the junction of the programming resistors and the current pullout resistor R12. Instantaneous changes in the output (due to load variations) or changes due to the manipulation of R10, result in an increase or decrease in the summing point potential. Q1A is then made to conduct more or less, in accordance with summing point voltage change. The resultant output "error" voltage is fed back to the series regulator via the remaining components of the feedback loop. Resistor R1, in series with the base Q1A, limits the current through the programming resistor during rapid voltage turn-down. Diodes CR1 and CR2 form a limiting network which prevents excessive voltage excursions from over driving stage Q1A. Capacitors C1 and C2, shunting the programming resistor, increase the high frequency gain of the input amplifier. Resistor R13, shunting pullout resistor R12, serves as a trimming adjustment for the programming current. Diode CR3, together with C7 and R9, improves the transient recovery time of the unit.

4-15 Capacitor C26, diode CR18, and resistor R98 form a long time constant network which achieves a slow turn-on characteristic. When the unit is first turned on, C26 provides a positive voltage to the cathode of CR16 to ensure that it is initially reverse biased. After C26 becomes fully charged, the control circuit is permitted to fire the SCR. Diode CR18 provides a discharge path for C26 when the unit is turned-off.

4-16 SERIES REGULATOR

4-17 The series regulator, (transistor Q6) serves as the series element, or pass transistor, which provides precise and fast control of the output. The conduction of Q6 is varied in accordance with feedback control signals obtained from driver Q4. Zener

Figure 4-4. Preregulator Control Circuit Waveforms



maintaining the constant voltage programming current constant.

4-22 CONSTANT CURRENT INPUT CIRCUIT

4-23 This circuit is similar in appearance and operation to the constant voltage input circuit. It consists of the coarse and fine current programming resistors (R16A and R16B), and a differential amplifier stage (Q2 and associated components). Like transistor Q1 in the voltage input circuit, Q2 consists of two transistors, having matched characteristics, that are housed in a single package.

4-24 The constant current input circuit continuously compares a fixed reference voltage with the voltage drop across the current sampling resistor. If a difference exists, the differential amplifier produces an "error" voltage which is proportional to this difference. The remaining components in the feedback loop (amplifiers and series regulator) function to maintain the drop across the current sampling resistor, and consequently the output current, at a constant value.

4-25 Stage Q2B is connected to +5 through impedance equalizing resistor R26. Resistors R25 and R28 are used to zero bias the input stage, offsetting minor base to emitter voltage differences in Q2. Instantaneous changes in output current on the positive line are felt at the current summing point (terminal A5) and, hence, the base of Q2A. Stage Q2A varies its conduction in accordance with the polarity of the change at the summing point. The change in Q2A's conduction also varies the conduction of Q2B due to the coupling effects of the common emitter resistor, R22. The error voltage is taken from the collector Q2B and ultimately varies the conduction of the series regulator.

4-26 Resistor R20, in conjunction with R21 and C3, helps stabilize the feedback loop. Diode CR5 helps stabilize voltage excursions on the base of Q2A. Resistor R19, shunting the pullout resistor, serves as a trimming adjustment for the programming current flowing through R16A and R16B.

4-27 VOLTAGE CLAMP CIRCUIT

4-28 The voltage clamp circuit keeps the constant voltage programming current relatively constant when the power supply is operating in the constant current mode. This is accomplished by clamping terminal A6, the voltage summing point, to a fixed bias voltage. During constant current operation the constant voltage programming resistor is a shunt load across the output terminals of the power supply. When the output voltage changes, the current through this resistor also tends to change. Since this programming current flows through the current sampling resistor, it is erroneously interpreted as a load change by the current input circuit. The clamp circuit eliminates this undesirable effect by

4-29 The voltage divider, R51, R52, and VR5, back biases CR30 and Q10 during constant voltage operation. When the power supply goes into constant current operation, CR30 becomes forward biased by the collector voltage of Q1A. This results in conduction of Q10 and the clamping of the summing point at a potential only slightly more negative than the normal constant voltage potential. Clamping this voltage at approximately the same potential that exists in constant voltage operation, results in a constant voltage across, and consequently a constant current through, the current pullout resistor (R12).

4-30 MIXER AND ERROR AMPLIFIERS

4-31 The mixer and error amplifiers amplify the error signal from the constant voltage or constant current input circuit to a level sufficient to drive the series regulator transistor. Transistor Q3 receives the error voltage input from either the constant voltage or constant current circuit via the OR-gate diode (CR3 or CR4) that is conducting at the time. Diode CR3 is forward biased, and CR4 reversed biased, during constant voltage operation. The reverse is true during constant current operation.

4-32 The RC network, composed of C5 and R30, is an equalizing network which provides for high frequency roll off in the loop gain response in order to stabilize the feedback loop. Error amplifier Q4 serves as the driver element for the series regulator.

4-33 REFERENCE CIRCUIT

4-34 The reference circuit is a feedback power supply similar to the main supply. It provides stable reference voltages which are used throughout the unit. The reference voltages are all derived from smoothed dc obtained from the full wave rectifier (CR22 and CR23) and filter capacitor C10. The constant voltage and current input circuits for comparison purposes, are developed across temperature compensated Zener diodes VR1 and VR2. Resistor R43 limits the current through the Zener diodes to establish an optimum bias level.

4-35 The regulating circuit consists of series regulating transistor Q9 and error amplifier Q8. Output voltage changes are detected by Q8 whose base is connected to the junction of a voltage divider (R41, R42) connected directly across the supply. Any error signals are amplified and inverted by Q8 and applied to the base of series transistor Q9. The series element then alters its conduction in the direction and by the amount necessary to maintain

4-37 The meter circuit provides continuous indications of output voltage or current on a single multiple range meter. The meter can be used either as a voltmeter or an ammeter depending upon the position of METER switch S2 on the front panel of the supply. This switch also selects one of two meter ranges on each scale. The metering circuit consists basically of a selection circuit (switch S2 and associated voltage dividers), a stable differential amplifier stage (Q11 through Q14), and the meter movement.

4-38 The selection circuit determines which voltage divider is connected to the differential amplifier input. When S2 is in one of the voltage positions, the voltage across the output of the supply) is the (connected across the output of the supply) is the input to the differential amplifier. When S2 is in one of the current positions, the voltage across divider R14, and R55 through R58 (connected across the sampling resistor) is the input to the differential amplifier. The amplified output of the differential amplifier is used to deflect the meter.

4-39 The differential amplifier is a stable device having a fixed gain of ten. Stage Q13 of the differential amplifier receives a negative voltage from the applicable voltage divider when S2 is in one of the voltage positions while stage Q11 is connected to the +S (common) terminal. With S2 in a current position, stage Q11 receives a positive voltage from the applicable voltage divider while stage Q13 is connected to the +S terminal. The differential output of the amplifier is taken from the collectors of Q12 and Q14. Transistor Q15 is a constant current source which sets up the proper bias current for the amplifier. Potentiometer R63 permits zeroing of the meter. The meter amplifier stage contains an inherent current limiting feature which protects the meter movement against overloads. For example, if METER switch S2 is placed in position A11, (low current range) when the power supply is actually delivering a higher amperage output, the differential amplifiers are quickly driven into saturation, limiting the current through the meter to a safe value.

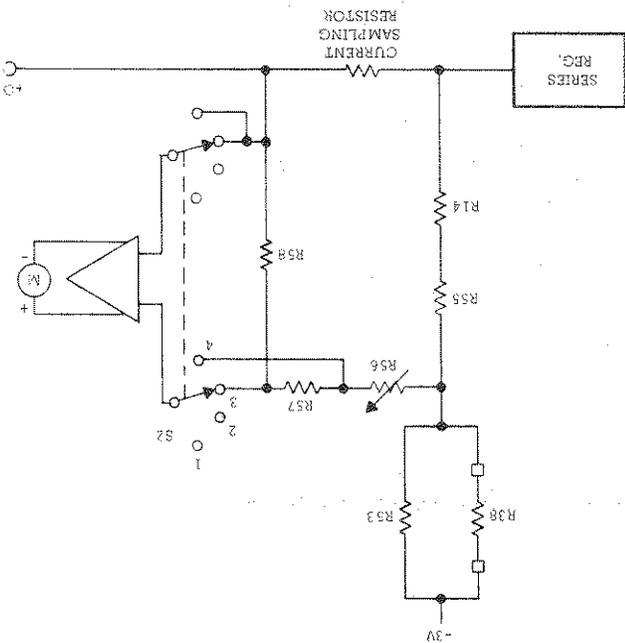
4-40 Figures 4-5 and 4-6 show the meter connections when S2 is in the higher voltage and current positions, respectively. For the sake of simplicity, some of the actual circuit components are not shown on these drawings. With METER switch S2 in the

4-36 METER CIRCUIT

the voltage across the supply constant. Resistor R46, the emitter resistor for Q8, is connected in a manner which minimizes changes in the reference voltage caused by variations in the input line. Output capacitor C9 stabilizes the regulator loop.

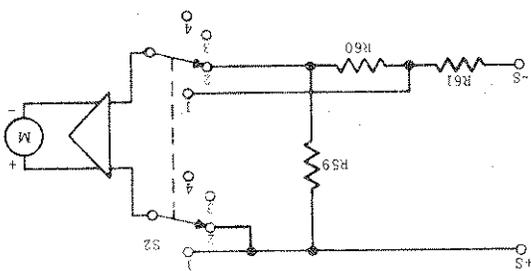
4-41 With S2 in the higher current range position (Figure 4-6) the voltage drop across R58 is applied to the meter amplifier and the meter indicates the output current which flows through R54. For low values of output current, S2 can be switched to position (4) and the voltage drop across R57 and R58 is applied to the meter amplifier.

Figure 4-6. Ammeter Connections, Simplified Schematic



higher voltage range, position (2), the voltage drop across R59 is the input to the meter amplifier and the meter indicates the output voltage across the +S and -S terminals. For low output voltages, S2 can be switched to position (1) resulting in the application of a larger percentage of the output voltage (drop across R59 and R60) to the meter amplifier.

Figure 4-5. Voltmeter Connections, Simplified Schematic



4-46 The rise in output voltage causes the voltage at A6 and thus the base of Q1A to decrease (go negative). Q1A now decreases its conduction and its collector voltage rises. The positive going error voltage is amplified and inverted by Q3 and fed to the base of series transistor Q6 via the emitter follower. The negative going input causes Q6 to decrease its conduction so that it drops more of the line voltage, and reduces the output voltage to its original level.

4-47 If the external load resistance is decreased to a certain crossover point, the output current increases until transistor Q2A begins to conduct. During this time, the output voltage has also decreased to a level so that the base of Q1A is at a high positive potential. With Q1A in full conduction, its collector voltage decreases by the amount necessary to reverse bias OR-gate diode CR3 and the supply is now in the constant current mode of operation. The crossover point at which constant current operation commences is determined by the setting of CURRENT control R16. The operation of the feedback loop during the constant current operating mode is similar to that during constant voltage operation except that the input to the differential amplifier comparison circuit is obtained from the current sampling resistor.

4-44 The series regulator feedback loop functions continuously to keep the output voltage constant, during constant voltage operation, and the output current constant, during constant current operation. For purposes of this discussion, assume that the unit is in constant voltage operation and that the programming resistor has been adjusted so that the supply is yielding the desired output voltage. Further assume that the output voltage instantaneously rises (goes positive) due to a variation in the external load circuit.

4-45 Note that the change may be in the form of a slow rise in the output voltage or a positive going ac signal. An ac signal is coupled to summing point A6 through capacitor C1 and a dc voltage is coupled to A6 through R10.

#### LOOP 4-43 OPERATION OF SERIES REGULATOR FEEDBACK

4-42 The -3 volt bias source provides an offset current to the meter circuit which compensates for the programming current that flows through the current sampling resistance. Resistor R38, mounted on stand-offs, is selected so that the offset current bucks out the programming current, allowing the ammeter to be zeroed.

| Type                         | Required Characteristics                                                             | Use                                         | Recommended Model           |
|------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------|-----------------------------|
| Differential Voltmeter       | Sensitivity: 1 mv full scale (min.). Input impedance: 10 megohms (min.).             | Measure DC voltages; calibration procedures | Ⓢ 3420 (See Note)           |
| Variable Voltage Transformer | Range: 90-130 volts. Equipped with voltmeter accurate within 1 volt.                 | Vary AC input                               | -----                       |
| AC Voltmeter                 | Accuracy: 2%. Sensitivity: 1 mv full scale deflection (min.).                        | Measure AC voltages and ripple.             | Ⓢ 403 B                     |
| Oscilloscope                 | Sensitivity: 100 $\mu$ v/cm. Differential input.                                     | Display transient response waveforms        | Ⓢ 140 A plus 1400A plug in. |
| Oscillator                   | Range: 5 cps to 600 Kc. Accuracy: 2%.                                                | Impedance checks                            | Ⓢ 200 CD                    |
| DC Voltmeter                 | Accuracy: 1%. Input resistance: 20,000 ohms/volt (min.).                             | Measure DC voltages                         | Ⓢ 412A                      |
| Repetitive Load Switch       | Rate: 60 - 400 Hz, 2 $\mu$ sec rise and fall time.                                   | Measure transient response.                 | See Figure 5-7              |
| Resistor                     | Value: See Paragraph 5-14. $\pm$ 5%, 75 watts                                        | Load Resistor                               | -----                       |
| Resistor                     | Value: 10 ohms, 1%, 200Watts (Model 6207B) 50 Watts (Model 6209B) 4-Terminal, 20ppm. | Current sampling                            | -----                       |
| Resistor                     | 1K, $\pm$ 1%, 2 watt non-inductive                                                   | Measure impedance                           | -----                       |
| Resistor                     | 100 ohms, $\pm$ 5%, 10 watt                                                          | Measure impedance                           | -----                       |
| Resistor                     | Value: See Paragraph 5-49. $\pm$ 0.1%, 5 watt.                                       | Calibrate programming current               | -----                       |
| Resistor                     | Value: See Paragraph 5-52. $\pm$ 0.1%, 5 watt.                                       | Calibrate programming current               | -----                       |
| Capacitor                    | 500 $\mu$ F, 50 wvdc                                                                 | Measure impedance.                          | -----                       |
| Decade Resistance Box        | Range: 0-150K (min.). Accuracy: 0.1% plus 1 ohm Make-before-break contacts.          | Measure programming coefficients.           | -----                       |

Table 5-1. Test Equipment Required

SECTION V  
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance check (Paragraph 5-10) should be made.

This check is suitable for incoming inspection. If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-28). After troubleshooting and repair (Paragraph 5-38), perform any necessary adjustments and calibrations (Paragraph 5-40).

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 general information regarding measurement techniques (Paragraph 5-3).

5-3 GENERAL MEASUREMENT TECHNIQUES

5-4 The measuring device must be connected across the sensing leads of the supply or as close to the output terminals as possible when measuring the output impedance, transient response, regulation, or ripple of the power supply in order to achieve valid measurements. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance several orders of magnitude greater than the supply impedance, thus invalidating the measurement.

5-5 The monitoring device should be connected to the +S and -S terminals (see Figure 3-2) or as shown in Figure 5-1. The performance characteristics should never be measured on the front terminals if the load is connected across the rear terminals. Note that when measurements are made at the front terminals, the monitoring leads are connected at A, not B, as shown in Figure 5-1. Failure to connect the measuring device at A will result in a measurement that includes the resistance of the leads between the output terminals and the point of connection.

5-6 For output current measurements, the current sampling resistor should be a four-terminal resistor. The four terminals are connected as shown in Figure 5-2. In addition, the resistor should be of the low noise, low temperature coefficient (less than 30 ppm/°C) type and should be used at no more than 5% of its rated power so that its temperature rise will be minimized.

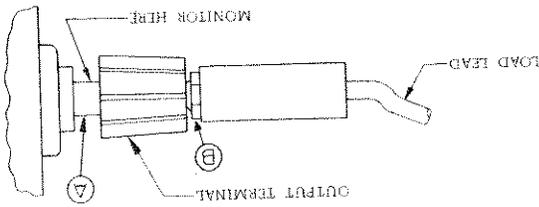


Figure 5-1. Front Panel Terminal Connections

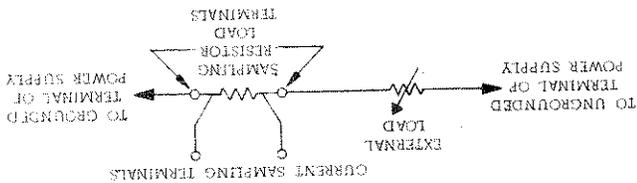


Figure 5-2. Output Current Measurement Technique

5-7 When using an oscilloscope, ground one terminal of the power supply and then ground the case of the oscilloscope to this same 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.

5-8 TEST EQUIPMENT REQUIRED

5-9 Table 5-1 lists the test equipment required to perform the various procedures described in this Section.

5-12 CONSTANT VOLTAGE TESTS

5-13 Rated Output and Meter Accuracy

5-14 Voltage. Proceed as follows:

- a. Connect load resistor across rear output terminals of supply. Resistor value is 800 ohms for Model 6207B or 3200 ohms for Model 6209B.
- b. Connect differential voltmeter across +S and -S terminals of supply observing correct polarity.
- c. Set METER switch to highest voltage range and turn on supply.
- d. Adjust VOLTAGE control until front panel meter indicates exactly the maximum rated output voltage.
- e. Differential voltmeter should indicate maximum rated output voltage within  $\pm 2\%$ .

5-15 Current. Proceed as follows:

- a. Connect test setup shown in Figure 5-4, leaving switch S1 open.

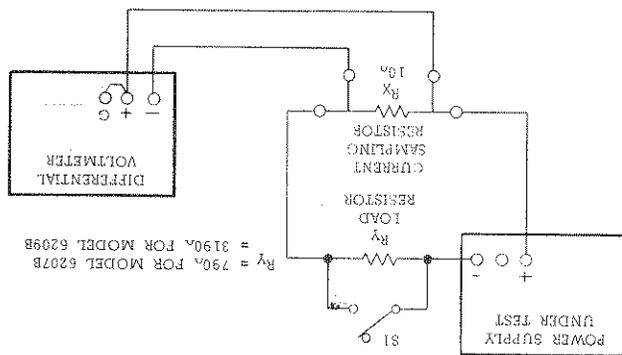


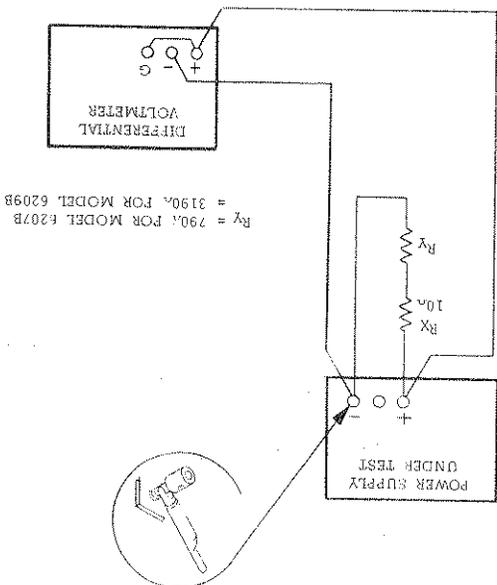
Figure 5-4. Output Current, Test Setup

- b. Turn CURRENT controls fully clockwise.
- c. Set METER switch to highest current range and turn on supply.
- d. Adjust VOLTAGE control until front panel meter indicates exactly the maximum rated output current.
- e. Differential voltmeter should read  $2.0 \pm 0.04$  Vdc for Model 6207B or  $1.0 \pm 0.02$  Vdc for Model 6209B.

5-16 Load Regulation. To check constant voltage load regulation, proceed as follows:

- a. Connect test setup as shown in Figure 5-5.
- b. Turn CURRENT controls fully clockwise.
- c. Set METER switch to highest current range and turn on supply.

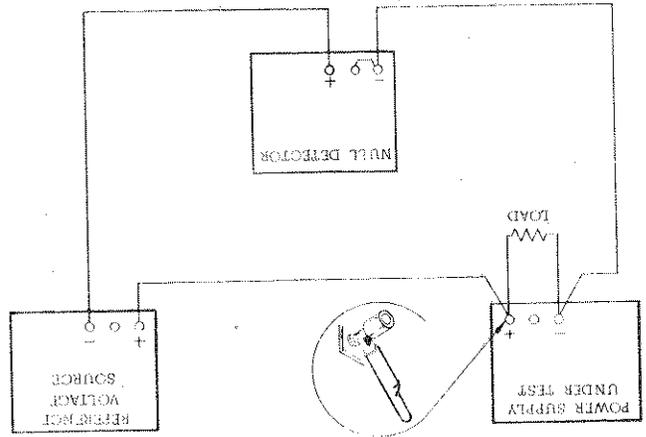
Figure 5-5. Load Regulation, Constant Voltage



- d. Adjust VOLTAGE control until front panel meter indicates exactly the maximum rated output voltage.
  - e. Read and record voltage indicated on differential voltmeter.
  - f. Disconnect load resistors.
  - g. Reading on differential voltmeter should not vary from reading recorded in step e by more than the following:
- | Model No. | Variation (mVdc) |
|-----------|------------------|
| 6207B     | $\pm 34$         |
| 6209B     | $\pm 66$         |
- 5-17 Line Regulation. To check the line regulation, proceed as follows:

- a. Connect variable auto transformer between input power source and power supply power input.
  - b. Turn CURRENT controls fully clockwise.
  - c. Connect test setup shown in Figure 5-5.
  - d. Adjust variable auto transformer for 105 VAC input.
  - e. Set METER switch to highest voltage range and turn on supply.
  - f. Adjust VOLTAGE control until front panel meter indicates exactly the maximum rated output voltage.
  - g. Read and record voltage indicated on differential voltmeter.
  - h. Adjust variable auto transformer for 125 VAC input.
  - i. Reading on differential voltmeter should not vary from reading recorded in step g by more than the following:
- | Model No. | Variation (mVdc) |
|-----------|------------------|
| 6207B     | $\pm 34$         |
| 6209B     | $\pm 66$         |

Figure 5-3. Differential Voltmeter Substitute, Test Setup



5-11 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated either to check the operation of the instrument after repairs or for periodic maintenance tests. The tests are performed using a 115-VAC 60 cps, single phase input power source. If the correct result is not obtained for a particular check, do not adjust any controls; proceed to troubleshooting (Paragraph 5-28).

5-10 PERFORMANCE TEST

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

CAUTION

A satisfactory substitute for a differential voltmeter is to arrange a reference voltage source and null detector as shown in Figure 5-3. 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. Examples of satisfactory null detectors are: a 419 A null detector, a DC coupled oscilloscope utilizing differential input, or a 50 mv meter movement with a 100 division scale. For the latter, a 2 mv change in voltage will result in a meter deflection of four divisions.

NOTE

|                   |                                   |                                                                             |                       |
|-------------------|-----------------------------------|-----------------------------------------------------------------------------|-----------------------|
| Recommended Model | Use                               | Required Characteristics                                                    | Type                  |
| -----             | Measure impedance.                | 500 $\mu$ l, 50 wdc                                                         | Capacitor             |
| -----             | Measure programming coefficients. | Range: 0-150K (min.), Accuracy: 0.1% plus 1 ohm Make-before-break contacts. | Decade Resistance Box |

5-24 CONSTANT CURRENT TESTS

5-25 Load Regulation. To check the load regulation, proceed as follows:

- Connect test setup as shown in Figure 5-4.
- Turn VOLTAGE control fully clockwise.
- Set METER switch to highest current range and turn on supply.
- Adjust CURRENT controls until front panel meter reads exactly the maximum rated output current.
- Read and record voltage indicated on differential voltmeter.
- Short out load resistor ( $R_L$ ) by closing switch S1.
- Reading on differential voltmeter should not vary from reading recorded in step e by more than 2mVdc.

5-26 Line Regulation. To check the line regulation proceed as follows:

- Utilize test setup shown in Figure 5-4 leaving switch S1 open throughout test.
- Connect variable auto transformer between input power source and power supply power input.
- Adjust auto transformer for 105 VAC input.
- Adjust CURRENT controls until front panel meter reads exactly the maximum rated output current.
- Read and record voltage indicated on differential voltmeter.
- Adjust variable auto transformer for 125 VAC input.
- Reading on differential voltmeter should not vary from reading recorded in step g by more than 2mVdc.

5-27 Ripple and Noise. To check the ripple and noise, proceed as follows:

- Use test setup shown in Figure 5-4, except connect AC voltmeter across sampling resistor instead of differential voltmeter.
- Rotate VOLTAGE control fully clockwise.
- Set METER switch to highest current range and turn on supply.
- Adjust CURRENT controls until front panel meter indicates exactly the maximum rated output current.
- Turn range switch on AC voltmeter to 1 mv position.
- The AC voltmeter should read less than 2mVac.

c. Adjust VOLTAGE control until front panel meter reads 20 volts (5 volts for Model 6203B supplies).

- Set AMPLITUDE control on Oscillator to 10 volts ( $E_{in}$ ), and FREQUENCY control to 100 cps.
- Record voltage across output terminals of the power supply ( $E_o$ ) as indicated on AC voltmeter.
- Calculate the output impedance by the following formula:  

$$Z_{out} = \frac{E_{in} - E_o}{E_o R}$$
- $E_o$  = rms voltage across power supply output terminals.
- $R = 1000$
- $E_{in} = 10$  volts

g. The output impedance ( $Z_{out}$ ) should be less than 0.020 ohms.

- Using formula of step f, calculate output impedance at frequencies of 50Kc and 500Kc. Values should be less than 0.5 ohm and 3.0 ohms, respectively.

5-22 OUTPUT INDUCTANCE

5-23 To check the output inductance, repeat steps a through f at frequencies of 10Kc, 50Kc and 100Kc. Calculate the output inductance ( $L$ ) using the following formula:

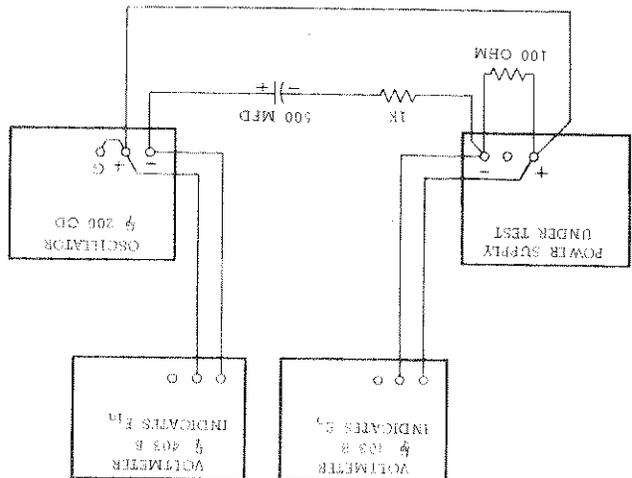
$$L = \frac{X_L}{2 \pi f} \quad (\text{See Note})$$

The oscillator frequency is equivalent to  $f$  in the equation. The output inductance should be less than 20 microhenries.

NOTE

The equation assumes that  $X_L$  is much greater than  $R_{out}$  and therefore  $X_L = Z_{out}$ .

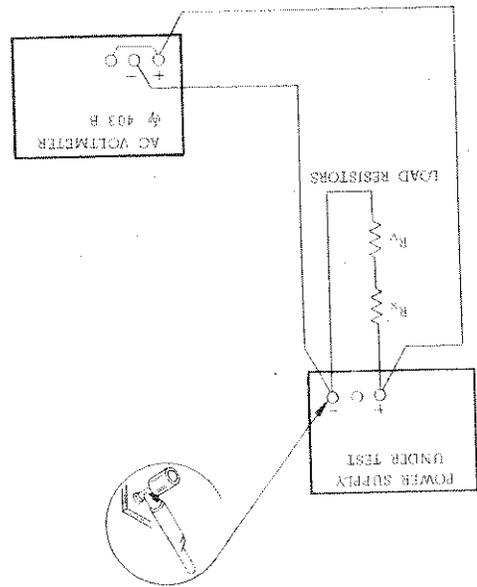
Figure 5-9. Output Impedance, Test Setup



- a. Connect test setup shown in Figure 5-7.
- b. Turn CURRENT controls fully clockwise.
- c. Set METER switch to highest current range and turn on supply.
- d. Adjust VOLTAGE control(s) until front panel meter indicates exactly the maximum rated output voltage.
- e. Close line switch on repetitive load switch setup.
- f. Adjust 25K potentiometer until a stable display is obtained on oscilloscope. Waveform

- a. Connect test setup shown in Figure 5-7.
- b. Turn CURRENT controls fully clockwise and adjust VOLTAGE control(s) until front panel meter indicates exactly the maximum rated output voltage.
- c. Set METER switch to highest current range.
- d. Turn CURRENT controls fully clockwise and adjust VOLTAGE control(s) until front panel meter indicates exactly the maximum rated output voltage.
- e. AC voltmeter should read less than 500μV rms for Model 6207B or less than 1mV rms for Model 6209B.

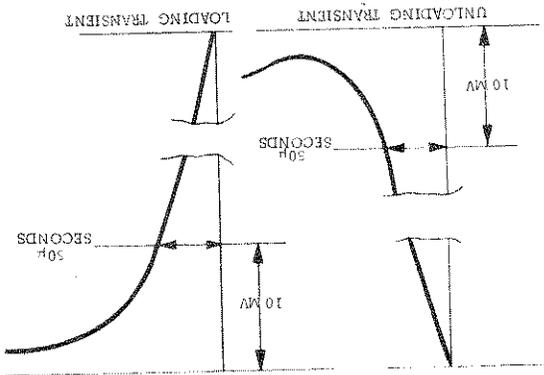
Figure 5-6. Ripple and Noise, Constant Voltage



- a. Retain test setup used for previous line regulation test except connect AC voltmeter across output terminals as shown in Figure 5-6.
- 5-18 Ripple and Noise. To check the ripple and noise, proceed as follows:

- a. Connect test setup shown in Figure 5-9.
  - b. Set METER switch to highest voltage range and turn on supply.
- 5-21 To check the output impedance, proceed as follows:
- 5-20 OUTPUT IMPEDANCE

Figure 5-8. Transient Recovery Time, Waveforms



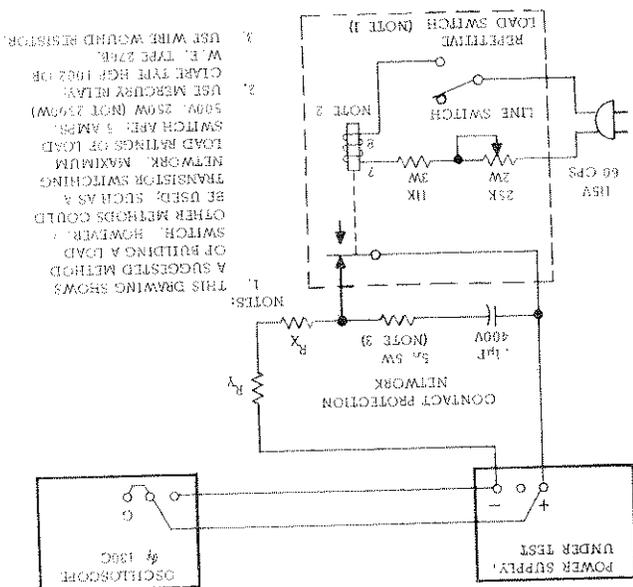
should be within the tolerances shown in Figure 5-8 (output should return to within 10mv of original value in less than 50 microseconds).

Figure 5-7. Transient Recovery Time, Test Setup

| MODEL NO. | RESISTANCE (OHMS) | R <sub>V</sub> | R <sub>K</sub> |
|-----------|-------------------|----------------|----------------|
| 6200B     | 1                 | 12             | 12             |
| 6201B     | 1                 | 12             | 12             |
| 6202B     | 2                 | 0.50           | 51             |
| 6203B     | 2                 | 0.50           | 51             |

| MODEL NO. | RESISTANCE (OHMS) | R <sub>V</sub> | R <sub>K</sub> |
|-----------|-------------------|----------------|----------------|
| 6204B     | 3                 | 30             | 30             |
| 6205B     | 3                 | 30             | 30             |
| 6206B     | 1                 | 10             | 10             |
| 6207B     | 10                | 10             | 10             |
| 6209B     | 10                | 10             | 10             |



| Step | Measure                         | Response                                              | Probable Cause                                                                                                                                                                               |
|------|---------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Voltage between TP23 and TP24   | a. 12V to 16V<br>b. Less than 12V or greater than 16V | a. Proceed to Step 2<br>b. Proceed to Table 5-5                                                                                                                                              |
| 2    | Disable Q2 by disconnecting CR4 | a. Normal output voltage<br>b. Low output voltage     | a. Constant Current circuit faulty; check CR4, Q2A, or R16 for short.<br>b. If supply is furnishing current without load, check CR34, C19, or C20 for short. If it is not, proceed to Step 3 |
| 3    | Voltage between 22 and 23       | a. More negative than 0V<br>b. More positive than 0V  | a. Q4 shorted<br>b. Q6 open<br>Proceed to Step 4                                                                                                                                             |
| 4    | Voltage between +S and A6       | a. More negative than 0V                              | a. Open strap A6 - A7<br>R10, C1 shorted<br>Proceed to Step 5                                                                                                                                |
| 5    | Voltage between +S and 12       | a. More positive than +4.3V<br>b. +2.7V to +4.3V      | a. Q1A open<br>Q1B or R3 shorted<br>b. Proceed to Step 6                                                                                                                                     |

Table 5-4. Low Output Voltage Troubleshooting

| Step | Measure                       | Response                                              | Probable Cause                                                                  |
|------|-------------------------------|-------------------------------------------------------|---------------------------------------------------------------------------------|
| 1    | Voltage between TP23 and TP24 | a. 12V to 16V<br>b. Less than 12V or greater than 16V | a. Proceed to Step 2<br>b. Proceed to Table 5-5                                 |
| 2    | Voltage between 22 and 23     | a. 0V or negative<br>b. More positive than 0V         | a. Q6 or VR3 shorted<br>b. Q4 open<br>Proceed to Step 3                         |
| 3    | Voltage between +S and A6     | a. 0V to +0.8V<br>b. More negative than 0V            | a. Open strap A7 - A8<br>R10 open<br>R12 or R13 shorted<br>b. Proceed to Step 4 |
| 4    | Voltage between +S and 12     | a. Less positive than +2.7V<br>b. +2.7V to +4.3V      | a. Q1A shorted<br>Q1B open<br>R3 open<br>b. Proceed to Step 5                   |
| 5    | Voltage between +S and 19     | a. Less negative than -0.6V                           | a. Q3 shorted<br>R33 shorted<br>Q17 shorted                                     |

Table 5-3. High Output Voltage Troubleshooting

5-28 TROUBLESHOOTING

5-29 Components within Hewlett-Packard power supplies are conservatively operated to provide maximum reliability. In spite of this, parts within a supply may fail. Usually the instrument must be immediately repaired with a minimum of "down time" and a systematic approach as outlined in succeeding paragraphs can greatly simplify and speed up the repair.

5-30 TROUBLE ANALYSIS

5-31 General. Before attempting to trouble shoot this instrument, ensure that the fault is with the instrument and not with an associated circuit. The performance test (Paragraph 5-10) enables this to be determined without having to remove the instrument from the cabinet.

5-32 Once it is determined that the power supply is at fault, check for obvious troubles such as open fuse, a defective power cable, or an input power failure. Next, remove the top and bottom covers (each held by four retaining screws) and inspect for open connections, charred components, etc. If the trouble source cannot be detected by visual inspection, follow the detailed procedure outlined in succeeding paragraphs. Once the defective component has been located (by means of visual inspection or trouble analysis) correct it and re-conduct the performance test. If a component is replaced, refer to the repair and replacement and adjustment and calibration paragraphs in this section.

5-33 A good understanding of the principles of

5-35 Series Regulator and Preregulator Feedback Circuits. Generally, malfunction of these two feedback circuits is indicated by high or low (or no) output voltage. If one of these situations

operation is a helpful aid in troubleshooting, and it is recommended that the reader review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, logical application of this knowledge used in conjunction with the normal voltage readings and waveforms shown on the schematic and the additional procedures given in the following paragraphs should suffice to isolate a fault to a component or small group of components. The normal voltages shown on the schematic are positioned adjacent to the applicable test points (identified by encircled numbers on the schematic and printed wiring boards). Additional test procedures that will aid in isolating troubles are as follows:

- a. Reference circuit check (Paragraph 5-34). This circuit provides critical operating voltages for the supply and faults in the circuit could affect the overall operation in many ways. This circuit should be checked first, before proceeding to other areas of the unit.
  - b. Series regulator and preregulator feedback loop checks (Paragraph 5-35).
  - c. Procedures for dealing with common troubles (Paragraph 5-36).
- 5-34 Reference Circuit.

- a. Make an ohmmeter check to be certain that neither the positive nor negative output terminal is grounded.
- b. Turn front-panel VOLTAGE and CURRENT controls fully clockwise (maximum).
- c. Turn-on power supply (no load connected).
- d. Proceed as instructed in Table 5-2.

Table 5-2. Reference Circuit Troubleshooting

| Step | Meter Common | Meter Positive | Normal Indication | If Indication Abnormal, Take This Action |
|------|--------------|----------------|-------------------|------------------------------------------|
| 1    | +S           | 33             | 6.2 ± 0.3vdc      | Check I2.4 volt bias or VR1              |
| 2    | +S           | 31             | 6.2 ± 0.3vdc      | Check I2.4 volt bias or VR2              |
| 3    | +S           | 37             | 12.4 ± 1.0vdc     | Check Q8, Q9, CR22, CR23, C10, T3        |

occur, disconnect the load and proceed as instructed in Table 5-3 or 5-4. Preregulator waveform are included on the schematic at the rear of the manual.

| Symptom                                        | Checks and Probable Causes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High Ripple                                    | <p>a. Check operating setup for ground loops.</p> <p>b. If output floating, connect 1µf capacitor between output and ground.</p> <p>c. Ensure that supply is not crossing over to constant current mode under loaded conditions.</p> <p>d. Check for low voltage across C14 or Q6.</p> <p>e. Check for excessive ripple on reference voltages. Peak-to-peak ripple should be less than 2mV for ±6.2V and less than 4mV for +12.4V.</p>                                                                                                                                                                                                                                                                                                                                      |
| Poor Line Regulation                           | <p>a. Check reference circuit (Paragraph 5-34).</p> <p>b. Check reference circuit adjustment (Paragraph 5-53).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Poor Load Regulation (Constant Voltage)        | <p>a. Measurement technique (Paragraph 5-16).</p> <p>b. Check the regulation characteristics of Zener diode VR1 as follows:<br/>                     (1) Connect differential voltmeter across VR1.<br/>                     (2) Connect appropriate load resistor (Ry), given in Figure 5-5, across (+) and (-) output terminals.<br/>                     (3) Perform steps b through f of Paragraph 5-16.<br/>                     (4) If the differential voltmeter reading varies by more than 1.2mV, replace VR1.</p> <p>c. Ensure that supply is not going into current limit. Check constant current input circuit.</p>                                                                                                                                             |
| Poor Load Regulation (Constant Current)        | <p>a. Check the regulation characteristics of Zener diode VR2 as follows:<br/>                     (1) Connect differential voltmeter across VR2.<br/>                     (2) Connect appropriate load resistor (Ry), given in Figure 5-5, across (+) and (-) output terminals.<br/>                     (3) Perform steps b through f of Paragraph 5-25.<br/>                     (4) If the differential voltmeter reading varies by more than the following, replace VR1:<br/>                     6207B 6mV<br/>                     6209B 12mV</p> <p>b. C19, C20, and CR34 leaky.</p> <p>c. Check clamp circuit Q10, CR30, VR5, and CR32.</p> <p>d. Ensure that supply is not crossing over to constant voltage operation. Check constant voltage input circuit.</p> |
| Oscillates (Constant Voltage/Constant Current) | <p>a. Check C5 for open, adjustment of R30 (Paragraph 5-56).</p> <p>b. Check R20, C3 in constant current input circuit.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Poor Stability (Constant Voltage)              | <p>a. Noisy programming resistor R10.</p> <p>b. CR1, CR2 leaky.</p> <p>c. Check R1, R12, R13, C2 for noise or drift.</p> <p>d. Stage Q1 defective.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Poor Stability (Constant Current)              | <p>a. Noisy programming resistor R16.</p> <p>b. CR5, CR34, C20, C3 leaky.</p> <p>c. Check R18, R19, R20, R21, R54, for noise or drift.</p> <p>d. Stage Q2 defective.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

Table 5-6. Common Troubles

5-36 Common Troubles. Table 5-6 lists the symptoms, checks, and probable causes for common troubles.

5-37 REPAIR AND REPLACEMENT

5-38 Before servicing a printed wiring board, refer to Figure 5-10. Section VI of this manual contains and adjustments that may be necessary.

Before replacing a list of replaceable parts. Before replacing a semiconductor device, refer to Table 5-7 which lists the special characteristics of selected semiconductors. If the device to be replaced is not listed in Table 5-7, the standard manufacturers part number listed in Section VI is applicable. After replacing a semiconductor device, refer to Table 5-8 for checks and adjustments that may be necessary.

| Step | Measure                        | Response                                                 | Probable Cause                                                                                                                                                                          |
|------|--------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | Waveform between 4 and 3 of T2 | a. Normal firing pulse<br>b. No firing pulse             | a. CR35 defective<br>R102 open<br>R84, L1, CR28, CR29, T1 defective<br>b. T2 open<br>Proceed to Step 2                                                                                  |
| 2    | Waveform between 23 and 67     | a. 0 Volts<br>b. +16 Volt level<br>c. Waveform distorted | a. Q19 shorted<br>C17 or C25 shorted<br>Q18 open<br>R96, primary T2 open<br>Proceed to Step 3<br>b. Q19 open<br>R96 shorted<br>Q18 shorted<br>Proceed to Step 3<br>c. Proceed to Step 3 |
| 3    | Waveform between 23 and 66     | a. Amplitude incorrect<br>b. Period incorrect            | a. C22, CR16, or CR17 defective<br>R91 thru R93, R97 thru R99 incorrect value or open<br>Proceed to Step 5<br>b. CR15 defective<br>Proceed to Step 4                                    |
| 4    | Waveform between 23 and 65     | a. Amplitude incorrect<br>b. Period incorrect            | a. CR13, CR14, CR15 defective<br>b. CR10, CR11 defective                                                                                                                                |
| 5    | Waveform between 23 and 64     | a. Amplitude incorrect<br>b. Period incorrect            | a. R100, R101, C23 defective<br>b. CR9, CR12 defective                                                                                                                                  |

Table 5-5. Preregulator/Control Circuit Troubleshooting

| Step | Measure                   | Response                    | Probable Cause                             |
|------|---------------------------|-----------------------------|--------------------------------------------|
| 6    | Voltage between +S and 19 | a. More negative than -0.6V | a. Q3 open<br>R33 open or high<br>Q17 open |

Table 5-4. Low Output Voltage Troubleshooting (Continued)

| Reference | Function                                | Check                                                                   | Adjust             |
|-----------|-----------------------------------------|-------------------------------------------------------------------------|--------------------|
| Q1        | Constant voltage differential amplifier | Constant voltage (CV) line and load regulation.<br>Zero volt output.    | R6 or R8           |
| Q2        | Constant current differential amplifier | Constant current (CC) line and load regulation.<br>Zero current output. | R25 or R28         |
| Q3, Q4    | Mixer and error amplifier               | CV/CC load regulation.<br>CV transient response.                        | R30                |
| Q6        | Series regulator                        | CV/CC load regulation.                                                  |                    |
| Q8, Q9    | Reference regulator                     | Reference circuit line regulation.                                      | R46                |
| Q10       | Clamp circuit                           | CC load regulation.                                                     |                    |
| Q11-15    | Meter circuit                           | Meter zero, Voltmeter/ammeter tracking.                                 | R63, R72, R56, R38 |
| Q18, Q19  | SCR control amplifiers                  | Voltage across Q6                                                       | R99                |
| CR1, CR2  | Limiting diodes                         | CV load regulation.                                                     |                    |

Table 5-8. Checks and Adjustments After Replacement of Semiconductor Devices

| Reference Designator      | Characteristics                                                                                                                      | Stock No. | Suggested Replacement |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------|
| Q1                        | Matched differential amplifier, NPN Si Planar, 70 (min.) hFE, $I_{CQ} = 1\text{ma}$ , $V_{CE} = 5\text{V}$ , $V_{CBO} = 5\text{V}$ . | 1854-0229 | 2N2917 G.E.           |
| Q2                        | Matched differential amplifier, NPN Si.                                                                                              | 1854-0221 | 2N4045 Union Carbide  |
| CR1, CR2-25, CR3, CR4     | Si. rectifier, 900ma, 200prv                                                                                                         | 1901-0327 | 1N5059 G.E.           |
| CR2-5, CR9-15, CR17, CR18 | Si. rectifier, 200ma, 180prv                                                                                                         | 1901-0033 | 1N485B Sylvania       |
| CR7                       | Si. diode, 10V, 400mw                                                                                                                | 1901-0460 | 1N4830 G.E.           |
| CR8, CR16                 | Si. rectifier, 400mw, 10prv                                                                                                          | 1901-0461 | 1N4828 G.E.           |
| VR3                       | Zener Diode, 40.2V, 1.5w                                                                                                             | 1902-0431 | 1N3803 Motorola       |
| VR4                       | Zener Diode, 16.2V, 400mw                                                                                                            | 1902-0184 | 1N966 Motorola        |
| VR5                       | Zener Diode, 4.22V, 400mw                                                                                                            | 1902-3070 | 1N749 Motorola        |

Table 5-7. Selected Semiconductor Characteristics

Figure 5-10. Servicing Printed Wiring 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.
3. Bend clean tinned lead 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.

If hole does not have an eyelet, insert a #57 drill from conductor side of board.

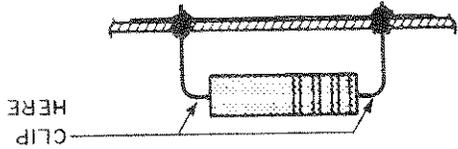
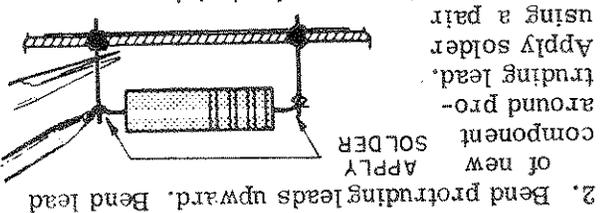
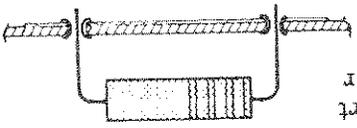
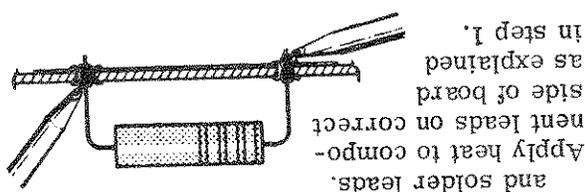
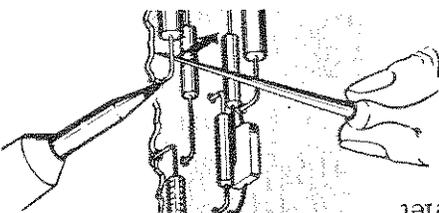
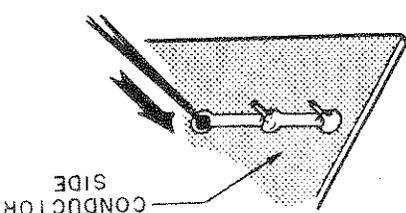
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole.

Apply heat to component leads on correct side of board as explained in step 1.

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. It is not used within the factory.

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.

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

5-36 Common Troubles. Table 5-6 lists the symptoms, checks, and probable causes for common troubles.

5-37 REPAIR AND REPLACEMENT

5-38 Before servicing a printed wiring board, refer to Figure 5-10. Section VI of this manual contains a list of replaceable parts. Before replacing a

semiconductor device, refer to Table 5-7 which lists the special characteristics of selected semiconductors. If the device to be replaced is not listed in Table 5-7, the standard manufacturers part number listed in Section VI is applicable. After replacing a semiconductor device, refer to Table 5-8 for checks and adjustments that may be necessary.

## 5-41 METER ZERO

5-42 Proceed as follows to zero meter:

- Turn off instrument (after it has reached normal operating temperature) and allow 30 seconds for all capacitors to discharge.

- Insert sharp pointed object (pen point or awl) into the small indentation near top of round black plastic disc located directly below meter face.
- Rotate plastic disc clockwise (cw) until meter reads zero, then rotate ccw slightly in order to free adjustment screw from meter suspension.

If pointer moves, repeat steps b and c.

## 5-43 VOLTMEETER TRACKING

5-44 To calibrate voltmeter tracking, proceed as follows:

- To electrically zero meter, set METER switch to highest current position and, with supply on and no load connected, adjust R63 until front panel meter reads zero.

- Connect differential voltmeter across supply, observing correct polarity.

- Set METER switch to highest voltage range and turn on supply. Adjust VOLTAGE control until differential voltmeter reads exactly the maximum rated output voltage.

- Adjust R72 until front panel meter also indicates maximum rated output voltage.

## 5-45 AMMETER TRACKING

5-46 To calibrate ammeter tracking proceed as follows:

- If meter has not been electrically zeroed, perform step a of paragraph 5-44.

- Turn VOLTAGE control fully clockwise, and set METER switch to low current range.

- Connect decade resistance box in place of R38.

- Turn on supply (no load connected) and rotate CURRENT controls fully ccw.

- Adjust decade resistance so that ammeter reads zero.

## 5-47 CONSTANT VOLTAGE PROGRAMMING CURRENT

5-48 To calibrate the zero volt programming accuracy, proceed as follows:

- Adjust R56 until front panel meter reads exactly the maximum rated output current.

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

- Short out voltage control by connecting jumper between terminals A6 and -S.

- Rotate CURRENT controls fully clockwise and turn on supply.

- Observe reading on differential voltmeter. If it is more positive than 0 volts, shunt resistor R6 with decade resistance box.

- Adjust decade resistance until differential voltmeter reads zero, then shunt R6 with resistance value equal to that of the decade resistance.

- If reading of step d is more negative than 0 volts, shunt resistor R8 with the decade resistance box.

5-49 To calibrate the constant voltage programming current, proceed as follows:

- Connect a 0.1%, 48K resistor (96K for Model 6209B) between terminals -S and A6 on rear barrier strip.

- Disconnect jumper between A7 and A8 (leaving A6 and A7 jumpered) on rear terminal barrier strip.

- Connect a decade resistance in place of R13.

- Connect a differential voltmeter between +S and -S and turn on supply.

- Adjust decade resistance box so that differential voltmeter indicates maximum rated output voltage within  $\pm 1.6$ Vdc for Model 6207B or 3.2Vdc for Model 6209B.

- Replace decade resistance with resistor of appropriate value in R13 position.

## 5-50 CONSTANT CURRENT PROGRAMMING

5-51 To calibrate the zero current programming accuracy proceed as follows:

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

- Short out current controls by connecting jumper between terminals A1 and A5.

- Rotate VOLTAGE control(s) fully clockwise and turn on supply.

- Observe reading on differential voltmeter. If it is more positive than 0 volts, shunt resistor R25 with a decade resistance box.

- Adjust decade resistance until differential voltmeter reads zero, then shunt R25 with resistance value equal to that of decade resistance.

- If reading of step d is more negative than 0 volts, shunt resistor R28 with decade resistance.

- Adjust decade resistance until differential voltmeter reads zero, then shunt R28 with resistance value equal to that of decade box.

|                |           |                                              |
|----------------|-----------|----------------------------------------------|
| Control Device | Paragraph | Adjustment or Calibration                    |
| Pointer        | 5-41      | Meter Zero                                   |
| R63 and R72    | 5-43      | Voltmeter Tracking                           |
| R63, R38, R56  | 5-45      | Ammeter Tracking                             |
| R6 or R8       | 5-48      | "Zero" Volt Output                           |
| R13            | 5-49      | "Voltage" Programming Current                |
| R25 or R28     | 5-51      | "Zero" Current Output                        |
| R19            | 5-52      | "Current" Programming Current                |
| R46            | 5-54      | Reference Circuit Line Regulation Adjustment |
| R30            | 5-55      | Transient Response                           |
| R99            | 5-57      | Preregulator Tracking                        |

Table 5-9. Calibration Adjustment Summary

5-39 ADJUSTMENT AND CALIBRATION

5-40 Adjustment and calibration may be required after performance testing, troubleshooting, or repair and replacement. Perform only those adjustments that affect the operation of the faulty circuit and no others. Table 5-9 summarizes the adjustments and calibrations contained in the following paragraphs.

| Reference              | Function                          | Check                                                                      | Adjust |
|------------------------|-----------------------------------|----------------------------------------------------------------------------|--------|
| CR3, CR4, CR5          | OR-gate diodes and limiting diode | CV/CC load regulation.                                                     |        |
| CR7, CR8               | Forward bias regulator            | Voltage across each diode.                                                 |        |
| CR22, CR25, CR24, CR29 | Rectifier diodes                  | Voltage across appropriate filter capacitor.                               |        |
| CR34                   | Protection diode                  | Output voltage                                                             |        |
| VR1                    | Positive reference voltage        | Positive reference voltage (+6.2V).                                        |        |
| VR2                    | Negative reference voltage        | Negative reference voltage (-6.2V).                                        |        |
| VR3                    | Protection diode                  | Short circuit supply. When short is removed, unit should operate normally. |        |
| VR4                    | Bias regulator                    | Voltage across C6                                                          |        |

Table 5-8. Checks and Adjustments After Replacement of Semiconductor Devices (Continued)

indicated by differential voltmeter does not change more than 0.2mVdc as input line voltage is varied from 105 to 125Vac.

g. Replace decade resistance with appropriate value resistor in R46 position.

5-55 CONSTANT VOLTAGE TRANSIENT RESPONSE

5-56 To adjust the transient response, proceed as follows:

a. Connect test setup as shown in Figure 5-7.

b. Repeat steps a through e as outlined in Paragraph 5-19.

c. Adjust R30 so that the transient response is as shown in Figure 5-8.

5-57 PREREGULATOR TRACKING

5-58 To adjust the preregulator, proceed as follows:

5-59

a. Connect decade resistance in place of R99.

b. Turn on supply and adjust VOLTAGE control for maximum rated output voltage (no load connected).

c. Connect dc voltmeter across series regulator (TP23 to TP24).

d. Adjust decade resistance so that dc voltmeter reads 15Vdc.

e. Replace decade resistance with appropriate resistor in R99 position.

5-52 To calibrate the constant current programming current, proceed as follows:

a. Connect power supply as shown in Figure 5-4.

b. Remove strap between A3 and A4 (leaving A4 and A5 jumpered).

c. Connect a 0.1%, 15K resistor between A1 and A5.

d. Connect decade resistance box in place of R19.

e. Set METER switch to highest current range and turn on supply.

f. Adjust the decade resistance so that the differential voltmeter indicates  $2.0 \pm 0.04$ Vdc for Model 6207B or  $1.0 \pm 0.02$ Vdc for Model 6209B.

g. Replace decade resistance with appropriate value resistor in R19 position.

5-53 REFERENCE CIRCUIT ADJUSTMENTS

5-54 Line Regulation. To adjust the line regulation capabilities of the instrument proceed as follows:

a. Connect the differential voltmeter between +S (common) and 33 (positive).

b. Connect variable voltage transformer between supply and input power source.

c. Adjust line to 105 VAC.

d. Connect decade resistance in place of R46.

e. Turn on supply and adjust VOLTAGE control for maximum rated output voltage.

f. Adjust decade resistance so that voltage

SECTION VI  
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts.

6-3 Table 6-4 lists parts in alpha-numerical order of the reference designators and provides the following information:

- a. Reference Designators. For abbreviations, refer to Table 6-1.
- b. Description. Refer to Table 6-2 for abbreviations.
- c. Total Quantity (TQ) used in the instrument; given only first time the part number is listed.

- d. Manufacturer's part number.
- e. Manufacturer's code number. Refer to Table 6-3 for manufacturer's name and address.
- f. 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 Miscellaneous.

6-4 ORDERING INFORMATION

6-5 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).

6-6 Specify the following information for each part:

- a. Model and complete serial number of instrument.
- b. Hewlett-Packard part number.
- c. Circuit reference designator.
- d. Description.

6-7 To order a part not listed in Table 6-4, give a complete description of the part and include its function and location.

Table 6-1. Reference Designators

|               |                  |
|---------------|------------------|
| A = assembly  | CR = diode       |
| B = motor     | DS = device,     |
| C = capacitor | signaling (lamp) |

Table 6-1. Reference Designators (Continued)

|                      |                  |
|----------------------|------------------|
| E = misc. electronic | RT = thermistor  |
|                      | S = switch       |
|                      | T = transformer  |
|                      | V = vacuum tube, |
|                      | neon bulb,       |
|                      | photo cell, etc. |
|                      | X = socket       |
|                      | XF = fuseholder  |
|                      | XDS = lampholder |
| R = resistor         | Z = network      |

Table 6-2. Description Abbreviations

|                               |                                            |
|-------------------------------|--------------------------------------------|
| a = amperes                   | abd = order by description                 |
| c = carbon                    | tion                                       |
| cer = ceramic                 | p = peak                                   |
| coef = coefficient            | pc = printed circuit board                 |
| com = common                  | pt = picofarads = 10 <sup>-12</sup> farads |
| comp = composition            | pp = peak-to-peak                          |
| conn = connection             | ppm = parts per million                    |
| crt = cathode-ray tube        | pos = position(s)                          |
| dep = deposited               | pot = potentiometer                        |
| elect = electrolytic          | prv = peak reverse voltage                 |
| encap = encapsulated          | rect = rectifier                           |
| f = farads                    | rot = rotary                               |
| fxd = fixed                   | rms = root-mean-square                     |
| GE = germanium                | s-b = slow-blow                            |
| gnd = ground(ed)              | sect = section(s)                          |
| h = henries                   | SI = silicon                               |
| Hg = mercury                  | sil = silver                               |
| imp = impregnated             | sl = slide                                 |
| ins = insulation(ed)          | td = time delay                            |
| K = kilo = 1000               | TIQ = titanium dioxide                     |
| ln = linear taper             | tol = tolerance                            |
| log = logarithmic             | trim = trimmer                             |
| MA = milli = 10 <sup>-3</sup> | trav = traveling wave                      |
| M = megohms                   | var = variable                             |
| ma = milliamperes             | w/ = with                                  |
| μ = micro = 10 <sup>-6</sup>  | W = watts                                  |
| mfr = manufacturer            | w/o = without                              |
| mtg = mounting                | cmo = cabinet mount                        |
| my = mylar                    | only                                       |
| NO = normally open            |                                            |
| Ne = neon                     |                                            |
| NC = normally closed          |                                            |

Table 6-3. Code List of Manufacturers

| CODE NO. | MANUFACTURER ADDRESS                                                                                                   |
|----------|------------------------------------------------------------------------------------------------------------------------|
| 06812    | Torrington Mfg. Co., West Div.<br>Van Nuys, Calif.                                                                     |
| 07137    | Transistor Electronics Corp.<br>Minneapolis, Minn.                                                                     |
| 07138    | Westinghouse Electric Corp.<br>Electronic Tube Div. of<br>Elmira, N.Y.                                                 |
| 07263    | Fairchild Semiconductor Div. of<br>Fairchild Camera and Instrument Corp.<br>Mountain View, Calif.                      |
| 07387    | Bircher Corp., The<br>Los Angeles, Calif.                                                                              |
| 07397    | Sylvania Electric Products Inc.<br>Mountain View Operations of<br>Sylvania Electronic Systems<br>Mountain View, Calif. |
| 07716    | International Resistance Co.<br>Burlington, Iowa                                                                       |
| 07910    | Continental Device Corp. Hawthorne, Calif.                                                                             |
| 07933    | Raytheon Mfg. Co., Semiconductor Div.<br>Mountain View, Calif.                                                         |
| 08530    | Reliance Mica Corp.<br>Brooklyn, N.Y.                                                                                  |
| 08717    | Sloan Company<br>Sun Valley, Calif.                                                                                    |
| 08730    | Vemaline Products Co. Franklin Lakes, N.J.                                                                             |
| 08863    | Nylomatic Corp.<br>Morrisville, Pa.                                                                                    |
| 09182    | Hewlett-Packard Co., Harrison Division<br>Berkeley Heights, N. J.                                                      |
| 09353    | C & K Components<br>Newton, Mass.                                                                                      |
| 11236    | GTS of Berne, Inc.<br>Berne, Ind.                                                                                      |
| 11237    | Chicago Telephone of California, Inc.<br>So. Pasadena, Calif.                                                          |
| 11711    | General Instrument Corp., Semiconductor<br>Prod. Group, Rectifier Div. Newark, N.J.                                    |
| 12136    | Philadelphia Handle Co., Inc.<br>Camden, N.J.                                                                          |
| 12697    | Clarostat Mfg. Co.<br>Dover, N.H.                                                                                      |
| 14493    | Hewlett-Packard Co.,<br>Loveland Division<br>Loveland, Colo.                                                           |
| 14655    | Cornell-Dubilier Elec. Corp. Newark, N.J.                                                                              |
| 14936    | General Instrument Corp., Semiconductor<br>Prod. Group, Semiconductor Div.<br>Hicksville, N.Y.                         |
| 15909    | Daven Div. of Thos. Edison Industries,<br>McGraw Edison Co.<br>Livingston, N.J.                                        |
| 16299    | Corning Glass Works,<br>Electronic Components Div.<br>Raleigh, N.C.                                                    |
| 16758    | Delco Radio Div. of General Motors Corp.<br>Kokomo, Ind.                                                               |
| 17545    | Atlantic Semiconductors, Inc.<br>Asbury Park, N.J.                                                                     |

| CODE NO. | MANUFACTURER ADDRESS                                                                            |
|----------|-------------------------------------------------------------------------------------------------|
| 00629    | EBY Sales Co.<br>New York, N.Y.                                                                 |
| 00656    | Aerovox Corp.<br>New Bedford, Mass.                                                             |
| 00853    | Sangamo Electric Company,<br>OrdIII Division (Capacitors) Marion, Ill.                          |
| 01121    | Allen Bradley Co.<br>Milwaukee, Wis.                                                            |
| 01255    | Litton Industries, Inc.<br>Beverly Hills, Calif.                                                |
| 01281    | TRW Semiconductors, Inc.<br>Lawndale, Calif.                                                    |
| 01295    | Texas Instruments, Inc. Semiconductor-<br>Components Division<br>Dallas, Texas                  |
| 01686    | RCL Electronics, Inc. Manchester, N. H.                                                         |
| 01930    | Amerock Corp.<br>Rockford, Ill.                                                                 |
| 02114    | Ferroxcube Corp. of America<br>Saugerties, N. Y.                                                |
| 02606    | Fenwal Laboratories<br>Morton Grove, Ill.                                                       |
| 02660    | Amphenol-Borg Electronics Corp.<br>Broadview, Ill.                                              |
| 02735    | Radio Corp. of America, Commercial<br>Receiving Tube and Semiconductor Div.<br>Somerville, N.J. |
| 03508    | G. E. Semiconductor Products Dept.<br>Syracuse, N. Y.                                           |
| 03797    | Eidema Corp.<br>Compton, Calif.                                                                 |
| 03877    | Transition Electronic Corp.<br>Wakefield, Mass.                                                 |
| 03888    | Pyrofilm Resistor Co. Cedar Knolls, N.J.                                                        |
| 04009    | Arrow, Hart and Hegeman Electric Co.<br>Hartford, Conn.                                         |
| 04072    | ADC Electronics, Inc. Harbor City, Calif.                                                       |
| 04213    | Caddell-Burns Mfg. Co. Inc.<br>Mineola, N. Y.                                                   |
| 04404    | Dymec Division of<br>Hewlett-Packard Co. Palo Alto, Calif.                                      |
| 04713    | Motorola, Inc., Semiconductor<br>Products Division<br>Phoenix, Arizona                          |
| 05277    | Westinghouse Electric Corp.<br>Semi-Conductor Dept. Youngwood, Pa.                              |
| 05347    | Ultronic, Inc.<br>Grand Junction, Colo.                                                         |
| 06486    | North American Electronics, Inc.<br>Lynn, Mass.                                                 |
| 06540    | Amathom Electronic Hardware Co., Inc.<br>New Rochelle, N. Y.                                    |
| 06555    | Beebe Electrical Instrument Co., Inc.<br>Penacook, N. H.                                        |
| 06666    | General Devices Co., Inc.<br>Indianapolis, Ind.                                                 |
| 06751    | Nuclear Corp. of America, Inc.,<br>Phoenix, Arizona                                             |

| CODE NO. | MANUFACTURER                                                      | ADDRESS                |
|----------|-------------------------------------------------------------------|------------------------|
| 73138    | Helipot Div. of Beckman Instruments, Inc.                         | Fulerton, Calif.       |
| 73293    | Hughes Components Division of Hughes Aircraft Co.                 | Newport Beach, Calif.  |
| 73445    | Amperex Electronic Co., Div. of North American Phillips Co., Inc. | Hicksville, N.Y.       |
| 73506    | Bradley Semiconductor Corp.                                       | New Haven, Conn.       |
| 73559    | Carling Electric, Inc.                                            | Hartford, Conn.        |
| 73734    | Federal Screw Products, Inc.                                      | Chicago, Ill.          |
| 73978    | Hardwick Handle Co.,                                              |                        |
| 74193    | Memcor Components Div. Huntington, Ind.                           |                        |
| 74545    | Harvey Hubbel, Inc.                                               | Bridgeport, Conn.      |
| 74868    | FXR Div. of Amphenol-Borg                                         |                        |
| 75042    | International Resistance Co.                                      | Danbury, Conn.         |
| 75183    | Howard B. Jones Div. of Cinch Mfg. Corp.                          | Philadelphia, Pa.      |
| 75382    | Kuika Electric Corp.                                              | New York, N.Y.         |
| 75915    | Littlefuse, Inc.                                                  | Des Plaines, Ill.      |
| 76493    | J. W. Miller Co.                                                  | Los Angeles, Calif.    |
| 76854    | Oak Manufacturing Co.                                             | Crystal Lake, Ill.     |
| 77068    | Bendix Corp., Bendix-Pacific Div.                                 | No. Hollywood, Calif.  |
| 77221    | Phaeatron Instrument and Electronic Co.                           | South Pasadena, Calif. |
| 77252    | Philadelphia Steel and Wire Corp.                                 | Philadelphia, Pa.      |
| 77342    | American Machine and Foundry,                                     |                        |
| 77342    | Potter and Brumfield Div. Princeton, Ind.                         |                        |
| 77630    | TRW Electronics, Components Div.                                  | Camden, N.J.           |
| 77664    | Resistance Products Co.                                           | Harrisburg, Pa.        |
| 78189    | Shakeproof Div. of Illinois Tool Works                            |                        |
| 78488    | Stackpole Carbon Co.                                              | St. Marys, Pa.         |
| 78526    | Stanwyck Winding Co., Inc.                                        |                        |
| 78553    | Tinnerman Products, Inc.                                          | Cleveland, Ohio        |
| 79307    | Whitehead Metal Products Co., Inc.                                | New York, N.Y.         |
| 79727    | Continental-Wirt Electronics Corp.                                | Philadelphia, Pa.      |
| 80031    | Mepco Div. of Sessions Clock Co.                                  | Morristown, N.J.       |
| 80294    | Bourns, Inc.                                                      | Riverside, Calif.      |

| CODE NO. | MANUFACTURER                            | ADDRESS               |
|----------|-----------------------------------------|-----------------------|
| 19315    | The Bendix Corp., Eclipse Pioneer Div.  | Teterboro, N.J.       |
| 19701    | Electra Mfg. Co.                        | Independence, Kan.    |
| 21520    | Fansteel Metallurgical Corp.            | No. Chicago, Ill.     |
| 22229    | Union Carbide Corp., Linde Div.,        | Mountain View, Calif. |
| 22767    | ITT Semiconductors, A Division of       |                       |
| 24446    | General Electric Co., Lamp Division     |                       |
| 24455    | General Electric Co., Schenectady, N.Y. |                       |
| 24655    | General Radio Co.                       | West Concord, Mass.   |
| 28480    | Hewlett-Packard Co.                     | Palo Alto, Calif.     |
| 28520    | Heyman Mfg. Co.                         | Kenilworth, N.J.      |
| 33173    | G. E., Tube Dept.                       | Owensboro, Ky.        |
| 35434    | P.R. Mallory & Co., Inc.                | Indianapolis, Ind.    |
| 37942    | Muter Co.                               | Chicago, Ill.         |
| 42190    | Ohmite Manufacturing Co.                | Skokie, Ill.          |
| 44655    | Polaroid Corporation                    | Cambridge, Mass.      |
| 47904    | Raytheon Mfg. Co., Microwave and        |                       |
| 49956    | Power Tube Div.                         | Waltham, Mass.        |
| 55026    | Simpson Electric Co.                    | Chicago, Ill.         |
| 56289    | Sprague Electric Co.                    | North Adams, Mass.    |
| 58474    | Superior Electric Co.                   | Bristol, Conn.        |
| 61637    | Union Carbide Corp.                     | New York, N.Y.        |
| 63743    | Ward-Leonard Electric Co.               | Mt. Vernon, N.Y.      |
| 70563    | Ampertite Co., Inc.                     | Union City, N.J.      |
| 70903    | Belden Mfg. Co.                         | Chicago, Ill.         |
| 71218    | Bud Radio, Inc.                         | Willoughby, Ohio      |
| 71400    | Bussmann Mfg. Div. of                   |                       |
| 71450    | McGraw-Edison Co.                       | St. Louis, Mo.        |
| 71468    | I. T. T. Cannon Electric Inc.           | Elkhart, Ind.         |
| 71590    | Centralab Div. of Globe Union, Inc.     | Los Angeles, Calif.   |
| 71700    | The Cornish Wire Co.                    | Milwaukee, Wis.       |
| 71744    | Chicago Miniature Lamp Works            | New York, N.Y.        |
| 71785    | Cinch Mfg. Co.                          | Chicago, Ill.         |
| 71984    | Dow Corning Corp.                       | Midland, Mich.        |
| 72619    | Dialight Corporation                    | Brooklyn, N.Y.        |
| 72699    | General Instrument Corp.,               |                       |
| 72765    | Capacitor Div.                          | Newark, N.J.          |
| 72982    | Erle Technological Products, Inc.       | Erie, Pa.             |

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

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

| CODE NO. | MANUFACTURER                              | ADDRESS                                  |
|----------|-------------------------------------------|------------------------------------------|
| 81042    | Howard Industries, Inc.                   | Racine, Wis.                             |
| 81483    | International Rectifier Corp.             | El Segundo, Calif.                       |
| 81751    | Columbus Electronics Corp.                | Yonkers, N.Y.                            |
| 82099    | Goodyear Sundries & Mechanical Co., Inc.  | New York, N.Y.                           |
| 82219    | Sylvania Electric Products, Inc.          | Electronic Tube Division, Emporium, Pa.  |
| 82389    | Switchcraft, Inc.                         | Chicago, Ill.                            |
| 82647    | Metals and Controls, Inc.                 | Chicago, Ill.                            |
| 82866    | Spencer Products                          | Attleboro, Mass.                         |
| 82877    | Research Products Corp.                   | Madison, Wis.                            |
| 82893    | Vector Electronic Co.                     | Glendale, Calif.                         |
| 83058    | Carr Fastener Co.                         | Cambridge, Mass.                         |
| 83186    | Victory Engineering Corp.                 | Springfield, N.J.                        |
| 83298    | Bendix Corp., Red Bank Div.               | Fatontown, N.J.                          |
| 83330    | Herman H. Smith, Inc.                     | Brooklyn, N.Y.                           |
| 83385    | Central Screw Co.                         | Chicago, Ill.                            |
| 83501    | Gavitt Wire and Cable Co., Div. of        | Brookfield, Mass.                        |
| 83508    | Grant Pulley and Hardware Co.             | Brookfield, Mass.                        |
| 83594    | Burroughs Corp., Electronic               | West Nyack, N.Y.                         |
| 83877    | Yardeny Laboratories, Inc.                | Plainfield, N.J.                         |
| 84171    | Arco Electronics, Inc.                    | Great Neck, N.Y.                         |
| 84411    | TRW Capacitor Div.                        | Ogallala, Neb.                           |
| 86684    | Radio Corporation of America, Electronic  | Components & Devices Div.                |
| 87034    | Marco Industries Co.                      | Anaheim, Calif.                          |
| 87216    | Philco Corp. (Lansdale Div.)              | Lansdale, Pa.                            |
| 87585    | Stockwell Rubber Co., Inc.                | Philadelphia, Pa.                        |
| 87929    | B. M. Tower Co., Inc.                     | Bridgeport, Conn.                        |
| 88140    | Cutler-Hammer, Inc.                       | Lincoln, Ill.                            |
| 89473    | General Electric Distributing Corp.       | Schenectady, N.Y.                        |
| 91345    | Miller Dial and Nameplate Co.             | El Monte, Calif.                         |
| 91637    | Dale Electronics, Inc.                    | Columbus, Neb.                           |
| 91662    | Elco Corp.                                | Willow Grove, Pa.                        |
| 91929    | Honeywell, Inc., Micro Switch Div.        | Freeport, Ill.                           |
| 93332    | Sylvania Electric Prod., Inc., Semicon-   | ductor Prod. Div., Woburn, Mass.         |
| 93410    | Stevens Mfg. Co., Inc.                    | Mansfield, Ohio                          |
| 94144    | Raytheon Co., Components Div., Industrial | Components Operation                     |
| 94154    | Tung-Sol Electric, Inc.                   | Newark, N.J.                             |
| 94310    | Tru-Ohm Products, Memcor                  | Components Div., Huntington, Ind.        |
| 95263    | Leecraft Mfg. Co., Inc.                   | Long Island City, N.Y.                   |
| 95354    | Method Mfg. Co.                           | Chicago, Ill.                            |
| 96791    | Amphenol Controls Div. of Amphenol-       | Borg Electronics Corp., Janesville, Wis. |
| 98291    | Sealectro Corp.                           | Mamaroneck, N.Y.                         |
| 98978    | International Electronic Research Corp.   | Burbank, Calif.                          |
| 99934    | Renbrandt, Inc.                           | Boston, Mass.                            |
| 00000    | Cooltron                                  | Oakland, Calif.                          |
| 00000    | Plastic Ware Co.                          | Brooklyn, N.Y.                           |

THE FOLLOWING H-P VENDORS HAVE NO NUMBERS ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

| Reference       | Designator | Description                                      | Quantity | Mfr. Part # or Type | Mfr.       | Code  | Stock No. | RS |
|-----------------|------------|--------------------------------------------------|----------|---------------------|------------|-------|-----------|----|
| C1              | C2, 3, 18  | fxd, elect 1µf 450vdc                            | 1        | 45D10255            | Sprague    | 56289 | 0180-1845 | 1  |
| C4, 8, 11, 13,  |            | fxd, film .01µf 200vdc                           | 3        | 192P10392           | Sprague    | 56289 | 0160-0161 | 1  |
| C5              | 15, 16, 21 | NOT ASSIGNED                                     | -        | -                   | -          | -     | -         | -  |
| C6, 26          |            | fxd, elect 20µf 15vdc                            | 2        | 30D206G015BB4       | Sprague    | 56289 | 0180-0300 | 1  |
| C7              |            | fxd, film .0022µf 200vdc                         | 1        | 192P22292           | Sprague    | 56289 | 0160-0154 | 1  |
| C9              |            | fxd, elect 4.7µf 35vdc                           | 1        | 150D475X903B52      | Sprague    | 56289 | 0180-0100 | 1  |
| C10             |            | fxd, elect 100µf 50vdc                           | 1        | D32218              | HIAB       | 09182 | 0180-1852 | 1  |
| C12             |            | fxd, elect 490µf 85vdc                           | 1        | D38618              | HIAB       | 09182 | 0180-1888 | 1  |
| C14             |            | fxd, elect 300µf 250vdc                          | 1        | D39343              | HIAB       | 09182 | 0180-1886 | 1  |
| C17             |            | fxd, film .1µf 200vdc                            | 1        | 192P10492           | Sprague    | 56289 | 0160-0168 | 1  |
| C19             |            | fxd, film 1µf 200vdc                             | 1        | 118P1059253         | Sprague    | 56289 | 0160-2465 | 1  |
| C20             |            | fxd, film 80µf 300vdc                            | 1        | D39041              | HIAB       | 09182 | 0180-1851 | 1  |
| C22             |            | fxd, elect 1µf 35vdc                             | 1        | 150D105X9035A2      | Sprague    | 56289 | 0180-0291 | 1  |
| C23, 24         |            | fxd, elect 5µf 65vdc                             | 2        | D33689              | HIAB       | 09182 | 0180-1836 | 1  |
| C25             |            | fxd, film .001µf 200vdc                          | 1        | 192P10292           | Sprague    | 56289 | 0160-0153 | 1  |
| CRL, 22-25,     |            | Rect. st. 900ma 200prv                           | 7        | INS059              | G.E.       | 03508 | 1901-0327 | 6  |
| CR2-5,          |            | 9-15, 17,                                        |          |                     |            |       |           |    |
| CR6, 19, 21,    |            | Rect. st. 200ma 180prv                           | 16       |                     | HIAB       | 09182 | 1901-0033 | 8  |
| CR7             |            | Diode, st. 10V 400mw                             | 1        |                     | HIAB       | 09182 | 1901-0460 | 1  |
| CR8, 16         |            | Rect. st. 400mw 10prv                            | 2        |                     | HIAB       | 09182 | 1901-0461 | 2  |
| CR26, 27        |            | NOT USED                                         | -        | -                   | -          | -     | -         | -  |
| CR28, 29        |            | Rect. st. 700ma 800prv                           | 2        | SR1358              | Motorola   | 04713 | 1901-0030 | 2  |
| CR35            |            | SCR st. 2A 600prv                                | 1        | 2N4102              | R.C.A.     | 02735 | 1884-0044 | 1  |
| DS1             |            | Lamp neon                                        | 1        | 599-124             | Drake      | 72765 | 1450-0048 | 1  |
| F1              |            | Fuse cartridge 2A @ 250V 3AG                     | 1        | 312002              | Littlefuse | 75915 | 2110-0002 | 5  |
| L1              |            | Coil                                             | 1        |                     | HIAB       | 09182 | 9100-1854 | 1  |
| Q1              |            | SS NPN diff. amp. st.                            | 1        |                     | HIAB       | 09182 | 1854-0229 | 1  |
| Q2              |            | NPN diff. amp. st.                               | 1        |                     | HIAB       | 09182 | 1854-0221 | 1  |
| Q3, 4, 8, 10,   |            | SS NPN st.                                       | 7        | 2N297A              | Sprague    | 56289 | 1853-0099 | 6  |
| Q5, 7, 16       |            | NOT ASSIGNED                                     | -        | -                   | -          | -     | -         | -  |
| Q6              |            | Power NPN st.                                    | 1        |                     | HIAB       | 09182 | 1854-0228 | 1  |
| Q9, 11, 13,     |            | SS NPN st.                                       | 6        | SK1124              | T.I.       | 01295 | 1854-0071 | 6  |
| R1, 12          |            | fxd, ww 2K $\Omega$ $\pm$ 5% 3w 20ppm            | 2        | 242E2025            | Sprague    | 56289 | 0811-1806 | 1  |
| R2, 5, 3, 86    |            | fxd, met. film 6.2K $\Omega$ $\pm$ 1% 1/8w       | 3        | Type CEA T-O        | I.R.C.     | 07716 | 0698-5087 | 1  |
| R3, 4, 6, 4, 65 |            | fxd, met. film 20K $\Omega$ $\pm$ 1% 1/8w        | 4        | Type CEA T-O        | I.R.C.     | 07716 | 0757-0449 | 1  |
| R5, 26, 29,     |            | fxd, met. film 1.5K $\Omega$ $\pm$ 1% 1/8w       | 5        | Type CEA T-O        | I.R.C.     | 07716 | 0757-0427 | 2  |
| R6, 25          |            | fxd, comp 360K $\Omega$ $\pm$ 5% $\frac{1}{2}$ w | 2        | EB-3645             | A.B.       | 01121 | 0686-3645 | 1  |
| R7              |            | fxd, comp 430K $\Omega$ $\pm$ 5% $\frac{1}{2}$ w | 1        | EB-4345             | A.B.       | 01121 | 0686-4345 | 1  |
| R8, 28          |            | fxd, comp 560K $\Omega$ $\pm$ 5% $\frac{1}{2}$ w | 2        | EB-5645             | A.B.       | 01121 | 0686-5645 | 1  |
| R9              |            | fxd, comp 1meg $\pm$ 5% $\frac{1}{2}$ w          | 1        | EB-1055             | A.B.       | 01121 | 0686-1055 | 1  |
| R10             |            | var. ww 50K $\Omega$ 10-turn                     | 1        |                     | HIAB       | 09182 | 2100-1994 | 1  |

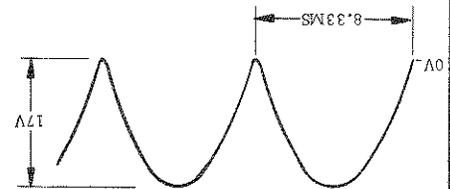
| Reference    | Designator | Description                                 | Quantity | Mfr. Part #  | Mfr.    | Code  | Stock No. | RS |
|--------------|------------|---------------------------------------------|----------|--------------|---------|-------|-----------|----|
|              |            | NOT ASSIGNED                                |          |              |         |       |           |    |
| R11, 17, 27, | 32, 35-37, |                                             |          |              |         |       |           |    |
|              | 39, 78, 79 |                                             |          |              |         |       |           |    |
| R13, 19, 38  |            | fxd, comp SELECTED $\pm 5\% \frac{1}{2}w$   | 3        | Type EB      | A.B.    | 01121 | 0686-0335 | 1  |
| R14          |            | fxd, comp 3.3u $\pm 5\% \frac{1}{2}w$       | 1        | EB-0335      | A.B.    | 01121 | 0686-8235 | 1  |
| R15          |            | fxd, comp 82K $\pm 5\% 1w$                  | 1        | GB-8235      | A.B.    | 01121 | 2100-2068 | 1  |
| R16          |            | var, ww DUAL 18K - 200u                     | 1        | E30          | R.C.L.  | 01686 | 0811-2077 | 1  |
| R18          |            | fxd, ww 65K $\pm 1\% \frac{1}{2}w$          | 1        |              |         |       | 0757-0338 | 1  |
| R20, 48      |            | fxd, met, film 1K $\pm 1\% \frac{1}{2}w$    | 2        | Type CEB T-O | I.R.C.  | 07716 | 0686-3915 | 1  |
| R21          |            | fxd, comp 390u $\pm 5\% \frac{1}{2}w$       | 1        | EB-3915      | A.B.    | 01121 | 0757-0460 | 1  |
| R22, 23      |            | fxd, comp 61.9K $\pm 1\% 1/8w$              | 2        | Type CEA T-O | I.R.C.  | 07716 | 0698-5090 | 1  |
| R24          |            | fxd, met, film 43K $\pm 1\% 1/8w$           | 1        | Type CEA T-O | I.R.C.  | 07716 | 2100-1824 | 1  |
| R30          |            | var, ww 5K (Modify)                         | 1        | Type 110-F4  | C.T.S.  | 11236 | 0686-1025 | 1  |
| R31          |            | fxd, comp 1K $\pm 5\% \frac{1}{2}w$         | 1        | EB-1025      | A.B.    | 01121 | 0686-6225 | 1  |
| R33          |            | fxd, comp 6.2K $\pm 5\% \frac{1}{2}w$       | 1        | EB-6225      | A.B.    | 01121 | 0686-3925 | 1  |
| R34, 96      |            | fxd, comp 3.9K $\pm 5\% \frac{1}{2}w$       | 2        | EB-3925      | A.B.    | 01121 |           |    |
| R40, 57, 60  |            | fxd, met, film 900u $\pm 1\% 1/8w$          | 4        | Type CEA T-O | I.R.C.  | 07716 | 0757-1099 | 1  |
| R41, 99      |            | fxd, comp 12K $\pm 5\% \frac{1}{2}w$        | 2        | EB-1235      | A.B.    | 01121 | 0686-1235 | 1  |
| R42          |            | fxd, comp 6.8K $\pm 5\% \frac{1}{2}w$       | 1        | EB-6825      | A.B.    | 01121 | 0698-5145 | 1  |
| R43          |            | fxd, met, film 510u $\pm 1\% \frac{1}{2}w$  | 1        | Type CEB T-O | I.R.C.  | 07716 | 0686-4735 | 1  |
| R44          |            | fxd, comp 47K $\pm 5\% \frac{1}{2}w$        | 1        | EB-4735      | A.B.    | 01121 | 0686-5125 | 1  |
| R45          |            | fxd, comp 5.1K $\pm 5\% \frac{1}{2}w$       | 1        | EB-5125      | A.B.    | 01121 | 0686-1045 | 1  |
| R46          |            | fxd, comp 100K $\pm 5\% \frac{1}{2}w$       | 1        | EB-1045      | A.B.    | 01121 | 0686-5615 | 1  |
| R47          |            | fxd, comp 560u $\pm 5\% \frac{1}{2}w$       | 1        | EB-5615      | A.B.    | 01121 | 0811-0954 | 1  |
| R49          |            | fxd, ww 15K $\pm 5\% 10w$                   | 1        | EB-1005      | A.B.    | 01121 | 0686-1005 | 1  |
| R50          |            | fxd, comp 10u $\pm 5\% \frac{1}{2}w$        | 1        | EB-1005      | A.B.    | 01121 | 0686-3035 | 1  |
| R51          |            | fxd, comp 30K $\pm 5\% \frac{1}{2}w$        | 1        | EB-3035      | A.B.    | 01121 | 0686-2235 | 1  |
| R52          |            | fxd, comp 22K $\pm 5\% \frac{1}{2}w$        | 1        | EB-2235      | A.B.    | 01121 | 0811-1894 | 1  |
| R54          |            | fxd, ww 7.5u $\pm 1\% 10w$                  | 1        | 247E7255     | Sprague | 56289 | 0757-0316 | 1  |
| R55          |            | fxd, met, film 42.2u $\pm 1\% 1/8w$         | 1        | Type CEA T-O | I.R.C.  | 07716 | 2100-0391 | 1  |
| R56          |            | var, ww 1K (Modify)                         | 1        | Type 110-F4  | C.T.S.  | 11236 | 0757-0401 | 1  |
| R58, 59      |            | fxd, met, film 100u $\pm 1\% 1/8w$          | 2        | Type CEA T-O | I.R.C.  | 07716 | 0757-0311 | 1  |
| R61          |            | fxd, met, film 182K $\pm 1\% \frac{1}{2}w$  | 1        | Type CEC T-O | I.R.C.  | 07716 | 2100-0396 | 1  |
| R63          |            | var, ww 10K                                 | 1        | Type 110-F4  | C.T.S.  | 11236 | 0698-4640 | 1  |
| R66, 67      |            | fxd, met, film 3.40K $\pm 1\% \frac{1}{2}w$ | 2        | Type CEB T-O | I.R.C.  | 07716 | 0757-0723 | 1  |
| R68, 69      |            | fxd, met, film 365u $\pm 1\% \frac{1}{2}w$  | 2        | Type CEB T-O | I.R.C.  | 07716 |           |    |
| R70, 71      |            | fxd, met, film 3K $\pm 1\% 1/8w$            | 4        | Type CEA T-O | I.R.C.  | 07716 | 0757-1093 | 1  |
| R72          |            | var, ww 250u (Modify)                       | 1        | Type 110-F4  | C.T.S.  | 11236 | 2100-0439 | 1  |
| R73          |            | fxd, met, film 750u $\pm 1\% 1/8w$          | 1        | Type CEA T-O | I.R.C.  | 07716 | 0757-0420 | 1  |
| R74          |            | fxd, met, film 9.09K $\pm 1\% 1/8w$         | 1        | Type CEA T-O | I.R.C.  | 07716 | 0757-0288 | 1  |
| R80          |            | fxd, comp 33K $\pm 5\% \frac{1}{2}w$        | 1        | EB-3335      | A.B.    | 01121 | 0686-3335 | 1  |
| R81          |            | fxd, ww 50u $\pm 5\% 5w$                    | 1        | Type 5XM     | Sprague | 56289 | 0811-1854 | 1  |
| R82          |            | fxd, comp 1.5M $\pm 5\% \frac{1}{2}w$       | 1        | EB-1555      | A.B.    | 01121 | 0686-1555 | 1  |
| R83          |            | fxd, comp 1.6K $\pm 5\% \frac{1}{2}w$       | 1        | EB-1625      | A.B.    | 01121 | 0686-1625 | 1  |
| R84          |            | fxd, ww 2u $\pm 5\% 3w 20ppm$               | 1        | 242E2R05     | Sprague | 56289 | 0811-1831 | 1  |
| R87          |            | fxd, ww 3K $\pm 5\% 3w 20ppm$               | 1        | 242E3025     | Sprague | 56289 | 0812-0010 | 1  |
| R88          |            | fxd, comp 1.5K $\pm 5\% 1w$                 | 1        | GB-1525      | A.B.    | 01121 | 0689-1525 | 1  |
| R89          |            | fxd, comp 220u $\pm 5\% 1w$                 | 1        | GB-2215      | A.B.    | 01121 | 0689-2215 | 1  |
| R90          |            | fxd, comp 6.2K $\pm 5\% 1w$                 | 1        | GB-6225      | A.B.    | 01121 | 0689-6225 | 1  |
| R91          |            | fxd, comp 39K $\pm 5\% \frac{1}{2}w$        | 1        | HB-3935      | A.B.    | 01121 | 0686-4335 | 1  |
| R92          |            | fxd, comp 43K $\pm 5\% \frac{1}{2}w$        | 1        | HB-4335      | A.B.    | 01121 | 0686-4335 | 1  |
| R93, 95      |            | fxd, comp 10K $\pm 5\% \frac{1}{2}w$        | 2        | EB-1035      | A.B.    | 01121 | 0686-1035 | 1  |
| R94          |            | fxd, comp 120K $\pm 5\% \frac{1}{2}w$       | 1        | EB-1245      | A.B.    | 01121 | 0686-1245 | 1  |
| R96          |            | fxd, comp 3.9K $\pm 5\% \frac{1}{2}w$       | 1        | EB-3925      | A.B.    | 01121 | 0686-3925 | 1  |
| R97          |            | fxd, comp 16K $\pm 5\% \frac{1}{2}w$        | 1        | EB-1635      | A.B.    | 01121 | 0686-1635 | 1  |
| R98          |            | fxd, comp 2.2K $\pm 5\% \frac{1}{2}w$       | 1        | EB-2225      | A.B.    | 01121 | 0686-2225 | 1  |

| Reference | Designator | Description                                     | Quantity | Mfr. Part # or Type    | Mfr.         | Code  | Stock No. | RS |
|-----------|------------|-------------------------------------------------|----------|------------------------|--------------|-------|-----------|----|
| R100      |            | fxd, comp 330 $\Omega$ $\pm$ 5% 1w              | 1        | GB-3315                | A. B.        | 01121 | 0686-3315 | 1  |
| R101      |            | fxd, comp 22 $\Omega$ $\pm$ 5% $\frac{1}{2}$ w  | 1        | EB-2205                | A. B.        | 01121 | 0686-2205 | 1  |
| R102      |            | fxd, comp 100 $\Omega$ $\pm$ 5% $\frac{1}{2}$ w | 1        | EB-1015                | A. B.        | 01121 | 0686-1015 | 1  |
| S1        |            | Switch, SPST ON/OFF                             | 1        | T110-72                | Carling      | 73559 | 3101-1055 | 1  |
| S2        |            | Meter switch, wafer                             | 1        |                        | HIAB         | 09182 | 3100-1910 | 1  |
| T1        |            | Power Transformer                               | 1        |                        | HIAB         | 09182 | 9100-1825 | 1  |
| T2        |            | Pulse Transformer                               | 1        |                        | HIAB         | 09182 | 9100-1824 | 1  |
| T3        |            | Bias Transformer                                | 1        |                        | HIAB         | 09182 | 9100-1826 | 1  |
| VR1, 2    |            | Diode - zener 6.2V                              | 2        | IN821                  | N. A. Elect. | 06486 | 1902-0761 | 2  |
| VR3       |            | Diode - zener 40.2V 1.5W                        | 1        |                        | HIAB         | 09182 | 1902-0431 | 1  |
| VR4       |            | Diode - zener 16.2V 400MW                       | 1        |                        | HIAB         | 09182 | 1902-0184 | 1  |
| VR5       |            | Diode - zener 4.22V 400MW                       | 1        |                        | HIAB         | 09182 | 1902-3070 | 1  |
|           |            | 5 Way binding post (maroon)                     | 1        | DF21Mn                 | HIAB         | 09182 | 1510-0040 | 1  |
|           |            | 5 Way binding post (black)                      | 2        | DF21BC                 | Superior     | 58474 | 1510-0039 | 1  |
|           |            | Fastener                                        | 1        | C17373-012-24B         | Tinnerman    | 89032 | 0510-0123 | 1  |
|           |            | Line cord plug PH151 7 $\frac{1}{2}$ ft.        | 1        | KH-4096                | Beldon       | 70903 | 8120-0050 | 1  |
|           |            | Strain relief bushing                           | 1        | SR-5P-1                | Heyco        | 28520 | 0400-0013 | 1  |
|           |            | Knob 5/8 dia. $\frac{1}{4}$ insert              | 1        |                        | HIAB         | 09182 | 0370-0084 | 1  |
|           |            | Knob 5/8 dia $\frac{1}{4}$ insert (no arrow)    | 1        | 422-13-11 013          | Cinch        | 71785 | 0360-1274 | 2  |
|           |            | Barrier strip                                   | 1        |                        | HIAB         | 09182 | 0360-1234 | 1  |
|           |            | Rubber bumper                                   | 4        | MB50                   | Stockwell    | 87575 | 0403-0088 | 1  |
|           |            | Rubber bumper                                   | 3        | 4072                   | Stockwell    | 87575 | 0403-0086 | 1  |
|           |            | Rubber bumper                                   | 1        |                        | HIAB         | 09182 | 0370-0101 | 1  |
|           |            | Knob pointer 17/64 insert                       | 1        |                        | HIAB         | 09182 | 0370-0179 | 1  |
|           |            | Knob $\frac{1}{2}$ dia. 3/16 insert             | 1        |                        | HIAB         | 09182 | 4040-0295 | 1  |
|           |            | Bezel 1/6 mod                                   | 1        | 342014                 | Littlefuse   | 75915 | 1400-0048 | 1  |
|           |            | Fuse holder                                     | 1        |                        | HIAB         | 09182 | 1120-1231 | 1  |
|           |            | Meter 2 $\frac{1}{2}$ " DUAL 0-200V             | 1        |                        | HIAB         | 09182 | 1460-0720 | 1  |
|           |            | 0-240ma                                         | 4        |                        | HIAB         | 09182 | 0510-0275 | 2  |
|           |            | Spring                                          | 8        | C8091-632-24B          | Tinnerman    | 89032 | 0510-0275 | 2  |
|           |            | Fastener                                        | 1        | 734                    | Reliance     | 08530 | 0340-0174 | 1  |
|           |            | Mica insulator                                  | 2        |                        | HIAB         | 09182 | 0340-0166 | 1  |
|           |            | Insulator, transistor pin                       | 2        |                        | HIAB         | 09182 | 0340-0168 | 1  |
|           |            | Insulator                                       | 2        |                        | HIAB         | 09182 | 0340-0168 | 1  |
| 08        |            | Current 10-turn Potentiometer                   | 1        | Series 8400            | IRC          | 07716 | 2100-1864 | 1  |
| 13        |            | Voltage Decadal Control                         | 1        | (Includes: RD-411      | IRC          | 07716 | 1140-0020 | 1  |
| 14        |            | Current Decadal Control                         | 1        | (Includes: Series 8400 | IRC          | 07716 | 2100-1864 | 1  |
|           |            | Current 10-turn Pot.                            | 1        |                        | IRC          | 07716 | 1140-0020 | 1  |
|           |            | Decadal Assembly                                | 1        | RD-411                 | IRC          | 07716 | 1140-0020 | 1  |

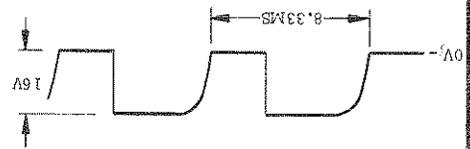
OPTIONS

- NOTES:
1. ALL WAVEFORMS TAKEN WITH 115VAC, 60HZ, SINGLE-PHASE INPUT AT MAXIMUM RATED OUTPUT VOLTAGE WITH NO LOAD CONNECTED (EXCEPT B AND C INDICATED). WAVEFORM AMPLITUDES ARE TYPICAL  $\pm 10\%$ .
  2. OSCILLOSCOPE DC COUPLED AND REFERENCED TO TEST POINT 23 UNLESS OTHERWISE INDICATED.
  3. FOR CLARITY, WAVEFORMS ARE NOT DRAWN TO SCALE.

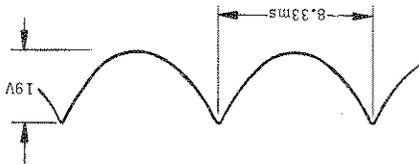
F. TEST POINTS 23-CR9 & CR12 (CATHODE)



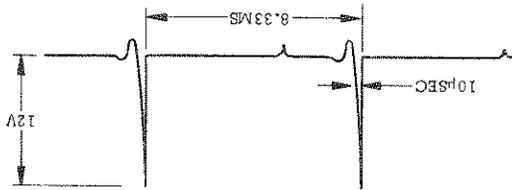
D. TEST POINTS 67-23



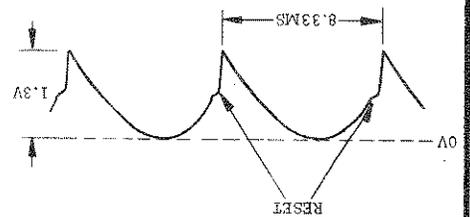
G. TEST POINTS 65-23



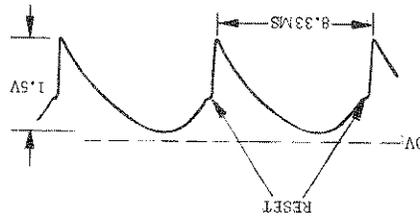
E. TEST POINTS 68-T2-4



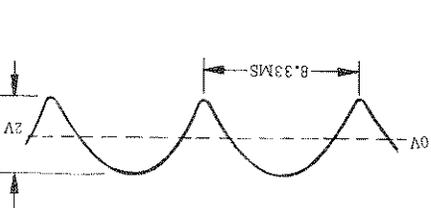
A. TEST POINTS 66-23 (NO LOAD)



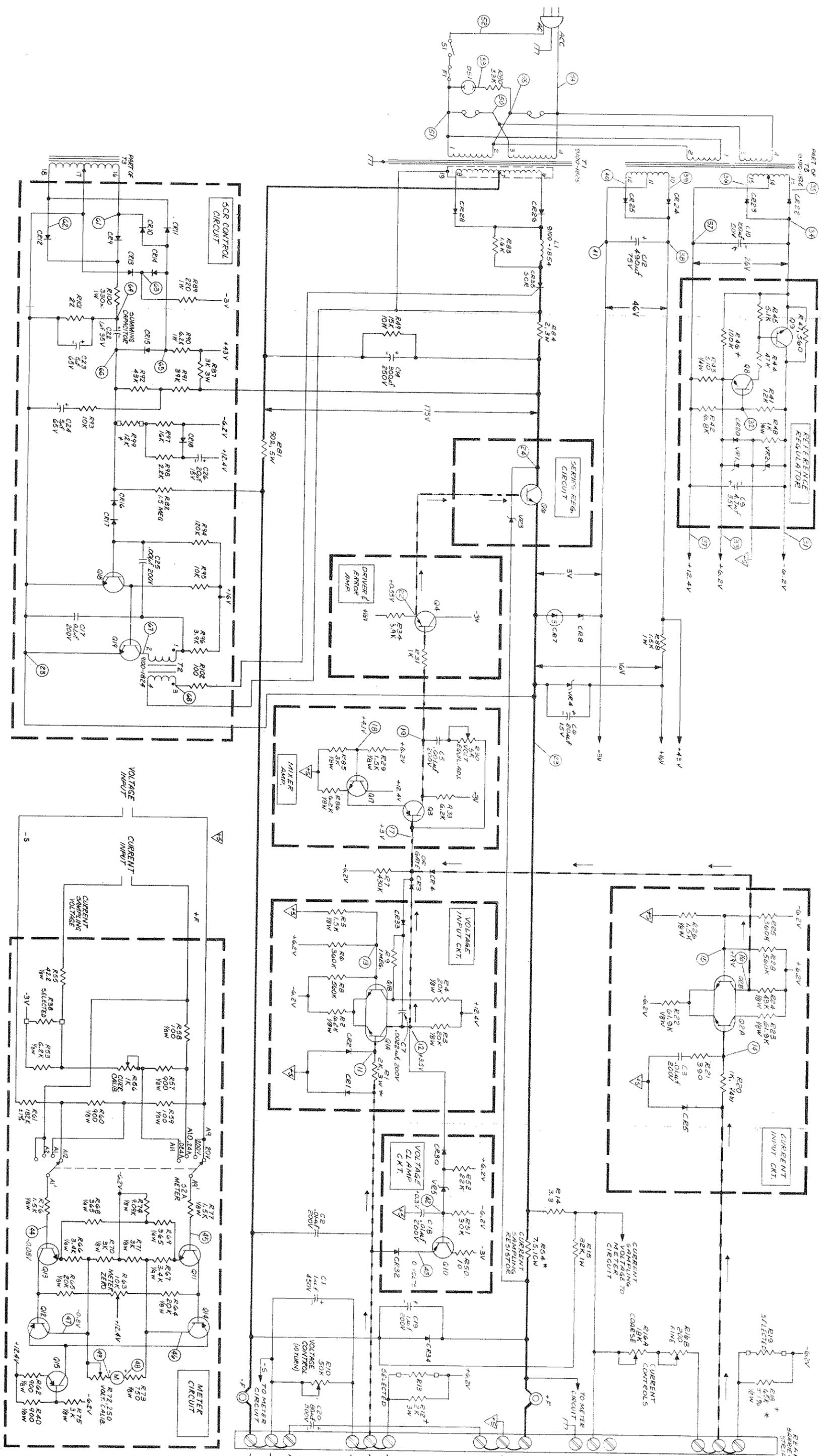
B. TEST POINTS 66-23 (FULL LOAD)



C. TEST POINTS 66-23 (NO LOAD, 10V OUTPUT)







CIRCUIT PATENTS APPLIED FOR. LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HEWLETT-PACKARD HARRISON DIV.

NOTES:

1. ALL RESISTORS ARE 1/2 WATT 5% UNLESS OTHERWISE NOTED
2. ALL 1/4 W & 1/4 W RESISTORS ARE 1% IN TOLERANCE
3. \* DENOTES NOMINAL VALUE, COMPONENTS SELECTED FOR OPTIMUM PERFORMANCE
4. \* DENOTES 20 PPM WIRE TEMPERATURE COEFFICIENT
5. REAR TERMINALS ARE SHOWN IN NORMAL STRAPPING FOR USE OF FRONT PANEL CONTROLS
6. --- DENOTES VOLTAGE SIGNAL
7. --- DENOTES CURRENT SIGNAL

8. R16A & R16B ARE DUAL START FRONT PANEL CONTROLS
9. TRANSFORMER SHOWN STRAPPED FOR 115 VAC OPERATION. SEE INSTRUCTION MANUAL FOR 220 VAC
10. DC VOLTAGES WERE MEASURED UNDER THE FOLLOWING CONDITIONS:
  - A. SIMPSON MODEL 260, OR EQUIVALENT
  - B. 1/15 VAC INPUT
  - C. VOLTAGES REFERENCED TO +5, UNLESS OTHERWISE INDICATED
  - D. VOLTAGES ARE TYPICAL, ±10% UNLESS OTHERWISE INDICATED
  - E. ALL READINGS TAKEN WITH SUPPLY IN CONSTANT VOLTAGE OPERATION AT MAXIMUM RATED OUTPUT WITH NO LOAD CONNECTED. CURRENT CONTROLS SHOULD BE TURNED FULLY CLOCKWISE.

|                                           |           |         |     |
|-------------------------------------------|-----------|---------|-----|
| DATE                                      | BY        | CHKD    | REV |
| 1954-11-10                                | W.D. REY  | 9-5-54  |     |
| <b>6207 B SCHEMATIC</b>                   |           |         |     |
| NO.                                       | REV.      | DATE    | BY  |
| 1                                         | AS ISSUED | 1-25-54 |     |
| 2                                         |           | 1-25-54 |     |
| HEWLETT-PACKARD<br>LABORATORY INSTRUMENTS |           |         |     |
| PART NO. <b>E-06207-91001-1</b>           |           | REV. 1  |     |

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