INSTRUCTION MANUAL

MODEL 6150 **SERIAL** ____________

POWER DESIGNS INC.
1700 SHAMES DR. WESTBURY, N.Y. 11590
TEL: 516-333-6200 TWX 510-222-6561

POWER DESIGNS PACIFIC INC.
3381 MIRANDA AVE. PALO ALTO, CA. 94304
TEL: 415-~~493-6111~~ TWX 910-373-1251

DC POWER SOURCE MODEL 6150

SECTION 1
GENERAL DESCRIPTION

1-1. DESCRIPTION

The Model 6150 is a voltage regulated DC power source that functionally replaces four conventional power supplies. It utilizes a regulator technique* trademarked UNIPLY® which provides regulator efficiencies and operating features not obtainable with common dissipative type circuits.

The Model 6150 is a higher power version of the Model 6050 and reflects improved circuit techniques and human engineering design reflecting two years of field experience with this unique instrument.

The UNIPLY® circuit comprises a number of unregulated DC sources, a number of power semiconductors, a series of "OR" gates and a single control amplifier which selects that combination of unregulated source and power transistor which most satisfies the demands of the load and the setting of the panel controls with minimum power loss.

Ranging is transient-free and automatic. Operation is completely electronic without relays or manual switching. An inhibit switch limits the ranging to 6 volts to avoid accidental damage to integrated circuit loads.

The regulator system is RFI-free and employs linear circuits only. No triacs, SCR's or switching circuits are used.

Power output capability increases with increasing AC line voltage. Up to 150% of rating is available at line voltages over 105 volts. Useful regulated output at reduced levels is available at line voltages as low as 85 volts. The Model 6150 may be operated continuously into an overload or short circuit without damage. A flashing panel indicator signals loss of regulation when load demands exceed the supply capability or the AC line voltage is too low to support increased output levels.

An integral, front panel adjustable "crowbar" protects load circuits from overload conditions due to internal or external malfunctions.

Taut-band suspension, flush mounting meters offer superior reliability in dusty environments. Two voltage and two current ranges are provided to increase meter resolution. Ranges switch automatically with panel range setting.

Lightweight and portable, the Model 6150 is suitable for both laboratory bench and rack applications. A bail/carrying handle permits tilting of the panel for viewing ease.

1-2. ELECTRICAL SPECIFICATIONS

INPUT: 105-125 volts, 57-440 Hz, 270 watts at nominal 115 V line. 210-250 volt, 50 Hz operation is available as an option.

*Patents applied for.

OUTPUT: 0-60 volts DC, continuously adjustable with the following minimum output levels: 0-6 V, 0-15 A; 0-15 V, 0-7.5 A; 0-25 V, 0-5 A; 0-60 V, 0-2 A.

LINE REGULATION: 0.01% +1 millivolt for AC line variations from 105-125 volts.

LOAD REGULATION: 0.01% +1 millivolt for 0-100% changes in rated output current, measured at the rear terminals or at the junction of the load and remote sense leads. Regulation at the front panel terminals is 0.01% +1 millivolt per ampere of load current due to binding post voltage drops.

POLARITY: Either the positive or negative output terminal may be grounded or the supply may be floated up to 200 VDC between any output terminal and chassis.

RIPPLE AND NOISE: Less than one millivolt peak-to-peak over a 1 MHz band at an input line frequency of 60 Hz.

SOURCE IMPEDANCE: Less than 5 milliohms at DC, 100 milliohms at 20 KHz, one ohm to 1 MHz.

RECOVERY TIME: Output voltage will return to within a 15 millivolt band of the original voltage setting within 50 µs for a step change (1 µs rise time) in rated load of 20-100%.

STABILITY: Better than 0.02% +3 millivolts per 24 hours at constant line, load and ambient temperature, after warm-up. Better than 0.01% +1 millivolt with external low temperature coefficient programming resistance.

TEMPERATURE: Operating: 0-50°C; Storage: -20 to +85°C.

TEMPERATURE COEFFICIENT: Output voltage change is less than 0.02%/°C.

VOLTAGE CONTROL: A toggle switch and potentiometer provide continuous adjustment of the output voltage in two ranges: 0-6V, 0-60V. Precious metal contact potentiometer provides 20 millivolt resolution in the 0-6V range.

CURRENT CONTROL: A toggle switch and potentiometer provide continuous adjustment of the output current (current limit) in two ranges: 0-1.5A, 0-15A. Precious metal contact potentiometer provides 6 mA resolution in the 0.15A range.

METERING: Front panel, flush taut-band suspension meters monitor output voltage and current in four ranges, automatically selected by the position of the voltage and current range switches: 0/6V/60V, 0/1.5A/15A, with an accuracy of better than 3% of full scale.

OVERVOLTAGE CROWBAR: 3-60V panel adjustable crowbar operates to short circuit the output of the supply in less than 500 microseconds at any output voltage in excess of a preset level. When operating the supply in the 0-6V range, the crowbar may be set to operate instantaneously if the 6V/60V range switch is inadvertently thrown.

OUTPUT TERMINALS:

FRONT PANEL: Three insulated "5-way" binding posts for positive, negative and ground.

REAR PANEL: Eight screw terminals on a molded barrier block for positive, negative, ground, remote voltage programming, remote sensing and parallel operation.

REMOTE PROGRAMMING: Terminals are provided for remote resistance programming of the output voltage. Programming resistance ratio to output voltage is 1000 ohms per volt with the voltage range switch in the 6V position and 100 ohms per volt in the 60V position. When the supply is remote programmed, the overvoltage crowbar may be set to provide a voltage compliance limit to protect load circuits if the remote programming resistance is open-circuited.

1-3. MECHANICAL SPECIFICATIONS

DIMENSIONS: 19" wide x 3-1/2" high x 16" deep (Standard EIA Rack Panel).

WEIGHT: 27 lbs.

FINISH: Light gray vinyl synthetic enamel panel with black nomenclature. Gray epoxy enamel dust covers. Handles and rails brushed anodized natural aluminum. Chassis finished in gold chromate.

SECTION 2
INSTALLATION AND OPERATION

2-1. INSTALLATION

2.1.1 Laboratory Bench. The Model 6150 is a self-contained unit. No preliminary processing or unpacking is required. The power supply is ready for operation as shipped from the factory. A snap-out, bail-carrying handle assembly tilts the front panel for viewing ease.

2.1.2 Rack Mounting. The Model 6150 is designed for rack mounting in a standard EIA Relay Rack.

2-2. OPERATION

2.2.1 Procedure

(a) Be sure the AC switch is off and shorting links on rear terminal block between the DC+ and S+, DC- and S-, and terminals 1 and 2 are tightened securely.

(b) Turn OVERVOLTAGE CROWBAR screw-slot potentiometer to its maximum clockwise position.

(c) Set the CURRENT LIMIT RANGE toggle switch to the desired output current range. Note that the full scale reading of the meter corresponds to the switch position. Set the CURRENT control fully clockwise.

(d) Connect the AC line cord to a source of 105-125 volts, 57-440 Hz.

(e) Turn ON/RESET (AC) switch on. AC indicator should light.

(f) Set the VOLTAGE RANGE toggle switch to the desired output voltage range. Note that the full scale reading of the meter corresponds to the switch position.

(g) Set the VOLTAGE control to the desired value of output voltage, as indicated on the panel meter.

(h) Connect the DC+ and DC- output terminals on the front panel or rear panel to the load. The positive or negative output terminal may be operated at ground potential by means of a jumper or left floating, if desired. If the output terminals are left floating, a large AC potential at the AC line frequency may be introduced into the load through common mode coupling between the AC line, the power supply, the load and/or AC operated instruments connected to the load. A capacitor (about 1 μf, 200 VDC, paper or film dielectric) connected from either DC output terminal to the power supply ground terminal will reduce this ripple to a usually satisfactory level.

2.2.2 Operation Above Panel Ratings

The output voltage and current ratings of the supply are listed on the front panel. At AC input line voltages over 105 volts, the power supply may be operated at voltage and current levels above these ratings without overload or damage to the power supply. Simply increase the output voltage or output load current to the desired level. If the power supply regulator system cannot support the increased output (line voltage inadequacy or supply power limitations) it will signal this inability to regulate by flashing of the FAULT indicator. Note that the power supply may be operated indefinitely into this overload mode without damage.

Similarly, the supply may be operated below 105 line volts at reduced output levels, the flashing FAULT indicator functioning as an indicator of regulator operation.

The CURRENT LIMIT control continues to function even when the power supply is operated beyond panel ratings. It may still be used to limit maximum output currents in this region.

If, when operating the supply above panel ratings, the FAULT indicator suddenly starts to flash, this signals that the AC input voltage has dropped below a level necessary to support the increased output power.

CAUTION: NEVER OPERATE THE MODEL 6150 ABOVE ITS MAXIMUM RATED AC INPUT LINE VOLTAGE OF 125 VOLTS.

2.2.3 Remote Sensing

When the sense terminals are connected at the supply to the DC terminals (shorting links between S+ and DC+, S- and DC- on the rear terminal block), the power supply is connected for local sensing. When the shorting links are removed and the sense leads connected to the power output leads at the load, the supply is connected for remote sensing and the output voltage is compensated for voltage drops due to the DC resistance of the power leads.

Remote sensing may introduce substantial phase shift at high frequencies between the sense (input) terminals of the amplifier and the power (output) terminals due to the inductive reactance of the sense and load leads. This condition may be corrected by the addition of a high frequency, low impedance capacitor across the output of the supply at the junction of the load and sense leads. A tantalum or electrolytic capacitor of suitable voltage rating and low impedance characteristics should be used. The capacitance should be large enough to correct for poor dynamic regulation due to the reactance of the power output leads if the load is switched or pulsed. A good rule of thumb for the value of this capacitor is 100 μf per ampere of load current.

For Remote Sensing:

(a) Remove the shorting links from the rear terminal block DC+ and S+ and DC- and S- terminals.

(b) Connect the S+ and S- leads to the positive and negative power leads at the load. Run the sense leads as a tightly twisted, shielded pair, if possible. Wire size is not important unless long runs are involved (over twenty feet). Connect the shield to GND (ground) terminal at the supply to minimize electrostatic noise pickup.

2.2.4 Series Operation

As many as three Model 6150 supplies may be connected in series to provide up to 180 volts output at 2 amperes, or up to 18 volts at 15 amperes. Connect the positive DC output terminal of one supply to the negative output terminal of the next, in the same manner as connecting batteries in series. The ground terminals on all units should be left floating or tied together and connected to either the most positive or most negative output terminal.

CAUTION: THE VOLTAGE AND CURRENT LIMIT CONTROLS OF ALL SERIES CONNECTED MODEL 6150 UNITS SHOULD BE SET AT THE SAME LEVEL TO AVOID HEAVY REVERSE CURRENTS FLOWING IN ONE OF THE SUPPLIES WHEN THE REGULATOR IS IN THE CURRENT LIMITED MODE AND THE OUTPUT IS REVERSED BY THE OTHER SERIES-CONNECTED SUPPLIES. THE MODEL 6150 SHOULD NEVER BE OPERATED IN SERIES FOR MORE THAN A SHORT PERIOD WITH ANY OF THE LIMIT INDICATOR LAMPS FLASHING.

To avoid loss of regulation due to the voltage drop in the interwiring leads when connecting the power supplies in series, disconnect the shorting link between S+ and DC+ output terminals on all but the most positive output source. Connect a jumper wire between an S+ terminal and the S- terminal on the next more positive source.

For remote sensing, disconnect the S+ link on the most positive source and reconnect the S+ terminal by a suitable lead to the DC+ power output lead at the load. Similarly, disconnect the S- link on the most negative source and reconnect to the DC- power output lead at the load. Refer to paragraph 2.2.3 for remote sensing recommendations.

2.2.5 Parallel Operation. In parallel operation one power supply functions as a master supply to control the output of the second (slave) source. Two supplies may be operated in parallel to supply twice the output current. An unbalance in current sharing of up to 30% may result from resistance drops of connecting wires.

1. Set the CURRENT LIMIT switch of both Master and Slave to the same range.
2. Connect the Master for standard operation as in paragraph 2.2.1. Do not remove shorting links from the rear terminal block.
3. Remove the shorting links at the rear of the Slave Supply.
4. Make the following connections at the rear of the supplies using No. 16 wire or heavier for the DC power leads:

   (a) Master DC+ to Slave DC+ at rear output terminals.
   (b) Master DC- to Slave DC- at rear output terminals.
   (c) Master PAR. OPR. terminal to Slave terminal 1.
   (d) Slave PAR. OPR. terminal to Slave S+.
   (e) Slave DC- to Slave S-.

5. Connect the load to the REAR terminals of the Slave Supply for optimum current sharing.

CAUTION: DO NOT CONNECT THE LOAD TO THE FRONT PANEL TERMINALS OF EITHER SUPPLY. INTERNAL DAMAGE MAY RESULT.

For remote sensing connect the Master Supply S+ and S- terminals only (not the Slave Supply) to the power output leads at the load as described in paragraph 2.2.3 for a single supply.

2.2.6 Remote Voltage Programming

The output voltage can be programmed remotely by an external fixed or variable resistance as follows:

(a) Turn the power supply off.

(b) Set the VOLTAGE control to zero (extreme counterclockwise position).

(c) Set the VOLTAGE range switch to the desired output voltage range. In the 0 to 6V range, the programming resistance is 1000 Ω/V. In the 0 to 60V range, the programming resistance is 100 Ω/V. The wattage rating of this resistance should be large enough to minimize drift due to heating.

(d) Remove the shorting link between the rear panel 1 and 2 terminals.

(e) Connect the external programming resistance between the 1 and 2 terminals using twisted, shielded wire. Connect the shield to chassis ground (G terminal) to minimize output ripple.

(f) Turn on the power supply.

CAUTION: IF THE REMOTE PROGRAMMING CONNECTIONS ARE OPENED WHILE THE SUPPLY IS OPERATING, THE OUTPUT VOLTAGE WILL RISE TO A LEVEL AS HIGH AS 90 VOLTS, DEPENDING UPON OUTPUT LOAD CURRENT. IF A SWITCH IS USED TO SELECT RESISTORS FOR OUTPUT VOLTAGE PROGRAMMING, USE ONE WITH SHORTING TYPE CONTACTS TO AVOID VOLTAGE TRANSIENTS PRODUCED BY OPENING THE REMOTE PROGRAMMING TERMINALS BETWEEN STEPS.

2.2.7 Current Limiting

The maximum output current may be limited to any value from zero to the maximum output current rating of the supply at any preset output voltage level.

(a) Set the CURRENT LIMIT RANGE toggle switch to the desired output current range 1.5A or 15 A.

(b) With load connected to the supply, turn the CURRENT LIMIT knob fully clockwise.

(c) Turn current control slowly counterclockwise until the FAULT lamp flashes, then clockwise until flashing just stops. The current limit operating threshold is then approximately 10% above the actual load current.

NOTE: If the load current is greater than that shown on the front panel table for a given output voltage, the FAULT lamp may start to flash when the AC line voltage falls to a level which cannot support the increased output. This signal indicates AC input voltage inadequacy rather than current limiter circuit operation.

2.2.8 Overvoltage Crowbar

The Model 6150 contains a front panel adjustable overvoltage "crowbar" which operates to short circuit the power supply output in the event of an internal or external malfunction resulting in an output voltage in excess of the output voltage setting. To set the crowbar:

(a) Disconnect the load from the power supply.

(b) Adjust the output voltage to the desired overvoltage trip point.

(c) Turn screw-slot adjustment counterclockwise slowly until the crowbar fires. This can be observed by a sudden collapse of the output voltage and flashing of the FAULT lamp indicating the inability of the regulator to function into a short circuit.

(d) Reduce the output voltage setting by rotating the voltage control about a quarter turn counterclockwise.

(e) Reset the crowbar by turning off the POWER ON switch for a few seconds, then on again. Normal operation should be restored.

(f) Recheck the overvoltage trip point by increasing the output voltage slowly and observing where the crowbar fires. Repeat steps (a) through (f) if necessary.

Notes on Crowbar Operation:

False Tripping

(1) To avoid false tripping due to circuit transients, a time delay is built into the crowbar circuit of the Model 6150. This inhibits the crowbar firing time for approximately 25 microseconds and permits adjustment of the crowbar trip point closer to the operating voltage level of the supply. Large transients of longer duration may still result in false tripping, and adjustment of a suitable trip point far enough away from the supply's operating level to avoid false tripping may be necessary.

Parallel Battery (Etc.) Operation

(2) The Model 6150 crowbar circuit is designed to trip automatically at all operating output voltages above 3 volts when the POWER ON switch is turned off. This operation protects the power supply from damage when it is used with circuits containing a number of power sources where circuit "feed/through" can produce damaging currents or potentials across the Model 6150 when it is shut off. It is extremely important that A BLOCKING DIODE BE CONNECTED IN SERIES with one of the output terminals of the Model 6150 when the supply is operated in parallel with another external source (other than a Model 6150) or battery (as in battery charging applications) to avoid destructive discharge currents through the SCR crowbar circuits.

2.2.9 Digital Circuit Operation

The Model 6150 is a wide voltage range supply which incorporates features designed for almost foolproof protection from damage to digital or low operating voltage circuits due to supply malfunction or human error. For maximum protection of digital load circuits, the following operating procedures are recommended:

1. The VOLTAGE range switch should be set in the 6V position. This inhibits the automatic ranging circuits to a maximum output of six volts.

2. The OVERVOLTAGE CROWBAR should be set to a desired trip point using the procedure described in paragraph 2.2.8 if the voltage trip point falls in the six volt range. If it does not, it is recommended that this trip point be set to 7.5V by throwing the VOLTAGE range switch to 60V (with no load on the supply) and setting the crowbar to this trip point. Setting the crowbar to 7.5V offers another operating safety feature with digital circuit loads in that the power supply automatically shuts off if the user inadvertently turns the VOLTAGE range switch when the power supply is operating at digital circuit voltage levels (5-6 volts).

SECTION 3
THEORY OF OPERATION

3-1 GENERAL

The Model 6150 is a voltage regulated DC power source of the conventional linear series dissipative type in a unique configuration* which provides regulator efficiencies and operating features not commonly available in this class of regulator.

The conventional dissipative voltage regulator contains an unregulated DC source and a variable electronic resistance (series power transistor) between the unregulated source and the load. An amplifier measures the difference between a reference voltage and a fraction of the output voltage obtained through a resistor divider, amplifies and applies this differential to the series power transistor to control its resistance so as to maintain the output voltage constant with load current and input voltage variations. Since the series control transistor is, in effect, a resistance, it will dissipate power in the form of heat, depending upon the voltage across this resistance and the current through it. The regulated output voltage is usually adjusted by varying the voltage reference, the resistor divider ratio or both. In a wide range regulated supply the power dissipated in the series transistor increases with increasing unregulated source voltage, increasing output current and reduced output voltages.

The UNIPLY® regulator comprises a number of unregulated DC sources, a number of series power transistors, connected to diode "OR" gates and a single control amplifier which automatically selects that combination of unregulated source and power transistor which best satisfies the output voltage and load current requirements, maintaining, at the same time, a minimum voltage difference between the unregulated source and the load, thus reducing power dissipation. By the proper selection of unregulated source and series power transistor characterisitics, it is possible to design a regulator with essentially constant output power, i.e., as the output voltage is decreased, the available output current increases. Power losses in the regulator remain approximately constant, independent of output voltage or current.

As a guide in understanding the operation of the Model 6150, this section provides a step-by-step description of each circuit and each component function. Reference to the Schematic Diagram in the Appendix is recommended.

3-2 AC POWER SOURCE

AC input power (105 to 125 V, 57 to 440 Hz or 210-250 V, 47-440 Hz) is applied through a 3-wire power cord equipped with a 3-blade NEMA plug. The "hot" side (black wire) of the AC line flows through fuse F1 (which protects the supply in case of internal failure) through the AC switch S1, which turns on the power supply, to transformer T1 primary terminals 4 and 2. The other side of the AC input (white wire) goes to terminals 3 and 1 of transformer T1. Across terminals 4 and 3 of transformer T1 is a neon lamp, DS1, in series with current limiting resistor R1. DS1 glows when T1 is energized. Transformer T1 transforms the AC input voltage to the required secondary voltages.

*Trademarked UNIPLY Patent No. 3,699,352

3-3 VOLTAGE REFERENCE SOURCE

The T1 transformer secondary voltage from terminals 13 to 14 is approximately 47 VAC. Transformer secondary terminal 14 goes to RF1 filter capacitor C2 and rectifier diode CR1. The other side of C2 goes to secondary terminal 13. The cathode of CR1 goes to the positive terminal of filter capacitor C3. The negative terminal of C3 goes through peak current limiting resistor R2 to secondary terminal 13. This circuit generates an unregulated, filtered voltage of 53.5 VDC for the reference circuits.

The unregulated filtered voltage of 53.5 VDC across C3 is applied to a 20 volt pre-regulator zener diode CR3 through current limiting resistor R3.

The pre-regulated voltage across CR3 is applied to a constant current regulator comprising transistor Q3, diode CR4, zener diode CR5 and resistors R9, R10 and R11.

Current flows from the cathode (+) side of CR3, through diode CR4 (which compensates for the base-emitter voltage change of transistor Q3 with temperature), through zener diode CR5, used as a reference to produce a constant voltage across resistor R9 (6.3V), through bias current resistor R11 and back to CR3 anode through diode CR6. The function of diode CR6 will be discussed in paragraph 3.8.

The voltage across R9 and thus its current is controlled by transistor Q3, which compares the voltage drop across R9 with the voltage across reference diodes CR4, CR5 and adjusts its collector current to hold the voltages equal. This results in a constant current that flows through the collector of transistor Q3 and reference zener CR7. Resistor R10 is used to improve the regulation of the constant current circuit by forming a balanced bridge network consisting of R9, R10, R11, CR4 and CR5, which functions to correct small voltage variations in CR3 due to AC line voltage changes.

3-4 FAULT LIGHT CIRCUITRY

Transformer secondary terminals 11 and 12 supply the voltage for the flashing FAULT light circuitry: neon light DS2, capacitor C4, capacitor C5, diode CR2, transistor Q1 and resistors R4, R5 and R6.

When the power supply is operating within its regulation limits, the neon FAULT light DS2 is not illuminated since Q1 is saturated by current flowing through R5 and R6. The collector-emitter voltage across Q1 is too low to ignite the neon lamp (90V minimum). The action of this circuit in its flashing mode is described in paragraph 3.12.

3-5 UNREGULATED DC POWER SOURCES

In the Model 6150 there are four unregulated sources of power which are electronically connected to the load by three diode "OR" gates, CR22, CR21 and CR14.

For reference purposes in this description we will designate:

* (a) The voltage across C24 as Source 1 (approximately 11 volts).

(b) The voltage across C23 as Source 2 (approximately 25 volts).

(c) The voltage across C22 as Source 3 (approximately 45 volts).

(d) The voltage across C21 as Source 4 (approximately 90 volts).

Source 1 develops its rectified DC voltage by current flowing from transformer secondary terminal 6 to C24+, through C24 and rectifier CR17 to terminal 7 for one half cycle, and from secondary terminal 6 to C24+, through C24 and rectifier CR19 to terminal 5 on the other half cycle (full wave center-tap connection).

Source 2 receives its voltage by current flowing from transformer secondary terminal 7 through CR18 to C23+, through C23 and rectifier CR19 to terminal 5 for one half cycle, and from secondary terminal 5 through CR20 to C23+, through C23 and rectifier CR17 to terminal 7 on the other half cycle (full wave bridge connection). Both Source 1 and Source 2 are derived from the same secondary winding, but Source 2 is approximately twice the voltage of Source 1.

Source 3 receives its voltage by means of current flowing from transformer secondary terminal 9 to C22+, through C22 and rectifier CR10 to terminal 10 for one half cycle, and from secondary terminal 9 to C22+, through C22 and rectifier CR12 to terminal 8 for the other half cycle (full wave center tap connection).

Source 4 receives its voltage by means of current flowing from transformer secondary terminal 10 through CR11 to C21+, through C21 and rectifier CR12 to terminal 8 for one half cycle, and from secondary terminal 8 through CR13 to C21+, through C21 and rectifier CR10 to terminal 10 for the other half cycle (full wave bridge connection).

Source 1 and Source 2 both derive their voltages from transformer secondary terminals 5, 6 and 7 (20.5 VAC). Source 3 and Source 4 both derive their voltages from transformer secondary terminals 8, 9 and 10 (66 VAC).

Capacitor C16, which is connected across transformer terminals 5 and 7, and capacitor C11, which is connected across transformer terminals 8 and 10, reduce the effect of high frequency transients generated by the recovery time characteristics of rectifier diodes CR10 through CR13, and CR17 through CR20.

The negative output terminals of Sources 1, 2, 3 and 4 are all common to one another and are connected directly to the "DC-" output of the power supply through internal fuse F2.

* See table on Schematic Diagram for actual voltages

3-6 SERIES REGULATOR TRANSISTORS

The positive output of Source 1 (C24+) is connected to the DC+ output of the supply through diode "OR" gate CR22, Source 1 regulating transistors Q19 through Q22, output current sensing resistors R46 and R47, R48, R49 (1.5 ampere maximum output current) or S3, determined by S3 switch setting (S3 switch contacts 5 and 6 are open for 1.5A output, closed for 15.0A output.).

The positive output of Source 2 (C23+) is connected to the DC+ output of the supply through diode "OR" gate CR21, Source 2 regulating transistors Q16, Q17, Source 2 current sensing resistors R53, R54, Q19 through Q22 base-emitter junctions, R46 and R47, R48, R49 or S3, determined by S3 switch setting. R53 and R54 function as emitter current balancing resistors for Q16 and Q17.

The positive output of Source 3 (C22+) is connected to the DC+ output of the supply through diode "OR" gate CR14, Source 3 regulating transistors Q13, Q14, Source 3 current sensing resistors R43, R44, Q16, Q17 base-emitter junctions, Source 2 current sensing resistors R53, R54, Q19 through Q22 base-emitter junctions, R46 and R47, R48, R49 or S3 (determined by S3 switch setting). R43 and R44 function as emitter current balancing resistors for Q13 and Q14.

The positive output of Source 4 (C21+) is connected to the DC+ output of the supply through the Source 4 regulating transistors Q8 and Q10, Source 4 current sensing resistors R35, R36, Q13, Q14 base-emitter junctions, Source 3 current sensing resistors R43, R44, Q16, Q17 base-emitter junctions, Source 2 current sensing resistors R53, R54, Q19 through Q22 base-emitter junctions, R46 and R47, R48, R49 or S3 (determined by S3 switch setting). R35 and R36 function as current balancing resistors for Q8 and Q10.

3-7 VOLTAGE REGULATOR AMPLIFIER CIRCUITRY

The drive current for the series regulator transistors of Sources 1 through 4 is obtained from driver Q7. The emitter of Q7 is in series with the base-emitter junctions of Q8 and Q10, current sensing resistors R35, R36 (Source 4), the base-emitter junctions of Q13, Q14, current sensing resistors R43, R44 (Source 3), the base-emitter junctions of Q16 and Q17, current sensing resistors R53, R54 (Source 2), the base-emitter junctions of Q19 through Q22 (in parallel), and current sensing resistors R46 and R47, R48, R49 or S3 (depending upon the setting of S3).

Resistor R56 across Q19 through Q22 base-emitter junctions minimizes the effect of I_{cbo} upon the drive circuitry particularly at low output current levels. Resistor R50 performs the same function for Q16, Q17 as does R40 for Q13, Q14, R27 for Q8, Q10 and R26 for Q7.

The base of driver Q7 is (Darlington) connected to the emitter of driver amplifier Q6. The collector of Q6 is connected to C3+ through current limiting resistor R24. The voltage at C3 is large enough to permit operation of the series connected base emitter junctions. The base of Q6 is connected to the collector of amplifier Q4 and to the positive side of pre-regulator reference CR3 (+20V) through decoupling resistor R12 to obtain drive current. The purpose of RC network C10 and R15 connected across Q4 base to collector and C28 connected across Q5 (base to collector) is to stabilize the power supply amplifier circuitry throughout its operating frequency range. The base of Q4 is connected to the collector of Q5 and obtains its drive current from the positive side of the 6.2V supply voltage reference (CR7 cathode) through R14. The emitters of Q4 and Q5 are connected to the junction of SENSE+ output terminal, the anode of CR7 (the supply voltage reference zener), CR6 anode, R10, R11 and C8.

The base of Q5 (amplifier input) is connected through current limiting resistor R17 to the junction of R18 and CR8 anode. The other side of resistor R18 is connected to the positive of the 6.2V supply voltage reference (CR7 cathode). This resistor provides a bias current through diode CR8 whose temperature coefficient compensates changes in base-emitter voltage of Q5. The cathode of CR8 is the voltage sensing point (summing junction) of the power supply regulator.

At this summing junction the output voltage of the power supply is compared to the reference voltage (CR7) by means of a divider network. For 0-6V operation (depending upon concentric panel switch S2 setting) this network is made up of R19, R20 and R34, the panel voltage control. R19 drains current from the 6.2V supply reference in the 0-6V mode of operation to maintain a constant load on this reference voltage for 0-6V or 0-60V operation. For 0-60V operation this network comprises R20 in parallel with R23 trimmer, R22 and R121 (connected in series) and R34 panel control. As in a conventional feedback regulator, the amplifier operates to control the series regulator transistor voltage drop to maintain the summing junction voltage close to zero. The voltage drop across R20 will, thus, be equal to the reference voltage (CR7). The current through R20 to provide this drop will flow through R34 and establish the output voltage control range (0-6V). In the 0-60V position of S2, the current through R20 in parallel with R23, R22 and R121 is approximately ten times greater, increasing the range of R34 proportionately. R23 trimmer permits accurate adjustment of this range.

Capacitor C15, which is connected across output voltage adjusting potentiometer R34, decreases the amplitude of the ripple and noise at the power supply output by increasing the AC feedback ratio.

The positive terminals of output capacitors C19 and C20 are connected to the SENSE+ output terminal and the negative to the SENSE- output terminal. These capacitors supply energy required by rapid load changes which are faster than the response time of the regulator system.

When the output voltage of the power supply is being controlled internally by potentiometer R34, the remote programming terminals 1 and 2 at the rear terminal block are shorted together by a jumper.

When the output voltage is being controlled remotely by an external resistor, the internal potentiometer R34 is set to zero ohms (maximum counterclockwise position) and the external programming resistor replaces the jumper between terminals 1 and 2. Note that the position of S2 determines the output voltage to programming resistance ratio.

When the output voltage is sensed directly at the DC+ and DC- output terminals of the supply, a jumper is connected between SENSE+ and DC+ and between SENSE- and DC- on the rear terminal block.

When the output voltage is remotely sensed, the SENSE+ terminal is connected to the desired location on the lead that goes from the DC+ terminal to the load, and the SENSE- termin is connected to the desired location on the lead that goes from the DC- terminal to the load. Rated supply regulation is maintained at these points (junction of load and sense leads).

3-8 CURRENT LIMIT CIRCUITRY

The current limit circuits consist of a dual range 0-1.5A/0-15A adjustable current limit utilizing a concentric switch/potentiometer assembly, S3/R39 on the front panel, a fixed curren limiter for Source 2 to limit the maximum safe output current of this source independent of the setting of the panel CURRENT LIMIT controls, and similar fixed current limiters for Sources 3 and 4. These four separate current limiter circuits are connected to a common transistor Q2, in an "OR" configuration which functions to control the biasing of current amplifier transistor Q and thus the output current of the supply.

The dual range adjustable limiter circuit comprises output current sensing resistors R4 in series with R48 in parallel with R47 and R49. These current sensing resistors are connectec between emitters of Q19 through Q22 and the +DC output terminal. Switch S3 shorts out R48 in parallel with R47 and R49 for 15.0 ampere operation. R49 permits calibration for 1.5 ampere operation when S3 contacts 5 and 6 are open.

Q12 monitors the voltage drop across R46 or R46 in series with R48 in parallel with R and R49. This voltage is a function of output current. The emitter of Q12 is connected throu diode CR16 to the junction of Q19 through Q22 and R46. CR16 functions to compensate the chan in base-emitter voltage of Q12 with temperature. R31 functions to keep CR16 in a forward biased condition. The base of Q12 is connected to the arm of the panel CURRENT LIMIT contr potentiometer R39. One side of the potentiometer is tied to the DC+ output terminal side of the current sensing resistor string. The other side of the potentiometer is connected to a high stability DC source (CR7) through R33 and a calibrating trimmer R32. Thus, adjustment of R39 varies the bias voltage on Q12. The voltage drop across the output current sensing resistors with changes in output current adds to this bias voltage to turn Q12 on. The collector current of Q12 flows through resistor R7 and base-emitter junction of Q2. Q2, normally cut off, is driven into conduction by the current through R7 when collector current flows in Q12. This controls the bias of driver amplifier Q6 to limit the output current of the supply to a level depending upon the setting of R39.

Source 2 current limiting circuit consists of Q18, current sensing resistors R53 and R5 and resistor R55 which protects Q18 from excessive base-emitter current due to load transient This circuit operates to limit Source 2 output current to 7.5 amperes, regardless of the setting of R39 panel control.

Q15, R43, R44 and R45 function similarly to limit Source 3 to a maximum of 5 amperes
Q9, R35, R36 and R37 function similarly to limit Source 4 to a maximum of 2 amperes.

The collectors of Q18, Q15, Q9 and Q12 are connected together. When collector curr flows in any of these transistors, it will flow through R7 to turn Q2 on and control the supply output current. RC network C7 and R8 decrease the response time of the current limiter syste for loop stabilization purposes. CR6 provides collector voltage for Q12.

3-9 METER CIRCUITRY

The output voltage and current is monitored by separate panel instruments with four ranges total. Two voltage and two current ranges are provided to increase meter resolution. 0-6V/0-60V range is selected by the position of concentric panel VOLTAGE control/range switch (S2). 0-1.5A/0-15A range is selected by the position of concentric panel CURRENT LIMIT control/range switch (S3).

The positive terminal of voltmeter M1 is connected to the SENSE+ output terminal. The negative terminal of M1 is connected to the SENSE- output terminal through R74 in series with R72 multiplier resistor (6V range) or R73 multiplier resistor (60V range), depending upon the position of S2 (contacts 4, 5, 6).

R74 and diode CR28 form a protective circuit to limit the peak current through M1 from charged output capacitors (internal or external to the supply) when the VOLTAGE range switch is turned from 60V to 6V.

The positive terminal of current meter M1 is connected through R58 and calibrating trimmer R57 to one side of R46. The negative terminal of M1 is connected to the junction of calibrating trimmer R49 and S3. When S3 is in 0-15A range, M1 measures the current through R46 and is calibrated by R57. When S3 is in 0-1.5A range, M1 measures the current through R46 in series with R48 in parallel with R47 and R49 and is calibrated by R49.

3-10 OPERATION OF THE UNIPLY REGULATOR

When the power supply is operated at an output voltage lower than the unregulated voltage for Source 1 and where the unregulated voltage is sufficiently high to overcome the voltage drop in the series regulating transistors Q19 through Q22 and current sensing resistors R46, R47, R48, R49, Source 1 will supply the output power to the load. Series regulating transistors Q16 and Q17 of Source 2, Q13 and Q14 of Source 3, Q8 and Q10 of Source 4, Q7 current amplifier and Q6 driver, function as Darlington connected current amplifiers and drivers for Q19 through Q22.

If the unregulated voltage of Source 1 falls below a level necessary to sustain regulated output either as a result of a decrease in AC input voltage to the supply, an increase in load current beyond the 15.0 ampere rating of Source 1, or a load current greater than the setting of the panel CURRENT LIMIT control, the panel FAULT indicator will begin to flash signalling a loss of regulation.

If the Source 1 unregulated voltage falls below a level necessary to sustain regulated output as a result of a decrease in AC input voltage or an increase in output voltage setting, and the output load current is within the current rating of Source 2 (7.5 amperes) or below the setting of the panel CURRENT LIMIT control (under 7.5 amperes) diode CR22 will stop conducting. The higher voltage unregulated supply of Source 2 will now furnish regulated output to the load through CR21, series regulating transistors Q16 and Q17, R53, R54 and the base-emitter junctions of Q19 through Q22. Reverse current flow into the unregulated supply of Source 1 through the forward biased base-collector junctions of Q19 through Q22 is prevented by the blocking action of diode "OR" gate CR22.

Similarly, Source 3 and Source 4 will furnish current to the load through the base-emitter junctions of Sources 2 and 1 if the desired output voltage is increased by adjustment of the panel VOLTAGE controls. Diode "OR" gates CR22, CR21 and CR14 will similarly prevent reverse current flow into the non-functioning unregulated sources through the base-collector junctions of the idle series regulator transistors. Note that the supply will continue to provide voltage regulated output as long as the output current does not exceed the maximum current rating of the source supplying the output, i.e., 7.5A for Source 2, 5A for Source 3, 2A for Source 4 and if the CURRENT LIMIT control is set to levels greater than these respective values.

Conversely, if Source 4 (maximum rating of 2A) is supplying current to the load and the load current rises above the maximum of 2 amperes (or some lower setting of the CURRENT LIMIT controls) such as to actuate the limiter circuits, the supply will cease to regulate and the output voltage will drop with decreasing load resistance. When the output voltage falls below the unregulated voltage for Source 3, Source 4 will cease conducting and Source 3 will now furnish current to the load up to its maximum rating of 5 amperes (or a lower setting of the CURRENT LIMIT controls). Similarly, if the load resistance decreases such that the output voltage is below the unregulated voltage of Source 2, Source 3 will be cut off and Source 2 will furnish output current to the load up to its maximum rating of 7.5 amperes, or a lower setting of the CURRENT LIMIT controls. This transfer will continue as the load resistance decreases up to a short circuit at the output terminals. Under this condition, Source 1 will furnish output current up to approximately 16A, or to any other value to which the CURRENT LIMIT controls are adjusted. Note that since the original setting of the VOLTAGE controls required that Source 4 provide a regulated output within its voltage and current capabilities, the panel FAULT indicator will flash when Source 4 ceases to regulate and will continue to flash down to a short circuit across the power supply output terminals.

The UNIPLY system is unique in that it will furnish more output power than its panel ratings at AC line voltages above its minimum operating level.

The following are output ratings that can be delivered by each source, depending upon AC line voltage:

	Panel Rating	105 VAC	115 VAC	125 VAC
Source 1	0-6V, 0-15A	0-6V, 0-15A	0-7V, 0-15A	0-8V, 0-15A
Source 2	0-15V, 0-7.5A	6-17V, 0-7.5A	7-20V, 0-7.5A	8-22V, 0-7.5A
Source 3	0-25V, 0-5A	17-29V, 0-5A	20-33V, 0-5A	22-37V, 0-5A
Source 4	0-60V, 0-2A	29-60V, 0-2A	33-60V, 0-2A	37-60V, 0-2A

These are typical ratings and may vary somewhat from unit to unit.

It can be seen from the three sets of output ratings that transfer from one source to another will be dependent not only on DC output voltage, but also on available input AC line voltage. The power supply automatically selects that source which will deliver the output ratings required. (The lowest numerically of Sources 1-4.)

3-11 "FAULT" LIGHT CHARACTERISTICS

If an output requirement is such that it cannot be handled by any of the four sources, or if the supply is in a current limited mode, the FAULT indicator light will flash about 2-5 times per second until the load requirements are within the power supply capability, or the supply is no longer in a current limited condition.

3-12 FAULT LIGHT OPERATION

Whenever the current limit control transistor Q2 is activated or the AC line voltage is too low to support a desired output voltage, the current through R7 will cause the base-emitter junction of Q1 to be reverse-biased, cutting off its collector current. The current flowing through R4 then flows through C4 until the voltage drop across C4 reaches the ignition voltage of the neon lamp DS2. The lamp ignites and begins to discharge C4. When the charged potential falls to a level too low to support the ionization of DS2 (55V), neon lamp DS2 will extinguish. Capacitor C4 will then charge until the ignition voltage of neon lamp DS2 is reached again, and the cycle repeats. The circuit components are selected so that the FAULT neon lamp DS2 will flash 2 to 5 times per second. The capacitor C5 from Q1 emitter to the junction of R5 and R6 filters the pulsating DC current flowing from transformer terminal 12, through Q1 base-emitter junction, resistors R5 and R6, and diode CR2 to transformer terminal 11. This capacitor functions to prevent pulsating DC potentials from being coupled into the power supply amplifier at the junction of Q1 and Q2 bases.

3-13 VOLTAGE REGULATOR OPERATION

Two typical operating levels, 6V and 60V, are selected to describe regulator action.

3.13.1 6 VDC Output

When the resistance of the load is decreased, the output voltage will tend to decrease, with the resultant load current increase. This decrease in output voltage is sensed by transistor Q5 as an increase in base current. The increase in Q5 base current increases its collector current which flows through resistor R14, decreasing base current of Q4, decreasing its collector current, which increases drive current to the base of driver transistor Q6 through R12. This increases driver transistor Q7 base current, which increases the driver transistors Q8 and Q10 (Source 4 series regulating transistors) base current, which increases the driver transistors Q13 and Q14 (Source 3 series regulating transistors) base current, which increases the driver transistors Q16 and Q17 (Source 2 series regulating transistors) base current, which increases the Source 1 series regulating transistors Q19 through Q22 base currents, which decreases the effective resistance of Q19 through Q22 until the output voltage is within the load regulation specification of the power supply.

3.13.2 60 VDC Output

The operation at 60 VDC output is the same as the operation at 6 VDC output except that the driver transistors Q8 and Q10 in the 0 to 6 VDC output mode is the Source 4 series regulating transistors. The increase in Q8 and Q10 base currents increases their collector currents which flow through R35 and R36, Q13 and Q14 base-emitter junctions, R43 and R44, Q16 and Q17 base-emitter junctions, R53 and R54, Q19 through Q22 base-emitter junctions and R46, R47, R48, R49 to the +DC output terminal of the supply. When Q8 and Q10 are acting as the series regulator, diodes CR22, CR21 and CR14 have automatically disconnected Sources 1, 2 and 3 respectively from the load.

3-14 OVERVOLTAGE CROWBAR OPERATION

The overvoltage crowbar compares the output voltage of the supply with an internal voltage reference through an adjustable ratio resistance divider to trip a sensitive gate complementary SCR (anode gate). This SCR in turn fires a heavy current SCR crowbar connected across the output terminals. Resistors R66 and R67 (OVERVOLTAGE CROWBAR control potentiometer) form a divider connected in series across the 20V zener CR3 and the output of the supply. The anode and cathode of CR26 are connected across the supply output terminals. The non-trip setting of R67 puts a positive bias on the gate of CR26. CR26 requires a negative firing potential between gate and anode. This voltage is applied through 25 μs delay RC network R68 and C25. When the sum of the output voltage and the potential appearing across R66 and R67 produce a voltage across potentiometer R67 which exceeds the negative firing voltage of CR26, it will conduct heavily through cathode resistor R69. The voltage drop across R69 will be coupled through R70 current limiting resistor to the gate of power SCR CR27. This potential will trip CR27 to short circuit the power supply. Under short circuit conditions, the anode-cathode voltage across CR27 is approximately 1.5V. If the panel VOLTAGE control is turned counter-clockwise to a level below 1.5V, the holding current through CR27 will be reduced sufficiently to reset the crowbar. Normal resetting of the crowbar is accomplished by turning off the power supply until the voltage across CR27 has decayed below 1.5 volts, then turning the power supply on again.

Another feature of the overvoltage crowbar circuit is that the bias voltage obtained from CR3, which provides a cut-off bias to CR26 and functions to protect the Model 6150 when used with a load operating from a multiplicity of DC sources. If the power supply is turned on and a voltage from an external source appears across the output terminals that exceeds the overvoltage crowbar threshold setting, the crowbar will be activated to protect the supply.

When a conventional power supply is turned off, a current feedthrough condition can exist where potentials and currents from other sources can be connected through load circuits to the output terminals of the supply. These potentials may damage the input circuitry of the turned-off source. Protection against this condition is normally provided when the applied potentials are in reverse polarity to the normal output polarity of the power supply. This is accomplished by internally connecting a safety diode across the output terminals. This safety diode is connected in reverse polarity (CR29) and is normally non-conducting. In the event of a reverse potential appearing across the output terminals, the diode conducts to limit the voltage to approximately one volt. The rating of the diode is chosen large enough to anticipate the maximum possible reverse current.

In the Model 6150 the time constant of decay of the supply output voltage is much longer than the decay of the reference potential generated by CR3. Thus, when the power supply is turned off, CR26 becomes negatively biased almost instantaneously and trips the crowbar system, short-circuiting the output terminals. If external voltages of the same polarity applied to the output terminals of the Model 6150 are high enough, a holding current to keep CR27 in its conducting condition will maintain a short circuit across the power supply even though it is turned off. This will limit the output voltage across the power supply (for potentials of the same polarity) to approximately 1.5V. It is important, however, that a blocking diode be connected in series with the output terminals of the Model 6150 when used with a floating battery across the output terminals or for battery charging functions to prevent the battery current from flowing back through CR27 at levels that may damage the device.

APPENDIX

1. INTRODUCTION

This Appendix contains an Electrical Parts List, Schematic Diagram, Parts Location Diagram and equipment Warranty.

2. ELECTRICAL PARTS LIST

All electrical and electronic parts are listed in the sequence of their circuit numbers as shown on the Schematic Diagram. A brief description of each part is given, followed by the code number of the manufacturer and his part number. All manufacturers' code numbers are taken from Cataloging Handbooks H4-1 and H4-2, Federal Supply Code for Manufacturers. These handbooks can be obtained from Federal Agencies or ordered directly from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

We recommend that all parts with the code number 98095 be ordered directly from Power Designs, Inc. The commercial equivalents of these parts may have wide parameter tolerances or require special factory inspection or modification before they can be used in the power supply.

All components used in the power supply or supplied as replacements are carefully inspected at the factory. Inspections are performed on a 100% basis or at AQL levels to Military Specification MIL-Q-9858 under which Power Designs, Inc. has been qualified.

All semiconductors are inspected on a 100% basis, not only for operating parameters, but also for critical characteristics related to reliability and predictable life expectancy. Some of these characteristics are observed when the device is taken beyond its normal operating regions. These test techniques have been developed under a "predictable reliability" program in operation at Power Designs, Inc. for the past twelve years. Under this program, quality control procedures are constantly revaluated and updated as advances are made in solid state technology and experience is gained from field history.

Semiconductor manufacturers are continually modifying their products. Complete lines are discontinued to be replaced by devices having improved gain, operating voltage levels and frequency responses. The high gain, closed loop DC amplifiers used in regulator circuits are particularly sensitive to slight changes in these parameters. Commercial or military "equivalent" transistors may affect the performance of the power supply. We can assure compliance with the original specifications if replacement semiconductors are ordered from the Factory.

All replacement semiconductors are processed and stocked at the factory to insure complete interchangeability with the devices in the original equipment. The original devices are coded with a Power Designs Inc. part number. For example:

MS	1028	A
Semiconductor Manufacturer's Code	Power Designs Inc. Type	Suffix Identifying Special Parameters

When ordering replacements, please identify the device as thoroughly as possible, giving the model and serial number if available.

The replacement part you receive may not have the same part number as that shown on the Electrical Parts List. This can be due to several factors:

a. A different prefix indicates that Power Designs Inc. is using another vendor source. The operating characteristics of the devices are identical.

b. A completely different part number indicates:

(1) The original vendor has discontinued manufacture of the item or can no longer manufacture it to the original specifications.

(2) A better device for use in a particular circuit has been substituted.

(3) Tighter controls for interchangeability have provided greater assurance of reliability with the replacement.

CODE LIST OF MANUFACTURERS FOR MODEL 6150

01121	Allen-Bradley Company	Milwaukee, Wisconsin
71400	Bussman Manufacturing Division	St. Louis, Missouri
75382	Kulka Electric Corporation	Mount Vernon, New York
98095	Power Designs Inc.	Westbury, New York

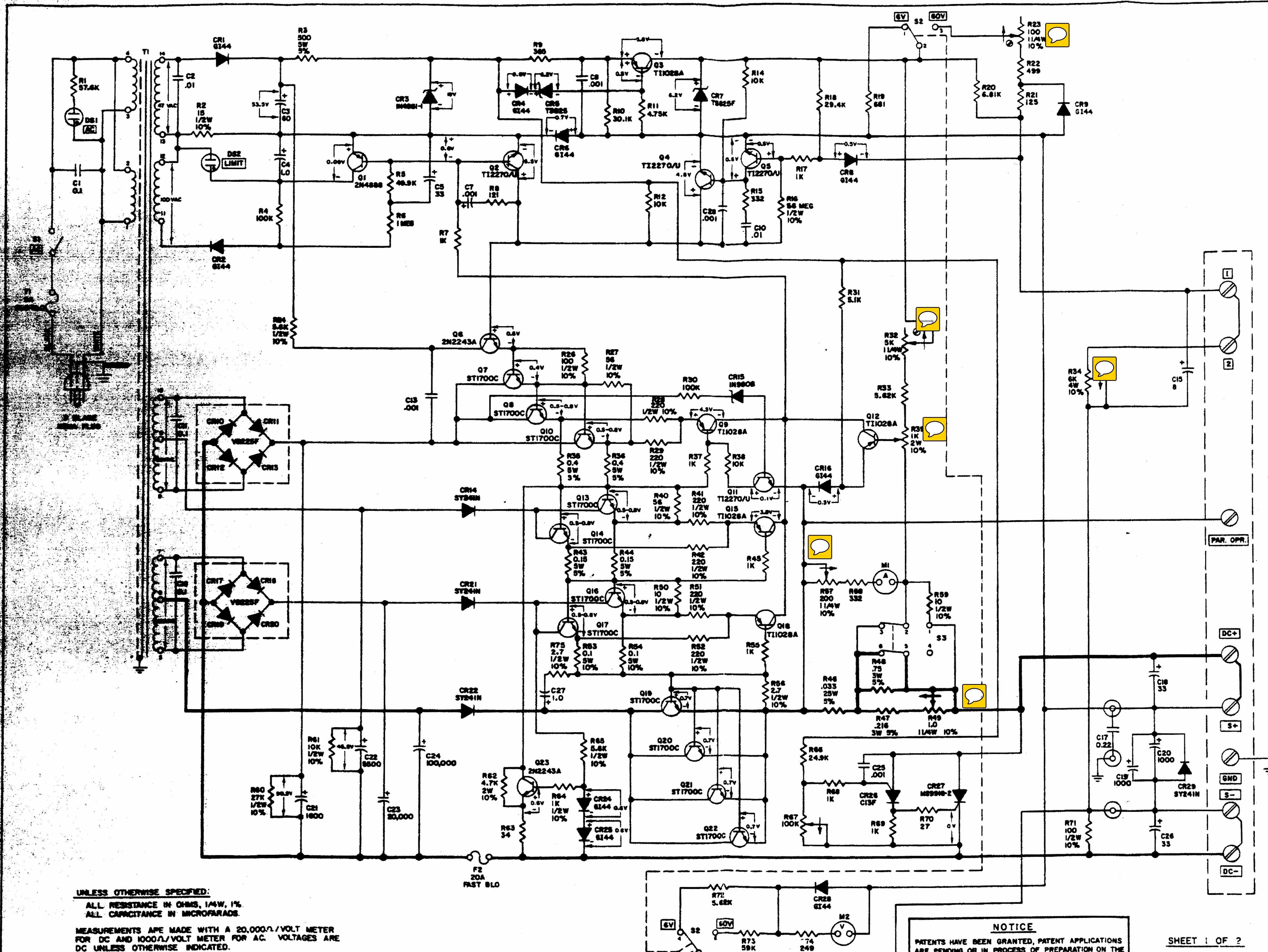
ELECTRICAL PARTS LIST

NOTE: Before replacing semiconductors, see paragraph 2 of the Appendix.

Circuit No.	Description	Mfr Code No.	Part No.
C1	Capacitor, ceramic disc, 0.1 µf, 600 vdc	98095	CC-37-6
C2	Capacitor, ceramic disc, 0.01 µf, 1 kvdc	98095	CC-A01-102
C3	Capacitor, electrolytic, 60 µf, 75 vdc	98095	CE-600-.75
C4	Capacitor, electrolytic, 1 µf, 100 vdc	98095	CE-59-1
C5	Capacitor, tantalum, 33 µf, 10 vdc	98095	CE-33-.10
C7, C8	Capacitor, plastic film, 0.001 µf, 200 vdc	98095	CP-24-2
C10	Capacitor, plastic film, .01 µf, 200 vdc	98095	CP-18-2
C11	Capacitor, ceramic disc, 0.1 µf, 200 vdc	98095	CC-24-2
C13	Capacitor, plastic film, 0.001 µf, 200 vdc	98095	CP-24-2
C15	Capacitor, electrolytic, 8 µf, 100 vdc	98095	CE-42-1
C16	Capacitor, ceramic disc, 0.1 µf, 200 vdc	98095	CC-24-2
C17	Capacitor, plastic film, 0.22 µf, 200 vdc	98095	CP-22-2
C18	Capacitor, tantalum, 33 µf, 10 vdc	98095	CE-33-.10
C19, C20	Capacitor, electrolytic, 1000 µf, 50-70 vdc	98095	CE-102-50
C21	Capacitor, electrolytic, 1600 µf, 100 vdc	98095	CE-162-100
C22	Capacitor, electrolytic, 5500 µf, 50 vdc	98095	CE-552-50
C23	Capacitor, electrolytic, 20,000 µf, 30 vdc	98095	CE-203-30
C24	Capacitor, electrolytic, 100,000 µf, 15 vdc	98095	CE-104-15
C25	Capacitor, ceramic disc, 0.001 µf, 1 kvdc	98095	CC-17-10
C26	Capacitor, tantalum, 33 µf, 10 vdc	98095	CE-33-.10
C27	Capacitor, tantalum, 1 µf, 35 vdc	98095	CE-1-35
CR1, CR2	Diode, silicon	98095	GI-44
CR3	Diode, silicon, zener	98095	1N4881-1
CR4	Diode, silicon	98095	GI-44
CR5	Diode, silicon, zener	98095	TS825
CR6	Diode, silicon	98095	GI-44
CR7	Diode, silicon, zener	98095	TS825F
CR8, CR9	Diode, silicon	98095	GI-44
CR10 thru CR13	Rectifier bridge	98095	VB225F
CR14	Diode, silicon	98095	SY241N
CR15	Diode, silicon, zener	98095	1N980B
CR16	Diode, silicon	98095	GI-44
CR17 thru CR20	Rectifier bridge	98095	VB225F
CR21, CR22	Diode, silicon	98095	SY241N
CR24, CR25	Diode, silicon	98095	GI-44
CR26	Anode gate silicon controlled rectifier	98095	C13F
CR27	Silicon controlled rectifier	98095	MS9918-2
CR28	Diode, silicon	98095	GI-44
CR29	Diode, silicon	98095	SY241N
DS1	Indicator lamp	98095	PLA-13
DS2	Indicator lamp	98095	PLA-15

Circuit No.	Description	Mfr Code No.	Part No.
F1	Fuse, 5 A, Slo-Blo	71400	Type MDX
F2	Fuse, 20 A, 32 V, Fast-Blo	71400	Type AGC
M1	Meter, 0-15 A, 0-1.5 A	98095	MA-125
M2	Meter, 0-60 V, 0-6 V	98095	MV-123
Q1	Transistor, silicon, PNP	98095	2N4888
Q2	Transistor, silicon, NPN	98095	TI2270/U
Q3	Transistor, silicon, PNP	98095	TI-1028A
Q4, Q5	Transistor, silicon, NPN	98095	TI-2270/U
Q6	Transistor, silicon, NPN	98095	2N2243A(Sele
Q7, Q8	Transistor, silicon, NPN	98095	ST-1700C
Q9	Transistor, silicon, PNP	98095	TI-1028A
Q10	Transistor, silicon, NPN	98095	ST-1700C
Q11	Transistor, silicon, NPN	98095	TI-2270/U
Q12	Transistor, silicon, PNP	98095	TI-1028A
Q13, Q14	Transistor, silicon, NPN	98095	ST-1700C
Q15	Transistor, silicon, PNP	98095	TI-1028A
Q16, Q17	Transistor, silicon, NPN	98095	ST-1700C
Q18	Transistor, silicon, PNP	98095	TI-1028A
Q19, Q20	Transistor, silicon, NPN	98095	ST-1700C
Q21, Q22	Transistor, silicon, NPN	98095	ST-1700C
Q23	Transistor, silicon, NPN	98095	2N2243A(Se
R1	Resistor, precision, metal film, 57.6 kΩ ±1%, 1/4 w	98095	RD-5762-1QA
R2	Resistor, composition, 15 Ω ±10%, 1/2 w	01121	EB1501
R3	Resistor, wirewound, 500 Ω ±5%, 5 w	98095	RW-501-3D
R4	Resistor, precision, metal film, 100 kΩ ±1%, 1/4 w	98095	RD-104-1QA
R5	Resistor, precision, metal film, 49.9 kΩ ±1%, 1/4 w	98095	RD-4992-1QA
R6	Resistor, precision, metal film, 1 megΩ ±1%, 1/4 w	98095	RD-105-1QA
R7	Resistor, precision, metal film, 1 kΩ ±1%, 1/4 w	98095	RD-102-1QA
R8	Resistor, precision, metal film, 121 Ω ±1%, 1/4 w	98095	RD-1210-1QA
R9	Resistor, precision, metal film, 365 Ω ±1%, 1/4 w	98095	RD-3650-1QA
R10	Resistor, precision, metal film, 30.1 kΩ ±1%, 1/4 w	98095	RD-3012-1QA
R11	Resistor, precision, metal film, 4.75 kΩ ±1%, 1/4 w	98095	RD-4751-1QA
R12	Resistor, precision, metal film, 10 kΩ ±1%, 1/4 w	98095	RD-103-1QA
R14	Resistor, precision, metal film, 10 kΩ ±1%, 1/4 w	98095	RD-103-1QA
R15	Resistor, precision, metal film, 332 Ω ±1%, 1/4 w	98095	RD-3320-1QA
R16	Resistor, composition, 56 megΩ ±10%, 1/2 w	01121	EB5661
R17	Resistor, precision, metal film, 1 kΩ ±1%, 1/4 w	98095	RD-102-1QA
R18	Resistor, precision, metal film, 29.4 kΩ ±1%, 1/4 w	98095	RD-2942-1QA
R19	Resistor, precision, metal film, 681 Ω ±1%, 1/4 w	98095	RD-6810-1QA
R20	Resistor, precision, metal film, 6.81 kΩ ±1%, 1/4 w	98095	RD-6811-1QA
R21	Resistor, precision, metal film, 125 Ω ±1%, 1/4 w	98095	RD-1250-1QA
R22	Resistor, precision, metal film, 499 Ω ±1%, 1/4 w	98095	RD-4990-1QA
R23	Resistor, wirewound, trimpot, 100 Ω ±10%, 1-1/4 w	98095	RWTP-101
R24	Resistor, composition, 5.6 kΩ ±10%, 1/2 w	01121	EB5621
R26	Resistor, composition, 100 Ω ±10%, 1/2 w	01121	EB1011
R27	Resistor, composition, 56 Ω ±10%, 1/2 w	01121	EB5601

Circuit No.	Description	Mfr. Code No.	Part No.
R28, R29	Resistor, composition 220 Ω ± 10%, 1/2 w	01121	EB2211
R30	Resistor, precision, metal film, 100 kΩ ±1%, 1/4 w	98095	RD-104-1QA
R31	Resistor, precision, metal film, 5.1 kΩ, ± 1%, 1/4 w	98095	RD-512-1QA
R32	Resistor, wirewound, trimpot, 5 kΩ, ± 10%, 1-1/4 w	98095	RWTP-502-C4
R33	Resistor, precision, metal film, 5.62 kΩ ±1%, 1/4 w	98095	RD-5621-1QA
R34	Resistor, wirewound, variable, 6 kΩ ±10%, 4 w	98095	RWV-602M4-.8
R35, R36	Resistor, wirewound, 0.4 Ω ±5%, 5 w	98095	RW-0F4-3DA
R37	Resistor, precision, metal film, 1 kΩ ±1%, 1/4 w	98095	RD-102-1QA
R38	Resistor, precision, metal film, 10 kΩ ±1%, 1/4 w	98095	RD-103-1QA
R39	Resistor, wirewound, variable, 1 kΩ ±10%, 2 w	98095	RWV-102C4-.8
R40	Resistor, composition, 56 Ω ±10%, 1/2 w	01121	EB5601
R41, R42	Resistor, composition, 220 Ω ±10%, 1/2 w	01121	EB2211
R43, R44	Resistor, wirewound, 0.15 Ω ±5%, 5 w	98095	RW-F15-3DA
R45	Resistor, precision, metal film, 1 kΩ ±1%, 1/4 w	98095	RD-102-1QA
R46	Resistor, wirewound, 0.033 Ω ±5%, 25 w	98095	RW-F033-3GF
R47	Resistor, wirewound, 0.216 Ω ±5%, 3 w	98095	RW-F216-3KA
R48	Resistor, wirewound, 0.75 Ω ±5%, 3 w	98095	RW-F75-3KA
R49	Resistor, wirewound, trimpot 1 Ω ±10%, 1-1/4 w	98095	RWTP-010-C4
R50	Resistor, composition, 10 Ω ±10%, 1/2 w	01121	EB1001
R51, R52	Resistor; composition, 220 Ω ±10%, 1/2 w	01121	EB2211
R53, R54	Resistor, wirewound, 0.1 Ω ±10%, 5 w	98095	RW-0F1-4DA
R55	Resistor, precision, metal film, 1 kΩ ±1%, 1/4 w	98095	RD-102-1QA
R56	Resistor, composition, 2.7 Ω ±10%, 1/2 w	01121	EB27G1
R57	Resistor, wirewound, trimpot, 200 Ω ±10%, 1-1/4 w	98095	RWTP-201-C4
R58	Resistor, precision, metal film, 332 Ω ±1%, 1/4 w	98095	RD-3320-1QA
R59	Resistor, composition, 10 Ω ±10%, 1/2 w	01121	EB1001
R60	Resistor, composition, 27 kΩ ±10%, 1/2 w	01121	EB2731
R61	Resistor, composition, 10 kΩ ±10%, 1/2 w	01121	EB1031
R62	Resistor, composition, 4.7 kΩ ±10%, 2 w	01121	HB4721
R63	Resistor, precision, metal film, 34 Ω ±1%, 1/4 w	98095	RD-340-1QA
R64	Resistor, composition, 1 kΩ ±10%, 1/2 w	01121	EB1021
R65	Resistor, composition, 5.6 kΩ ±10%, 1/2 w	01121	EB5621
R66	Resistor, precision, metal film, 24.9 kΩ ±1%, 1/4 w	98095	RD-2492-1QA
R67	Resistor, variable, composition, 100 kΩ	98095	RVC-104B4-0
R68, R69	Resistor, precision, metal film, 1 kΩ ±1%, 1/4 w	98095	RD-102-1QA
R70	Resistor, composition, 27 Ω ±10%, 1/2 w	01121	EB2701
R71	Resistor, composition, 100 Ω ±10%, 1/2 w	01121	EB1011
R72	Resistor, precision, metal film, 5.62 kΩ ± 1%, 1/4 w	98095	RD-5621-1QA
R73	Resistor, precision, metal film, 59 kΩ ±1%, 1/4 w	98095	RD-593-1QA
R74	Resistor, precision, metal film, 249 Ω ±1%, 1/4 w	98095	RD-2490-1QA
R75	Resistor, composition, 2.7 Ω ±10%, 1/2 w	01121	EB27G1
S1	Switch, toggle, SPST	98095	ST-5
S2	Switch, toggle, DPDT	98095	ST-33
S3	Switch, toggle, DPDT	98095	ST-2
T1	Transformer	98095	TTM-6150-1
TB1	Terminal Block	75382	599-2004-8



UNLESS OTHERWISE SPECIFIED:
ALL RESISTANCE IN OHMS, 1/4W, 1%.
ALL CAPACITANCE IN MICROFARADS.

MEASUREMENTS ARE MADE WITH A 20,000Ω/VOLT METER FOR DC AND 1000Ω/VOLT METER FOR AC. VOLTAGES ARE DC UNLESS OTHERWISE INDICATED.

VOLTAGES INDICATED ARE MEASURED WITH 115V, 60Hz INPUT.

VOLTAGE TABLE

OUTPUT	6VDC,15A	15VDC,7.5A	25VDC,5A	60VDC,2A
Q6 VCE	27V	27V	27V	22V
Q7,8,9,10 VCE	81V	72V	57V	21V
Q12VCE	2.7V	2.3V	2.1V	2V
Q12VBE	0.5V	0.2V	0.1V	0.004V
Q13,14 VCE	35.9V	26.3V	10V	0.03V
Q15 VCE	3.8V	3.93V	4.14V	3.3V
Q16,17 VCE	15.8V	6V	0.06V	0.03V
Q18 VCE	3.2V	3.2V	2.8V	2.3V
Q19,20,21,22VCE	2V	0.06V	0.045V	0.02V
Q23 VCE	8.6V	17.6V	28V	62.5V
C21	92.1V	91V	86.9V	85.4V
C22	45.6V	45.1V	39.5V	43.3V
C23.	25V	24V	27.3V	28.2V
C24	10.5V	12.2V	13.6V	14V
CR14	0.6V	0.66V	0.8V	19V
CR21	0.7V	0.85V	0.63V	32V
CR22	0.8V	3.5V	12V	46V
CR26, 27	6V	15V	25V	60V
* CR26 (A-G)	15V	13V	11V	4.4V
R35, 36	0	0	0.27V	0.4V
R43, 44	0	0	0.4V	0.16V
R46	0.5V	0.25V	0.17V	0.07V
R53, 54	0.04V	0.4V	0.27V	0.1V

* OV CROWBAR (R67) MAX. CW

NOTES TO VOLTAGE TABLE:

1. VOLTAGES INDICATED ARE MEASURED WITH 115V, 60Hz INPUT WITH OUTPUT LEVELS AS SHOWN.
2. VOLTAGES NOT LISTED DO NOT CHANGE WITH OUTPUT LEVEL AND ARE SHOWN DIRECTLY ON SCHEMATIC DIAGRAM.

NOTICE

SHEET 1 OF 2

REVISIONS

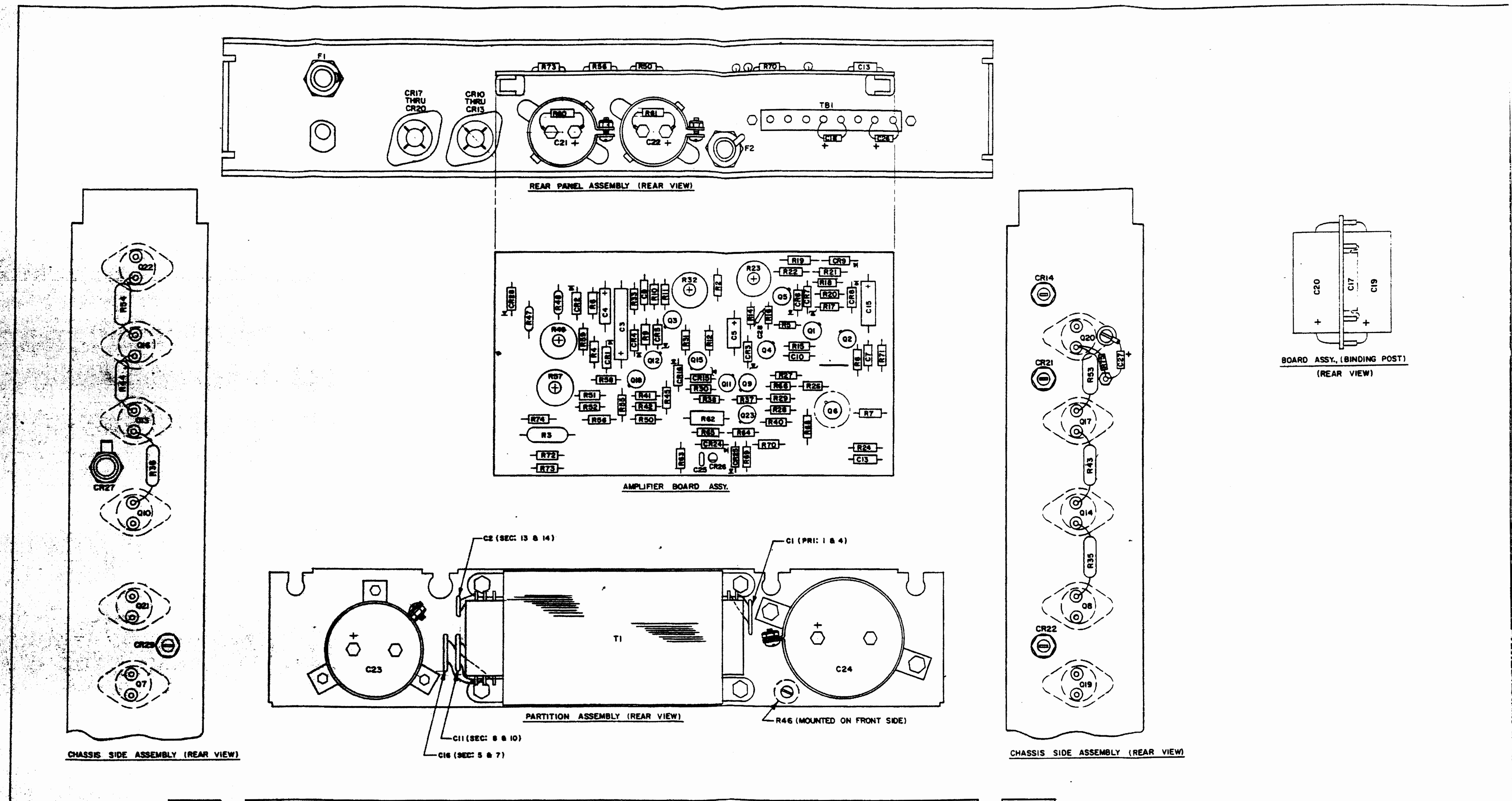
SYM.	DESCRIPTION	APPD.	DATE
D	REVISED ECN 2342	[illegible]	[illegible]
C	REVISED ECN 2201	[illegible]	[illegible]
B	REVISED ECN 2131	[illegible]	[illegible]
A	RELEASED	[illegible]	[illegible]

DRAWING NO. PS-6150-2 — REV. D

TITLE SCHEMATIC, MODEL 6150 POWER SUPPLY

DRAWN R. Z.	CHECKED [illegible]	APPROVED [illegible]
DATE 2-15-72	DATE 5-19-72	DATE 5-19-72

Power Designs inc.
NEW YORK



REAR PANEL ASSEMBLY (REAR VIEW)

AMPLIFIER BOARD ASSY.

BOARD ASSY., (BINDING POST) (REAR VIEW)

CHASSIS SIDE ASSEMBLY (REAR VIEW)

PARTITION ASSEMBLY (REAR VIEW)

CHASSIS SIDE ASSEMBLY (REAR VIEW)

FRONT PANEL ASSEMBLY (REAR VIEW) WITH BOARD ASSY., BINDING POST REMOVED

SHEET 2 OF 2

SYM.	DESCRIPTION	APPD	DATE
D	REVISED ECN 2342		
C	REVISED ECN 2201		
B	REVISED ECN 2131		
A	RELEASED		

REVISIONS

DRAWING NO. PS-6150-2 REV. D

TITLE LOCATION OF COMPONENTS
MODEL 6150

DRAWN R.Z.	CHECKED	APPROVED
DATE 2-16-72	DATE 5-19-72	DATE 5-19-72

Power Designs inc.
NEW YORK