



INSTRUCTION MANUAL
FOR

**HCR
POWER SUPPLY**

MODEL _____ SERIAL NO. _____

(201) 922-9300

ELECTRONIC MEASUREMENTS INC.

405 ESSEX ROAD, NEPTUNE, N.J. 07753



FIVE-YEAR WARRANTY

Electronic Measurements, Inc. warrants this equipment manufactured by us and sold by us or our authorized agents to a manufacturer or end user to be free from defects in material or workmanship. Our liability under this warranty is limited to servicing and repair or replacement of parts when equipment is returned to us with transportation charges prepaid within a period of five years after original shipment and when the equipment is shown by our inspection to be thus defective, normal wear and tear excepted.

This warranty does not apply to equipment subjected to abuse or incorrect installation or operation, nor to equipment repaired or modified outside of the Electronic Measurements, Inc. factory unless prior written approval to make such repairs or modifications has been received from the factory. The foregoing warranty is in lieu of all other express or implied warranties except of title.

* ***** *
* *
* **CAUTION** *
* *
* *
* While this supply is designed for safe operation certain precautions *
* must be observed. The unit is intended to be operated by technically *
* competent personnel generally familiar with the principles of elec- *
* trical safety. *
* *
* Whenever the AC power supply circuit is energized there are EXPOSED *
* LETHAL VOLTAGES within the enclosure. Hence, the supply circuit must *
* be turned off by unplugging the unit or, in the case of units hard *
* wired to the power source, removing the line fuses or securing the *
* breaker supplying the unit before attempting any operation requiring *
* entry. Remember that even after the line is disconnected energy can *
* still be stored in capacitors and such unexpected places as the *
* interwinding capacitance of transformers. *
* *
* The input, output and sensing terminals of the supply are all poten- *
* tially hazardous. These risks are not always obvious. Most people *
* are aware of the dangers inherent in high voltage equipment. However, *
* available energy must also be considered. For example, the output *
* terminals of a 5 volt supply are not usually thought of as dangerous. *
* In addition to the steady state energy available, such supplies are *
* typically terminated by very large capacitors, which can deliver huge *
* surge currents. Consider what could happen if a ring, wrist watch, *
* or other metallic object attached to a person were to short across *
* the output of such a device. *
* *
* High current supplies are capable of vaporizing metallic objects, *
* such as screwdrivers. This can result in molten metal being *
* sprayed on people. *
* *
* Exercise extreme caution when using these supplies. *
* ***** *





MEMORANDUM TO USERS OF E/M POWER SUPPLIES IN RACK INSTALLATIONS

All E/M power supplies have been designed and tested to provide full rated current and voltage throughout the specified line voltage range at the rated ambient air temperature. To achieve this maximum rating, airflow as provided by the internal fans, proportioned and directed by chassis openings and internal partitions, must not be impeded. It is not required but is desirable to prevent blocking air openings on the top of the supply.

On 3 Phase TCR supplies, air enters the unit on the right-hand side at the location of the fans and is transferred through the supply in a horizontal direction toward the left. Airflow is reduced any time there is a negative pressure at the air inlet or positive pressure at the air outlet. Each fan is capable of providing 100 to 130 cubic feet per minute of air flow (CFM) at zero static pressure. The supply itself produces some restrictions to this flow so that approximately 80% of the airflow is available. As static pressure increases, caused by additional restriction of airflow external to the power

supply, the efficiency of the fans drops significantly and airflow is greatly reduced. This reduction in airflow causes a substantial increase in internal temperatures of the supply, frequent thermostat shut down and reduced power supply reliability.

On Single Phase TCR power supplies, air enters the sides of the power supply and is exhausted out the rear. On the EMS series air enters the unit by means of slots in the front panel and along the sides and exits primarily from the rear. The same airflow considerations as previously discussed are still applicable.

Ideally when power supplies are mounted in a rack, the rack should have no sides or rear covers. Since this is usually not practical or safe, the installer must consider the effect of any enclosure on power supply airflow. Since the power supplies are heavy they must be supported by some sort of rail along the sides of the supply, front to rear. This rail must be chosen for proper strength but must not be either too close to or extend up too far along the side of the supply or airflow will be blocked. To minimize vertical height use an angle iron of substantial cross section and unequal leg dimension. Do not support the power supply from the front panel only in an attempt to minimize this problem.

The rail does not need to be continuous from front to back to support the supply but for safety and ease of installing and removing the supply it usually is.

Most commercial racks are available with louvered side panels and doors. Side panels are also available with an extended depth which provides an additional plenum space on each side of the rack for improved airflow.

Burn-in systems impose two additional considerations for power supply installation. The supply rack is often placed next to the oven and is sometimes integral with the oven. The thermal insulating qualities of the oven both through conduction, convection and radiation can impart substantial heat to the power supply rack and subsequently to the power supplies. If it is possible, separate the supply rack from the oven by a combination of space, insulation, reflective surfaces or moving air.

The ambient air in burn-in rooms, especially in tropical climates can also be very hot. Frequently high humidity is also present. This situation, while not ideal for power supply longevity, should itself cause little difficulty. When combined with insufficient airflow, however, it can significantly affect power supply reliability and the usable output current capability of the power supply.

The rack must exchange with ambient temperature air the same number of CFM as the power supplies circulate or the power supply exhaust air will be recirculated many times resulting in a continuously rising temperature until some elevated thermal equilibrium is reached. Each 3 1/3" fan in the system transfers 40 CFM while each 4 5/8" fan moves as much as 140 CFM. Air must be exchanged from outside to inside to outside the rack at a CFM value equal to the sum of the CFM ratings of all of the fans in all of the power supplies. In addition this transfer must be accomplished in such a way as to not impede each power supplies' internal airflow. When figuring out how to accomplish this in any given installation consider any action which would tend to increase air pressure at air outlet points is beneficial to supply cooling.

ELECTRICAL STANDARDS

All company primary standards are either certified directly or are traceable to certification by the National Bureau of Standards.

CLAIM FOR DAMAGE IN SHIPMENT

This instrument received comprehensive mechanical and electrical inspections before shipment. Immediately upon receipt from the carrier, and before operation, this instrument should be inspected visually for damage caused in shipment. If such inspection reveals internal or external damage in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. When referring to this equipment, always include the model and serial numbers.

RETURNING EQUIPMENT

Before returning any equipment to the factory, the following steps should be taken:

1. Notify Electronic Measurements, Inc., at 800-631-4298. Give a full description of the difficulty including the model and serial number of the unit in question. Upon receipt of this information we will assign a Return Material Authorization number (RMA) and give you shipping instructions.
2. Equipment returned to us must be packed in a manner to reach us without damage, and the shipping container must be marked with the RMA number in an area approximate to the shipping label with numbers that are easily read. All returned units that do not show the RMA number on the outside of the container will be refused.
3. For non-warranty repairs, we will submit a cost estimate for your approval prior to proceeding.

HCR MANUAL

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INSTRUCTION MANUAL
HCR POWER SUPPLY

SECTION I

GENERAL INFORMATION

1.1 DESCRIPTION

This manual contains operation and maintenance instructions covering the Electronic Measurements, Inc. series of Single Phase Triac Controlled power supplies. These supplies are constant voltage and constant current automatic crossover sources of regulated DC power packaged in 5.0 inches without rack adapter and 5 1/4 inches with rack adaptor for side by side mounting in 19 inch relay rack enclosures.

1.2 SPECIFICATIONS

The following specifications describe the published operational characteristics of this series of power supplies.

250 Watts nominal output.

AC Input: 250 watt model, 105-130V, 47-63Hz optional. Units are shipped with terminal block, line cord available on request.

REGULATION:

Voltage Mode: For line voltage variations and load current variations within the rating of the supply, the output voltage will not vary more than 0.1% of the maximum voltage rating.

Current Mode: For line voltage variations and load voltage variations within the rating of the supply, the output current will not vary more than .25% of the maximum current rating.

On those units in which the percentage of voltage or current ripple exceeds the specified regulation, the regulation will appear to be degraded due to the effect of this ripple on the measurement.

RIPPLE:

Measured with either positive or negative grounded and 100% output voltage and current into a resistive load. (See rating chart) (At 50Hz AC input is 30% above 60Hz rating)

STABILITY:

The output voltage or current will remain within 0.05% for 8 hours after warm-up, with constant external effects.

TRANSIENT RESPONSE:

Upon instant application of loads up to 50% of the maximum rating of the supply, the output voltage will recover to within 1.0% of its final value within 50ms. Instantaneous line variations are corrected to 1% within 50ms of their occurrence.

TEMPERATURE COEFFICIENT:

Output voltage T.C. is 0.02% per degree C of maximum rating. Output current T.C. is 0.03% per degree of maximum rating.

OPERATING TEMPERATURE:

0-50 Degree C (0-40 Degree C for 50Hz input) with no derating required. Derate current linearly to 50% of rating table (pg.) at 71 Degree C ambient.

STORAGE TEMPERATURE:

-40 Degrees to +85 Degrees C

GENERAL

RESOLUTION:

The voltage control is a ten turn potentiometer. The current control is a one turn cermet type potentiometer.

INSTRUMENTATION:

Voltmeter, ammeter and mode of operation indicator lights.

CONTROLS:

Circuit breaker on/off control, voltage and current controls.

COOLING:

All units are fan cooled and thermostatically protected. Air enters at sides of unit and exits at the rear. Consequently, no heat will be applied to other equipment above or below the power unit.

SIZE:

5.0" high, 7.75" wide, and 19.0' deep.

RATINGS AND ADDITIONAL SPECIFICATIONS

VOLTAGE	CURRENT (AMPS)	CV-rms 1 RIPPLE/REG	CC-rms 2 RIPPLE/REG	% EFF. (NOMINAL)	AC INPUT CUR. @ 115V AC INPUT
0-7.5	30	80MV	450MA	60	4
0-10	25	80MV	275MA	62	4
0-20	13	80MV	55MA	67	4
0-30	8	90MV	45MA	67	4
0-40	6	100MV	27MA	70	4
0-60	4	120MV	15MA	75	4
0-80	3	150MV	9MA	75	4
0-150	2	300mv	4.5MA	80	4
0-300	.9	500MV	2.5MA	83	4

¹ MV or .1% whichever is greater.

² MA or .25% whichever is greater.

FINISH:

Front panel painted tan; markings are black silk screened. All other metallic parts are either plated or chemical film treated.

NOTES:

For operation at 50Hz, ripple & transient response is degraded by a factor of 30% from 60Hz ratings.

On those units in which the percentage of voltage or current ripple exceeds the specified load regulation, the load regulation will appear to be degraded due to the affect of this ripple on the measurement.

1.3 FEATURES

The single phase triac line contains electrical and mechanical features, many of which will be described in additional detail in other sections. Some of these features are as follows:

- Circuit Breaker input protection.
- Optional adjustable over voltage protection.
- Remote programming of voltage and current by external voltage, current, and resistance.
- Remote sensing.
- 10 turn high resolution voltage control.
- 1 turn, cermet (high resolution) current control.
10 turn current control optional.

1.4 COOLING

Each power supply enclosure is cooled by a suitable sized blower fan exhausted warm air to the rear. Fresh air intake is from each side. No surface of the supply radiates heat to adjacent equipment. At least five inches of space should be allowed behind the supply & one inch along each side in the vicinity of the air inlet holes for unimpeded air flow.

1.5 MECHANICAL

The supply is capable of being rack or bench mounted. For rack mounting, additional support other than that provided by the front panel is required, except for short term stationary mounting. Angle iron slide in mounting support or cross beam member support are required for permanent mounting.

1.6 INSTALLATION

This supply is intended for rack or bench mount. Horizontal mounting is preferred, however, mounting in any position is allowed. DO NOT operate the supply continuously with the covers removed since the air flow pattern with the chassis will be adversely affected.

1.7 POWER REQUIREMENTS

A suitable source of AC power is required for this supply. The unit will operate on 50 or 60Hz line frequency. The line impedance from the power source should be fairly low since high peak currents are drawn. The service rating and connecting wire AWG is in the table shown below.

NOTE: This rating is not the actual specified line current, but is a slightly higher service rating.

	120V SERVICE RATING -----	AWG ---	220V SERVICE RATING -----	AWG ---
250W	15A	#14	7.5A	#16

Load line power runs should be made with conductor sized to match the current ratings of the supply. The following chart may be helpful in determining the proper sizes.

CURRENT -----	RECOMMENDED AWG -----
30A	10
20A	12
15A	14
10A	16
8A	18
6A	20
LESS	20



SECTION II OPERATING INSTRUCTIONS

CONTROLS AND INDICATORS

The front panel surface contains all the controls and indicators necessary to operate the supply in its normal mode. From left to right these include

- 1) Circuit breaker - ON/OFF switch
- 2) DC Voltmeter
- 3) Voltage adjustment control and Mode of operation indicator light
- 4) DC Ammeter
- 5) Current adjustment control and Mode of operation indicator light

2.2 GENERAL OPERATION

As shipped, the power supply is connected for local sensing, internal programming and nominal AC input as specified on rear of unit. The front panel voltage and current controls will set the boundary limits for the output voltage and current limits respectively. The impedance of the load will determine whether the unit is voltage or current controlled and the illumination of the respective mode indicator light will indicate the state. If either control is set to maximum counter clockwise rotation, the other control will have little or no effect. Each control must be set to the appropriate position for the proper operation.

2.3 PREPARATION FOR USE

2.3.1 UNPACKING

Carefully unpack unit saving all packaging material and included enclosures. Inspect for possible shipping damage. Check that there are no broken knobs or connectors, that the external surface is not scratched or dented, that meter faces are not damaged, and that all controls move freely. Any external damage may be an indication of internal damage.

2.3.2 ELECTRICAL CHECK

Check that the barrier strip jumper straps are as shown in the figure depicting "normal local sensing and programming configuration". It is recommended that the following brief electrical check be made shortly after unpacking the supply.

Set all controls to full counter clockwise, turn the circuit breaker ON/OFF switch to "OFF" and connect a short circuit to the power output (Terminals 2 &) terminal block rear panel or front terminals. WARNING: Never attempt to remove the power from the supply by means of the barrier strip (Terminals 1 & 5) since the wiring is not sized to handle the current capacity of the supply. Connect the supply to a suitable source of AC Voltage. For this test only 50% of rated AC current is required. Turn the circuit breaker ON/OFF switch to "ON". The fan should start.

There should be no output voltage or current. Advance the voltage control one turn clockwise and slowly advance the current control. The DC ammeter should deflect smoothly from zero to the rated current of the supply as this control is advanced to full clockwise. Return all controls fully counter clockwise and turn supply off. Disconnect output terminal block short circuit. Turn supply ON, advance current control 1/4 turn and slowly advance voltage control. The DC voltmeter should deflect from zero to maximum rating of the supply. If any of these events does not occur, the supply is defected and should not be operated. Depending on circumstances, either warranty service or troubleshooting as described elsewhere in this manual is required.

2.4 MODES OF OPERATION

The following five paragraphs discuss the various standard and optional modes of operation built into the design of the power supply.

2.4.1 NORMAL MODE

When shipped from the factory, the supply is configured for local sensing and internal adjustment control. Local sensing is accomplished by having barrier jumpers in place between TB2-1 and 2 and TB2-4 and 5. This connects the point of voltage sensing of the internal control circuitry to power output terminals. Internal or local voltage and current control is present when barrier jumpers are present between the following groups of terminals on TB1: Connection of terminals 1,2 & 3 connect the voltage programming current to the voltage sensing amplifier input and to the internal programming resistance (Adjustment Control). Connection of 5,6 & 7 interconnect the current programming current, the current sensing amplifier and the current programming resistance (current adjust control). Normal mode operation is usually used in most applications. All performance specifications unless otherwise stated, are defined

in this configuration. Ripple, programming speed, transient response and stability are optimized with the supply so configured.

2.4.2 REMOTE SENSING

In applications where the effect of the voltage drop (IXR) of the DC load wires would adversely effect the performance of the load, it is possible to sense the voltage at the load instead of the supply terminals. Remote sensing will therefore remove the effect of changes in the load current through the power distribution system. To operate in this mode, disconnect the jumpers between TB2-1 and 2, and TB2-4 and 5. Connect one end of a twisted pair of #20 AWG wires (shielded if strong AC or RF fields exist) to terminals 1 and 5 of TB2 and the other end of the pair to the point at the load. The wire connected to terminal 1 must be terminated at the positive point of the load and the wire to terminal 5 to the negative point of the load. It is sometimes necessary, to assure stability, to connect a capacitor within the range of .5 to 50uFD at the point of load or near the point of load at the point the twisted pair of sense leads join if the sense points are separated by some distance. If the capacitor used is electrolytic, be sure to observe polarity and voltage rating.

2.4.3 REMOTE PROGRAMMING

The supply may be operated in a remotely programmed mode (externally controlled) by the use of external resistance voltage or current control.

WARNING: If the control function in external programming fails so that the supply is programmed to voltage levels greater than 15% above ratings, damage to the electrolytic filter capacitors will occur. To protect against this, it is suggested that the over voltage protection module option be used which will limit the maximum voltage excursion and safely shut the supply down.

2.4.3.1 REMOTE PROGRAMMING, EXTERNAL RESISTANCE

Voltage Channel: Remove barrier jumper between TB1-2 and 3. Connect the external programming resistance between terminals 1,2 and 4. The programming resistance is 5000 ohms for full rated voltage output. For any voltage output within the range of the supply:

$$R_{\text{prog}} \text{ (OHMS)} = \frac{\text{DESIRED VOLTAGE}}{\text{FULL RATED OUTPUT}} \times 5000$$

Current Channel: Remove the barrier jumper between 6 and 7. Connect programming resistance between terminal 6 and 8. The programming resistance for full rated output is 100 ohms. For any current within the range of the supply:

$$R_{\text{prog}} \text{ (OHMS)} = \frac{\text{DESIRED VOLTAGE}}{\text{FULL RATED OUTPUT}} \times 100$$

2.4.3.2 REMOTE PROGRAMMING, EXTERNAL VOLTAGE

Voltage Channel: Remove barrier jumpers between 1,2 and 3. Connect the source of voltage programming between terminal 2 (positive) and terminal 4 (negative). This source must float with respect to the output of the supply unless local sensing is used. A programming source of 0 to 5 volts drives the supply from zero to full rated output voltage.

Current Channel: Remove barrier jumpers between 5,6 and 7. Connect the programming source between terminal 6 (positive) and terminal 8 (negative). The programming signal for zero to full output current is 0 to 100MV. A signal from a higher potential source may be attenuated to this 100MV level by a resistor divider. For best performance the source impedance of this divider should not exceed 1000 ohms.

NOTE: The negative end of the voltage and current channel programming terminals are not common.

2.4.3.3 REMOTE PROGRAMMING, EXTERNAL CURRENT

Voltage Channel: Remove the barrier jumper between 1 and 2. Connect the positive terminal of the current source to terminal 2 and the negative terminal to terminal 4. A current of 0 to 1MA programs the supply from zero to full current output. The current adjust pot must be fully clockwise.

Current Channel: Remove the barrier jumper between 5 and 6. Connect the positive terminal of the current source to terminal 6 and the negative terminal to terminal 8. A current of 0 to 1MA programs the supply from zero to full current output. The current adjust pot must be fully clockwise.

2.4.1 PARALLEL OPERATION

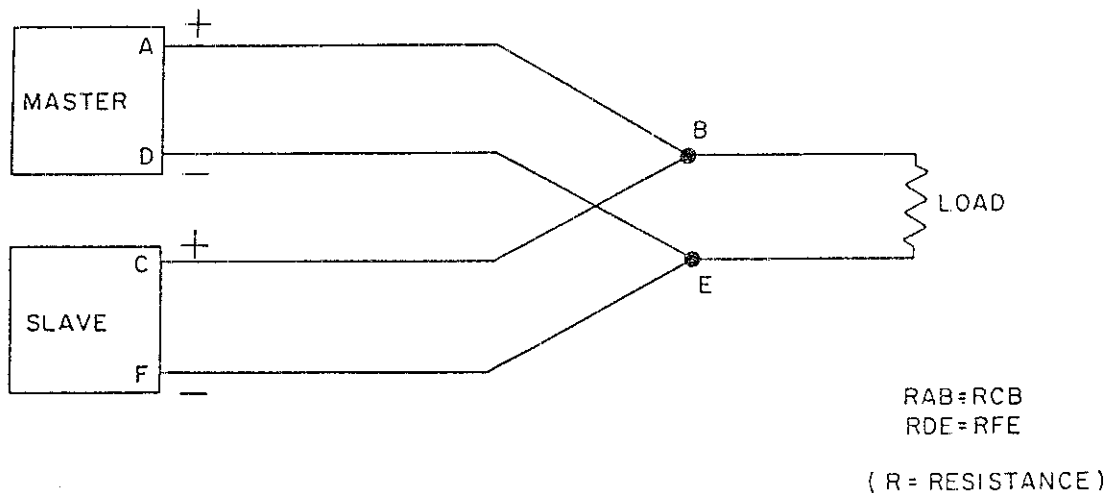
The triac series power supplies are equipped with provisions for parallel operation.

2.4.1.1 PARALLEL OPERATION - DIRECT CONNECTION

The simplest parallel connection involves attaching the positive terminals of all supplies to be paralleled to the positive point of load and negative terminals to the negative point of load. Equal wire lengths (impedances) should be used. Set all supplies to the appropriate output voltage (open circuit). Turn off supplies and connect load. Set current limit to maximum. Turn on supplies one at a time until the sum of the supply current capability exceeds the load current drawn. Balance each supply voltage for equal current. Set current limiting just above the running current so that if a unit drifts up in voltage, it will become current limited rather than carry an excessive share of load current.

2.4.1.2 PARALLEL OPERATION - MASTER/SLAVE

In this configuration, one supply is designated "Master" and drives itself and other supplies connected to it to equal output current without the benefit of the voltage or current circuits operative in the slaves. To use in this mode on TB1, remove links 9 to 10 and 5 to 6 to 7 on slave supplies, (maximum 3). Connect 8 of the master to 9 of each slave. Then, on each slave, connect 8 of slave 6 on slave unit. Turn each slave on and then the master. Adjust the master for required output voltage or current. The output leads from each power supply must be of equal resistance to the load point to assure equal sharing. (See Figure)



2.4.5 SERIES OPERATION

Two or more supplies may be operated in series simply by connecting the negative of one supply to the positive of another. Each units' adjustment functions independently and the output is the sum of each unit output. No plus or minus voltage should exceed 600 volts with respect to chassis ground.

SECTION III
PRINCIPLES OF OPERATION

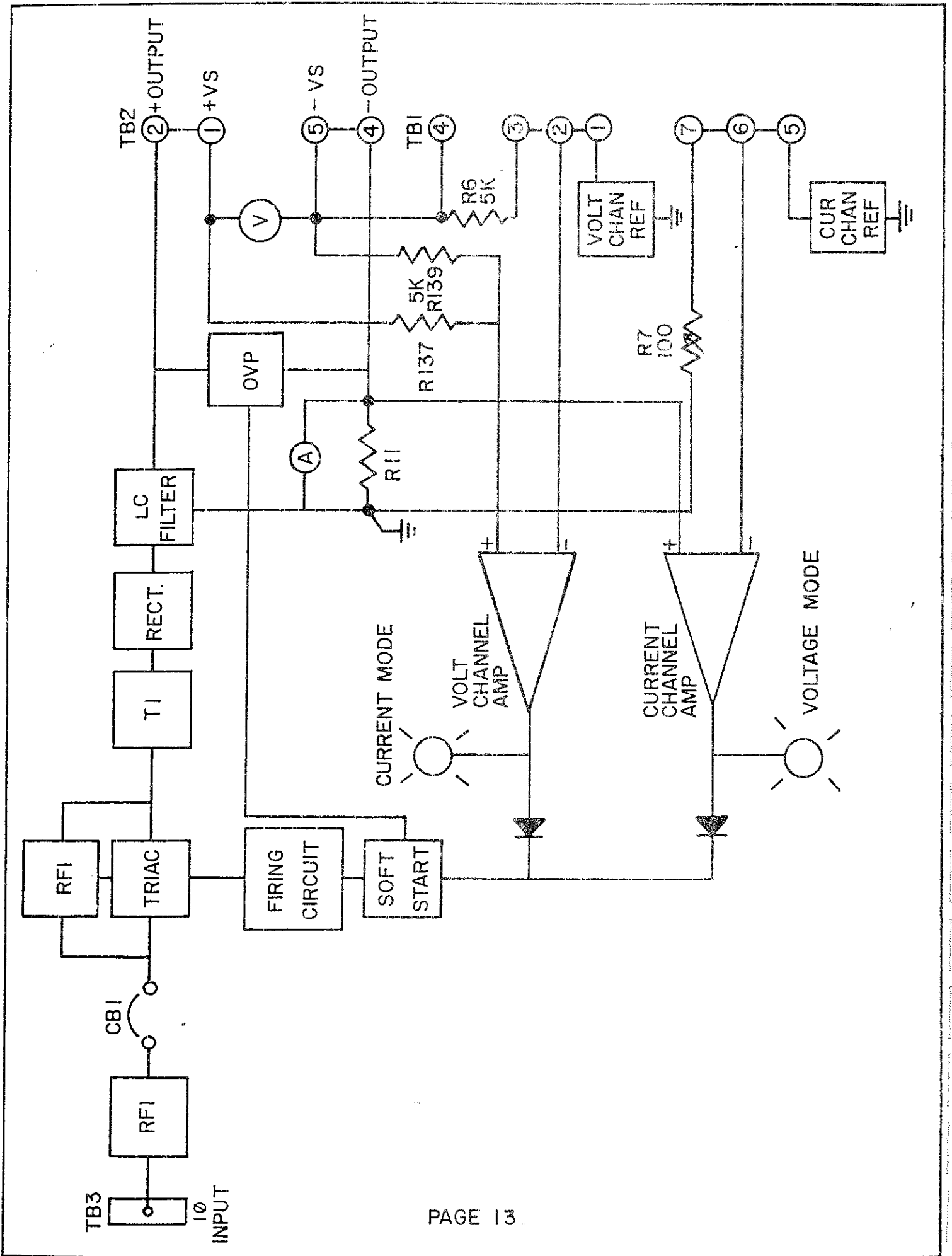
3.1 GENERAL

This power supply series converts alternating current within the rating of the particular unit into a regulated, adjustable direct current. The means of regulation and adjustment is by triac phase control of the primary input alternating current. The DC output is obtained by rectification and L/C filtering. The block diagram on the next page shows the major functional areas of the supply.

Power is applied to the bias transformer through the closure of the circuit breaker. The bias transformer energizes the +/-15V bias supply which operates all control circuitry. It also provides a phase related signal for line frequency referencing the firing circuit. The firing circuit combines this AC signal with a DC level from an "or" circuit the combination of which drives the phase control of the triac. The "or" circuit is driven from the overriding signal from either the voltage comparator/amplifier or the current comparator/amplifier whichever predominates, depending on control adjustment or load impedance. The comparator/amplifiers are referenced by two stable current sources which develop a comparison voltage when driven through the voltage & current adjustment controls. These resultant voltages are compared to a portion of the actual output voltage and current in the comparator/amplifier. The DC output of the "or" circuit, which is proportional to the setting of the adjustment, controls the phase angle of the primary triac and therefore the DC output of the supply. The phase controlled AC signal is transformer coupled to a rectifier bridge (or full wave center tap) and the resulting variable energy pulsating DC voltage is filtered (averaged and smoothed) in an L/C filter. Additional circuitry, such as fans, mode indicators, metering, RFI suppression and frequency compensation, which are also present will be discussed in detail later.

3.2 DETAIL THEORY OF OPERATION

The detailed theory of operation will be discussed by major functional areas and by the physical segregation of circuit functions in the unit. Major areas will include the power flow circuitry, circuit functions on the printed circuit board, metering and auxiliary functions. References to symbol numbers are made to ease understanding and it is best to refer to the enclosed schematic while reading this section.



3.2.1 POWER FLOW CIRCUITRY

AC power is transformed from the line cord or input barrier strip (depending on model) through an RFI filter to an intermediate internal strip, through circuit breaker CB1 to the triac network and primary of the power transformer.

The triac is connected in series with AC primary of transformer T1 so that when the AC waveform is positive or negative, Q107 will conduct. Each half cycle of conduction of the triac when delayed an equal period of time from zero axis crossings provide a partial sinusoid to the primary of transformer T1. As the sine wave is delayed, the energy available in the resultant wave form is reduced and when it is advanced (toward a full sine wave), maximum energy is available.

Transformer T1 converts the line voltage to the appropriate AC component of the load voltage and current. The secondary configuration is either full wave bridge or full wave center tapped, depending on model.

Diodes CR-1 through CR-4 rectify the phase controlled AC voltage from T1. The pulsating DC is filtered by L1 and C1. At load currents that allow L1 to remain "critical" (continuous current flow), the filter averages the voltage waveform at the input of the filter. At very low load currents, the inductance is somewhat ineffective and the capacitor peak charges to provide filtering. The phase delay of the input waveform must be greater than 90 degrees and capable of approaching 180 degrees at low output voltage and current.

R16 and C105 form a snubber network across the triac to prevent false triggering due to dv/dt effects. This unit has an RFI suppression network which reduces the amplitude of the spike appearing in the DC output voltage when the triac conducts. R301 and C301 minimize the effects of diode commutation by absorbing high frequency energy. Resistor R5 acts as a preload to assure stability of the loop and to improve the transient response when a load is suddenly disconnected from the supply.

3.2.2 CIRCUIT FUNCTIONS ON THE PRINTED CIRCUIT BOARD

The PC board contains a bias transformer and power supply, current & voltage channel current sources, the fixed portion of the programming resistors, voltage and current channel comparator/amplifiers, an "or" circuit, mode indicator drivers, a DC amplifier with soft start circuitry, the triac phase control and pulse generation circuitry, the

necessary loop frequency compensation networks and the barrier terminal strips necessary for alternate operating configuration of the supply.

The bias transformer has a center tapped secondary. Terminals 8 & 10 produce 20 volts RMS with respect to terminal 9. This voltage, when full wave rectified, produces + and - voltages on capacitors C106 and C107.

The control circuitry of the supply uses a +/-15VDC bias level. Plus 15V drain is about 150ma and minus 15V drain is 30ma. These voltages are regulated in the bias power supply. Q103 is used as an emitter follower driven from the voltage level on Zener Diode CR108, to produce the positive 15 volts. Resistor R111 and Zener Diode CR109 regulate the negative supply.

The signal necessary to provide control over the triac firing circuitry is derived from attenuated samples of a portion of the output voltage and current compared to the set point levels of the adjustment controls. The voltage signals produced at the adjustment controls are proportional to a constant reference current multiplied by the value of the resistance of the adjustment control in the circuit at any time.

A separate constant current reference is provided for the voltage and current channel. The collector current of Q108 drives the voltage channel and Q109 the current channel. These current sources are referenced by the voltage across CR121, a 1N823A temperature compensated Zener Diode.

Since the voltage difference across the summing junction of IC101 (terminals 13 & 14) is essentially zero, the voltage across the series combination of R143 and R144 (also R145 and R146, since the V_{be} of Q108 and Q109 is essentially equal). A constant voltage across a fixed resistance produces a constant current. The current level from each of these sources is adjustable to 1ma by R143 & R145.

The reference current level for the voltage channel flows from terminal 1 of TB1. With jumpers on terminals 1,2 and 3, the voltage level produced when this current flows through R6 (the voltage adjustment pot) is applied to pin 9 (a unity gain buffer amplifier) and then to pin 6 of IC101. The signal on the other amplifier input of IC101, pin 5 is derived from the output voltage level by the voltage division of R137, R138 and R139. Maximum voltage output of the supply produces 5 volts DC at pin 5 of IC101. Through the action of the feedback loop, as resistor R6 (the voltage adjustment pot) is increased in value the voltage at pin 6 of IC101 increases. The error signal developed at the output of IC101, pin 4 causes a proportional change

in output voltage which produces a voltage in pin 5 of IC101 equal to that applied to pin 6. The action of the current channel is identical to the voltage channel with the exception that the controlled quantity is the current that flows through shunt R11. The voltage level that this current produces is applied to one input of IC101, pin applied to pin 1 of IC101. The level of the signal applied to pins 1 and 2 of IC101 is 0 to 100mv.

The outputs of the voltage channels comparator/amplifier IC101 and the current channel comparator/amplifier are "ored" together in diodes CR113 and CR114. Whichever IC output is positive overrides the effect of the other, and represents that channel controlling the DC output. A positive going signal at the cathode of diodes CR113 and CR114 reduces the output of the supply by retarding or delaying the conduction of the primary triac.

The mode indicator lights are also driven from the outputs of IC101. Whichever output (pin 4 or 3) is negative, illuminates the respective light emitting diode indicator.

Transistor Q104 amplifies and level shifts the control signal from CR113 and CR114. The normal operating voltage at the collector of Q104 is 3.75V and a swing of +/-2 volts will range the supply from no output to full output. The lower the collector voltage on Q104, the lower the output of the supply. There are also some auxiliary functions also accomplished in the Q104 stage. R117 and C113 form a "soft start" network which reduces the turn on surge and allows bias levels to build up before output current is permitted. R150, C123, Q105, CR122 and CR123 resets the soft start circuitry. Thermostat TS1 is placed across C113, and when an over-temperature condition exists, the output voltage is inhibited by closure of the thermostat. The voltage signal developed across R118 is a source of feedback through channel respectively. Additional loop compensation is provided by R131 and C119 voltage channel, C108 and R134 in current channel.

The triac firing pulses are developed as the result of a comparison in IC102 between a sawtooth (pin 2) and the DC level from Q104. The sawtooth starts at 6V and ramps down to 1.5V. The sawtooth is in sync with the 60(50) Hz line voltage and the 6V point occurs at the zero crossing with the positive slope. IC201 compares the sawtooth to a DC level and when the sawtooth is more positive than the DC level, the output (pin 6) is low (close to zero), causing Q106 to be off. When the sawtooth is below the DC level, the output (pin 6) is high. A high at pin 6 will cause Q106 to oscillate pulsing the base of Q101 on and off at a 2.5KHz rate. The

pulses from the collector of Q101 are transformer coupled to the gate of Q107.

3.2.3

METERING AND AUXILIARY FUNCTIONS

Voltage monitoring is achieved by connection of a self contained DC voltmeter to the sensing terminals of the supply. Output current is measured using a shunt rated DC ammeter connected across the shunt R11. Calibration of this meter is made by adjustment of R123. The unit is cooled using fan B1 and is powered upon closure of the circuit breaker.

SECTION IV
MAINTENANCE AND TROUBLE SHOOTING

4.1 GENERAL

The power supply is divided into two basic circuit areas, power flow and signal control. The power flow circuitry consists of circuit breakers, triac, transformer, rectifiers, choke and capacitors as well as the cabling interconnecting them. The signal control circuitry is contained on the removable printed circuit card. Most unit malfunctions will originate on the circuit card.

An understanding of the theory of operation of the supply is useful in troubleshooting the supply. Also necessary is the following basic test equipment: Source of AC power, means of loading supply, a voltmeter with accuracy and resolution better than the unit specifications and an oscilloscope.

The chart that follows is a troubleshooting guide that should aid in finding operational problems in the supply.

WARNING: When servicing supply, dangerous voltage levels exist. Be especially careful of person and equipment when measuring primary circuitry since this is at line potential.

4.2 TROUBLE SHOOTING GUIDE

SYMPTOM -----	POSSIBLE CAUSE -----	REMEDY -----
1. Unit opens circuit breaker immediately upon turn on.	Control circuit defective.	Short, with a small clip lead, the end closest to Q101 of R103 to the end of R102 closest to Q101 and reapply power. If circuit breaker remains closed, problem is on PC board. If not, the triac or rectifiers are probably shorted.
	Triac shorted.	Replace.
	CR1 through CR4 shorted.	Replace.
	C1 shorted.	Replace.

2. Unit goes to high output immediately.	Control circuit defective.	Short with a small clip lead, the end of R103 closest to Q101 to the end of R102 also closest to Q101. Reapply power and if output remains low, problem is on PCB. If not, problem is a shorted triac.
	Triac shorted.	Replace.
	Programming control pots open.	Check pots and interconnecting wiring.
3. Unit puts out high ripple.	C1 defective.	Replace.
	Unit is oscillating.	Problems in control circuitry.

1.3 CONTROL CIRCUIT TROUBLESHOOTING

Since the entire supply is closed loop circuit, the failure of a single component can have its result presented far from the source. For this reason, troubleshooting any but obvious defects must be done by understanding of the power supply theory and effecting a repair.

1. Does 115/220 VAC reach T101?
2. Is the voltage on T101-9 & 8, and T101-9 & 10, 20 volts RMS? If not, T101 may be defective.
3. Are there ramps across C104?
4. Are there triac firing pulses at T102-3 (collector Q101)? Do they arrive at Triac?
5. Is the DC voltage level at T102-4 approximately 15 volts?
6. Does IC101 feel warm to the touch? A failure of this amplifier in output stage causes current to flow through the chip producing heat?
7. Is 15 volts DC present on C110 and C111? If not, check for problems in the bias supply section.

8. As R6 is rotated from zero to maximum, does the voltage across it vary from zero to 5 volts DC? If not, IC101 or Q108 may be defective.
9. As in 8, if R7 is rotated, does its voltage vary from zero to 100MV.

4.4 CALIBRATION

There are three calibration controls on the Single Phase unit.

4.4.1 AMMETER CALIBRATION

To calibrate the ammeter, connect a reference DC ammeter equal to the rating of the unit across the output terminals of the supply (do not forget to use a shunt with a shunt rated ammeter). Turn the supply on and adjust the output current for full output current. Adjust R123 until the unit ammeter equals the reading on the external reference ammeter.

4.4.2 PROGRAMMING CALIBRATION

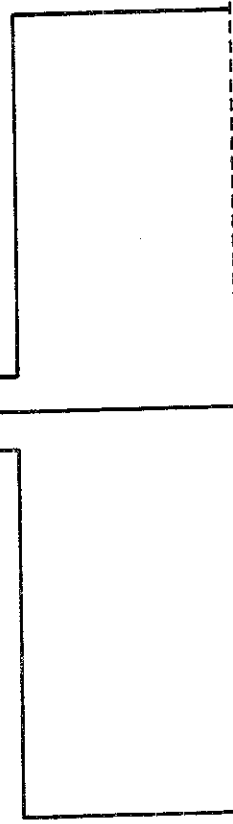
Resistors R143 and R145 are included to provide approximately 8% variation of the voltage and current channel programming current. Their adjustment depends on the requirements of the user. In local programming mode, they should be adjusted so as to allow full output at or near maximum pot rotation. For external resistance programming, they may be adjusted for an exact programming constant.

4.4.3 ZERO OFFSET

When both voltage and current controls are fully counter clockwise, the power output is nearly inhibited. At the factory, R154 is selected in test to slightly suppress output current into a short circuit. In the voltage channel into an open circuit, a slight voltage may appear at the output. This is caused by current bypassing on Q107 through the snubbers C105 and R116. Additional output pre-loading will minimize this effect.



HCR XX-XXX-XXX



INPUT	OVP	ACCESSORIES
1 105/125V - 47-63HZ	0 NOT CHOSEN	0 NOT CHOSEN
2 190/253V - 47-63HZ	1 OVER VOLTAGE	1 LINE CORD

THE FOLLOWING OPTIONS ARE INCORPORATED IN THE BASIC SUPPLY:

- 1. RFI LINE FILTER
- 2. TEN TURN POT
- 3. CURRENT LIMIT
- 4. PARALLELING
- 5. MODE LAMPS
- 6. AMP METER/VOLTMETER
- 7. REMOTE PROGRAMMING
- 8. CIRCUIT BREAKER
- 9. DETACHABLE LINE CORD
- 10. RACK ADAPTER AVAILABLE
- 11. CONSTANT VOLTAGE OR CONSTANT CURRENT OUTPUT WITH AUTOMATIC CROSSOVER

LINE CORD INSTALLATION INSTRUCTIONS

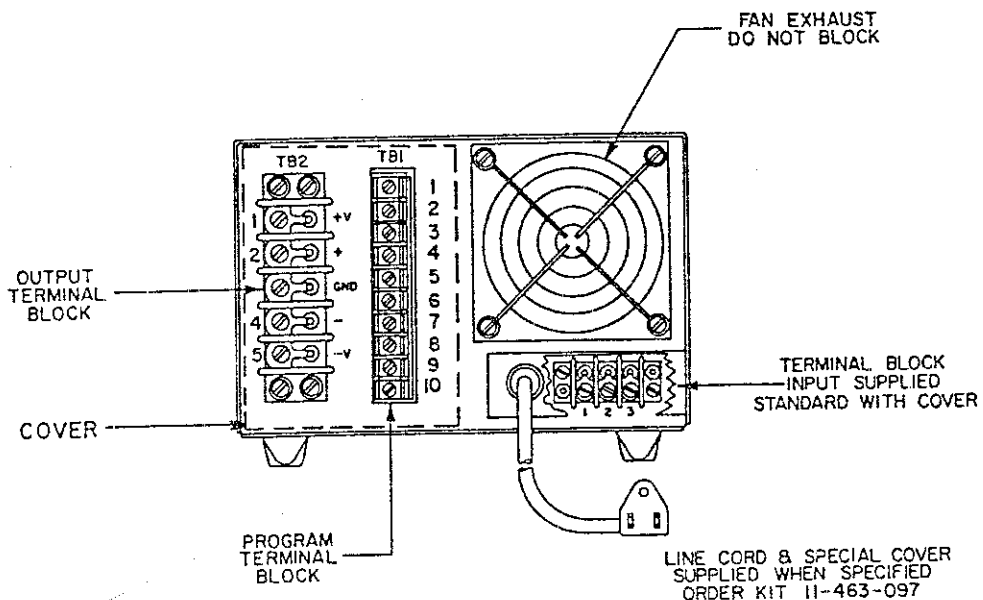
CAUTION:

The line cord (11-463-097) can only be used for 115VAC, DO NOT USE FOR 220VAC.

1. Remove metal cover over TB3, under the fan at the rear of the power supply.
2. Attach the line cord black wire to TB3-1.
3. Attach the line cord white wire to TB3-2.
4. Attach the line cord green wire to TB3-3.

NOTE: Connect the lugs so that the lugs and wire come out facing upward or the cover will not fit properly.

Install the cover on the line cord with the same screws from the blank covers.



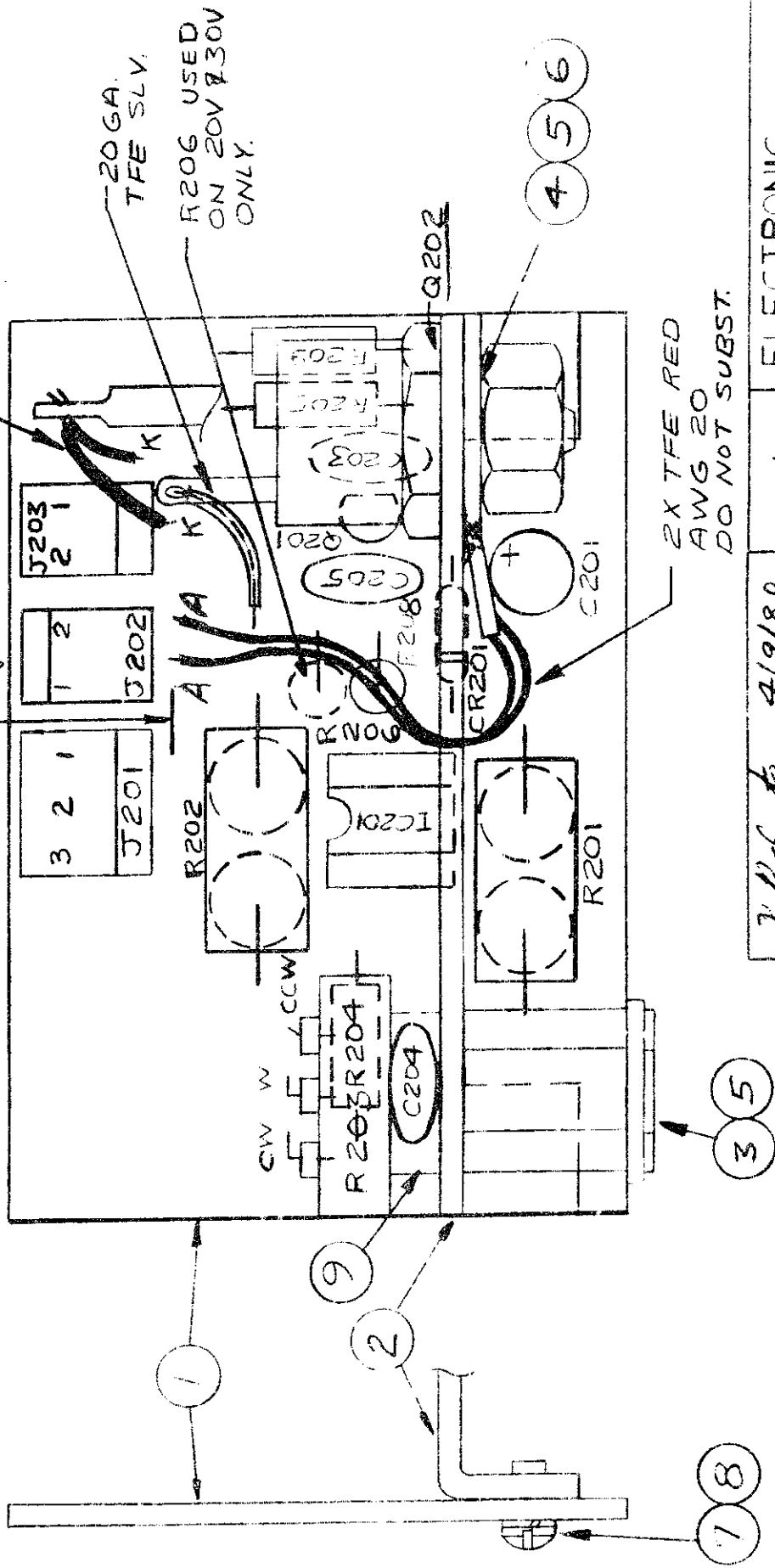
2 X TFE BLK
AWG 20
DO NOT SUBST.

14 GA. BUS WIRE

20 GA.
TFE SLV.

R20G USED
ON 20V 230V
ONLY.

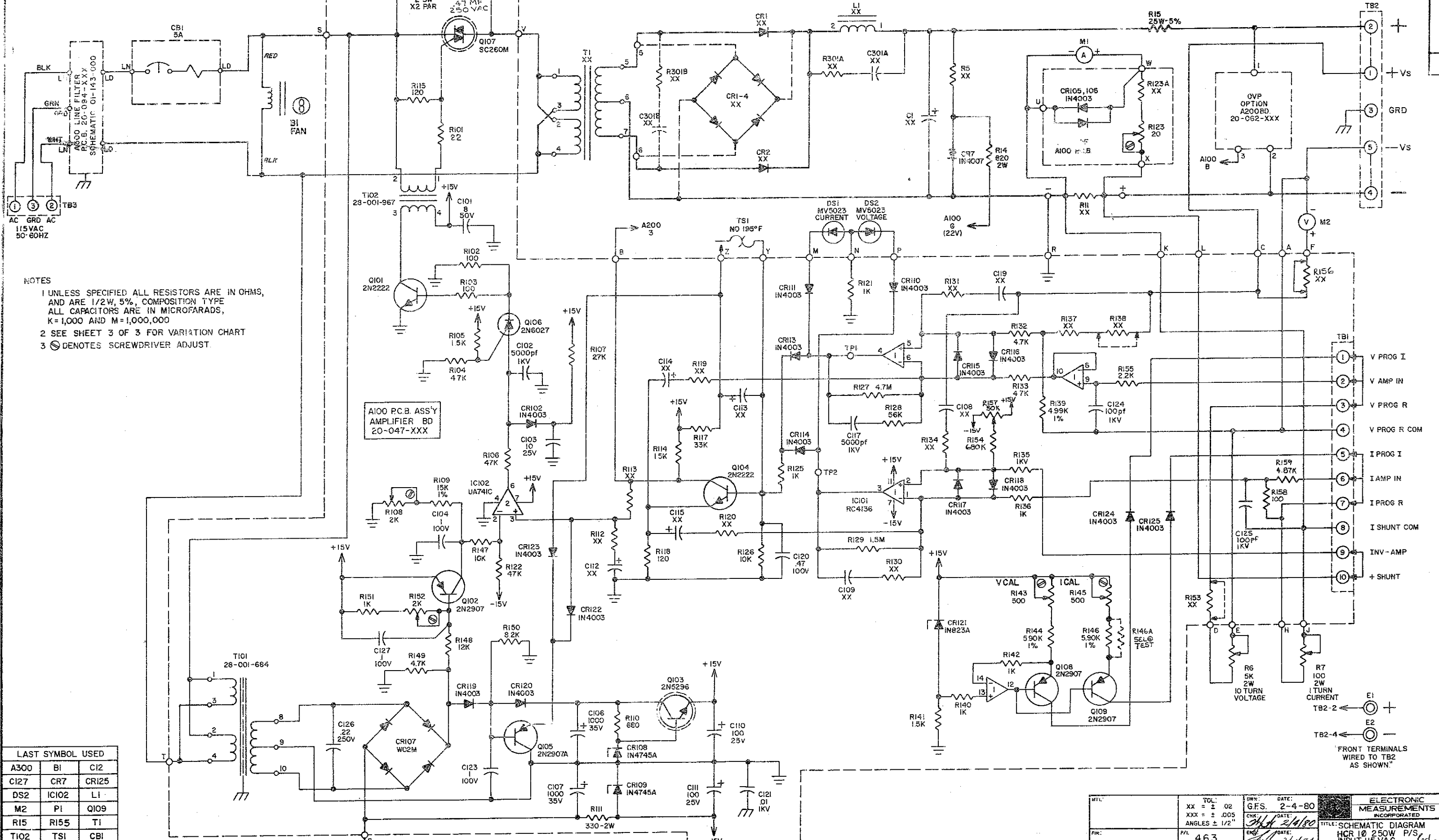
2 X TFE RED
AWG 20
DO NOT SUBST.



<i>J. Roberts</i>	<i>4/9/80</i>	E/M	ELECTRONIC
<i>John</i>	<i>4/22/80</i>		
<i>John</i>	<i>4/22/80</i>		
FOR PARTS LIST, SEE BMI SHT OF		MEASUREMENTS	
		A200 PCB ASSEMBLY	
		OVP CRT. - MOD. IV	
		HCR 10 - 250W	
A	20-062-000	E	
SCALE - 2:1		SHT 20F4	

100-100

APPLICATION			LTR.	E.C.O. NO.	BY	APP.
USED ON	NEXT ASSY.	QTY.	G	ECO. NO. 7683	J.V.D.	JV
			H	ECO. NO. 7743	J.V.D.	JV
			J	ECO. NO. 7843	Wiles	W
			K	ECO. NO. 1034	BN	BN



NOTES
 1 UNLESS SPECIFIED ALL RESISTORS ARE IN OHMS, AND ARE 1/2W, 5%, COMPOSITION TYPE ALL CAPACITORS ARE IN MICROFARADS, K=1,000 AND M=1,000,000
 2 SEE SHEET 3 OF 3 FOR VARIATION CHART
 3 Ⓢ DENOTES SCREWDRIVER ADJUST.

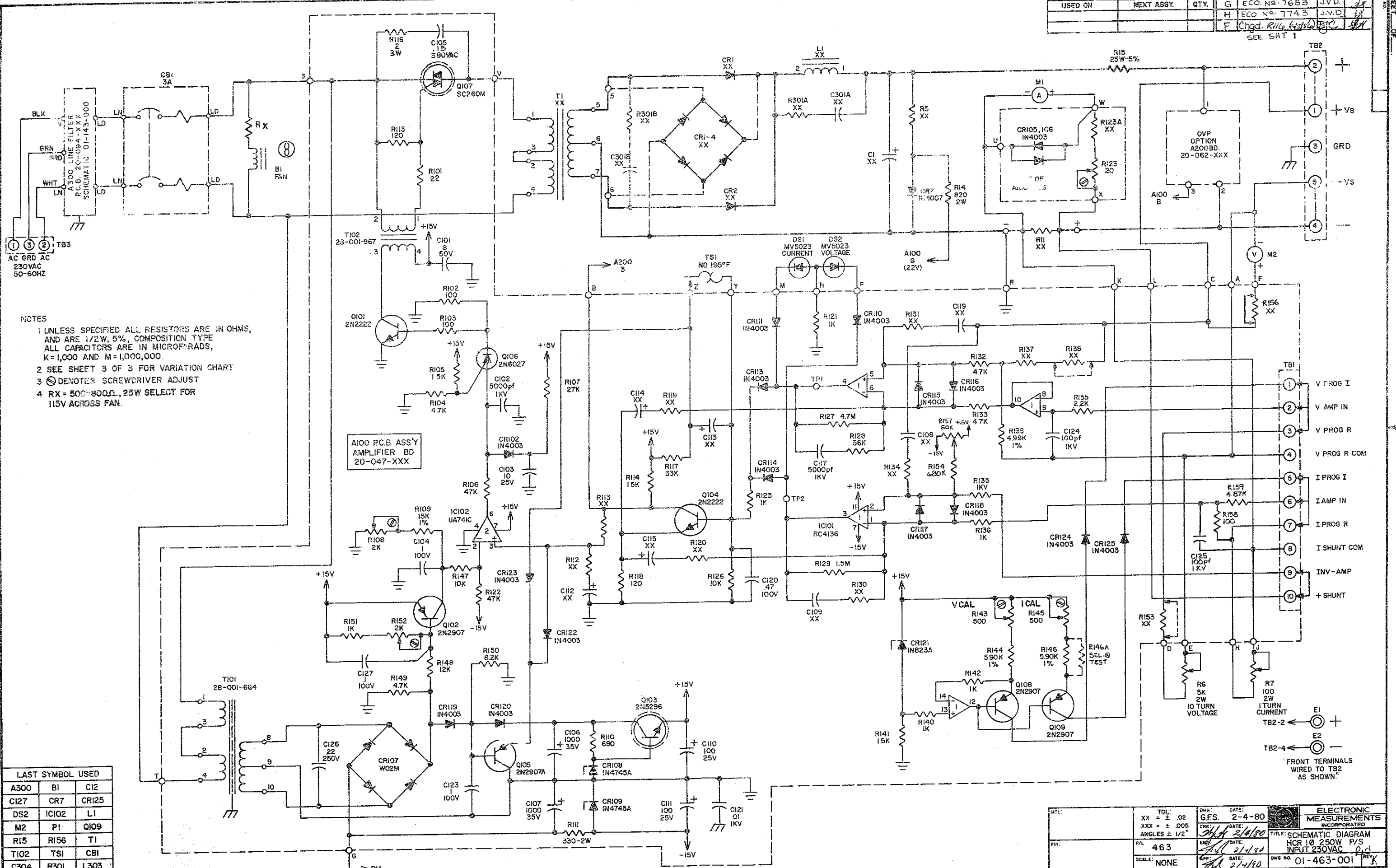
A100 P.C.B. ASSY
 AMPLIFIER BD
 20-047-XXX

LAST SYMBOL USED		
A300	BI	C12
C127	CR7	CR125
DS2	IC102	LI
M2	PI	Q109
R15	R155	TI
T102	TS1	CBI
C304	R301	L303

BY:	YCL:	DRN:	DATE:	ELECTRONIC MEASUREMENTS INCORPORATED
XX	± 02	G.F.S.	2-4-80	
FK:	XXX ± .005	CHK:	DATE:	TITLE: SCHEMATIC DIAGRAM HCR 10 250W P/S INPUT 115VAC
	ANGLES ± 1/2"	DATE:	DATE:	
		APP:	DATE:	DWG NO. 01-463-001
		SCALE: NONE		SHEET 1 OF 3

APPLICATION			LTR.	E.C.O. NO.	BY	APP.
USED ON	NEXT ASSY.	QTY.	G	ECO. NO. 7683	J.V.D.	J.V.D.
			H	ECO. NO. 7743	J.V.D.	J.V.D.
			F	Crtd. Rile (4/1/80) BJC		

SEE SAT 1



NOTES

- UNLESS SPECIFIED ALL RESISTORS ARE IN OHMS, AND ARE 1/2W, 5%, COMPOSITION TYPE. ALL CAPACITORS ARE IN MICROFARADS, K=1,000 AND M=1,000,000.
- SEE SHEET 3 OF 3 FOR VARIATION CHART
- ⊗ DENOTES SCREWDRIIVER ADJUST
- RX = 500-800Ω, 25W SELECT FOR 115V ACROSS FAN.

A100 P.C.B. ASSY
AMPLIFIER BD
20-047-XXX

LAST SYMBOL USED		
A300	BI	C12
C127	CR7	CR125
DS2	IC102	LI
M2	PI	Q109
R15	R156	TI
T102	TSI	CBI
C304	R301	L303

ELECTRONIC MEASUREMENTS INCORPORATED	
TITLE: SCHEMATIC DIAGRAM	DATE: 2/4/80
HCR 10 250W P/S	DATE: 2/1/80
INPUT 230VAC	DATE: 2/1/80
DWG NO. 01-463-001	SCALE: NONE
SHEET 2 OF 3	

USED ON	NEXT ASSY.	QTY.	E 7402 (1-27-80)	37
			B 0161-24-22	32
			C 000-0426-0427	31
			D 0161-24-22	31

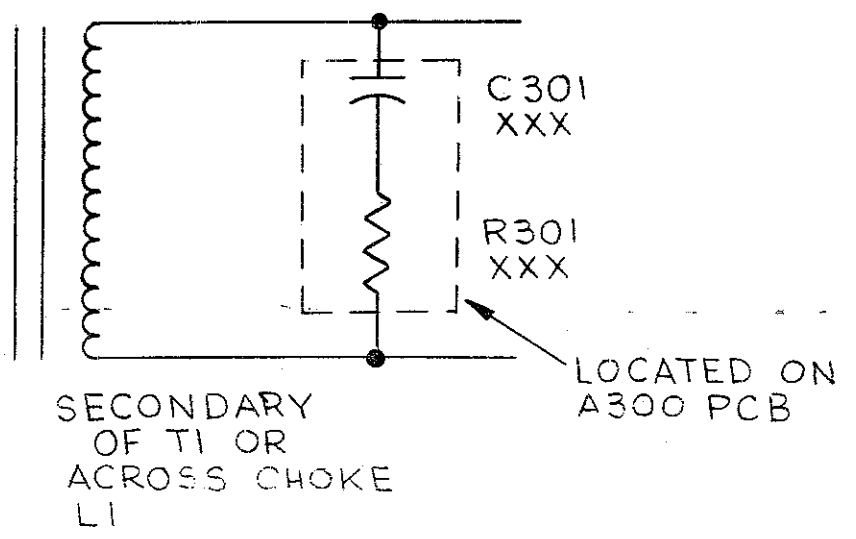
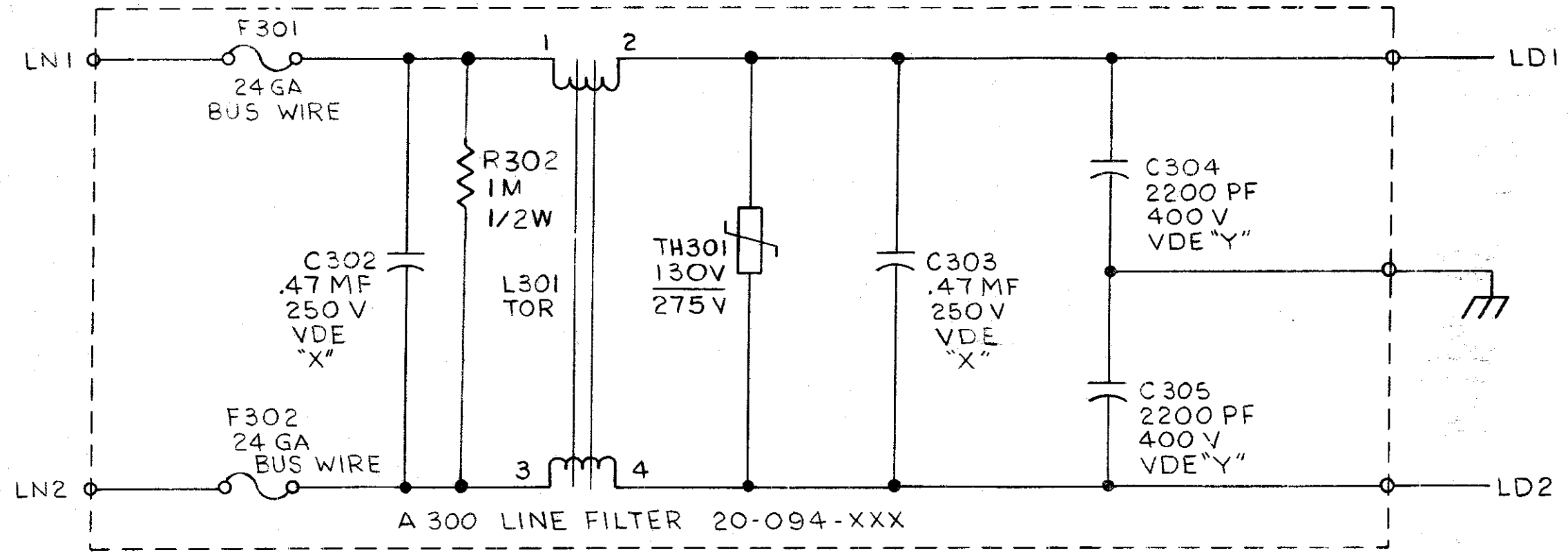
	250 WATT									250 WATT SPECIALS						
	7.5V-30A	10V-25A	20V-13A	30V-8A	40V-6A	60V-4A	80V-3A	150V-2A	300V-9A	40-6-0426	40-6-0427	30-8-100-0470	10V-10A	30V-10A	400V-0.5A	
A100 20-047-XXX 115V	-001	-002	-003	-004	-005	-006	-007	-008	-009	-010	NA	005	004	012	013	
A100 20-047-XXX 230V	-026	-027	-028	-029	-030	-031	-032	-033	-034	NA	030	NA	029			
A200 20-062-XXX	-102	-103	-105	-106	-107	-109	-111	-114	-118	-108	107	107	-106			
C1	166K-15V	166K-15V	75K-25V	40K-50V	24K-75V	24K-75V	14K-100V	3.6K-200V	1.9K-350V	32K-75V	32K-75V	32K-75V	60K-50V	200K-15V	60K-50V	1.6K-450V
C301B	1MF-100V	1MF-100V	.47MF-480V	.47MF-480V	.22MF-480V	.22MF-480V	.1MF-480V			.22MF-480V	.22MF-480V	.22MF-480V	.47MF-480V	1MF-100V	.47MF-480V	
C301A								.047MF-480V	.047MF-480V							.047MF-480V
CRI-CR4	2XIN1189A	2XIN1189A	2XIN1189A	PW 60	PW 60	PW 60	PW 60	PW 60	4XSCDA6	PW60	PW60	PW60	PW60	2XIN1189A	PW60	4XSCDA6
BASIC AMMETER 66-054-000 SCALE 66-054-XXX	0-30A -006	0-30A -006	0-15A -005	0-10A -004	0-6A -003	0-6A -003	0-3A -002	0-3A -002	0-1A -001	0-6A -003	OMIT	0-10A -004	0-10A -004	0-10A -004	0-10A -004	0-1A -001
BASIC VOLTMETER 66-055-000 SCALE 66-055-XXX	0-10V -001	0-10V -001	0-25V -002	0-40V -003	0-40V -003	0-80V -004	0-80V -004	0-150V -005	0-300V -006	0-80V -004	OMIT	0-40V -003	0-40V -003	0-10V -001	0-40V -003	0-400V -003
R5	10-25W	15-25W	50-25W	100-25W	200-25W	500-25W	1K-25W	2.5K-25W	10K-25W	500-25W	200-25W	200-25W	100-25W	15-25W	100-25W	20K-25W
R301B	33-2W	33-2W	56-2W	56-2W	560-2W	680-2W	1K-2W			680-2W	560-2W	560-2W	56-2W	33-2W	56-2W	
R301A								1.5K-2W	2.7KV-2W							
R11 SHUNT	95MV-30A -010	95MV-25A -009	95MV-13A -008	95MV-8A -007	95MV-6A -006	95MV-4A -005	95MV-3A -004	95MV-2A -003	95MV-9A -002	95MV-4A -003	95MV-6A -006	95MV-8A -007	95MV-10A -011	95MV-10A -011	95MV-10A -011	95MV-0.5A -001
R15	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	1.5-25W	5-25W	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	5-25W
LI 28-001-XXX	-969	-971	-973	-975	-977	-979	-981	-983	-985	002-136	-977	002-232	002-633	-971	-212	-666
TI 28-001-XXX	-968	-970	-972	-974	-976	-978	-980	-982	-984	002-137	-976	002-233	002-632	-970	-299	-665
C108	.47MF-100V	.47MF-100V	.47MF-100V	.22MF-200V	.22MF-200V	.1MF-200V	.1MF-200V	.047MF-480V	.022-600V	.1MF-200V	.22-200V	.22-200V	22MF-200V			
C109	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005MF-1KV	.005-1KV	.005-1KV	.005MF-1KV			
C112	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100-25V	100-25V	100MF-25V			
C113	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100MF-25V	100-25V	100-25V	100MF-25V			
C114	33MF-15V	33MF-15V	33MF-15V	25MF-25V	25MF-25V	25MF-25V	10MF-25V	10MF-25V	10MF-25V	25MF-25V	25-25V	25-25V	25MF-25V			
C115	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10MF-15V	10-15V	10-15V	10MF-15V			
C119	.47MF-100V	.47MF-100V	.47MF-100V	.22MF-200V	.22MF-200V	.1MF-200V	.1MF-200V	.047MF-480V	.022MF-600V	.1MF-200V	.22-200V	.22-200V	22MF-200V			
R112	270	270	270	390	470	680	680	820	1.5K	680	470	470	390			
R113	560	560	680	680	820	820	1K	1.5K	2.2K	820	820	820	680			
R119	2.2K	2.2K	3.3K	4.7K	5.6K	6.8K	10K	12K	15K	6.8K	5.6K	5.6K	4.7K			
R120	10K	10K	10K	8.2K	8.2K	6.8K	6.8K	4.7K	4.7K	6.8K	8.2K	8.2K	8.2K			
R123A	38.3	57.6	49.9	60.4	82.5	100	56.2	75.8 10 SER	45.2	100	OMIT	82.5	60.4			
R130	150K	150K	150K	150K	150K	150K	150K	150K	150K	150	150K	150K	150K			
R131	2.2K	2.2K	4.7K	10K	22K	47K	100K	220K	470K	47K	22K	22K	10K			
R134	6.8K	6.8K	10K	10K	22K	22K	47K	100K	220K	22K	22K	22K	10K			
R137	2.49K-1%	4.99K-1%	15K-1%	20K-1%	15K-1%	JUMPER	75K-1%	75K-1%	294K-1%	40.2K-1%	15K-1%	15K-1%	20K-1%			
R138	JUMPER	JUMPER	JUMPER	4.99K	20K-1%	54.9K-1%	JUMPER	69.8K-1%	JUMPER	4.99K-1%	20K-1%	20K-1%	4.99K-1%			
R156	JUMPER	JUMPER	JUMPER	JUMPER	JUMPER	JUMPER	JUMPER	JUMPER	JUMPER	JUMPER	OMIT	JUMPER	JUMPER			
R146	5.9K	6.49K	6.49K	5.9K	6.49K	5.9K	5.9K	6.49K	6.49K	4.99K-1%	6.49K	6.49K	5.9K			


R137, R138, 124K & UP RN 70 3/4W 1% OR 100K DOWN RN 65 1/2W 1% OR RN 60 1/4W 1% OR RN 55 1/8W 1%

DATE: 6-11-80	DATE: 6/12/80	DATE:	DATE:
SCALE: 463	SCALE:	SCALE:	SCALE:
ELECTRONIC MEASUREMENTS INCORPORATED		TITLE: SCHEMATIC DIAGRAM	
HCR POWER SUPPLY		REV: 01-463-001	

APPLICATION			LTR.	E.C.O. NO.	BY	APP.
USED ON	NEXT ASSY.	QTY.	A	ECO #8209 3/1/89	REW	JVD

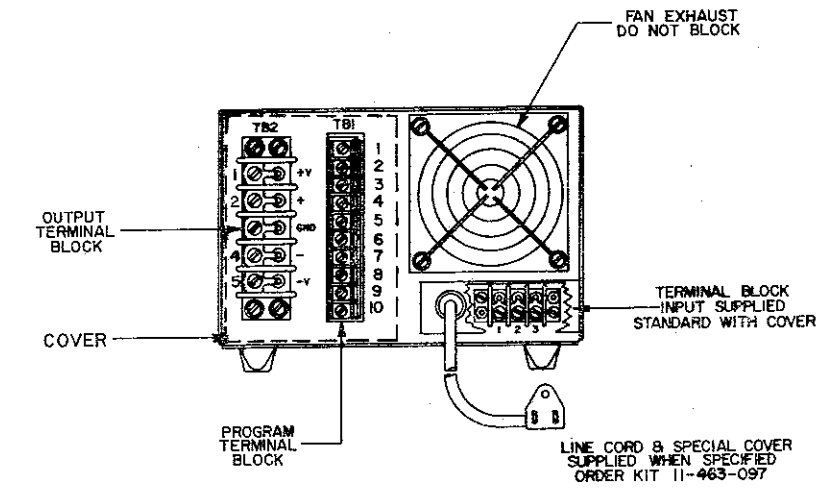
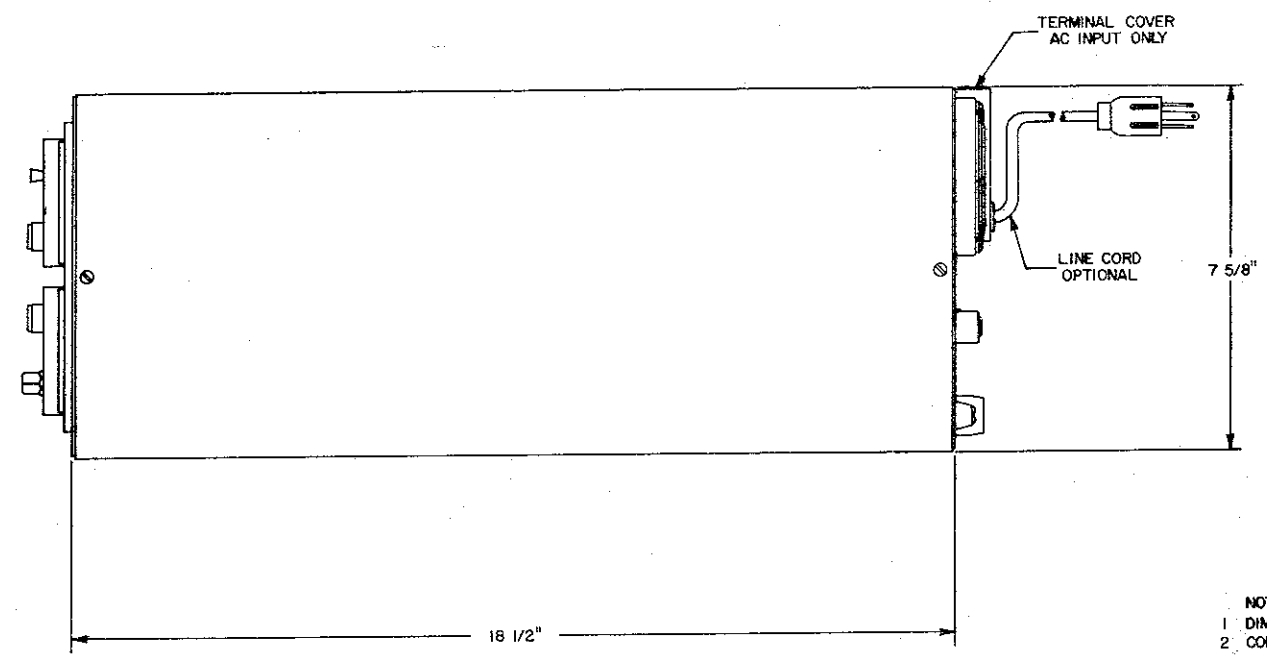
SHEET 1 OF 1
 DWG. NO. 01-143-000
 REV.



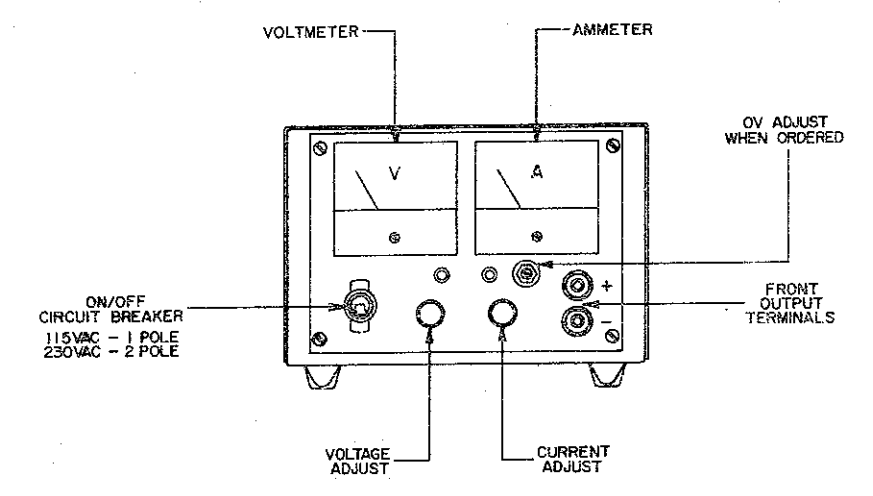
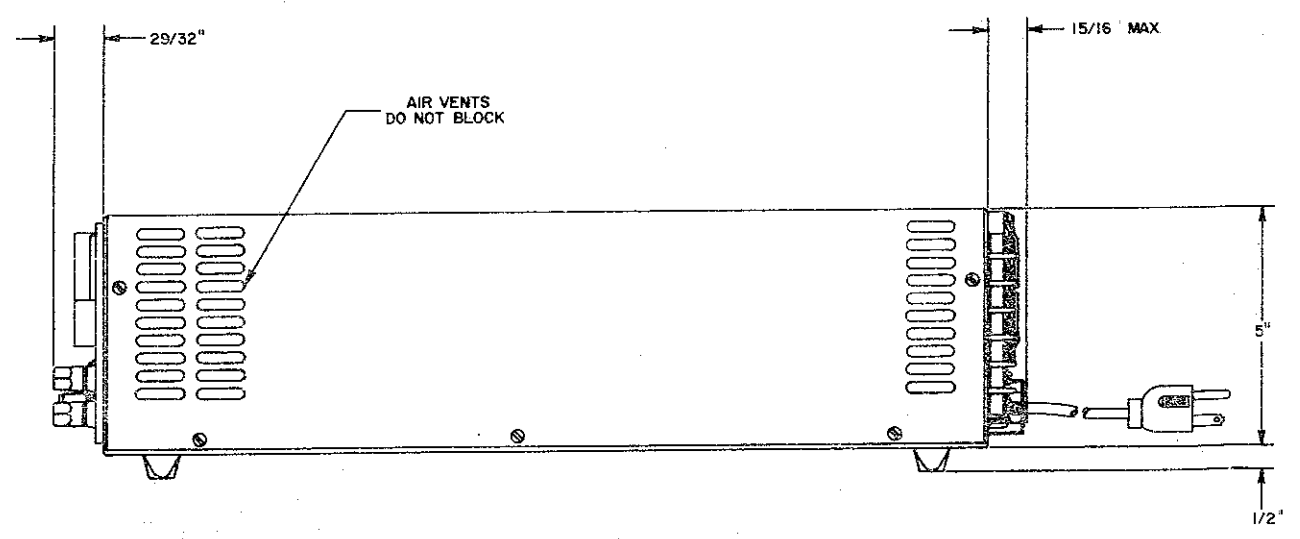
MTL:	TOL: XX = ± .02" XXX = ± .005" ANGLES ± 1/2"	DWN: J.V.D. 6/5/84	DATE: 6/5/84	 ELECTRONIC MEASUREMENTS INCORPORATED	
FIN:	P/L 463	CHK: C.C. 6/5/84	DATE: 6/5/84		TITLE: A300 LINE FILTER FOR HCR SCHEMATIC
	SCALE: —	APP: JVD 6/5/84	DATE: 6/5/84	DWG NO. 01-143-000	REV. A

BRUNING 46560

APPLICATION			LTR:	E.C.O. NO.	BY	APP.
USED ON	NEXT ASSY.	QTY.				



- NOTES:
- 1 DIMENSIONS SHOWN FOR REFERENCE ONLY
 - 2 COLOR E/M TEXTURED TAN
 - 3 OPTIONAL INPUT 115VAC OR 230VAC 50-60HZ.
 - 4 OPTIONAL INPUT CONNECTION, TERMINAL BLOCK OR LINE CORD BOTH WITH COVER.
 - 5 POWER SUPPLY CAN BE MOUNTED ON STANDARD 19" PANEL 5 1/4" HIGH EITHER ALONE OR 2 SUPPLIES PER PANEL ASK FOR RACK ADAPTORS RA-1 OR RA-2. (REMOVE RUBBER FEET.)
 - 6 OVER VOLTAGE PROTECTION AVAILABLE AS OPTIONAL FEATURE MUST BE SPECIFIED AT TIME OF ORDER.
 - 7 FRONT & REAR OUTPUT TERMINALS SUPPLIED ON ALL SETS AS STANDARD FEATURE.



MTL:	TOL:	DWG. DATE:	ELECTRONIC MEASUREMENTS INCORPORATED
	FRAC. ± 1/32"	B.G. 1-30-80	
FIN:	P/L 458	CHK: DATE:	TITLE: DIMENSIONAL OUTLINE HCR 10 250W P/S
	SCALE: 1/2	APP: DATE:	DWG. NO. 02-463-001

