OPERATING AND SERVICE MANUAL

MODEL 890A

DC POWER SUPPLY

MANUFACTURING CODE 4G

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD
HARRISON DIVISION

INDEX

SPECIFICATIONS

Input: 105-125VAC, single phase 60 cps, 3.9A and 255W at 117VAC input and full output.

Output: 0-320 volts, 0-0.6 amperes

Load Regulation: Less than 0.007% or 20 mv change (whichever is greater) for a 0.6 ampere load change.

Line Regulation: Less than 0.007% or 20 mv change (whichever is greater) for 105 to 125 volt line change.

Ripple and Noise: Less than 2 millivolts rms. Plus or minus output terminal must be grounded through a low impedance path.

Maximum Operating Temperature: 50°C

Temperature Coefficient: Output voltage change per degree Centigrade is less than 0.03% plus 1.5 millivolts.

Stability: The total drift for 8 hours (after 30 minutes warmup) at a constant ambient temperature is less than 0.1% plus 5 millivolts.

Internal Impedance:

Less than 0.04 ohms from DC to 1 Kc.
Less than 0.2 ohms from 1 Kc to 10 Kc.
Less than 1.0 ohms from 10 Kc to 1 Mc.
Less than 10 ohms from 1 Mc to 10 Mc.

Transient Recovery Time: Less than 100μsec is required for output voltage recovery to within 20 millivolts of the nominal output voltage following a 0.6 ampere change in output current. For this measurement, the nominal output voltage is defined as the mean between the no load and full load voltages.

Overload Protection: An all-electronic, continuously acting current limit circuit protects the power supply for all overloads, including a short circuit placed directly across the output terminals. However, a fuse is placed in the output circuit to protect against an instantaneous short circuit at high output voltages. The unit may be safely turned on into a short circuit.

Turn-on--Turn-off Transient: On output voltages above 10 volts, there will be no turn-on or turn-off overshoot and will be less than 0.2 of a volt at 10 volts or less output.

Controls: A 10-turn potentiometer (with concentric knoblock) on the front panel makes possible continuous adjustment of the output voltage over the entire range from 0 to 320 volts.

Meters: A 0-320V voltmeter and 0-0.8A ammeter are provided.

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

Error Sensing & Remote Programming: Error sensing is normally accomplished at rear terminals, and provision for remote error sensing is included on the rear terminal strip. Remote programming of the supply output at approximately 300 ohms ±1%/volt is also made available on the rear terminal strips.

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

Size: 3-1/2"H x 16-3/4"D x 19"W (standard relay rack mounting)

Weight: 35 pounds

Finish: Light gray front panel with dark gray wrinkle case.

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

PRELIMINARY CHECKOUT

CONTROLS AND TERMINALS

Toggle off-on switch and indicator lamp -- The toggle switch located near the lower left edge of the panel controls the power supplied to the equipment from the power line. The indicator lamp, immediately above the switch, when lighted, indicates that AC power is applied to the transformer primary.

Output control -- This control, located in the center of the front panel, controls the output voltage of the supply in the local programming mode of operation. This control is a ten-turn potentiometer with a concentric knoblock.

CAUTION: This control should not be turned down rapidly when there is no load on the supply. See Special Considerations.

Fuses -- The AC fuse, located in the lower righthand corner of the front panel, is a 3AG 5 amp fuse. This fuse is for the protection of the entire instrument. This fuse is not intended for output overload protection. The DC fuse, located in the upper righthand corner of the front panel is a 3AG 1 amp fuse. Never use slow blow fuses. This fuse is to protect the supply from severe fast overloads at high output voltages. This fuse will not blow when the supply is shorted at low output voltage, when the overload is applied slowly over a period of two or three seconds, or when the supply is turned on into an overload.

Rear terminals -- There are seven rear terminals--1 positive output terminal 1 negative output terminal, a positive sensing terminal, a negative sensing terminal, a chassis ground terminal, and two terminals marked A1 and A2. Terminals A1 and A2 are used for local and remote programming connections.

Three wire line cord -- The third wire in the line cord is used for grounding the supply to an earth ground via the power line conduit, etc. Either the plus or the minus output terminals should be grounded preferably to the chassis at the rear strip. However, if the supply will be grounded at some point in the equipment to be powered, then grounding at the rear terminals is not recommended because of possible ground loops being formed. It is still recommended that the supply chassis be grounded via the line cord.

TESTING

Generally, about 90% of all types of failure due to shipping damage will manifest itself as either nearly zero volts output or excessive output voltage. Therefore, it is suggested that the following test be made immediately upon unpacking the instrument.

Before power is applied:

1. Ascertain that no visible shipping damage has occurred and that the small transistors are in their sockets. Six small transistors should be visible through the cover perforations.

2. Check to see that the rear terminals are strapped in accordance with Figure 1 in the rear of the manual marked Rear Terminal Conn.--Local Programming & Sensing and assuring that the terminals are tight.

3. Check to see that a 5 amp fuse and a 1 amp fuse are installed in the AC & DC fuseholders, respectively.

4. Turn the output control to full clockwise, then back two turns.

5. Turn power switch to off and plug line cord into a three wire receptacle.

With the above items taken care of, the supply may be turned on. The output current meter should immediately rise to 0.8 amperes and the output voltmeter should rise to approximately 260 volts in about 1 second. The rising should cease as the voltmeter reaches approximately 260 volts and the ammeter should return to zero. This initial current is due to the charging of the output capacitor. If the voltmeter remains at or near zero or if it rises off scale shut the unit off immediately and contact the factory. Under no conditions should the programming control be spun down. If the supply operates normally the programming control may be adjusted to obtain any desired output voltage but it should not be turned down rapidly. See Programming Control under Special Considerations. If further testing is desired see the section on Service.

PUTTING THE SUPPLY INTO SERVICE

MODE OF OPERATION

Preparing the supply for service usually consists of only selecting the desired mode of operation and wiring the terminals accordingly. There are four possible modes of operation: Local Programming & Local Sensing (Normal mode as shipped from the factory); Local Programming & Remote Sensing; Remote Programming & Local Sensing; and Remote Programming & Remote Sensing.

LOCAL PROGRAMMING & LOCAL SENSING

The power supply is shipped already wired in this mode. It allows the output voltage to be controlled from the front panel control and the output impedance to a minimum at the output terminals. For minimum coupling between equipments being powered by the supply the equipments must be individually connected to the output terminals of the supply. To wire the supply for this mode from some other mode connect the negative sensing terminal (-S) to the negative output terminal (-) and the plus sensing (+S) to the plus output terminal. Connect terminal A2 to the plus sensing terminal (+S) and connect either the plus (+) or minus (-) output terminals to ground. See Figure 2.

LOCAL PROGRAMMING & REMOTE SENSING

This mode of operation is used to establish a low impedance at the load rather than at the power supply terminals. The load is connected to the plus (+) and minus (-) output terminals. The minus sensing (-S) is connected to the minus side of the load and the plus sensing (+S) is connected to the plus side of the load. A jumper should connect A2 and plus sensing (+S) terminals. See Figure 4 or 5. This connection will establish a low impedance at the load for DC and low frequencies. Under this form of operation the transient recovery time specification is not valid. However, if a low high-frequency impedance and a good transient response is desired, then it is necessary to remove C26 from the supply and place it at the load's terminals. When using remote sensing it is important not to exceed 0.5 ohm in the minus sensing lead connecting the minus sensing terminal (-S) to the minus side of the load. In addition, it is necessary not to exceed .5 ohm in each leg of the power carrying leads. Lead resistance in the minus output wire will tend to reduce the current limit setting and it may have to be readjusted. The current limit may be readjusted by shorting the supply at the load, then turning on the supply and adjusting P4 for 0.8 amperes on the ammeter. All of the leads should be shielded with the shield connected to the supply ground.

REMOTE PROGRAMMING, LOCAL OR REMOTE SENSING

Remote programming may be accomplished by two different methods: (1) It can be done by inserting a potentiometer or rheostat between terminals A1 and plus sensing (+S). (2) It can be programmed by an external voltage source connected between terminals A1 and plus sensing (+S) with the positive terminal of the source connected to the plus sensing terminal. However, it is suggested that the factory be consulted first. The first case which is more commonly used, the output voltage will increase at a rate of 0.0033 volts/ohm of programming resistance. For stable operation, the external programming rheostat or potentiometer should be a wire-wound device with a temperature coefficient of 30 ppm or better. The potentiometer must be capable of carrying 3.3 ma or more. It is also recommended that the programming lead be shielded and the shield connected to the ground of the supply. See Figures 3 and 5.

CAUTION: 1. If the programming terminals are open circuited the output voltage will rise well in excess of 320 volts and damage to the supply may result if operated in this condition over a prolonged period.

2. A rapid turndown of the programming potentiometer, internal or external, may burn out the potentiometer. It is recommended that the programming potentiometer be turned down no faster than the voltage needle falls on the front panel meter.

SPECIAL CONSIDERATIONS

PROGRAMMING RESISTANCE

It has previously been warned that a rapid turndown could damage the programming potentiometer. While it is unlikely that the internal programming potentiometer will be burned out by even an instantaneous turndown from 320 volts to zero, it is possible to overheat the lower resistance region of the resistance element and thus cause it to become noisy at the low end. When the supply is heavily loaded a reasonably rapid turndown will not be detrimental to the potentiometer.

PROGRAMMING RATES

The maximum safe rising programming rate is about 50 volts/sec. The maximum falling programming rate is determined by the load current and the supply capacitance. At heavy output currents down programming rates up to 50 volts/second are feasible whereas at low voltage and no load the down programming rate may be as low as 1/2 volt/second.

SHORTING THE SUPPLY

The supply is designed only to sustain a shortcircuit across the load terminals. Inadvertent shorts between one of the output terminals and the sensing on the A terminals will result in the failure of the instrument. It is important to insure that the sensing terminals are tight and that the shorting occurs on the output terminal leads and not on the sensing leads.

LEAD IMPEDANCE AND LOCAL DECOUPLING

It is important that local decoupling be used at the load if long leads are used due to the high impedance of the leads at high frequencies. For very long leads a heavy, shielded, twisted pair type of cable should be utilized. .01μf ceramic capacitors across the output leads at the load are also recommended.

NEGATIVE CURRENT LOADING

The supply is not built to regulate when current is pumped into the output of the supply from an external source. If it is necessary to operate in this manner, then a resistor must be used to load the output terminals of the supply by an amount equal to the maximum instantaneous current pumped into the supply.

MAINTENANCE

MEASURING THE PERFORMANCE OF THE SUPPLY

When measuring the output impedance, transient response, or ripple of the supply, be sure the measuring device (differential voltmeter, digital voltmeter or oscilloscope) is attached to the sensing leads of the supply. It is important that none of the output current flows through the lead lengths in series with the monitoring device since such lead lengths can easily have an impedance of the same order of magnitude as the supply impedance and thus effectively make the measurement invalid. When measuring the power supply ripple, connect either the positive or negative terminal of the supply to the chassis ground, and the scope case to the same point making certain that the scope case is not also grounded by some other means (such as a three wire power cord). To be doubly certain that the scope is not exhibiting a ripple or transient spike that actually is not coming from the power supply, connect both scope leads simultaneously to the power supply ground terminal. No ripple or transient spike should be visible if the power supply is properly connected to the scope.

The only maintenance required of this supply is that it be kept reasonably clean and free of dust and metallic particles.

CIRCUIT DESCRIPTION

As shown in the block diagram and on the schematic diagram, Figures 8 and 9, the power transformer feeds D10 and C5 to provide -30 volts. The 30 volt supply provides current to the bases of the transistors in the series regulator, to the preregulator control circuit, and to the -15 volt bias regulator. The -15 volt bias regulator is comprised of R18, D9 (a 15 volt zener diode), Q4 in an emitter follower configuration, and R6, a bleed resistor. The 15 volt bias supply provides current to the preregulator control circuit, to the overvoltage protection circuit (P5 etc) and to the -12 volt reference regulator. In the 12 volt reference circuit D14 is used to provide a constant voltage on the emitter of Q6. The output of the reference supply is picked off by R20 and R21 and connected to the base of Q6 via the temperature compensating network of D11, D12, R25, and R26. Any change in the output of the 12 volt reference supply voltage will cause a change in base current in Q6, and thus eventually a change in current in Q3 tending to hold the voltage of the reference supply constant. R16 is used to reduce the power dissipation in Q3. P2 and R19 is a circuit to provide a compensation for slight changes of the -15 volt supply due to line voltage variations.

The output of the power supply is sensed by two transistors, Q1 and Q2, in a differential amplifier configuration. The base of Q2 is connected to the minus sensing lead via a 1.5K resistor which for sake of easy explanation tightly ties the base to the minus sensing. Normally, the minus sensing is connected to the minus output terminal of the supply. The base of Q1 is connected via a 2K resistor to the junction of R1 and P8. R1 is connected to the -12 volt reference supply and P8 to the positive output terminal. Now if any potential difference occurs between the base of Q1 and Q2, the signal is amplified and applied to the series regulator. The signal is such that the voltage on the output of the supply is charged until there no longer exists any potential difference between the bases of Q1 and Q2. Thus, the potential at the junction of R1 and P8, usually called the "summing point", will remain at approximately zero with respect to the minus sensing lead. R4 is used to protect P8 from damage under overload conditions. D1 and D2 protect Q1 from overload. R10 and P1 form a positive feedback loop used to adjust the load regulation of the supply. D20, D21, and D22 provide a positive 2.4 volt bias supply with respect to the minus output bus. D3 and D7 comprise a 1.3 volt bias source for the emitters of the differential amplifiers.

The output signal from the differential amplifier is coupled to the predriver base via two diodes. In addition to the differential amplifier signals, the base of Q5, the predriver, also receives information if the current of the supply exceeds a specific limit. The current is sensed by monitoring the voltage drop across R27. P4 is the current overload adjustment. If the current output of the supply exceeds a certain value, the diode D8 is forced into conduction and causes Q5 to conduct heavily which will cause the series regulator to limit the current output of the supply. C6, C8, and P3 connected as collector to base feedback in the collector of Q5 is the high-frequency equalizer. The output of Q5 is fed to Q7 through R75, an overload protecting resistor. Also into the base of Q7 is fed a signal from the overvoltage protection circuit. If the output voltage of the supply tends to exceed a preset value, the circuit produces a signal which will limit the output voltage of the supply. Q7 is an emitter follower driver for the series regulating transistor. Operating bias for Q7 is developed across D17.

Generally speaking, Q8 is the main control element in the supply. It is the series regulator transistor. This transistor responds to the signals presented by the error amplifier and provides more or less current to the output in order to keep the output voltage constant. However, under certain conditions the power dissipation would be relatively high in Q8 so Q9 and R78 comprise an additional series element to reduce the power dissipation in Q8. The voltage across the two series elements is held between 10 to 15 volts by the preregulator control circuit and preregulator. The voltage across Q8 and Q9 is sensed via R32, R31, and D18 (if used).

The preregulator control circuit consists basically of Q10, and T1 which comprise a blocking oscillator. The voltage on the base of Q10 is held constant at nearly -15 volts. If the emitter of Q10 becomes more positive than -15 volts, the blocking oscillator fires producing a 50μsec long pulse which is fed to the SCR's in the preregulator. The emitter of Q10 is normally biased more negative than -15 volts by a waveform shown in stepp 11 of Table I. It is produced by D34, D35, C18, and R44. In series with this waveform the voltage across C12 is added. When the sum of these two voltages becomes zero then the blocking oscillator is caused to fire. The voltage across C12 is shown in step 13 of Table I. It is an exponentially rising ramp whose rise rate is increased for decreasing voltage across Q8 and Q9. The blocking oscillator is prevented from firing again due to a charge built up on C19. Once each half cycle of the line voltage C19 and C12 are clamped to the -15 volt supply, the whole process starts over. The clamping voltages are produced by D40, D42, D37, D38, D33, and R47. C12 is clamped via D36 and C19 via D41. D39 prevents C19 from drifting negative and D43 prevents the emitter of Q10 from becoming more positive than -15 volts. C20 and R48 isolates the pulse currents through Q10 from the -15 volt supply. D27 prevents ringing of the blocking oscillator transformer. R33 and C39 at the junction of R31 and R32 make up an equalizer while C11, R34, R35, D28, and D29 permit a slow, smooth, controlled turn-on.

D47 through D54 are the main bridge rectifiers which feed power to the SCR preregulator. The SCR's when fired by the blocking oscillator pulses conduct until the anode voltage on the SCR's becomes zero or negative just as in a thyratron.

A small amount of voltage is developed by D25, D26, and C25, and added in series with the preregulator supply. At the junction of the bias supply and the minus side of the preregulator supply a diode, D16, is connected and run to the minus output terminal. If the output of the supply is shorted D16 conducts the energy stored in C27 to the output rather than dissipating this energy in the series passing transistors. If the supply is shorted, F2 will open. D23 is used to protect the ammeter from surge currents. Finally, R36 and C10 are used to dissipate the magnetizing current of the transformer when the supply is turned off.

SERVICE

PROCEDURE

Should for any reason a failure occur in service it is very helpful if the conditions at the time of failure are reported to the company. Items such as ambient temperature, line voltage, output voltage and current, mode of operation, and overload conditions, if present, will be helpful in making an accurate diagnosis and prompt repair of the unit. Other symptoms such as excessive voltage, no voltage, excessive ripple are of great use in determining the nature of the defect.

TROUBLE SHOOTING

Malfunction of the power supply will in most cases manifest itself as excessive voltage, no voltage, or widely varying voltage. In any case the first step is to examine the printed circuit board for loose transistors, broken copper, burned spots or heavy dust on the transistor and SCR heat sink. The second step is to make an insulation test between the minus output terminal and the chassis. Be sure to disconnect any leads connected to the rear terminal strips. The test procedure is to connect a 1 meg resistor in series with a 1000 volt power supply and the minus output terminal. Then measure the voltage drop in the resistor or the voltage applied to the supply with a meter rated at 100,000 ohms/volt or higher. A VTVM is not satisfactory unless battery powered and an input impedance of 100 megohms. See Figure 6A. The voltage rise should not exceed 50 volts except in extremely humid environments when the power supply under test is disconnected from the test circuit. Any fluctuations may be sporadic arcing between the SCR's or the tee. If for any reason the SCR's or the power transistors are disturbed the high voltage insulation test is a must. If the insulation test is satisfactory then follow the testing section under Preliminary Checkout. If the unit operates normally then the failure was due to the opening of a sensing lead, load lead, programming lead originated in the equipment being powered, or is of an intermittent nature. If the unit operates normally but there is a desire to assure its operation in detail then start at step #9. in the alignment procedure. If the unit operates abnormally then proceed to Table I if servicing is to be done by the customer.

TABLE I.

Operating Conditions: Line voltage -- 117 volts
Output voltage -- 50-320 volts, at rated current, unit connected for normal operation, output control one turn from full clockwise.

Note: If output voltage exceeds 400 volts or is periodically rising and falling, use Table II to locate trouble. If either fuse blows within a second or so after turn on and does not do so if Q10 is removed from its socket then immediately inspect D16, D19, C27, and C26 for leakage or short. If these fail to be the cause of trouble, then follow the Alignment Procedure from Step 1. Voltages are measured with a Simpson 269 multimeter or equivalent and a Tektronix 502 oscilloscope. Test points are numbered and marked in red on the printed circuit board.

	Test Points		Voltage	Ripple P-P	Comments
1	-S	13	-33V ±10%	2.5V max.	If voltage is abnormal check D10, C5, T3
2	-S	12	-15.5 ±10%	50 mv max.	" " " " " D9, Q4
3	-S	5	11.7 ±5%	300µv max.	" " " " " Q3, Q6, D14 D11, D12, C3
4	-S	11	-9.4 ±5%	300µv max.	" " " " " Q3, Q6, D14 D11, D12, C3
5	-S	17	+2.4 ±10%	10 mv max.	" " " " " D20, D21, D22
6	-S	8	+1.3 ±10%	1 mv max.	" " " " " D3, D7
7	-S	19	-7 ±30%	3.0V max.	--
8	28	26	+1.0 ±20%	----------	" " " " " D17
9	28	31	-1.5 ±20% or 2.3 ±20%	----------	" " " " " D30, D31, Q8
10	28	27	2.2 max	----------	If voltage is over 2.2 check Q9

TABLE II.

		Normal Response	
1	Remove Q7	E_{OUT} should rise above 50V.	If voltage stops at about 15-20V then trouble is in SCR's, SCR control circuit, or main bridge rectifier. If voltage is zero trouble is in Q8, 9.
2	Short Q7 emitter to collector	$E_{OUT} = 0$	If voltage rises, trouble is in Q8 and 9, D17, the SCR's or the SCR control circuit. If voltage is zero go on to step 4.
3	Short Q7 emitter to collector and remove Q10	$E_{OUT} = 0$	If voltage rises to 15-20 volts, then trouble is isolated to Q8, and Q9 the series regulator. If voltage rises above 50 volts, trouble is in the SCR's. If voltage remains at zero and voltage rose in step 2, trouble is in SCR control circuit.
4	Remove only Q5	E_{OUT} should rise to above 50 volts.	If $E_{OUT} = 0$ then replace Q7 with new transistor or check to see if R30 is open or D15 is shorted. **
5	Remove Q1	$E_{OUT} = 0$	If E_{OUT} rises, replace Q5.
6	--Remove Q2	E_{OUT} should rise above 50 volts.	If voltage stays at zero, check Q1, Q2, D7, D3, D1, D2 and R1 and P8
	**Remove Q5 and short emitter to collector.	$E_{OUT} = 0$	If E_{OUT} risea above 50 volts, replace Q7 as it is open.

ALIGNMENT PROCEDURE

890A

Step 1. High-Voltage Test
See Preliminary of Service Section and Figure 6A.

Step 2. Preturn-on Adjustments

A. Set voltmeter and ammeter to zero.
B. Set programming control full clockwise.
C. Set line switch to off.
D. Check for proper fuses (DC 1 amp, AC 5 amp).
E. Wire for normal operation, see Figure 1.
F. Disconnect main power rectifier from T3 (lugs 11 & 12).

Step 3. Turn on Unit
Output voltage should rise to about 20 volts.

Step 4. Connect A1 to +Output
Output voltage should fall to zero. If 3 or 4 are not correct, check voltages 1 through 7 in Table I and check Q1, 2, 5, 7, 8, 9.

Step 5. Connect a 0-1.0 amp ammeter directly across the output terminals. Adjust P4 for .8 ampere on external meter. Adjust P7 for .8 ampere on internal meter. Remove meter.

Step 6. Turn programming control down until supply goes into regulation--about 3/4 turn from full counterclockwise. Rock control up and down. Connect an oscilloscope between minus bus and test point 30. Waveform should shift left and right. See Figure 6B. Improper waveform indicates trouble in SCR control circuit.

Step 7. Turn control about one turn up from full counterclockwise. Connect scope between the cathode and gate of each SCR and observe waveforms as in Figure 6C. A very low on high pulse voltage usually indicates a defective SCR.

Step 8. Adjust output voltage to about 5 volts. Load supply to .65 amperes and observe output voltage with scope. The peak-to-peak ripple should be less than 300μv.

Step 9. Turn off unit and reconnect the main rectifier bridge to lugs 11 and 12 on T3. Set programming control to one turn from full clockwise. Turn on unit. Output voltage should rise to about 300 volts. Observe output voltage on scope. Ripple should not exceed 300μv peak-to-peak.

Step 10. Increase load on supply slowly. Output current meter should rise to 0.8 ampere then remain constant as the load resistance is decreased. P4 can be used to adjust the current limit.

Step 11. Load supply from nearly zero current to .65 amperes at any voltage above 20 volts output. Measure the voltage between 28 and 27 with a voltmeter. It should drop from about 15 volts to about 1.3 volts as the current is increased from zero to about 150 ma and then remain nearly constant as the load current is further increased.

Step 12. Set output voltage to about 320 volts. Vary line from 105 to 125. Load supply to .65 amps. Observe output of supply at its sensing terminals with digital voltmeter or potentiometric differential voltmeter such as a John Fluke Model 801H. Adjust P2 until output voltage shifts less than 2 mv as an immediate shift of line voltage.

Step 13. Apply and remove the .65 amp load. Observe output as in step 12. Adjust P1 until output voltage change is less than 2 mv.

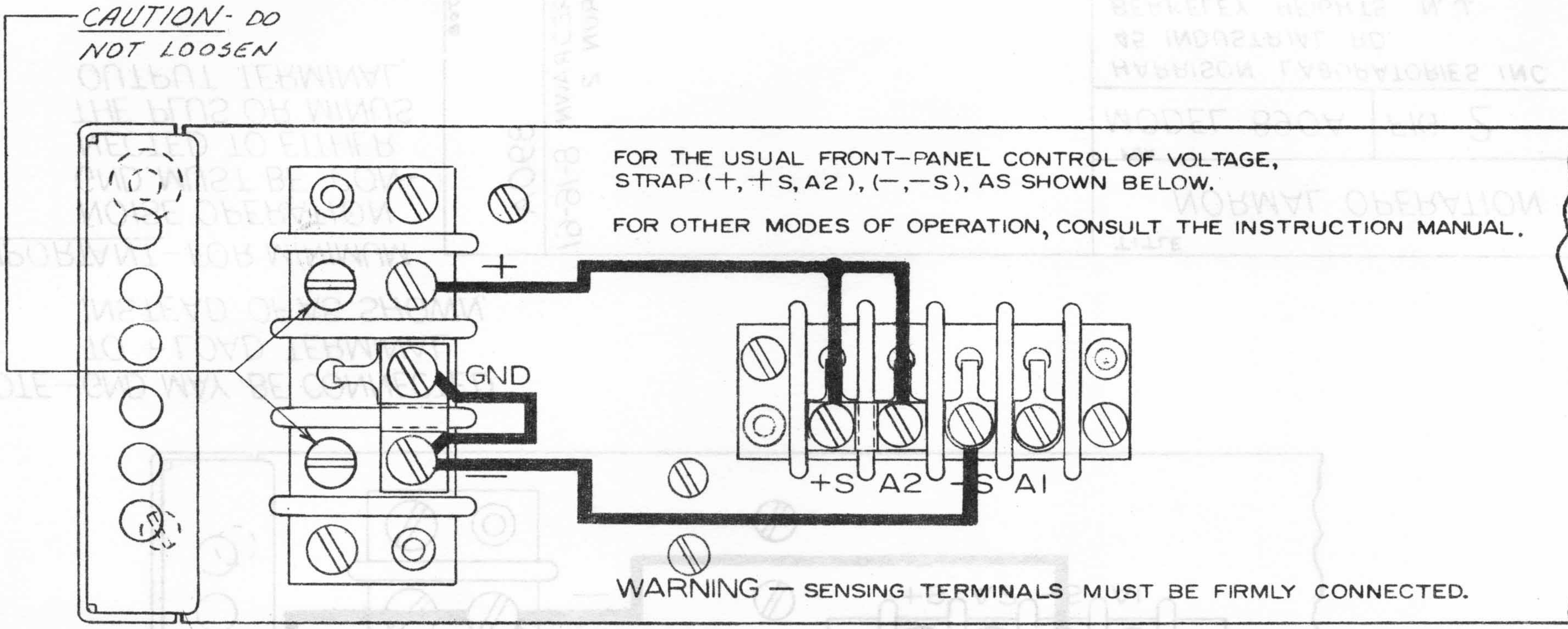
Step 14. Alternately apply and disconnect the .65 amp load (non-inductive) with a Mercury wetted relay at any frequency up to 100 cps (Relay--Clare type HGP 1002). Observe output voltage on scope at the sensing terminals. Adjust P3 until trace is similar to Figure 6D.

Step 15. Turn line voltage to 125 volts. Remove load from supply. Pull Q5 from its socket. Observe output voltage on a multimeter. Adjust P5 for 400 volts output.

Step 16. Turn off supply, replace Q5, disconnect +S from A2, connect a 96K ±1/2% 5 watt resistor between +S and A1. Turn on unit. Output voltage should rise to 320 volts ±1/2%. If unit is outside of this value then turn off unit and remove R2 on the stand-off terminals and replace it with a resistance decade box. Turn on unit and adjust the decade box for exactly 320 volts output. Substitute a fixed resistor for the decade box and recheck. Do not use a value less than 47K unless it has a temperature coefficient less than 100 ppm/^{O}C. Adjust P6 until output voltmeter reads 320 volts.

Step 17. Short output of the supply with a short clip lead. Be sure to connect to the load terminals and not the sensing terminals. Turn off supply. Wait one minute then replace the DC fuse (1 amp 3AG). Turn on the unit. It should return to the same voltage and no change should have occurred in the line or load regulation. If a change has occurred check all the transistors and D16 and R66.

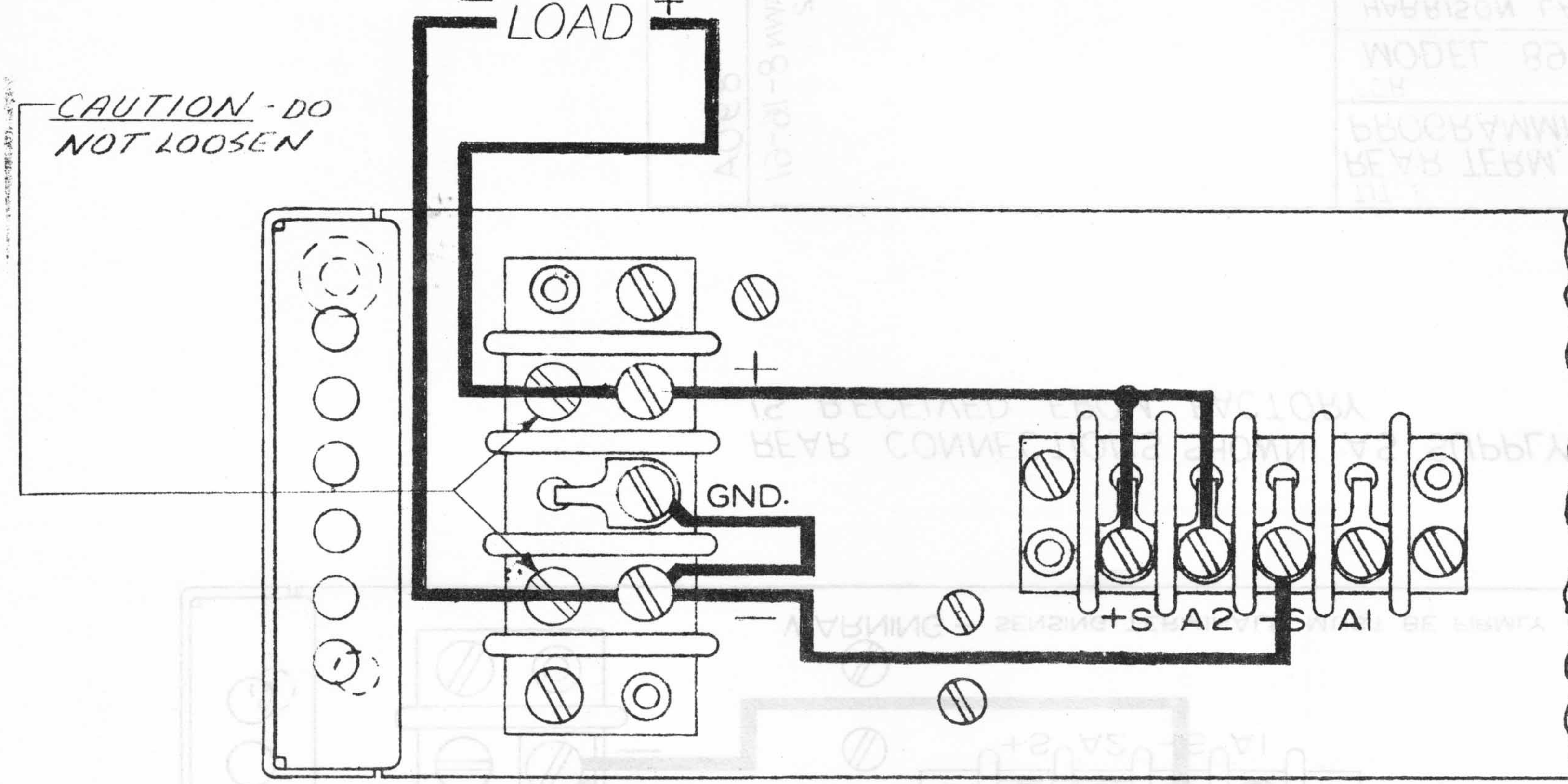
Step 18. Glyptol all pots, put on covers, wire unit for proper mode of operation, and the supply is ready for service.



REAR CONNECTIONS SHOWN AS SUPPLY IS RECEIVED FROM FACTORY

JOB	890A
REDRAWN 8-16-61 RUN-2	

TITLE REAR TERM. CONN. - LOCAL PROGRAMMING & SENSING	
FOR MODEL 890A	FIG I.
HARRISON LABORATORIES INC 45 INDUSTRIAL ROAD BERKELEY HEIGHTS N.J.	

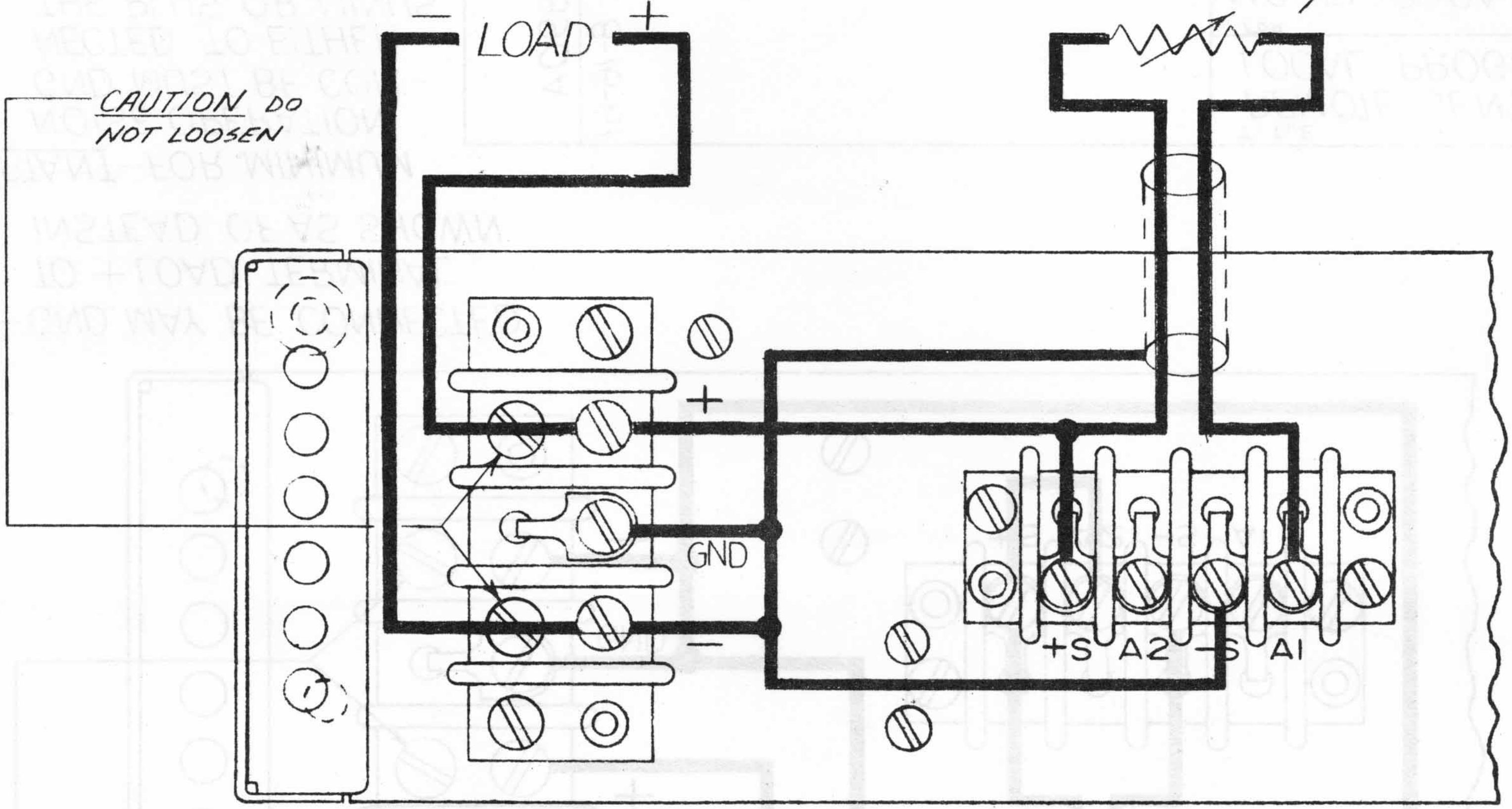


NOTE—GND. MAY BE CONNECTED TO + LOAD TERMINAL INSTEAD OF AS SHOWN.

IMPORTANT—FOR MINIMUM NOISE OPERATION GND. MUST BE CONNECTED TO EITHER THE PLUS OR MINUS OUTPUT TERMINAL.

JOB 890A	REDRAWN 8-16-61 RUN 2	TITLE NORMAL OPERATION	
		FOR MODEL 890A	FIG. 2
		HARRISON LABORATORIES INC. 45 INDUSTRIAL RD. BERKELEY HEIGHTS N. J.	

PROGAMMING POT. MUST BE ABLE TO CARRY 4MA. PROGRAMING COEFFICIENT IS 300Ω ±1%/VOLT



NOTE— GND MAY BE CONNECTED TO + LOAD TERMINAL INSTEAD OF AS SHOWN.

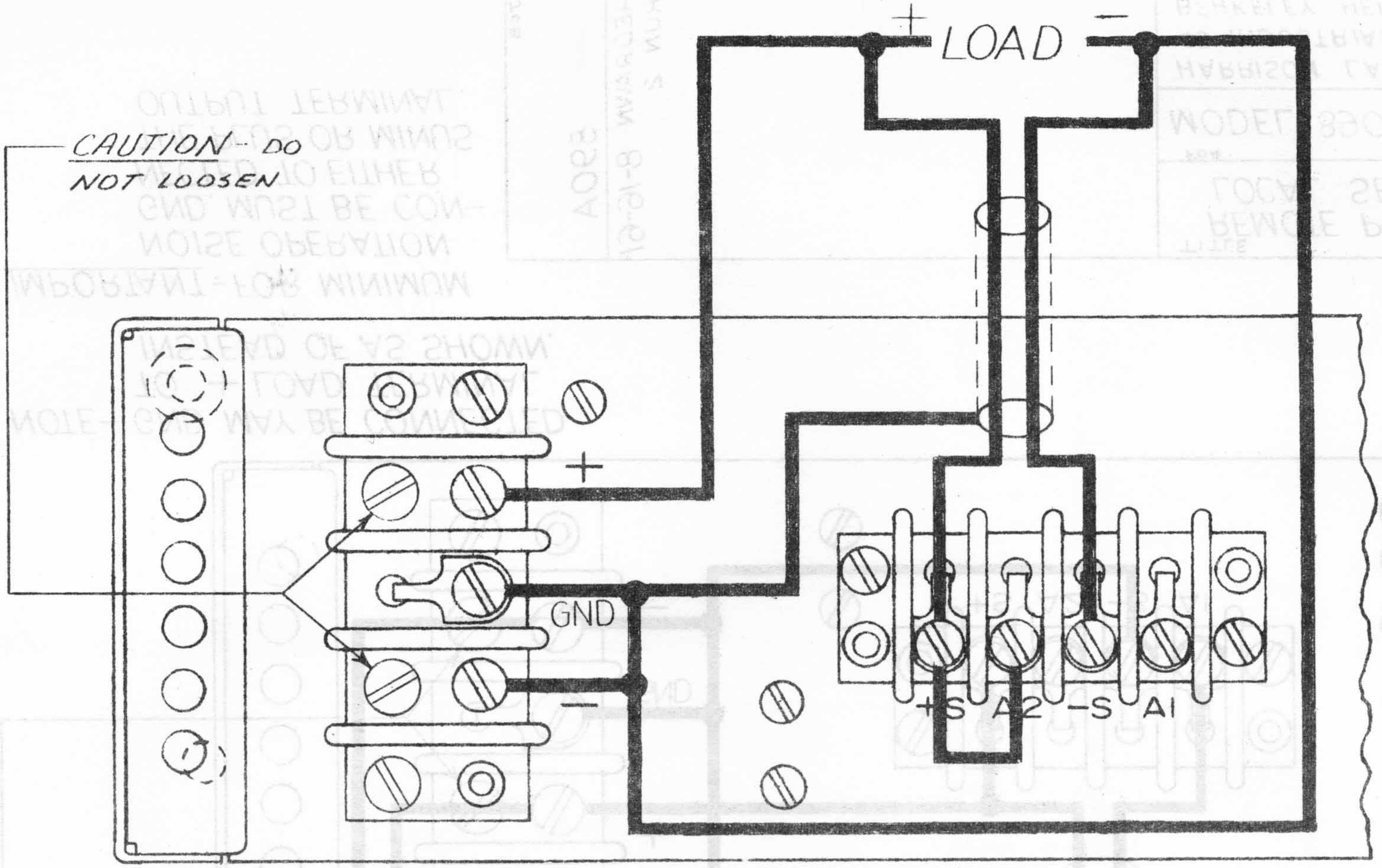
IMPORTANT—FOR MINIMUM NOISE OPERATION GND. MUST BE CONNECTED TO EITHER THE PLUS OR MINUS OUTPUT TERMINAL.

JOB	890A
REDRAWN RUN 2	8-16-61

TITLE REMOTE PROGRAMING — LOCAL SENSING

FOR MODEL 890A | FIG. 3

HARRISON LABORATORIES INC.
45 INDUSTRIAL RD.
BERKELEY HEIGHTS N. J.



NOTE—GND. MAY BE CONNECTED TO + LOAD TERMINAL INSTEAD OF AS SHOWN

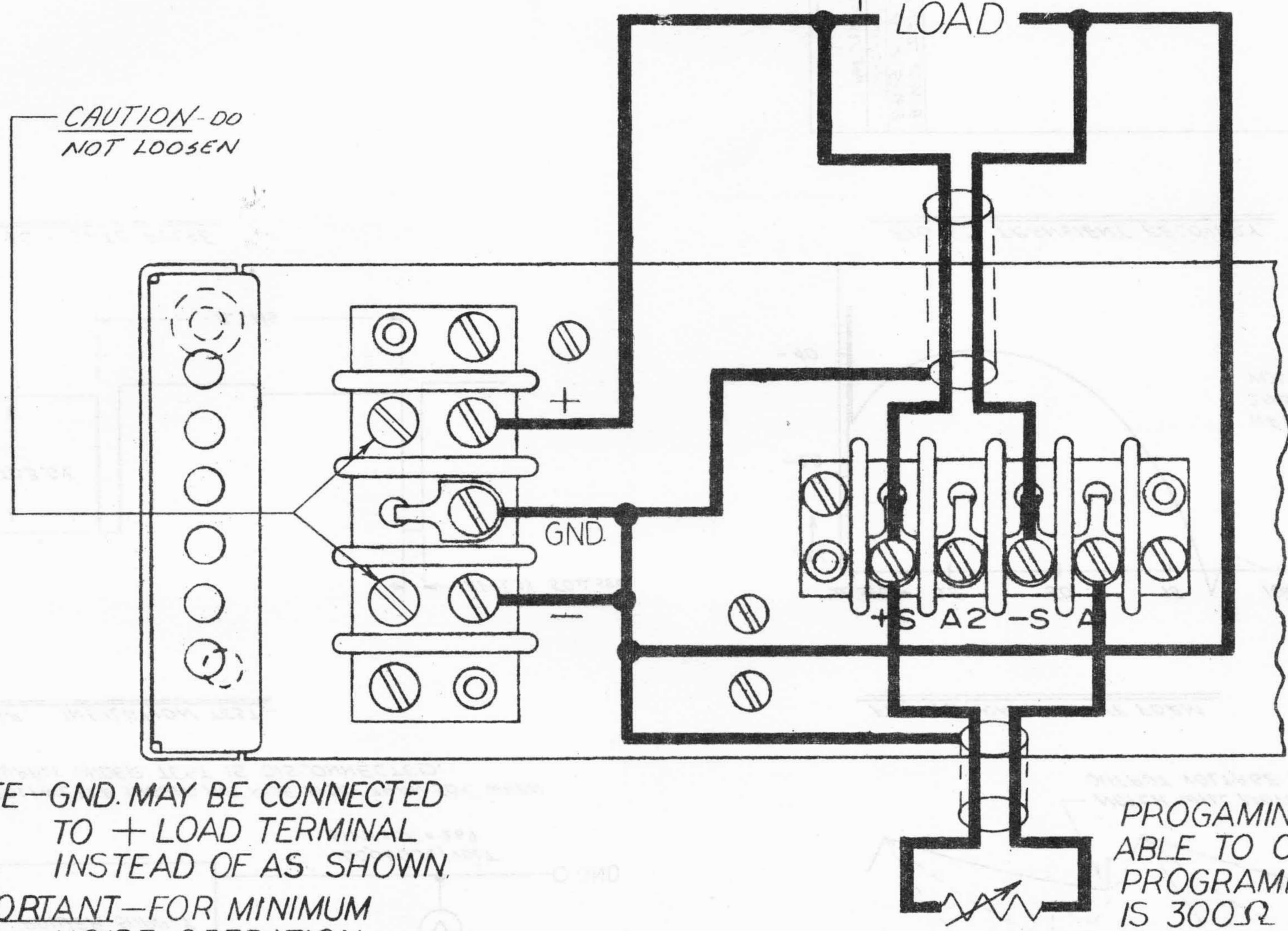
IMPORTANT—FOR MINIMUM NOISE OPERATION GND. MUST BE CONNECTED TO EITHER THE PLUS OR MINUS OUTPUT TERMINAL

JOB 890A	REDRAWN 8-16-61 RUN 2

TITLE REMOTE SENSING & LOCAL PROGRAMING

FOR MODEL 890A | FIG. 4

HARRISON LABORATORIES INC.
45 INDUSTRIAL RD.
BERKELEY HEIGHTS N. J.

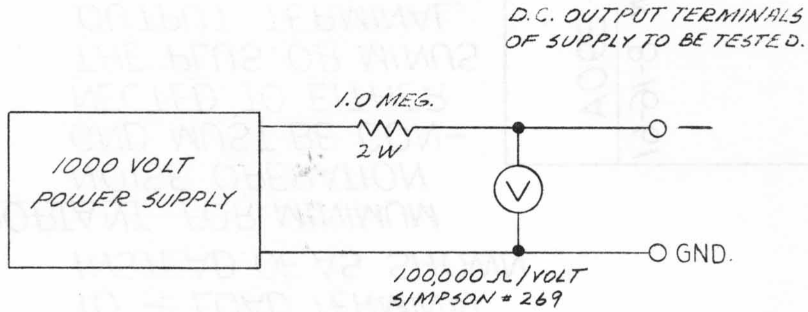


NOTE—GND. MAY BE CONNECTED TO + LOAD TERMINAL INSTEAD OF AS SHOWN.

IMPORTANT—FOR MINIMUM NOISE OPERATION GND. MUST BE CONNECTED TO EITHER THE PLUS OR MINUS OUTPUT TERMINAL.

PROGAMING POT MUST BE ABLE TO CARRY 4MA. PROGRAMING COEFFICIENT IS 300Ω ±1%/VOLT.

JOB 890A	REDRAWN 8-16-61 RUN 2	TITLE REMOTE SENSING & REMOTE PROGRAMING	
		FOR MODEL 890	FIG. 5
		HARRISON LABORATORIES INC. 45 INDUSTRIAL RD. BERKELEY HEIGHTS N. J.	



NOTE: VOLTMETER SHOULD NOT RISE MORE THAN 50V. WHEN SUPPLY UNDER TEST IS DISCONNECTED.

FIG 6A - INSULATION TEST

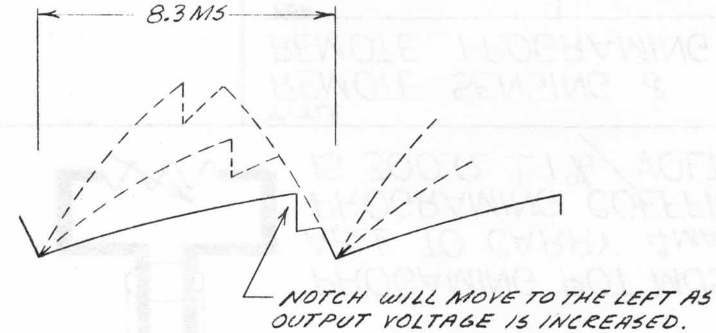


FIG. 6B RAMP WAVE FORM

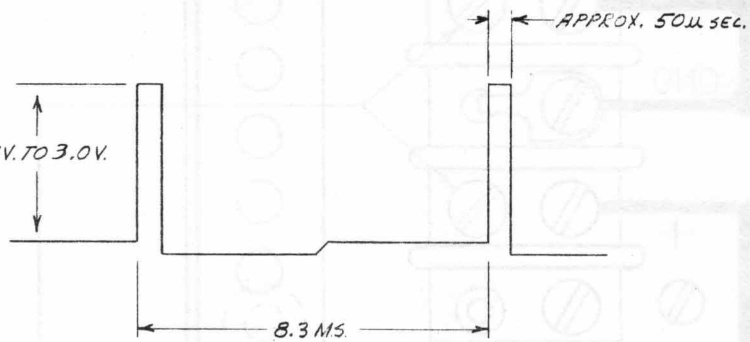


FIG. 6C - GATE PULSE

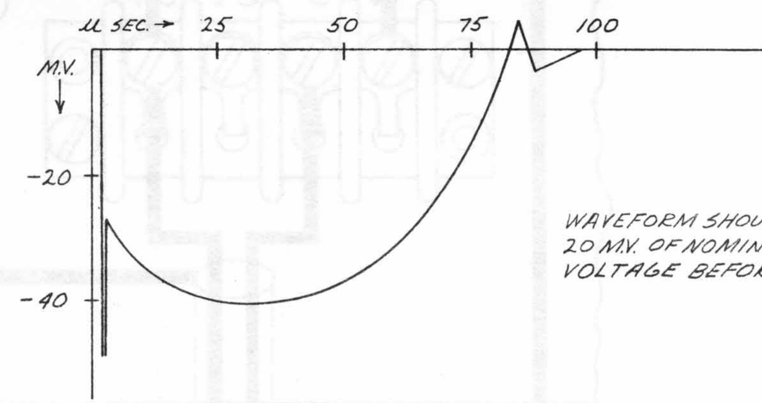
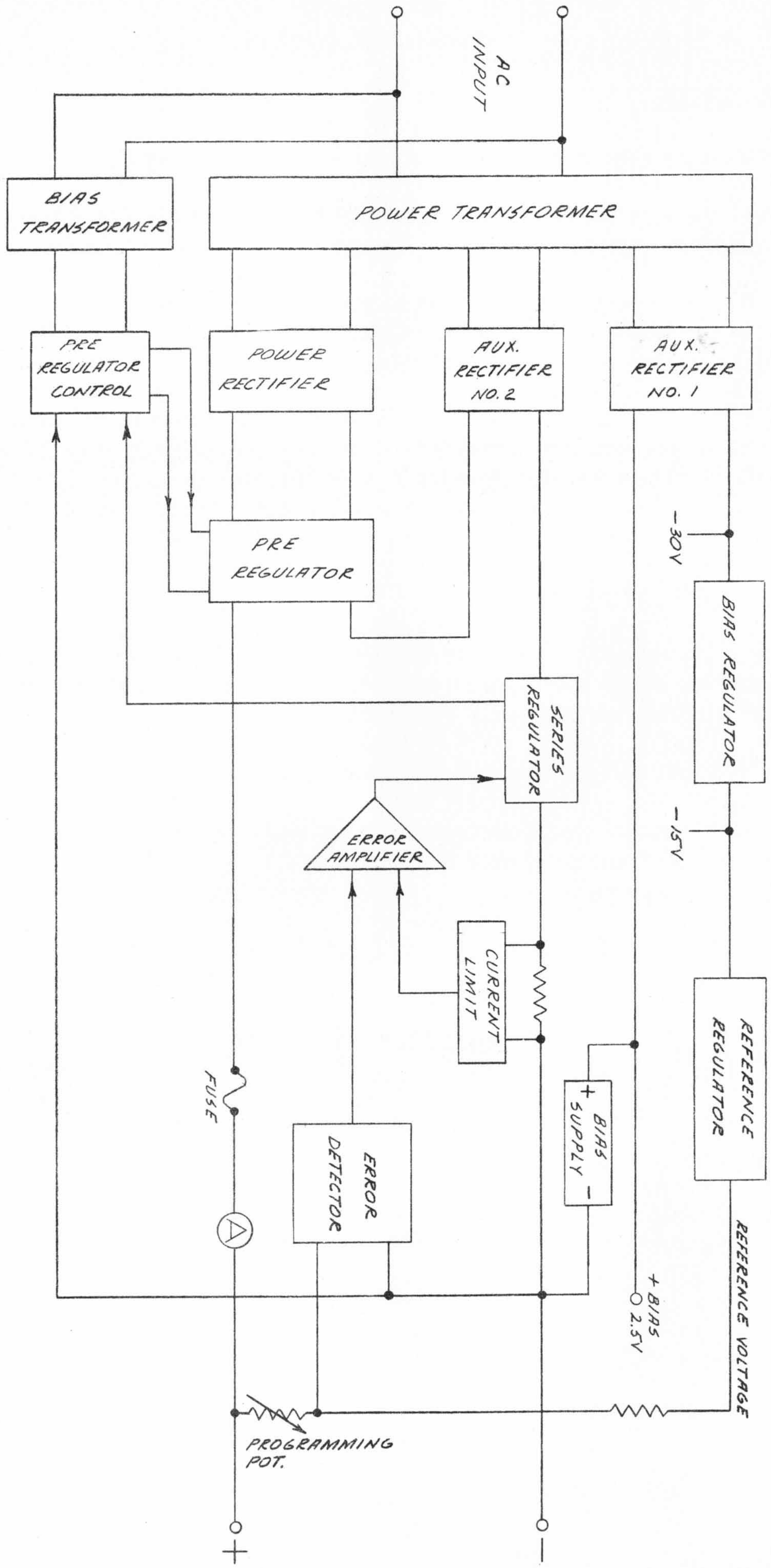


FIG. 6D TRANSIENT RECOVERY

JOB NO 890, 895, 896	TITLE TEST DATA
DWN 10-12-61	FOR 890A, 895A, 896A — FIG. 6 -
REV A 2-5-63	HARRISON LABORATORIES, INC.
ECN 152 RUN 8	BERKELEY HEIGHTS, NEW JERSEY



JOB NO. 890, 895, 896
DRAWN 2-16-61
REV A 10-11-61
REVISED WIRING
890, 895 RUN 2
896 RUN 1

HARRISON LABORATORIES, INC.
45 INDUSTRIAL ROAD
BERKELEY HEIGHTS, N. J.

FIG. 8

TITLE BLOCK DIAGRAM
MODEL 890A, 895A, 896A

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

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

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

A. Description (See list of abbreviations below).
B. Total quantity used in the instrument.
C. Manufacturer's part number.
D. Manufacturer.
E. The Manufacturer's code number as listed in the Federal Supply Code for Manufacturers H4-1.
F. The H-P Part Number.
G. The recommended spare parts quantity for complete maintenance during one year of isolated service. (Column A).

6-4 ORDERING INFORMATION

6-5 To order replacement parts, address order or inquiry either to your authorized Harrison Laboratories sales representative or to Customer Service, Harrison Laboratories, 100 Locust Avenue, Berkeley Heights, New Jersey.

6-6 Specify the following information for each part:

A. Model and complete serial number of instrument.
B. Circuit reference designator.
C. Description.

6-7 To order a part not listed in Table 6-1, give a complete description of the part and include its function and location.

Reference Designators

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

ABBREVIATIONS

a = amperes
c = carbon
cer = ceramic
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube
dep = deposited
elect = electrolytic
encap = encapsulated
f = farads
fxd = fixed
GE = germanium
grd = ground (ed)
h = henries
Hg = mercury
impg = impregnated
ins = insulation (ed)
lin = linear taper
log = logarithmic taper
m = milli = 10^{-3}
M = megohms
ma = milliamperes
μ = micro = 10^{-6}
mfr = manufacturer
mtg = mounting
my = mylar
NC = normally closed
Ne = neon
NO = normally open
nsr = not separately replaceable
K = kilo = 1000
obd = order by description
p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
ppm = parts per million
pos = position (s)
poly = polystyrene
pot = potentiometer
prv = peak reverse voltage
rect = rectifier
rot = rotary
rms = root-mean-square
s-b = slow-blow
sect = section (s)
Si = silicon
sil = silver
sl = slide
td = time delay
TiO_2 = titanium dioxide
tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube
var = variable
w/ = with
W = watts
ww = wirewound
w/o = without
cmo = cabinet mount only

MANUFACTURERS

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

MODEL 890A

REVISION:

Note the following changes in the Specifications, Page 2.

Load Regulation: Change 20 mv or 0.007% to 10 mv or 0.007%.
Line Regulation: Change 20 mv or 0.007% to 10 mv or 0.007%.
Ripple and Noise: Change 2.0 to 1.0.

Note the following changes in the Parts List, Page 18 and Schematic, Figure 9.

Change: R41 470K 1 watt AB to 470K <u>1/2 watt</u> AB.

Change: C28 and C29 0.1µf 400 volt 191P to 0.1µf 400 volt 160P.

Change: C26 and C27 1050µf 400 volt D38713 to 1000µf 400 volt 36D102F400CE6B.

MANUAL CHANGES

DC POWER SUPPLY
Model 890A
Manual Serial Number Prefix 4G

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

SERIAL		MAKE CHANGES
Prefix	Number	
ALL	0931 - 1110	Errata
4G		1
4G	1111 - up	1,2

SERIAL		MAKE CHANGES
Prefix	Number	

ERRATA: Change the following Specifications on Page 2:

Load Regulation: Change 20 mV or 0.007% to 10 mV or 0.007%.
Line Regulation: Change 20 mV or 0.007% to 10 mV or 0.007%.
Ripple and Noise: Change 2 mV rms to 1 mV rms.

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

C26,C27: Should be 1000μf, 400V, 36D102F400CE6B.
C28,C29: Should be 0.1μf, 400V, 191P.
R41: Should be 470K, 1/2 W, AB.

CHANGE 2: In the replaceable parts table make the following corrections:

C25: Change to 10,000μf, 75V, D39062.
D10: Add hp part No. 1901-0389.
D17,24,25,26: Change part No. to MR1032B.
D19: Change part No. to MR1034B.
D47-50: Add hp part No. 1901-0388.

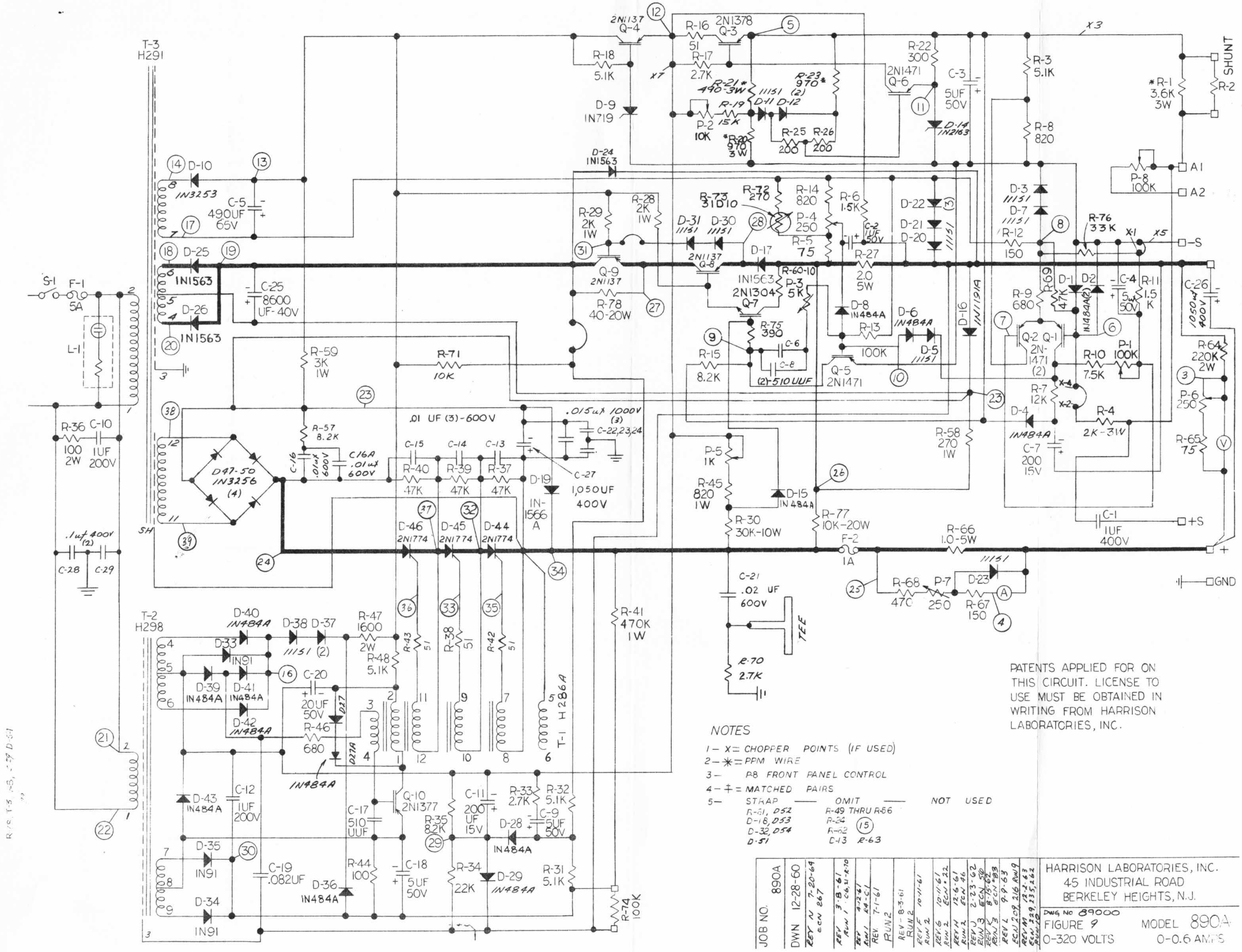
PARTS LIST 890A

Circuit Symbol	Description	*Spares
T3	Transformer H291A Cycle	1
T2	" H298 Cycle	1
T1	" H286A Cycle	1
P8	Potentiometer 100K Helipot Series A	1
P2	" 10K CTS Series 70	1
P1	" 100K CTS Series 70	1
P3	" 5K CTS Type 110	1
P4,6,7	" 250 CTS Type 110	3
P5	" 1K CTS Type 110	1
C26,27	Capacitor 1050µf 400V Sp.	2
C25	" 8600µf 40V Sp.	1
C5	" 490µf 65V Sp.	1
C7,11	" 200µf 15V Sp.	2
C20	" 20µf 50V Sp.	1
C3,4,9,18	" 5µf 50V Sp.	4
C1	" 1.0µf 400V Sp.	1
C10,12	" 1.0µf 200V Sp.	2
C19	" .082µf 100V Sp.	1
C21	" .02µf 600V Erie #Ed.-.02	1
C22,23,24	" .015µf 1000V Sp#366263A	3
C6,8,17	" 510µµf Mica	3
C2	" 1µf 50V Sp.	1
C13,14,15,16,16A	" .01 µf 600V Erie Ed.-.01	5
C28,29	" .1µf 400V Sp.	2
D44,45,46	SCR 2N1774 G.E.	3
D47,48,49,50	Rectifier 1N3256	4
D3,5,7,11,12,20,21,22, 23,30,31,37,38	Diode 111S1	13
D1,2,4,6,8,15,27,27A, 28,29,36,39,40,41,42,43	Diode 1N484A	16
D10	" 1N3253	1
D33,34,35	" 1N91	3
D14	" 1N2163	1
D9	" 1N719	1
D17,24,25,26	" 1N1563 Mo.	4
D19	" 1N1566A Mo.	1
D16	" 1N1191A D.	1
D51,52,53,54	Strap	
Q1,2,5,6	Transistor 2N1471	4
Q3	" 2N1378	1
Q7	" N272 (2N1304)	1
Q10	" 2N1377	1
Q4,8,9	" B1217 (2N1137)	3

Circuit Symbol	Description		*Spares
R1	Resistor	3.6K 3W Sp.	1
R2	"	Shunt 1/2watt AB	1
R3,18,31,32,48	"	5.1K 1/2watt AB	5
R4	"	2K 3watt Sp.	1
R5,65	"	75 1/2watt AB	2
R6,11	"	1.5K 1/2watt AB	2
R7	"	12K 1/2watt AB	1
R8,14	"	820 1/2watt AB	2
R9,46	"	680 1/2watt AB	2
R10	"	7.5K 1/2watt AB	1
R12,67	"	150 1/2watt AB	2
R13,74	"	100K 1/2watt AB	2
R15,35,57	"	8.2K 1/2watt AB	3
R16,38,42,43	"	51 1/2watt AB	4
R17,33,70	"	2.7K 1/2watt AB	3
R19	"	15K 1/2watt Sp.	1
R20,23	"	970 3watt Sp.	2
R21	"	490 3watt Sp.	1
R22	"	300 1/2watt AB	1
R25,26	"	200 1/2watt AB	2
R27	"	2 5watt W.L. HH	1
R28,29	"	2K 1watt AB	2
R30	"	30K 10watt WL. HH	1
R34	"	22K 1/2watt AB	1
R36	"	100 2watt AB	1
R37,39,40,69	"	47K 1/2watt AB	4
R41	"	470K 1watt AB	1
R44	"	100 1/2watt AB	1
R45	"	820 1watt AB	1
R47	"	1.6K 2watt AB	1
R58	"	270 1watt AB	1
R59	"	3K 1watt AB	1
R60	"	10 1/2watt AB	1
R64	"	220K 2watt AB	1
R66	"	1.0 5watt WL. HH	1
R68	"	470 1/2watt AB	1
R71	"	10K 1/2watt AB	1
R72	"	270 1/2watt AB	1
R73	Thermistor	3iD10	1
R75	Resistor	390 1/2watt AB	1
R76	"	33K 1/2watt AB	1
R77	"	10K 20watt WL. HH	1
R78	"	40 20watt WL. HH	1
F1	Fuse	5A Littelfuse Type 314 3AB	1
F2	"	1A Buss A6C-1 3AG	2
S1	Switch on/off	#11TS1131-2 Micro	1

*Spare parts recommended for 10 units for one year.

Note: All AB resistors are ±5%.



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

NOTES

1 – X = CHOPPER POINTS (IF USED)
2 – ✱ = PPM WIRE
3 – P8 FRONT PANEL CONTROL
4 – ǂ = MATCHED PAIRS
5 – STRAP — OMIT — NOT USED
R-41, D52 | R-49 THRU R-56
D-16, D53 | R-24
D-32, D54 | R-62 (15)
D-51 | C-13 R-63

| JOB NO. 890A | DWN 12-28-60 | REV N 7-20-64 ECN 267 | REV 3-8-61 RUN 1 C.6,11-R-10 | REV 4-12-61 RUN 1 | REV. 7-1-61 RUN 2 | REV - 8-3-61 RUN 2 | REV F 10-11-61 RUN 2 | REV G 10-11-61 ECN 22 | REV H 12-6-61 RUN 2 ECN 46 | REV J 2-23-62 RUN 3 ECN 50 | REV K 8-15-62 RUN 3 ECN 83 | REV L 9-9-63 | ECN 209, 216 RUN 9 | REV M 12-2-63 ECN 229, 235, 262 RUN 10 |

HARRISON LABORATORIES, INC.
45 INDUSTRIAL ROAD
BERKELEY HEIGHTS, N.J.

DWG NO 89000
FIGURE 9
0-320 VOLTS

MODEL 890A
0-0.6 AMPS

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