

## Errata

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### HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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HEWLETT  
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For  
Serials  
2208A-00101

Model 6205C  
Dual DC Power Supply  
Operating and Service Manual

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AAIH

# OPERATING AND SERVICE MANUAL

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### **CERTIFICATION**

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*The above statements apply only to the standard product warranty. Warranty options, extended support contracts, product maintenance agreements and customer assistance agreements are also available. Contact your nearest Hewlett-Packard Sales and Service office for further information on HP's full line of Support Programs.*

## SAFETY SUMMARY

*The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.*

### BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

### GROUND THE INSTRUMENT.

This is safety class I equipment. To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument must be connected to ac power through a three-conductor power cable, with the third wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

### DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of this instrument in such an environment constitutes a definite safety hazard. This equipment is designed for indoor use only. It may be subjected to a temperature range from 0°C to 50°C without degradation of safety.

### KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power, discharge circuits and remove floating voltages before touching components.

### DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

### SAFETY SYMBOLS.



Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (refer to Table of Contents).



Indicates hazardous voltages on terminals supplied from the interior at 1000 volts or more.



Indicates earth (ground) terminal connected to accessible conductive parts.

**WARNING**

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

**CAUTION**

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

### DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

## TABLE OF CONTENTS

Section	Page No.	Section	Page No.
I	GENERAL INFORMATION.....	1-1	
1-1	Description	1-1	
1-6	Specifications	1-1	
1-8	Options	1-1	
1-10	Accessories	1-2	
1-12	Instrument and Service Manual Identification	1-2	
1-15	Ordering Additional Manuals	1-2	
II	INSTALLATION.....	2-1	
2-1	Initial Inspection	2-1	
2-3	Mechanical Check	2-1	
2-5	Electrical Check	2-1	
2-7	Installation Data	2-1	
2-9	Location	2-1	
2-11	Outline Diagram	2-1	
2-13	Rack Mounting	2-1	
2-17	Input Power Requirements	2-3	
2-19	Connections for 230 Volt Operation	2-3	
2-21	Power Cable	2-3	
2-24	Repackaging for Shipment	2-3	
III	OPERATING INSTRUCTIONS.....	3-1	
3-1	Turn-On Checkout Procedure	3-1	
3-3	Operating Modes	3-1	
3-5	Normal Operating Mode	3-1	
3-7	Constant Voltage	3-1	
3-9	Changing Current Limit	3-2	
3-11	Connecting Load	3-2	
3-14	Operation Beyond Normal Rated Output	3-2	
3-16	Optional Operating Modes	3-2	
3-17	Remote Programming, Constant Voltage	3-2	
3-25	Remote Sensing	3-3	
3-30	Series Operation	3-4	
3-35	Auto-Tracking Operation	3-5	
3-38	Special Operating Considerations	3-6	
3-39	Pulse Loading	3-6	
3-41	Output Capacitance	3-6	
3-43	Reverse Voltage Loading	3-6	
3-45	Reverse Current Loading	3-6	
IV	PRINCIPLES OF OPERATION.....	4-1	
4-1	Overall Description	4-1	
4-8	Detailed Circuit Analysis	4-2	
4-9	Feedback Loop	4-2	
4-13	Series Regulator	4-2	
4-15	Constant Voltage Comparator	4-2	
4-19	Error Amplifier and Driver	4-2	
4-22	Current Limit Circuit	4-3	
4-26	Reference Circuit	4-3	
4-29	Meter Circuit	4-3	
V	MAINTENANCE.....	5-1	
5-1	Introduction	5-1	
5-3	General Measurement Techniques	5-1	
5-8	Test Equipment Required	5-2	
5-10	Performance Test	5-3	
5-12	Constant Voltage Tests	5-3	
5-38	Output Impedance	5-6	
5-48	Troubleshooting	5-7	
5-53	Overall Troubleshooting Procedure	5-8	
5-58	Repair and Replacement	5-8	
5-60	Adjustment and Calibration	5-12	
5-62	Meter Zero	5-12	
5-64	Ammeter Tracking	5-12	
5-66	Constant Voltage Programming Current	5-12	
5-69	Reference Circuit Adjustments	5-12	
5-71	Constant Voltage Transient Recovery Time	5-12	
5-73	Current Limit Adjustment	5-12	
VI	REPLACEABLE PARTS.....	6-1	
6-1	Introduction	6-1	
6-4	Ordering Information	6-1	
	APPENDIX A.....	A-1	
	VII CIRCUIT DIAGRAMS.....	7-1	

## 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 operations. The dual supply consists of two independently controlled dual range sections; both identical to the other. Each section can furnish either a 0-40 Volt output at 300mA or a 0-20 Volt output at 600mA. Each section has its own front panel meter and operating controls. The operating modes (40V or 20V) are selected by means of the front panel RANGE switches. The VOLTAGE controls permit each output voltage to be continuously adjusted throughout either output range.

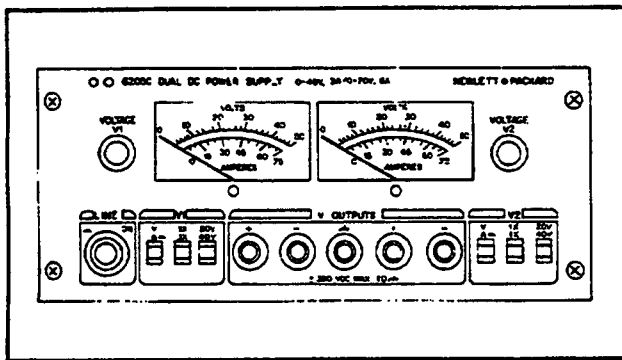


Figure 1-1. DC Power Supply, Model 6205C

1-3 Both sections of the supply are of the regulated, Constant Voltage/Current Limiting, type. Each section is fully protected from overloads by the fixed current limit which is set by means of an internal adjustment.

1-4 Both front and rear terminals are available for each section. Either the positive or negative terminals may be grounded or the supply can be operated at up to a maximum of 300 Volts off ground. Each meter can be used to measure either output voltage or output current in one of two ranges. The voltage or current ranges are selected by the applicable meter button on the front panel.

1-5 Two sets of programming terminals, located at the rear of the unit, allow ease in adapting to the many operational capabilities of the 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.

011

#### 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 10 $\mu$ sec imposes a virtual short-circuit (crowbar) across the power supply output if the preset trip voltage is exceeded. When Option 11 is requested by the customer the device is connected at the factory.

Trip Voltage Range: 2.5 to 44 Volts, screwdriver adjustable.

Detailed coverage of Option 11 is included in Appendix A at the rear of manuals that support power supplies containing Option 11.

015 Three Digit Graduated Decadial Voltage Control: Dial that replaces voltage control knobs permitting accurate resettability.

028 230Vac Input: Supply as normally shipped is wired for 115Vac input. Option 28 consists of reconnecting the input transformer for 230Vac operation.

040 Interfacing for Multiprogrammer operation. Prepares standard HP power supplies for resistance programming by the HP Multiprogrammer. Multiprogrammer operation requires that the power supply be subjected to a special calibration and a protection checkout. The special calibration insures that the power supply can be accurately set to zero and to its maximum rated output voltage or current when programmed by the Multiprogrammer. The protection checkout insures that the power supply will not be damaged by the rapid repetitive programming possible with the Multiprogrammer.

910 One additional operating and service manual shipped with the supply.

## 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

14513A Rack Kit for mounting one 3½" high supply. (Refer to Section II for details.)

14523A Rack Kit for mounting two 3½" high supplies. (Refer to Section II for details.)

## 1-12 INSTRUMENT AND SERVICE MANUAL IDENTIFICATION

1-13 Hewlett-Packard power supplies are identified by a two-part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits of the prefix indicate the year (20 + 80, 21 + 81, etc.), the second two digits indicate the week, and the letter "A" designates the USA as the country of manufacture. The second part of the serial number is different sequential number assigned to each power supply, starting with 00101.

1-14 If the serial number on your instrument does not agree with those on the title page of this manual, a yellow Manual Change sheet supplied with the manual defines the difference between your instrument and the instrument described by this manual.

## 1-15 ORDERING ADDITIONAL MANUALS

1-16 One manual is shipped with each power supply. Additional manuals may be purchased directly from your local Hewlett-Packard Sales office. Specify the model number, instrument serial number prefix, and the manual part number provided on the title page. (When ordered at the same time as the power supply, additional manuals may be purchased by adding Option 910 to the order and specifying the number of additional manuals desired.)



Table 1-1. Specifications

<p><b>INPUT:</b> 115Vac <math>\pm</math>10%, single phase, 48-440Hz.</p> <p><b>OUTPUT:</b> Two independent outputs, each of which can be set at either 0-40 Volts @ 0.3 Amp or 0-20 Volts @ 0.6 Amp.</p> <p><b>LOAD REGULATION:</b> Less than 0.01% plus 4mV for a full load to no load change in output current.</p> <p><b>LINE REGULATION:</b> Less than 0.01% plus 4mV for any line voltage change within the input rating.</p> <p><b>RIPPLE AND NOISE:</b> Less than 200<math>\mu</math>Vrms 1mV p-p.</p> <p><b>TEMPERATURE RANGES:</b> Operating: 0 to 50°C. Storage: -40 to +75°C.</p> <p><b>TEMPERATURE COEFFICIENT:</b> Less than 0.02% plus 1mV per degree Centigrade.</p> <p><b>STABILITY:</b> Less than 0.10% plus 5mV total drift for 8 hours after an initial warm-up time of 30 minutes at constant ambient, constant line voltage, and constant load.</p> <p><b>OUTPUT IMPEDANCE (Typical):</b> Approximated by a 25 milliohm resistance in series with a 1 microhenry inductance.</p> <p><b>TRANSIENT RECOVERY TIME:</b> Less than 50<math>\mu</math>sec for output recovery to within 10mV following a full load current change in the output.</p> <p><b>OVERLOAD PROTECTION:</b> A fixed current limiting circuit protects the power supply for all overloads including a direct short placed across the terminals in constant voltage operation.</p> <p><b>METERS:</b> Each front panel meter can be used as either a</p>	<p>0-50 or 0-5 Volt voltmeter or as a 0-0.75 or 0.075 Amp ammeter.</p> <p><b>OUTPUT CONTROLS:</b> Range buttons select desired operating mode for each section and ten-turn VOLTAGE controls set desired output voltages.</p> <p><b>OUTPUT TERMINALS:</b> Five output posts (two for each section of supply and one chassis ground) are provided on the front panel and two output terminal strips (one per section) are located on the rear of the chassis. All power supply output terminals are isolated from the chassis and either the positive or negative terminals may be connected to the chassis through separate ground terminals located on the output terminal strips.</p> <p><b>ERROR SENSING:</b> Error sensing is normally accomplished at the front terminals if the load is attached to the front or at the rear terminals if the load is attached to the rear terminals. Also, provisions are included on the rear terminal strips for remote sensing.</p> <p><b>REMOTE RESISTANCE PROGRAMMING:</b> 200 ohms per Volt.</p> <p><b>REMOTE VOLTAGE PROGRAMMING:</b> 1 Volt per Volt.</p> <p><b>COOLING:</b> Convection cooling is employed. The supply has no moving parts.</p> <p><b>SIZE:</b> 3<math>\frac{1}{2}</math>" H x 12-5/8" D x 8<math>\frac{1}{2}</math>" W. Two of the units can be mounted side by side in a standard 19" relay rack.</p> <p><b>WEIGHT:</b> 10 lbs. net, 13 lbs. shipping.</p> <p><b>FINISH:</b> Light gray front panel with dark gray case.</p> <p><b>POWER CORD:</b> A three-wire, five-foot power cord is provided with each unit.</p>
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## 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, a claim should be filed with the carrier. Hewlett-Packard Sales and Service office should be notified.

### 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 III contains a "brief" checkout procedure and section V includes a complete 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 OUTLINE DIAGRAM

2-12 Figure 2-1 is an outline diagram showing the dimensions of the instrument.

### 2-13 RACK MOUNTING

2-14 This instrument may be rack mounted in a standard 19 inch rack panel either alongside a similar unit or by itself. Figures 2-2 and 2-3

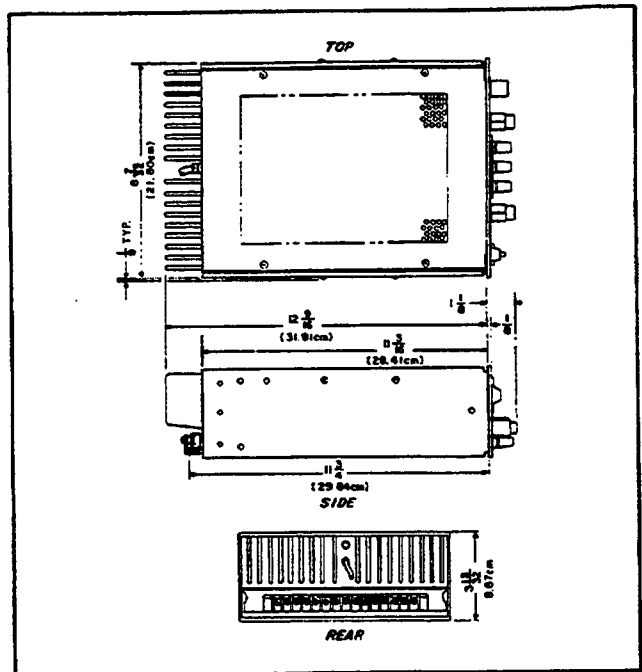


Figure 2-1. Outline Diagram

show how both types of installations are accomplished.

2-15 To mount to units side-by-side, proceed as follows:

- Remove bottom cover and clip tabs on main P.C. board surrounding switch. This allows LINE switch and small section of P.C. board to move forward with front panel. Replace bottom cover.
- Remove four screws from front panels of both units.
- Slide rack mounting ears between the front panel and case of each unit.
- Slide combining strip between the front panels and cases of the two units.
- After fastening rear portions of units together using the bolt, nut, and spacer, replace panel screws.

2-16 To mount a single unit in the rack panel, proceed as follows:

- Bolt rack mounting ears, combining straps, and angle brackets to each side of center

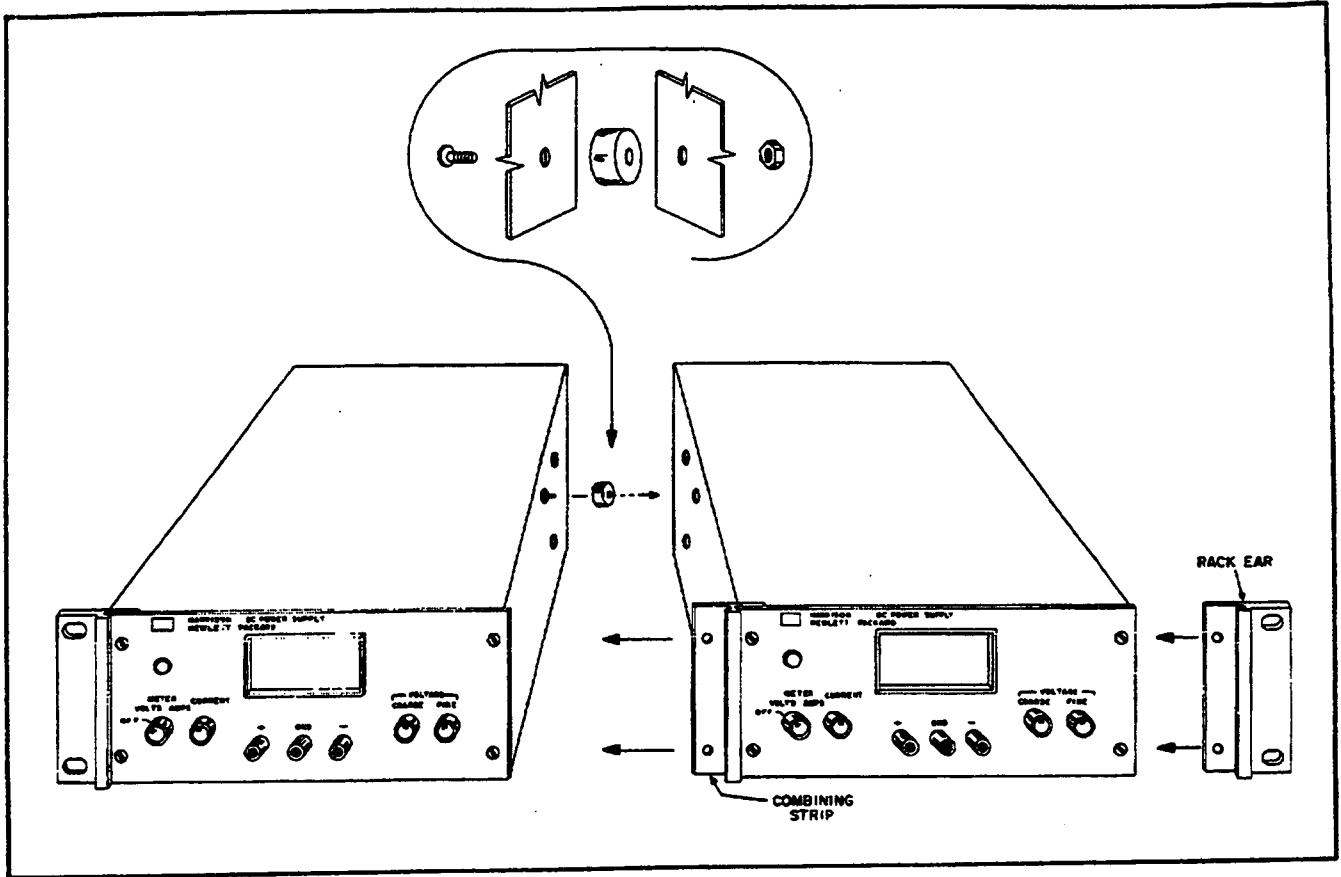


Figure 2-2. Rack Mounting, Two Units

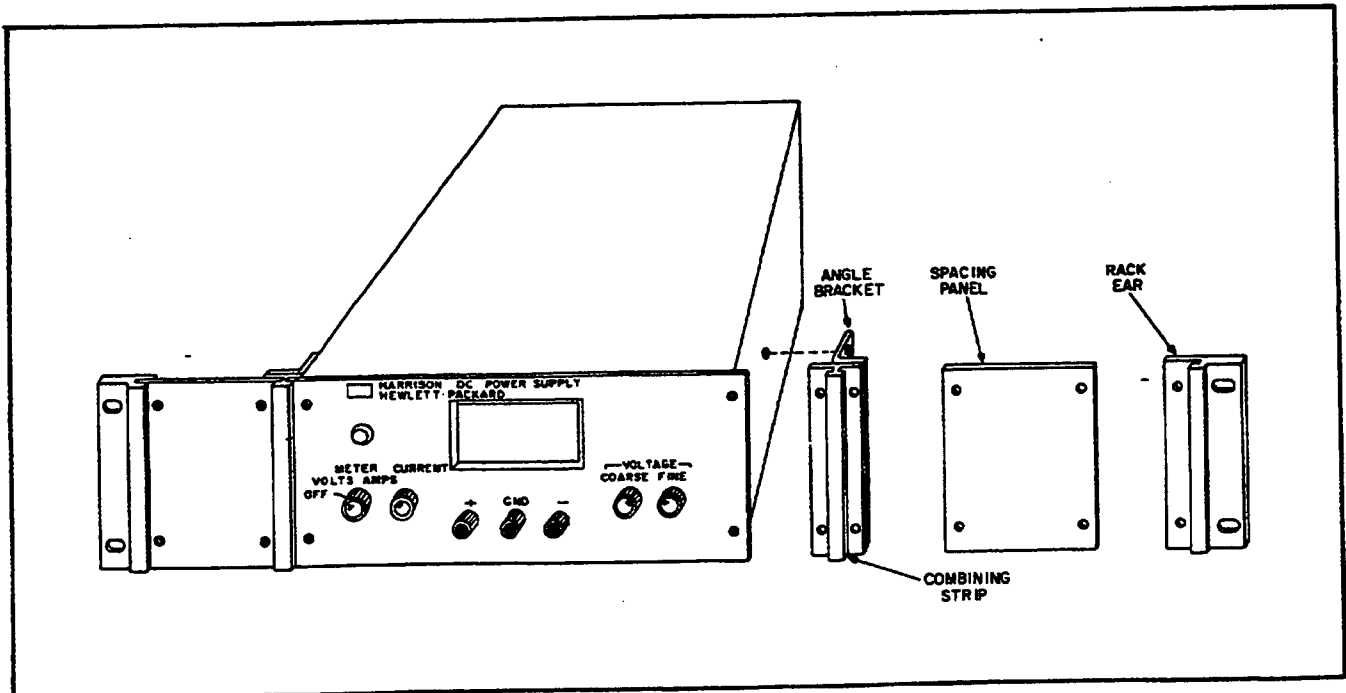


Figure 2-3. Rack Mounting, One Unit

spacing panels. Angle brackets are placed behind combining straps as shown in Figure 2-3.

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.

## 2-17 INPUT POWER REQUIREMENTS

2-18 This power supply may be operated from either a nominal 115 Volt or 230 Volt 48-440 Hertz 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 Hertz power source at full load is 31 Watts and 0.35 Amperes.

## 2-19 CONNECTIONS FOR 230 VOLT OPERATION

2-20 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. Connect windings in parallel, as shown in Figure 2-4.

c. Replace existing fuse with 1 Ampere fuse. Return unit to case and operate normally.

## 2-21 POWER CABLE

2-22 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.

2-23 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.

## 2-24 REPACKAGING FOR SHIPMENT

2-25 To insure safe shipment of the instrument, it is recommended that the package designed for

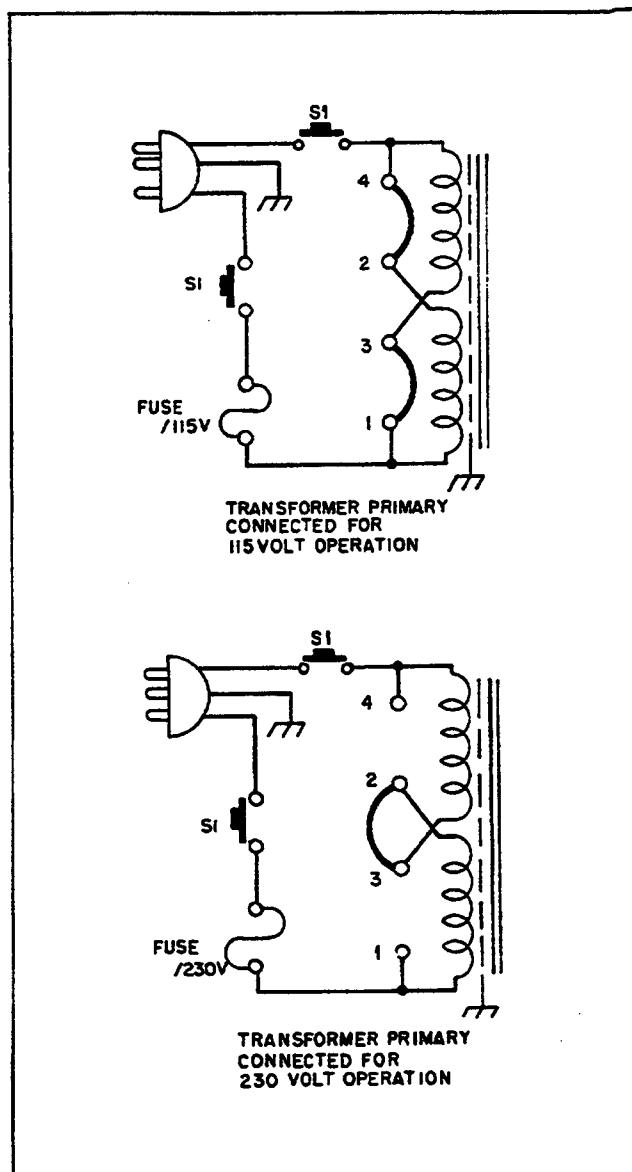


Figure 2-4. Primary Connections

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 TURN-ON CHECKOUT PROCEDURE

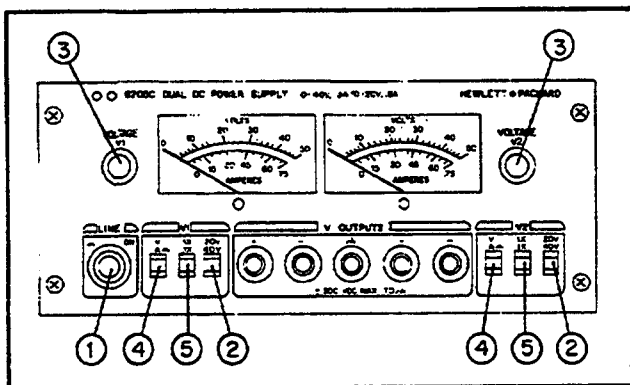


Figure 3-1. Front Panel Controls and Indicators

3-2 The front panel controls and indicators are shown in Figure 3-1. The normal turn-on sequence, is described below:

- A. Push LINE button ①.
- B. Set range button ② to desired operating mode 20 V or 40 V and meter buttons ④ and ⑤ to V and X1 positions.
- C. Adjust voltage control ③ until desired output voltage is indicated on meter.
- D. Set range button ② to highest current range (20 V) turn-off supply. Short circuit output terminals.
- E. Set meter button ④ to A position and circuit output current on meter.
- F. Remove short and connect load to output terminals (front or rear).
- G. For Model 6205C, this procedure should be used for both sections of supply.

### 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 op-

erational capabilities of the supply. A more theoretical description concerning these operational features is contained in Application Note 90 and in various Tech Letters. 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).

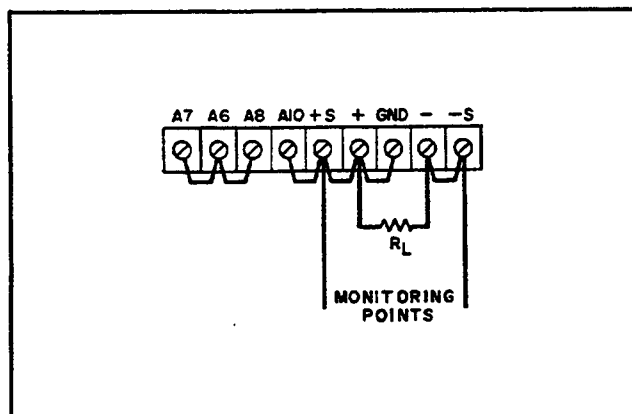


Figure 3-2. Normal Strapping Pattern

### 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 100mA above the current rating of the supply. If the existing current limit 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 5-74. In Models 6204B and 6206B, the current limit may be reduced to a value lower than that attainable by adjusting R81, by adding an external resistor as shown in Figure 3-3. The approximate value of the external resistance ( $R_x$ ) can be determined by using the following equation

$$R_x \approx \frac{1.75}{I_E} - R_I$$

where:  $I_E$  = the output current

$R_I$  = the internal current sampling resistance for the particular operating mode to be used.

1.75 = the approximate voltage drop across the internal sampling resistance at the current limit crossover point.

#### NOTE

The power supply's performance will be somewhat degraded if it is operated too close to (within 100mA) the current limit crossover point.

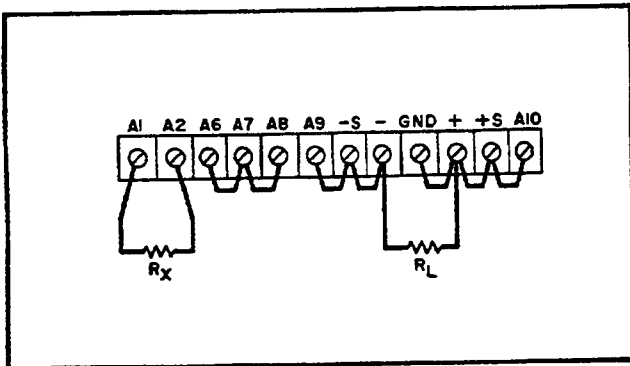


Figure 3-3. Current Limit Alteration

### 3-11 CONNECTING LOAD

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

3-13 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (Paragraph 3-25).

### 3-14 OPERATION BEYOND NORMAL RATED OUTPUT

3-15 Although the supply can deliver greater than the rated output on both the lower and higher voltage ranges without being damaged, it can not be guaranteed to meet all of its performance specifications. Generally when operating the supply in this manner, the output is unstable when connected to a load. When greater than the lower rated voltage is required, the higher voltage range should be used. This range will deliver half as much output current and all specifications will apply as listed in Table 1-1. However, if the line voltage is maintained above its nominal value, the supply will probably operate within specifications above its rated output.

### 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 and 6204C 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 accuracy is 1% of the programmed voltage. If greater programming accuracy is required, it may be achieved by adjusting R13 as outlined in Section V.

3-20 The output voltage of the power supply should be zero Volts  $\pm$  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 Section V.

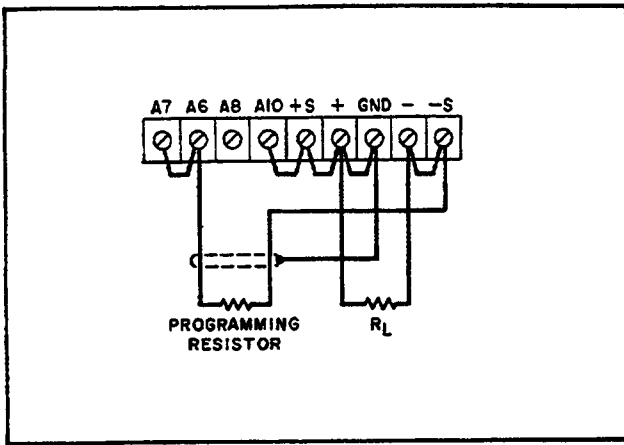


Figure 3-4. Remote Resistance Programming

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 30ppm 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.

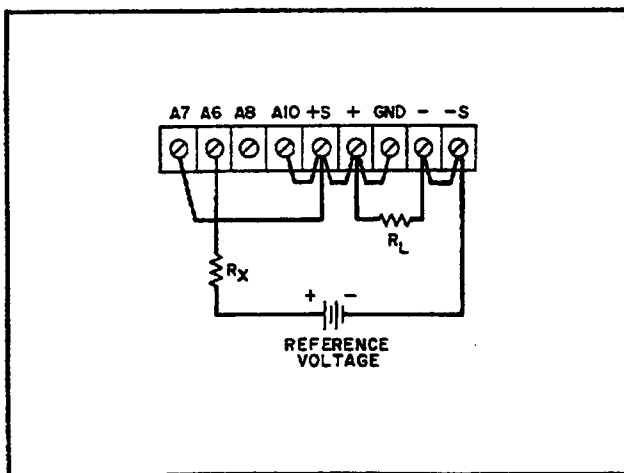


Figure 3-5. Remote Voltage Programming

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. The programming accuracy is 1% of the programmed voltage.

3-24 Methods of voltage programming with gain are discussed in Application Note 90, Power Supply Handbook; available at no charge from your local Sales Office.

3-25 REMOTE SENSING (See Figure 3-6)

3-26 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.

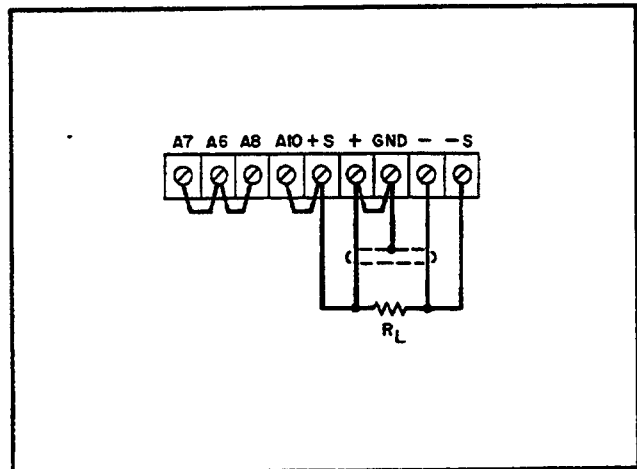


Figure 3-6. Remote Sensing

3-27 For reasonable load lead lengths, remote sensing greatly improves the performance of the supply. However, if the load is located a considerable distance from the supply, added precautions must be observed to obtain satisfactory operation. Notice that the voltage drop in the load leads sub-

tracts directly from the available output voltage and also reduces the amplitude of the feedback error signals that are developed within the unit. Because of these factors it is recommended that the drop in each load lead not exceed 1 Volt. If a larger drop must be tolerated, please consult a sales engineer.

**NOTE**

Due to the voltage drop in the load leads, it may be necessary to readjust the current limit in the remote sensing mode.

3-28 Another factor that must be considered is the inductance of long load leads which could affect the stability of the feedback loop and cause oscillation. In these cases, it is recommended that the output capacitor (C20) be physically removed from the power supply and placed across the output terminals.

3-29 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.

**3-30 SERIES OPERATION**

3-31 Normal Series Connections (Figure 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 volt-

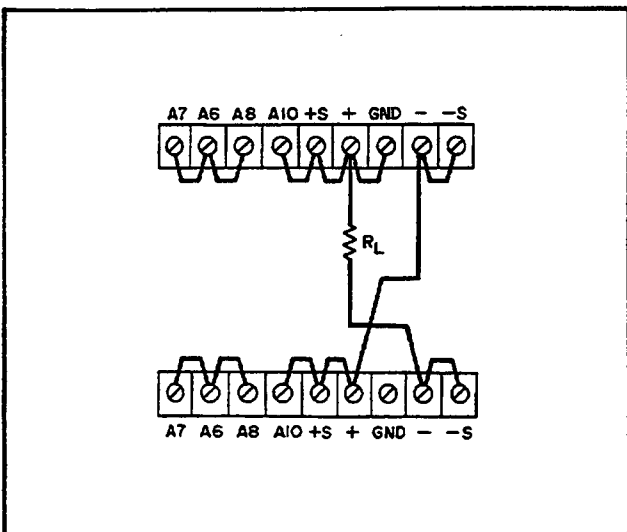


Figure 3-7. Normal Series Connections

ages 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.

3-32 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

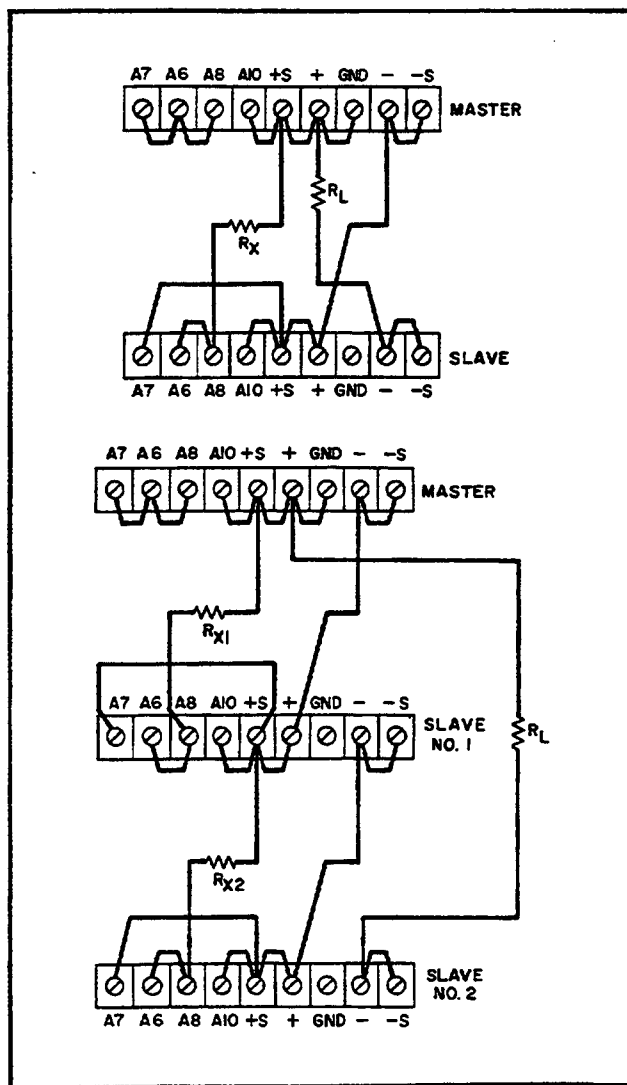


Figure 3-8. Auto-Series, Two and Three Units



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.

3-33 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 30ppm per degree Centigrade) resistors. The value of each resistor is dependant on the maximum voltage rating of the master supply. The value of  $R_x$  is this voltage divided by the voltage programming current of the slave supply ( $1/K_p$  where  $K_p$  is the resistance programming coefficient for constant voltage operation). The

voltage programming current of the model 6205C is 1/200 ohms per volt, or 5 milliamps.

3-34 Auto-Parallel. 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 the output current from one master power supply. The output current of each slave will be approximately equal to the master's regardless of the load conditions. Because the output current controls of each slave are operative, they should be set to maximum to avoid having the slave revert to constant current operation; this would occur if the master output current setting exceeded the slave's. In Model 6205C, it is necessary to make internal connections in order to operate the supply in this mode. The internal connections, specified in Figure 3-9, are made to the sampling terminals of the current sampling terminals of the current sampling resistor, R54 (see Figure 5-2).

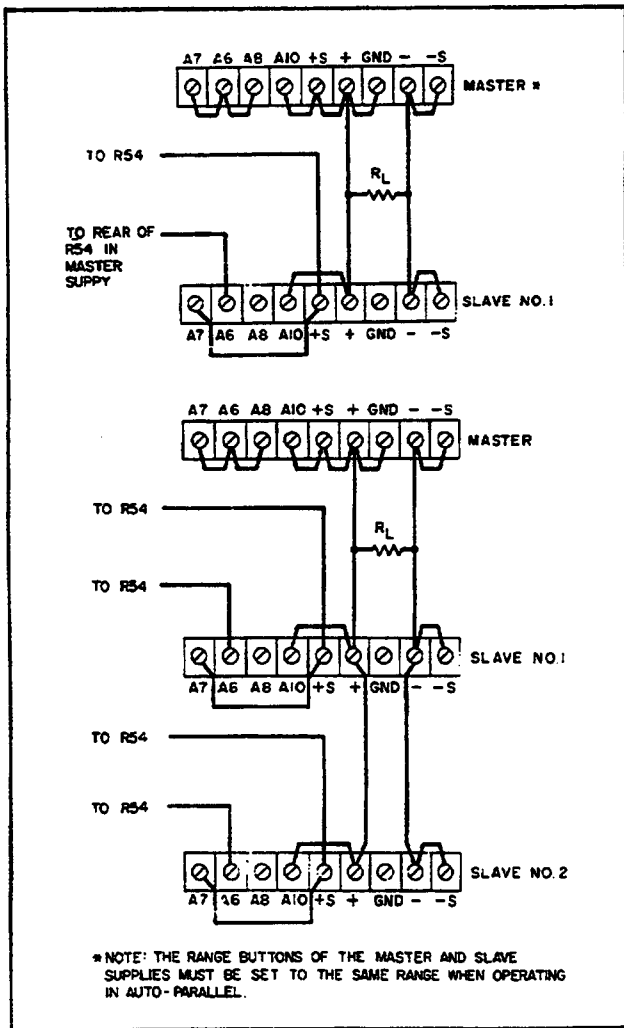


Figure 3-9. Auto-Parallel, Two and Three Units

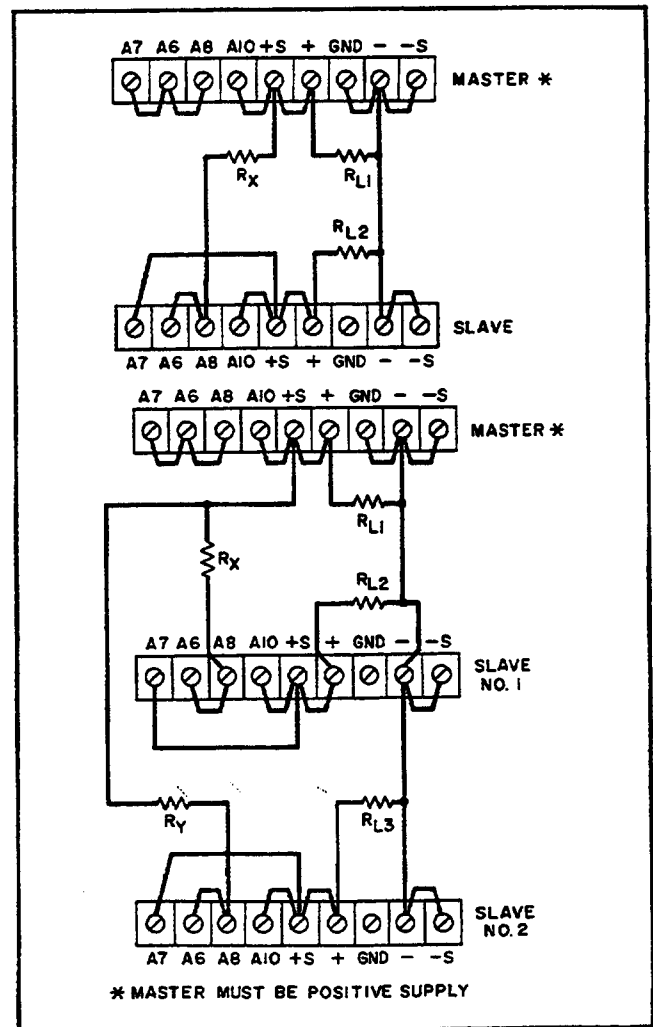


Figure 3-10. Auto-Tracking, Two and Three Units

### 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  $R_Y$ ) and the voltage control of the slave supply,  $R_p$ , where:

$$E_S = \frac{EMRP}{R_X + R_p}$$

Turn-on and turn-off of the power supplies is controlled by the master. Remote sensing and programming can be used; although the strapping patterns for these modes show only local sensing and programming. In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors should be stable, low noise, low temperature (less than 30ppm per °C) resistors.

### 3-38 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.

#### 3-43 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.

#### 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 its operating cycle. An external source cannot be allowed to pump current into the supply without loss of regulation and possible damage to the output capacitor. To avoid these effects, it is necessary to preload the supply with a dummy load resistor so that the power supply delivers current through the entire operating cycle of the load device.

## SECTION IV PRINCIPLES OF OPERATION

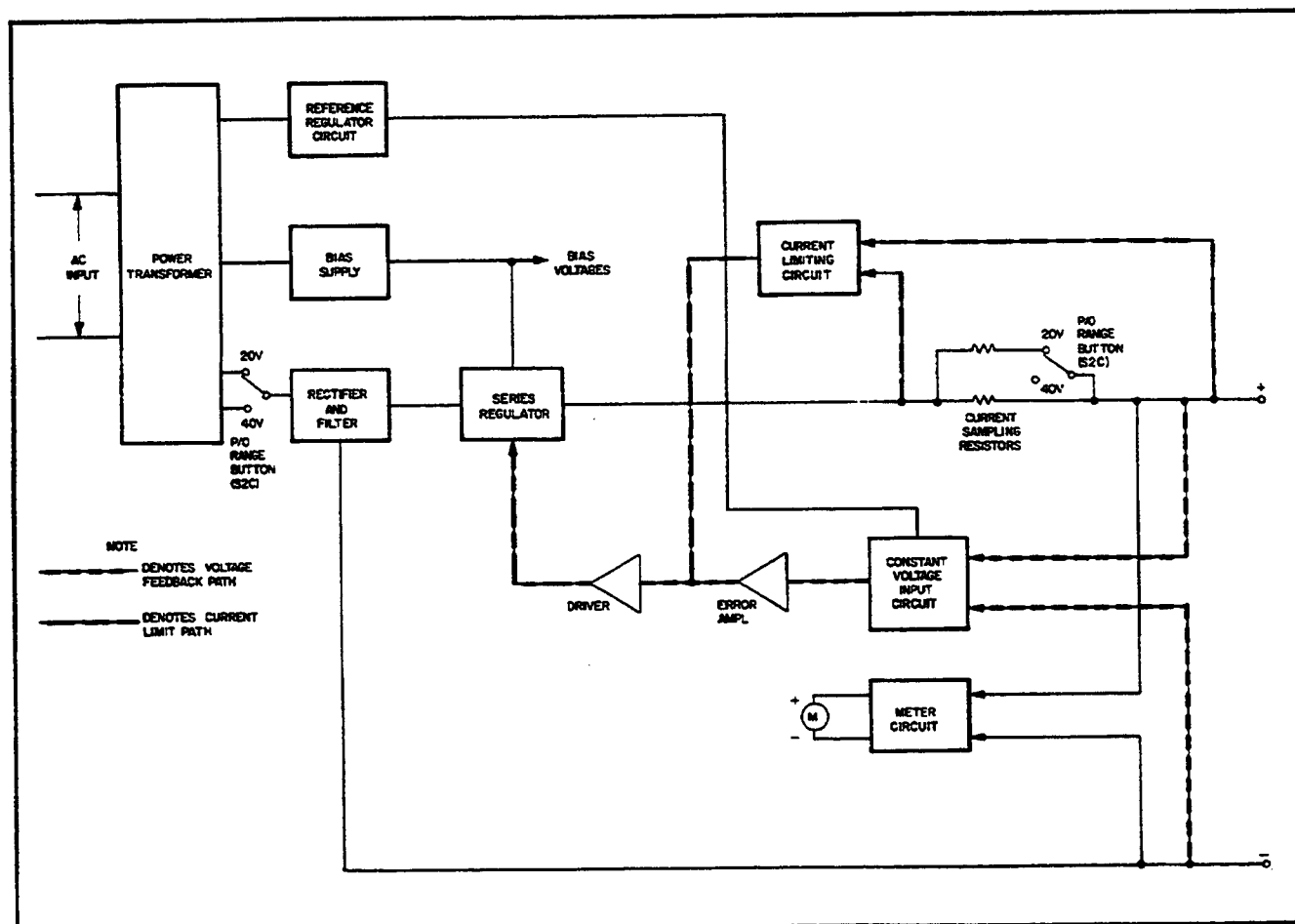


Figure 4-1. Overall Block Diagram

### 4-1 OVERALL DESCRIPTION

4-2 Figure 4-1 shows one section of the Model 6205c dual power supply. The supply consists of two dual range sections; each identical to the other. Each section consists of a rectifier and filter, a series regulator, an error amplifier and driver, a constant voltage input circuit, a current limiting circuit, a reference regulator circuit, a bias supply, and a metering circuit. Since both sections of the supply are identical, only one section is described below.

4-3 The ac line voltage is first applied to the power transformer. The tap for the appropriate voltage range is selected by range button S2C. The input is then rectified and filtered. This raw dc is then fed to the series regulator which alters

its conduction to obtain the proper regulated dc output voltage.

4-4 Any changes in output voltage are felt by the constant voltage comparator which compares a portion of the output with a fixed reference voltage. If a difference exists, the comparator circuit sends an error signal to the series regulator via the error amplifier and driver stages. This error signal changes the conduction of the series regulator so that a constant output voltage is maintained.

4-5 Changes in output current are reflected in the voltage drop across the current sampling resistor network. If this voltage drop exceeds a preset limit, the current limit transistor conducts, sending a turn-down signal to the series regulator via the driver. This signal changes the conduction of the

series regulator so that the output current is limited to the proper value.

4-6 The reference circuit provides stable reference voltages used in the constant voltage comparator and current limit circuits. The bias circuit provides the less critical bias voltages used in the supply.

4-7 The meter circuit provides a continuous indication of output voltage or current in both ranges.

#### 4-8 DETAILED CIRCUIT ANALYSIS

##### 4-9 FEEDBACK LOOP

4-10 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.

4-11 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 its conduction so that it drops more of the line voltage, reducing the output voltage to its original level.

4-12 If the external load resistance decreases to a certain crossover point, the supply will operate in the current limiting mode. In the current limit mode, Q10 conducts sending a negative going, turn-down signal to the series regulator via driver Q4.

##### 4-13 SERIES REGULATOR

4-14 The series regulator consists of transistor stage Q7 (and Q6 on Model 6206B). 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 transistor(s) is controlled by the feedback voltage obtained from driver Q4. Diode CR11, connected across the regulator circuit, protects the series transistor(s) against reverse voltages that could develop across it during parallel or auto-parallel operation if one supply is turned on before the other.

##### 4-15 CONSTANT VOLTAGE COMPARATOR

4-16 The circuit consists of programming resistor (R10), 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.

4-17 The constant voltage comparator 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 (mixer) 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.

4-18 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 resistors, R12 and R13. Instantaneous changes in output voltage result in an increase or decrease in the summing point potential. Q1A is 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, in series with pullout resistor R12, is factory set so that all of the +6.2 Volt reference is dropped across R12 and R13. Linear constant voltage programming is assured with a constant current flowing through R10. C20 stabilizes the feedback loop and may be removed to avoid current surges and increase the programming speed.

##### 4-19 ERROR AMPLIFIER AND DRIVER

4-20 The error and driver amplifiers amplify the error signal from the constant voltage comparator circuit to a level sufficient to drive the series regulator transistor(s). Driver Q4 also receives a current limiting input if Q10, the current limiting transistor, conducts.

4-21 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. Q17 establishes a stable emitter bias potential for error amplifier Q3. Emitter follower transistor(s) Q4 (and Q5) serves as the driver (and predriver) element for the series regulator.

#### 4-22 CURRENT LIMIT CIRCUIT

4-23 The current limit circuit limits the output current to a preset value determined by the setting of R81. Pushbutton S2C selects the proper sampling resistance to maintain an equal voltage drop across the current sampling network in both ranges.

4-24 When S2C is set to the 20 Volt position, R54 and R55 are connected in parallel. When S2C is set to the 40 Volt position, the current sampling network consists solely of R54. Note that in the twenty Volt range, twice as much current can be delivered as in the forty Volt range. Since the twenty Volt range has a sampling resistance equal to half the value of that for the forty Volt range, an equal sampling resistor voltage drop is obtained in both ranges. This also applies to S2 in the 6206B.

4-25 R81 sets the bias of Q10, and thus, the threshold point at which Q10 conducts and current limiting begins. If this threshold is exceeded, Q10 begins to conduct, forward biasing CR16 and sending a turn-down signal to the series regulator via the driver. If the current through the current sampling network decreases below the threshold point, Q10 turns off and no longer affects the operation of the supply.

#### 4-26 REFERENCE CIRCUIT

4-27 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 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.

4-28 The reference circuit consists of series regulating transistor Q9 and error amplifier Q8. Output voltage changes are detected by Q8 whose base is connected to the function 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.

#### 4-29 METER CIRCUIT (Figure 4-2)

4-30 The meter circuit provides a continuous indication 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 pushbutton S2A on the front panel of the supply. Pushbutton S2B selects one of two meter ranges on each scale. The meter circuit consists of pushbutton switches S2A, S2B, S2C, various multiplying resistors and the meter movement.

4-31 When measuring voltage, the meter is placed directly across the output of the supply between the +S and -S terminals by having switch S2A in the out position. With switch S2B in the higher voltage range (out position) multiplying resistors R60, R61, R72, and are in series with the meter. For low output voltages, switch S2B can be depressed which removes R61 from its series position allowing a larger percentage of the output voltage to be felt across the meter.

4-32 When measuring current, the meter circuit is connected across the current sampling resistor network as shown on Figure 4-2, by depressing switch S2A. This indicates the output current that flows through the network. Switch S2C connects the appropriate resistance in series with the meter so that its maximum deflection range is full-scale in the high current (20 volt) operating mode and half-scale in the low current (40 volt) 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.

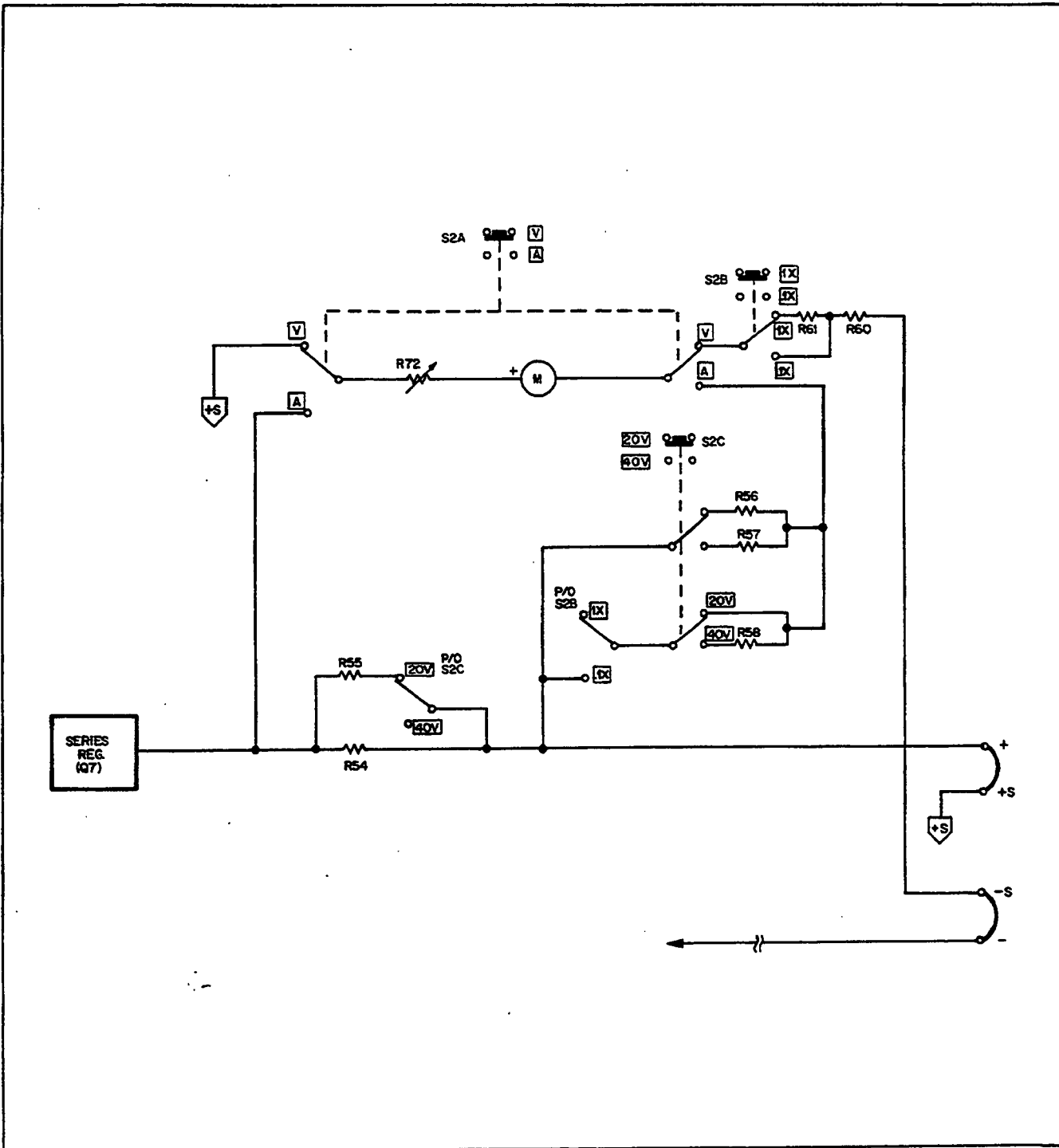


Figure 4-2. Multiple Range Meter Circuit, Simplified Schematic

## 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 5-48). After troubleshooting and repair (Paragraph 5-58), perform any necessary adjustments and calibrations (Paragraph 5-60). 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.

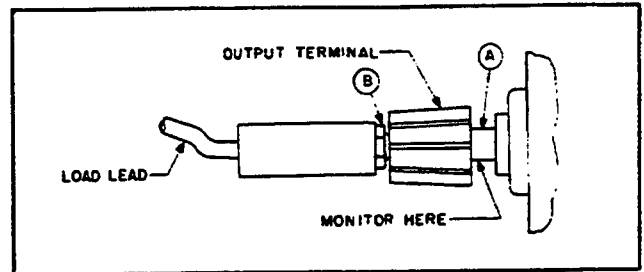


Figure 5-1. Front Panel Terminal Connections

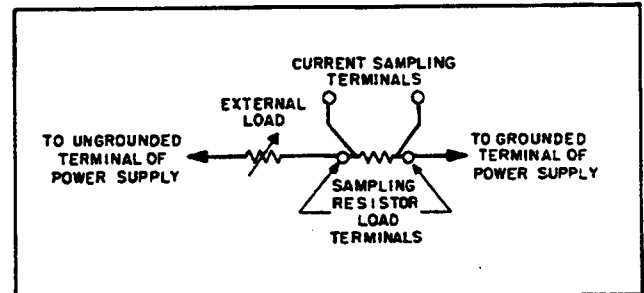


Figure 5-2. Output Current Measurement Technique

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 30ppm/ $^{\circ}$ C) type and should be used at no more than 5% of its rated power so that its temperature rise will be minimized.

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.

**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: Hewlett-Packard 419A null detector, a dc coupled oscilloscope utilizing differential input, or a 50mV meter movement with a 100 division scale. For the latter, a 2mV change in voltage will result in a meter deflection of four divisions.

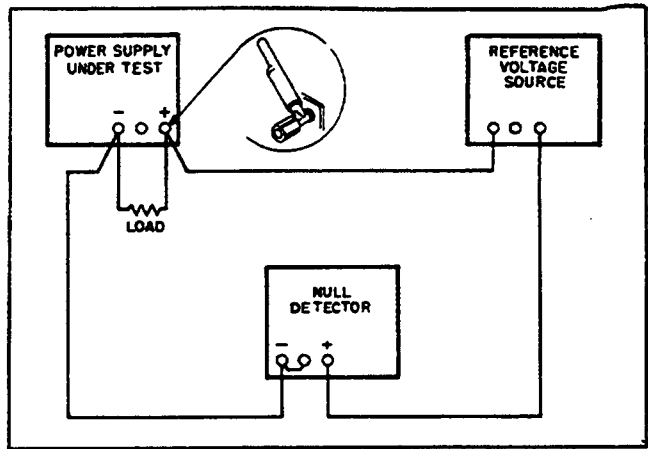


Figure 5-3. Differential Voltmeter Substitute, Test Setup

**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.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Differential Voltmeter	Sensitivity: 1mV full scale (min.). Input impedance: 10 megohms (min.).	Measure dc voltages; calibration procedures	Hewlett-Packard 3420 (See Note)
Variable Voltage	Range: 90-130 Volts Equipped with voltmeter accurate within 1 Volt.	Vary ac input	---
AC Voltmeter	Accuracy: 2%. Sensitivity: 1mV full scale deflection (min.).	Measure ac voltage and ripple	Hewlett-Packard 403 B
Oscilloscope	Sensitivity: 10µV/cm. Differential input.	Display transient waveforms	Hewlett-Packard 140 A plus 1402A plug in.
Oscillator	Range: 5Hz to 600KHZ Accuracy: 2%	Impedance Checks	Hewlett-Packard 200 CD
DC Voltmeter	Accuracy: 1%. Input resistance: 20,000 ohms/Volt (min.).	Measure dc voltages	Hewlett-Packard 412 A
Repetitive Load Switch	Rate: 60-400Hz, 2µsec rise and fall time.	Measure transient response	See Figure 5-6
Resistor	6204B, 6205C; 133Ω ±10% 15W 6206B; 120Ω, ±10% 15W	Load Resistor, HIGH range	---
Resistor	Value: 5Ω, 0.5%, 4.5 Watts, 20ppm, 4-Terminal.	Current sampling	R54 or R55, Section VI



Table 5-1. Test Equipment Required (Cont.)

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Resistor	Value: 6204B and 6205C, 28Ω, 2W (min.). 6206B, 27Ω, 10W (min.).	Load resistor, low range	---
Resistor	1KΩ ±1%, 2 Watt non-inductive	Measure impedance	---
Resistor	100 ohms, ±5%, 10 Watt	Measure impedance	---
Resistor	Value: See Paragraph 5-67, ±0.1%, 5 Watt	Calibrate programming current	---
Capacitor	500μf, 50V Vdc	Measure impedance	---
Decade Resistance Box	Range: 0-150K(min.). Accuracy: 0.1% plus 1 ohm Make-before-break contacts.	Measure programming coefficients	---

**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 115Vac 60Hz, 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 5-48).

**NOTE**

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

**5-12 CONSTANT VOLTAGE TESTS**

5-13 For Constant Voltage measurements, the measuring device must be connected across the rear sensing terminals of the supply in order to achieve valid indications. 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 (1 milliohm at dc), thus invalidating the measurement.

5-14 To avoid mutual coupling effects, each monitoring device must be connected directly to the sensing terminals by separate pairs of leads. The load resistor is connected across the output terminals and must be selected according to the output voltage and current of the supply.

5-15 Voltage Output and Voltmeter Accuracy. 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 range button to 40V and meter buttons to V and X1.

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

e. Differential voltmeter should indicate maximum rated output voltage within 3%.

5-16 Output Current and Ammeter Accuracy. To check the output current, proceed as follows:

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

b. Set meter button to low current range X.1, and range button to high voltage mode, (40V).

c. Turn on supply and adjust VOLTAGE control until front panel meter indicates exactly 300 mA (0.5 Ampere for Model 6206B supplies).

d. Differential voltmeter should read 1.5± 0.045Vdc.

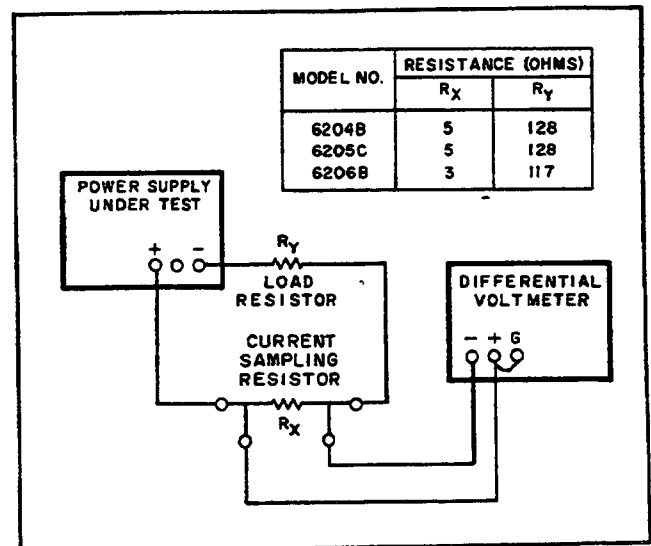


Figure 5-4. Output Current Test Setup

5-17 Load Regulation.

Definition: The change  $\Delta E_{OUT}$  in the static value of dc output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice versa).

5-18 To check the constant voltage load regulation, proceed as follows:

- a. Connect test setup as shown in Figure 5-5.
- b. Turn-on supply and adjust VOLTAGE control unit front panel voltmeter indicates exactly the maximum rated output voltage.
- c. Read and record voltage indicated on differential voltmeter.
- d. Disconnect load resistors.
- e. Reading on differential voltmeter should not vary from reading recorded in Step c by more than 8mVdc for Models 6204B and 6205C or 10mVdc for Model 6206B supply.

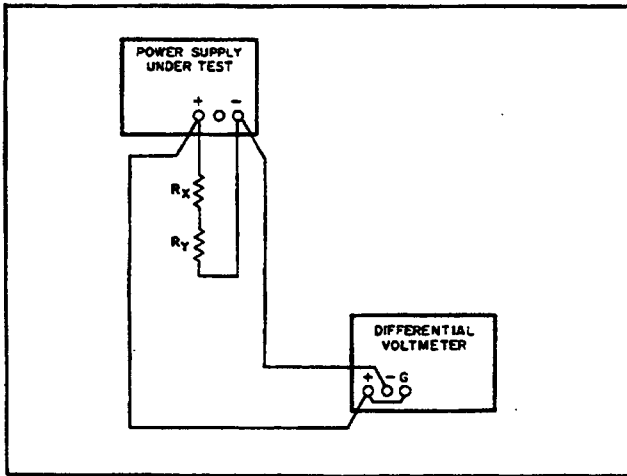


Figure 5-5. Load Regulation, Test Setup

5-19 Line Regulation.

Definition: The change,  $\Delta E_{OUT}$  in the static value of dc output voltage resulting from a change in ac input voltage over the specified range from low line 10% less than nominal to high line 10% more than nominal or from high line to low line.

5-20 To test the constant voltage 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 low line (104Vac).
- d. Set meter and range buttons to V.X1 and 20V and turn on supply.
- e. Adjust VOLTAGE control until front panel voltmeter indicates exactly the maximum rated output voltage.
- f. Read and record voltage indicated on differential voltmeter.

g. Adjust variable auto transformer for high line (126Vac).

h. Reading on differential voltmeter should not vary from reading recorded in Step f by more than 8mVdc for Models 6204B and 6205C or 10mVdc for Model 6206B.

5-21 Ripple and Noise.

Definition: The residual ac voltage which is superimposed on the dc output of a regulated power supply. Ripple and noise may be specified and measured in terms of its RMS or (preferably) peak-to-peak value.

Ripple and noise measurement can be made at any input ac line voltage combined with any dc output voltage and load current within rating.

5-22 The amount of ripple and noise that is present on the power supply output is measured either in terms of the RMS or (preferably) peak-to-peak value. The peak-to-peak measurement is particularly important for applications where noise spikes could be detrimental to a sensitive load, such as logic circuitry. The RMS measurement is not an ideal representation of the noise, since fairly high output noise spikes of short duration could be present in the ripple and not appreciably increase the RMS value.

5-23 The technique used to measure high frequency noise or "spikes" on the output of a power supply is more critical than the low frequency ripple and noise measurement technique; therefore the former is discussed separately in Paragraph 5-31.

5-24 Ripple and Noise Measurements. Figure 5-6A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential  $E_G$  between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting noise signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply, and can completely invalidate the measurement.

5-25 The same ground current and pickup problems can exist if an RMS voltmeter is substituted in place of the oscilloscope in Figure 5-6. However, the oscilloscope display, unlike the true RMS meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120Hz) or 16.7 milliseconds (1/60Hz). Since the fundamental ripple frequency present on the output of an Hewlett-Packard supply is 120Hz (due to full-wave

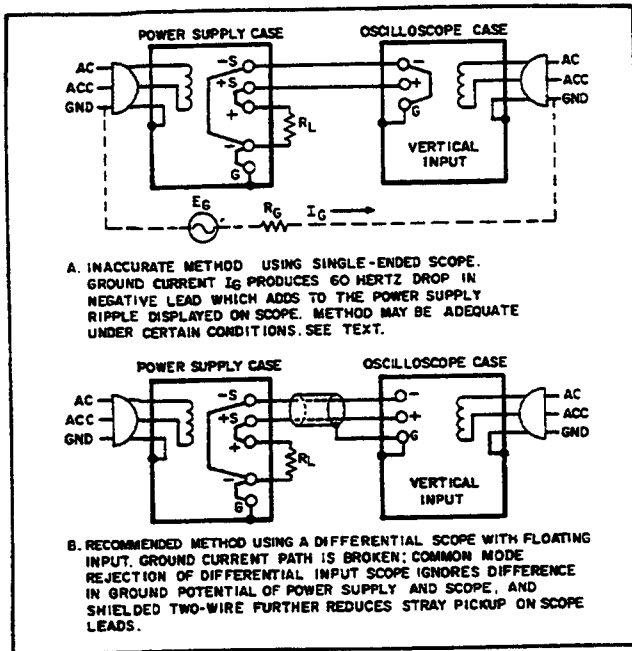


Figure 5-6. CV Ripple and Noise, Test Setup

rectification), an oscilloscope display showing a 120Hz fundamental component is indicative of a "clean" measurement setup, while the presence of a 60Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measured ripple.

5-26 Although the method shown in Figure 5-6A is not recommended for ripple measurements, it may prove satisfactory in some instances provided certain precautionary measures are taken. One method of minimizing the effects of ground current flow ( $I_G$ ) is to ensure that both the supply and the test instrument are plugged into the same ac power buss.

5-27 To minimize pickup, a twisted pair of (preferably) a shielded two-wire cable should be used to connect the output terminals of the power supply to the vertical input terminals of the scope. When using a twisted pair, care must be taken that one of the two wires is connected both to the grounded terminal of the power supply and the grounded input terminal of the oscilloscope. When using shielded two-wire cable, it is essential for the shield to be connected to ground at one end only to prevent any ground current flowing through this shield from inducing a signal in the shielded leads.

5-28 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (-) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-29 If the foregoing measures are used, the single-ended scope of Figure 5-6A may be adequate to eliminate non-real components of ripple so that

a satisfactory measurement can be obtained. However, in stubborn cases or in measurement situations where it is essential that both the power supply case and the oscilloscope case be connected to ground (e.g. if both are rack-mounted), it may be necessary to use a differential scope with floating input as shown in Figure 5-6B. If desired, two single-conductor shielded cables may be substituted in place of the shielded two-wire cable with equal success. Because of its common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal introduced because of the difference in the ac potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CTR. If this trace is not a straight line, the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

5-30 To check the ripple and noise output, proceed as follows:

- Connect the oscilloscope or RMS voltmeter as shown in Figures 5-6A or 5-6B.
- Adjust VOLTAGE control until front panel meter indicates maximum rated output voltage.
- The observed ripple and noise should be less than 200 $\mu$ Vrms and 1mV p-p.

5-31 Noise Spike Measurement. When a high frequency spike measurement is being made, an instrument of sufficient bandwidth must be used; an oscilloscope with a bandwidth of 20MHz or more is adequate. Measuring noise with an instrument that has insufficient bandwidth may conceal high frequency spikes detrimental to the load.

5-32 The test setup illustrated in Figure 5-6A is generally not acceptable for measuring spikes; a differential oscilloscope is necessary. Furthermore, the measurement concept of Figure 5-6B must be modified if accurate spike measurement is to be achieved:

- As shown in Figure 5-7, two coax cables, must be substituted for the shielded two-wire cable.
- Impedance matching resistors must be included to eliminate standing waves and cable ringing, and the capacitors must be connected to block the dc current path.
- The length of the test leads outside the coax is critical and must be kept as short as possible; the blocking capacitor and the impedance matching resistor should be connected directly from the inner conductor of the cable to the power supply terminals.
- Notice that the shields of the power supply end of the two coax cables are not connected to the power supply ground, since such a connection would give rise to a ground current path through the coax shield resulting in an erroneous measurement.

5. Since the impedance matching resistors constitute a 2-to-2 attenuator, — the noise spikes observed on the oscilloscope should be less than 0.5mV p-p instead of 1mV.

5-33 The circuit of Figure 5-7 can also be used for the normal measurement of low frequency ripple and noise; simply remove the four terminating resistors and the blocking capacitors and substitute a higher gain vertical plug-in in place of the wide-band plug-in required for spike measurements. Notice that with these changes, Figure 5-7 becomes a two-cable version of Figure 5-6C.

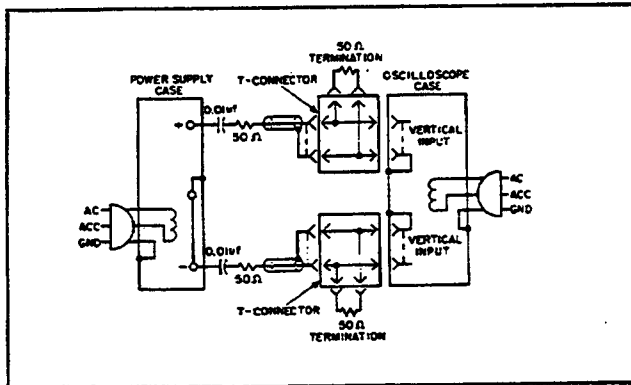


Figure 5-7. CV Noise Spike, Test Setup

#### 5-34 Transient Recovery Time.

Definition: The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" Amp step change in load current — where: "Y" is specified as 10 millivolts. The nominal output voltage is defined as the dc level half way between the static output voltage before and after the imposed load change, and "Z" is the specified load current change, which is 5 Amperes.

5-35 A mercury-wetted relay, as connected in the load switching circuit of Figure 5-8 should be used for loading and unloading the supply. When this load switch is connected to a 60Hz ac input, the mercury-wetted relay will open and close 60 times per second. Adjustment of the 25K control permits adjustment of the duty cycle of the load current switching and reduction in jitter of the oscilloscope display.

5-36 The maximum load ratings listed in Figure 5-4 must be observed in order to preserve the mercury-wetted relay contacts. Switching of larger load currents can be accomplished with mercury pool relays; with this technique fast rise times can still be obtained, but the large inertia of mercury pool relays limits the maximum repetition rate of load switching and makes the clear display of the transient recovery characteristic on an oscilloscope more difficult.

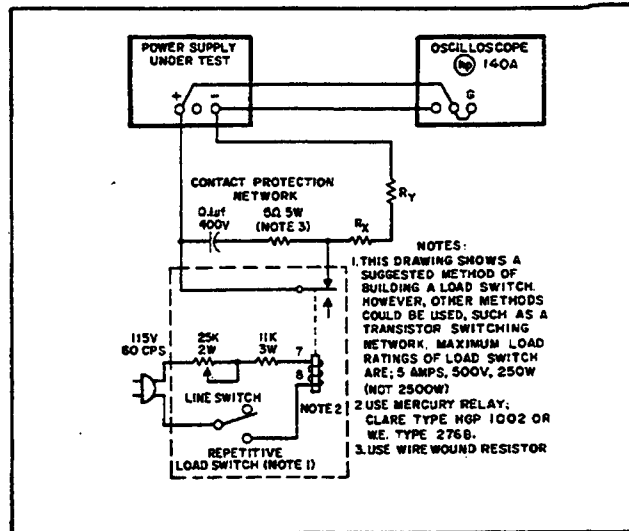


Figure 5-8. Transient Recovery Time, Test Setup

5-37 To check the transient recovery time of the supply, proceed as follows:

- Connect test setup shown in Figure 5-8.
- Set range button to 20V and meter buttons to V and X1.
- Turn on supply and adjust VOLTAGE control until front panel meter indicates exactly the maximum rated output voltage.
- Close line on repetitive load switch setup.
- Adjust 25KΩ potentiometer until a stable display is obtained on oscilloscope. Waveform should be within the tolerances shown on Figure 5-9 (output should return to within 10mV of original value in less than 50 microseconds).

#### 5-38 OUTPUT IMPEDANCE

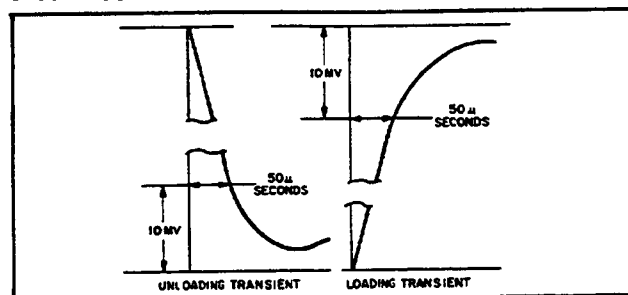


Figure 5-9. Transient Recovery Time, Waveforms

5-39 To check the output impedance, proceed as follows:

- Connect test setup shown in Figure 5-10.
- Set range button to 40V and meter buttons to V and X1.
- Turn on supply and adjust VOLTAGE control until front panel meter reads 20 Volts.
- Set AMPLITUDE control on oscillator to 10 Volts ( $E_{in}$ ), and FREQUENCY control to 100Hz.
- 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 50kHz and 500kHz. Values should be less than 0.5 ohm and 3.0 ohms, respectively.

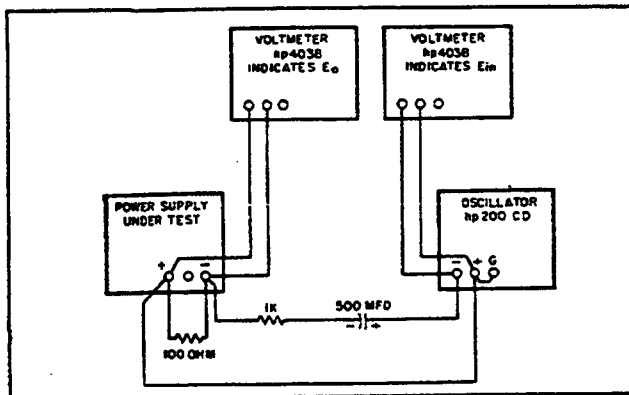


Figure 5-10. Output Impedance, Test Setup

#### 5-40 Temperature Coefficient.

Definition: The change in output voltage per degree Centigrade change in the ambient temperature under conditions of constant input ac line voltage, output voltage setting, and load resistance.

5-41 The temperature coefficient of a power supply is measured by placing the power supply in an oven and varying it over any temperature span within its rating. (Most Hewlett-Packard power supplies are rated for operation from 0°C to 55°C.) The power supply must be allowed to thermally stabilize for a sufficient period of time at each temperature of measurement.

5-42 The temperature coefficient specified is the maximum temperature-dependent output voltage change which will result over any 5°C interval. The differential voltmeter or digital voltmeter used to measure the output voltage change of the supply should be placed outside the oven and should have a long term stability adequate to insure that its drift will not affect the overall measurement accuracy.

5-43 To check the temperature coefficient, proceed as follows:

- a. Connect test setup shown in Figure 5-5.
- b. Adjust front panel VOLTAGE control until the front panel voltmeter indicates 10Vdc.

c. Insert the power supply into the temperature-controlled oven (differential voltmeter and load resistance remain outside oven). Set the temperature to 30°C and allow 30 minutes warm-up.

d. Record the differential voltmeter indication.

e. Raise the temperature to 40°C and allow 30 minutes warm-up.

f. The differential voltmeter indication should change by less than 90mV from indication recorded in Step d.

#### 5-44 Output Stability.

Definition: The change in output voltage for the first eight hours following a 30 minute warm-up period. During the interval of measurement all parameters, such as load resistance, ambient temperature, and input line voltage are held constant.

5-45 This measurement is made by monitoring the output of the power supply on a differential voltmeter or digital voltmeter over the stated measurement interval; a strip chart recorder can be used to provide a permanent record. A thermometer should be placed near the supply to verify that the ambient temperature remains constant during the period of measurement. The supply should be put in a location immune from stray air currents (open doors or windows, air conditioning vents); if possible, the supply should be placed in an oven which is held at a constant temperature. Care must be taken that the measuring instrument has a stability over the eight hour interval which is at least an order of magnitude better than the stability specification of the power supply being measured. Typically, a supply may drift less over the eight hour measurement interval than during the ½ hour warm-up period.

5-46 Stability measurement can be made while the supply is remotely programmed with a fixed wire-wound resistor, thus avoiding accidental changes in the front panel setting due to mechanical vibration or "knob-twiddling."

5-47 To check the output stability, proceed as follows:

- a. Connect test setup shown in Figure 5-5.
- b. Adjust VOLTAGE controls for 40Vdc output.
- c. Allow 30 minutes warm-up then record the differential voltmeter indication.
- d. After 8 hours, differential voltmeter should change by less than 45mV from indication recorded in Step c.

#### 5-48 TROUBLESHOOTING

5-49 Before attempting to troubleshoot 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.

5-50 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, refer to the overall troubleshooting procedures in Paragraph 5-53 to locate the symptom and probable cause.

5-51 The schematic diagram at the rear of the manual (Figure 7-1) contains normal voltage readings taken at various points within the circuits. These voltages are positioned adjacent to the applicable test points (identified by encircled numbers). Component and test point designations are marked directly on the main printed wiring board.

5-52 If a defective component is located, replace it and re-conduct the performance test. When a component is replaced, refer to the repair and replacements and adjustment and calibration paragraphs in this section.

#### 5-53 OVERALL TROUBLESHOOTING PROCEDURE

5-54 To locate the cause of trouble follow Steps 1, 2, and 3 in sequence.

(1) Check for obvious troubles such as open fuse, defective power cord, input power failure, or defective voltage or current meter. Next remove the top cover (held by four retaining screws) and inspect for open connections, charred components, etc. If the trouble source cannot be detected by visual inspection, proceed with Step 2.

(2) In almost all cases, the trouble can be caused by improper dc bias or reference voltages; thus, it is a good practice to check voltages in Table 5-2, before proceeding with Step 3.

(3) Disconnect the load and examine Table 5-3 to determine your symptom and probable cause.

Table 5-2. Reference Circuit Troubleshooting

STEP	METER COMMON	METER POSITIVE	NORMAL INDICATION	NORMAL RIPPLE (P-P)	IF INDICATION ABNORMAL, TAKE THIS ACTION
1	+S	33	6.2±0.3Vdc	.3mV	Check 12.4 Volt bias or VR1 (See next paragraph)
2	31	+S	6.2±0.3Vdc	.4mV	Check 12.4 Volt bias or VR2 (See next paragraph)
3	+S	37	12.4±1.0Vdc	2.8µV	Check Q8, Q9, CR22, CR23, C10, T1
4	38	41	7.5±.7Vdc	1V	Check C12, CR8, CR24, CR25

Table 5-3. Overall Troubleshooting

SYMPTON	CHECK AND PROBABLE CAUSES
High output voltage	a. Front panel meter defective. b. Series regulator feedback loop defective. Refer to Table 5-4.
Low output voltage	a. Fuses blown (Check CR26-CR29 or C14 for short). b. Front panel meter defective. c. Series regulator feedback loop defective. Refer to Table 5-5.
Will not current limit High ripple	a. Q10 open. R81 defective. 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.

Table 5-3. Overall Troubleshooting (continued)

SYMPTON	CHECKS AND PROBABLE CAUSES
Poor line regulation	a. Check reference circuit (Paragraph 5-55). b. Check reference circuit adjustment (Paragraph 5-69).
Poor load regulation (constant voltage)	a. Measurement technique. (Paragraph 5-17). b. Check reference circuit (Paragraph 5-55) and adjustment (Paragraph 5-69). c. Ensure that supply is not going into current limit.
Oscillates (constant voltage)	a. Check C5 for open, adjustment of R30 (Paragraph 5-72).
Poor stability	a. Check $\pm 6.2\text{Vdc}$ reference voltages (Paragraph 5-55). b. Noisy programming resistor R10. c. CR1, CR2 leaky. d. Check R1, R12, R13, for noise or drift. e. Stage Q1 defective.

5-55 To check the zener diodes in the reference circuit, proceed as follows:

- a. Connect differential voltmeter across zener diode.
- b. Connect appropriate load resistor, given in Figure 5-4, across (+) and (-) output terminals.
- c. Turn VOLTAGE control fully clockwise.
- d. Set range button 20V and meter buttons to V and X1.
- e. Read and record voltage indicated on differential voltmeter.
- f. Short out load resistor by closing S1.
- g. If reading on differential voltmeter differs by more than 1.07mV for 6204B and 6205C or .946mV for 6106B from the reading in Step f, replace zener diode.

5-56 Series Regulating Feedback Loop. When troubleshooting the series regulating loop, it is useful to open the loop since measurements made anywhere within a closed loop may appear abnormal. With a loop closed, it is very difficult to separate cause from effect. As described in Tables 5-4 and 5-5, the conduction or cutoff capability of each stage is checked by shorting or opening a previous stage, as follows:

1. Shorting the emitter to collector of a transistor simulates saturation, or the full ON condition.
2. Shorting the emitter to base of a transistor cuts it off, and simulates an open circuit between emitter and collector.

5-57 Although a logical first choice might be to break the loop somewhere near its mid-point, and then perform successive subdividing test, it is more useful to trace the loop from the series regulator backwards a stage at a time, since loop failures occur more often at the higher power levels.

Table 5-4. High Output Voltage Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	Check turn off of series regulator by shorting Q4 emitter to collector.	a. Output voltage remains high. b. Output voltage decreases.	a. Series regulator Q7 (or Q6) shorted. b. Remove short and proceed to Step 2.
2	Check turn on of Q4 by disconnecting collector of Q3.	a. Output voltage remains high.	a. Q4 open. b. Reconnect lead and proceed to Step 3.
3	Check turn off of Q3 by disconnecting collector of Q1A.	a. Output voltage remains high. b. Output voltage decreases.	a. Q3 shorted. b. Check Q1A for short, Q1B for open. Check for open strap between A6 and A8. Check R10 for open.

Table 5-5. Low Output Voltage Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	Check turn on of Q7 (and Q6, if included) by opening the emitter of Q4.	a. Output voltage remains low. b. Output voltage increases.	a. Q7 (or Q6) open. b. Reconnect lead and proceed to Step 2.
2	Eliminate the current limit circuit as a source of trouble by disconnecting the anode of CR16.	a. Output voltage increases. b. Output voltage remains low.	a. Q10 shorted, R81 defective. b. Reconnect lead and proceed to Step 3.
3	Check turn off of Q4 by shorting Q3 emitter to collector.	a. Output voltage remains low. b. Output voltage increases.	a. Q4 shorted. b. Remove the short and proceed to Step 4.
4	Check turn on of Q3 by shorting Q1A emitter to collector.	a. Output voltage remains low b. Output voltage increases	a. Q3 open b. Check Q1A for open, Q1B for short. Check R10 for short or open strap between A7 and A6.



5-58 REPAIR AND REPLACEMENT

5-59 Before servicing a printed wiring board, refer to Figure 5-11. Section VI of this manual contains a tabular list of the instruments replaceable parts. Before replacing a semiconductor device, refer to Table 5-6 which lists the special charac-

teristics of selected semiconductor. 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.

Table 5-6. Selected Semiconductor Characteristics

REFERENCE DESIGNATOR	CHARACTERISTICS	HEWLETT-PACKARD STOCK NO.	SUGGESTED REPLACEMENT
Q1	Matched differential amplifier. 70(min.) $h_{FE}$ $i_C = 1mA$ , $V_{CE} = 5V$ , $I_{CO} = 0.01\mu A$ @ $V_{cbo} = 5V$ .	1854-0229	2N2917 G.E.
Q7	NPN Power $h_{FE} = 35$ (min.) @ $I_C = 4A$ ; $V_{CE} = 4V$ .	1854-0225	2N3055 R.C.A.

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

REFERENCE	FUNCTION	CHECK	ADJUST
Q1	Constant voltage differential	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.	VR1, VR2, CR20
CR1, CR2	Limiting diodes	CV load regulation.	
CR8	Forward bias regulator	Voltage across diode 2.0 to 2.4 Volts.	
Q10 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	R46, VR2

## 5-60 ADJUSTMENT AND CALIBRATION

5-61 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 not others.

### 5-62 METER ZERO

5-63 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.

### 5-64 AMMETER TRACKING

5-65 To calibrate the ammeter, proceed as follows:

- a. Connect test setup as shown on Figure 5-4.
- b. Set range button to 40V and meter buttons to A and X1.
- c. Turn on supply and adjust VOLTAGE control so that differential voltmeter indicates exactly 40Vdc.
- d. Front panel meter should read 0.3 Amp for Model 6204B and 6205C supplies, or 0.1 Amp for Model 6206B supply. If it does not, adjust R72.

### 5-66 CONSTANT VOLTAGE PROGRAMMING CURRENT

5-67 Programming Accuracy. 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 differential voltmeter between +S and -S terminals on rear barrier strip.
- d. Set range button to 40V and meter button to X1. Turn on supply.
- e. Adjust R13 so that differential voltmeter reads  $40 \pm 0.4$ Vdc for Models 6204B and 6205C or  $60 \pm 0.6$ Vdc for Model 6206B supplies.

5-68 Zero Output Voltage. 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,

### 5-69 REFERENCE CIRCUIT ADJUSTMENTS

5-70 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 105Vac.
- d. Connect decade resistance in place of R46.
- e. Set range button to 40V mode and turn on supply.
- f. Adjust decade resistance so that voltage indicated by differential voltmeter does not change more than 1.08 millivolts for 6204B and 6205C or .946V for 6206B as input line voltage is varied from 105 to 125Vac.
- g. Replace decade resistance with appropriate value resistor in R46 position.

### 5-71 CONSTANT VOLTAGE TRANSIENT RECOVERY TIME

5-72 To adjust the transient response, proceed as follows:

- a. Connect test setup as shown in Figure 5-8.
- b. Repeat Steps a through f as outlined in Paragraph 5-37.
- c. Adjust R30 so that the transient response is as shown in Figure 5-9.

### 5-73 CURRENT LIMIT ADJUSTMENT

5-74 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 5-5.
- b. Shortout load resistor (R<sub>L</sub>).
- c. Set Range button to 20V (high current) mode.
- d. Turn on supply and rotate VOLTAGE control fully clockwise (maximum).
- e. Adjust R81 until differential voltmeter indicates 3.5Vdc for Models 6204B and 6205C supplies or 3.6Vdc for Model 6206B supply.

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

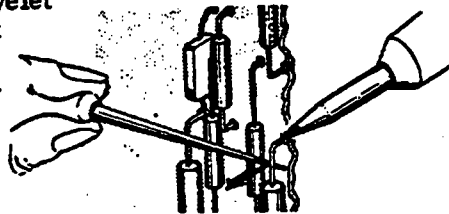
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

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

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

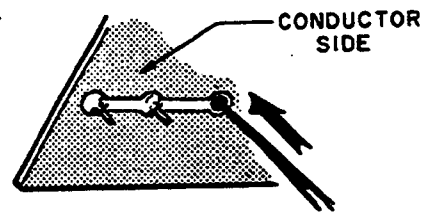
**WARNING:** If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

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

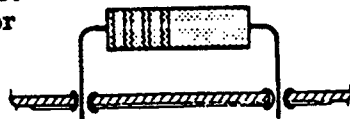


2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole.

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

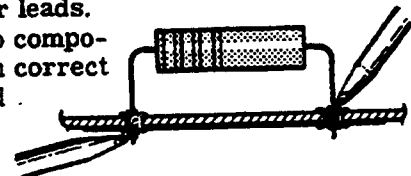


3. Bend clean tinned lead on new part and carefully insert through eyelets or holes in board.



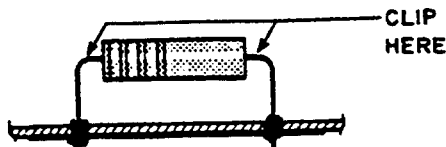
4. Hold part against board (avoid overheating) and solder leads.

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

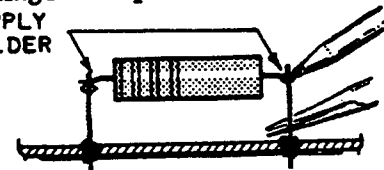


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



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



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

Figure 5-11. Servicing Printed Wiring Boards

## SECTION VI REPLACEABLE PARTS

### 6-1 INTRODUCTION

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

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

### 6-3 ORDERING INFORMATION

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

Table 6-1. Reference Designators

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

Table 6-1. Reference Designators (Continued)

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

Table 6-2. Description Abbreviations

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

**Table 6-3. Code List of Manufacturers**

Code	Manufacturer	Address
01121	Allen Bradley Co.	Milwaukee, Wis.
03508	S.E. Semiconductor Products Dept.	Syracuse, N.Y.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
07716	DRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
24546	Corning Glassworks (Bradford)	Bradford, Penn.
27167	Corning Glassworks (Wilmington)	Wilmington, N.C.
28480	Hewlett-Packard Co.	Palo Alto, California
56289	Sprague Electric Co.	North Adams, Mass.
70903	Belden Corp.	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.

Table 6-4. Replaceable Parts

Ref. Desig.	HP Part No.	TQ	Description	Mfr. Code	Mfr. Part No.
C1	0180-1836	2	fxd elect 5 $\mu$ F 65 V	28480	
C2-4			NOT ASSIGNED		
C5	0160-0153	2	fxd poly 1000pf 200 V	28480	
C6-8			NOT ASSIGNED		
C9	0180-0100	2	fxd elect 4.7 $\mu$ F 35 V	56289	150D475X9035B2
C10	0180-1852	4	fxd elect 100 $\mu$ F 50 V	28480	
C11			NOT ASSIGNED		
C12	0180-1852		fxd elect 100 $\mu$ F 50 V	28480	
C13			NOT USED		
C14	0180-1888	2	fxd elect 490 $\mu$ F 85 V	28480	
C15			NOT USED		
C16	0150-0052	2	fxd cer 0.05 $\mu$ F 400 V	28480	
C17-19			NOT USED		
C20	0180-1851	2	fxd elect 80 $\mu$ F 300 V	28480	
CR1,2	1901-0033	8	diode-gen. pur. 180 V 200mA	28480	
CR3-5			NOT USED		
CR6	1901-0461	2	diode-gen. pur. 10 V 200mA	28480	
CR7, 8	1901-0460	4	diode-stabistor 30 V 150mA	28480	
CR9, 10			NOT USED		
CR11	1901-0327	24	diode-pwr. rect. 200 V 1A	03508	A14B
CR12-15			NOT USED		
CR16	1901-0033		diode-gen. pur. 180 V 200mA	28480	
CR17, 18	1901-0327		diode-gen. pwr.	03508	A14B
CR19			NOT USED		
CR20	1901-0033		diode-gen. pur. 180 V 200mA	28480	
CR21			NOT USED		
CR22-29	1901-0327		diode-pwr. rect.	03508	A14B
CR30-33			NOT USED		
CR34	1901-0327		diode-pwr. rect.	03508	A14B
F1	2110-0002	1	fuse 2A 250 V	75915	312002
M1,2	1120-1398	2	Meters Dual Scale 0-50 V 0-.75A	28480	
Q1	1854-0229		NPN Si	28480	
Q2			NOT USED		
Q3	1853-0099	4	PNP Si	28480	
Q4	1853-0041	2	PNP Si	28480	
Q5, 6			NOT USED		
Q8	1853-0099		PNP Si	28480	
Q9, 10	1854-0823	4	NPN Si	28480	
R1	0813-0001	4	fxd ww. 1k 5% 3 W	28480	
R2	0698-5087	2	fxd film 6.2k 1% 1/8W	24546	C4-1/8-TO-6201-F
R3, 4	0698-3269	4	fxd film 23k 1% 1/8W	24546	C4-1/8-TO-2302-F
R5	0757-0427	2	fxd film 1.5k 1% 1/8W	24546	C4-1/8-TO-1501-F
R6	0686-3645	2	fxd comp 360k 5% W	01121	EB-3645
R7			NOT USED		

Table 6-4. Replaceable Parts (cont.)

Ref. Desig.	HP Part No.	TQ	Description	Mfr. Code	Mfr. Part No.
R8	0686-5645	2	fxd comp 560k 5% ½W	01121	EB-5645
R9			NOT USED		
R10	2100-3624	2	VOLTAGE control, 10k 5%	28480	
R11			NOT USED		
R12	0813-0001		fxd ww 1k 5% 3W	28480	
R13	2100-0554	2	trmr 500Ω 10%	28480	
R14-28			NOT USED		
R29	0686-5125	4	fxd comp 5.1k 5% ½W	01121	EB-5125
R30	2100-1775	2	trmr 5k 5%	28480	
R31	0686-1025	2	fxd comp 1k 5% ½W	01121	EB-1025
R32			NOT USED		
R33	0686-2425	2	fxd comp 2.4k 5% ½W	01121	EB-2425
R34	0686-3015	2	fxd comp 300 5% ½W	01121	EB-3015
R35-40			NOT USED		
R41	0686-1235	2	fxd comp 12k 5% ½W	01121	EB-1235
R42	0686-6825	2	fxd comp 6.8k 5% ½W	01121	EB-6825
R43	0698-3506	2	fxd film 470 1% ¼W	24546	C5-¼-TO-470R-F
R44	0686-4735	2	fxd comp 47k 5% ½W	01121	EB-4735
R45	0686-5125		fxd comp 5.1k 5% ½W	01121	EB-5125
R46	0686-1045	2	fxd comp 100k 5% ½W	01121	EB-1045
R47	0686-7515	2	fxd comp 750 5% ½W	01121	EB-7515
R48			NOT USED		
R49	0698-3642	2	fxd film 3k 5% w²	27167	FP42-2-TOO-3001-J
R50			NOT USED		
R51	0686-2035	2	fxd comp 20k 5% ½W	01121	EB-2035
R52	0757-0274	2	fxdf film 1.21k 1% 1/8W	24546	C4-1/8-TO-1211-F
R53	0686-4715	2	fxd comp 470 5% ½W	01121	EB-4715
R54, 55	0811-1920	4	fxd ww 5 0.5% 3/8W	28480	
R56	0698-4463	2	fxd film 845 1% 1/8W	24546	C4-1/8-TO-84SR-F
R57	0757-0278	2	fxd film 1.78k 1% 1/8W	28480	
R58	0698-4402	2	fxd film 97.6 1% 1/8W	24546	C4-1/8-TO-97R6-F
R59			NOT USED		
R60	0698-3386	2	fxd film 2.4k 1% 1/8W	28480	
R61	0757-0349	2	fxd film 22.6k 1% 1/8W	24546	C4-1/8-TO-2262-F
R62-71			NOT USED		
R72	2100-5068	2	trmr 100 10%	28480	
R73-80			NOT USED		
R81	2100-3211	2	trmr 1k 10%	28480	
S1	3101-2287	1	line switch-push	28480	
S2	<del>3101-2580</del> 1120-1398	1	switch-3 station	28480	
T1	9100-2611	1	transformer	28480	
VR1	1902-0761	2	zener 6.2V 5%	04713	IN821
VR2	1902-003	2	zener 6.2V 5%	04713	IN823

Table 6-4. Replaceable Parts (cont.)

Ref. Desig.	HP Part No.	TQ	Description	MFR. Code	Mfr. Part No.
	5000-9424	2	Cover, top	28480	
	5060-7955	1	Chassis, left	28480	
	5060-7956	1	Chassis, right	28480	
	06205-00006	1	Panel, front	28480	
	1510-0091	4	Binding Post (RED)	28480	
	1510-0107		Binding Post (BLACK)	28480	
	0370-2486	6	Knob, push button	28480	
	0370-1091	2	Knob, base round	28480	
	5020-5541	1	Guard, barrier strip	28480	
	0400-0013	1	Strain Relief Bushing	28520	SR-5P-1
	8120-0050	1	Line Cord Plug PH151 7½"	70903	KH-4096
	0360-1143	10	Jumper, barrier strip	71785	422-13-11-013
	0360-1273	1	Barrier Block	28480	
	2110-0564	12	Fuseholder Body	28480	
	2110-0565	1	Fusholder Cap	28480	
	2110-0569	1	Fuseholder Nut	28480	
	06205-00002	2	Bracket, transf. mtg.	28480	
	5000-6060	2	Heatsink,, rear	28480	
	5020-8423	2	Bracket, heatsink	28480	
	0403-0266	4	Rubber Bumper Feet	28480	
	06205-60022		Printed Circuit Board	28480	
	1205-0033	2	Heat Dissipator (Q4)	28480	
	0340-0181	2	Heat Dissipator (Q7)		
	0340-0166	4	Insulator, Transistor pins (Q7)	28480	
	0340-0168	4	Insulator, (Q4)	28480	
	9220-2703	1	End caps	28480	
	9211-2570	1	Carton	28480	
	3131-0419	1	Nut, plastic gray	28480	
	0360-1190	1	Terminal Lug	28480	
	0360-0365	3	Terminal Lug	28480	
	2190-0079	6	Washer	28480	
	2950-0144	5	Hex Nut	28480	
			Option 15 Decadial		
	1140-0020	2	Decadial	07716	RD-411



## APPENDIX A

### Option 11, Overvoltage Protection "Crowbar"

#### DESCRIPTION:

This option is installed in DC Power Supplies, 6200B, 6201B, 6202B, 6203B, 6204B, 6205C, and 6206B, and tested at the factory. It consists of a printed circuit board, screwdriver-type front panel potentiometer, and six wires that are soldered to the main power supply board.

The crowbar monitors the output voltage of the power supply and fires an SCR that effectively shorts the output when it exceeds the preset trip voltage. The trip voltage is determined by the setting of the CROWBAR ADJUST control on the front panel (except in the model 6205C, where it is accessible through a hole in the top cover). The trip voltage range is as follows:

Model	6200B	6201B	6202B	6203B	6204B	6205C	6206B
Trip Voltage Range	2.5-44V	2.5-23V	2.5-44V	2.5-10V	2.5-44V	2.5-44V	2.5-65V

To prevent transients from falsely tripping the crowbar, the trip voltage must be set higher than the power supply output voltage by the following margin: 4% of the output voltage plus 2V. The margin represents the minimum crowbar trip setting for a given output voltage; the trip voltage can always be set higher than this margin.

#### OPERATION:

1. Turn the CROWBAR ADJUST fully clockwise to set the trip voltage to maximum.
2. Set the power supply VOLTAGE control for the desired crowbar trip voltage. To prevent false crowbar tripping, the trip voltage should exceed the desired output voltage by the following amount: 4% of the output voltage plus 2V.
3. Slowly turn the CROWBAR ADJUST ccw until the crowbar trips, output goes to 0 Volts or a small positive voltage.
4. The crowbar will remain activated and the output shorted until the supply is turned off. To reset the crowbar, turn the supply off, then on.
5. If the CROWBAR must be completely disabled, remove the lead attached to the CROWBAR ADJUST potentiometer R5.

Table A-1. Replaceable Parts

Ref. Desig.	Description	TQ	Mfr. Part No.	Mfr. Code	Part No.	RS
C1	fxd, elect 1 $\mu$ 5f 50Vdc	2	30D105G050BA2	56289		
C2	fxd, mica 510 $\mu$ f 500Vdc	2	RCM15E511J	04062	0140-0047	1
CR1-CR3	Rect. Si. 200mA 200prv	6	IN485B	93331	1901-0033	6
CR4	SCR 7.4A 100prv	2	C20B	03508	1884-0032	2
Q1,2	SS NPN Si.	4	2N3417	03508	1854-0087	4
R1	fxd, met. film 10 $\Omega$ $\pm$ 1% 1/8W	2	Type CEA T-O	07716	0757-0346	1
R2	fxd, comp 3K $\Omega$ $\pm$ 5% 2W	2	Type C42S	16299	0698-3642	1
R3	fxd, met. film 1.21K $\Omega$ $\pm$ 1% 1/8W	2	Type CEA T-O	07716	0757-0274	1
R4	fxd, met. film 6.5K $\Omega$ $\pm$ 1% 1/8W	2	Type CEA T-O	07716	0757-0440	1
R5	var. ww 10K $\Omega$ $\pm$ 5%	2		09182	2100-1854	1
R6	fxd, ww 1K $\Omega$ $\pm$ 5% 3W	2	242E1025	56289	0813-0001	1
R7	fxd, comp 22 $\Omega$ $\pm$ 5% 1/2W	2	EB-2205	01121	0686-2205	1
R8	fxd, met. film 196 $\Omega$ $\pm$ 1% 1/8W	2	Type CEA T-O	07716	0698-3440	1
T1	Transformer, Pulse	1		09182	5080-7122	1
VR1	Diode, Zener 6.19V $\pm$ 5%	2	IN753	04713	1902-0049	2
VR2	Diode, Zener 2.37V $\pm$ 5%	2	IN4370	04713	1902-3002	2
	<b>Miscellaneous</b>					
	Printed Circuit Board (Blank	1		09182	06205-20021	
	P.C. Board (Includes Components)	1		09182	06205-60021	
	Heat Sink	1		09182	06205-00003	
	Insulator (CR4)	2		09182	0340-0462	1
	Mica Washer	2		09182	2190-0709	1

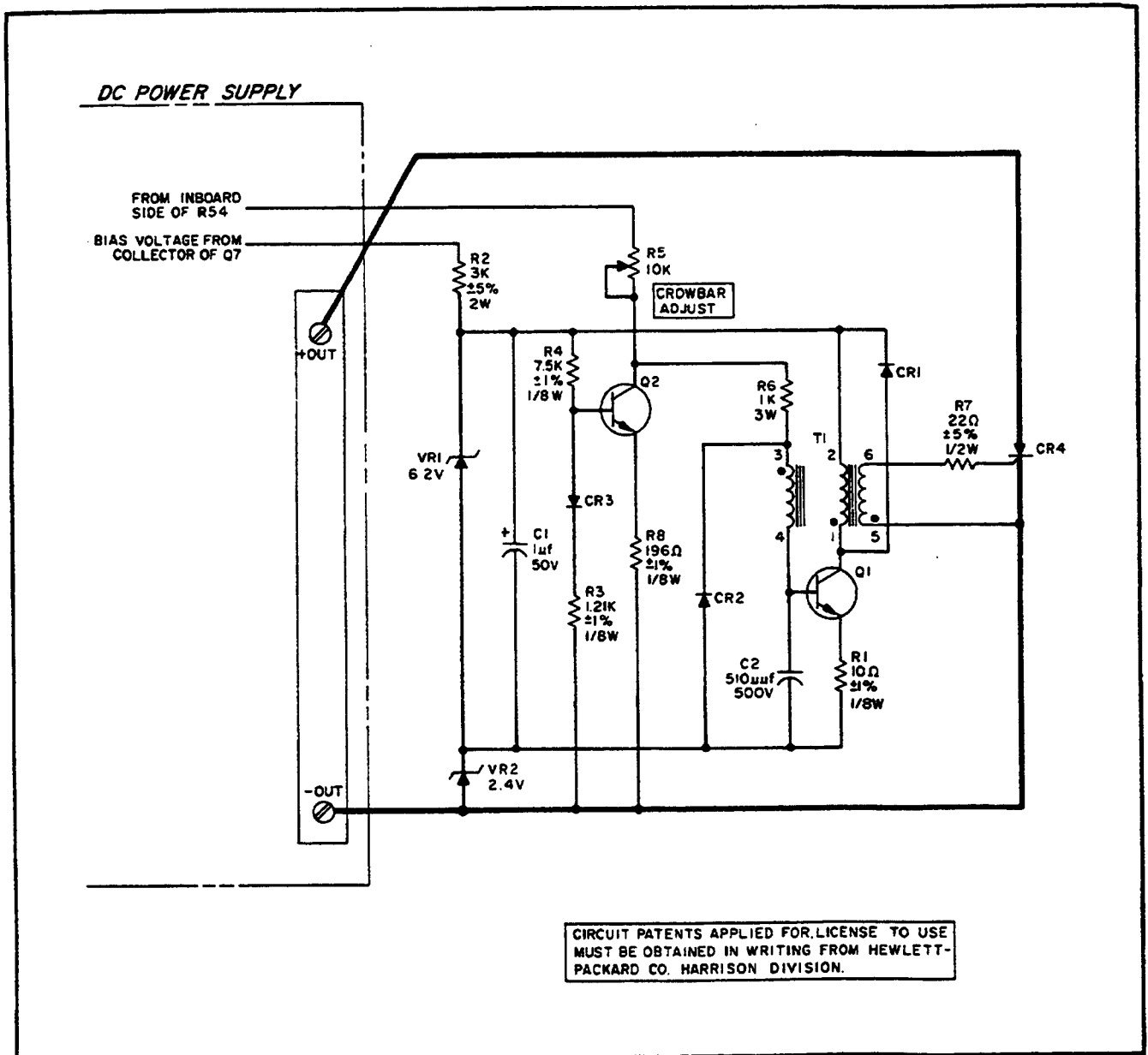


Figure A-1. Models 6200B, 6204B, and 6205B\* Overvoltage Protection "Crowbar"

\*For Model 6205B the above circuit is duplicated on each half of the assembled board, 06205-60021.

## SECTION VII CIRCUIT DIAGRAMS

This section contains the circuit diagrams necessary for the operation and maintenance of this power supply. Included are:

a. Component Location Diagram, Figure 7-1, which shows the physical location and reference designator of parts mounted on the printed

wired board.

b. Schematic Diagram, Figure 7-2, which illustrates the circuitry for the entire power supply. Voltages are given adjacent to test points, identified by encircled numbers on the schematic and printed wiring board.

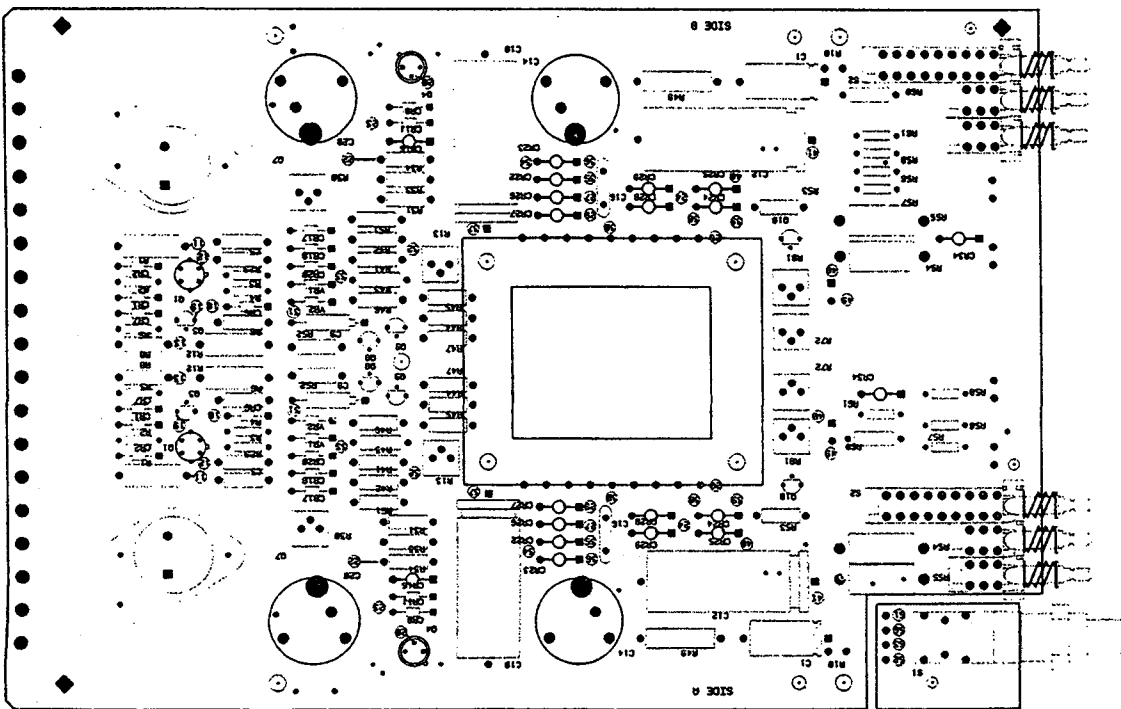
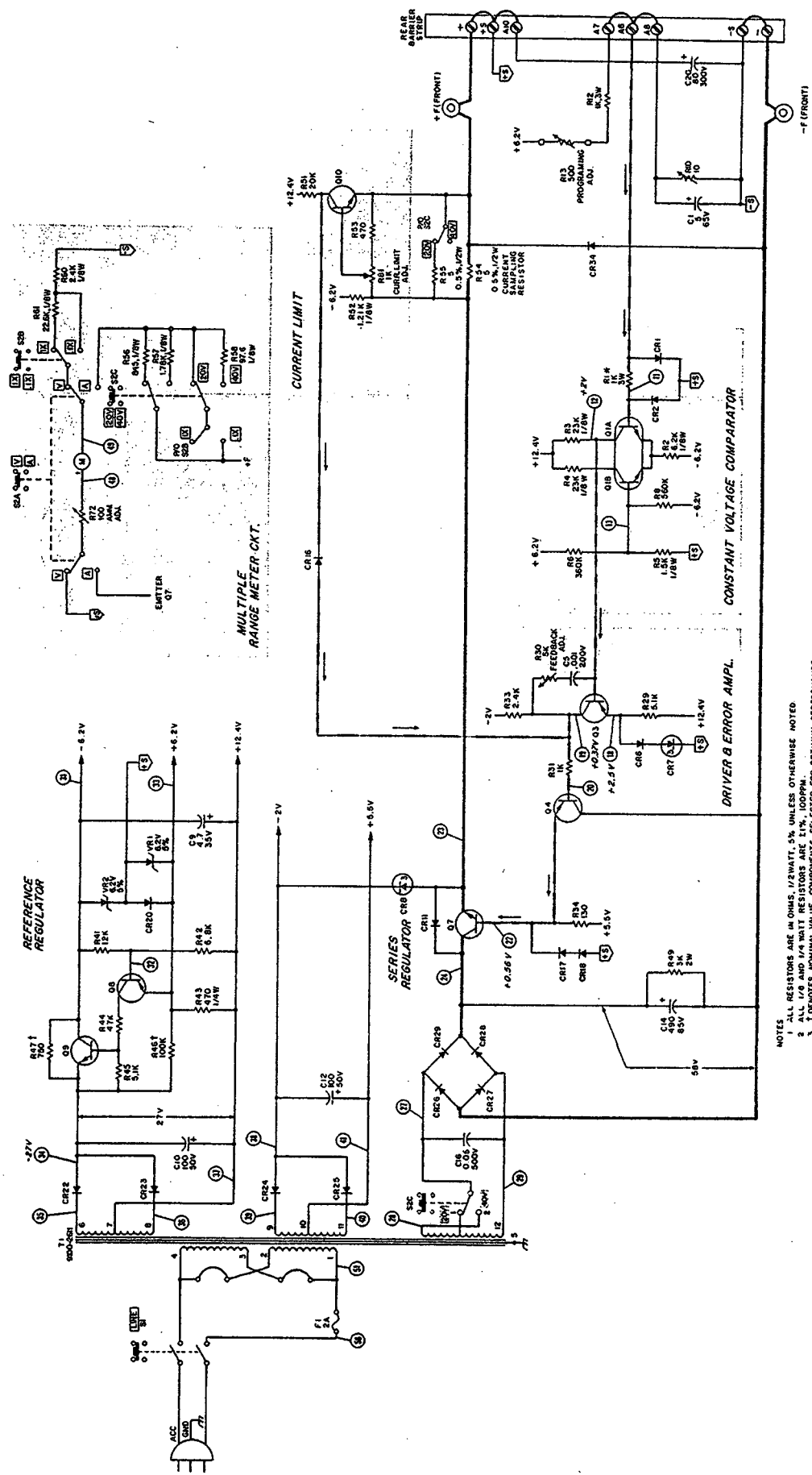


Figure 7-1. Component Location Diagram



- NOTES
1. ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE NOTED
  2. ALL 1/8 AND 1/4 WATT RESISTORS ARE TO BE LOCATED FOR OPTIMUM PERFORMANCE.
  3. T DENOTES TOLERANCE VALUE. COMPONENTS SELECTED FOR OPTIMUM PERFORMANCE.
  4. TRANSFORMER SHOWN STRAPPED FOR HVAC OPERATION. SEE INSTRUCTION MANUAL FOR STRAPPING.
  5. --- DENOTES VOLTAGE FEEDBACK SIGNAL.
  6. --- DENOTES TEMPERATURE FEEDBACK SIGNAL.
  7. --- DENOTES FRONT PANEL MARKING.
  8. X DENOTES 20PPM WIRE TEMPERATURE COEFFICIENT.
  9. DC VOLTAGES WERE MEASURED UNDER THE FOLLOWING CONDITIONS:  
 A. INPUT VOLTAGE: 100V AC  
 B. INPUT CURRENT: 250 OR EQUIVALENT
  10. VOLTAGES ARE TYPICAL TO  $\pm 5\%$  UNLESS OTHERWISE NOTED.
  11. VOLTAGES ARE TYPICAL TO  $\pm 10\%$  UNLESS OTHERWISE NOTED.
  12. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION AT 100V AC INPUT UNLESS OTHERWISE NOTED.
  13. ALL READINGS TAKEN IN CONSTANT CURRENT OPERATION AT 100V AC INPUT UNLESS OTHERWISE NOTED.
  14. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
  15. CIRCUIT ABOVE IS ONE OF TWO IDENTICAL SECTIONS. EVERYTHING TO RIGHT OF TRANS IS DUPLICATED.

Figure 7-2. 6205C, Schematic Diagram.



Order Part Number  
06205-90004

E0182

Printed in USA

Manufacturing Part Number

06205-90004



MANUAL CHANGES  
Model 6205C DUAL DC Power Supply  
Manual HP P/N 06205-90004

6/28/88

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

SERIAL		MAKE CHANGES
Prefix	Number	
All	---	Errata
2228A	00701-02600	1
2228A	02601-02700	1-2
2401A	02701-03200	1-3
2411A	03201-up	1-4

ERRATA

On page 1-1, paragraph 1-4 change "300V off ground" to "240V off ground".

On page 1-2 delete all of option 015.

In the replaceable parts list, page 6-5, delete Decadial HP P/N 1140-0020.

In Appendix A, page A-3, change "6205B" in the figure title and footnote to "6205C"

In figures 1-1 and 3-1, change the +/- 300V written under the front panel binding posts to +/- 240V.

In paragraph 3-19, change "6204C" in the first sentence to "6205C".

In the replaceable parts list, page 6-4, change S2 to HP P/N 3101-2580.

CHANGE 1:

In the replaceable parts list, on page 6-5, change the front panel to HP P/N 06205-00008 and add meter bracket, qty. 1, HP P/N 06205-00009; nut, qty. 1, HP P/N 2420-0019; washer, qty. 1. HP P/N 2190-0018; washer.

CHANGE 2:

In the replaceable parts list, on page 6-5, add spacer, round HP P/N 0380-1660 qty. 1. The spacer is located between the meter bracket and the front panel of the power supply.

ERRATA:

On page 3-3 add the following warning to paragraph 3-22;

WARNING

When the power supply is remote programmed with a voltage source, the programming voltage will appear at the output terminals when the AC input power is turned off. Therefore, do not contact the output terminals. The front panel meters will not indicate the presence of this voltage.

In the replaceable parts list, page 6-5, change Rubber Bumper Feet to HP P/N 0403-0002 and change Barrier Block to HP P/N 0360-2184. On page 6-5, change the description of Guard, Barrier Strip, HP P/N 5020-5541 to Barrier Strip Cover (red). On page 6-3, add transistor Q7, NPN, Si, HP P/N 1854-1017, TQ 2.

CHANGE 3:

In the replaceable parts list, page 6-4, change Potentiometer R30 to ceramic, 5K, HP P/N 2100-3252.

CHANGE 4:

In the replaceable parts list, page 6-5, add the following mechanical assembly; Barrier Strip Guard Assembly, 5060-2861, qty 1.

ERRATA:

On page 2-1, add step a., paragraph 2-15 (Rack Mounting two units side by side) to paragraph 2-16 (Rack mounting one unit). The tabs that are clipped on the main P.C. board during the rack mounting of two units must also be clipped when rack mounting one unit.

Page -2- HP Model 6205C

>ERRATA:

In the replaceable parts list page 6-4, change R72 to HP P/N 2100-0586.

In the replaceable parts list, page 6-4 change resistor R10 to HP P/N 2100-1866 and S2 to HP P/N 3101-2580.

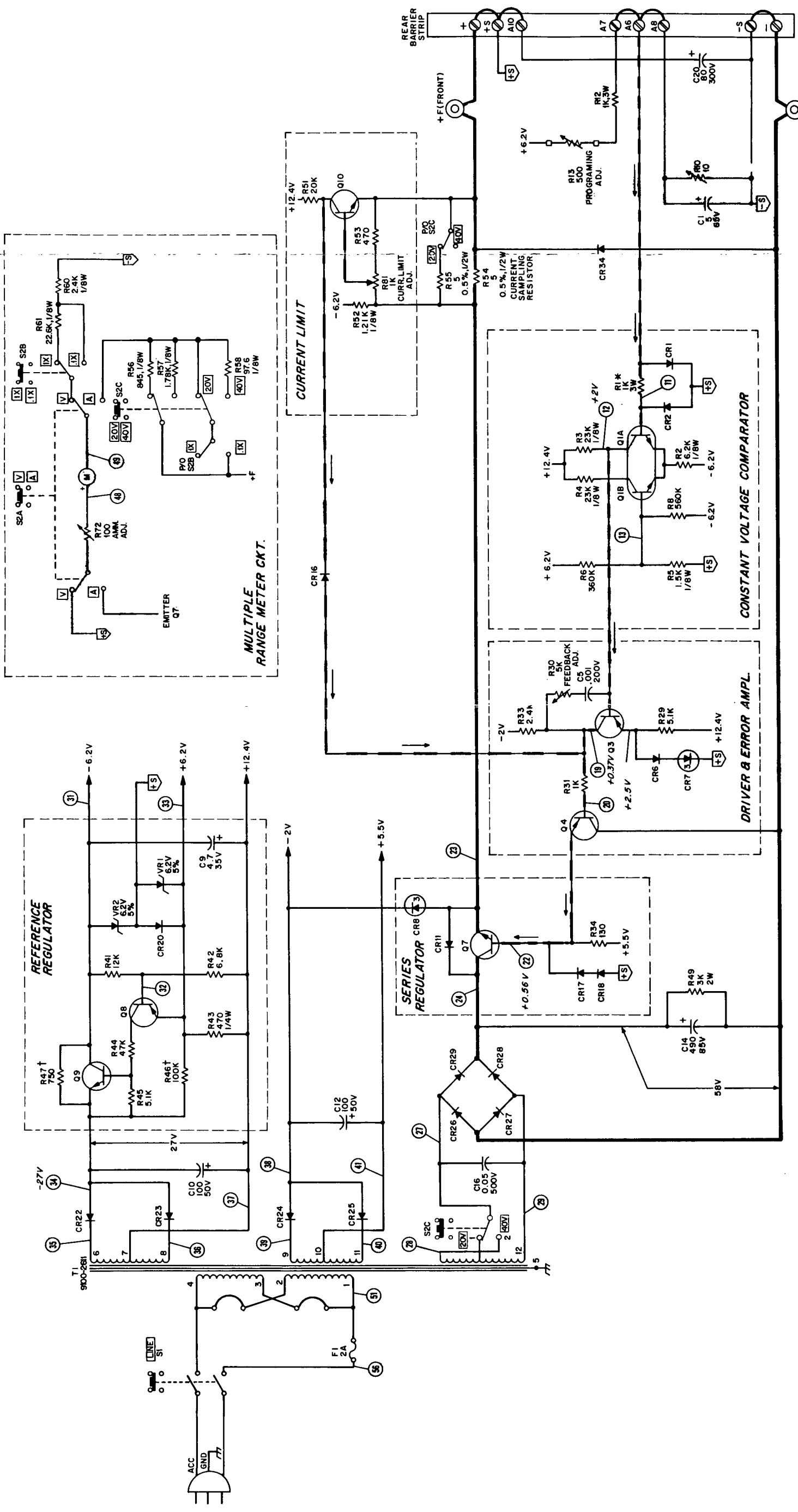
ERRATA:

In the Operating and Service manual, for units with Option 040, add the following note.

NOTE

When calibrated for Option 040, units may not meet full output voltage or current specification when used with the front panel potentiometer. This is due to the resistance tolerance of the potentiometer and the programming coefficient accuracy required for Option 040.





- NOTES:
1. ALL RESISTORS ARE IN OHMS, 1/2WATT, 5% UNLESS OTHERWISE NOTED.
  2. ALL 1/8 AND 1/4 WATT RESISTORS ARE  $\pm 1\%$ , 100PPM.
  3. † DENOTES NOMINAL VALUE. COMPONENTS SELECTED FOR OPTIMUM PERFORMANCE.
  4. TRANSFORMER SHOWN STRAPPED FOR 115VAC OPERATION. SEE INSTRUCTION MANUAL FOR 220VAC.
  5. — DENOTES VOLTAGE FEEDBACK SIGNAL.
  6. — DENOTES CURRENT FEEDBACK SIGNAL.
  7. — DENOTES FRONT PANEL MARKINGS.
  8. \* DENOTES 20PPM WIRE TEMPERATURE COEFFICIENT.
  9. DC VOLTAGES WERE MEASURED UNDER THE FOLLOWING CONDITIONS:
    - A. SIMPSON MODEL 269 OR EQUIVALENT.
    - B. 115VAC INPUT.
    - C. VOLTAGES REFERENCED TO +S UNLESS OTHERWISE NOTED.
    - D. VOLTAGES ARE TYPICAL  $\pm 10\%$  UNLESS OTHERWISE NOTED.
    - E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION AT MAXIMUM RATED OUTPUT WITH NO LOAD CONNECTED.
  10. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
  11. CIRCUIT ABOVE IS ONE OF TWO IDENTICAL SECTIONS. EVERYTHING TORIGHT OF TRANS. IS DUPLICATED.

Figure 7-2. 6205C, Schematic Diagram