DC POWER SUPPLY

LAB SERIES, MODEL 6207B

SERIAL NUMBER PREFIX 6J

Printed: September, 1966.
hp Stock Number: 06207-90001

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MANUAL CHANGES

DC POWER SUPPLY
Model 6207B
Manual Serial Number Prefix 6J

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

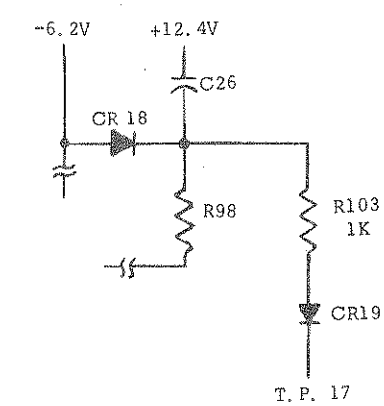
SERIAL		MAKE
Prefix	Number	CHANGES
7E	0476 - 0625	1
7E	0626 - 1025	1, 2
ALL	-	Errata

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

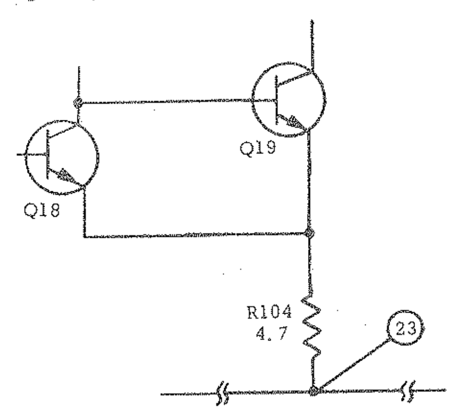
CHANGE 1: On the title page, change Serial Number Prefix from "6J" to "7E".

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

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, hp Stock No. 1901-0033) across secondary of pulse transformer T2 (anode to term. 4 and cathode to term. 3).
CR28, 29: Change hp Stock No. to 1901-0388.
CR19, R103: Add new components CR19 and R103 as shown in the sketch below. CR19 is 200mA, 180prv, hp Stock No. 1901-0033. R103 is 1K, $\frac{1}{2}$w, hp Stock No. 0686-1025.



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



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

Q6: Change to hp Part No. 1854-0225.
R40: Delete resistor R40.
R62: Change to 750Ω, 1/8w, hp Part No. 0757-0420.
R63: Change to 5KΩ potentiometer hp Part No. 2100-1824.
R64: Change to 12K, 1/8w, hp Part No. 0698-5088
VR6: Add new Zener diode, (VR6 4.22V, hp 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.

ERRATA: Q3,4,8,10,12,14,15: Change to 2N2907A, Sprague, 56289, hp Part No. 1853-0099.

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

C1: Change to 0.47μf, 400V, Sprague, 220P47494B, hp Part No. 0160-3356.
R49: Change to 15KΩ, 10W, Axial lead, hp Part No. 0815-0045.
R89: Change to 220Ω, fxd ww, 2W, hp Part No. 0811-1763.

11-19-68

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 This power supply, Figure 1-1, is completely 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.

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
05	50 Hz Regulator Realignment: Standard instruments will operate satisfactorily at both 60 and 50 Hz without adjustment. However Option 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.

Option No.	Description
06	Overvoltage Protection "Crowbar": A completely separate circuit for protecting delicate loads against power 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. When Option 06 is requested by the customer the device is attached to the rear of the power supply at the factory. Overvoltage Margin: 1 to 4 volts, screwdriver adjustable. Power Requirement: 15ma continuous drain from power supply being protected. Size: Add 5 inches to power supply depth dimension. Weight: Add 2 lbs. net. NOTE Detailed coverage of Option 06 is included in an addendum at the rear of manuals that support power supplies containing Option 06.
08	Current 10-Turn Pot: A single control that replaces both coarse and fine current controls and improves output settability.
13	Three Digit Graduated Decadial Voltage Control: Control that replaces 10-turn voltage control permitting accurate resettability.
14	Three Digit Graduated Decadial Current Control: Control that replaces coarse and fine current controls permitting accurate resettability.
28	Rewire For 230V AC Input: Supply as normally shipped is wired for 115 Vac input. Option 28 consists of reconnecting the input transformer for 230 Vac operation.

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).

ⓗⓟ Part No.	Description
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.)

1-12 INSTRUMENT IDENTIFICATION

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.

1-14 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, backdating information is given in an appendix at the rear of the manual.

1-15 ORDERING ADDITIONAL MANUALS

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 ⓗⓟ stock number provided on the title page.

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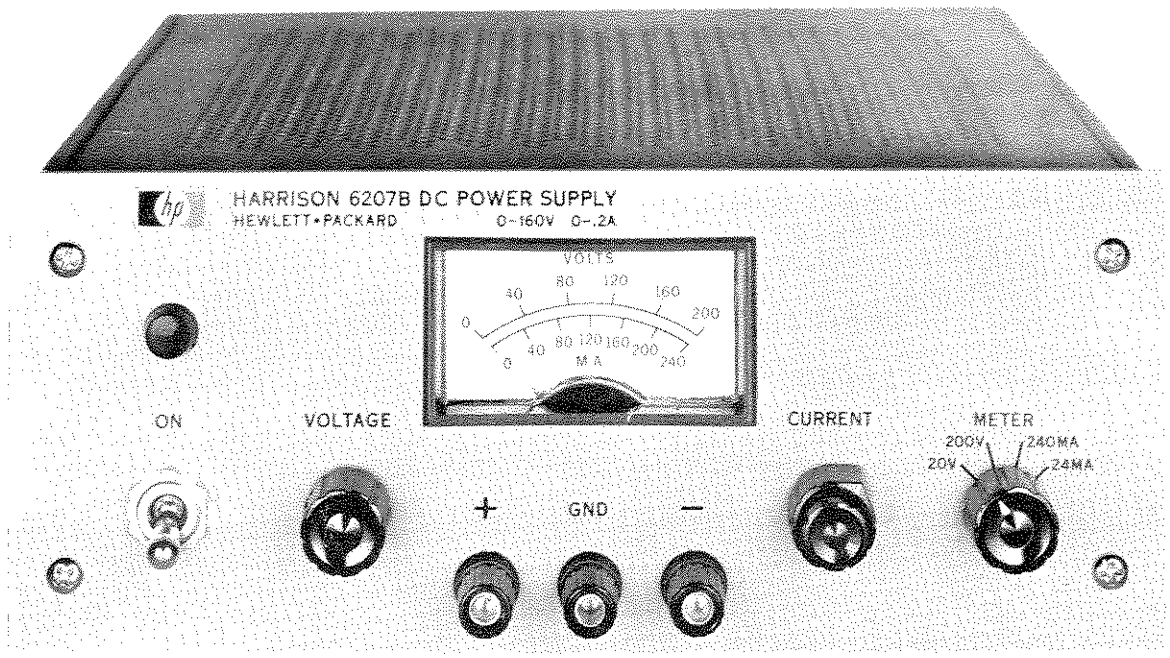


Figure 1-1. DC Power Supply, Model 6207B

Table 1-1. Specifications

INPUT:
105-125/210-250Vac, single phase, 48-63Hz.

OUTPUT:
0-160 volts @ 0-0.2 amps.

LOAD REGULATION:
Constant Voltage -- Less than 0.02% plus 2mV for a full load to no load change in output current.
Constant Current -- Less than 200μA for a zero to maximum change in output voltage.

LINE REGULATION:
Constant Voltage -- Less than 0.02% plus 2mV for any line voltage change within the input rating.
Constant Current -- Less than 200μA for any line voltage change within the input rating.

RIPPLE AND NOISE:
Constant Voltage -- Less than 500μV rms.
Constant Current -- Less than 200μA rms.

TEMPERATURE RANGES:
Operating: 0 to 50°C. Storage: -40 to +85°C.

TEMPERATURE COEFFICIENT:
Constant Voltage -- Less than 0.02% plus 1mV per degree Centigrade.
Constant Current -- Less than 0.02% plus 150μA per degree Centigrade.

STABILITY:
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.
Constant Current -- Less than 0.10% plus 750μA total drift for 8 hours after an initial warm-up time of 30 minutes at constant ambient, constant line voltage, and constant load.

INTERNAL IMPEDANCE AS A CONSTANT VOLTAGE SOURCE:
Less than 0.02Ω from DC to 1kHz.
Less than 0.5Ω from 1kHz to 100kHz.
Less than 3.0Ω from 100kHz to 1MHz.

TRANSIENT RECOVERY TIME:
Less than 50μsec for output recovery to within 10mv following a full load current change in the output.

OVERLOAD PROTECTION:
A continuously acting constant current circuit protects the power supply for all overloads including a direct short placed across the terminals in constant voltage operation. The constant voltage circuit limits the output voltage in the constant current mode of operation.

METER:
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.

OUTPUT CONTROLS:
Ten-turn voltage control and coarse and fine current controls are provided on the front panel.

OUTPUT TERMINALS:
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.

ERROR SENSING:
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 terminals. Also, provision is included on the rear terminal strip for remote sensing.

REMOTE PROGRAMMING:
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.

COOLING:
Convection cooling is employed. The supply has no moving parts.

SIZE:
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.

WEIGHT:
13 lbs. net, 18 lbs. shipping.

FINISH:
Light gray front panel with dark gray case.

POWER CORD:
A three-wire, five-foot power cord is provided with each unit.

SECTION II
INSTALLATION

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 instrument to a source of power and it is ready for operation.

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 panel screws.

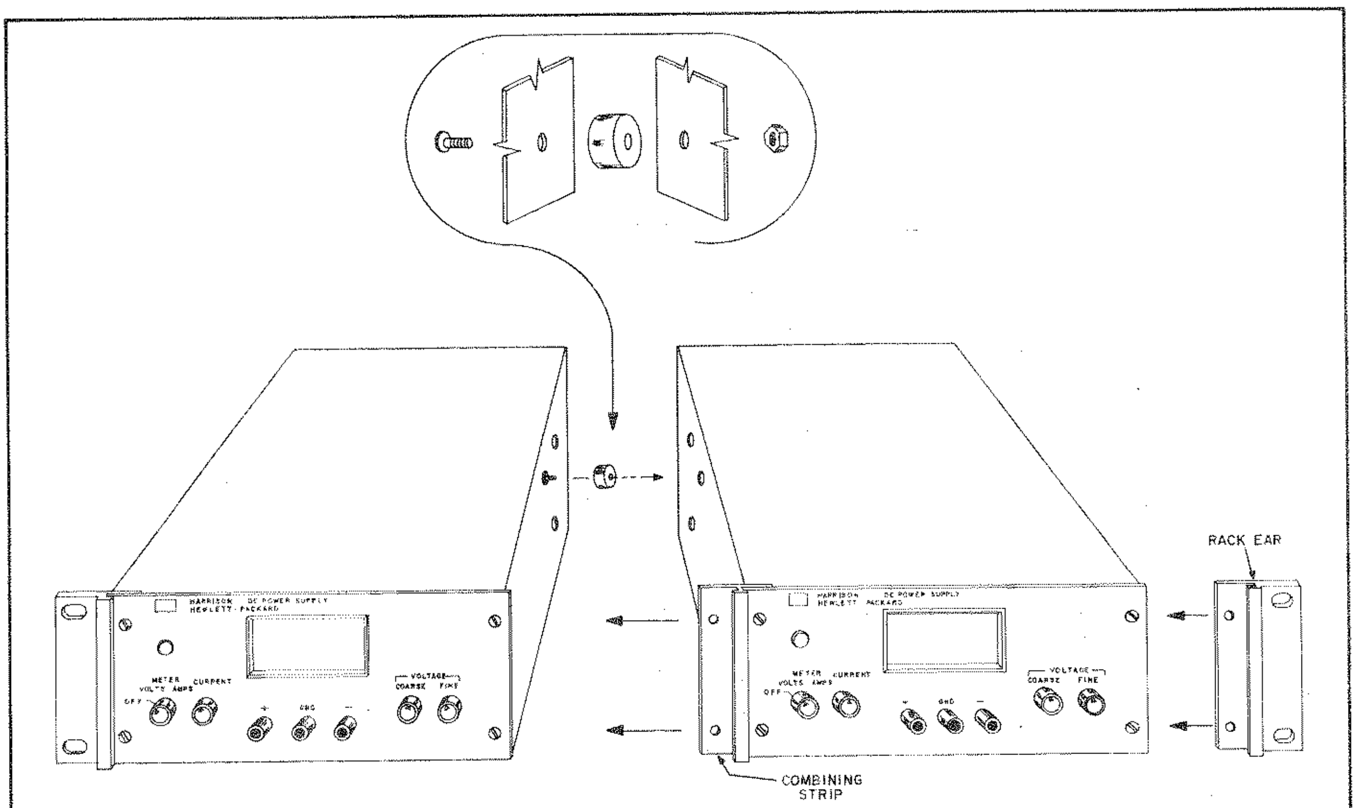


Figure 2-1. Rack Mounting, Two Units

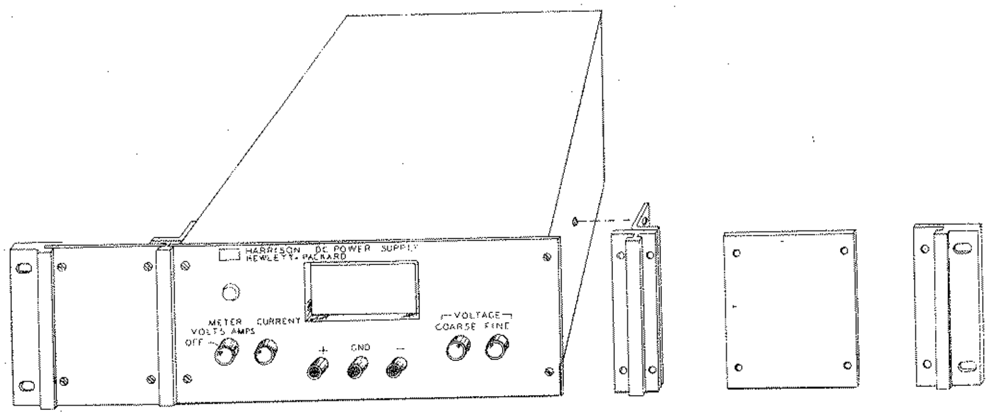


Figure 2-2. Rack Mounting, One Unit

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

a. 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.

b. Remove four screws from front panel of unit.

c. Slide combining strips between front panel and case of unit.

d. Bolt angle brackets to front sides of case and replace front panel screws.

2-15 <u>INPUT POWER REQUIREMENTS</u>

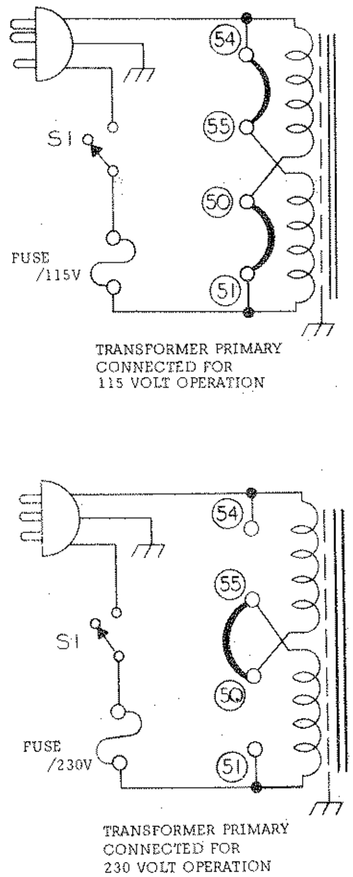
2-16 This power supply may be operated from either a nominal 115 volt or 230 volt 48-63 cycle power source. The unit, as shipped from the factory, is wired for 115 volt operation. The input power required when operated from a 115 volt 60 cycle power source at full load is 60 watts and 1.0 ampere.

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:

a. Unplug the line cord and remove top and bottom covers from unit.

b. Break the copper between 54 and 55 and also between 50 and 51 on the printed circuit board. These are shown in Figure 2-3, and are labeled on copper side of printed circuit board.



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 2-3. Primary Connections

c. Add strap between 50 and 55.

d. Replace existing fuse with 1 ampere, 230 volt fuse. Return unit to case and operate normally.

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.

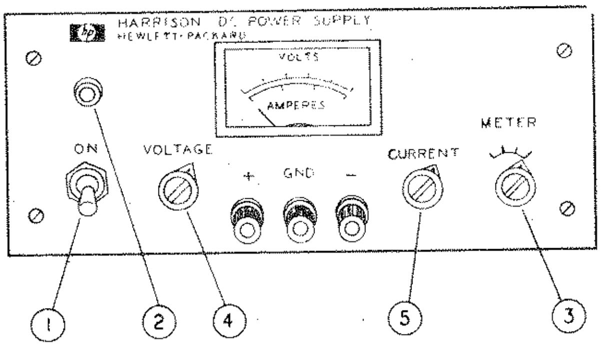
2-22 REPACKAGING FOR SHIPMENT

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.



TURN-ON SEQUENCE

1. SET AC POWER SWITCH TO ON.
2. OBSERVE THAT PILOT LIGHT GOES ON.
3. SET METER SWITCH TO DESIRED VOLTAGE RANGE.
4. ADJUST COARSE AND FINE VOLTAGE CONTROLS UNTIL DESIRED OUTPUT VOLTAGE IS INDICATED ON METER.
5. SHORT CIRCUIT OUTPUT TERMINALS. SET METER SWITCH TO DESIRED CURRENT RANGE, AND ADJUST CURRENT CONTROLS FOR DESIRED OUTPUT CURRENT.
6. REMOVE SHORT AND CONNECT LOAD TO OUTPUT TERMINALS (FRONT OR REAR).

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 theoritical description concerning the operational features of this supply 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).

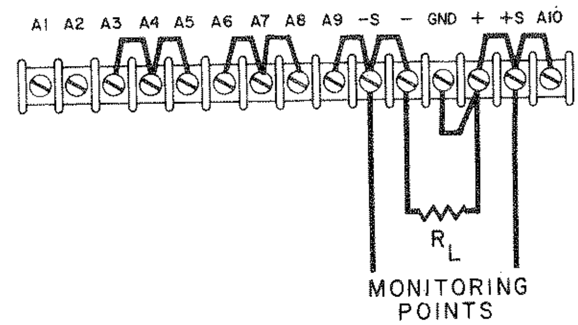


Figure 3-2. Normal Strapping Pattern

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 current allowable (current limit), as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically 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.

b. Open output terminals and adjust VOLTAGE controls for maximum output voltage allowable (voltage limit), as determeined 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).

3-11 CONNECTING LOAD

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

3-13 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (Paragraph 3-28).

3-14 OPTIONAL OPERATING MODES

3-15 REMOTE PROGRAMMING, CONSTANT VOLTAGE

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.

3-17 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 R13.

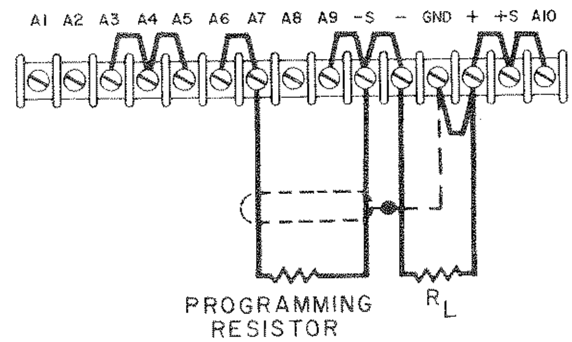


Figure 3-3. Remote Resistance Programming (Constant Voltage)

3-18 The output voltage of the power supply should be zero volts ±20 millivolts when zero ohms is connected across the programming terminals. If a zero ohm voltage closer than this is required, it may be achieved by changing resistor R6 or R8 as described in Paragraph 5-49.

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.

3-20 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.

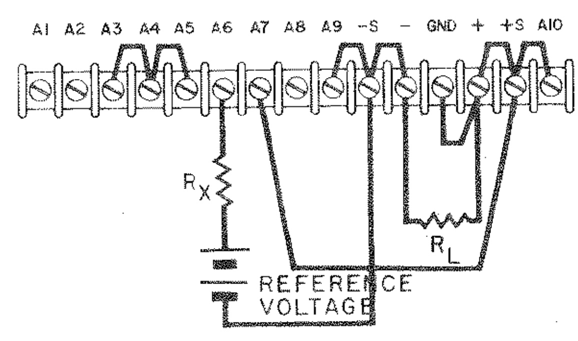


Figure 3-4. Remote Voltage Programming (Constant Voltage)

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.

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 resistor R19.

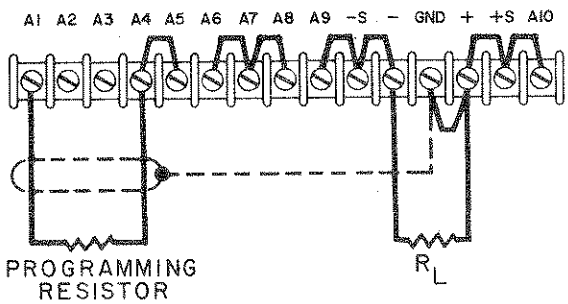


Figure 3-5. Remote Resistance Programming (Constant Current)

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

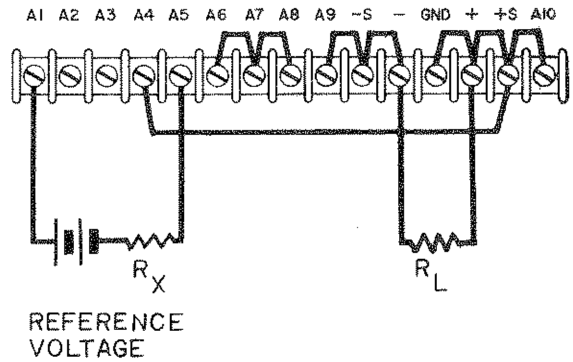


Figure 3-6. Remote Voltage Programming (Constant Current)

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 (R_X) 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.

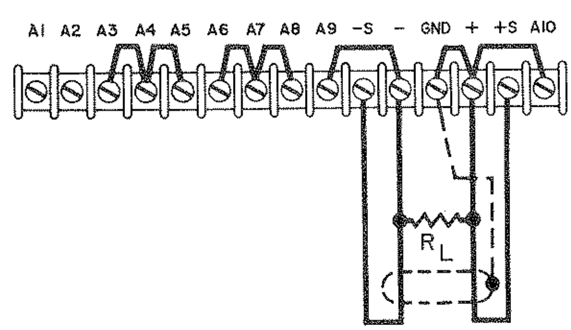


Figure 3-7. Remote Sensing

CAUTION

Observe polarity when connecting the sensing leads to the load.

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.

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.

3-32 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.

NOTE

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

3-33 SERIES OPERATION

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

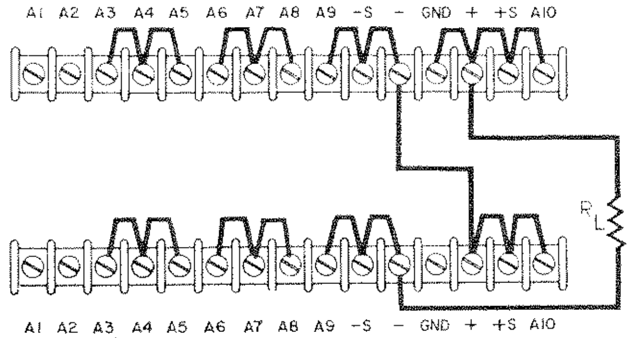


Figure 3-8. Normal Series

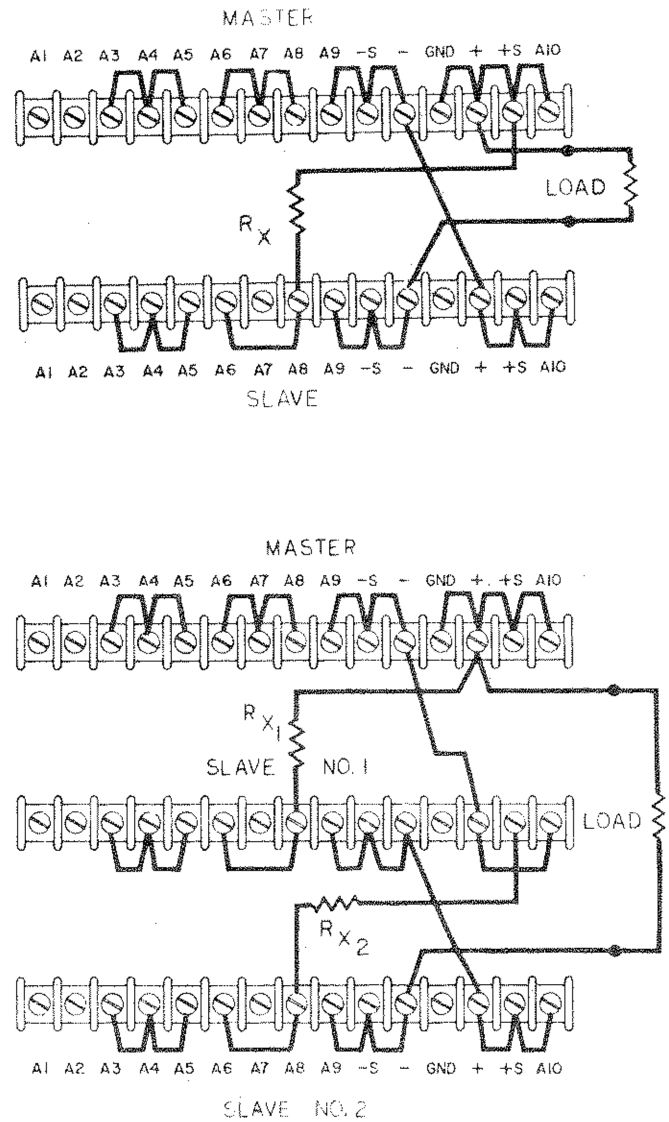


Figure 3-9. AUTO-Series, Two and Three Units

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.

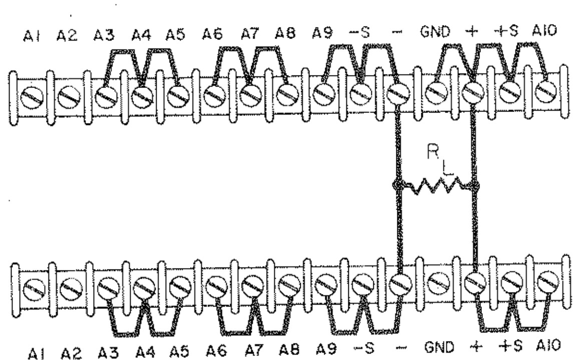


Figure 3-10. Normal Parallel

3-39 Auto-Parallel. The Strapping Patterns for Auto-Parallel operation of two and three power 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.

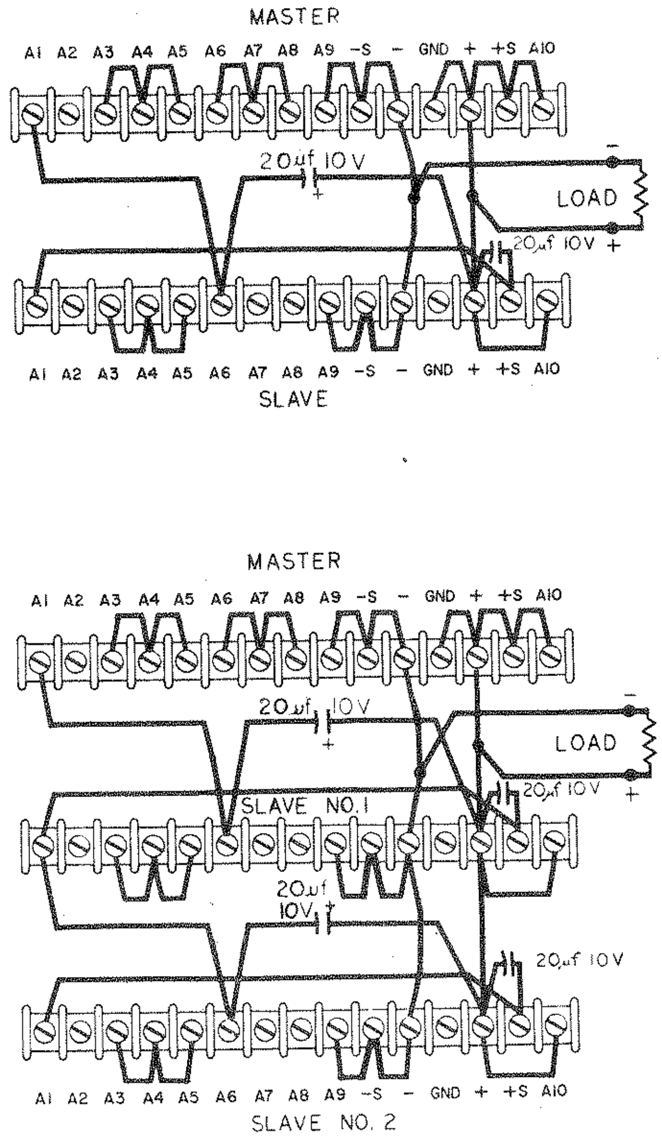


Figure 3-11. Auto-Parallel, Two and Three Units

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_X and R_Y) 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 <u>SPECIAL OPERATING CONSIDERATIONS</u>

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.

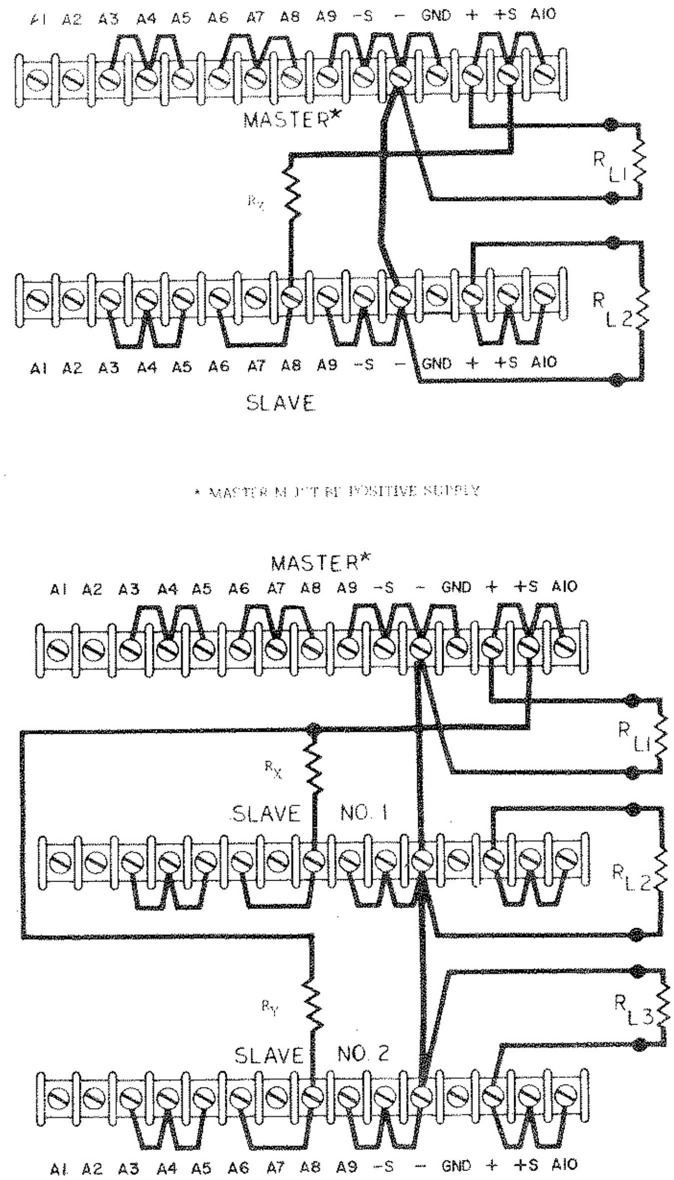


Figure 3-12. Auto-Tracking, Two and Three Units

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 <u>current</u> 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 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 it's 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.

SECTION IV
PRINCIPLES OF OPERATION

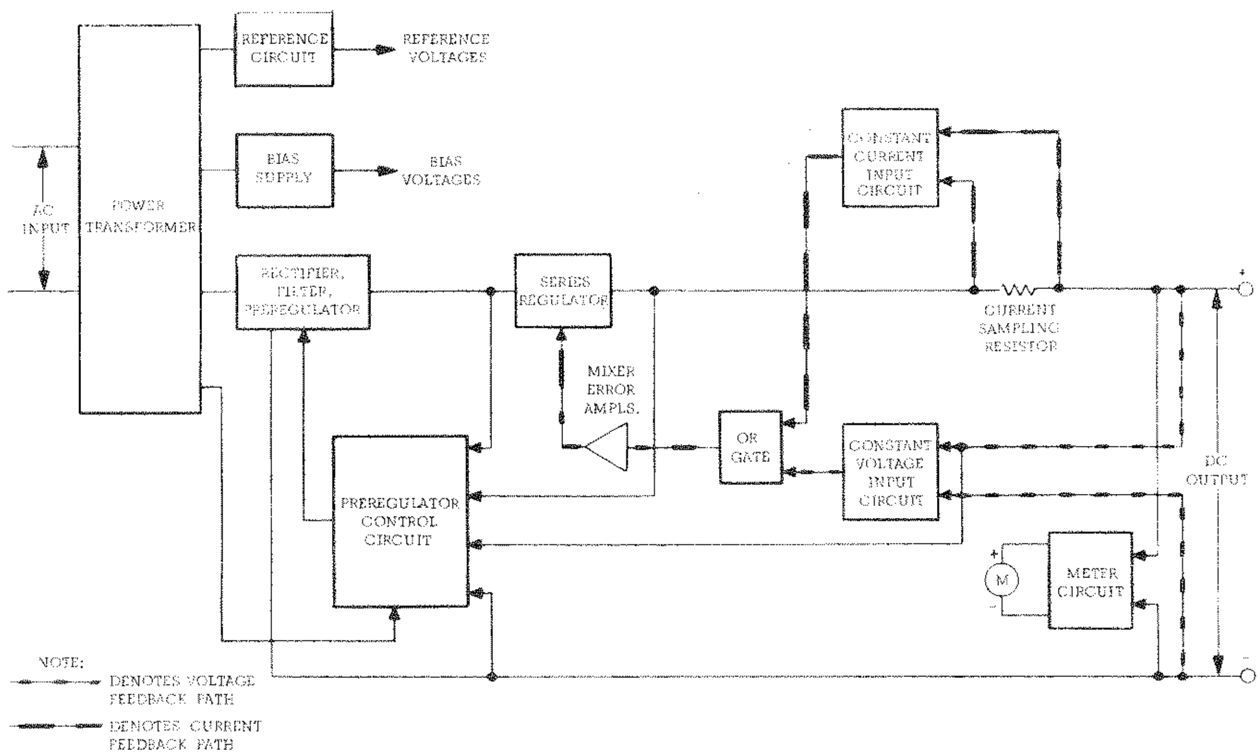


Figure 4-1. Overall Block Diagram

4-1 OVERALL BLOCK DIAGRAM DISCUSSION

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, preregulator 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 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 half cycle that the firing pulse will be generated. By adjusting the firing time of the SCR, the amplitude of the dc 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 relatively "slow" regulation demands. The dc current from the series regulator passes through a current sampling resistor before reaching the positive output terminal.

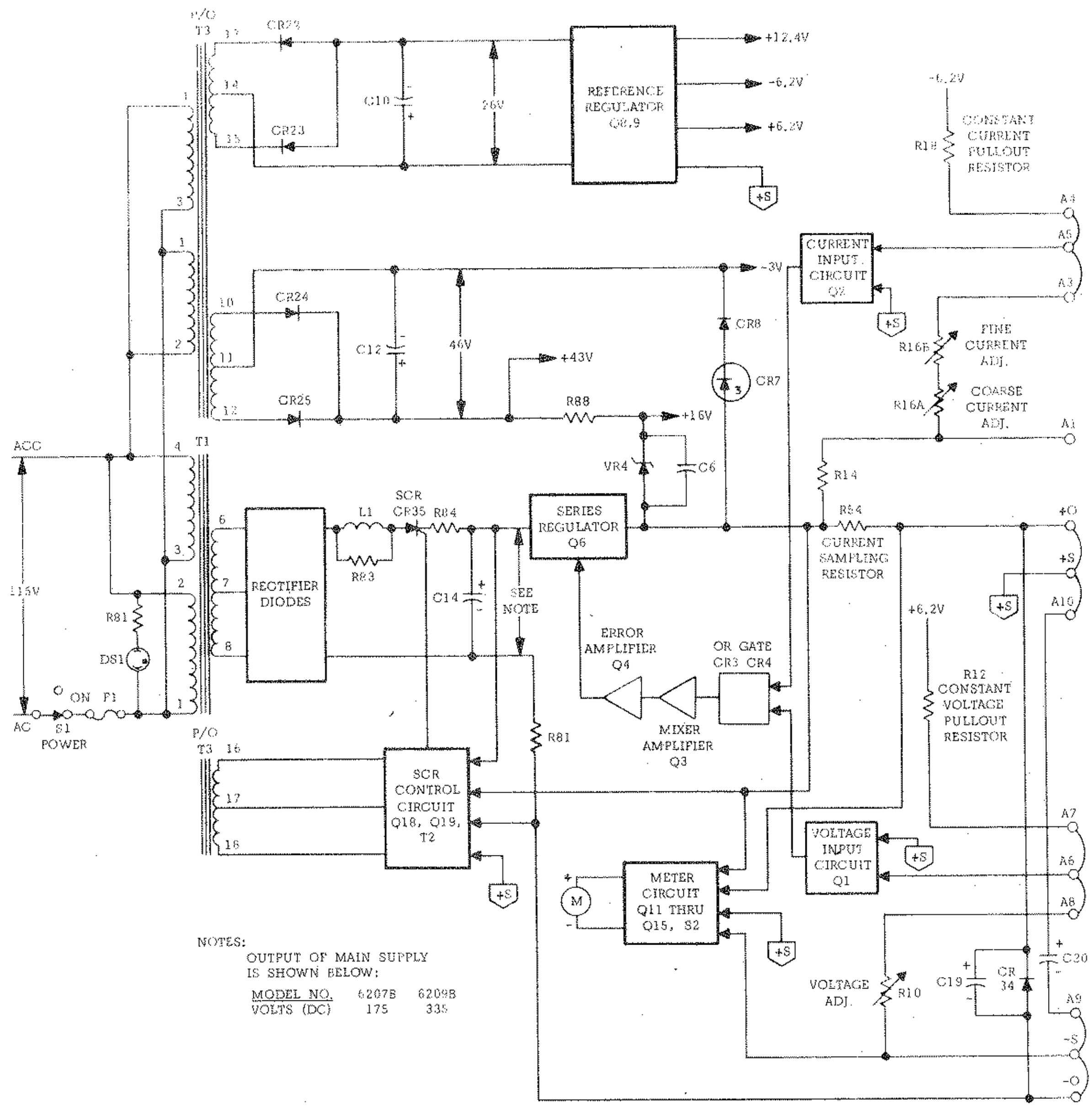


Figure 4-2. Simplified Schematic

4-4 The feedback signals that control the conduction of the series regulator are originated within the constant voltage input circuit or the constant current input circuit. The output voltage of the power supply is sampled by the constant voltage input circuit by means of the sensing terminals (±S). The voltage developed across the current sampling resistor is the input to the constant current input circuit. This voltage drop varies in direct proportion to the output current. Any changes in output voltage/current are detected in the constant voltage/constant current input circuit, amplified by the mixer and error amplifiers, and applied to the series regulator in the correct phase and amplitude to counteract the changes.

4-5 The reference circuit provides stable reference voltages which are used by the constant voltage/current input circuits for comparison purposes. The bias supply furnishes voltages which are used throughout the instrument for biasing purposes. The meter circuit provides an indication of output voltage or current.

4-6 SIMPLIFIED SCHEMATIC

4-7 A simplified schematic of the power supply is shown in Figure 4-2. It shows the operating controls; the ON-off switch, the voltage programming control (R10) and the current programming controls (R16A and R16B). The METER switch, included in 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 115Vac 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.

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

4-9 PREREGULATOR AND CONTROL CIRCUIT

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.

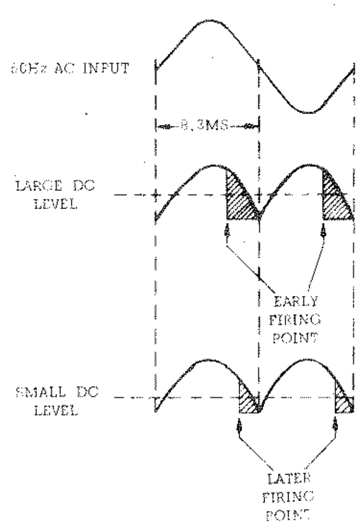


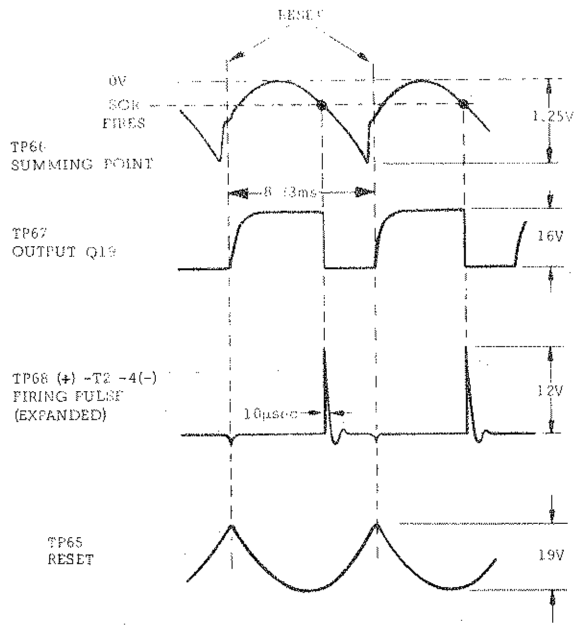
Figure 4-3. SCR Phase Control Over DC Input Level

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.

4-12 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 vaires 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 silimar 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, 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



NOTES:

1. ALL WAVEFORMS TAKEN AT MAXIMUM RATED OUTPUT VOLTAGE WITH NO LOAD CONNECTED.
2. ALL WAVEFORMS DC COUPLED AND REFERENCED TO T.P. 23 EXCEPT FIRING PULSE WHICH IS REFERENCED TO TERMINAL 4 OF T2.
3. FOR CLARITY, WAVEFORMS ARE NOT DRAWN TO SCALE. WAVEFORMS AT T.P. 66 AND T.P. 68 ARE EXPANDED.

Figure 4-4. Preregulator Control Circuit Waveforms

to its "on" state. Consequently, Q19 is turned off and capacitor C17 charges up through R96 at a comparatively slow rate until the collector voltage of Q19 reaches approximately +16 volts. The above action causes the small negative spike that appears across the winding of pulse transformer T2 at reset time.

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 diode VR3, connected across Q6 and R54, protects the series transistor if the output terminals of the supply are shorted. Resistor R81 limits the current through VR3.

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 prevent 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 CR33, together with C7 and R9, improves the transient recovery time of the unit.

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 +S 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 limits 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 maintaining the constant voltage programming current constant.

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 +6.2 and -6.2 voltages, which are used in 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 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.

4-36 METER CIRCUIT

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 divider R59, R60, and R61 (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 ampere 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

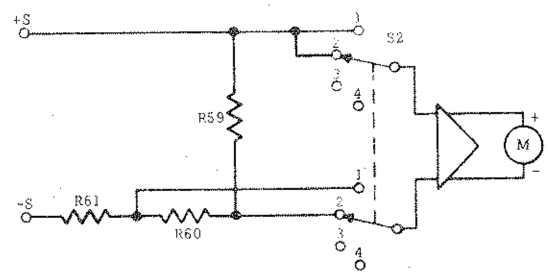


Figure 4-5. Voltmeter Connections, Simplified Schematic

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.

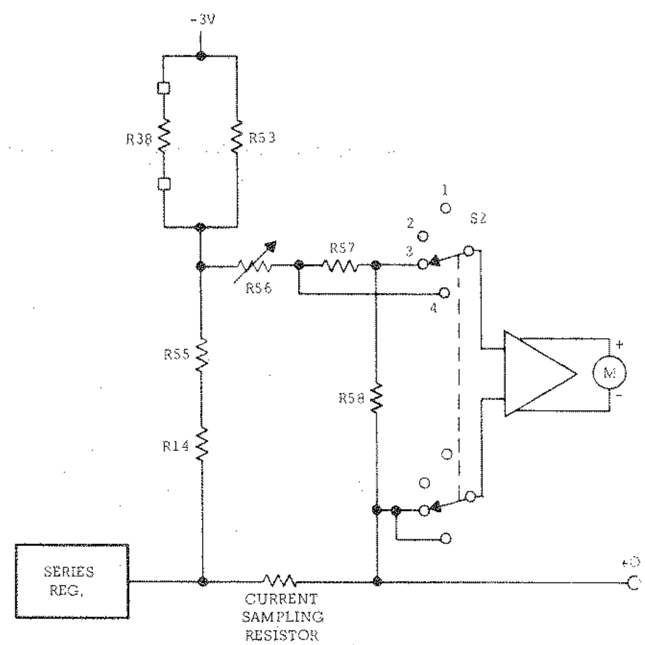


Figure 4-6. Ammeter Connections, Simplified Schematic

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.

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.

4-43 OPERATION OF SERIES REGULATOR FEEDBACK LOOP

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.

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.

Table 5-1. Test Equipment Required

Type	Required Characteristics	Use	Recommended Model
Differential Voltmeter	Sensitivity: 1 mv full scale (min.). Input impedance: 10 megohms (min.).	Measure DC voltages; calibration procedures	hp 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.	hp 403 B
Oscilloscope	Sensitivity: 100 µv/cm. Differential input.	Display transient response waveforms	hp 140 A plus 1400A plug in.
Oscillator	Range: 5 cps to 600 Kc. Accuracy: 2%.	Impedance checks	hp 200 CD
DC Voltmeter	Accuracy: 1%. Input resistance: 20,000 ohms/volt (min.).	Measure DC voltages	hp 412A
Repetitive Load Switch	Rate: 60 — 400 Hz, 2µsec rise and fall time.	Measure transient response.	See Figure 5-7
Resistor	Value: See Paragraph 5-14. ±5%, 75 watts	Load Resistor	----------------
Resistor	Value: 10 ohms, 1%, 200Watts (Model 6207B) 50 Watts (Model 6209B) 4-Terminal, 20ppm.	Current sampling	----------------
Resistor	1KΩ ±1%, 2 watt non-inductive	Measure impedance	----------------
Resistor	100 ohms, ±5%, 10 watt	Measure impedance	----------------
Resistor	Value: See Paragraph 5-49. ±0.1%, 5 watt.	Calibrate programming current	----------------
Resistor	Value: See Paragraph 5-52. ±0.1%, 5 watt.	Calibrate programming current	----------------
Capacitor	500µf, 50 wvdc	Measure impedance.	----------------
Decade Resistance Box	Range: 0-150K (min.). Accuracy: 0.1% plus 1 ohm Make-before-break contacts.	Measure programming coefficients.	----------------

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/^oC) type and should be used at no more than 5% of its rated power so that its temperature rise will be minimized.

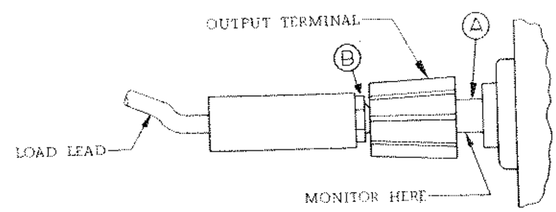


Figure 5-1. Front Panel Terminal Connections

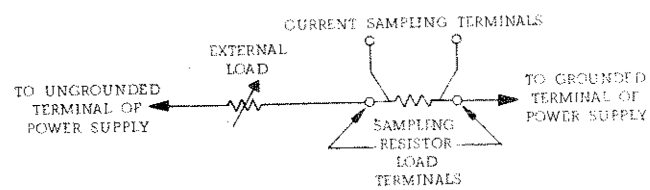


Figure 5-2. Output Current Measurement Technique

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 ±2%.

5-15 Current. Proceed as follows:

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

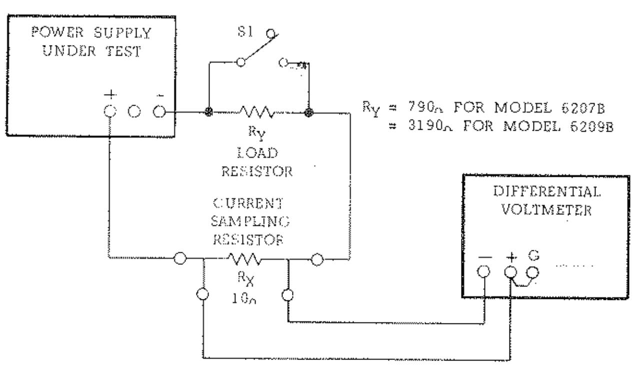


Figure 5-4. Output Current, Test Setup

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 ± 0.04 Vdc for Model 6207B or 1.0 ± 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.

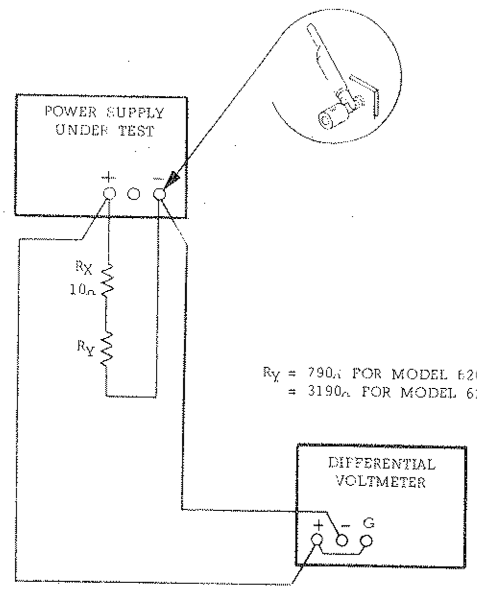


Figure 5-5. Load Regulation, Constant Voltage

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.	6207B	6209B
Variation (mvdc)	±34	±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.	6207B	6209B
Variation (mvdc)	±34	±66

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

NOTE

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: ⓗⓟ 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.

CAUTION

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

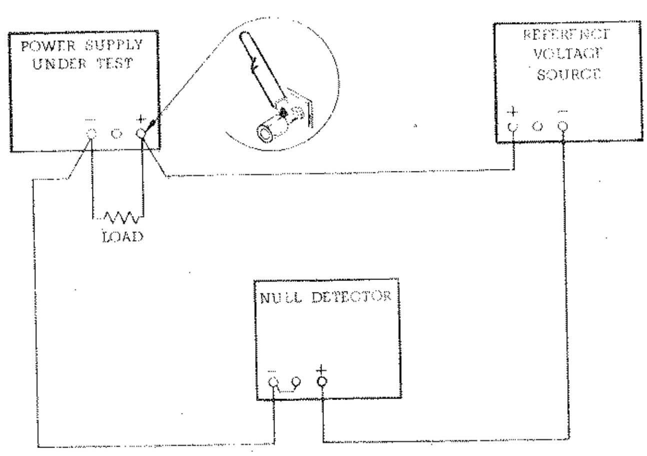


Figure 5-3. Differential Voltmeter Substitute, Test Setup

5-10 PERFORMANCE TEST

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).

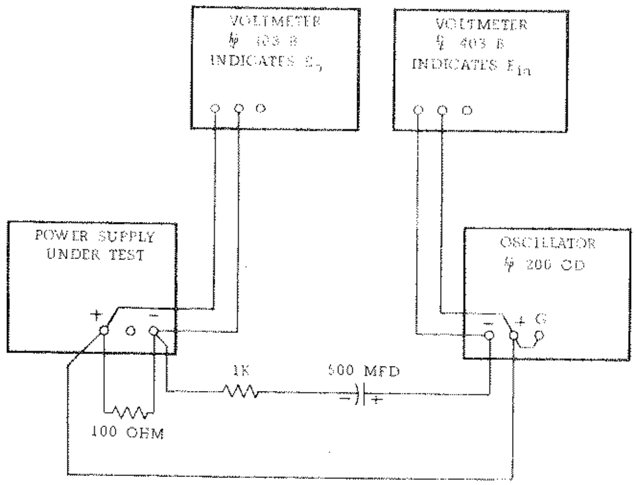


Figure 5-9. Output Impedance, Test Setup

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

d. Set AMPLITUDE control on Oscillator to 10 volts (E_{in}), and FREQUENCY control to 100 cps.

e. Record voltage across output terminals of the power supply (E_o) as indicated on AC voltmeter.

f. Calculate the output impedance by the following formula:

$$Z_{out} = \frac{E_oR}{E_{in} - E_o}$$

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.

h. 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 $X_L = Z_{out}$.

5-24 CONSTANT CURRENT TESTS

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

a. Connect test setup as shown in Figure 5-4.

b. Turn VOLTAGE control fully clockwise.

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

d. Adjust CURRENT controls until front panel meter reads exactly the maximum rated output current.

e. Read and record voltage indicated on differential voltmeter.

f. Short out load resistor (R_Y) by closing switch S1.

g. 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:

a. Utilize test setup shown in Figure 5-4 leaving switch S1 open throughout test.

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

c. Adjust auto transformer for 105 VAC input.

d. Turn VOLTAGE control(s) fully clockwise.

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

f. Adjust CURRENT controls until front panel meter reads exactly the maximum rated output current.

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 2mVdc.

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

a. Use test setup shown in Figure 5-4, except connect AC voltmeter across sampling resistor instead of differential voltmeter.

b. Rotate VOLTAGE control fully clockwise.

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

d. Adjust CURRENT controls until front panel meter indicates exactly the maximum rated output current.

e. Turn range switch on AC voltmeter to 1 mv position.

f. The AC voltmeter should read less than 2mVac.

5-18 Ripple and Noise. To check the ripple and noise, proceed as follows:

a. Retain test setup used for previous line regulation test except connect AC voltmeter across output terminals as shown in Figure 5-6.

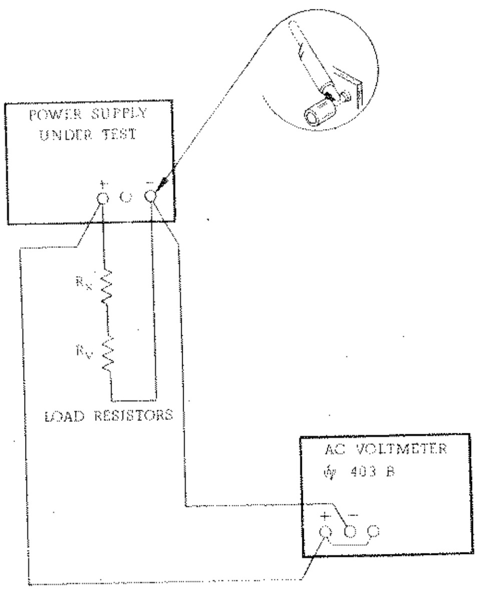


Figure 5-6. Ripple and Noise, Constant Voltage

b. Adjust variable auto transformer for 125 VAC input.

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.

5-19 Transient Recovery Time. To check the transient recovery time proceed as follows:

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

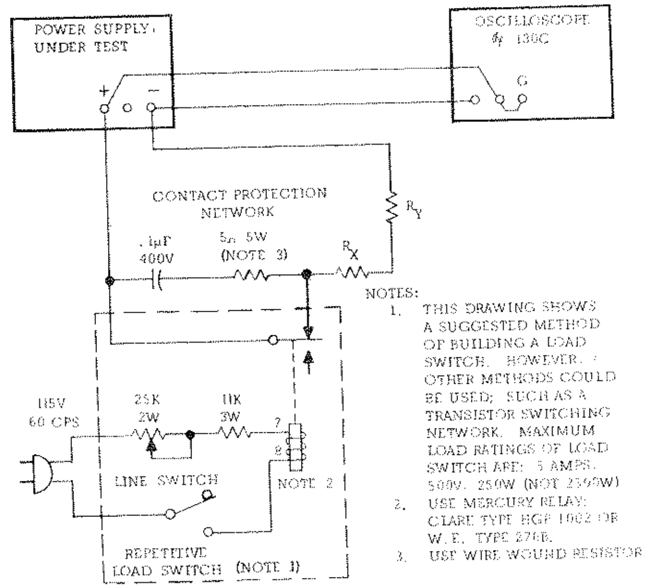
b. Turn CURRENT controls fully clockwise.

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



MODEL NO.	RESISTANCE (OHMS) R_X	R_Y
6200B	1	12
6201B	1	12
6202B	2	51
6203B	0.50	2

MODEL NO.	RESISTANCE (OHMS) R_X	R_Y
6204B	3	30
6205B	3	30
6206B	1	29
6207B	10	790
6209B	10	3190

Figure 5-7. Transient Recovery Time, Test Setup

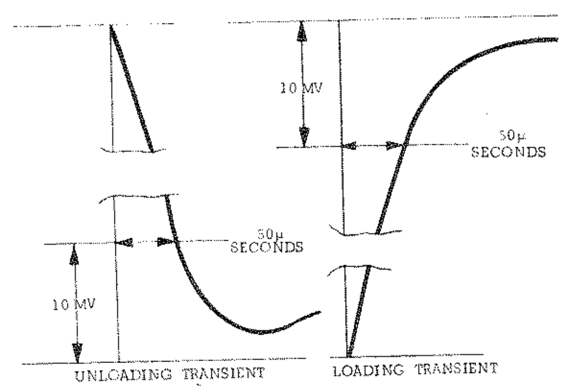


Figure 5-8. Transient Recovery Time, Waveforms

5-20 OUTPUT IMPEDANCE

5-21 To check the output impedance, proceed as follows:

a. Connect test setup shown in Figure 5-9.

b. Set METER switch to highest voltage range and turn on supply.

Table 5-3. High Output Voltage Troubleshooting

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

Table 5-4. Low Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Voltage between TP23 and TP24	a. 12V to 16V b. Less than 12V or greater than 16V	a. Proceed to Step 2 b. Proceed to Table 5-5
2	Disable Q2 by disconnecting CR4	a. Normal output voltage b. Low output voltage	a. Constant Current circuit faulty; check CR4, Q2A, or R16 for short. 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 b. More positive than 0V	a. Q4 shorted b. Q6 open Proceed to Step 4
4	Voltage between +S and A6	a. More negative than 0V	a. Open strap A6 - A7 R10, C1 shorted Proceed to Step 5
5	Voltage between +S and 12	a. More positive than +4.3V b. +2.7V to +4.3V	a. Q1A open Q1B or R3 shorted b. Proceed to Step 6

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 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 12.4 volt bias or VR1
2	31	+S	6.2 ± 0.3vdc	Check 12.4 volt bias or VR2
3	+S	37	12.4 ± 1.0vdc	Check Q8, Q9, CR22, CR23, C10, T3

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

Table 5-6. Common Troubles

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

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

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

Table 5-5. Preregulator/Control Circuit Troubleshooting

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

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 in 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.

Table 5-7. Selected Semiconductor Characteristics

Reference Designator	Characteristics	hp Stock No.	Suggested Replacement
Q1	Matched differential amplifier. NPN Si Planar. 70 (min.) h_{FE} ic = 1ma. V_{CE} = 5V. I_{co} 0.01 μa @ V_{cbo} = 5V.	1854-0229	2N2917 G.E.
Q2	Matched differential amplifier. NPN Si.	1854-0221	2N4045 Union Carbide
CR1, CR22-25, CR32, CR34	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 5-8. Checks and Adjustments After Replacement of Semiconductor Devices

Reference	Function	Check	Adjust
Q1	Constant voltage differential amplifier	Constant voltage (CV) line and load regulation. Zero volt output.	R6 or R8
Q2	Constant current differential amplifier	Constant current (CC) line and load regulation. Zero current output.	R25 or R28
Q3, Q4	Mixer and error amplifier	CV/CC load regulation. 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.	

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.

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

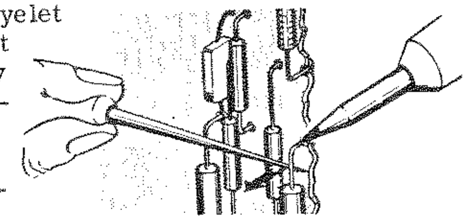
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

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

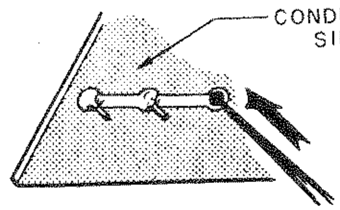
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

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

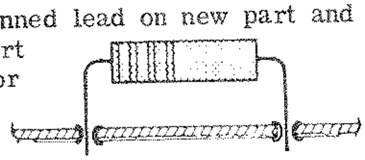
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



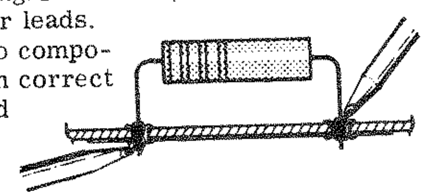
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



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

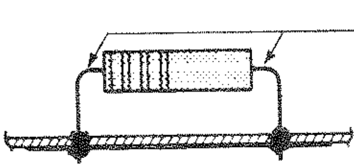


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

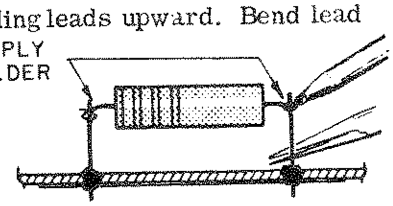


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



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



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

Figure 5-10. Servicing Printed Wiring Boards

5-41 METER ZERO

5-42 Proceed as follows to zero meter:

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

b. Insert sharp pointed object (pen point or awl) into the small indentation near top of round black plastic disc located directly below meter face.

c. 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 VOLTMETER TRACKING

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

a. 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.

b. Connect differential voltmeter across supply, observing correct polarity.

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

d. 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:

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

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

c. Connect decade resistance box in place of R38.

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

e. Adjust decade resistance so that ammeter reads zero.

f. Turn off supply and connect test setup as shown on Figure 5-4. Leave S1 open.

g. Turn on supply and adjust CURRENT control until differential voltmeter reads 2Vdc (Model 6207B) or 1Vdc (Model 6209B).

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

5-47 CONSTANT VOLTAGE PROGRAMMING CURRENT

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

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

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

c. Rotate CURRENT controls fully clockwise and turn on supply.

d. Observe reading on differential voltmeter.

e. If it is more positive than 0 volts, shunt resistor R6 with decade resistance box.

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

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

h. Adjust decade resistance until differential voltmeter reads zero then shunt R8 with resistance value equal to that of the decade box.

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

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

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

c. Connect a decade resistance in place of R13.

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

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

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

5-50 CONSTANT CURRENT PROGRAMMING CURRENT

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

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

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

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

d. Observe reading on differential voltmeter.

e. If it is more positive than 0 volts, shunt resistor R25 with a decade resistance box.

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

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

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

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

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	

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.

Table 5-9. Calibration Adjustment Summary

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

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 ± 0.04Vdc for Model 6207B or 1.0 ± 0.02Vdc 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 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:

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.

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. (hp) 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, signaling (lamp)
C = capacitor	

Table 6-1. Reference Designators (Continued)

E = misc. electronic part	RT = thermistor
F = fuse	S = switch
J = jack	T = transformer
K = relay	V = vacuum tube, neon bulb, photocell, etc.
L = inductor	
M = meter	X = socket
P = plug	XF = fuseholder
Q = transistor	XDS = lampholder
R = resistor	Z = network

Table 6-2. Description Abbreviations

a	= amperes	obd	= order by description
c	= carbon		
cer	= ceramic	p	= peak
coef	= coefficient	pc	= printed circuit board
com	= common		
comp	= composition	pf	= picofarads = 10^{-12} farads
conn	= connection		
crt	= cathode-ray tube	pp	= peak-to-peak
		ppm	= parts per million
dep	= deposited	pos	= position(s)
elect	= electrolytic	poly	= polystyrene
encap	= encapsulated	pot	= potentiometer
f	= farads	prv	= peak reverse voltage
fxd	= fixed		
GE	= germanium	rect	= rectifier
grd	= ground(ed)	rot	= rotary
h	= henries	rms	= root-mean-square
Hg	= mercury	s-b	= slow-blow
impg	= impregnated	sect	= section(s)
ins	= insulation(ed)	Si	= silicon
K	= kilo = 1000	sil	= silver
lin	= linear taper	sl	= slide
log	= logarithmic taper	td	= time delay
		TiO_2	= titanium dioxide
mA	= milli = 10^{-3}	tog	= toggle
M	= megohms	tol	= tolerance
ma	= milliamperes	trim	= trimmer
µ	= micro = 10^{-6}	twt	= traveling wave tube
mfr	= manufacturer		
mtg	= mounting	var	= variable
my	= mylar	w/	= with
NC	= normally closed	W	= watts
		w/o	= without
Ne	= neon	cmo	= cabinet mount only
NO	= normally open		

Table 6-3. Code List of Manufacturers

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

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

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

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., Kemet Dept.	Mountain View, Calif.
22767	ITT Semiconductors, A Division of International Telephone & Telegraph Corp.	Palo Alto, Calif.
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co., Lamp Division	Nela Park, Cleveland, Ohio
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	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
44655	Ohmite Manufacturing Co.	Skokie, Ill.
47904	Polaroid Corporation	Cambridge, Mass.
49956	Raytheon Mfg. Co., Microwave and 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	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Elkhart, Ind.
71468	I. T. T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Centralab Div. of Globe Union, Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72619	Dialight Corporation	Brooklyn, N.Y.
72699	General Instrument Corp., Capacitor Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72982	Erie Technological Products, Inc.	Erie, Pa.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, 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 Hindle Co., Memcor Components Div.	Huntington, Ind.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Harvey Hubbel, Inc.	Bridgeport, Conn.
74868	FXR Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
75042	International Resistance Co.	Philadelphia, Pa.
75183	Howard B. Jones Div., of Cinch Mfg. Corp. (Use 71785)	New York, N.Y.
75382	Kulka Electric Corp.	Mt. Vernon, 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	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry, Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronics, Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Div. of Illinois Tool Works	Elgin, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Co., Inc.	Newburgh, N.Y.
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.

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., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp., Electronic Components Div.	Plainfield, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	Radio Corporation of America, Electronic Components & Devices Div.	Harrison, N.J.
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., Semiconductor Prod. Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
94144	Raytheon Co., Components Div., Industrial Components Operation	Quincy, Mass.
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	Methode 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.

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

CODE NO.	MANUFACTURER	ADDRESS
0000	Cooltron	Oakland, Calif.
00000	Plastic Ware Co.	Brooklyn, N.Y.

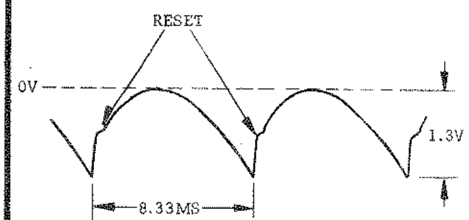
Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
C1	fxd, elect 1μf 450vdc	1	45D10255	Sprague	56289	0180-1845	1
C2, 3, 18	fxd, film .01μf 200vdc	3	192P10392	Sprague	56289	0160-0161	1
C4, 8, 11, 13, 15, 16, 21	NOT ASSIGNED	-	-	-	-	-	-
C5	fxd, film .001μf 200vdc	1	192P10292	Sprague	56289	0160-0153	1
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	HLAB	09182	0180-1852	1
C12	fxd, elect 490μf 85vdc	1	D38618	HLAB	09182	0180-1888	1
C14	fxd, elect 300μf 250vdc	1	D39343	HLAB	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	HLAB	09182	0180-1851	1
C22	fxd, elect 1μf 35vdc	1	150D105X9035A2	Sprague	56289	0180-0291	1
C23, 24	fxd, elect 5μf 65vdc	2	D33689	HLAB	09182	0180-1836	1
C25	fxd, film .001μf 200vdc	1	192P10292	Sprague	56289	0160-0153	1
CR1, 22-25, 32, 34	Rect. si. 900ma 200prv	7	IN5059	G. E.	03508	1901-0327	6
CR2-5, 9-15, 17, 18, 20, 30, 33	Rect. si. 200ma 180prv	16		HLAB	09182	1901-0033	8
CR6, 19, 21, 31	NOT ASSIGNED	-	-	-	-	-	-
CR7	Diode, si. 10V 400mw	1		HLAB	09182	1901-0460	1
CR8, 16	Rect. si. 400mw 10prv	2		HLAB	09182	1901-0461	2
CR26, 27	NOT USED	-	-	-	-	-	-
CR28, 29	Rect. si. 700ma 800prv	2	SR1358	Motorola	04713	1901-0030	2
CR35	SCR si. 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		HLAB	09182	9100-1854	1
Q1	SS NPN diff. amp. si.	1		HLAB	09182	1854-0229	1
Q2	NPN diff. amp. si.	1		HLAB	09182	1854-0221	1
Q3, 4, 8, 10, 12, 14, 15	SS PNP si.	7	2N2907A	Sprague	56289	1853-0099	6
Q5, 7, 16	NOT ASSIGNED	-	-	-	-	-	-
Q6	Power NPN si.	1		HLAB	09182	1854-0228	1
Q9, 11, 13, 17-19	SS NPN si.	6	SK1124	T.I.	01295	1854-0071	6
R1, 12	fxd, ww 2KΩ ±5% 3w 20ppm	2	242E2025	Sprague	56289	0811-1806	1
R2, 53, 86	fxd, met. film 6.2KΩ ±1% 1/8w	3	Type CEA T-O	I. R. C.	07716	0698-5087	1
R3, 4, 64, 65	fxd, met. film 20KΩ ±1% 1/8w	4	Type CEA T-O	I. R. C.	07716	0757-0449	1
R5, 26, 29, 76, 77	fxd, met. film 1.5KΩ ±1% 1/8w	5	Type CEA T-O	I. R. C.	07716	0757-0427	2
R6, 25	fxd, comp 360KΩ ±5% ½w	2	EB-3645	A. B.	01121	0686-3645	1
R7	fxd, comp 430KΩ ±5% ½w	1	EB-4345	A. B.	01121	0686-4345	1
R8, 28	fxd, comp 560KΩ ±5% ½w	2	EB-5645	A. B.	01121	0686-5645	1
R9	fxd, comp 1meg ±5% ½w	1	EB-1055	A. B.	01121	0686-1055	1
R10	var. ww 50KΩ 10-turn	1		HLAB	09182	2100-1994	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	ⓗⓟ Stock No.	RS
R11, 17, 27, 32, 35-37, 39, 78, 79	NOT ASSIGNED	-	-	-	-	-	-
R13, 19, 38	fxd, comp SELECTED ±5% $\frac{1}{2}$w	3	Type EB	A. B.	01121		1
R14	fxd, comp 3.3Ω ±5% $\frac{1}{2}$w	1	EB-0335	A. B.	01121	0686-0335	1
R15	fxd, comp 82KΩ ±5% 1w	1	GB-8235	A. B.	01121	0689-8235	1
R16	var. ww DUAL 18K - 200Ω	1		HLAB	09182	2100-2068	1
R18	fxd, ww 65K ±1% $\frac{1}{2}$w	1	E30	R. C. L.	01686	0811-2077	1
R20, 48	fxd, met. film 1KΩ ±1% $\frac{1}{4}$w	2	Type CEB T-O	I. R. C.	07716	0757-0338	1
R21	fxd, comp 390Ω ±5% $\frac{1}{2}$w	1	EB-3915	A. B.	01121	0686-3915	1
R22, 23	fxd, comp 61.9K ±1% 1/8w	2	Type CEA T-O	I. R. C.	07716	0757-0460	1
R24	fxd, met. film 43K ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0698-5090	1
R30	var. ww 5KΩ (Modify)	1	Type 110-F4	C. T. S.	11236	2100-1824	1
R31	fxd, comp 1KΩ ±5% $\frac{1}{2}$w	1	EB-1025	A. B.	01121	0686-1025	1
R33	fxd, comp 6.2KΩ ±5% $\frac{1}{2}$w	1	EB-6225	A. B.	01121	0686-6225	1
R34, 96	fxd, comp 3.9KΩ ±5% $\frac{1}{2}$w	2	EB-3925	A. B.	01121	0686-3925	1
R40, 57, 60, 62	fxd, met. film 900Ω ±1% 1/8w	4	Type CEA T-O	I. R. C.	07716	0757-1099	1
R41, 99	fxd, comp 12KΩ ±5% $\frac{1}{2}$w	2	EB-1235	A. B.	01121	0686-1235	1
R42	fxd, comp 6.8KΩ ±5% $\frac{1}{2}$w	1	EB-6825	A. B.	01121	0686-6825	1
R43	fxd, met. film 510Ω ±1% $\frac{1}{4}$w	1	Type CEB T-O	I. R. C.	07716	0698-5145	1
R44	fxd, comp 47KΩ ±5% $\frac{1}{2}$w	1	EB-4735	A. B.	01121	0686-4735	1
R45	fxd, comp 5.1KΩ ±5% $\frac{1}{2}$w	1	EB-5125	A. B.	01121	0686-5125	1
R46	fxd, comp 100KΩ ±5% $\frac{1}{2}$w	1	EB-1045	A. B.	01121	0686-1045	1
R47	fxd, comp 560Ω ±5% $\frac{1}{2}$w	1	EB-5615	A. B.	01121	0686-5615	1
R49	fxd, ww 15KΩ ±5% 10w	1		HLAB	09182	0811-0954	1
R50	fxd, comp 10Ω ±5% $\frac{1}{2}$w	1	EB-1005	A. B.	01121	0686-1005	1
R51	fxd, comp 30KΩ ±5% $\frac{1}{2}$w	1	EB-3035	A. B.	01121	0686-3035	1
R52	fxd, comp 22KΩ ±5% $\frac{1}{2}$w	1	EB-2235	A. B.	01121	0686-2235	1
R54	fxd, ww 7.5Ω ±1% 10w	1	247E7255	Sprague	56289	0811-1894	1
R55	fxd, met. film 42.2Ω ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0316	1
R56	var. ww 1KΩ (Modify)	1	Type 110-F4	C. T. S.	11236	2100-0391	1
R58, 59	fxd, met. film 100Ω ±1% 1/8w	2	Type CEA T-O	I. R. C.	07716	0757-0401	1
R61	fxd, met. film 182KΩ ±1% $\frac{1}{2}$w	1	Type CEC T-O	I. R. C.	07716	0757-0311	1
R63	var. ww 10KΩ	1	Type 110-F4	C. T. S.	11236	2100-0396	1
R66, 67	fxd, met. film 3.40KΩ ±1% $\frac{1}{4}$w	2	Type CEB T-O	I. R. C.	07716	0698-4640	1
R68, 69	fxd, met. film 365Ω ±1% $\frac{1}{4}$w	2	Type CEB T-O	I. R. C.	07716	0757-0723	1
R70, 71, 75, 85	fxd, met. film 3KΩ ±1% 1/8w	4	Type CEA T-O	I. R. C.	07716	0757-1093	1
R72	var. ww 250Ω (Modify)	1	Type 110-F4	C. T. S.	11236	2100-0439	1
R73	fxd, met. film 750Ω ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0420	1
R74	fxd, met. film 9.09KΩ ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0288	1
R80	fxd, comp 33KΩ ±5% $\frac{1}{2}$w	1	EB-3335	A. B.	01121	0686-3335	1
R81	fxd, ww 50Ω ±5% 5w	1	Type 5XM	Sprague	56289	0811-1854	1
R82	fxd, comp 1.5M ±5% $\frac{1}{2}$w	1	EB-1555	A. B.	01121	0686-1555	1
R83	fxd, comp 1.6KΩ ±5% $\frac{1}{2}$w	1	EB-1625	A. B.	01121	0686-1625	1
R84	fxd, ww 2Ω ±5% 3w 20ppm	1	242E2R05	Sprague	56289	0811-1831	1
R87	fxd, ww 3KΩ ±5% 3w 20ppm	1	242E3025	Sprague	56289	0812-0010	1
R88	fxd, comp 1.5KΩ ±5% 1w	1	GB-1525	A. B.	01121	0689-1525	1
R89	fxd, comp 220Ω ±5% 1w	1	GB-2215	A. B.	01121	0689-2215	1
R90	fxd, comp 6.2K ±5% 1w	1	GB-6225	A. B.	01121	0689-6225	1
R91	fxd, comp 39KΩ ±5% $\frac{1}{2}$w	1	EB-3935	A. B.	01121	0686-3935	1
R92	fxd, comp 43KΩ ±5% $\frac{1}{2}$w	1	EB-4335	A. B.	01121	0686-4335	1
R93, 95	fxd, comp 10KΩ ±5% $\frac{1}{2}$w	2	EB-1035	A. B.	01121	0686-1035	1
R94	fxd, comp 120KΩ ±5% $\frac{1}{2}$w	1	EB-1245	A. B.	01121	0686-1245	1
R96	fxd, comp 3.9KΩ ±5% $\frac{1}{2}$w	1	EB-3925	A. B.	01121	0686-3925	1
R97,	fxd, comp 16KΩ ±5% $\frac{1}{2}$w	1	EB-1635	A. B.	01121	0686-1635	1
R98	fxd, comp 2.2K ±5% $\frac{1}{2}$w	1	EB-2225	A. B.	01121	0686-2225	1

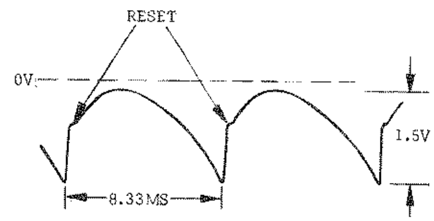
Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
R100	fxd, comp 330Ω ±5% 1w	1	GB-3315	A. B.	01121	0686-3315	1
R101	fxd, comp 22Ω ±5% ½w	1	EB-2205	A. B.	01121	0686-2205	1
R102	fxd, comp 100Ω ±5% ½w	1	EB-1015	A. B.	01121	0686-1015	1
S1	Switch, SPST ON/OFF	1	T110-72	Carling	73559	3101-1055	1
S2	Meter switch, wafer	1		HLAB	09182	3100-1910	1
T1	Power Transformer	1		HLAB	09182	9100-1825	1
T2	Pulse Transformer	1		HLAB	09182	9100-1824	1
T3	Bias Transformer	1		HLAB	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		HLAB	09182	1902-0431	1
VR4	Diode - zener 16.2V 400MW	1		HLAB	09182	1902-0184	1
VR5	Diode - zener 4.22V 400MW	1		HLAB	09182	1902-3070	1
	5 Way binding post (maroon)	1	DF21Mn	HLAB	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 7½ 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. ¼ insert	1		HLAB	09182	0370-0084	1
	Knob 5/8 dia ¼ insert (no arrow)	1		HLAB	09182	0370-0137	1
	Jumper	8	422-13-11 013	Cinch	71785	0360-1274	2
	Barrier strip	1		HLAB	09182	0360-1234	1
	Rubber bumper	4	MB50	Stockwell	87575	0403-0088	1
	Rubber bumper	3	4072	Stockwell	87575	0403-0086	1
	Knob pointer 17/64 insert	1		HLAB	09182	0370-0101	1
	Knob ½dia. 3/16 insert	1		HLAB	09182	0370-0179	1
	Bezel 1/6 mod	1		HLAB	09182	4040-0295	1
	Fuse holder	1	342014	Littlefuse	75915	1400-0048	1
	Meter 2¼" DUAL 0-200V 0-240ma	1		HLAB	09182	1120-1231	1
	Spring	4		HLAB	09182	1460-0720	1
	Fastener	8	C8091-632-24B	Tinnerman	89032	0510-0275	2
	Mica insulator	1	734	Reliance	08530	0340-0174	1
	Insulator, transistor pin	2		HLAB	09182	0340-0166	1
	Insulator	2		HLAB	09182	0340-0168	1

OPTIONS

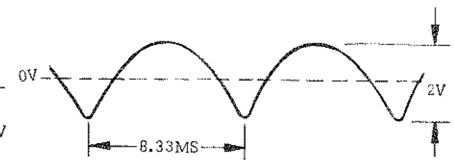
08	Current 10-turn Potentiometer	1	Series 8400	IRC	07716	2100-1864	1
13	Voltage Decadial Control	1	(Includes:)				
	Decadial Assembly	1	RD-411	IRC	07716	1140-0020	1
14	Current Decadial Control	1	(Includes:)				
	Current 10-turn Pot.	1	Series 8400	IRC	07716	2100-1864	1
	Decadial Assembly	1	RD-411	IRC	07716	1140-0020	1



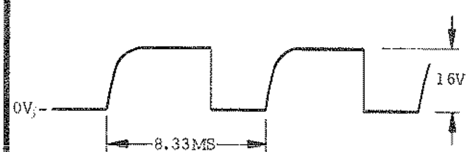
A. TEST POINTS 66-23
(NO LOAD)



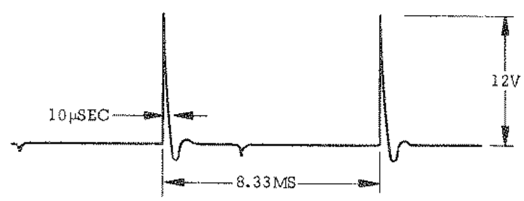
B. TEST POINTS 66-23
(FULL LOAD)



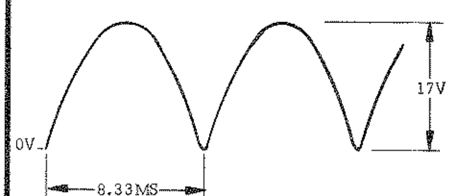
C. TEST POINTS 66-23
(NO LOAD, 10V OUTPUT)



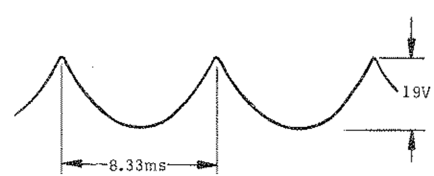
D. TEST POINTS 67-23



E. TEST POINTS 68-T2-4



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



G. TEST POINTS 65-23

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 ± 10%.
2. OSCILLOSCOPE DC COUPLED AND REFERENCED TO TEST POINT 23 UNLESS OTHERWISE INDICATED.
3. FOR CLARITY, WAVEFORMS ARE NOT DRAWN TO SCALE.

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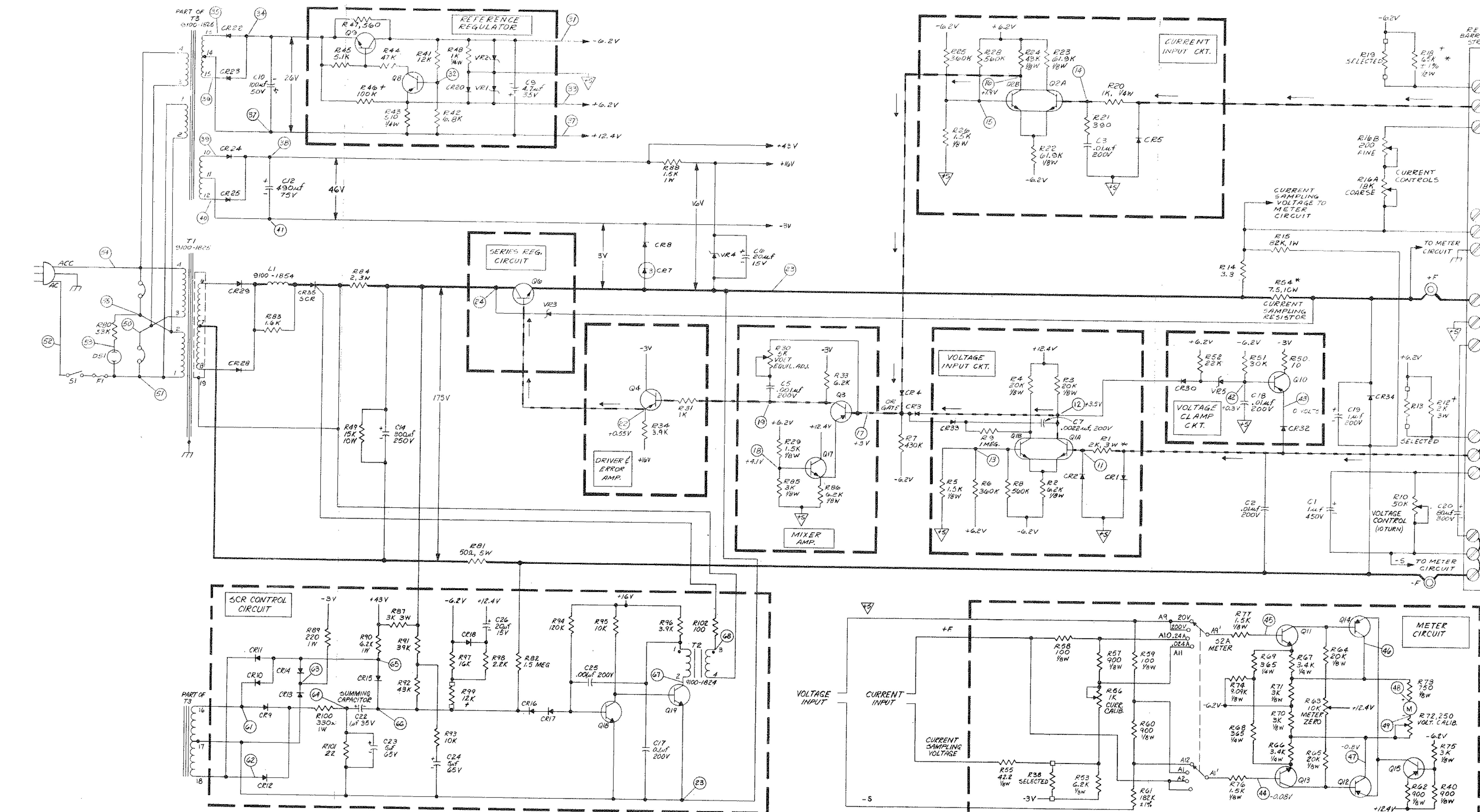

NOTES:

1. ALL RESISTORS ARE 1/2 WATT, 5% UNLESS OTHERWISE NOTED
2. ALL 1/8W & 1/4W 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 SHAFT 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. 115 VAC INPUT
    C. VOLTAGES REFERENCED TO +S, 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.

SYM	REVISIONS	APPROVED	DATE
C	ECN 970 RUN 1	WRD	10-10-66
B	ECN 967 RUN 1	WRD	9-27-66
A	AS ISSUED	WRD	9-15-66

DRAWN BY W. DARCY DATE 9-15-66

TITLE 6207 B SCHEMATIC

HEWLETT PACKARD LABORATORY INSTRUMENTS

DWG NO E-06207-91001-1

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