DC POWER SUPPLY

LAB SERIES, MODEL 6206B

SERIAL NUMBER PREFIX 6J

Printed: August, 1966
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MANUAL CHANGES

DC POWER SUPPLY
Model 6206B
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 CHANGES
Prefix	Number	
6J	0776 - up	1

SERIAL		MAKE CHANGES
Prefix	Number	

CHANGE 1: In Section IV of the manual, make the following corrections:

Page 4-2, Figure 4-2, add "Q5" under "Driver" and "Q17" under "Error Amplifier".

Page 4-4, Paragraph 4-16, add "Transistor Q17 establishes a stable emitter bias potential for error amplifier Q3. Emitter follower transistors Q4 and Q5 serve as the driver and pre-driver elements, respectively, for the series regulator".

On Figure 4-4, the error amplifier circuit should appear as shown on the schematic at the rear of the manual.

In Section V of the manual, make the following corrections:

Page 5-7, Table 5-3, Step 2, change "less positive than 1.8V" to "less positive than 2.1V" and "+1.8V to 2.2V" to "+2.1V to +3.9V".

Page 5-7, Table 5-4, Step 1, change entry in "Measure" column to "Unsolder CR16 from R81". In Step 3, change "More positive than 2.2V" to "More positive than 3.9V" and "+2V to +3.8V" to "+2.1V to +3.9V".

Page 5-10, Table 5-6, delete CR6 and CR7 from first column.

Page 5-10, Table 5-7, add "Q5" to "Q3, Q4" in the first column. Delete CR6, and CR7 and associated information from table.

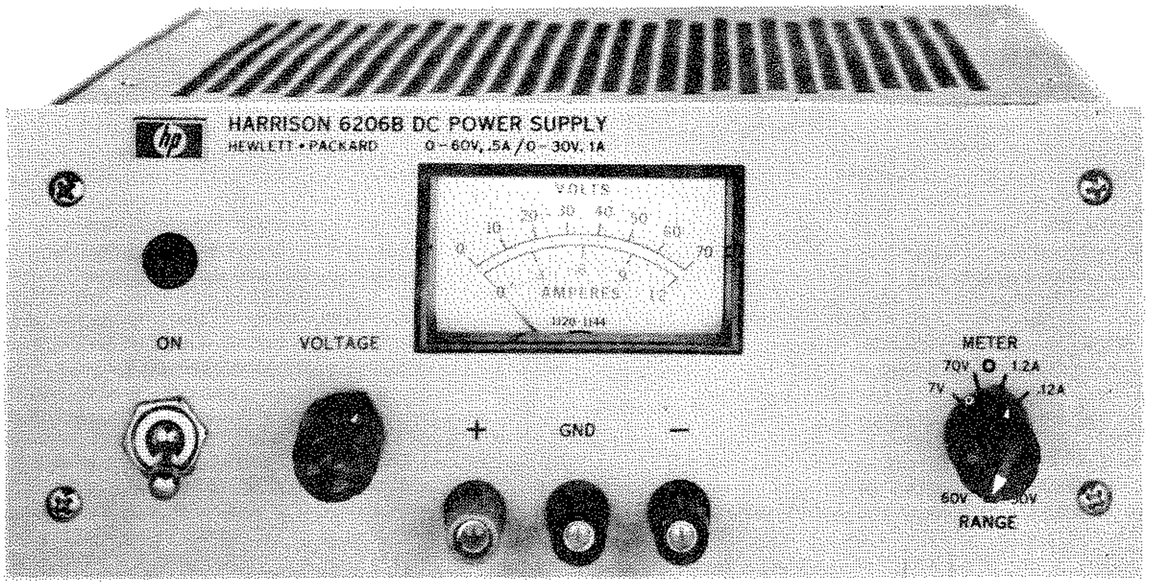


Figure 1-1. DC Power Supply, Model 6206B

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 dual range, compact, regulated, Constant Voltage/Current Limiting supply. The unit can be operated in one of two modes with selection of the operating mode provided by the front panel RANGE switch. The output voltage can be continuously adjusted throughout either output range. The power supply is fully protected from overloads by a fixed current limit which is set by means of an internal adjustment.

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 or 300 volts off ground.

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

1-5 The programming 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 which takes place 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
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: 15 ma continuous drain from power supply being protected.

Size: Add 5 inches to power supply depth dimension.

Weight: Add 2 lbs. net

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

Option No.	Description
07	Voltage 10-Turn Pot: A single control that replaces both coarse and fine voltage controls and improves output settability.
13	Three Digit Graduated Decadial Voltage Control: Control that replaces coarse and fine voltage controls permitting accurate resettability.
19	Rewire For 230V AC Input: Supply as normally shipped is wired for 115 Vac input. Option 19 consists of reconnecting the input transformer for 230Vac 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 $3\frac{1}{2}$"-high supply. (Refer to Section II for details.)
14523A	Rack Kit for mounting two $3\frac{1}{2}$"-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.

Table 1-1. Specifications

INPUT:
105-125/210-250 VAC, single phase, 50-400 cps.

OUTPUT:
0-60 volts @0.5 amp or 0-30 volts @ 1 amp.

LOAD REGULATION:
Less than 0.01% plus 4 mv for a full load to no load change in output current.

LINE REGULATION:
Less than 0.01% plus 4 mv for any line voltage change within the input rating.

RIPPLE AND NOISE:
Less than 200µv rms.

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

TEMPERATURE COEFFICIENT:
Less than 0.02% plus 1 mv per degree Centigrade.

STABILITY:
Less than 0.10% plus 5 mv 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 0.02 ohms from DC to 1 Kc.
Less than 0.5 ohms from 1 Kc to 100 Kc.
Less than 3.0 ohms from 100Kc to 1 Mc.

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

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

METER:
The front panel meter can be used as either a 0-70 or 0-7 volt voltmeter or as a 0-1.2 or 0-.12 amp ammeter.

OUTPUT CONTROLS:
Coarse and fine voltage controls set desired output voltage. RANGE switch selects desired operating mode.

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 operation is made available at the rear terminals.

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" relay rack.

WEIGHT:
12 lbs. net, 17lbs. 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.

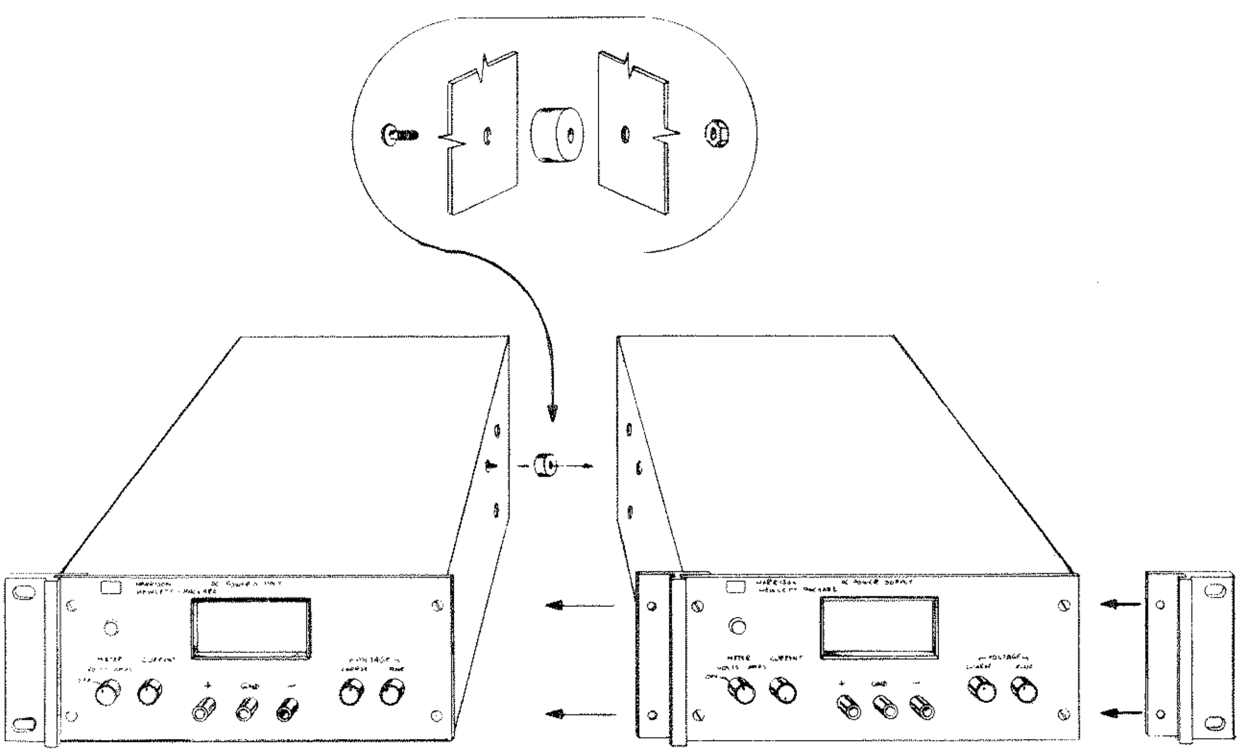


Figure 2-1. Rack Mounting, Two Units

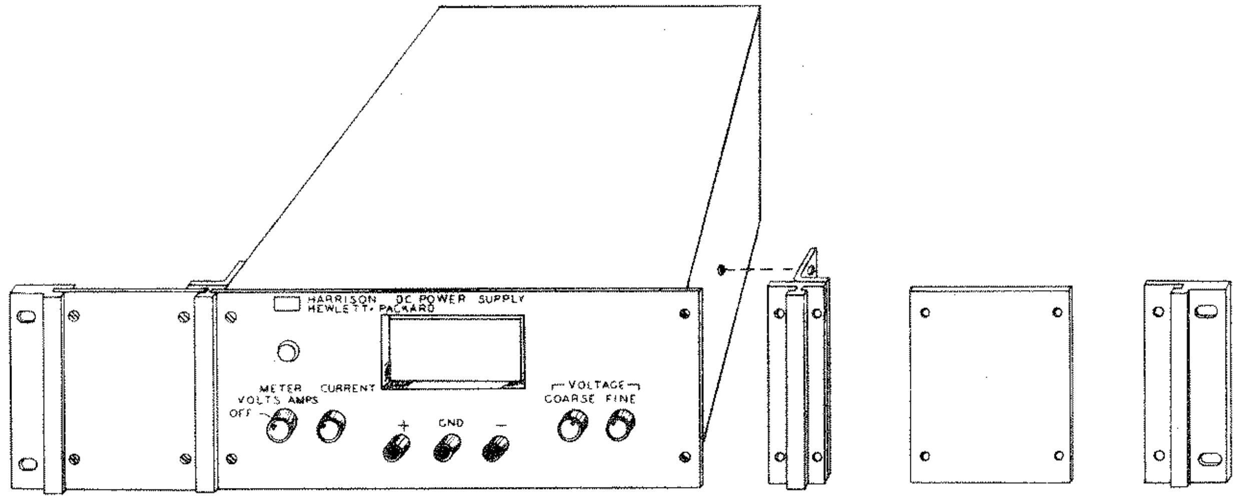


Figure 2-2. Rack Mounting, One Unit

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 INPUT POWER REQUIREMENTS

2-16 This power supply may be operated from either a nominal 115 volt or 230 volt 50-500 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 70 watts and 0.85 amperes.

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 the unit from case.

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.

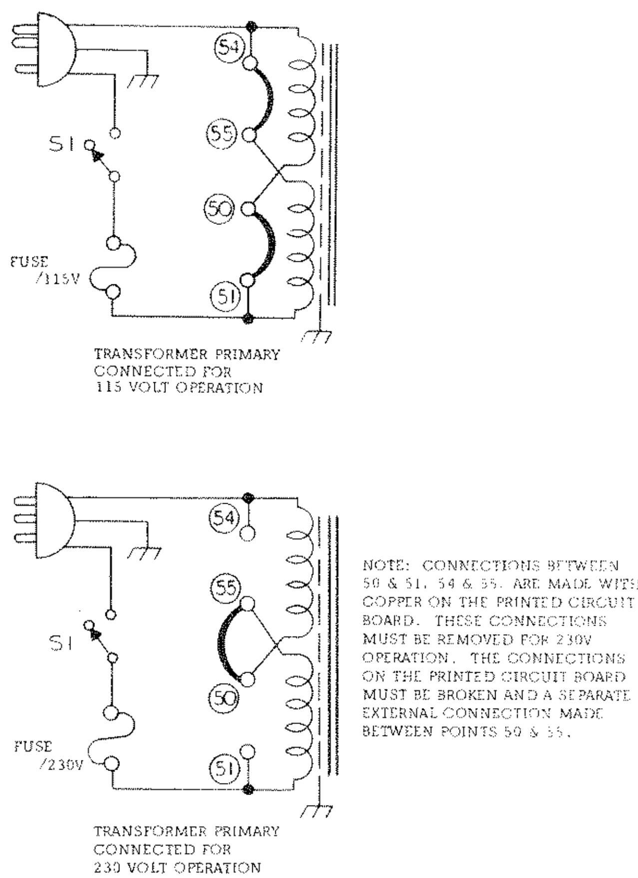


Figure 2-3. Primary Connections

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.

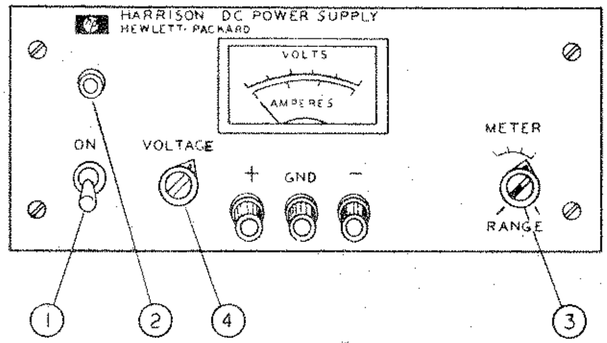
2-22 REPACKAGING FOR SHIPMENT

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 RANGE SWITCH TO DESIRED OPERATING MODE AND METER SWITCH TO DESIRED VOLTAGE RANGE.
4. ADJUST COARSE AND FINE VOLTAGE CONTROLS UNTIL DESIRED OUTPUT VOLTAGE IS INDICATED ON METER.
5. SET METER SWITCH TO HIGHEST CURRENT RANGE AND SHORT CIRCUIT OUTPUT TERMINALS.
6. OBSERVE SHORT CIRCUIT OUTPUT CURRENT ON METER.
7. REMOVE SHORT AND CONNECT LOAD TO OUTPUT TERMINALS (FRONT OR REAR).

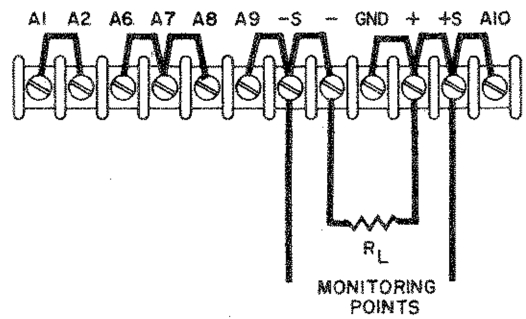
3-1 Front Panel Controls and Indicators

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 300vdc off ground (floating). The following paragraphs describe the procedures for utilizing the various operational capabilities of the supply. A more theoretical description concerning these operational features 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/Current Limiting, local sensing, local programming, single unit mode of operation. This strapping pattern is illustrated in Figure 3-2. The operator selects a constant voltage output using the front panel controls (local programming, no strapping changes are necessary).



3-2 Normal Strapping Pattern

3-7 CONSTANT VOLTAGE

3-8 To select a constant voltage output turn on the supply and, with no load connected, adjust the VOLTAGE controls for the desired output voltage. To check the current limit, connect an external ammeter across the output of the supply, turn the VOLTAGE controls fully clockwise, and observe the reading. The current limit is factory adjusted to approximately 250 ma above the current rating of the supply. If the existing current is not compatible with the anticipated load requirements, the limit can be changed as outlined in the following paragraphs.

3-9 CHANGING CURRENT LIMIT

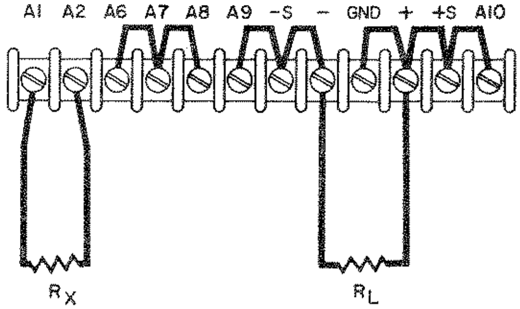
3-10 The current limit can be varied by adjusting resistor R81, located on the printed wiring board. This adjustment procedure is described in Paragraph 5-53. If the current limit must be reduced to a value lower than that attainable by adjusting R81, add an external resistance to the circuit as shown on Figure 3-3. The approximate value of the external resistance (R_X) can be determined by using the following equation.

$$R_X \approx \frac{2.0}{I_E} - R_I$$

where: I_E = the output current
R_I = the internal current sampling resistance for the particular operating mode to be used.
2.0 = the approximate voltage drop across the internal sampling resistance at the current limit crossover point.

NOTE

The power supplies performance will be somewhat degraded if it is operated too close to (within 200 ma) the current limit crossover point.



3-3 Current Limit Alteration

3-11 CONNECTING LOAD

3-12 Each load should be connected to the power supply output terminals using separate pairs of connnecting 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 3-24).

3-14 OPERATION OF SUPPLY BEYOND RATED OUTPUT

3-15 The shaded area on the front panel meter face indicates the amount of output voltage or current that is available in excess of the normal rated output. Although the supply can be operated in this shaded region without being damaged, it cannot be guaranteed to meet all of its performance specifications. However, if the line voltage is maintained above 115 VAC, the supply will probably operate within its specifications.

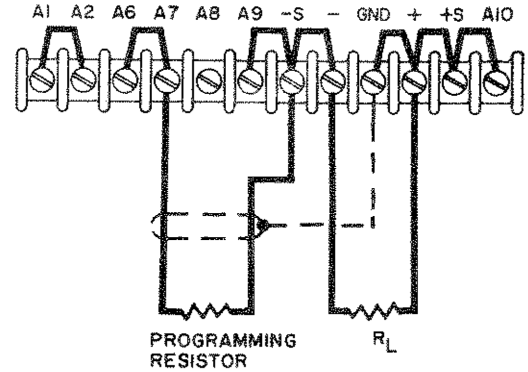
3-16 OPTIONAL OPERATING MODES

3-17 REMOTE PROGRAMMING, CONSTANT VOLTAGE

3-18 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 pickup. The VOLTAGE controls on the front panel are disabled according to the following procedures.

3-19 Resistance Programming (Figure 3-4). In this mode, the output voltage will vary at a rate determined by the programming coefficient (200 ohms per volt for Model 6204B or 300 ohms per volt for Model 6206B). The output voltage will increase by 1 volt for each 200 ohms (or 300 ohms) added in series with the programming terminals. The programming coefficient is determined by the programming current. This current is factory adjusted to within 2% of 5 ma for Model 6204B and 6205B supplies and 2% of 3.3 ma for Model 6206B supplies. If greater programming accuracy is required, it may be achieved by changing resistor R13 as outlined in Section V.

3-20 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 5-45.

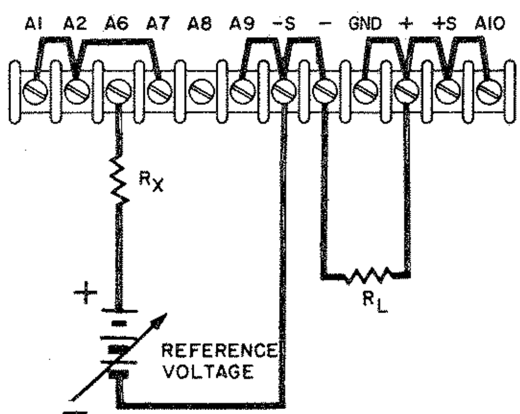


3-4. Remote Resistance Programming

3-21 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.

3-22 Voltage Programming (Figure 3-5). Employ the strapping pattern shown on Figure 3-5 for voltage programming. In this mode, the output voltage will vary in a 1 to 1 ratio with the programming voltage (reference voltage) and the load on the programming voltage source will not exceed 25 microamperes.

3-23 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.



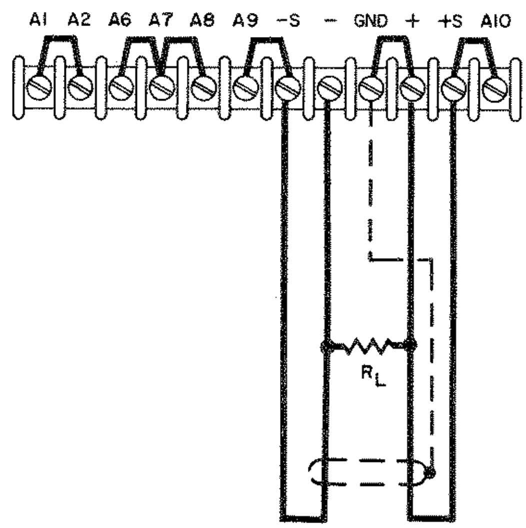
3-5. Remote Voltage Programming

3-24 REMOTE SENSING (SeeFigure 3-6)

3-25 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 3-6. 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.

CAUTION

Observe polarity when connecting the sensing leads to the load.



3-6. Remote Sensing

3-26 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.

3-27 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:

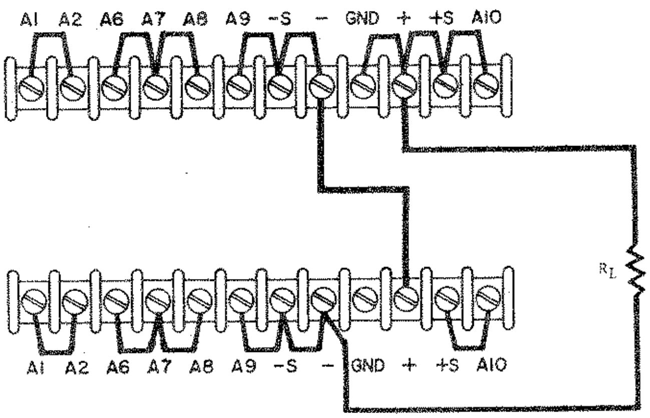
a. Disconnect output capacitor C20, by disconnecting the strap between A10 and +S.

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.

3-28 Although the strapping patterns shown in Figures 3-4 and 3-5 employ local sensing, notice that it is possible to operate a power supply simultaneously in the remote sensing and the remote programming modes.

3-29 SERIES OPERATION

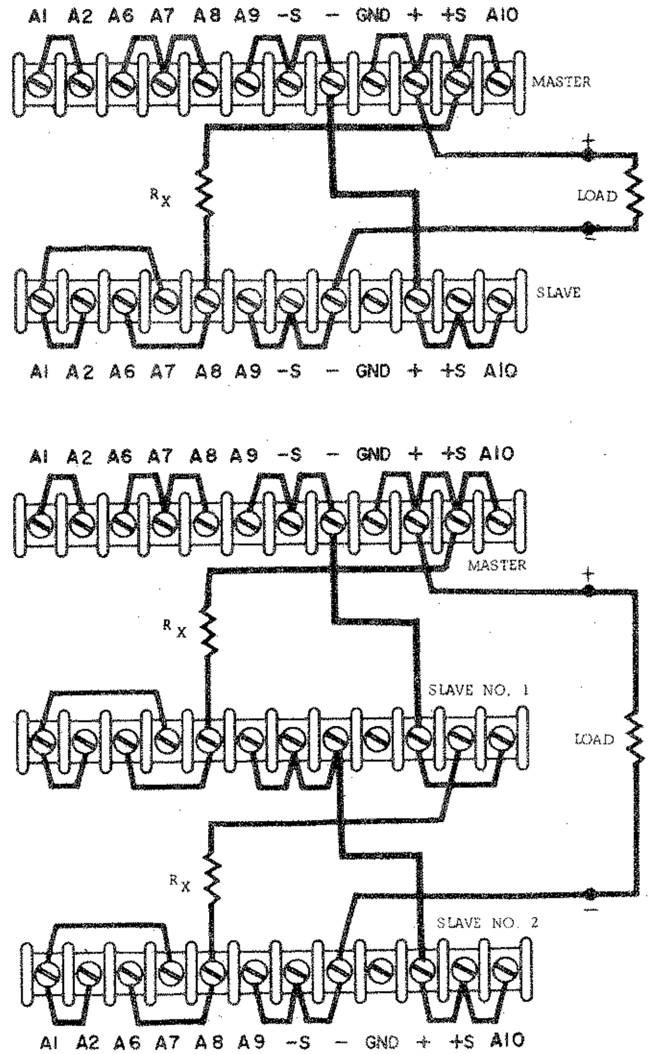
3-30 Normal Series Connections (Figures 3-7). Two or more power supplies can be operated in series to obtain a higher voltage than that available from a single supply. When this configuration is used, the output voltage is the sum of the voltages of the individual supplies. Each of the individual supplies 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.



3-7. Normal Series Connections

3-31 Auto-Series Connections (Figure 3-8). 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 master supply must be the most positive supply of the series. The current limit settings of all series units are effective and the current limit for the entire configuration is equal to the lowest current limit setting. If any of the settings are too low, automatic crossover to current limiting 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.

3-32 In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors (R_X) shown in Figure 3-8 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.

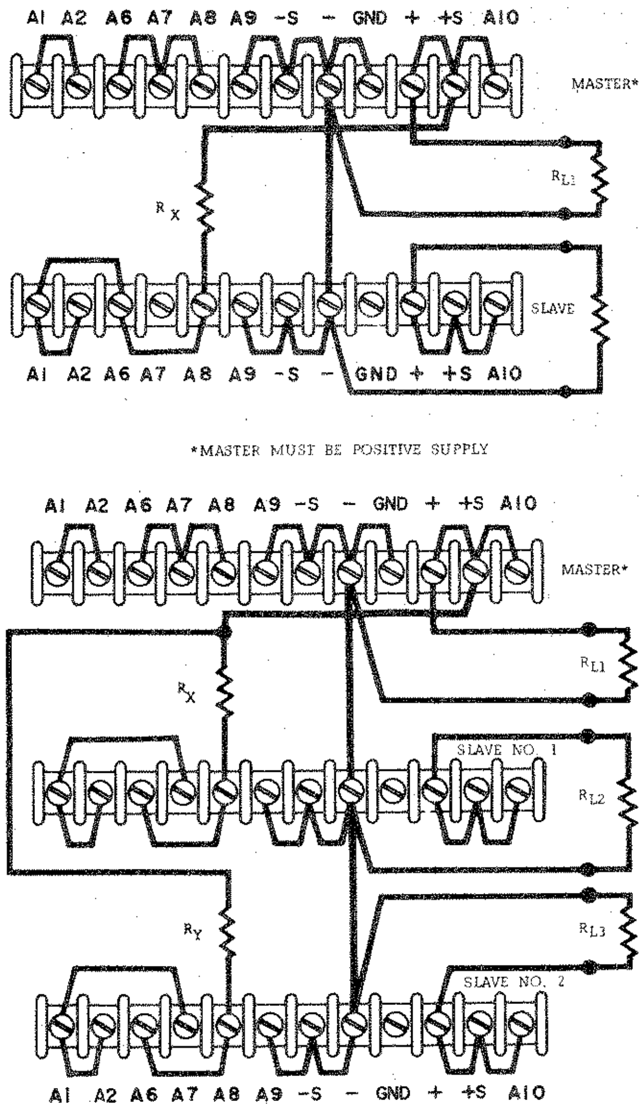


3-8. Auto-Series, Two and Three Units

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.

3-33 AUTO-PARALLEL OPERATION

3-34 The strapping patterns for Auto-Parallel operation of two and three power supplies are shown in Figure 3-9. 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 current limits of each slave are effective, they should be set high enough to avoid having the slave revert to current limiting operation.



3-9. Auto-Parallel, Two and Three Units

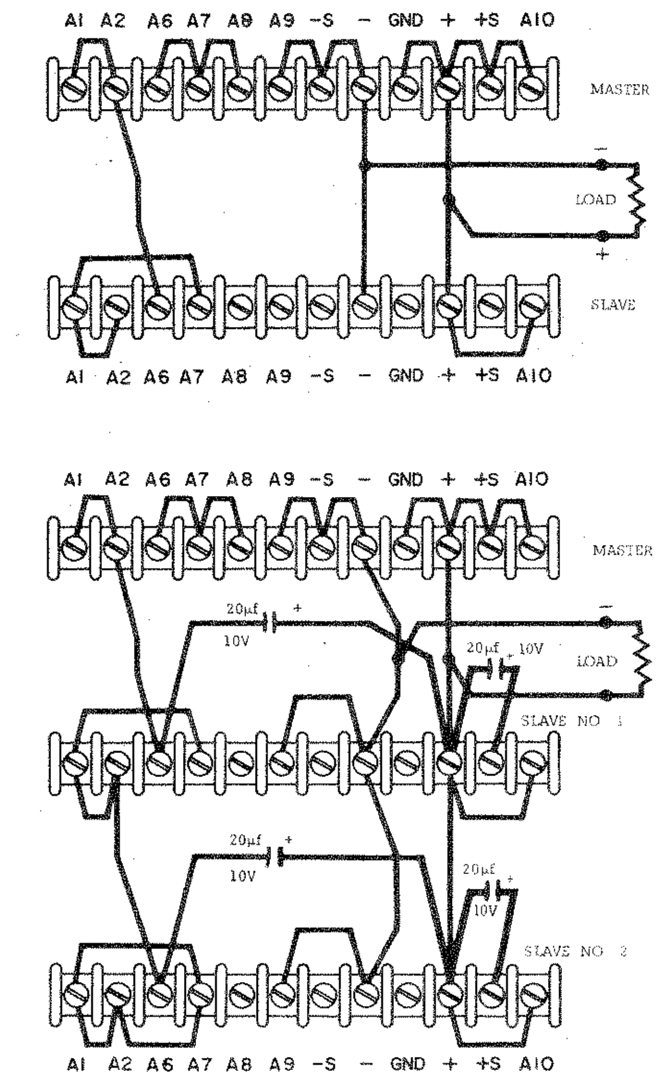
3-35 AUTO-TRACKING OPERATION (See Figure 3-10)

3-36 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 3-10).

3-37 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:

$$E_S = \frac{R_P}{R_X + R_P}$$

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 30 ppm per °C) resistors.



3-10. Auto-Tracking, Two and Three Units

3-38 SPECIAL OPERATING CONSIDERATIONS

3-39 PULSE LOADING

3-40 The power supply will automatically cross over from constant voltage to constant current operation in response to an increase (over the preset limit) in the output current. Although the preset limit may be set higher than the average output current high peak currents (as occur in pulse loading) may exceed the preset current 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.

3-41 OUTPUT CAPACITANCE

3-42 An internal capacitor, across the output terminals of the power supply, 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 current limiting circuit. A high-current pulse may damage load components before the average output current is large enough to cause the current limiting circuit to operate.

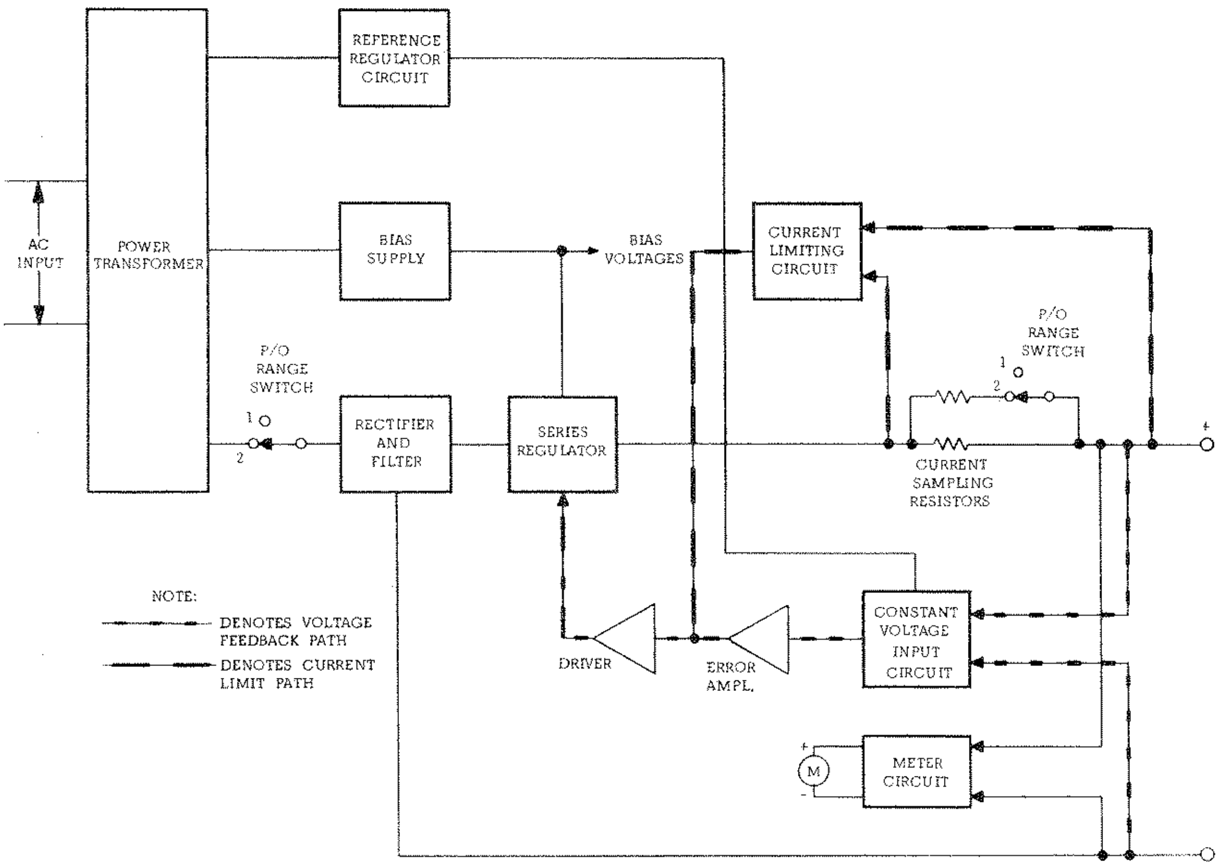
3-45 REVERSE CURRENT LOADING

3-46 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.

3-43 REVERSE VOLTAGE LOADING

3-44 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.

SECTION IV
PRINCIPLES OF OPERATION



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, rectifier and filter, series regulator, error amplifier and driver, constant voltage input circuit, current limiting circuit, reference regulator circuit, bias supply, and a metering circuit.

4-3 The input line voltage passes through the power transformer to the rectifier and filter via the RANGE section of the METER-RANGE switch. This switch selects the operating mode of the supply by picking off an ac voltage of the appropriate magnitude and applying it to the rectifier-filter. The rectifier-filter converts the ac input to raw dc which is fed to the positive terminal via the regulator and current sampling resistor network. The regulator, part of the feedback loop, is made to alter it's conduction to maintain a constant output voltage. The voltage developed across the current sampling resistor network is the input to the current limiting circuit. If the output current that passes through the sampling network exceeds a certain predetermined level, the current limiting circuit applies a feedback signal to the series regulator which alters the regulator's conduction so that the output current does not exceed the current limit. The RANGE section of the METER-RANGE switch selects the proper sampling resistor value so that the voltage dropped across the network is the same for currents that are proportional in each operating mode. The constant voltage input circuit obtains it's input by sampling the output voltage of the supply. Any changes in output voltage are detected in the constant voltage input circuit, amplified by the error amplifier and driver, and applied to the series regulator in the correct phase and amplitude to counteract the change in output voltage. The reference regulator circuit provides stable reference voltages which are used by the constant voltage input circuit for comparison purposes. The bias supply furnishes voltages which are used throughout the instrument for biasing purposes. The meter circuit provides indications of output voltage or current in either operating mode.

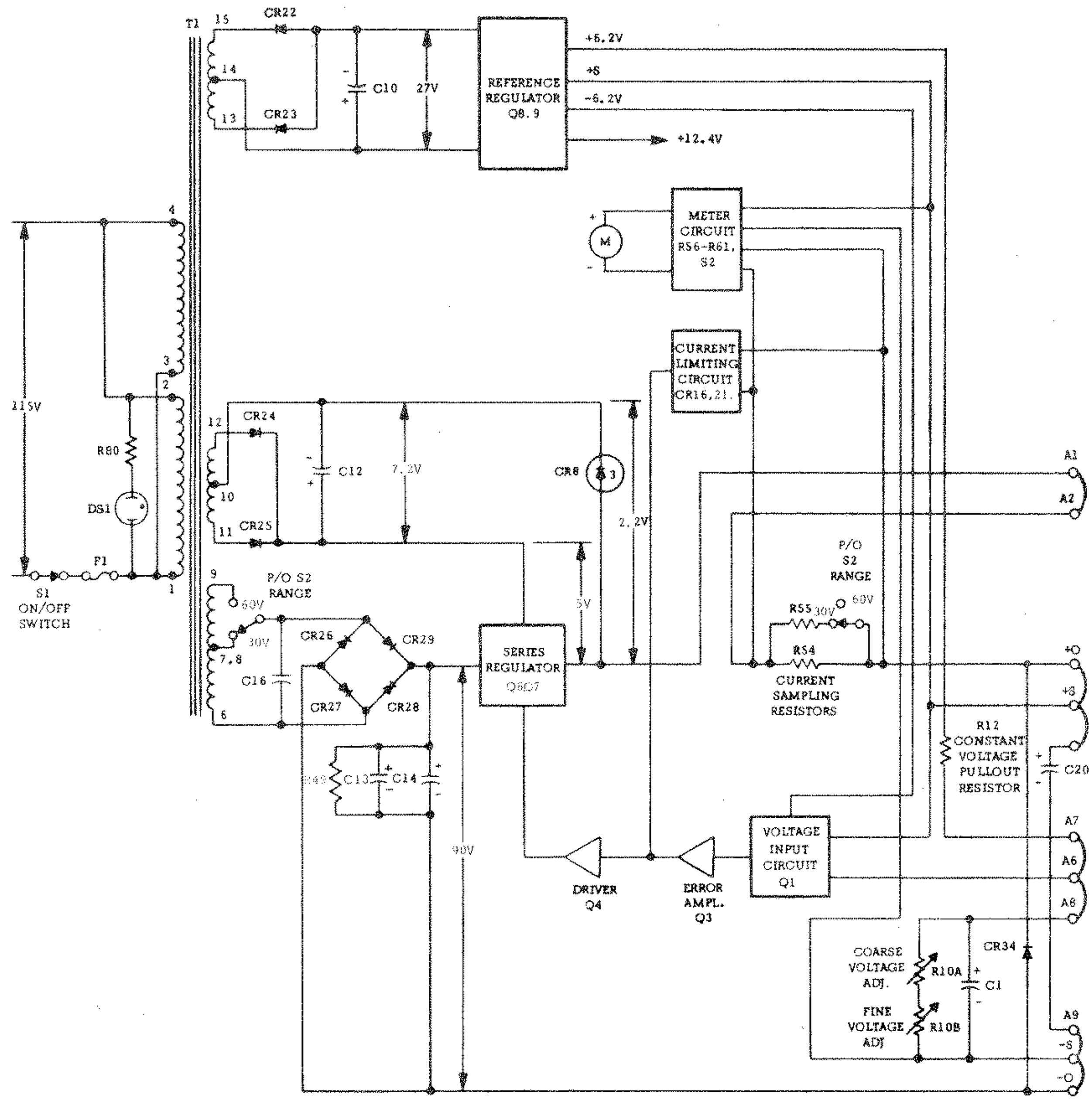


Figure 4-2. Simplified Schematic

4-4 SIMPLIFIED SCHEMATIC

4-5 A simplified schematic of the power supply is shown in Figure 4-2. It shows the operating controls; the ON-off switch, part of the RANGE section of the METER-RANGE switch (S2), the voltage programming controls (R10A and R10B), and the current programming controls (R16A and R16B). The METER section of the METER-RANGE switch, included in the meter circuit block on Figure 4-2, allows the meter to read output voltage or current in either of two ranges. Figure 4-2 also shows the internal sources of bias and reference voltages and their nominal magnitudes with an input of 115 Vac.

4-6 Switch S2 (RANGE section) selects the operating mode of the supply by applying the proper ac voltage to the bridge rectifier (CR26 through CR29). Capacitors C13 and C14 are the filter capacitors for the main supply.

4-7 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, is also connected across the output terminals when the normal strapping pattern shown on Figure 4-2 is employed. Note that this capacitor can be removed if an increase in the programming speed is desired.

4-8 SERIES REGULATOR

4-9 The series regulator consists of transistor stages Q6 and Q7 (see schematic at rear of manual). The transistors are connected in parallel so that approximately half of the output current flows through each one. The regulator serves as a series control element by altering its conduction so that the output voltage is kept constant and the current limit is never exceeded. The conduction of the transistors is controlled by the feedback voltage obtained from driver Q4. Diode CR11, connected across the regulator circuit, protects the series transistors against reverse voltages that could develop across them during parallel or auto-parallel operation if one supply is turned on before the other.

4-10 CONSTANT VOLTAGE INPUT CIRCUIT (Figure 4-3)

4-11 The circuit consists of the coarse and fine programming resistors (R10A and R10B), and a differential amplifier stage (Q1 and associated components). Transistor Q1 consists of two 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.

4-12 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 the error and driver 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. The above action maintains the output voltage constant.

4-13 Stage Q1B of the differential amplifier is connected to a common (+S) potential through impedance equalizing resistor R5. Resistors 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 at the junction of the programming resistors and the current pullout resistor, R12. Instantaneous changes in output voltage result in an increase or decrease in the summing point potential. Q1A is the 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 resistors during rapid voltage turn-down. Diodes CR1 and CR2 form a limiting network which prevent excessive voltage excursions from over driving stage Q1A. Capacitor C1, shunting the programming resistors , increases the high frequency gain of the input amplifier. Resistor R13, shunting pullout resistor R12, serves as a trimming adjustment for the programming current.

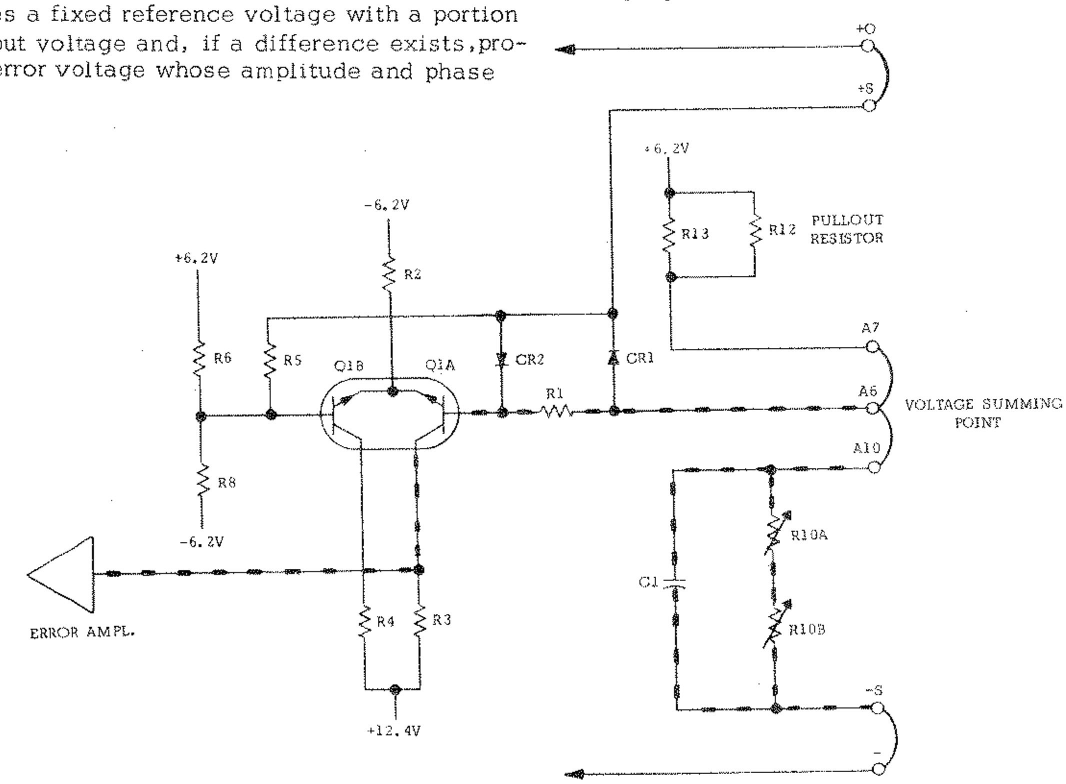


Figure 4-3. Constant Voltage Input Circuit, Simplified Schematic

4-14 ERROR AMPLIFIER AND DRIVER (Figure 4-4)

4-15 The error and driver amplifiers amplify the error signal from the constant voltage input circuit to a level sufficient to drive the series regulator transistors. Driver Q4 also receives a current limiting input if CR16 and CR21 the current limiting diodes become forward biased.

4-16 Stage Q3 contains a feedback equalizer network, C5 and R30, which provides for high frequency roll off in the loop gain in order to stabilize the feedback loop. Driver Q4, together with diode CR17, provides a low resistance discharge path for the output capacitance of the power supply during rapid down programming.

4-17 CURRENT LIMITING CIRCUIT

4-18 Figure 4-4 shows a simplified schematic of the current limiting circuit with the power supply operating in the high voltage mode. Under these condition the RANGE section of S2 is in position 1 and the sampling resistance consists solely of R54. In the low voltage (high current) operating mode, The RANGE switch is placed in position 2 and the sampling resistance consists of R54 and R55 in parallel. Note that the sampling resistance in the low voltage mode is equal to half that used in the high voltage mode. This keeps the voltage drop across the sampling network, and hence the input to the current limiting circuit, equalfor both operating modes.

4-19 Current limiting occurs when diodes CR16 and CR21 become forward biased. Their anode potential is determined by the voltage at the base of Q4. The cathode potential is determined by the voltage drop across resistors R53 and R81 which, in turn, are connected across the current sampling re sistor (s). The cathode potential of CR16 is a function of the output current. As this current increases, the drop across the sampling network increases, and CR16 and CR21 will start to conduct. Conduction of these diodes clamps the base of Q4 to a potential which decreases the conduction of the series regulator, thus limiting the output current. Potentiometer RB1 permits the cathode potential of CR16 to be varied and thus changes the current limiting threshold. The current limit can be reduced by opening the strap between A1 and A2 and inserting an addditional resistance as outlined in Section III.

4-20 REFERENCE CIRCUIT

4-21 The reference circuit (see schematic) 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

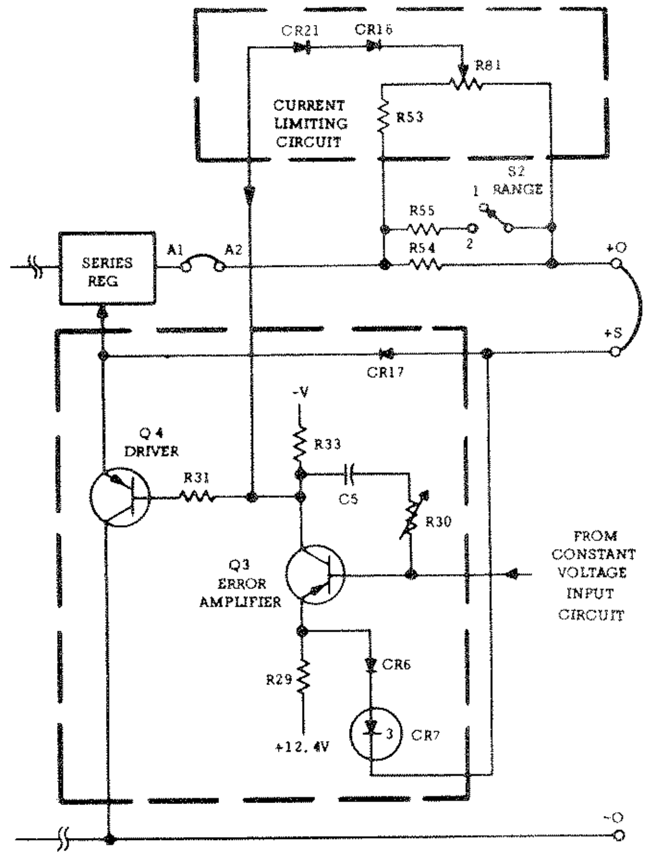
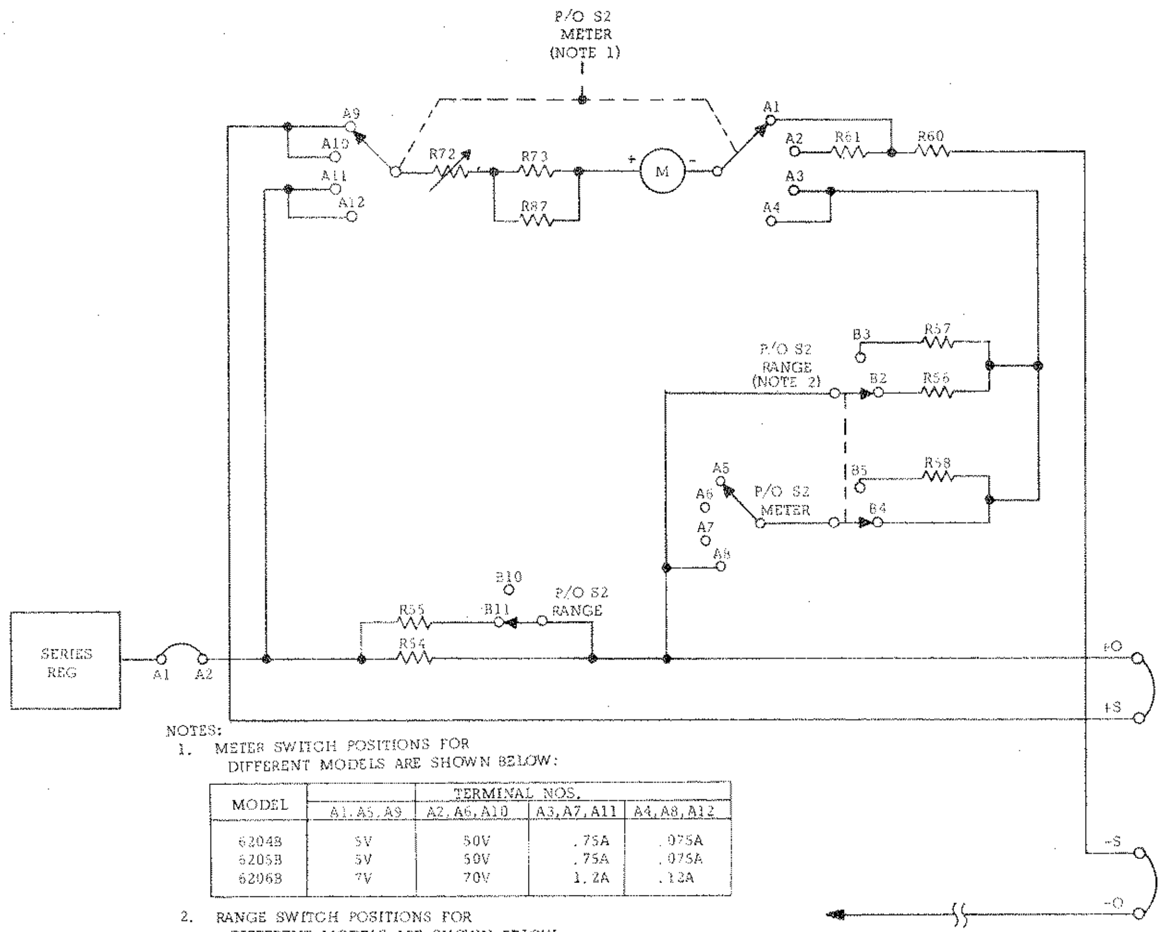


Figure 4-4. Error Amplifier and Current Limiting Circuits, Simplified Schematic

full wave rectifier (CR22 and CR23) and filter capacitor C10. The +6.2 and -6.2 voltages, which are used in the constant voltage input circuit 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.

4-22 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 VR1 and VR2 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.



NOTES:

1. METER SWITCH POSITIONS FOR DIFFERENT MODELS ARE SHOWN BELOW:

MODEL	TERMINAL NOS.			
	A1,A5,A9	A2,A6,A10	A3,A7,A11	A4,A8,A12
6204B	5V	50V	.75A	.075A
6205B	5V	50V	.75A	.075A
6206B	7V	70V	1.2A	.12A

2. RANGE SWITCH POSITIONS FOR DIFFERENT MODELS ARE SHOWN BELOW:

MODEL NO.	TERMINAL NOS.	
	B2,B4,B11	B3,B5,B10
6204B	20V	40V
6205B	20V	40V
6206B	30V	60V

4-5. Multiple Range Meter Circuit, Simplified Schematic

4-23 METER CIRCUIT (Figure 4-5)

4-24 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 the METER section of switch S2 on the front panel of the supply. This switch also selects one of two meter ranges on each scale. The meter circuit consists of METER-RANGE switch S2, various multiplying resistors and the meter movement.

4-25 When measuring voltage, the meter is placed directly across the output of the supply between the ±S terminals. With the METER section of S2 in the higher voltage position (terminals A2 and A10) multiplying resistors R60, R61, R72, and the parallel combination of R73 and R87, are in series with the meter. For low output voltages, the METER switch can be set to the first position (terminals A1 and A9) which removes R61 from its series position allowing a larger percentage of the output voltage to be felt across the meter.

4-26 When measuring current, the meter circuit is connected across the current sampling resistor network as shown on Figure 4-5 and indicates the output current than flows through the network. The RANGE section of S2 connects the appropriate resistance in series with the meter so that its maximum deflection range is full-scale in the high current (low voltage) operating mode and half-scale in the low current (high voltage) operating mode. This circuit obviates the need for a dual current scale which would be necessary since the voltages dropped across the current sampling network in both operating modes are equal for proportional currents.

4-27 OPERATION OF REGULATING FEEDBACK LOOP

4-28 The feedback loop functions continuously to keep the output voltage constant during normal operation of the supply. For purposes of this discussion, assume that the output voltage instantaneously rises (goes positive) due to a variation in the external load circuit. 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.

4-29 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 the series transistor(s) via emitter follower Q4. The negative going input causes the series transistor(s) to decrease it's conduction so that it drops more of the line voltage, reducing the output voltage to its original level.

4-30 If the external load resistance decreases to a certain crossover point, the supply will operate in the current limiting mode. The current limiting diode(s) will begin to conduct if the output current rises to a point where the voltage drop across the current sampling network exceeds approximately 2 volts.

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

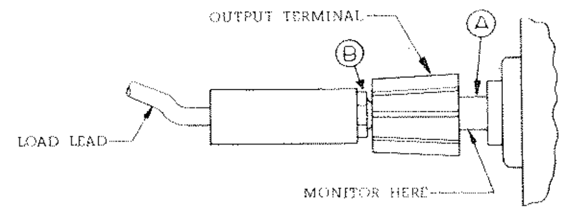


Figure 5-1. Front Panel Terminal Connections

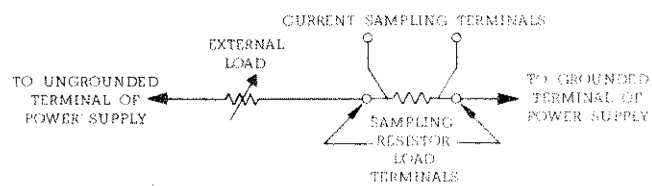


Figure 5-2. Output Current Measurement Technique

5-7 When using an oscilloscope, ground one terminal of the power supply and then ground the case of the oscilloscope to this same point. Make certain that the case is not also grounded by some other means (power line). Connect both oscilloscope input leads to the power supply ground terminal and check that the oscilloscope is not exhibiting a ripple or transient due to ground loops, pick-up, or other means.

5-8 TEST EQUIPMENT REQUIRED

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

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: 10 μv/cm. Differential input.	Display transient response waveforms	hp 140A 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 412 A
Repetitive Load Switch	Rate: 60-400 Hz, 2 μsec rise and fall time.	Measure transient response	See Figure 5-6
Resistor	Value: See Paragraph 5-13. ±5%, 75 watts	Load Resistor	-------
Resistor	Value: See Figure 5-4. 1%, 200 watts, 20ppm, 4-Terminal.	Current sampling	-------
Resistor	1 KΩ ±1%, 2 watt non-inductive	Measure impedance	-------
Resistor	100 ohms, ±5%, 10 watt	Measure impedance	-------
Resistor	Value: See Paragraph 5-46. ±0.1%, 5 watt.	Calibrate programming current	-------

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.

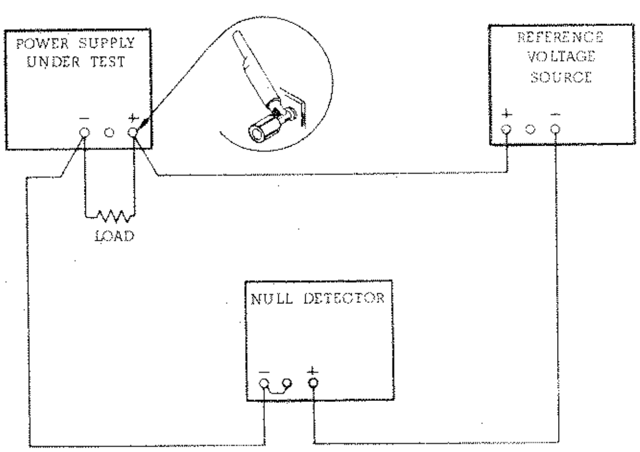


Figure 5-3. Differential Voltmeter Substitute, Test Setup

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 5-26).

NOTE

For Model 6205B supplies, the following performance checks should be performed twice in order to check both independent sections of the supply.

5-12 RATED OUTPUT AND METER ACCURACY

5-13 Voltage. To check the output voltage, proceed as follows:

a. Connect 133 ohm load resistor (120 ohms for Model 6206B) across rear output terminals of supply.

b. Connect differential voltmeter across +S and -S terminals of supply observing correct polarity.

c. Set METER switch to highest voltage range and RANGE switch to highest voltage mode and turn on supply.

d. Adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output voltage.

e. Differential voltmeter should indicate maximum rated output voltage within ±2%.

5-14 Current. To check the output current, proceed as follows:

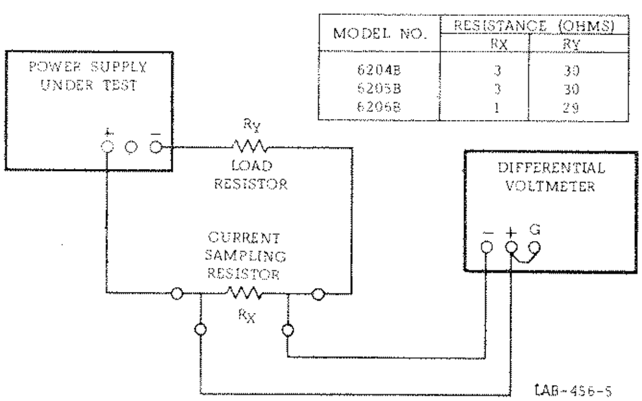
a. Connect test setup shown in Figure 5-4.

b. Set METER switch to highest current range and RANGE switch to low voltage mode.

c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly 600 ma (1 ampere for Model 6206B supplies).

d. Differential voltmeter should read as follows:

Model No.	6204B	6205B	6206B
Reading (Vdc)	1.80 ± 0.036	1.80 ± 0.036	1.0 ± 0.02



5-4. Output Current, Test Setup

5-15 LOAD REGULATION

5-16 To check the constant voltage load regulation, proceed as follows:

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

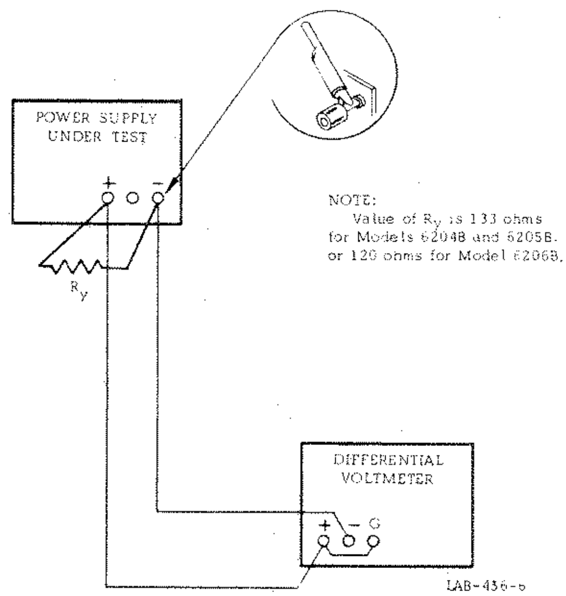
b. Set METER switch to highest current range and RANGE switch to high voltage, low current mode.

c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly 300 ma (500 ma for Model 6206B).

d. Read and record voltage indicated on differential voltmeter.

e. Disconnect load resistor.

f. Reading on differential voltmeter should not vary from reading recorded in step d by more than 8 mvdc for Model 6204B and 6205B supplies or 10 mvdc for Model 6206B supply.



5-5. Load Regulation, Test Setup

5-17 LINE REGULATION

5-18 To test the line regulation, proceed as follows:

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

b. Connect test setup shown in Figure 5-5.

c. Adjust variable auto transformer for 105 VAC input.

d. Set METER switch to highest voltage range and RANGE switch to high voltage mode.

e. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output voltage.

f. Read and record voltage indicated on differential voltmeter.

g. Adjust variable auto transformer for 125 VAC input.

h. Reading on differential voltmeter should not vary from reading recorded in step f by more than 8 mvdc for Model 6204B and 6205B supplies or 10 mvdc for Model 6206B supply.

5-19 RIPPLE AND NOISE

5-20 To check ripple and noise, proceed as follows:

a. Retain test setup used for previous line regulation test except connect AC voltmeter (hp 403B) across output terminals instead of differential voltmeter.

b. Adjust variable auto transformer for 125 VAC input.

c. Set METER switch to highest current range and RANGE switch to high voltage mode.

d. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly 300 ma (or 500 ma for Model 6206B supplies).

e. AC voltmeter should read less than 0.20 mv.

5-21 TRANSIENT RECOVERY TIME

5-22 To check the transient recovery time of the supply, proceed as follows:

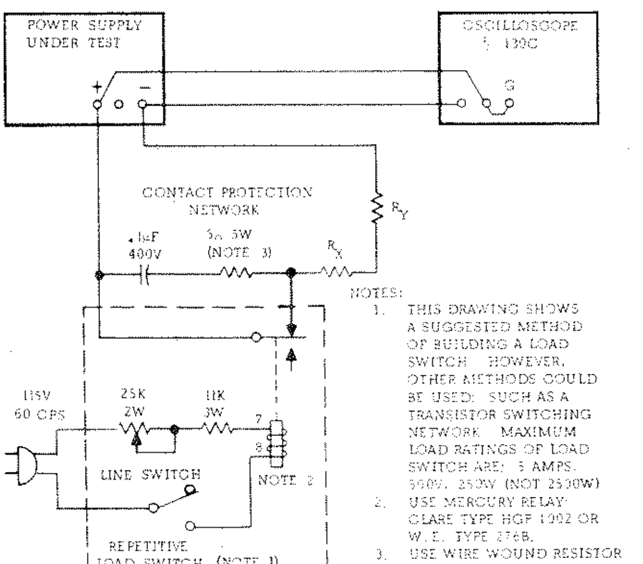
a. Connect test setup shown in Figure 5-6.

b. Set METER switch to highest current range and RANGE switch to lowest voltage mode.

c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output current.

d. Close line on repetitive load switch setup.

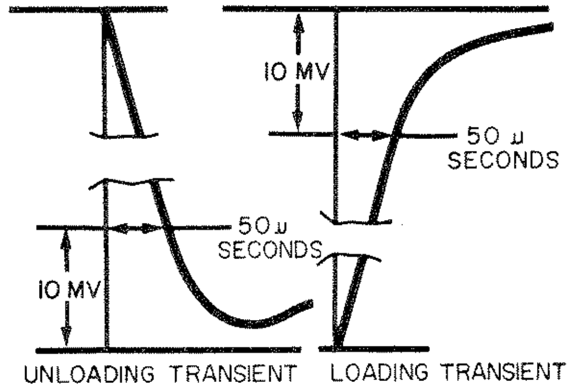
e. Adjust 25KΩ potentiometer until a stable display is obtained on oscilloscope. Waveform should be within the tolerances shown on Figure 5-7 (output should return to within 10 mv of original value in less than 50 microseconds).



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	35
6205B	3	30
6206B	1	29
6207B		
6209B		

5-6. Transient Recovery Time, Test Setup



5-7. Transient Recovery Time, Waveforms

5-23 OUTPUT IMPEDANCE

5-24 To check the output impedance, proceed as follows:

a. Connect test setup shown in Figure 5-8.

b. Set METER switch to highest voltage range.

c. Turn on supply and adjust VOLTAGE controls until front panel meter reads 20 volts.

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:

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

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.

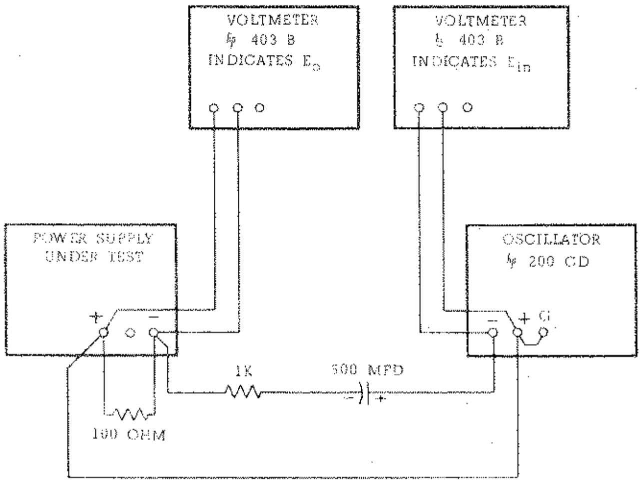
5-25 Output Inductance. To check the output inductance, repeat steps a through f at frequencies of 10Kc, 50Kc and 100Kc. Calculate the output inductance (L) using the following formula:

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

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 $X_L = Z_{out}$.



5-8. Output Impedance, Test Setup

5-26 <u>TROUBLESHOOTING</u>

5-27 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.

5-28 TROUBLE ANALYSIS

5-29 <u>General.</u> 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.

5-30 Once it is determined that the power supply is at fault, check for obvious troubles such as an 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 and replacement and and adjustment and calibration paragraphs in this section.

5-31 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 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 voltage 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 5-33). This circuit provides critical operating voltages for the supply and faults in the circuit could affect the overall operation in many ways.

b. Feedback loop checks (Paragraph 5-34).

c. Procedures for dealing with common troubles (Paragraph 5-35).

5-32 The following procedures apply equally to both sections of Model 6205B supplies.

5-33 <u>Reference Circuit.</u>

a. Make an ohmmeter check to be certain that neither the positive nor negative output terminal is grounded.

b. Turn front-panel VOLTAGE 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, T1

5-34 Feedback Circuit. Generally, malfunction of the feedback circuit is indicated by high or low output voltages. If one of these situations occur, disconnect the load and proceed as instructed in Table 5-3 or Table 5-4.

Table 5-3. High Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Voltage between +S and A6.	0V to +0.8V. More negative than 0V.	a. Open strap between A7 and A8. b. R10 Open. Proceed to Step 2.
2	Voltage between +S and 12.	Less positive than +1.8V. +1.8V to +2.2 V	a. Q1A shorted. b. Q1B open. c. R3 open. Proceed to Step 3.
3	Voltage between +S and 19.	More positive than -0.4 V. More negative than -0.4V	a. Q3 shorted. b. C5 shorted. Proceed to Step 4.
4	Voltage between 22 and A1	Less positive than +0.6V More positive than +0.6V	a. Q7 (or Q6) shorted b. CR11 shorted a. Q4 open. b. R34 shorted or low resistance

Table 5-4. Low Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Unsolder one end of CR16 from TP 19.	Normal output voltage Low output voltage.	a. Current limiting circuit faulty, check CR 16 for short. b. R81 or R53 open. c. Open strap between A1 and A2. Reconnect CR16 and Proceed to Step 2.
2	Voltage between +S and A6	More negative than 0V. 0.V to +0.8V	a. Open strap A6-A7. a. R10 or C1 shorted. b. Proceed to Step 3.
3	Voltage between +S and 12	More positive than 2.2V +2V to +3.8V	a. Q1A open. b. Q1B or R3 shorted Proceed to Step 4.

Step	Measure	Response	Probable Cause
4	Voltage between +S and 19	More negative than -0.4V More positive than -0.4V	a. Q3 open b. R33 shorted or low Proceed to Step 5.
5	Voltage between 22 and Al	Less positive than +0.6V More positive than +0.6V	a. Q4 shorted b. R34 open a. Q7 (and Q6) open

5-35 Common Troubles. Table 5-5 lists the symptoms, checks, and probable causes for common troubles.

Table 5-5. 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 current limit mode under loaded conditions.
Poor line regulation	a. Check reference circuit (Paragraph 5-33). b. Check reference circuit adjustment (Paragraph 5-48).
Poor load regulation (constant voltage)	a. Measurement technique. (Paragraph 5-16) b. Check reference circuit (Paragraph 5-33) and adjustment (Paragraph 5-49). c. Ensure that supply is not going into current limit.
Oscillates (constant voltage)	a. Check C5 for open, adjustment of R30 (Paragraph 5-51).
Poor stability (constant voltage)	a. Check ±6.2Vdc reference voltages (Paragraph 5-49). b. Noisy programming resistor R10. c. CR1, CR2 leaky. d. Check R1, R12, R13, for noise or drift. e. Stage Q1 defective.

5-36 REPAIR AND REPLACEMENT

5-37 Before servicing a printed wiring board, refer to Figure 5-9. Section VI of this manual contains a tabular list of the instruments replaceable parts.

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.

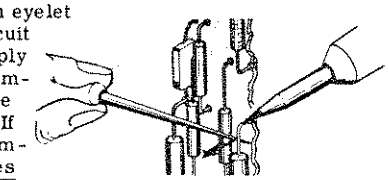
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

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.

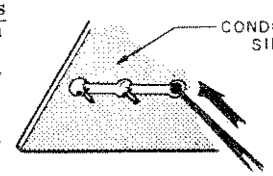
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

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.

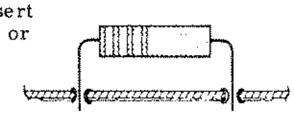
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



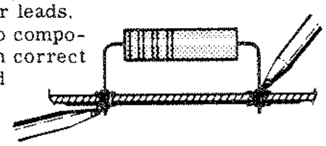
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



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

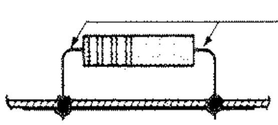


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

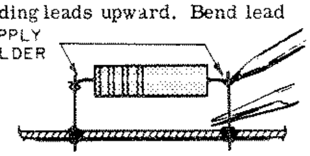


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

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.

5-9. Servicing Printed Wiring Boards

Before replacing a semiconductor device, refer to Table 5-6 which lists the special characteristics of selected semiconductors. If the device to be replaced is not listed in Table 5-6, the standard manufacturers part number listed in Section VI is applicable. After replacing a semiconductor, refer to Table 5-7 for checks and adjustments that may be necessary.

5-38 ADJUSTMENT AND CALIBRATION

5-39 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 5-8 summarizes the adjustments and calibrations contained in the following paragraphs.

Table 5-6. Selected Semiconductor Characteristics

Reference Designator	Characteristics	-hp- Stock No	Suggested Replacement
Q1	Matched differential amplifier. NPN Si planar. 70 (min) h_{FE} i_c =1 ma, V_{CE}=5V, I_{co}=0.01μa @V_{cbo}=5V.	1854-0229	2N2917 G.E.
Q4	PNP with selected I_{CEX}=0.1 ma (max) @V_{CE}=90V; V_{BE}=1.5V	1853-0040	2N3741 Motorola
Q6,7	NPN power. h_{FE} =35(min) @I_C =1 a; V_{CE}=4V. V_{CE} (sat)=1V max @I_C=1a, I_B=0.1a.	1854-0239	2N3442 R.C.A.
CR1,2,16,20	Si rectifier, 250 mw, 200 prv	1901-0033	1N485B Sylvania
CR6,21	Si stabistor, 400 mw, 10 prv	1901-0461	1N4828 G.E.
CR7,8	Si rectifier, 400 mw, 10 prv	1901-0460	1N4830 G.E.
CR11,17, 22-29,34	Si rectifier, 0.5 Amp, 200 prv	1901-0026	1N3253 R.C.A.

Table 5-7. 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
Q3, Q4	Error amplifiers	CV load regulation. CV transient response	R30
Q7(Q6)	Series Regulator	CV load regulation	
Q8, Q9	Reference Regulator	Reference circuit line regulation	R46
CR1, CR2	Limiting diodes	CV load regulation	
CR8	Forward bias regulator	Voltage across diode 2.0 to 2.4 volts.	
CR6,7	Bias error amplifier	Voltage across both diodes 2.0 to 2.4 volts.	

Reference	Function	Check	Adjust
CR16(CR21)		Current limit adjustment	R81
CR22 thru CR29	Rectifier diodes	Voltage across appropriate filter capacitor	
VR1	Positive reference voltage	+6.2V line and load regulation	R46, VR1
VR2	Negative reference voltage	-6.2V line and load regulation	R46, VR2

Table 5-8. Calibration Adjustment Summary

Adjustment or Calibration	Paragraph	Control Device
Meter Zero	5-40	Pointer
Ammeter Tracking	5-42	R72
"Zero" Volt Output	5-45	R6 or R8
"Voltage" Programming Current	5-46	R13
Reference Circuit Line Voltage Adjustment	5-48	R46
Negative Reference Load Adjustment	5-49	Replace VR2
Positive Reference Load Adjustment	5-50	Replace VR1
Transient Response	5-51	R30
Current Limit	5-53	R81

5-40 METER ZERO

5-41 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 hole at 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.

5-42 AMMETER TRACKING

5-43 To calibrate the ammeter, proceed as follows:

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

b. Set RANGE switch to low voltage mode and METER switch to lowest current range.

c. Turn on supply and adjust VOLTAGE controls so that differential voltmeter indicates exactly 0.18 VDC (0.10 VDC for Model 6206B supplies).

d. Front panel meter should read 0.06 amps for Model 6204B and 6205B supplies, or 0.10 amps for Model 6206B supply. If it does not, adjust R72.

5-44 CONSTANT VOLTAGE PROGRAMMING CURRENT

5-46 To calibrate the programming current, proceed as follows:

a. Connect an 8K, 0.1% resistor (18K resistor for Model 6206B supplies) between terminals -S and A6 on rear barrier strip.

b. Disconnect jumper between A7 and A8 (leaving A6 and A7 jumpered).

c. Connect decade resistance box in place of R13.

d. Connect differential voltmeter between +S and -S terminals on rear barrier strip.

e. Set RANGE switch to high voltage mode, METER switch to high voltage range, and turn on supply.

f. Adjust decade resistance box so that differential voltmeter reads 40 ± 0.8 VDC for Models 6204B and 6205B or 60± 1.2 VDC for Model 6206B supplies.

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

5-45 To calibrate the zero volt programming accuracy, proceed as follows:

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

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

c. Turn on supply and observe reading on differential voltmeter.

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

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

f. If reading of step C was more negative than 0 volts, shunt resistor R8 with the decade resistance box.

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

5-47 REFERENCE CIRCUIT ADJUSTMENTS

5-48 Line Regulation. To adjust the line regulation capabilities of the instrument proceed as follows:

a. Connect the differential voltmeter between +S (positive) and 31 (Common).

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. Set range switch to high voltage mode and turn on supply.

f. Adjust decade resistance so that voltage indicated by differential voltmeter does not change more than 0.2 millivolts as input line voltage is varied from 105 to 125 VAC.

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

5-49 Load Regulation, -6.2 Volt Reference. To check the load regulation of the -6.2 volt reference voltage, proceed as follows:

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

b. Connect differential voltmeter between +S and 31 (across VR2).

c. Repeat steps b through e of Paragraph 5-16.

d. The differential voltmeter reading should not vary by more than 0.2 mvdc.

e. If variation is greater than 0.2 mvdc, replace VR2.

5-50 Load Regulation, ± 6.2 Volt Reference. To check the load regulation of the +6.2 volt reference voltage, proceed as follows:

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

b. Connect differential voltmeter between 33 and +S (across VR1).

c. Repeat steps b through e of Paragraph 5-16.

d. The differential voltmeter reading should not vary by more than 0.2 mvdc.

e. If it does, replace VR1.

5-51 CONSTANT VOLTAGE TRANSIENT RECOVERY TIME

5-52 To adjust the transient response, proceed as follows:

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

b. Repeat steps a through f as outlined in Paragraph 5-22.

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

5-53 CURRENT LIMIT ADJUSTMENT

5-54 To adjust the current limit so that the supply can be used to furnish maximum rated output current, proceed as follows:

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

b. Short out load resistor (Ry).

c. Set RANGE switch to low voltage (high current) mode.

d. Turn on supply and rotate VOLTAGE controls fully clockwise (maximum).

e. Adjust R81 until differential voltmeter indicates 2.55 VDC for Model 6204B and 6205B supplies or 1.25 VDC for Model 6206B supplies.

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

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

6-3 Table 6-1 lists parts in the alpha-numerical order of the reference designators and provides the following information:

a. Description (See list of abbreviations below).

b. Total quantity used in the instrument.

c. Manufacturer's name and part number.

d. The Manufacturer's code number as listed in the Federal Supply Code for Manufacturers H4-1.

e. The hp Stock Number.

f. The recommended spare parts quantity for complete maintenance of one instrument during one year of isolated service. (Column RS)

6-4 ORDERING INFORMATION

6-5 To order a replacement part, address order or inquiry to your local Hewlett-Packard field 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 stock number.

c. Circuit reference designator.

d. Description.

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

REFERENCE DESIGNATORS

A	= assembly	Q	= transistor
B	= motor	R	= resistor
C	= capacitor	RT	= thermistor
CR	= diode	S	= switch
DS	= device signaling (lamp)	T	= transformer
E	= misc. electronic part	V	= vacuum tube, neon bulb, photocell, etc.
F	= fuse		
J	= jack		
K	= relay		
L	= inductor	X	= socket
M	= meter	XF	= fuseholder
P	= plug	XDS	= lampholder
		Z	= network

ABBREVIATIONS

a	= amperes	obd	= order by descri 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 square
Hg	= mercury		
impg	= impregnated	s-b	= slow-blow
ins	= insulation(ed)	sect	= section(s)
lin	= linear taper	Si	= silicon
log	= logarithmic taper	sil	= silver
		sl	= slide
m	= milli = 10^{-3}	td	= time delay
M	= megohms	TiO_2	= titanium dioxide
ma	= milliamperes	tog	= toggle
μ	= micro = 10^{-6}	tol	= tolerance
mfr	= manufacturer	trim	= trimmer
mtg	= mounting	twt	= traveling wave tube
my	= mylar		
NC	= normally closed	var	= variable
		w/	= with
Ne	= neon	W	= watts
NO	= normally open	w/o	= without
nsr	= not separately replaceable	cmo	= cabinet mount only
K	= kilo = 1000		

MANUFACTURERS

AB	Allen-Bradley	Mot	Motorola, Inc.
B	Bendix Corp.	RCA	Radio Corp. of America
Beede	Beede Elec. Instr. Co., Inc.	Reliance Mica	Reliance Mica Corp.
Buss	Bussman Mfg.		
Carling	Carling Elec.	Semcor	U.S. Semcor
CTS	CTS Corp.	Sloan	Sloan Co.
Elco	Elco Corp.	Sprague	Sprague Elec.
GE	General Elec.	Superior	Superior Elec.
GI	General Instru.	Sylv.	Sylvania Elec. Products, Inc.
HH	Hardwick-Hindle Co.	TI	Texas Instru.
Kulka	Kulka Electric	WL	Ward Leonard

6-8 CODE LIST OF MANUFACTURERS (Sheet 1 of 3)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
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
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01686	RCL Electronics, Inc.	Manchester, N. H.
01930	Amerock Corp.	Rockford, Ill.
02114	Ferroxcube Corp. of America	Saugerties, N. Y.
02660	Amphenol-Borg Electronics Corp.	Maywood, Ill.
02735	Radio Corp. of America, Commercial Receiving Tube and Semiconductor Div.	Somerville, N. J.
03508	G. E. Semiconductor Products Dept.	Syracuse, N. Y.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Cedar Knolls, N. J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N. Y.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Inc. Microwave Device Div.	Mountain View, 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	Amatom Electronic Hardware Co, Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co, Inc.	Penacook, N. H.
06751	Nuclear Corp. of America, Inc., U. S. Semcor Div.	Phoenix, Arizona
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.
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.
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.
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, L. I., 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.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
19315	The Bendix Corp., Eclipse Pioneer Div.	Teterboro, N. J.

FROM: F. S. C. Handbook Supplements
H4-1 October, 1965.
H4-2 October, 1965.

6-8 CODE LIST OF MANUFACTURERS (Sheet 2 of 3) CONT'D.

CODE NO.	MANUFACTURER	ADDRESS
19701	Electra Mfg. Co.	Independence, Mo.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp., Linde Div., Kemet Dept.	Mountain View, 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.
60437	Jas. H. Power Iron Works	Providence, R.I.
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.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Elkhart, Ind.
71468	I. T. T. Cannon Electric Co.	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., Semiconductor 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	Heineman 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.
75173	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.
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.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81453	Raytheon Mfg. Co., Industrial Components Operation, Component Div.	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.

FROM: F. S. C. Handbook Supplements
H4-1 October, 1965.
H4-2 October, 1965.

6-8 CODE LIST OF MANUFACTURERS (Sheet 3 of 3) CONT'D.

CODE NO.	MANUFACTURER	ADDRESS
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82219	Sylvania Electric Prod.Inc., Electronic Tube Div.	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.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
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 Corp. of America, Electronic Components & Devices Div.	Harrison, N.J.
87034	Marco Industries Co.	Anaheim, Calif.
87216	Philco Corp. (Lansdale Div.)	Lansdale, Pa.
87575	Stockwell Rubber Co., Inc.	Philadelphia, Pa.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
91345	Miller Dial and Nameplate Company	El Monte, Calif.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell, Inc., Micro-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.
96791	Amphenol Controls Div. of Amphenol-Borg Electronics Corp.	Janesville, Wis.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.

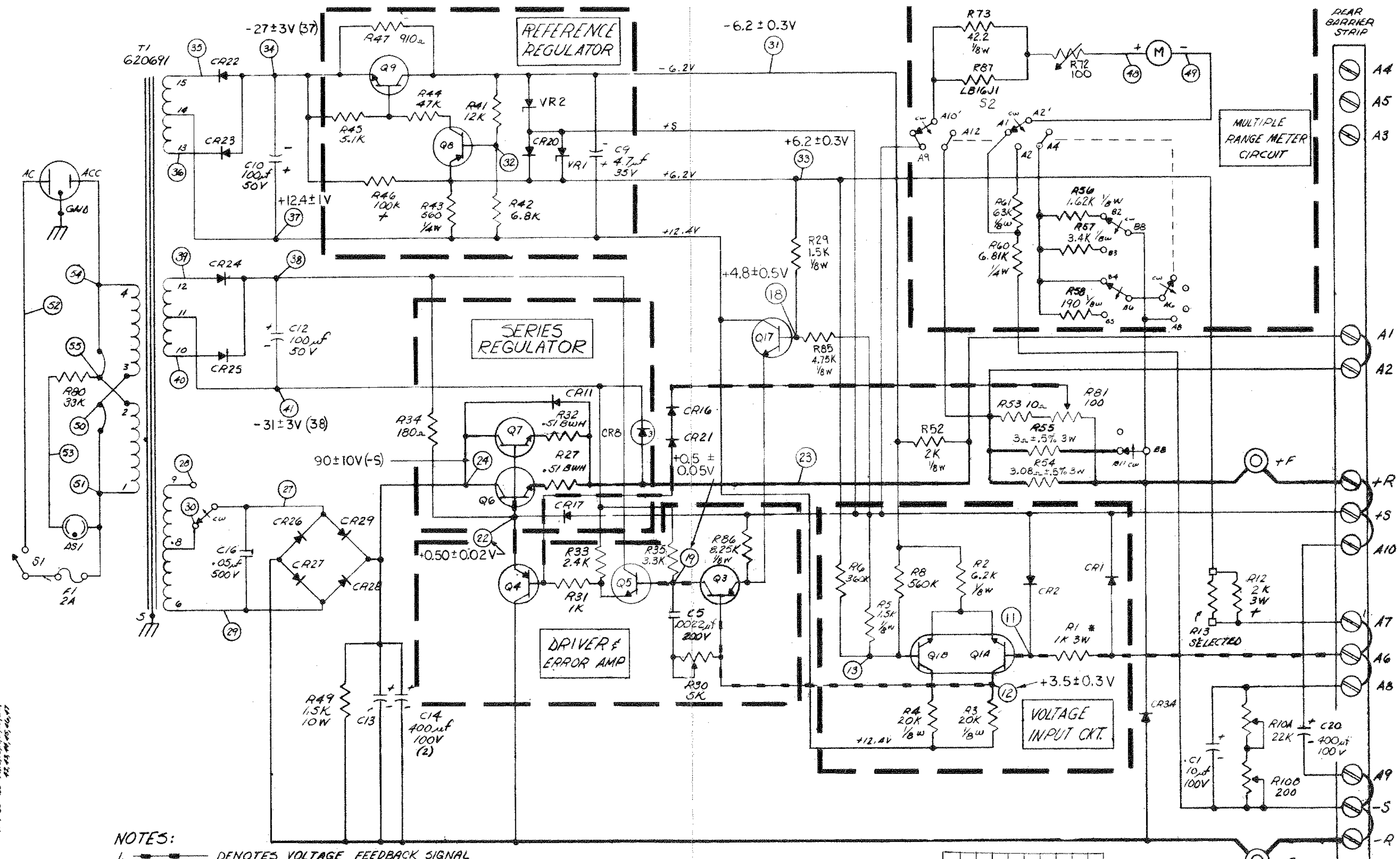
THE FOLLOWING H-P VENDORS HAVE NO NUMBERS ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000	Cooltron	Oakland, Calif.

FROM: F.S.C. Handbook Supplements
H4-1 October, 1965.
H4-2 October, 1965.

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	-hp- Stock No.	RS
C1	fxd, elect, 10μf 100vdc	1	30D106G100DD4	Sprague	56289	0180-0091	1
C2-4,6-8,11, 15,17-19	NOT ASSIGNED						
C5	fxd, film, .0022μf 200vdc	1	192P22292	Sprague	56289	0160-0154	1
C9	fxd, elect, 4.7μf 35vdc	1	150D475X9035B2	Sprague	56289	0180-0100	1
C10,12	fxd, elect, 100μf 50vdc	2	D32218	HLAB	09182	0180-1852	1
C13,14,20	fxd, elect, 400μf 100vdc	3	D37623	HLAB	09182	0180-1887	1
C16	fxd, cer, .05μf 500vdc	1	33C17A	Sprague	56289	0150-0052	1
CR1,2,16, 20	Rect. Si. 200ma 200prv 250mw	4	-	HLAB	09182	1901-0033	4
CR3-7,9,10, 12-15,18, 19,30-33	NOT ASSIGNED						
CR8	Rect. Si. 400mw 10prv	1		HLAB	09182	1901-0460	1
CR11,17, 22-29,34	Rect. Si. 500ma 200prv	11	1N3253	R.C.A.	02735	1901-0026	7
CR21	Rect. Si. 400mw 10prv	1		HLAB	09182	1901-0461	1
DS1	Indicator light, neon	1	599-124	Drake	72765	1450-0048	1
F1	Fuse cartridge 2A 250V 3Ag	1	312002	Littlefuse	75915	2110-0002	5
Q1	SS NPN Diff Amp	1		HLAB	09182	1854-0229	1
Q2,10-16	NOT ASSIGNED						
Q3,8	SS PNP Sil.	2	MPS 6517	Motorola	04713	1853-0065	2
Q4	SS PNP Sil.	1		HLAB	09182	1853-0040	1
Q5,9,17	SS NPN Sil.	3	2N3391	G.E.	03508	1854-0071	3
Q6,7	Power NPN Sil.	2	-	HLAB	09182	1854-0239	2
R1	fxd, ww, 1KΩ±5% 3w 20ppm	1	242E1025	Sprague	56289	0813-0001	1
R2	fxd, met, flm, 6.2KΩ ±1% 1/8 w	1	Type CEA T-O	I.R.C.	07716	0698-9087	1
R3,4	fxd, met, flm, 20KΩ ±1% 1/8 w	2	Type CEA T-O	I.R.C.	07716	0757-0449	2
R5,29	fxd, met, flm, 1.5KΩ±1% 1/8 w	2	Type CEA T-O	I.R.C.	07716	0757-0427	2
R6	fxd, comp, 360KΩ ±5% 1/2 w	1	EB-3645	A.B.	01121	0686-3645	1
R7,9,11 14-26,28, 36-40,48, 50,51,59, 62-71,74-79, 82-4	NOT ASSIGNED	-	-	-	-	-	-
R8	fxd, comp, 560KΩ ±5% 1/2 w	1	EB-5625	A.B.	01121	0686-5645	1
R10	var, ww, DUAL 22K-200Ω	1	-	HLAB	09182	2100-0998	1
R12	fxd, ww, 2KΩ ±5% 3w 20ppm	1	242E2025	Sprague	56289	0811-1806	1
R13	fxd, comp, SELECTED±5%1/2 w	1	Type EB	A.B.	01121	-	1
R27,32	fxd, ww, .51Ω ±5%	2	Type BWH	I.R.C.	07716	0811-0929	1
R30	var, ww, 5KΩ (Modify)	1	Type 110-F4	C.T.S.	11236	2100-1824	1
R31	fxd, ww, 1KΩ ±5%	1	EB-1025	A.B.	01121	0686-1025	1
R33	fxd, comp, 2.4KΩ ±5% 1/2 w	1	EB-2425	A.B.	01121	0686-2425	1
R34	fxd, comp, 180Ω ±5% 1/2 w	1	EB-1815	A.B.	01121	0686-1815	1
R35	fxd, comp, 3.3KΩ ±5% 1/2 w	1	EB-3325	A.B.	01121	0686-3325	1
R41	fxd, comp, 12KΩ ±5% 1/2 w	1	EB-1235	A.B.	01121	0686-1235	1
R42	fxd, comp, 6.8KΩ ±5% 1/2 w	1	EB-6825	A.B.	01121	0686-6825	1
R43	fxd, met, flm, 560Ω±1% 1/4 w	1	Type CEB T-O	I.R.C.	07716	0698-5146	1
R44	fxd, comp, 47KΩ±5% 1/2 w	1	EB-4735	A.B.	01121	0686-4735	1
R45	fxd, comp, 5.1KΩ ±5% 1/2 w	1	EB-5125	A.B.	01121	0686-5125	1
R46	fxd, comp, 100KΩ ±5% 1/2 w	1	EB-1045	A.B.	01121	0686-1045	1

Reference Designator	Description	Quantity	Mfr. Part# or Type	Mfr.	Mfr. Code	-hp- Stock No.	RS
R47	fxd, comp, 750Ω ±5% 1/2 w	1	EB-7515	A. B.	01121	0686-7515	1
R49	fxd, ww, 1.5KΩ ±5% 10w	2	Type 10XM	W. L.	63743	0811-1913	1
R52	fxd, met, flm, 2KΩ±1% 1/8 w	1	Type CEA T-O	I. R. C.	07716	0757-0283	1
R53	fxd, comp, 10Ω ±5% 1/2 w	1	EB-1005	A. B.	01121	0686-1005	1
R54	fxd, ww, 3.08Ω ±0.5% 3w	1	Type T-3	R. C. L.	01686	0811-1987	1
R55	fxd, ww, 3Ω ±0.5% 3w	1	Type T-3	R. C. L.	01686	0811-1986	1
R56	fxd, met, flm, 1.62KΩ ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0428	1
R57	fxd, met, flm, 3.4KΩ±1% 1/8 w	1	Type CEA T-O	I. R. C.	07716	0698-4440	1
R58	fxd, met, flm, 190Ω±1% 1/8 w	1	Type CEA T-O	I. R. C.	07716	0698-5868	1
R60	fxd, met, flm, 6.81KΩ±1% 1/4w	1	Type CEB T-O	I. R. C.	07716	0757-0750	1
R61	fxd, met, flm, 63KΩ±1% 1/8 w	1	Type CEA T-O	I. R. C.	07716	0698-5152	1
R72, 81	var, ww, 100Ω(R72 Modify)	2	Type 110-F4	C. T. S.	11236	2100-0281	1
R73	fxd, met, flm, 42.2Ω±1% 1/8 w	1	Type CEA T-O	I. R. C.	07716	0757-0316	1
R80	fxd, comp, 33KΩ ±5% 1/2 w	1	EB-3335	A. B.	01121	0686-3335	1
R85	fxd, met, flm, 4.75KΩ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0437	1
R86	fxd, met, flm, 8.25KΩ ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0441	1
R87	Thermistor 64Ω±10%	1	LB16J1	Fenwal	15801	0837-0023	1
S1	Switch SPST On/Off	1	T110-72	Carling	73559	3101-1055	1
S2	Rotary Switch Concent. shafts	1	-	HLAB	09182	3100-1913	1
T1	Power Transformer	1	-	HLAB	09182	9100-1822	1
VR1	Diode Zener 6.2V	1	1N821	N. A. E.	06486	1902-0761	1
VR2	Diode Zener 6.19V±5% 400mw	1	-	HLAB	09182	1902-0049	1
	5 Way Binding Post(red)	1	-	HLAB	09182	1510-0040	1
	5 Way Binding Post(black)	2	DF21BC	Superior	58474	1510-0039	1
	Line cord Plug PH151 7 1/2'	1	KH-4096	Beldon	70903	8120-0050	1
	Strain Relief Bushing	1	SR-5P-1	Heyco	28520	0400-0013	1
	Barrier Strip	1	-	HLAB	09182	0360-1234	1
	Rubber Bumper	4	MB50	Stockwell	87575	0403-0088	1
	Rubber Bumper(PCB)	3	4072	Stockwell	87575	0403-0086	1
	Knob 1/4 insert pointer(black)	1	-	HLAB	09182	0370-0107	1
	Knob 17/64 insert pointer(bl)	1	-	HLAB	09182	0370-0101	1
	Knob, bar 1/8 insert pointer(r)	1	-	HLAB	09182	0370-0102	1
	Knob 3/16 insert (red)	1	-	HLAB	09182	0370-0179	1
	Meter Bezel 1/6 Mod	1	-	HLAB	09182	5040-0651	1
	Fuse Holder	1	342014	Littlefuse	75915	1400-0084	1
	Meter, dual scale 0-70V 0-1.2A	1	-	HLAB	09182	1120-1144	1
	Meter spring	4	-	HLAB	09182	1460-0720	1
	Mica Insulator	2	734	Reliance	08530	0340-0174	1
	Insulator, transistor pin	4	-	HLAB	09182	0340-0166	1
	Insulator	4	-	HLAB	09182	0340-0168	1



NOTES:

1. ——— DENOTES VOLTAGE FEEDBACK SIGNAL
2. ——— DENOTES CURRENT FEEDBACK SIGNAL
3. ALL RESISTORS ARE ½WATT, 5% UNLESS OTHERWISE NOTED.
4. ALL ⅛W AND ¼W RESISTORS ARE 1% IN TOLERANCE
5. † DENOTES NOMINAL VALUE, COMPONENTS SELECTED FOR OPTIMUM PERFOMANCE
6. * DENOTES 20 PPM WIRE TEMPERATURE COEFFICIENT.
7. REAR TERMINALS ARE SHOWN IN NORMAL STRAPPING. FOR USE OF FRONT PANEL CONTROLS
8. R10A & R10B ARE DUAL SHAFT FRONT PANEL CONTROLS
9. TRANSFORMER SHOWN STRAPPED FOR 115 VAC OPERATION. SEE INSTRUCTION MANUAL FOR 220 VAC
10. TEST POINT VOLTAGES MEASURED WITH SIMPSON MODEL 269 (OR EQUIVALENT). ALL VOLTAGES REFERENCED TO +S TERMINAL UNLESS OTHERWISE INDICATED BY TEST POINT NUMBER IN PARETHESES ADJACENT TO READING. READINGS TAKEN AT 60 VOLTS OUTPUT WITH NO LOAD CONNECTED.

S2 POSITIONS

1. — 7V
2. — 70V
3. — 1.2A
4. — .12A

CIRCUIT PATENTS APPLIED FOR. LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HARRISON LABORATORIES

JOB NO 6206B

TITLE 6206B SCHEMATIC

FOR 0-60V @ .5A, 0-30V @ 1A — DWG NO C-06206-91001-1

HEWLETT-PACKARD CO
HARRISON DIVISION
BERKELEY HEIGHTS, N.J.