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DC POWER SUPPLY
LVR SERIES, MODEL 6265A
SERIAL NUMBER PREFIX 6L

SPECIFICATIONS

Input: 105-125/210-250 VAC, single phase, 50-60 cps.

Output: 0-36 volts @ 0-3 amperes.

Load Regulation: Constant Voltage -- Less than 0.01% plus 500 μ v for a full load change.

Constant Current -- Less than 0.02% plus 500 μ a for a full load change.

Line Regulation: Constant Voltage -- Less than 0.01% plus 500 μ v for a change in line voltage from 105 to 125 volts (or 125 to 105 volts).

Constant Current -- Less than 0.02% plus 500 μ a for a change in line voltage from 105 to 125 volts (or 125 to 105 volts).

Line Regulation: Constant Voltage -- Less than 500 μ v rms. Constant Current -- Less than 3 ma rms.

Ripple and Noise: Constant Voltage -- Less than 500 μ v rms. Constant Current -- Less than 3 ma rms.

Maximum Operating Temperature: 50°C.

Temperature Coefficient: Output voltage change per degree Centigrade is less than 0.01% plus 500 μ v. Output current change per degree Centigrade is less than 0.01% plus 1 ma.

Stability: As a constant voltage source, the total drift for 8 hours (after 30 minutes warm-up) at a constant ambient is less than 0.03% plus 2 mv. As a constant current source, the total drift for 8 hours (after 30 minutes warm-up) at a constant ambient is less than 0.03% plus 2 ma.

Internal Impedance as a Constant Voltage Source: Less than .001 ohms from DC to 100 cycles. Less than .01 ohms from 100 cycles to 1 Kc. Less than .2 ohms from 1 Kc to 100 Kc. Less than 2 ohms from 100 Kc to 1 Mc.

Transient Recovery Time: Less than 50 microseconds is required for output voltage recovery (in constant voltage operation) to within 10 millivolts of the nominal output voltage following a full load change in output current. For this measurement, the nominal output voltage is defined as the mean between the no load and full load voltages.

Overload Protection: An all-electronic, continuously acting constant current circuit protects the power supply for all overloads, including a direct short placed across the output terminals. A front panel control permits continuous adjustment of the constant current value from 0 amps to 3.4 amps.

MANUAL CHANGES

DC POWER SUPPLY

Model 6255A

Manual Serial Number Prefix 7F

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

SERIAL		MAKE	
Prefix	Number	Prefix	CHANGES
7F	0851 - 0950	1	
ALT		Errata	
7L	0951 - 1275	1, 2	

SERIAL		MAKE	
Prefix	Number	Prefix	CHANGES
7L	1276 - 1500	7L	1, 2, 3
	1501 - 1560	7L	1, 2, 3, 4
	1561 - up	8L	1 thru 5

CHANGE 1: In the replaceable parts table, make the following changes:

- R15: Change to 240K, 1/2W, Φ Part No. 0686-2445.
- R35: Change to 120 Ω , 1/2W, Φ Part No. 0686-1215.
- R40: Delete resistor R40.
- R62: Change to 750 Ω , 1/8W, Φ Part No. 0757-0420.
- R63: Change to 5K Ω potentiometer, Φ Part No. 2100-1824.
- R64, 65: Change to 12K Ω , 1/8W, Φ Part No. 0698-5088.
- VR6: Add new Zener diode, VR6, (4.22V) Φ Part No. 1902-3070.

On the schematic, delete resistor R40 in the meter circuit and connect VR6 in its place. Anode of VR6 to base of Q15 and cathode to +12.4V.

ERRATA: Change F1 to 4 Amperes, 250V, 3AG, Φ Part No. 2100-0055, on parts list and schematic.

CHANGE 2: On the Title Page, change Serial Number Prefix from "7F" to "7L".

In the replaceable parts table, delete switch/indicator S1/DS1 and add new "toggle" type switch and separate indicator, as follows:

- S1: Switch, SPST, ON/OFF, Φ Part No. 3101-1055.
- DS1: Indicator lamp, neon, Φ Part No. 1450-0048.

CHANGE 3: In the replaceable parts table and on the schematic, add new resistor R78, 100 Ω , 5%, $\frac{1}{2}$ W, Φ Part No. 0686-1015. Connect R78 between base of Q4 and emitter of Q5.

ERRATA: Q3, 5, 8, 10, 12, 14, 15: Change to 2N2907A, Sprague, 56289, 1853-0099.

On page 3-5, Figure 3-11, remove straps between A10 and +S and +S and + terminals, on all "slave" supplies. Connect A10 to + terminal on all "slaves".

CHANGE 4: In the replaceable parts table, change Q11 to 2N4045, Φ Part No. 1854-0221.

CHANGE 5: On the Title Page, change Serial Number Prefix to "8L".

In the replaceable parts table, make the following changes:

Controls: A single control makes possible continuous adjustment of the output voltage over the entire range from 0 to 36 volts. A vernier control is also provided. The current control permits adjustment of the output current to the optimum value for protection of the load device and serves as the output current control when the supply is used as a constant current source. A vernier current control is also provided.

Meters: A 40V voltmeter and a 0-3 ammeter are provided.

Output Terminals: The output terminal strip is located on the rear of the chassis. All power supply output terminals are isolated from the chassis, and either the positive or negative terminal must be connected to the chassis through a separate ground terminal located adjacent to the output terminals.

Remote Error Sensing: Error sensing is normally accomplished at the rear terminals if the load is attached to the rear terminals. Also, provision is included on the rear terminal strip for remote error sensing.

Remote Programming: Remote programming of the output voltage at 200 ohms/volts is made available on the rear terminal strip. Also, the output current may be remotely programmed at 300 ohms/amp.

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

Size: 3-1/2" H x 16-3/4" D x 19"W (Standard Relay Rack Mounting).

Weight: 36 pounds net; shipping weight 47 pounds.

Finish: Light gray front panel with dark gray case.

Power Cord: A 3-wire 5 foot power cord is provided with each unit.

1-7 Harrison Laboratories power supplies are identified by a three-part serial number tag. The first part is the power supply model number; the second part is the power supply serial number; the third part is the Manufacturing Code Letter. The manual applies directly to all instruments which carry the same Manufacturing Code Letter as appears on the instruments which carry the same Manufacturing Code Letter as appears on the Title Page of this manual. Revision Sheets will be supplied with this manual which will specify changes required to make the manual apply to units having a Manufacturing Code Letter other than that appearing on the Title Page.

1-6 INSTRUMENT IDENTIFICATION

- A. Remote Programming
The power supply may be programmed from a remote location by means of an external voltage source of resistance.
- B. Remote Sensing
The degradation in regulation which will occur at the load because of the voltage drop occurring in the load may be ameliorated by using the power supply in the remote sensing mode of operation.
- C. Series Operation
Power supplies are used in series when a higher output voltage than the maximum output voltage of the power supply is required or greater voltage compliance is required when the power supply is used as a constant current source.
- D. Parallel Operation
This power supply may be operated in parallel with similar power supplies when a greater output current is required.

1-5 There are a number of optional modes in which the power supply may be operated:

- 1-3 Front panel meters indicate the output current and voltage.
- 1-4 The power supply has rear output terminals. Power supply insulation permits it to be operated as high as 400 volts off ground, and either output terminal may be grounded.

1-2 The Harrison Laboratories LVR Series are regulated constant voltage/constant current DC power supplies suitable for relay rack operation. These power supplies are completely transistorized general purpose power supplies. They are useful wherever continuously variable well-regulated DC power sources are required. The continuously variable current control may be used to set the maximum output current (overload or shortcircuit current) when the supply is used as a constant voltage source; or the voltage control may be used to set the maximum output voltage (voltage ceiling) when the power supply is used as a constant current source.

1-1 GENERAL INFORMATION

1-8 COOLING SYSTEM

1-9 This power supply is convection cooled and requires no maintenance except for an occasional dusting. There should be sufficient space to the rear and along the sides of the instrument to permit free flow of cooling air.

1-10 POWER CABLE

1-11 A 5 foot three conductor power cable is supplied with the instrument terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association (NEMA). NEMA recommends that the instrument panel and cabinet be grounded. All Harrison Laboratories instruments are equipped with a power cable which when plugged into an appropriate receptacle grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

1-12 To preserve the protection feature when operating the instrument from a two contact outlet, use a three-prong to two-prong adaptor and connect the green pigtail on the adaptor to ground.

- a. Unplug the line cord and remove top cover.
- b. Remove the strap between 1 and 3 and 2 and 4 on the power transformer (T1).
- c. Add strap between 2 and 3.
- d. Replace fuse F1 with a 230 volt fuse having one half the previous current rating.
- e. Replace top cover. Turn on instrument and operate normally.

2-7 The LVR series can be operated from either 115 or 230 volts AC, 48 to 63 cps source. The instrument as shipped from the factory is normally wired for 115 volt operation. If the instrument is to be used on a 230 volt line, the following changes must be made.

2-6 POWER REQUIREMENTS

2-5 This instrument is air cooled. Sufficient space to permit free flow of cooling air along the sides and to the rear of the instrument should be considered when installing. It should be used in an area where the ambient temperature does not exceed 50°C. (122°F).

2-4 The LVR series are shipped ready for relay rack mounting. It is only necessary to connect the power cable supplied with the instrument to the POWER input and the instrument is ready for operation.

2-3 INSTALLATION

2-2 The instrument should be unpacked and inspected both mechanically and electrically upon receipt. Observe packing method and retain packing materials until unit has been inspected. Mechanical inspection involves checking for signs of physical damage such as scratched panel surfaces, broken knobs, etc. If damage is apparent, file a claim with the carrier. The electrical inspection involves checking the instrument against its specifications. Section V includes a performance check which is an "in-cabinet" check to verify proper instrument operation (see paragraph 5-55). It is recommended as an incoming inspection test. Refer to the warranty page if there is an electrical malfunction.

2-1 INCOMING INSPECTION

SECTION II.

If the instrument is to be shipped to Harrison Laboratories for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair to be accomplished. In any correspondence be sure to identify the instrument by model number and serial number.

NOTE

- e. Mark the packing box with "Fragile--Delicate Instrument," etc.
- d. Use heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.
- c. Use plenty of packing material around all sides of the instrument and protect the panel with cardboard strips.
- b. Wrap the instrument in heavy paper or plastic before placing it in the shipping container.
- a. Use the original container designed for the instrument. If a new container is required, a foam pack and container can be ordered from Harrison Laboratories. The stock number is given in the table of replaceable parts under miscellaneous.

2-13 The following list is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Harrison Laboratories sales representative.

2-12 REPACKAGING FOR SHIPMENT

- 2-11 To preserve the protection feature when operating this instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green digital on the adapter to ground.
- 2-10 For the protection of operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

2-9 THREE-CONDUCTOR POWER CABLE

- a. The instrument can be operated at frequencies ranging from 48 to 63 cycles without internal adjustment at a maximum ambient of 35°C.
- b. In order to maintain operation at a maximum ambient of 50°C, the internal adjustments outlined in Section 5-29 must be followed.

2-8 Instruments with an output capacity exceeding 5 amperes and operating at frequencies other than 57-63 cycles have the following options:

3-11 The power supply may be programmed from the remote location by means of an external voltage source or a resistance. It is necessary to change the strapping pattern on the barrier strip on the rear panel. The front panel pot is disabled when the following remote programming procedures are followed.

3-10 REMOTE PROGRAMMING -- CONSTANT VOLTAGE

3-9 The step-by-step operating procedure for the instrument is outlined in Figure 3-1. The steps are keyed to controls and indicators on the figure.

3-8 OPERATING PROCEDURE

3-7 Sensing is automatically accomplished at the rear terminals of the power supply as shipped from the factory. The user should realize that the specifications describing the electrical characteristics of the power supply are written for measurements made on the sensing terminals of the power supply. The user should be cognizant of the voltage drop which will occur in the load leads. For example, if two amperes flows through #16 stranded wire, the drop in the leads will be approximately 8 mv per foot. This drop can be minimized by using a larger size wire and minimizing the lead length to the load. Regulation at the load can be maintained within the specifications of the power supply by using remote sensing as described in this section of the manual.

3-6 The load is connected to the rear output terminals of the power supply. The leads should be twisted or shielded if they are run past a source of interference.

3-5 CONNECTIONS TO LOAD

3-4 Check strapping pattern on rear terminals of the unit. (See Figure 3-2.) The power supply as shipped from the factory is strapped for local programming, local sensing as indicated on the rear of the unit. It will be necessary to change the strapping pattern if the power supply is used in some other mode. Wiring instructions for other operating configurations are outlined later in this section.

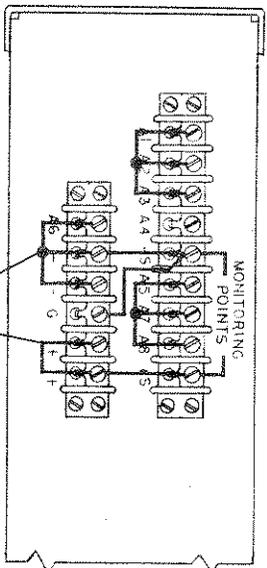
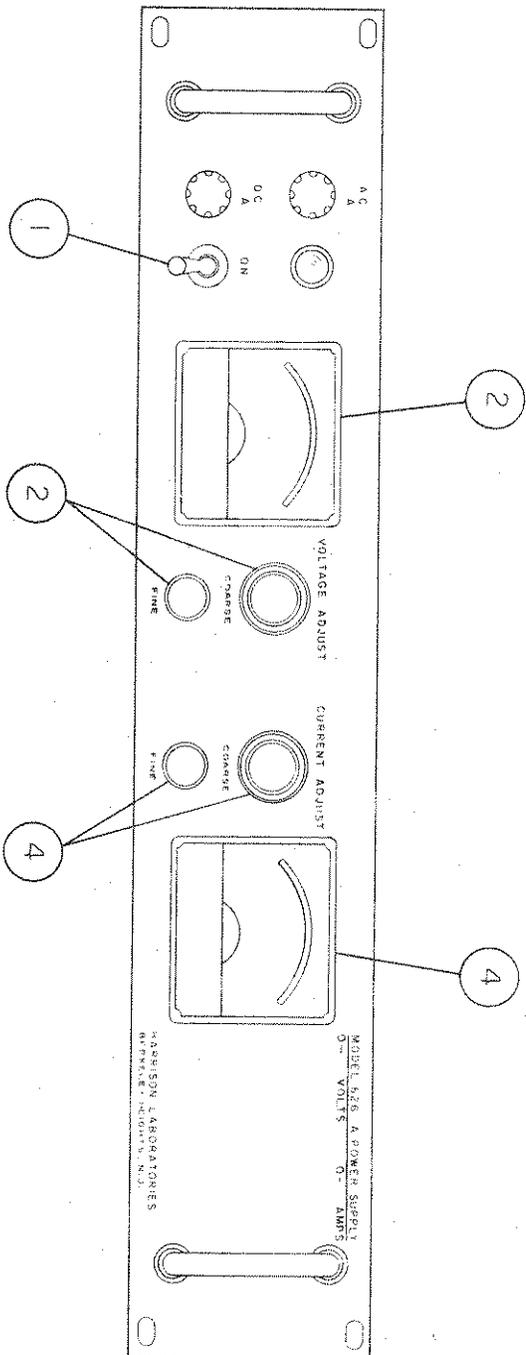
3-3 PRELIMINARY CONSIDERATIONS

3-2 Controls and indicators and their functions are shown in Figure 3-1.

3-1 OPERATING CONTROLS

OPERATION

SECTION III.



1. TURN A.C. POWER ON.
2. ADJUST COARSE AND FINE VOLTAGE CONTROLS UNTIL THE VOLTAGE ON THE OUTPUT VOLTAGE METER IS OF DESIRED VALUE.
3. SHORT CIRCUIT THE OUTPUT TERMINALS.
4. ADJUST COARSE AND FINE CURRENT CONTROLS UNTIL THE CURRENT ON THE OUTPUT CURRENT METER IS OF DESIRED VALUE.
5. REMOVE SHORT AND CONNECT LOAD.

OPERATING PROCEDURE
FIG 3-1

NOTE: 3.33 milliamperes corresponds to 300 ohms per volt.

$$V_O = V_{REF} \times \frac{R_f}{R_p}$$

- equation when R_f is varied.
- (6) The output voltage will vary in accordance with the following is varied.
- (5) The output voltage will vary as the ratio of R_p to R_f when R_p is changed.
- (4) The output voltage will vary linearly as the reference voltage R_p is varied.
- (3) The power supply may be programmed by varying the reference voltage, by varying resistor R_f or by varying resistor R_p .
- (2) R_f and R_p should be selected so that the impedance looking into their junction is a maximum of 1000 ohms.
- (1) Stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) programming resistors should be used.
- c. Voltage-Resistance Programming (See Figure 3-5C)
- (1) The output voltage will vary in a one to one ratio with the external programming voltage.
- (2) The maximum load on the programming voltage will be approximately 25 microamperes.
- (3) The impedance looking into the external programming voltage should be approximately 1000 ohms.
- b. Voltage Programming (See Figure 3-5B)
- (1) The output voltage will vary in a one to one ratio with the external programming voltage.
- (2) The output voltage will vary at a rate determined by the programming coefficient--200 ohms per volt (i.e., The output voltage will vary 1 volt for each 200 ohms connected across the programming terminals.) The programming current is adjusted to within 2% of 5 milliamperes at the factory for the models having a maximum rated output less than 60V and 3.33 milliamperes for models with a capability equal to or greater than 60V. If greater programming accuracy is required, it may be achieved by changing the shunt resistor. SEE NOTE:
- a. Resistance Programming (See Figure 3-5A)
- (1) Stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) programming resistors should be used.
- (2) The output voltage will vary at a rate determined by the programming coefficient--200 ohms per volt (i.e., The output voltage will vary 1 volt for each 200 ohms connected across the programming terminals.) The programming current is adjusted to within 2% of 5 milliamperes at the factory for the models having a maximum rated output less than 60V and 3.33 milliamperes for models with a capability equal to or greater than 60V. If greater programming accuracy is required, it may be achieved by changing the shunt resistor. SEE NOTE:

FIG. 3-4 REMOTE SENSING 8 REMOTE PROGRAMMING.

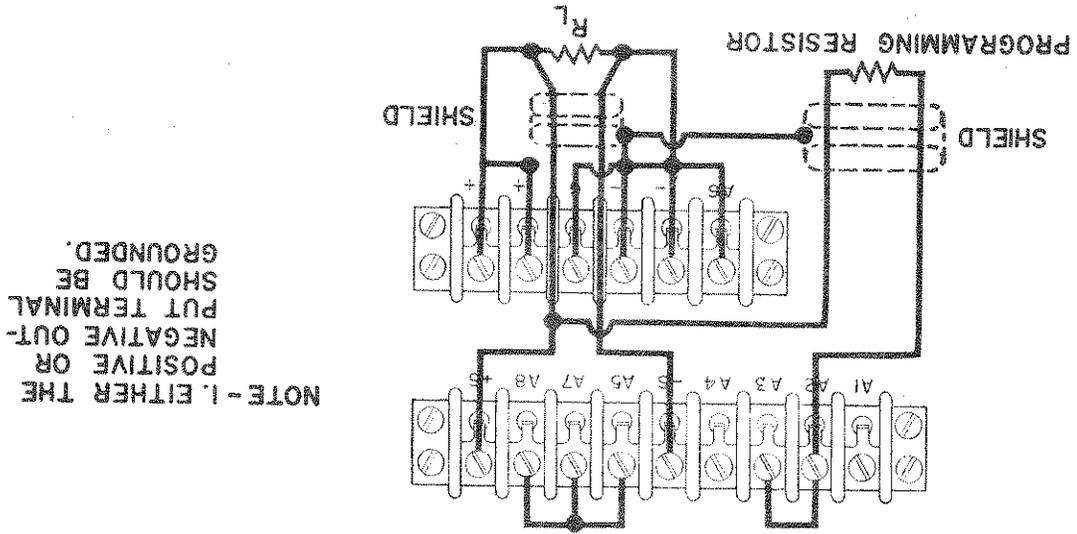


FIG. 3-3 REMOTE SENSING.

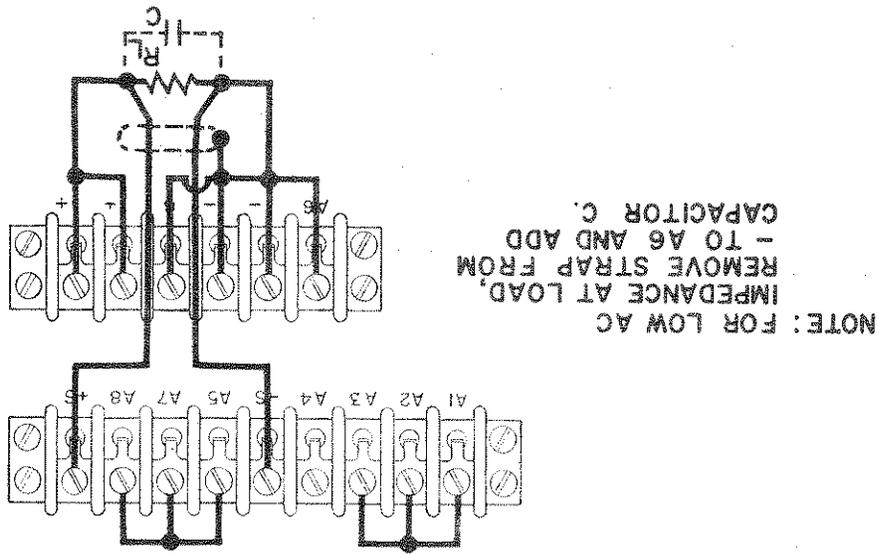


FIG. 3-2 NORMAL.

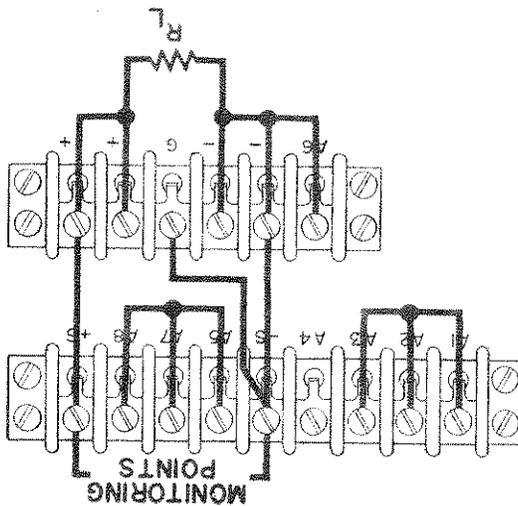


FIG. 3-5 C (VOLTAGE-RESISTANCE PROGRAMMING) REMOTE PROGRAMMING CONSTANT VOLTAGE

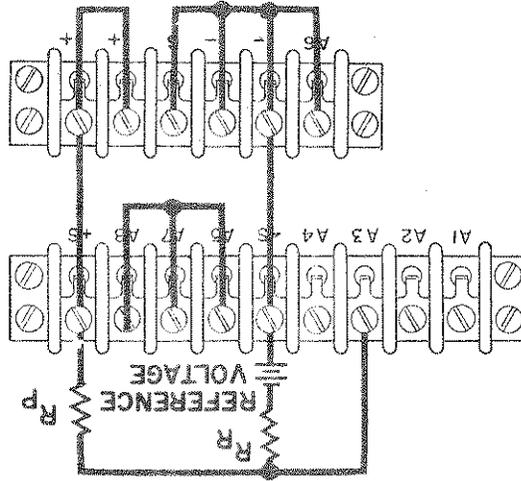


FIG. 3-5 B (VOLTAGE PROGRAMMING) REMOTE PROGRAMMING CONSTANT VOLTAGE

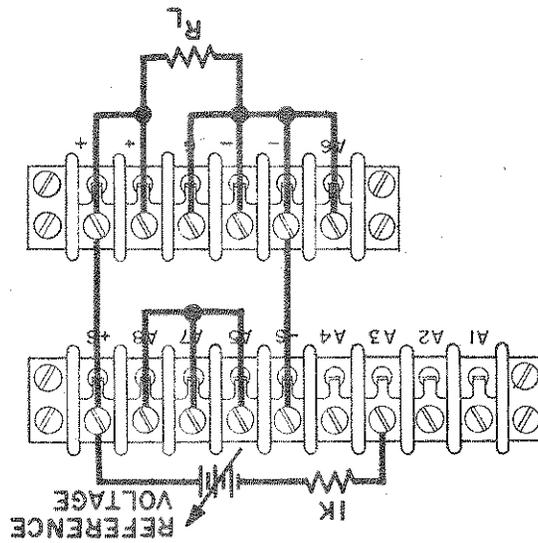
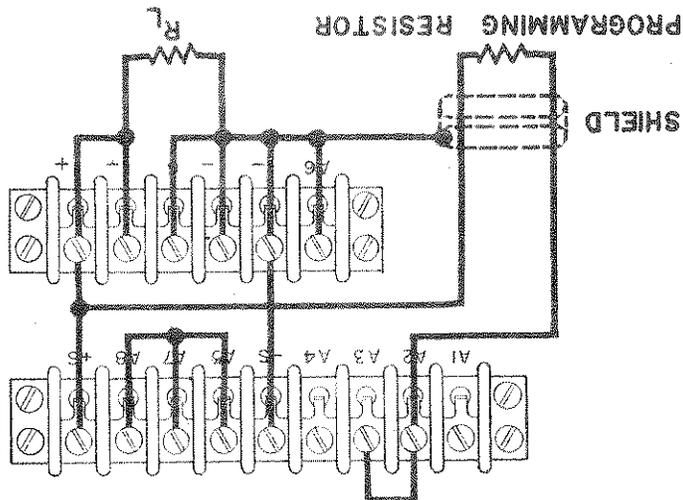


FIG. 3-5 A (RESISTANCE PROGRAMMING) REMOTE PROGRAMMING CONSTANT VOLTAGE



- a. Disconnect the jumper between -S and - and +S and +.
- b. Run a separate pair of leads from -S to the negative load terminal and +S to the positive load terminal.
CAUTION: Polarity must be observed.
- c. It is not required that these leads be as heavy as the load leads. However, it is recommended that they be twisted or shielded to minimize hum pickup.

3-14 Remote sensing is used to maintain good regulation at the load and amell- leads between the power supply and the load. Remote sensing is accomplished as follows: (See Figure 3-3).

3-13 REMOTE SENSING

$$I_o = V_{REF} \frac{R_M}{R_A} \frac{R_B}{R_A}$$

the following:

- (1) Stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) programming resistors should be used.
- (2) R_A and R_B should be selected so that the impedance looking into their junction is a maximum of 1000 ohms.
- (3) The output current will vary linearly as a function of V_{REF} , R_A , and R_B . The equation for the output current is given by

c. Voltage Resistance Programming (See Figure 3-6C)

- (1) The output current will vary in the following manner:
 $I_o = V_R \frac{R_M}{R_A}$ Amps
 V_R = Reference Voltage
 R_M = Internal Monitoring Resistor
- (2) The maximum load on the reference voltage is approximately 10 microamperes.
- (3) The impedance looking into the external programming voltage should be approximately 1000 ohms.

b. Voltage Programming (See Figure 3-6B)

- (1) Stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) programming resistors should be used.
- (2) The output current will vary at a rate determined by the programming coefficient. (See Remote Programming in Specifications). The programming coefficient is determined by the programming current which can be varied by means of an internal adjustment.

a. Resistance Programming (See Figure 3-6A)

3-12 REMOTE PROGRAMMING -- CONSTANT CURRENT

FIG. 3-6C (VOLTAGE & RESISTANCE PROGRAMMING) REMOTE PROGRAMMING CONSTANT CURRENT

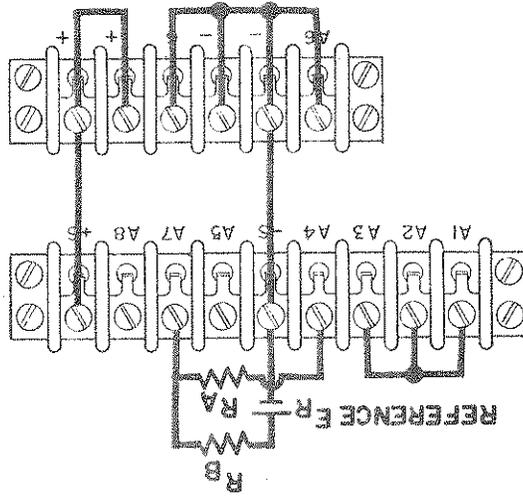


FIG. 3-6B (VOLTAGE PROGRAMMING) REMOTE PROGRAMMING CONSTANT CURRENT

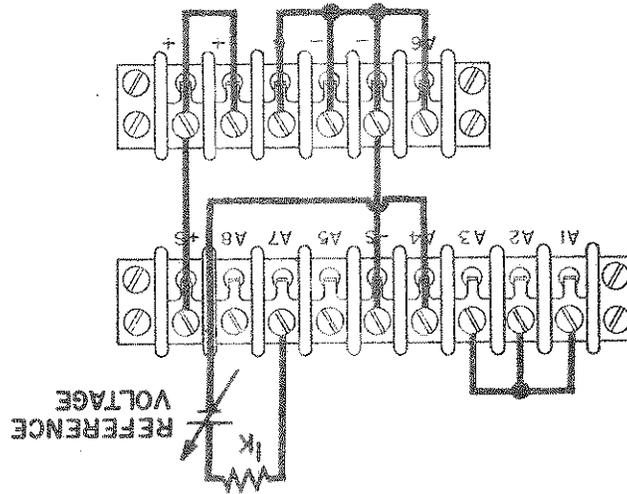
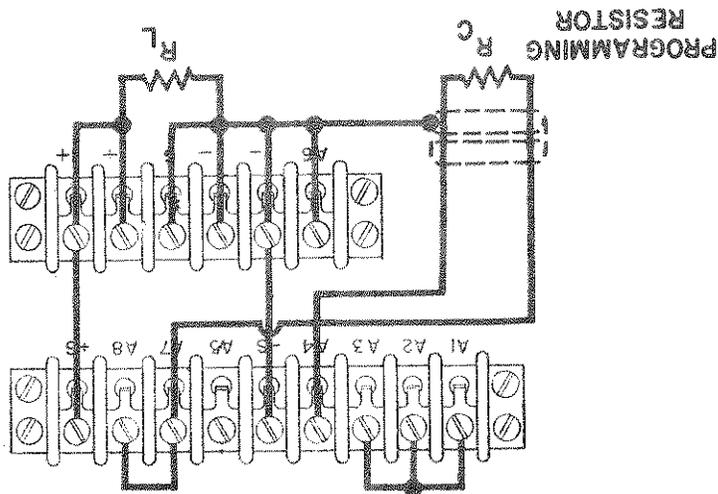


FIG. 3-6A REMOTE RESISTANCE PROGRAMMING CONSTANT CURRENT



- a. The most negative power supply must be selected as the master or control unit.
- 3-21 Auto-tracking is useful when it is desirable to have several power supplies referenced to a common bus vary proportionally. The connections are made in accordance with Figure 3-8.

3-20 AUTO-TRACKING OPERATION

- a. Stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) resistors should be used for R_x and R_y .
- b. R_x and R_y should be selected so that a current equal to the programming current flows at maximum output voltage. The voltage across R_x will be equal to the output voltage of the master unit. The voltage across R_y will equal the output voltage of slave unit one.
- c. The most negative supply must be selected as the master or control unit.

NOTE:

- a. Stable, low noise, low temperature coefficient (less than 30 ppm per degree Centigrade) resistors should be used for R_x and R_y .
- b. R_x and R_y should be selected so that a current equal to the programming current flows at maximum output voltage. The voltage across R_x will be equal to the output voltage of the master unit. The voltage across R_y will equal the output voltage of slave unit one.
- c. The most negative supply must be selected as the master or control unit.
- 3-19 The power supplies should be connected in the Auto-Series configuration if it is desirable to have the voltage of two or more power supplies, connected in series, track each other or vary proportionally. (See Figures 3-7A and 3-7B for wiring diagrams). See note.
- 3-18 Two or more supplies may be operated in series to obtain a higher voltage (the 6260A Series may be operated as much as 400 volts above ground) than that obtainable from a single supply. Power supplies are operated in series by connecting the positive terminal of one of the power supplies to the negative terminal of the second supply. The load is then taken across the two unconnected output terminals.

3-17 CONSTANT VOLTAGE SERIES OPERATION

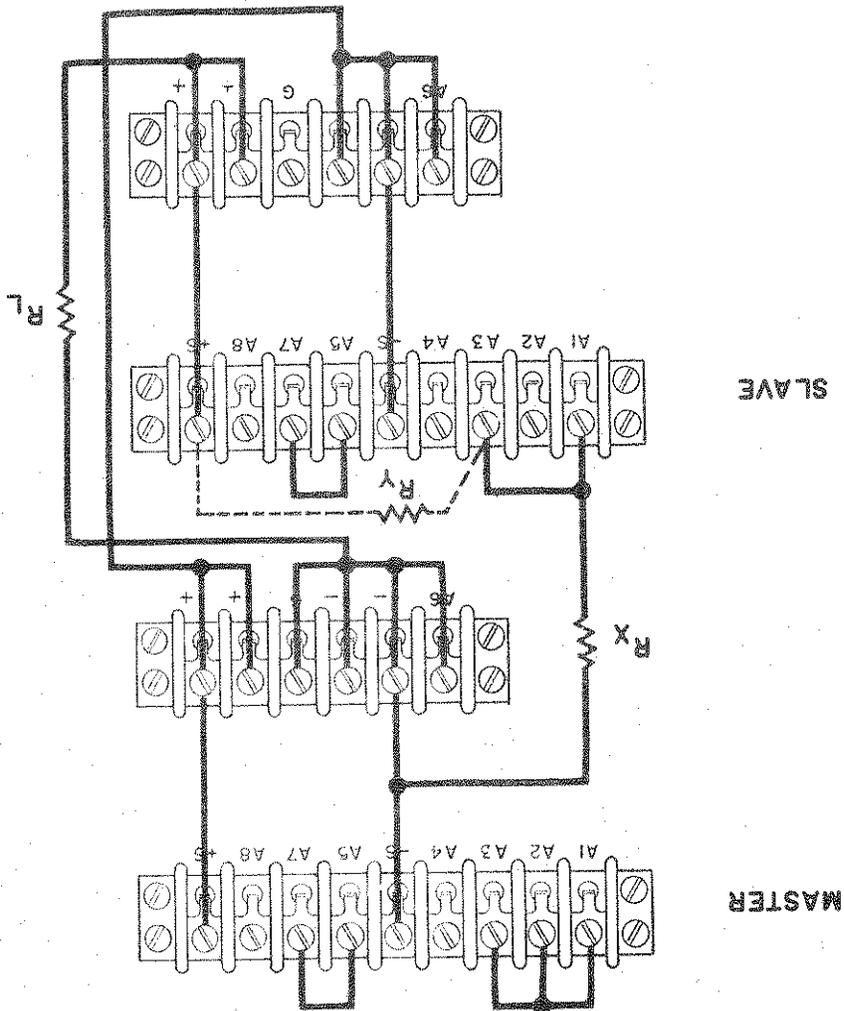
- 3-16 A combination of remote programming and remote sensing may be used. The wiring for this combination is shown in Figure 3-4.
- a. Remove the strap between A6 and -.
- b. Reconnect the output capacitor or an equivalent capacitor across the load using a separate pair of leads and being careful to minimize the length of these leads.

3-15 The above precautions will result in a low DC output impedance at the load. However, if a low AC impedance is required, it is recommended that the following precautions be taken.

NOTE-1. EITHER THE POSITIVE OR
NEGATIVE OUTPUT TERMINAL
SHOULD BE GROUNDED.

FIG. 3-7A AUTO SERIES
(2 UNITS)

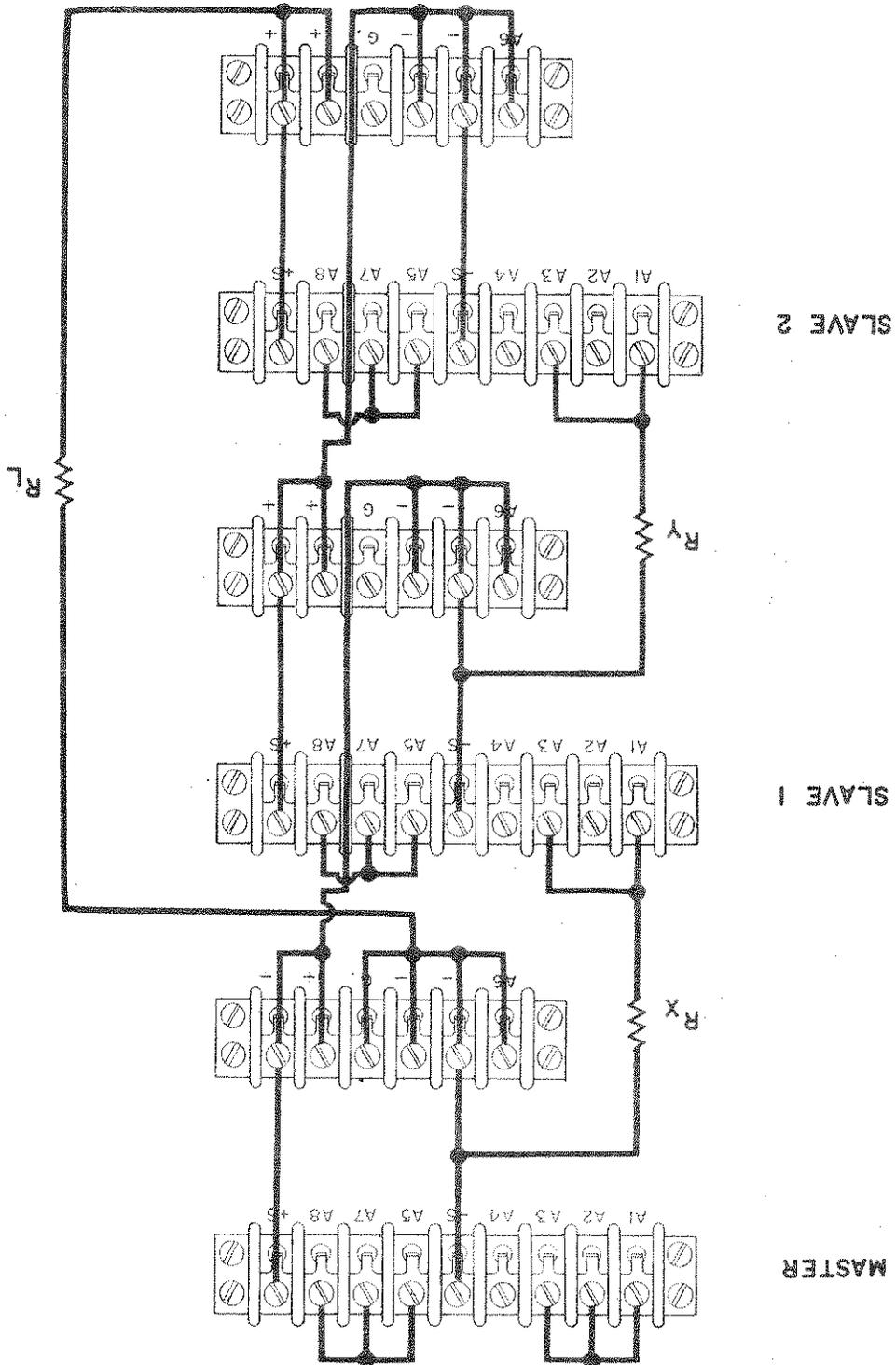
NOTE: FOR EXTERNAL PROGRAMMING
OF SLAVE SUPPLY, ADD R_y.
REMOVE STRAP FROM A1
TO A2 ON SLAVE UNIT.



MASTER

SLAVE

FIG. 3-7B AUTO SERIES
(3 UNITS)



3-30 A load on the power supply may cause current to flow into the positive terminal of the power supply rather than out of the positive terminal as in normal operation, i.e., the power supply may be subjected to negative current loading. The series regulating transistors are unilateral devices and must always conduct in the forward direction if the output regulation of the power supply is to be maintained; therefore, an external source cannot be allowed to pump current into the supply such that the direction of current flow in the series transistors will be reversed. It is necessary to load the supply with a dummy load so that the direction of current flow in the supply does not change if the power supply is to be subjected to negative current loading.

3-29 NEGATIVE CURRENT LOADING

3-28 It is imperative that each load taken from the power supply have two separate leads brought back to the power supply terminals if full advantage is to be taken of the low output impedance of the power supply and mutual coupling effects between equipments being powered from the same supply are to be avoided.

3-27 MULTIPLE POWER SUPPLY LOADING

3-26 The operation of the power supply may be improved in the constant current mode of operation when operating at reduced current levels by increasing the size of the current sensing resistors R82 and R83. The resistor should be selected so that at maximum operating current, the voltage drop across the resistor will be 1.0 volts. The line and load regulation of the power supply will now be 0.05 percent of maximum operating current rather than 0.05 percent of rated output current. The resistor used to replace the current sensing resistor (s) should be a low noise, low temperature coefficient (less than 30 ppm/°C) resistor. It should be selected so that at maximum operating current, it dissipates no more than 5% of its rated power.

3-25 INCREASING SENSITIVITY OF THE POWER SUPPLY IN CONSTANT CURRENT OPERATION

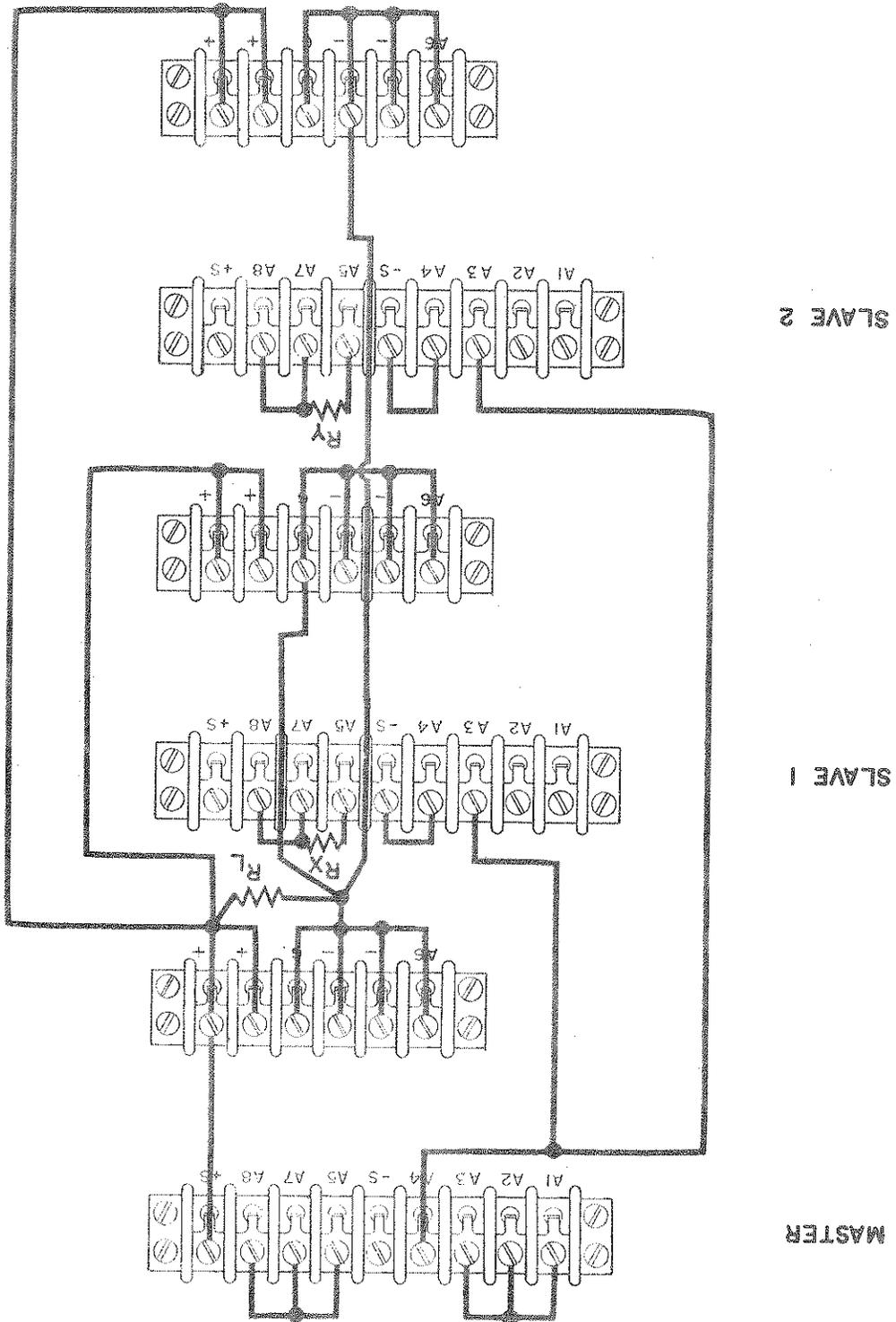
3-24 Power supplies are connected in Auto-Parallel in accordance with Figure 3-9. Kx and Ry are stable, low noise, and low temperature coefficient (less than 30 ppm per °C) and selected such that the individual slave output currents equal ($\pm 10\%$) the master output current.

3-23 Auto-Parallel operation is used when it is desirable to have a larger current than is available from a single supply.

3-22 PARALLEL OPERATION

- c. Either the positive or negative output terminal of the slave units may be connected to the common bus.
- b. Resistors Rx and Ry are selected so that the current through the resistors is approximately equal to the programming current at maximum output voltage.

FIG. 3-9 AUTO PARALLEL



3-37 The voltage threshold (open circuit voltage) should be set a minimum of 2.0 volts greater than the maximum operating voltage when operating in the constant current mode of operation.

3-36 The current threshold should be set at a minimum of 100 ma greater than the maximum load current when operating in the constant voltage mode of operation.

3-35 There will be a time during which both the constant voltage input transistor and the constant current input transistor will be conducting. This will occur when the power supply has been operating in the constant voltage mode of operation and is overloaded, or when the power supply has been operating in the constant current mode of operation and the load is changed so that the output voltage increases and exceeds the voltage ceiling threshold. The transition during which both transistors are conducting is called the crossover region.

3-34 AUTOMATIC Crossover

3-33 When the supply is used in the constant current mode of operation, a voltage ceiling or threshold is established by the output voltage control. That is, if the IR product of the load and the constant current exceeds the threshold as established by the constant voltage control, the supply will operate as a constant voltage supply.

3-32 Special notice should be taken of the action of the current regulating circuit. The power supply will automatically switch to constant current operation when the power supply is overloaded in the constant voltage mode of operation. The constant current regulating circuit will limit the output current to the magnitude established by the current control setting. Since the protection circuit must necessarily be a fast-acting circuit, it follows that the power supply will not perform properly if the current threshold is exceeded in constant voltage operation. For example, if the load on the power supply consists of a class B amplifier which is drawing peak currents in excess of the threshold current, the protection circuit will begin to limit the output current even though the ammeter (which reads only the average current) indicates a current considerably less than the threshold value.

3-31 OVERLOAD PROTECTION CIRCUIT

A diode is connected across the output terminals of the power supply so that in the event a negative voltage is applied to the power supply, the current will be shunted across the output terminals by the protective diode. This diode is used to protect the series transistors and the electrolytic capacitor connected across the output terminals of the power supply.

3-38 MEASURING THE PERFORMANCE OF THE POWER SUPPLY

3-39 The measuring device (differential voltmeter, digital voltmeter, or oscilloscope) 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. It is important that none of the output current flows through the lead lengths in series with the monitoring device since such lead lengths can easily have an impedance of the same order of magnitude as the supply impedance and thus effectively invalidate the measurement.

3-40 Connect either the positive or negative terminals of the supply to the chassis ground and the scope case to the same point, making certain that the scope case is not also grounded by some other means such as the power cord when measuring the power supply ripple. Connect both scope leads simultaneously to the power supply ground terminal to be doubly certain that the scope is not exhibiting a ripple or transient spike that is not coming from the power supply.

3-41 The monitoring device should be connected to the +S and -S terminals (See Figure 3-2) not on the load terminals when conducting performance checks.

3-42 It is recommended that a four-terminal resistor be used to make constant current measurements. The resistor should be a low noise, low temperature coefficient (less than 30 ppm/°C) resistor and should be used at no more than 5% of its rating power.

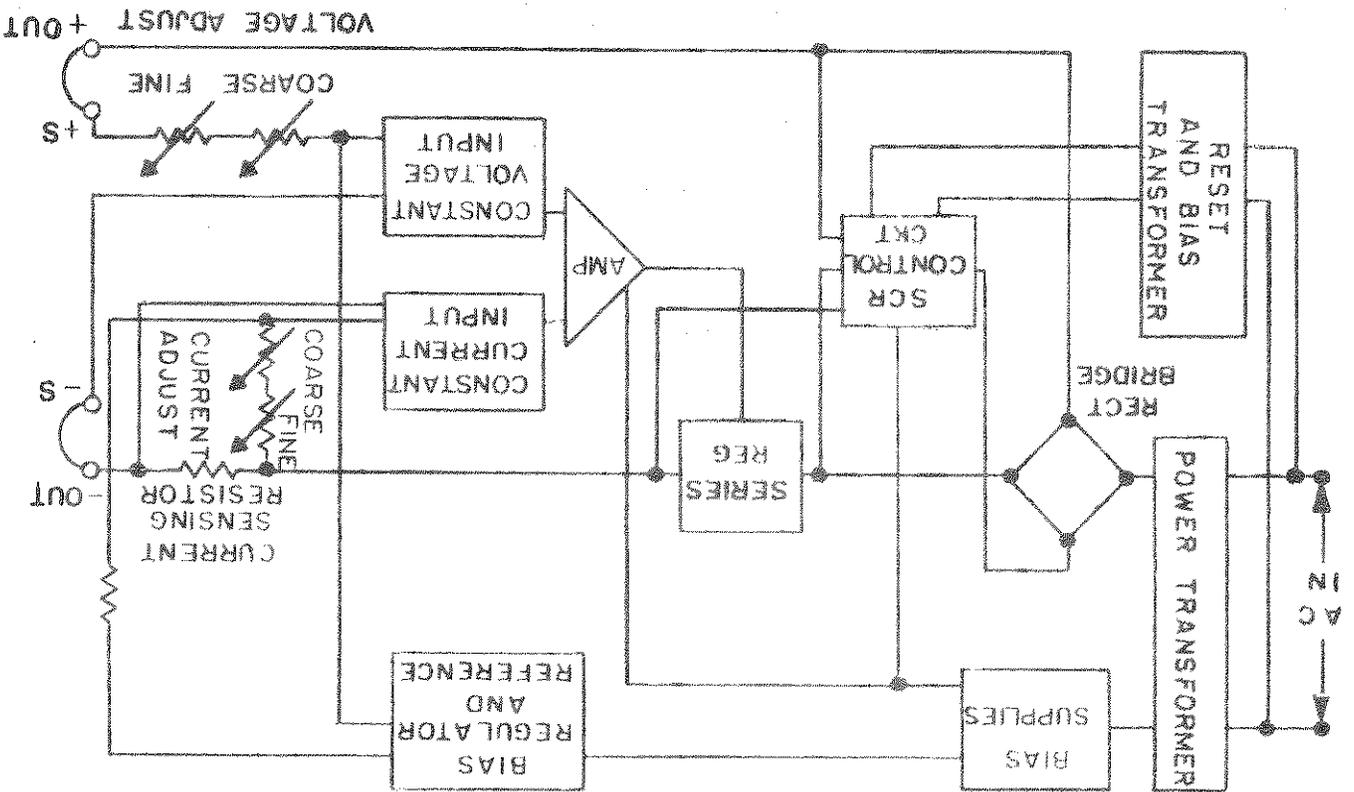
4-4 The auxiliary windings of T1 supply AC voltage to the bias rectifiers and all pertinent voltages are shown in Figure 4-2. Alternating preregulating control voltages (reset and AC compensation) are also supplied by transformer T1.

4-3 BIAS AND RESET SUPPLIES

4-2 The main power transformer supplies AC voltage to the main and auxiliary supplies as control elements. The function of the preregulator is to minimize the power dissipated in the series control element for all output and input conditions. The output current is monitored by a current sensing resistor. The voltage across the current sensing resistor is directly proportional to the output current and provides signal voltage to the current limit input circuit. The output voltage of the power supply is monitored by a constant voltage input circuit through the sensing terminals. Any changes in the output voltage/output current are detected in the constant voltage/constant current input circuit, amplified in the error amplifier, and applied to the series regulator in a manner which tends to counteract the changes in the output voltage/current. The bias supplies furnish voltages which are used throughout the instrument for reference and supply purposes.

4-1 OVERALL BLOCK DIAGRAM (Figure 4-1)

FIG. 4-1 BLOCK DIAGRAM



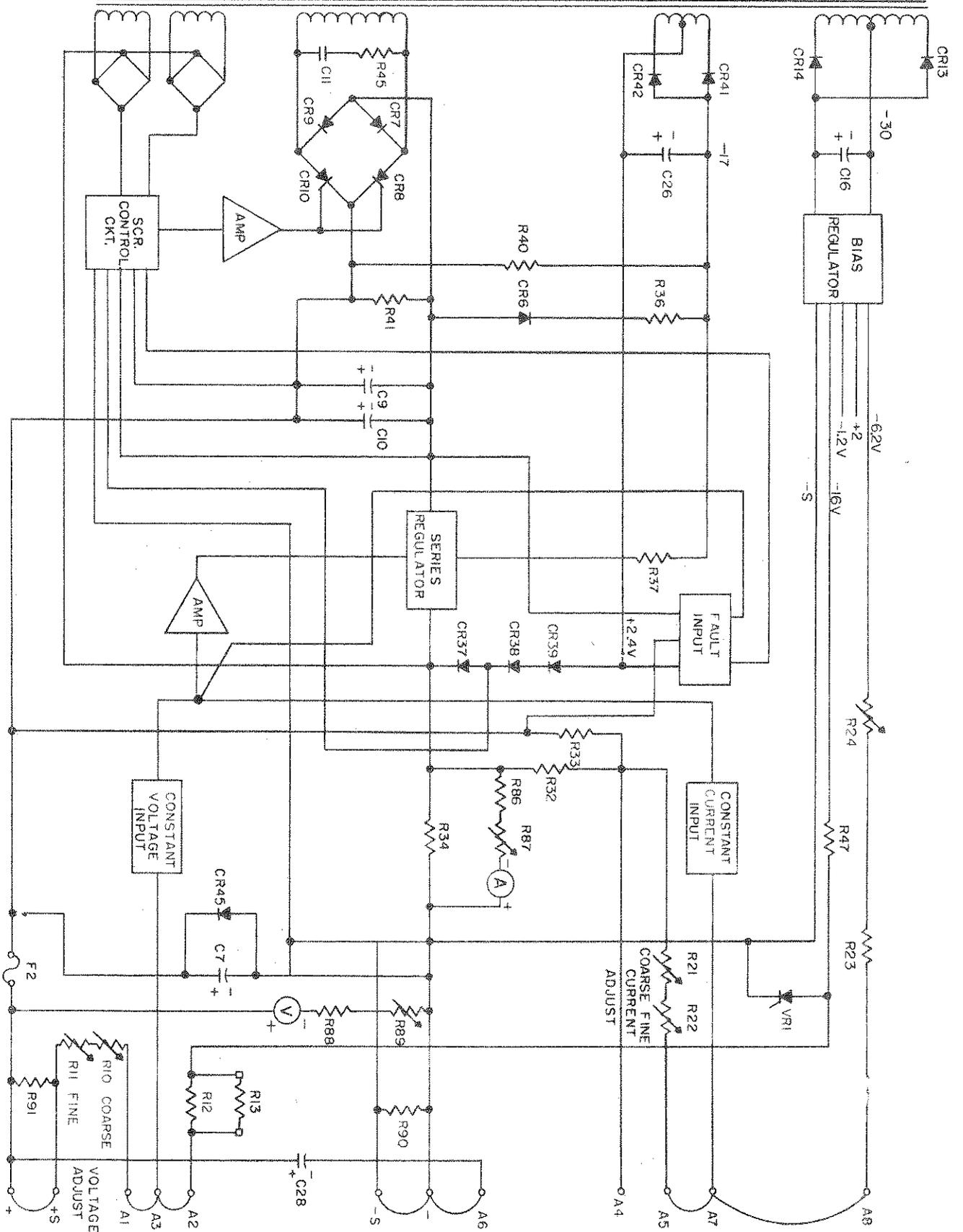


FIG. 4-2 SIMPLIFIED SCHEMATIC

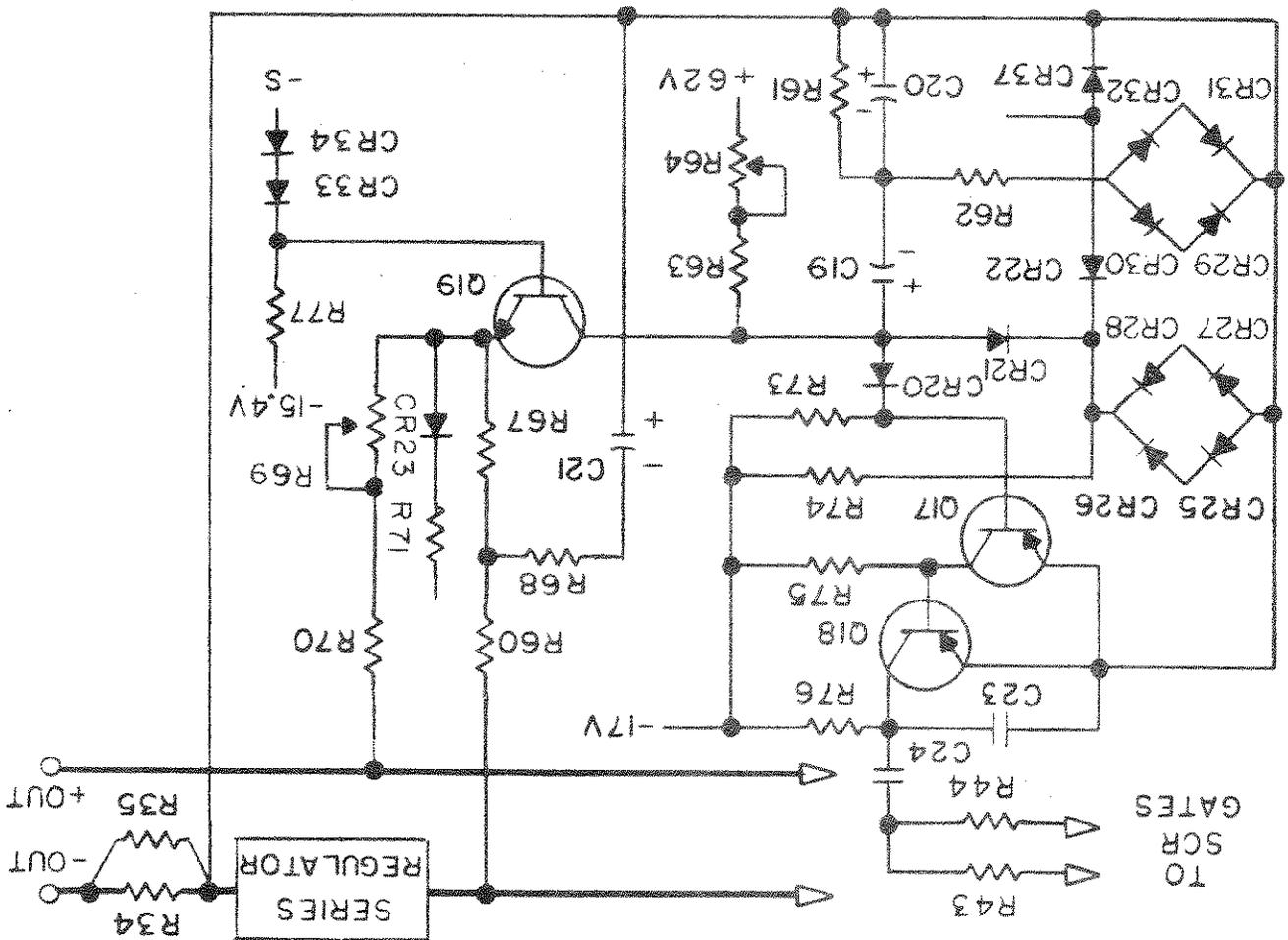
4-5 PREREGULATOR CIRCUIT (Figure 4-3)

4-6 By minimizing the losses in the control element, the prerregulator maintains a high efficiency for all output conditions. The operation of the prerregulator circuit is outlined in the following paragraphs.

4-7 The collector of Q19 serves the summing point for all signal inputs to the prerregulator control circuit. The composite waveform and the individual components of the summing point waveform are shown in Figure 4-4. The presentation will be simplified by examining each signal component separately, followed by the algebraic summation of the signal components (composite waveform). Figure 4-4 will be used for all waveform references.

4-8 E_a is an offset voltage derived by charging the ramp capacitor (C19) with a constant current, supplied through R63 and R64. This current is necessary to sustain a net positive charging current into the ramp capacitor, maintaining maximum output current at low output voltages.

FIG. 4-3 PREREGULATOR

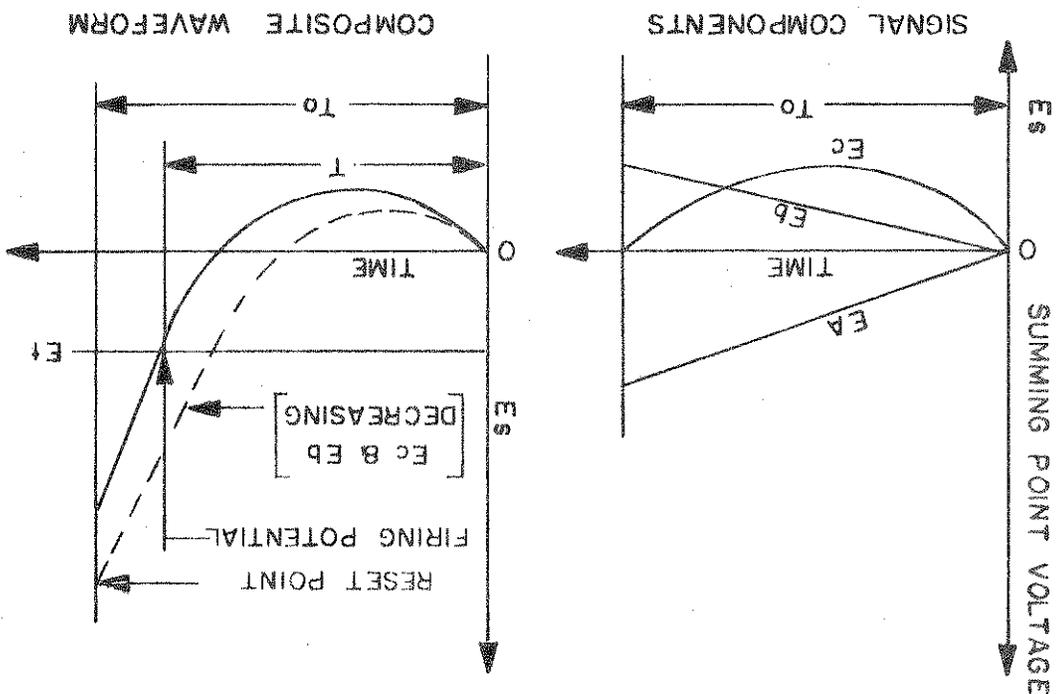


4-11 The algebraic summation of E_a , E_b , and E_c gives rise to a composite waveform E_s . The level necessary to fire the pulse generating circuit is E_t . Upon reaching the voltage, E_t , diode CR20 closes, applying a turn-off signal to the base of Q17, which in turn applies a turn-on signal to the base of Q18. Due to the saturation of Q18, the charge stored in C24 is discharged through the gates of the silicon controlled rectifiers. C23 is high frequency shunt and R43 and R44 are gate current limiting resistors. R71 and CR23 form a turn-on inhibitor circuit which limits the input peak currents.

4-10 E_c is a negative fullwave rectified sinewave voltage, attenuated by the divider action of R61 and R62, and coupled into the summing point by means of the ramp capacitor. The amplitude of E_c is directly proportional to the input line voltage. C20 is used to smooth out any distortion which occurs in the cusp region (zero volts).

4-9 E_b is derived by charging the ramp capacitor with a current controlled by Q19 in accordance with the signals applied to its emitter. R69 and R70 connected between the emitter of Q19 and the positive output bus, are the source of a signal which is proportional to the output voltage. R66 and R67 sense the voltage across and the current through the series transistor. This signal polarity is negative with respect to the signal injected through R69 and R70. The slope of E_b is proportional to the output voltage, the output current, and the voltage across the series transistors. For a given load current, E_b is directed such that the series regulator voltages is maintained constant for all output voltage conditions. C21 and R68 provide equalization necessary to maintain loop stability.

FIG. 4-4



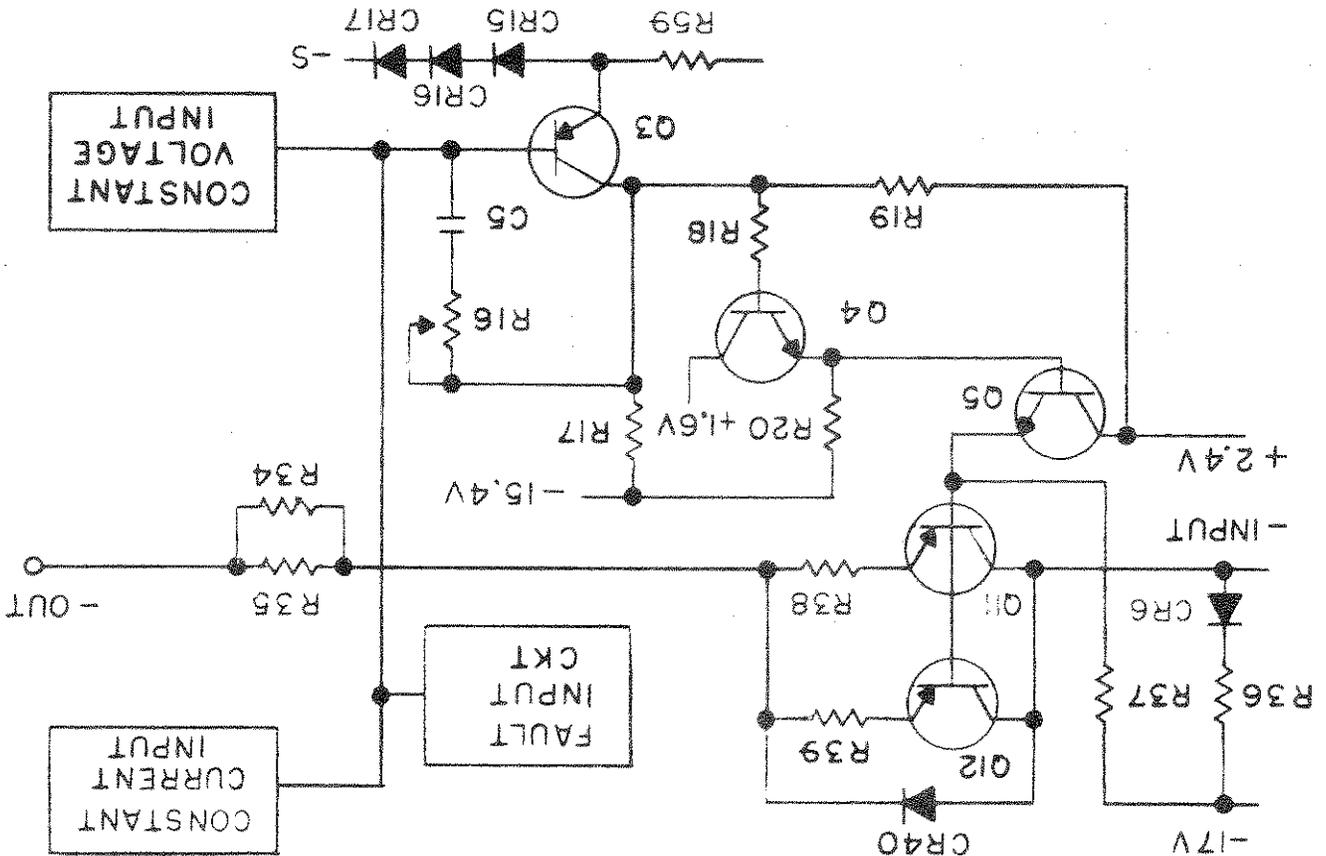
4-12 The firing angle is directly proportional to the time 't' necessary for the E_s to reach E_t . Increasing line input increases E_c and time 't'. Increasing output voltage and load current decreases the slope E_p and time 't'.

4-13 The period of E_s (T_0) is equal to twice the line input frequency (120 cycles). Reset is accomplished by application of a positive fullwave rectified sine wave to the cathode of CR21. Near the completion of the period, E_s becomes more positive than the receding reset sine wave (in the cusp region) and forward biases CR21. C19 is discharged and returned to a voltage level established by CR21, CR22, and CR37.

4-14 SERIES REGULATOR AND ERROR AMPLIFIER (Figure 4-5)

4-15 The series regulator consists of transistors Q11 and Q12. Transistor Q5, an emitter follower, is the drive for the series transistors and Q4, also an emitter follower, is the error amplifier transistor and signals applied to the base are amplified and applied to the base of Q4. C5 and R16 stabilize the feedback loop and CR40 is a protective diode.

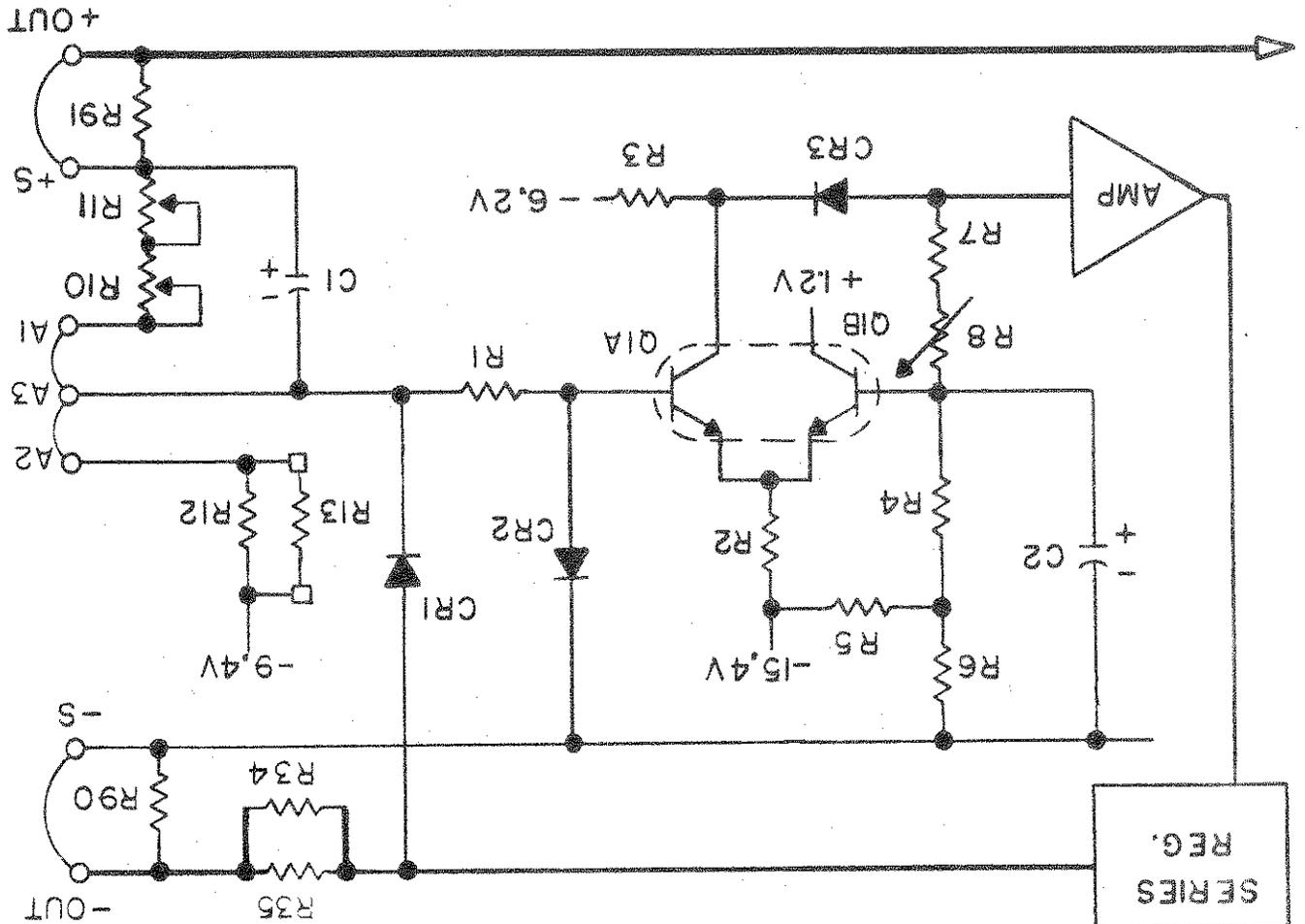
FIG. 4-5 ERROR AMPLIFIER AND SERIES REGULATOR



4-18 A differential amplifier (Q1A and Q1B) and associated circuitry are employed as a detector-amplifier in the constant voltage mode. R12 and R13 (a shunt resistor) are used to establish the programming current level. R10 and R11 are the voltage adjustment potentiometers and are shunted by C1, a low impedance AC signal path. The base of Q1B is grounded through resistors R4 and R6 in order to achieve desired thermal characteristics. The base of Q1A is connected to the junction of the programming resistor and the current pullout resistor R12 through a current limiting resistor (R1). Diode CR1 and CR2 limit voltage excursions on the base of Q1A. R1 limits the current through the programming resistor under conditions of rapid voltage turnaround. R7 and R8 are a positive feedback loop to increase the DC circuit gain, and C2 stabilizes this local feedback loop. CR3 and R3 comprise a decoupling network isolating the constant voltage input when in other modes of operation.

4-17 CONSTANT VOLTAGE INPUT (Figure 4-6)

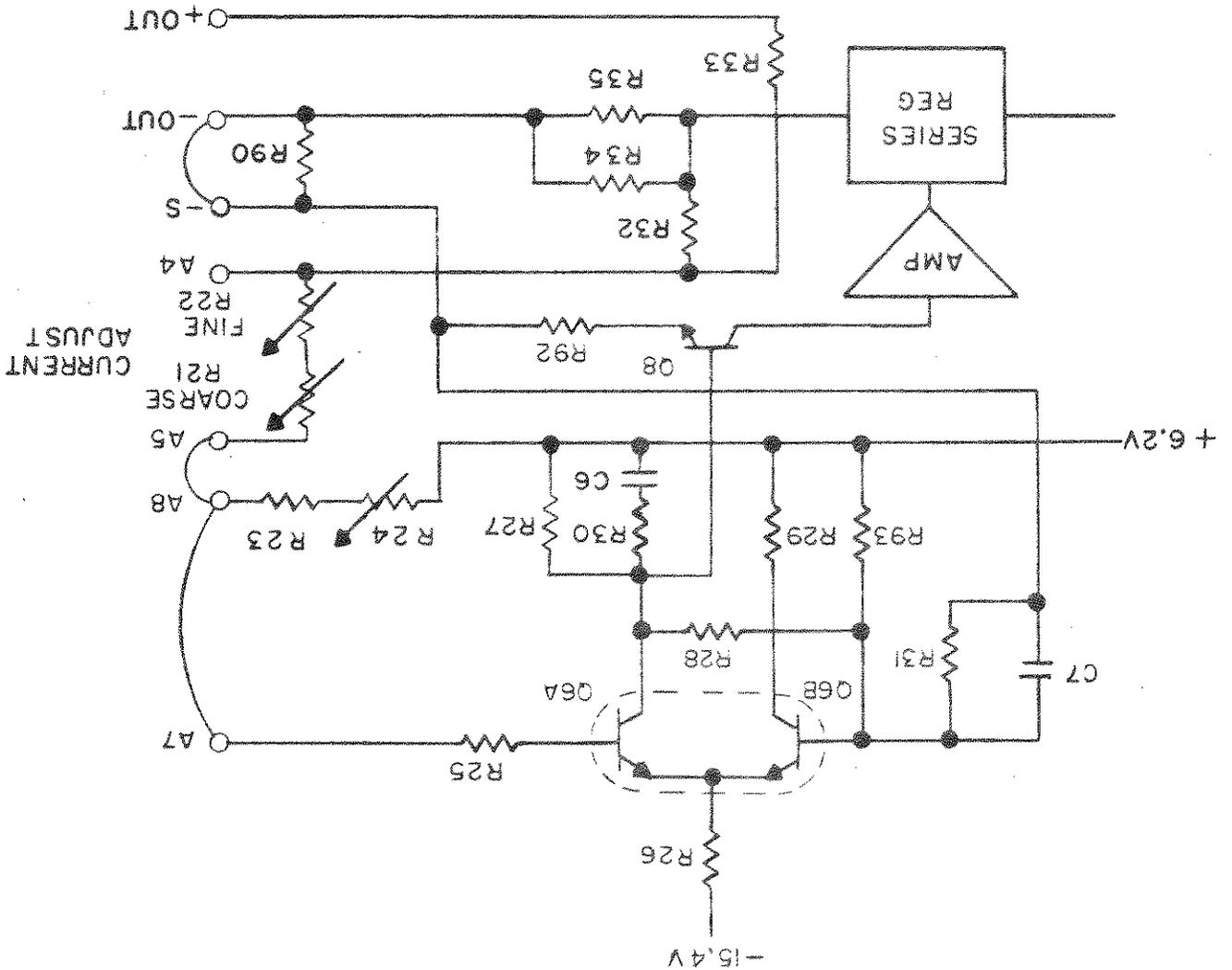
FIG. 4-6 INPUT CIRCUIT, CONSTANT VOLTAGE



4-20 The constant current input circuit consists of the fine current control, R22 and the coarse current control, R21, the amplifier transistors Q6A and Q6B, and associated circuit. The base of Q6B is grounded through the impedance equalizing resistor R31 in order to achieve desired thermal characteristics. The base of Q6A is connected to the junction of the programming resistors and the current pullout resistor, R23, through the impedance equalizing resistor, R25. R24 is used to adjust the programming current. R28 is used to increase DC circuit gain. C7 stabilizes the local feedback loop. R32 and R33 are arranged in a network which changes the bias voltage of Q6A as the output voltage changes. This network is required to compensate for an error current generated by the voltmeter shunting the output terminals. R30 and C6 provide required loop stability in constant current operation. Q8, a common emitter amplifier, increases loop gain, decreasing the current change necessary to traverse the crossover region.

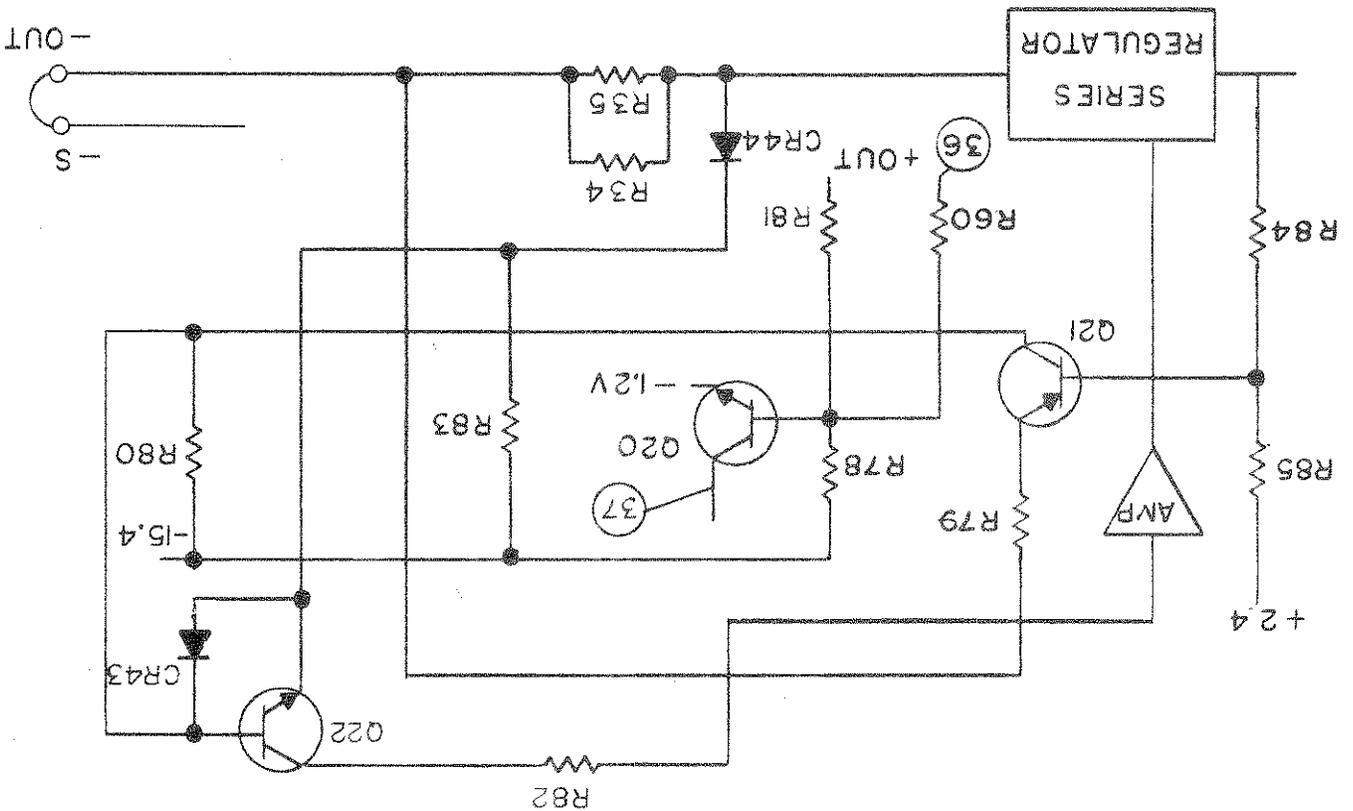
4-19 INPUT CIRCUIT CONSTANT CURRENT (Figure 4-7)

FIG. 4-7 INPUT CONSTANT CURRENT



4-21 OVERVOLTAGE AND SHORT CIRCUIT INPUTS (Figure 4-8)

FIG. 4-8 FAULT INPUT CIRCUIT



4-22 A circuit configuration consisting of Q20, R60, R78, and R81 forms an overvoltage detector. One end of the divider R78 and R81 is supplied from the -15.4 volt source and the other is connected to the positive output. Fullwave rectified sinewave voltage is applied through R60 and exercises a stabilizing influence. If the output rises above a predetermined level, Q20 is acted upon and conducts, transmitting a turn-off signal to the preregulator control circuit. The overvoltage circuit is set for approximately 115% of maximum rated output.

4-23 Short circuit protection is accomplished by means of Q21, Q22, R79, R80, R84, and R85. Divider R84 and R85 is connected between the series regulator collector and the +2.4 volt supply. Q21 and Q22 are non-conducting under normal conditions; however, under short circuit conditions, the increased voltage across the series regulator drives Q21 into the saturated mode of operation. The voltage established by divider R79 and R80 at the base of Q22 forward biases Q22. The action of Q22 is to limit the current flow in the series regulator to a prescribed level. While maintaining a safe power level in the series regulator, the current discharges the input capacitors rapidly and insures quick recovery.

4-25 The unregulated input voltage across C16 is finely regulated by means of Q14, Q15, Q16 and associated circuitry. The series regulator, Q16, is driven by Q15, an error amplifier, and the error amplifier is driven by the detector, Q14. The reference element for the bias regulator and the entire unit is VR1. R48 and R50 are the comparison elements and VR2 is utilized for an additional bias source. R57 attains output immunity to line variations. R56 minimizes power dissipation in Q16 and C17 and C14 stabilize the bias regulator loop.

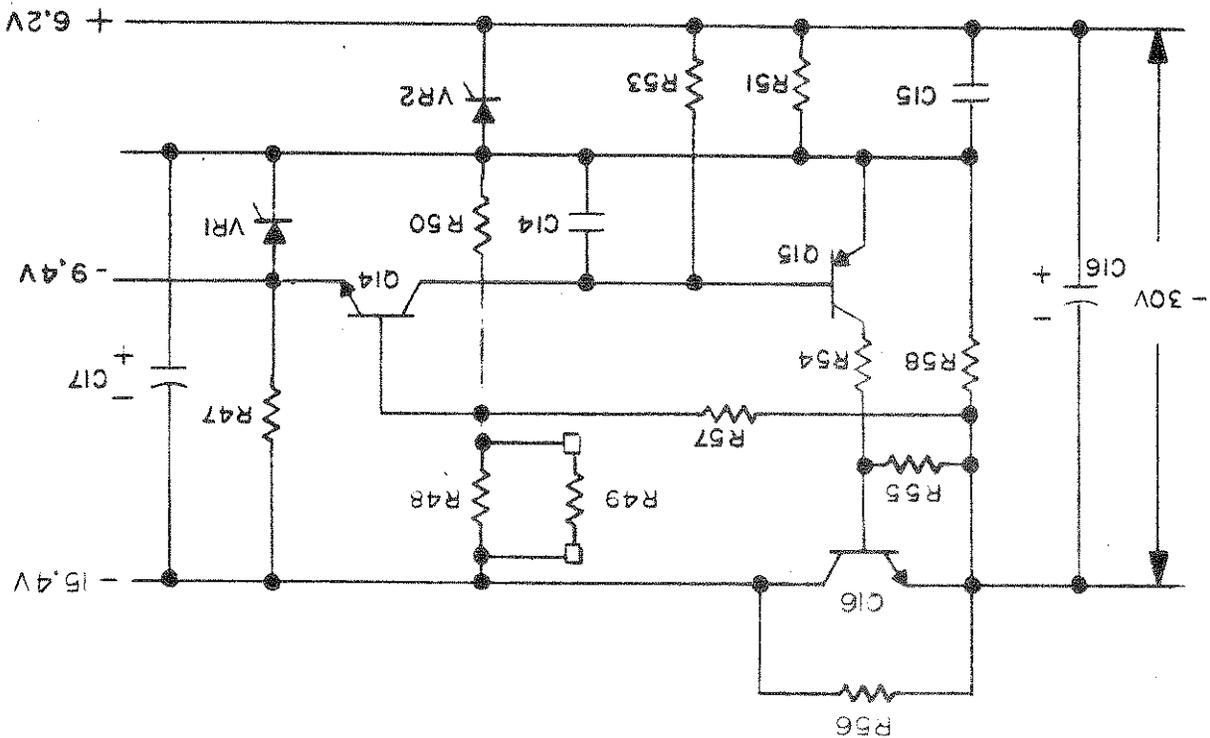
4-26 REGULATOR CIRCUIT OPERATION

4-27 The circuit functions as follows when the output voltage changes. The change may be a slow shift in the output voltage or an AC signal. AC signals are fed to the base of Q1A through C1, and DC signals are coupled through R10 and R11. The signals are amplified, reversed in phase, and coupled to the base of Q3 through the gating diode CR3.

4-28 The voltage on the anode of the CR3 and the collector of Q8 is established by the base voltage of Q3. The cathode voltage of CR3 is established by the collector voltage of Q1A. The base voltage of Q8 is established by the collector voltage of Q6A. Transistor Q1A will be conducting when the supply is in the constant voltage mode of operation and CR3 is forward biased.

4-24 REFERENCE AND BIAS CIRCUIT (Figure 4-9)

FIG. 4-9 BIAS REGULATORS AND REFERENCE CIRCUIT



4-29 Transistor Q6A, begins to conduct when the supply goes into the constant current mode of operation. At this time, the voltage across the output terminals decreases. The signal applied to the base of Q1A will result in its collector voltage going positive and reverse biasing CR3. Q8 is forward biased due to the conduction of Q6A. There is a transistor region during which both inputs will be active and is referred to as the crossover region.

4-30 The signal applied to Q3 is amplified, inverted and applied to the base of the predriver Q4 which applies the amplified signal in phase to the base of Q5 the driver. This signal is amplified by Q5 and applied to the base of the series transistors Q11 and Q12. The signal is applied in the phase and amplitude required to restore the original operating conditions, thus maintaining the output voltage/output current of the power supply constant.

4-31 The DC output voltage is changed by varying the front panel controls. Resistor R12, in conjunction with the reference voltage, can be considered a constant current source since the voltage at the summing point (11) is at circuit ground when the loop is in equilibrium. Potentiometer R10 and R11 are connected between the summing point and the positive sensing terminal, and since the current through it is constant, feedback action of the regulator loop will maintain the output voltage of the power supply equal to the drop across this resistor.

4-32 The DC output current is changed by varying the front panel controls. The operation of the constant current circuit is similar to the constant voltage mechanism, the input to the constant current circuit is the algebraic sum of the voltage across R21, R22, R34. R21 and R22 set the constant current level and R34 monitors the output level. Any changes are detected, amplified, and applied in proper phase to restore the original operating conditions.

Section V

MAINTENANCE

5-1 COVER REMOVAL AND REPLACEMENT

5-2 The cover is divided into top and bottom. Removal of the top cover provides access to a printed circuit board.

5-3 TOP COVER REMOVAL

- a. Remove the six retaining screws.
- b. Lift cover from the instrument.

5-4 TOP COVER REPLACEMENT

5-5 Replace the top cover by positioning the cover flat over the six retaining screw holes. Replace the cover retaining screws.

5-6 BOTTOM COVER REMOVAL

- a. Remove the six retaining screws.
- b. Lift cover from the instrument.

5-7 BOTTOM COVER REPLACEMENT

- a. Replace the cover by positioning the cover flat over the six retaining screw holes.
- b. Replace the cover retaining screws.

5-8 TEST EQUIPMENT REQUIRED

5-9 The test equipment required for adjustment of the instrument is listed in Table 5-1. The table includes the type of equipment required, critical specifications, where the equipment is used, and recommended available commercial test equipment.

5-10 TROUBLE SHOOTING

5-11 The purpose of the trouble shooting procedure is to enable maintenance personnel to isolate troubles to a specific area, not necessarily a component. A systematic approach, such as is given later in this section, can speed up repair and minimize down time.

(continued on Page 5-12)

This voltage is measured between -S and Z7 and should be 9.4

1. Reference Voltage

5-21 Measure Power Supply Voltages. The following precautions should be taken before power supply voltages are measured. The voltage control pot and current control pot should be turned to the maximum clockwise position. The power supply should be unloaded. It is advisable to make an ohmmeter check to be certain that neither the positive or negative output terminal is grounded. The power supply may now be turned on. The following voltages which are particularly critical should then be measured first.

5-20 DETAILED TROUBLE SHOOTING PROCEDURE

5-19 The semiconductor in Harrison Laboratories power supplies generally have an H-Lab designation. Table 5-3 lists the characteristics of the semiconductors used in this power supply and suggested commercial replacements.

5-18 Before removing any transistors from the power supply, the transistors should be labeled so that in the event a defective transistor is found, its circuit location may be identified and therefore aid in isolating the source of trouble.

5-17 SEMICONDUCTOR REPLACEMENT

5-16 The circuit consisting of series regulators and amplifiers presents a difficult problem for systematic trouble analysis. This is a feedback circuit in which a faulty component anywhere will affect the operation of the entire loop. If it is necessary to replace any component refer to Table 5-2. Replacement Guide, for adjustments or tests which may be necessary.

5-15 Perform a visual inspection for broken leads, overheated resistors, or cold solder joints.

5-14 A systematic trouble shooting procedure can be followed with this instrument. For instance, if there is no voltage throughout the instrument, check for obvious faults such as burned out fuses (AC and DC), defective power cable, or power line failure, or improper strapping.

5-13 Before attempting to trouble shoot this instrument, make sure the fault is with the instrument and not with the associated circuit. The performance test will enable one to determine this without having to remove the instrument from the cabinet. The performance test will be found in paragraph 5-50.

5-12 TROUBLE ANALYSIS

Instrument Type	Required Characteristics	Use	Suggested Test Equipment
DC Voltmeter	Accuracy of $\pm 2\%$ Approx. ranges 0-2.5 volts 0-50 volts 0-150 volts	Measure DC	Simpson Model 269
DC Ammeter	0-10 amps Accuracy $\pm 1\%$	Measure DC Currents	
AC Voltmeter	Accuracy of $\pm 2\%$ Approx. voltage ranges 0-150 volts	Measure AC Voltages	Simpson Model 269
AC Voltmeter	Accuracy of $\pm 1\%$ 90-130 Volts Expanded scale 100-130 volt ranges 5 amp current capacity	Measure Input Line Voltage Change AC Input Voltage	Triplet Model 420M Superior Type Q116U
Variable Transformer			
Oscilloscope	200 μ v/cm sensitivity differential input	Measure Ripple, trans- ient Response	HP Model 130C
Differential Voltmeter	1mv resolution	Measure Regulation	See note
Load Switch	2 μ sec rise and fall time	Measure Transient Response	Mercury Relay, Clare Type HGP1002

TABLE 5-1

CAUTION: Care must be exercised when using an electronic null detector in which one input terminal is grounded.

NOTE: A satisfactory substitute for a differential voltmeter is a stable reference voltage and null detector. One side of the reference voltage is connected to the power supply sensing terminal. The null detector is connected between the other power supply sensing terminal and the reference voltage. A null meter (HP Model 425A) or DC coupled scope utilizing the differential input (HP Model 130C) may be used as the null detector. A simple and satisfactory null detector is a 50 millivolt meter movement. On a 100 division scale, a two millivolt change in voltage results in a meter deflection of 4 divisions which is adequate resolution. Suitable differential voltmeters are Fluke Model 801H and Keithly Model 660.

Instrument Type	Required Characteristics	Use	Suggested Test Equipment
Load	12 ohms, 200 watts 6 ohms, 100 watts, and 3 ohms, 20 watts	Measure Loaded Characteristics	at 36 volts, 18 volts and 9 volts.
Current Monitoring Resistor	0.3 ohm 1%, 200 watts 20 ppm temperature coefficient	Measure Constant Current Operation and Adjust ammeter	

TABLE 5-2

REPLACEMENT GUIDE

Check the following and readjust:

If you change:

Q1A, Q1B, CR3, CR15, CR16, CR17
CR37, CR38, CR39, VR2

Q3, Q4, Q11

Load regulation, transient response,
constant voltage, R8, R16

Q6A, Q6B, Q8, VR2

Line and load regulation, constant current.

Q14, Q15, Q16, VR1, VR2, CR8

Line regulation at 15.4 volt source

CR33, CR34, Q19, VR2

Series Regulator Voltage R64

Component	Characteristics	H-Lab Designation	Suggested Replacement
Q4,16	NPN Si planar 50 < h _{FE} < 250 I _C = 1 ma V _{CE} = IV, I _{CO} 0.25 ma @ V _{CB0} = 30V	4JX1C710	2N2195A GE 2N2219 Mot.
Q3,17,18,21	PNP Alloy 70 < h _{FE} < 200 I _C = 1 ma, V _{CE} = IV I _{CO} 2 ma @ V _{CB0} = 5V	GT2555	2N520A GI 2N404A GE RCA
Q15	PNP Alloy 75 < h _{FE} I _C = 50 ma, V _{CE} = IV F _{MAX} 90 mx @ 70° C Ambient	2N1377	2N1377 TI
Q1A, B Q6A, B	PNP Power Drift Field 70 < h _{FE} I _C = 1 ma, V _{CE} = IV I _{CO} = 10 na @ 250° C V _{CB0} = 20V V _{CE0} = 15V V _{BE1} - V _{BE2} = 2 mv Δ V _{BE1} - Δ V _{BE2} = 25 μV/°C	4JX1ZA839	2N2640TI 2N2480A GE 12A8 GE
Q8,14,19,20, 22	NPN 75 < h _{FE} < 225 I _C = 2 ma V _{CE} = 4.5V I _{CO} = .5 ma @ 250° C V _{CB0} = 18V	16B2	2N2195A GE 2N2219 Mot.
Q11	PNP Power 75 < h _{FE} < 150 I _C = 3A V _{CE} = IV I _{CO} = 2 ma 250° C V _{CB0} = 60V V _{CEs} = 75V	B1203	2N1137A Bendix

TABLE 5-3

TABLE 5-3 (Cont'd)

Component	Characteristics	H-Lab Designation	Suggested Replacement
CR1, 2, 3, 6, 11, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32	SI Diode Low Leakage	IN485B	IN485B IN484A
CR15, 16, 17, 33, 34, 37, 38, 39	SI Rectifier .2 Amps	1N151	IN484A SYL. IN485B SYL.
CR13, 14, 41, 42	SI Rectifier	IN3253	IN3253 RCA IN2611
CR8, 10	SCR 20 Amp rms 100 volt PRV	C20A	C20A GE C11A GE
CR7, 9	SI Rectifier 12 Amps	IN1200A	IN1200A RCA IN1342 RCA
CR40, 45	SI Rectifier 3A, 200 PRV	MR1032B	MR1032B Mot IN1200 RCA
VR2	6.2V 400 mw zener	1N821	1N821 NA
VR1	9.4 Temperature compensated reference diode	IN2163	IN2163 Semcor IN2621

*NOTE: These components are mounted using a mica washer and silicon grease. When replacing transistors or diodes be sure to replace the insulating washer and the silicon grease so that these components will have good heat conduction to the chassis.

NOTE: The voltages listed above are measured at 36 volts, no load, and 115 volts line. These voltages will vary with line and load. The DC voltages were measured with a one hundred thousand ohms per volt voltmeter (Simpson Model 269). The ripple voltages were measured with an HP Model 130C oscilloscope using the differential mode of operation and grounded at the negative output terminal of the power supply.

200µV	±0.4V	9.4V	27	-S
1.0V	±2.0V	25.0V	32	-S
2 mV	±0.2V	1.2V	50	-S
1.0V	±2.0V	17.0V	58	-S
1mV	±0.4V	1.2V	56	-S
30 mV	±0.2V	5.8V	25	-S
500µV	±1.0V	15.4V	28	-S
1 mV	±0.4V	6.2V	-S	33
2 mV	±0.2V	1.8V	-S	15
20 mV	±0.4V	2.4V	-S	59
2 mV	±2.0V	22V	28	33
0.5V	±2.0V	30V	32	33
30 mV	±0.5V	41.0	39	+
500 µV	----	36.0V	-	+

Measured From
+ to -

POWER SUPPLY VOLTAGES

TABLE 5-4

MISCELLANEOUS TROUBLES

TABLE 5-5

Check:

Trouble and Description

1. Excessive Output Ripple
 - a. Check to see if output is grounded. Use 1µf capacitor if it is impossible to DC ground.
 - b. Check voltage across series transistors Q1. Use a scope, DC coupled to make the measurement which should be $3.5V \pm 0.4V$.
 - c. Check 22 volt ripple. Should be maximum of 2 mv peak-to-peak. Check current control to be certain power supply is not operating in constant current mode.
 - d. Check current control to be certain

2. Poor Line Regulation

Check 15.4 volt line regulation.

3. Poor Load Regulation
(Constant Voltage)

- a. Measurement Technique -- should measure across the sensing terminals.
- b. Check adjustment of R8.
- c. Incorrect strapping of sensing terminals.
- d. Q1A, Q1B, or Q3 defective.
- e. Current control set too close to maximum operating current.

4. Poor Load Regulation
(Constant Current)

C27 leaky -- External load across output terminals (i.e. low impedance voltmeter) Q8, Q3, Q6A, Q6B, or VR2 defective. Voltage control set too close to maximum operating voltage.

5. Oscillates

Check adjustment of R16 (equalizer), capacitor C5, and strap between A6 minus.

TABLE 5-5 (Cont'd)

Trouble and Description	Check:
6. Voltage Limited (Cannot reach maximum output voltage)	<p>a. Check the voltage across series regulator Q11 for $3.5V \pm 0.4V$.</p> <p>b. Check Q4, Q19, VR1, CR33 and CR34 if less than required.</p> <p>c. Check R10 (voltage programming), R21 (constant current programming), reference voltage (9.4V), Q3, Q22, CR15, CR16, CR17, CR37, CR38, CR39, VR1 and -17 volt unregulated bias if series regulator voltage is high.</p>
7. Current Limited	<p>a. Check the voltage across series regulator Q11 for $3.5V \pm 0.4V$.</p> <p>b. Check drop across R34 which should be 0.9 volts at 3.0 amps. The resistance of R67 should be 0.30 ohms $\pm 5\%$. Check VR2, Q6A, Q6B and Q8 if series regulator voltage is high.</p> <p>c. Check R10 (voltage programming potentiometer), Q3, Q4, and -17 unregulated supply if the series regulator voltage is low.</p>
8. Stability (Constant Voltage)	<p>a. Measure stability of reference voltage (9-9.8V). Change diode VR1 if this voltage is unstable.</p> <p>b. Check programming resistor (use supply in Remote Programming with a good quality, stable 20 ppm programming resistor.</p> <p>c. Replace R12 noting R13 should be a minimum of ten times larger in resistance than R12.</p> <p>d. Check Q1A, Q1B, Q3, CR1, CR2 and CR3.</p>
9. Stability (Constant Current)	<p>a. Measure stability of reference voltage 6.2 volts measured between -S and change VR2 if unstable.</p> <p>b. Operate power supply in constant current remote programming mode using a good quality, stable 20 ppm and TC Resistor, as programming resistor to check R34 as source of drift. Check R23, R24, and R26.</p>

9. Stability (Constant Current)
c. Change Q6A and Q6B if above steps do not yield positive results.

Trouble and Description
Check:

A. A differential voltmeter is used to monitor the voltage between -S and 28.

5-28 Regulated Bias Adjustment

5-27 The line switch is turned on. The output voltage should exceed 36 volts. Vary the output voltage with the voltage control pot to be certain that the voltage control is operative. If the output voltage cannot be changed, follow the trouble shooting procedure as outlined in section 5-20.

5-26 Make sure that both the AC and DC fuses are inserted in the fuseholders. The front panel voltage control and current control pots should be turned to the maximum clockwise position. Use an ohmmeter to make certain the negative output terminal, and the collector of Q11 the anodes of CR25 and CR27 and the cathodes CR8 and CR10 are not grounded.

5-25 The following adjustments procedure is that which is followed in the factory and is normally not required when a unit is repaired.

5-24 POWER SUPPLY ADJUSTMENTS

5-23 Generally, malfunction of the supply is indicated by the absence of or excessive output voltage. Table 5-5 is a list of malfunctions and circuit areas to check.

5-22 Table 5-4 lists other voltages to measure the tolerances of these voltages, and typical peak-to-peak ripple.

This voltage is measured between -S and 26. It should be 6.2 volts ± 0.4 volts. Diode VR2 is probably defective if this voltage is out of specification.

3. +6.2 Volts

This voltage is measured between -S and 28. It should be 15.4 volts ± 1.0 volts. If this voltage is out of specification, R48 may be defective. Diodes VR1, VR2, transistors Q14, Q15 or Q16 may be defective.

2. 15.4 Volt Regulated Bias Voltage

The 15.4 volt regulated bias voltage is out of tolerance or diode VR1 is probably defective if this voltage is out of specification.

- A. Turn on instrument and allow it to come up to normal operation temperature (about 20 minutes).
- B. Turn the instrument off. Wait 3 minutes for power supply capacitors to discharge completely.
- C. Rotate adjustment screw on top of meter clockwise until the meter pointer is to the left of zero and further clockwise rotation will move the pointer up scale towards zero.
- D. Turn the adjustment screw clockwise until the pointer is exactly over the zero mark on the scale. If the screw is turned too far, repeat steps C and D.
- 5-32 The meter pointer must rest on the zero calibration mark on the meter scale when the instrument is at normal operating temperature, resting in its normal operating position, and the instrument is turned off. To zero-set the meter proceed as follows:
- 5-31 ZERO SETTING THE METER
- A. R24 is adjusted so that the output current is limited to 3.4 amps ± 0.1 amp. (Note: The output voltage will drop since the power supply will go into constant current operation).
- B. The coarse current control is set to maximum counterclockwise position to check for zero current.
- 5-30 Constant Current Adjustments. The output voltage of the power supply is set to 3 volts. The coarse current adjust is set to a maximum clockwise position. The fine current control is set to the maximum counterclockwise position. The power supply is short circuited.
- A. The output of the power supply is set at 36 volts and 3 amperes. The voltage across points 25 and 22 (series regulator voltage) is monitored using a Simpson 269 or equivalent. R64 is adjusted for 3.5 volts ± 0.1 volt.
- B. The output of the power supply is set at 3 volts and 3 amperes. The voltage is checked for 3.5 volts ± 0.4 volts.
- 5-29 Series Regulator Voltage Adjustments
- B. R49 is adjusted so that this voltage is approximately 15.4 volts.
- C. The input line voltage is varied from 102 to 127 volts. The voltage should not vary more than 10 mv as the input line voltage is varied.

- E. Turn meter adjustment screw counterclockwise about 15 degrees to break contact between adjustment screw and pointer mounting yoke, but not far enough to move the pointer back downscale. If the screw is turned too far, as shown by the needle moving, repeat the procedure. The meter is now zero-set for best accuracy and mechanical stability.
- 5-33 Ammeter Calibration. An external ammeter accurate to 1.0% or better is used to measure the output current at 3.0 amperes. R87 is adjusted so that the front panel meter indicates 3.0 amperes.
- 5-34 Current Equalization Check. The power supply is operated at 12.0 volts out, 3.0 amperes load, and 125 volts line. The voltage between points 25 and 52 is monitored using an AC coupled scope, and the ripple unbalance should be less than 25%.
- 5-35 Programming Current Adjustment
- A. A differential voltmeter is connected between -S and +S. The strap between A1 and A2 is removed. A 7.2K, 0.5% programming resistor is connected between A2 and +S. A decade resistance is connected in the position of R13 and the power supply is turned on.
- B. The decade resistance is adjusted so the output voltage of the power supply as indicated by the differential voltmeter is 36 volts \pm 2%.
- C. The value of the decade resistance is noted. The power supply is turned off and the decade resistance is replaced with a fixed resistor of equal value (\pm 5%).
- D. The value of the shunt resistor should be a minimum of 10 times the resistance of R12. If it is less than this, R12 should be replaced.
- 5-36 Voltmeter Adjustment (See 5-32 for meter zero adjustment). An external voltmeter (accuracy of 1.0% or better) is used to measure the output voltage of the power supply. The output voltage is set to 36 volts. R89 is adjusted so the front panel meter indicates 36 volts.
- 5-37 Load Regulation. The power supply is operated at 36 volts out, 115 volts line. A differential voltmeter is connected between -S and +S. The output load is varied from 0 to 3 amperes. R11 is adjusted so that the output voltage does not decrease more than 3 mv when the load is applied.
- 5-38 Line Regulation. The power supply is operated at 36 volts out and full load. A differential voltmeter is connected between -S and +S. The input line voltage is varied from 105 to 125 volts. The output voltage should not vary more than 3 mv as the input voltage is varied. The line regulation of diode VRI should be checked in the event the output voltage varies more than 3 mv.

- 5-39 Output Ripple. The power supply is operated at 36 volts out, full load and 102 volts line. An oscilloscope is connected between +S and -S. One of the output terminals of the power supply must be grounded. The maximum 120 cycle peak-to-peak ripple as indicated on the oscilloscope should not exceed 1 mv.
- 5-40 Low Voltage Ripple. The power supply is operated at 3 volts out, no load and 125 volts line. An oscilloscope is connected between +S and -S. One of the output terminals of the power supply must be grounded. The maximum 120 cycle peak-to-peak ripple should not exceed 1 mv.
- 5-41 Transient Response. The power supply output voltage is set at 36 volts. A switch is used to vary the power supply load from no load to 3.0 amperes. An oscilloscope is connected between +S and -S. R16 is adjusted so that the decay of the transient spike is a smooth exponential curve without undershoot, overshoot, or ringing for both the loading and unloading transients. The voltage should recover to within 10 mv of the nominal output voltage in less than 50µseconds. NOTE: The load should be non-inductive. The switch should have a maximum rise and fall time of 2µseconds. A mercury relay such as the Clare relay type HGP 1002, manufactured by the C.P. Clare & Company, Chicago, Illinois, operated at line frequency is a satisfactory switch.
- 5-42 Constant Current Checks.
- 5-43 The strap between A6 and minus is removed. This removes capacitor C28 from across the output terminals of the power supply.
- 5-44 A one ohm resistor is connected in series with an 11.0 ohm load. The one ohm resistor will be used to monitor the output current of the power supply. It should be a stable, low noise resistor having a temperature coefficient of 20 ppm or better and used at no more than 5% of its rated power. Refer to 3-42 for recommended measurement techniques. The output voltage of the power supply is changed in constant current operation by changing the load.
- 5-45 The power supply is turned on and the front panel voltage controls set fully clockwise and adjust load for 36 volts at 3 amperes.
- 5-46 Constant Current Ripple. An oscilloscope is connected across the current monitoring resistor. The maximum peak-to-peak ripple observed on the oscilloscope should not exceed 3 mv (3ma).
- 5-47 Line Regulation. A differential voltmeter is connected across the current monitoring resistor. The power supply is operated at 36 volts out and 3 amperes load, and 105 volts line. The voltmeter reading is noted. The line voltage is changed to 125 volts. The change in voltage across the current monitoring resistor, should not exceed 1 mv (1 ma).

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5-16

5-59 A one ohm, 200 watt, low temperature coefficient, wirewound resistor is connected in series with a 12.0 ohm load. The one ohm resistor is the current sensing or monitoring resistor. The power supply voltage controls are turned to the maximum clockwise position.

5-58 CONSTANT CURRENT

5-57 Transient Response. The power supply is operated at 36 volts out and 115 volts line. A switch having a rise and fall time of 250 microseconds or less is connected in series with a non-inductive load resistor selected so that the power supply is operated at 3.0 amperes. An oscilloscope is connected across the sensing terminals. The output voltage should recover to within 10 millivolts of the nominal output voltage within 50 microseconds for both the loading and unloading transients. The decay of the transients should be a smooth exponential decay without ringing, overshoot, or undershoot. (See 5-41).

5-56 Load Regulation. The power supply is operated at 36 volts out and 115 volts line. A differential voltmeter is connected across the sensing terminals. The output voltage should not decrease by more than 3 millivolt when a 3 ampere load is applied.

5-55 Line Regulation. The power supply is operated at 36 volts and 3 amperes load. A differential voltmeter is connected across the sensing terminals. The input line voltage is varied from 105 to 125 volts. The output voltage should not vary more than 3 millivolts.

5-54 Ripple Check. The power supply is operated at 36 volts out and full load and at an input line voltage equal to 105 volts. An oscilloscope is connected across the sensing terminals. Maximum peak-to-peak 120 cycle ripple should not exceed 1 mv. NOTE: One output terminal of the power supply must be grounded.

5-53 Voltmeter Check. An external voltmeter having an accuracy of 1% or better is connected across the output terminals and is used to check the front panel voltmeter at 36 volts out.

5-52 CONSTANT VOLTAGE

5-51 These tests are in-cabinet specification checks and are made before disturbing any of the internal power supply adjustments. The tests may be used as an incoming inspection test, periodic maintenance, or to check the instrument after repairs. Refer to section 3-38 before making measurements.

5-50 PERFORMANCE TEST

5-49 The power supply is turned off, the strap between A6 and minus is replaced.

5-48 Load Regulation. A differential voltmeter is connected across the current monitoring resistor. The power supply is operated at 36 volts out, 3 amperes load, and 115 volts line. The voltmeter reading is noted. The 12.0 ohm load is shorted. The change in voltage across the current monitoring resistor should not exceed 1 mv (1ma). NOTE: The supply will go momentarily into short circuit protection.

5-60 Ripple Current. An oscilloscope is connected across the current monitoring resistor. The current control is adjusted so that the output current is 10.0 ampere. The maximum peak-to-peak 120 cycle ripple should be less than 3 ma (3 mv across 1 ohm).

5-61 Line Regulation. A differential voltmeter is connected across the current monitoring resistor. The power supply is operated at 3 amperes and 36 volts out. The line voltage is varied from 105 to 125 volts. The output current should not change more than 1 ma (1 mv across 1 ohm).

5-62 Load Regulation. A differential voltmeter is connected across the current monitoring resistor. The power supply is operated at 36 volts out and 3 ampere load. The voltage across the current monitoring resistor is noted. The external 12.0 ohm load is shortcircuited. The current magnitude as indicated by the differential voltmeter should not change more than 1 ma from that recorded at 36 volts output. NOTE: The supply will momentarily go into short circuit protection.

SECTION VI
REPLACABLE PARTS

6-1 INTRODUCTION

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

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

- a. Reference Designators. For abbreviations, refer to Table 6-1.
- b. Description. Refer to Table 6-2 for abbreviations.
- c. Total Quantity (TQ) used in the instrument; given only first time the part number is listed.
- d. Manufacturer's part number.
- e. Manufacturer's code number. Refer to Table 6-3 for manufacturer's name and address.
- f. Part Number.
- g. Recommended spare parts quantity (RS) for complete maintenance of one instrument during one year of isolated service.
- h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Miscellaneous.

6-4 ORDERING INFORMATION

6-5 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses).

6-6 Specify the following information for each part:

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

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

Table 6-1. Reference Designators

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

Table 6-1. Reference Designators (Continued)

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

Table 6-2. Description Abbreviations

a	= amperes
c	= carbon
cer	= ceramic
coef	= coefficient
com	= common
comp	= composition
conn	= connection
crt	= cathode-ray
dep	= deposited
elect	= electrolytic
encap	= encapsulated
f	= farads
fxd	= fixed
GE	= germanium
grd	= ground(ed)
h	= henries
Hg	= mercury
imp	= impregnated
ins	= insulation(ed)
K	= kilo = 1000
lin	= linear taper
log	= logarithmic
log	= taper
ma	= milli = 10 ⁻³
M	= megohms
ma	= milliamperes
μ	= micro = 10 ⁻⁶
mfr	= manufacturer
mtg	= mounting
my	= mylar
NC	= normally
Ne	= neon
NO	= normally open
cmo	= cabinet mount
only	
W	= watts
w/o	= without
var	= variable
tube	
tw	= travelling wave
trim	= trimmer
tol	= tolerance
tog	= toggle
TiO ₂	= titanium dioxide
td	= time delay
sl	= slide
sil	= silver
SI	= silicon
sect	= section(s)
s-b	= slow-blow
rms	= root-mean-square
rot	= rotary
rect	= rectifier
voltage	
prv	= peak reverse
pot	= potentiometer
poly	= polystyrene
pos	= position(s)
ppm	= parts per million
pp	= peak-to-peak
pf	= 10 ⁻¹² farads
board	
pc	= printed circuit
p	= peak
ton	
abd	= order by descrip-

Table 6-3. Code List of Manufacturers

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

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

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

CODE NO.	MANUFACTURER	ADDRESS
73138	Heliport Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Components Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73978	Hardwick Hindle Co.	
74193	Memcor Components Div. Huntington, Ind.	
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Harvey Hubbel, Inc.	Bridgeport, Conn.
74868	EXR Div. of Amphenol-Borg	
75042	Electronics Corp.	Danbury, Conn.
75183	Howard B. Jones Div. of Cinch Mfg. Corp.	Philadelphia, Pa.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
	(Use 71785)	New York, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76493	J. W. Miller Co.	Los Angeles, Calif.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., Bendix-Pacific Div.	
77221	Phaotron Instrument and Electronic Co.	No. Hollywood, Calif.
77252	Philadelphia Steel and Wire Corp.	South Pasadena, Calif.
77342	American Machine and Foundry	Philadelphia, Pa.
77630	TRW Electronics, Components Div.	
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Div. of Illinois Tool Works	Eggin, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Co., Inc.	
78553	Tinnerman Products, Inc.	Cleveland, Ohio
79307	Whitehead Metal Products Co., Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	New York, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Philadelphia, Pa.
	Morristown, N.J.	
80294	Bourns, Inc.	Riverside, Calif.

CODE NO.	MANUFACTURER	ADDRESS
19315	The Bendix Corp., Eclipse Pioneer Div.	Teterboro, N.J.
19701	Electra Mfg. Co.	Independence, Kan.
21520	Fanspel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp., Linde Div.	
22767	ITT Semiconductors, A Division of	Kemet Dept. Mountain View, Calif.
24455	General Electric Co., Lamp Division	
24455	General Electric Co., Schemmady, N.Y.	
24655	General Radio Co., West Concord, Mass.	
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	G. E., Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
44655	Omnite Manufacturing Co.	Skokie, Ill.
47904	Polaroid Corporation	Cambridge, Mass.
49956	Raytheon Mfg. Co., Microwave and	
5026	Simpson Electric Co.	Waltham, Mass.
5289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
70563	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71400	Bussmann Mfg. Div. of	
71450	McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Eikhart, Ind.
71468	I. T. L. Cannon Electric Inc.	
71590	Centralab Div. of Globe Union, Inc.	Los Angeles, Calif.
71700	The Cornish Wire Co.	Milwaukee, Wis.
71744	Chicago Miniature Lamp Works	New York, N.Y.
71785	Cinch Mfg. Co.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72619	Diallight Corporation	Brooklyn, N.Y.
72699	General Instrument Corp.	
72765	Capactor Div.	Newark, N.J.
72982	Drake Mfg. Co.	Chicago, Ill.
	Erie Technological Products, Inc.	Erie, Pa.

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

CODE NO.	MANUFACTURER	ADDRESS
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell, Inc., Micro Switch Div.	Freeport, Ill.
93332	Sylvania Electric Prod., Inc., Semicon-	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
94144	Raytheon Co., Components Div., Industrial	Quincy, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94310	Tru-Ohm Products, Memcor	Huntington, Ind.
95263	Leecraft Mfg. Co., Inc.	Long Island City, N.Y.
95354	Methodie Mfg. Co.	Chicago, Ill.
96791	Amphenol Controls Div. of Amphenol-	Chicago, Ill.
98291	Selectro Corp.	Mamaroneck, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.
THE FOLLOWING H-P VENDORS HAVE NO NUMBERS ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.		
00000	Coiltron	Oakland, Calif.
00000	Plastic Ware Co.	Brooklyn, N.Y.

CODE NO.	MANUFACTURER	ADDRESS
81042	Howard Industries, Inc.	Racine, Wis.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co., Inc.	New York, N.Y.
82219	Sylvania Electric Products, Inc.	Electronic Tube Division Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc.	Attleboro, Mass.
82866	Spencer Products	Madison, Wis.
82877	Roton Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Fatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of	Brookfield, Mass.
83508	Amerace Corp.	Brookfield, Mass.
83594	Barroughs Corp., Electronic	West Nyack, N.Y.
83877	Yardney Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	Radio Corporation of America, Electronic	Components & Devices Div.
87034	Marco Industries Co.	Anaheim, Calif.
87216	Philco Corp. (Lansdale Div.)	Lansdale, Pa.
87585	Stockwell Rubber Co., Inc.	Philadelphia, Pa.
87929	B. M. Tower Co., Inc.	Bridgeport, Conn.

REF. DESIG.	DESCRIPTION	QTY	MFR. PART NO.	MFR. CODE	PART NO.	RS
C1, 2, 7, 17, 20, 21, 03, 4, 8, 9, 18, 25	fxd, elect 5µf 65Vdc	6	D33689	56289	0180-1836	2
C5	NOT ASSIGNED	-	-	-	-	-
C6	fxd, film .002µf 200Vdc	1	192P22292	56289	0160-0154	1
C10	fxd, film .22µf 80Vdc	1	192P2249R8	56289	0160-2453	1
C11	fxd, elect 10,000µf 50Vdc	1	36D103G050CDB6A	56289	-	1
C12, 13	fxd, film .1µf 200Vdc	1	192P10492	56289	0160-0168	1
C14	fxd, ceramic .02µf 600Vdc	2	ED-02	72982	0160-0157	1
C15	fxd, film .0047µf 200Vdc	1	192P47292	56289	0180-0300	1
C16	fxd, elect 325µf 35Vdc	1	30D206G015BB4	56289	0180-0300	1
C19	fxd, elect 1µf 35Vdc	1	D34656	56289	0180-0332	1
C22	fxd, elect 20µf 50Vdc	1	150D105X9035A2	56289	0180-0291	1
C23	fxd, elect 20µf 50Vdc	1	30D206G050DC4	56289	0180-0049	1
C24	fxd, film .01µf 200Vdc	1	192P10392	56289	0160-0161	1
C26	fxd, film .082µf 200Vdc	1	192P82392	56289	0160-0167	1
C27	fxd, elect 40µf 50Vdc	1	D38303	56289	0180-1860	1
C28	fxd, elect 2200µf 50Vdc	1	D27906	56289	0180-1849	1
CRI-3, 6, 11	Diode, si.	18	1N485B	93332	1901-0033	8
CR4	NOT USED	-	-	-	-	-
CR5, 12, 18,	NOT ASSIGNED	-	-	-	-	-
CR7, 9	Rect, si. 12A 100prv	2	1N1200A	02735	1901-0002	2
CR8, 10	SCR 7A 100prv	2	C20A	03508	1884-0031	2
CR13, 14, 41,	Rect, si. 500mA 200prv	4	1N3253	02735	1901-0026	4
CR15-17, 33,	Rect, si. 200mA 10prv	10	11S1	93332	1901-0416	6
CR40, 45	Rect, si. 3A 200prv	2	MRI032B	04713	1901-0416	2
DS1	Indicator Light Neon	1	32RL2211T	95263	1450-0303	1
F1 110V oper,	Fuse Cartridge 3A@125V 3AG S.B.	1	313003	75915	2110-0029	5
F1 220V oper,	Fuse Cartridge 2A@250V 3AB	1	314002	75915	2110-0100	5
F2 DC	Fuse Cartridge 4A @ 250V 3AG	1	312004	75915	2110-0055	5
Q1, 6	SS NPN dHf. amp	2	4JX12A839	03508	1854-0229	2
Q2, 5, 7, 9,	NOT ASSIGNED	-	-	-	-	-
Q3, 17, 18, 21	SS PNP Ger.	4	GT2555	11711	-	-
Q4, 16	SS NPN si.	2	4JX1C710	03508	-	4
Q8, 14, 19, 22	SS PNP si.	4	4JX6B533	03508	-	4
Q11	Power PNP Ger.	1	B1203	83298	-	1
Q15	SS PNP Ger.	1	2N1377	01295	1850-0170	1
R1	fxd, ww 490Ω ±5% 3W 20ppm	1	242E4915	56289	0811-1801	1
R2, 71	fxd, comp 7.5KΩ ±5% 1/2W	2	EB-7525	01121	0686-7525	1
R3	fxd, comp 6.8KΩ ±5% 1/2W	1	EB-6825	01121	0686-6825	1
R4, 25, 31	fxd, comp 1.5KΩ ±5% 1/2W	3	EB-1525	01121	0686-1525	1

Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	QTY	MFR. PART NO.	MFR. CODE	PART NO.	RS
R5	fxd, comp 24K \pm 5% 1/2W	1	EB-2435	01121	0686-2435	1
R6, 79	fxd, comp 75 \pm 5% 1/2W	2	EB-7505	01121	0686-7505	1
R7	fxd, comp 51K \pm 5% 1/2W	1	EB-5135	01121	0686-5135	1
R8	var, comp 100K \pm 5% Ser. 70	1	HQ-3427	73450		1
R9, 17, 26,	fxd, comp 15K \pm 5% 1/2W	5	EB-1535	01121	0686-1535	1
R10	var, w 10K \pm 5%	1	971N	24655		1
R11, 22	var, comp 50 \pm 2W	2	JAIN040P500UA	01121	2100-1873	1
R12	fxd, w 2K \pm 5% 3W 20ppm	1	242E2025	56289	0811-1806	1
R13, 49	fxd, comp Selective \pm 5% 1/2W	3		01121		1
R14, 52	STRAP	-				-
R15	fxd, comp 2.4K \pm 5% 1/2W	1	EB-2425	01121	0686-2425	1
R16, 64, 89	var, w 5K \pm 5% (Modify)	3	Type 110-F4obd	11236	2100-1824	1
R18, 92	fxd, comp 1K \pm 5% 1/2W	2	EB-1025	01121	0686-1025	1
R19, 27, 29,	fxd, comp 10K \pm 5% 1/2W	4	EB-1035	01121	0686-1035	1
R20, 35, 38,	39, 46, 60,					
65, 69, 78	NOT ASSIGNED	-				-
R21	var, w 1K \pm 5%	1	971K	24655		1
R23	fxd, w 5.6K \pm 5% 3W 20ppm	1	242E5625	56289	0812-0091	1
R24	var, w 1K \pm 5% (Modify)	1	Type 110-F4 obd	11236	2100-0391	1
R28	fxd, comp 1 Meg \pm 5% 1/2W	1	EB-1055	01121	0686-1055	1
R32	fxd, comp 3.3 \pm 5% 1/2W	1	EB-0335	01121	0686-0335	1
R33	fxd, comp 680K \pm 5% 1/2W	1	EB-6845	01121	0686-6845	1
R34	fxd, w 3 \pm 5% 40W 20ppm	1	ZBR-37 Offset Mtg	73978		1
R36, 62	fxd, met, ox 220 \pm 5% 2W	2	Type C42S obd	16299	0698-3628	1
R37	fxd, w 200 \pm 5% 5W	1	Type 5XM obd	63743	0811-1204	1
R40	fxd, comp 5.1K \pm 5% 1W	1	GB-5125	01121	0689-5125	1
R41	fxd, w 600 \pm 5% 10W	1	Type 10XM obd	63743	0811-1910	1
R42	fxd, comp 100K \pm 5% 1/2W	1	EB-1045	01121	0686-1045	1
R43, 44	fxd, comp 150 \pm 5% 1/2W	2	EB-1515	01121	0686-1515	1
R45	fxd, w 820 \pm 5% 3W	1	242E8215	56289	0813-0010	1
R47	fxd, comp 390 \pm 5% 1W	1	GB-3915	01121	0689-3915	1
R48	fxd, comp 3.6K \pm 5% 1W	1	GB-3625	01121	0689-3625	1
R50	fxd, comp 4.3K \pm 5% 1W	1	GB-4325	01121	0689-4325	1
R51	fxd, comp 560 \pm 5% 1W	1	GB-5615	01121	0689-5615	1
R53	fxd, comp 62K \pm 5% 1W	1	GB-6235	01121	0689-6235	1
R54	fxd, comp 4.7K \pm 5% 1/2W	1	EB-4725	01121	0686-4725	1
R55	fxd, comp 300 \pm 5% 1/2W	1	EB-3015	01121	0686-3015	1
R56	fxd, comp 680 \pm 5% 1W	1	GB-6815	01121	0689-6815	1
R57	fxd, comp 4.7M \pm 5% 1/2W	1	EB-4755	01121	0686-4755	1
R58	fxd, comp 33K \pm 5% 1/2W	1	EB-3335	01121	0686-3335	1
R59	fxd, comp 560 \pm 5% 1/2W	1	EB-5615	01121	0686-5615	1
R61	fxd, comp 22 \pm 5% 1/2W	1	EB-2205	01121	0686-2205	1
R63	fxd, comp 12K \pm 5% 1/2W	1	EB-1235	01121	0686-1235	1
R66, 67	fxd, comp 3.3K \pm 5% 1/2W	2	EB-3325	01121	0686-3325	1
R68	fxd, comp 1.3K \pm 5% 1/2W	1	EB-1325	01121	0686-1325	1
R70, 73	fxd, comp 120K \pm 5% 1/2W	2	EB-1245	01121	0686-1245	1
R72, 83	fxd, comp 27K \pm 5% 1/2W	2	EB-2735	01121	0686-2735	1
R74	fxd, film 2K \pm 5% 2W	1	Type C42S obd	16299		1
R76	fxd, comp 3.9K \pm 5% 1/2W	1	EB-3925	01121	0686-3925	1
R77	fxd, comp 13K \pm 5% 1/2W	1	EB-1335	01121	0686-1335	1
R81	fxd, comp 39K \pm 5% 1/2W	1	EB-3935	01121	0686-3935	1
R82	fxd, comp 2.2K \pm 5% 1/2W	1	EB-2225	01121	0686-2225	1
R84	fxd, comp 240K \pm 5% 1/2W	1	EB-2445	01121	0686-2445	1

REP. DESIG.	DESCRIPTION	QTY	MFR. PART NO.	MFR. CODE	PART NO.	RS
R85	fxd, comp 43K \pm 5% 1/2W	1	EB-4335	01121	0686-4335	1
R86	fxd, comp 820 Ω \pm 5% 1/2W	1	EB-8215	01121	0686-8215	1
R87	var, wv 250 μ (Modify)	1	TYPE 110-F4 obd	11236		1
R88	fxd, comp 35K Ω \pm 5% 1/2W	1	EB-3635	01121	0686-3635	1
R90, 91	fxd, comp 100 Ω \pm 5% 1/2W	2	EB-1015	01121	0686-1015	1
R93	fxd, comp 360K \pm 5% 1/2W	1	EB-3645	01121	0686-3645	1
S1	Switch ON/OFF	1	T110	73559		1
T1	Power Transformer	1	636591	09182		1
VR1	Diode zener 9.4V T.C.	1	1N2163	06751	1902-0762	1
VR2	Diode zener 6.2V	1	1N821	06486	1902-0761	1
VR3	NOT USED	-	-	-	-	-
	Barrier Strip	1	601-YSY-6	75382	0360-1224	1
	Barrier Strip 1/16 wire term	1	obd	09182	0360-1235	1
	Jumper	7	601J	75382	0360-1280	2
	Handle 2-1/4"	2	obd	09182	1440-0059	1
	Ferrule	4	900-12	75915	1440-0053	1
	Fuse Holder	2	342014	75915	1400-0084	1
	Lockwasher	1	1224-08	78189	2190-0037	1
	Nut	1	903-12	75915	2950-0038	1
	Washer-Neoprene	1	901-2	75915	1400-0090	1
	Knob 5/8 Dia. BIK.	4	obd	09182	0370-0137	1
	Meter 0-40 Volts	1	obd	09182	1120-1328	1
	58 μ 1mA movement	1	obd	09182	1120-1333	1
	Meter 0-3 Amps	1	obd	09182	0510-0275	3
	Nut Captive	12	C8091 632-24B	89032		
	Lane Cord 6' 18-3 (16-30)	1				
	Slate Grey Stranded Plug PH151	1	KH-4629	70903	8120-0852	1
	Strain Relief Bushing	1	SR-6P3-4	28520	0400-0098	1
	Capacitor Clamp 2-9/16 3 Hole	1	4586-2D	56289	0180-1970	1
	Capacitor Clamp 1-3/8 2 Hole	1	4586-97A	56289	0160-2149	1
	Capacitor Clamp	1	obd	09182	1400-0321	1
	Eyelet-Tubular	8	obd	09182	0361-0327	2
	Transistor Socket	7	3305	91662	1200-0708	2
	Mica Insulator	1	734	08530	0340-0174	1
	Rubber Bumper Black	4	3066	87585	0403-0085	1
	Durom Hard 55/60	1	T4-4	79307	1400-0330	1
	Cable Clamp Nylon Plastic	1	652	83330	6960-0001	1
	Snap Button Hole Plug 3/8	2	obd	09182	0340-0166	1
	Insulator Transistor Pin	2	obd	09182	0340-0168	1
	Insulator	2	obd	09182	0340-0170	1
	Insulator	2	obd	09182	0340-0169	1


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