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Amateur Radio
4CX400A

TECHNICAL BULLETIN

4CX400A Russian Tubes for the MLA-2500 Amplifier By: B.-N. "Bob" Alper, W6KT

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Modification allows for economical tube substitution

There are many Dentron MLA-2500s out in the world. Someone may know exactly, but my information is that close to probably 6000 were manufactured. I've performed an MLA-2500 conversion that allows it to run a pair of 4CX400A ceramic tetrodes and will describe the process here.

The MLA-2500 is only five inches high, fourteen inches wide, and fourteen inches deep making it one of the most compact kilowatt amplifiers. The small size allows it to be placed on almost any desk or operating position. The major problem for MLA-2500 owners is that there is no economical source for the 8875 tubes used as the active amplifiers. For under \$350 including sockets and tubes, the amplifier can be converted to run two Svetlana Electron Devices, Inc. 4CX400A tetrodes. (The price of a Svetlana 4CX400A is \$140.)

The advantages in operating tetrodes are enumerated elsewhere, but typically they are easier to drive than triodes, can withstand more abuse (e.g., high reflected power, etc.), provide better linearity, and are easier to adjust for good performance.

The Svetlana 4CX400A tetrodes also have gold-plated grids and beam-forming mechanisms for secondary emission reduction and a dual focusing chambered anode feature (U.S. patented) that improves efficiency and linearity over conventional triodes and tetrodes. Table 1 compares the published original Eimac 8875 data and the published Svetlana 4CX400A data.

Because one of the great advantages of the MLA-2500 is its compact size, one of my goals was to make the conversion with no external chassis or other protrusions from the original cabinet. A review of the 8875 technical data and the MLA-2500 schematic prompted the selection of a pair of the Svetlana 4CX400As because the two Svetlana tubes mount side-by-side in the same mounting holes as the original 8875s. The 4CX400As also operate from the original heater supply. These factors helped me meet my goal of having all components inside the original case.

Table 1. A comparison of the published original Eimac 8875 data and the published Svetlana 4CX400 data sheet.

From Technical Data Sheet		
-	4CX400 *	8875 **
Useful Output RF Power (W)	605	505
Efficiency	60.5	46%
Plate Voltage (V)	2500	2200
Single Tone Plate Current (mA)	400	500
Zero Signal Plate Current (mA)	150***	22
Two-Tone Plate Current (mA)	Ñ	300
Plate Dissipation, Rated (W)	400	300
Screen Voltage (V) Max	400	N/A
Screen Current (mA) Max	20	N/A
Heater Voltage (V)	6.3	6.3
Heater Current (A)	3.2	3.0
DC Grid Voltage (V) Approx.	35	8
Cooling Air at Max Plate Dissipation	400W/8 CFM	300W/6 CFM
*= Grid Driven **= Cathode Driven ***= With 6 to 7-ohm cathode resistor installed.		

Overview of tasks

In performing the conversion, five specific needs must be addressed. These are:

- Modification of the final amplifier tube area.
- Adding a screen power supply.
- Meter switching board change.
- Adding a bias power supply.
- Installing the passive input grid circuit.

There are a number of possible solutions to each of these requirements. My desire to maintain the original MLA-2500 package as much as practical, rather than find the best technical solution, may have biased my judgement.

All modifications, with rare exceptions, were performed with light hand tools and available materials. In addition to the usual screwdriver and pliers, I used an electric hand drill, hand saw, two-inch pipe reamer (or hole saw), and tin snips (the saws could have been used instead of tin snips to

cut the fiberglass board), and a Dremel® tool. The latter was used to break three traces on the original meter switching board, PC-1003, ALC board, PC-1004.

Before starting the conversion, test the amplifier so you know its condition. Hopefully, all functions work even if the tubes are weak and provide only a small amount of additional output over your exciter. Inspect inside for broken wires, damaged or broken components, and so on. Make certain the plate power supply works and will stay on for long periods without arcing. Also, determine if the fan operates on high speed.* To check this, make sure the continuous button on the front panel is activated and relay control is closed to ground. Repairs to place the unit in normal operating condition should be made before your modification begins.

Specifics

Disconnect all power. Remove top and bottom covers. Carefully save and identify all components removed.

Final amplifier tube and cooling air plenum

Remove the tubes, sockets, input terminating resistors (these were not noninductive resistors on my amplifier), bypass capacitors, thermostat switch, the Zener diode and other diodes in the tube cathode circuits, etc. Leave relay RLY1, all cabling, and everything from the plate RF choke to the front panel in place. Clean the chassis and remaining components thoroughly. Seal all holes in the bottom of the tube compartment with duct tape to make a relatively airtight floor in the area in front of the fan forward to the plate choke.

Mount the new Svetlana SK2A sockets in the original tube socket holes using the original hardware. The keys on the center grid pins should face each other. Using G-19 fiberglass epoxy board or masonite (I used the latter), cut two pieces to the approximate dimensions of Figure 1. Leave an extra 1/8 inch in each dimension in order to file them to fit. I used a right-angle mending bracket at the corner between the two side panel pieces and made bottom brackets from soft aluminum strips about 1/2 inch wide. Make certain the height of the side panels plus the planned G-10 top cover are no higher than the top edge of the anode cooler and preferably 1/8 inch lower than the edge of the cooler of the 4CX400A. This is to assure air flow through the 4CX400A coolers. Mount the original fan thermostat on the longer side panel of the plenum. The position selected may be as shown in [Figure 1](#). (The thermostat may not exist on some models.)

Cut a piece of G-10 to fit the top of the air plenum just fabricated (as shown in Figure 1). Locate the centers of the tubes and cut two holes in the G-10 to fit the anode cooler of the 4CX400As. Also, cut out a portion of the G-10 in front of the fan to accommodate the MLA-2500 air deflector as shown.

Before sealing the G-10 to the side panels, plug the 4CX400As into the sockets. Attempt to remove them using only a hold on the plate cap and a limited rocking motion no larger than the holes in the G-10. If you can't remove the tubes this way, carefully loosen the tension caused by the SK2A socket. To do so, use an object that's slightly larger than the tube (e.g., finishing nail) to press into the tube pin contacts. Seal the edges of the G-10 top to the side panels using duct tape.

Turn the amplifier over and wire the final amplifier tube sockets in accordance with [Figure 2](#). You can use most of the original components removed from the old sockets.

Meter switching board (PC-1003)

Disconnect the white plastic plug on the top of the board and remove the four mounting screws holding it in place. Next, carefully disengage the pushbuttons from the front panel. Do not lose the

four mounting grommets.

Looking at the wiring side of the pc board (bottom view), break the pc traces at the three points shown in [Figure 3A](#). Add the three jumpers shown in [Figure 3B](#) to the bottom of the board. Remove the old grid shunt metering resistor R19, 510 ohms.

Screen power supply

Remove PC-1004 (the old ALC board) and carefully extract all the components except the fuse clips and the 100-k potentiometer at the top. Now, place the voltage tripler circuit shown in [Figure 4B](#) on the PC-1004 board. Figure 4A shows the cut of the large pc pad and the added jumper.

Detach the blue lead on PC-1002, which comes from the power transformer. Carefully work it out through the transformer lead feed hole on the bottom of the chassis. Now reroute this lead to PC-1004. Add a piece of blue wire to lengthen the transformer lead if necessary. Mount the shunt regulator transistor, NTE 2300, using a single screw and adequate silicon heat transfer compound (see [Figure 5](#)). Solder it to a newly mounted tie point as shown in the figure. Place the shunt regulator components of Figure 4A on the tie point, connecting the transistor to the circuit.

Bias power supply

A small low-voltage transformer is used as the bias power transformer. I chose an 18-volt transformer because I had one; a 12-volt or possibly a 24-volt transformer will be adequate. The bias regulating circuit consisting of the 56-volt, 1/2-watt Zener diode and 10-k, 1/2-watt resistor is based on the use of the 18-volt transformer. Because the MLA-2500 is so tightly packed, I had trouble finding a place for the transformer. I mounted it between the forward foot of PC-1002 and a screw on PC-1003 the meter switching board. You may find it easier to mount this transformer on the rear apron of the MLA-2500.

Locate diode D16 and capacitor C28 on PC-1002. These are near the edge of the board closest to the front panel. Unsolder and reverse the polarity of D16 and C28 (to provide the negative bias voltage). Wire one side of the 110-volt winding of the low-voltage transformer to PC-1002 terminal B3. Connect the other side of the 110-volt winding and one side of the 12-volt winding to ground. Connect the other side of the 12-volt winding to PC-1002, terminal B2.

Grid input circuit

Mount the 50-ohm, 50-watt noninductive resistor (Caddock model MP850 in TO-220 package) near the antenna changeover relay (RLY1) on the wall of the tube compartment as in [Figure 6](#). Remove all original RF input terminating resistors mounted on the chassis wall near RLY1 and connect one end of the 50-ohm noninductive resistor to the center lead of the coax and the other connection to ground.

Miscellaneous

Disconnect R8 (47-k, cathode "standby" bias) resistor and ground the red lead that was connected to this resistor. Find the B+HV lead on the underside of the chassis and remove R2 (approximately 1 ohm). (May not exist on later models.) Connect a 50-ohm, 50-watt resistor in place of R2 (in series with the B+HV) to protect the tube in the event of an internal arc. Mount the DPDT grid current select switch (selects control grid or screen grid) at a convenient location on the front panel. See [Figure 5](#) for my under the chassis location. Connect the switch as shown in [Figure 3B](#).

This wiring provides a selection of control grid current (0 to 1 mA) or screen grid current (0 to 100 mA) to be read on M2 when the grid pushbutton is depressed.

Energizing the modified amplifier

Resistance checks (primary power disconnected).

Place all pushbutton meter switches in the "out" or fully forward position. Remove all tubes, and RLY2 and RLY3, from their plug-in sockets on PC-1002. Using an ohmmeter, check all new wiring; check plate and screen power supplies for shorts. Strap the MLA-2500 primary power strapping for 120 or 240 volts AC operation, as preferred. Depress the plate voltage pushbutton.

Applying AC primary power.

Initial operation should be performed with tubes and RLY2 and RLY3 removed.

Check again to make certain the plate caps are clear of all components. Insert a device in the primary line to limit primary power (a variable voltage transformer set at one-half line voltage or a 150 watt lamp as a series resistor). Turn the amplifier AC power switch on, pressing SW1 (top cover interlock) as control. Danger! High voltage is now present in the amplifier! If all is okay, the plate voltage should rise to between 1000 and 2000 volts and the screen voltage (measured at the top of the fuse clip PC-1004 with a VOM) should increase to between 200 and 300 volts. There should be no smoke, sparks, etc. in evidence.

Note how long the plate and screen meters take to fall to zero after releasing SW1. There is no bleeder resistor on the plate power supply or the screen supply. Therefore, before working on the MLA-2500, always discharge all power supplies to ground using an insulating probe.

Remove the primary power limiting device and reconnect the power plug and again apply power to the amplifier. The plate voltage should be approximately 2200 volts (no load). Screen power supply voltage should be approximately 500 volts (no load).

Turn off and short power supplies DC to ground. During this procedure, make sure to discharge each power supply each time the primary power is removed.

Adjust the 2500-ohm, 25-watt resistor for about 2300 ohms and insert a 0 to 50 mA meter in series with the 100-ohm resistor in the emitter circuit of Q1. The variable 2500-ohm, 25-watt resistor must be set to protect the screens of the 4CX400As. Turn the AC on and read the current drawn by QA and shown on the 0 to 50 mA meter. Turn the AC off and set the Q1 current at 35 mA, limiting screen power to a maximum of 16 watts (8 watts per tube). The voltage on the collector side of the 2500-ohm, 25-watt resistor should measure about 382 volts.

Measure the grid bias voltage at the center grid pin on each tube socket. Turn the 100-k potentiometer at the top of PC-1002 to maximum. This voltage should be 50 volts or more, depending on the bias voltage transformer selected.

Turn off the amplifier and insert the two 4CX400A tubes, time delay relay RLY3, and control relay RLY2. Depress the panel "plate voltage" meter switch to B+. Depress the "continuous" switch so the fan (on most models) runs at full speed when the amplifier is in transmit mode. Connect a dummy load and an RF power meter (if available) to the RF output connector (on the rear panel). Turn the amplifier AC power switch off and mechanically close the top cover interlock using a plastic tie-wrap or other convenient means. Place the MLA-2500 bandswitch in the 28-MHz position.

Apply primary power and observe plate voltage and screen voltage. This should be at/near those previously recorded.

At the base of each tube, carefully remeasure and record:

Heater voltage (should be a nominal 6.3 volts AC \pm 0.3 volts).

Plate voltage, screen voltage, and grid voltage (should equal the previously recorded voltage).
Danger! High voltage!

Observe the green "ready" light. For the initial energizing of the tube, it's a good idea to allow additional warm-up time. Ten minutes should be adequate for this class of power tube. After this initial warmup, the RLY3 filament heating delay time of 75 seconds will be conservative (A 30-second warmup is specified for the 4CX400A.)

Depress the plate current switch; there should be no reading.

Close the external relay control line (phono connector on rear) to ground. The red "transmit" light should energize. The fan speed should increase to fast. There should be no plate current indicated.

At the tube socket, measure the screen voltage at each tube. This DC voltage should be as recorded previously. It shouldn't be more than 400 volts DC. Remove the meter test probe.

While observing the plate current, adjust the 100-k potentiometer with an insulated tool (should rotate counterclockwise) to 300 mA. Grid voltage at the 4CX400A grid should now measure 30 to - 35 volts DC.

With the "load" control set at "1" (minimum loading), slowly rotate the "tune" control completely through 360 degrees while observing the RF output meter and plate current meter. No RF output or plate current variation should be observed. Connect your exciter to the RF input connector and set the MLA-2500 bandswitch and exciter bandswitch for 28 MHz, and CW or RTTY operation. Turn both the exciter RF output control and the mic gain to zero. It may be necessary to construct a resistive pad to be placed between the exciter and the MLA-2500. (Refer to any of the popular Radio Handbooks.) Many exciters have a variable RF output control but the output, even in the minimum position, may be 5 to 10 watts.

Energize the amplifier with a few watts of exciter RF output, and quickly adjust the "tune" for maximum RF output from the MLA-2500. Note: Maximum transmit time during initial adjustment steps in this portion should be limited to 10 seconds of keydown operation.

Alternately adjust the "load" and "tune" control for maximum RF output as indicated on the panel meter. Next, increase the exciter output until you observe an increase in the MLA-2500 plate current to at least 400 mA. Once again, adjust the "tune" and "load" controls for maximum RF output.

Check the screen current (grid pushbutton depressed and DPDT panel switch in screen grid position). Observe the screen current; it should never exceed 40 mA. Slowly increase the RF drive and again alternately optimize the "tune" and "load" controls for maximum RF output. Slowly increase RF drive until RF output won't increase further. The grid current on my MLA-2500 ran from 0 to 0.25 mA.

Increase loading under loaded conditions until not more than 800 mA of plate current is indicated. Again, make certain the screen current is less than 40 mA.

If a calibrated external RF wattmeter is available, adjust "wattmeter calibrate" R11 on PC-1001 for the same reading as the external wattmeter using an insulated tool. The old MLA-2500 manual suggests 20 meters for this calibration. It may be necessary to adjust C14 of PC-1001 and compromise the error difference of the front panel meter readings and the external wattmeter between lower and higher frequency bands, as the MLA-2500 wattmeter circuit probably won't track the external wattmeter from band to band.

If operation is from a 120 volt AC primary power source, the plate voltage can be expected to sag to

1800 to 1900 volts and the screen voltage to 370 to 380 volts.

Table 2 summarizes modified (4CX400A) MLA-2500 operation into a dummy load for all amateur HF bands. I recommend that you make a PA tune and load chart for each band. A helpful addition to Table 2 is the approximate RF output level control setting or exciter driving power. While the 4CX400As are very rugged and will accept much abuse (I know this from personal experience gained while developing this modification), longevity will be increased if tune up is accomplished rapidly. A complete, revised schematic of the modified MLA-2500 is shown in [Figure 7](#).

Table 2. RCX400A/MLA-2500 Performance

CONDITIONS:

Primary Power 117 VAC**
 Exciter = ICOM 765
 RF Load = 50 ohm antenna
 RF Power Meter = Bird 43 1 kW Element

Operating Frequency MHz	28.5	24.9	21.3	18.15*	14.2	10.1	7.2	3.8	1.9
Power Output Watts	750	750	760	750	800	830	840	760	710
Bandswitch	28	21	21	21	14	7	7	3.5	1.8
Drive Power Watts	10	11	11	11	14	15	15	15	15
Efficiency	54	56	57	55	60	65	62	56	53
Plate Voltage**	1820	1820	1820	1820	1820	1850	1820	1875	1875
Plate Current Amps (Single Tone)	0.77	0.73	0.73	0.75	0.73	0.69	0.74	0.72	0.71
Screen Current Amps	0.025	0.028	0.03	0.026	0.023	0.027	0.022	0.022	0.024
Grid Current mA	0.0	0.0	0.0	0.0	0.1	0.15	0.1	0.25	0.1
* My plate choke (which had been damaged) resonated at 18.18 MHz and required adding inductance to move resonance to approximately 16 MHz.									
** No Load Plate Voltage = 2250									

SSB adjustments

Although the adjustment method described here provided adequate results, the best way to set up an exciter-power amplifier combination is to use the techniques described in The ARRL Handbook. Grid bias may be adjusted for minimum distortion while not exceeding the zero-signal plane current that results in not more than 800 watts plate dissipation.

Operational notes and summary

On the air testing was performed with local stations and other stations at 1200 to 1500 miles under strong signal (9+20 dB) conditions. Signal bandwidth reported was 3 to 3.3 kHz under the adjustments described.

Anomalies and unusual observations

1. Depending on the test configuration it's possible to observe a high VSWR on the exciter VSWR

meter. This didn't shut down my IC-765 exciter/transceiver which was operating at relatively low RF outputs (under 50 watts) forward power.

2. The linear amplifier conversion is very stable. No instabilities were observed for any of the tuning settings. The RF drive power required at 10 meters is less than that required at 40 meters. This indicates a regenerative effect (or possibly a reduction in degeneration), but amplifier instabilities were not observed.

Acknowledgements

George Badger, W6TC, provided the principal encouragement for this article and also offered many good ideas and suggestions. Others influencing the article include: Bill Orr, W6SAI, George Daughters, AB6YL, David King, KK6WQ, and Don Priebe, K4QKR. L

- [Figure 1](#)
- [Figure 2](#)
- [Figure 3A](#)
- [Figure 3B](#)
- [Figure 4A](#)
- [Figure 4B](#)
- [Figure 4C](#)
- [Figure 5](#)
- [Figure 6](#)
- [Figure 7](#) □

Parts List - 4CX400A Conversion for MLA-2500

The following are the only parts needed for the 4CX400/MLA2500 □

Resistors	Capacitors	Diodes & Transistors	Miscellaneous
2 - 100 ohm non-inductive 50 watt; Caddock MP850, Caddock Electronics, Inc.,1717 Chicago Ave.,Riverside, CA 92507- 2364 1 - 400 ohm 1/2 watt 1 - 10,000 ohm 1/2 watt 6 - 75 ohm 2 watt 1 - 5000 ohm 25 watt 1 - 100 ohm 1/2 watt 1 - 6,200 ohm 1/2 watt 3 - 10 ohm 1/2 watt 1 - 47,000 ohm 1/2 watt 4 - 200,000 ohm 1/2 watt 1 - 2500 ohm adjustable, 25 watt 1 - 50 ohm 50 watt wire wound	6 - .01 MFD 1000 VDC 2 - 210 MFD 250 VDC 3 - 47 MFD 250 VDC	1 - IN4762 82 VDC 1W Zener Diode 3 - IN4764 100 VDC 1W Zener Diode 3 - IN4001 1000 VDC 1A 1 - IN4758 56 VDC 1/2W 1 - NTE 2300 (Po = 125 W; Ic = 8A; BVcbo = 1500 VDC; BVceo = 700 VDC; BVebo = 6VDC	1 - 12 VAC - 120 VSC transformer 1 - Tube of heat conducting silicon grease 1 - Ferrite bead (existing) 1 - Fuse 0.1A 2 - Svetlana SK2A tube sockets 1 - DPDT bat handle switch 2 - 4CX400A Electron Tubes

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[Back to Technical Bulletins Listing](#)

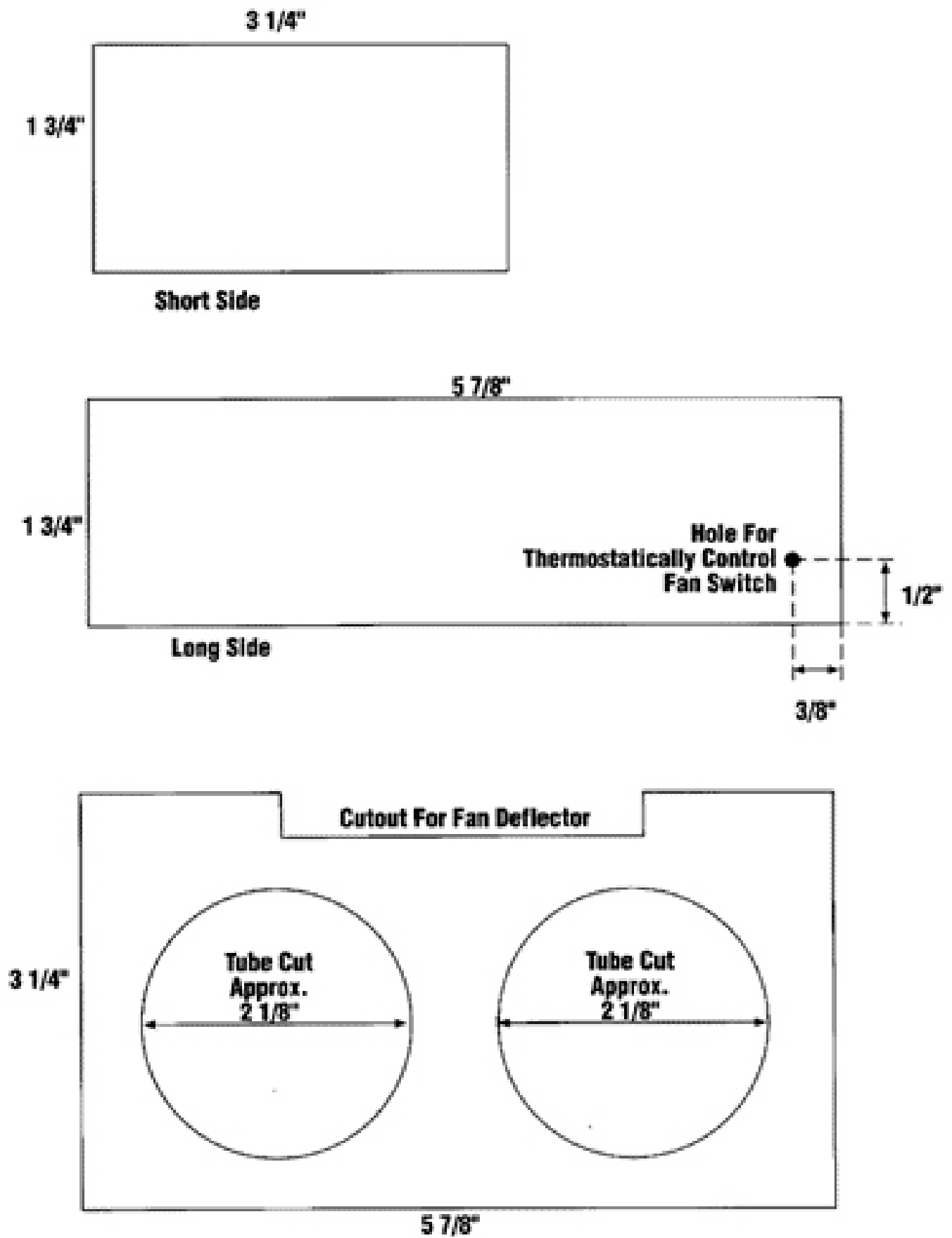


Fig 1. Air plenum parts fabrication

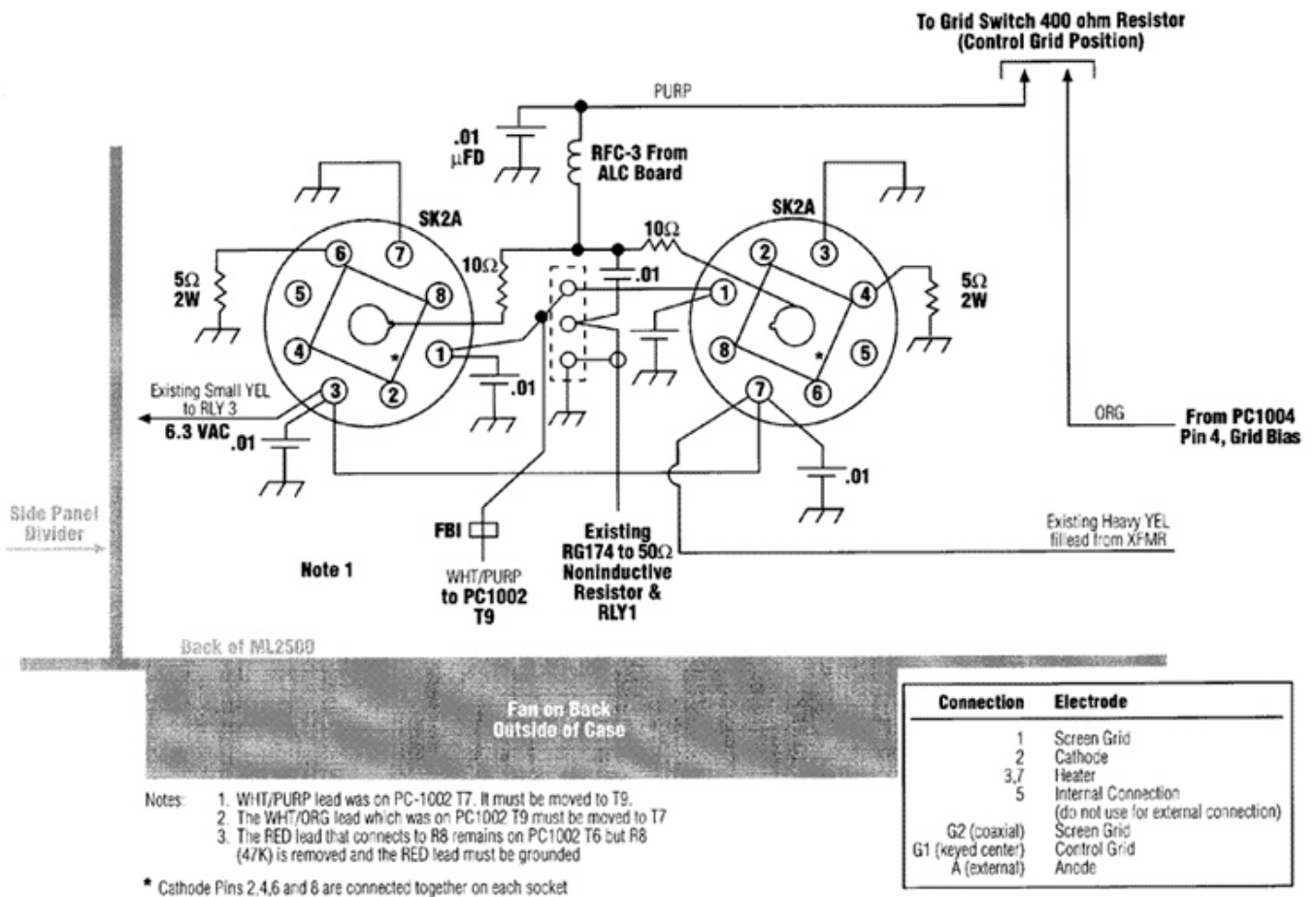
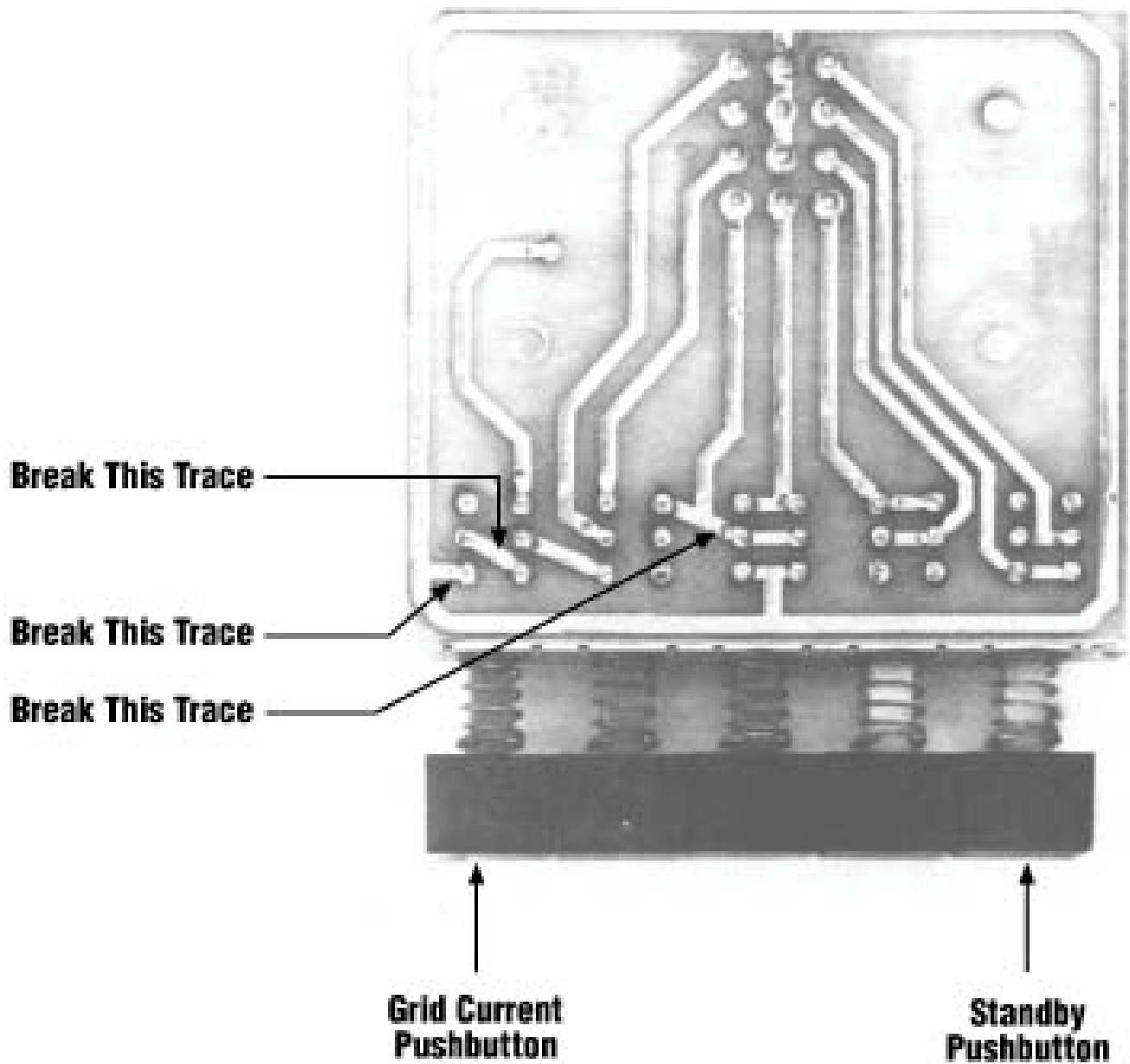


Fig 2. A bottom view of the RCX400A Socket Wiring.

Figure 3A
Unmodified PC-1003
Bottom View of Meter Switching Board



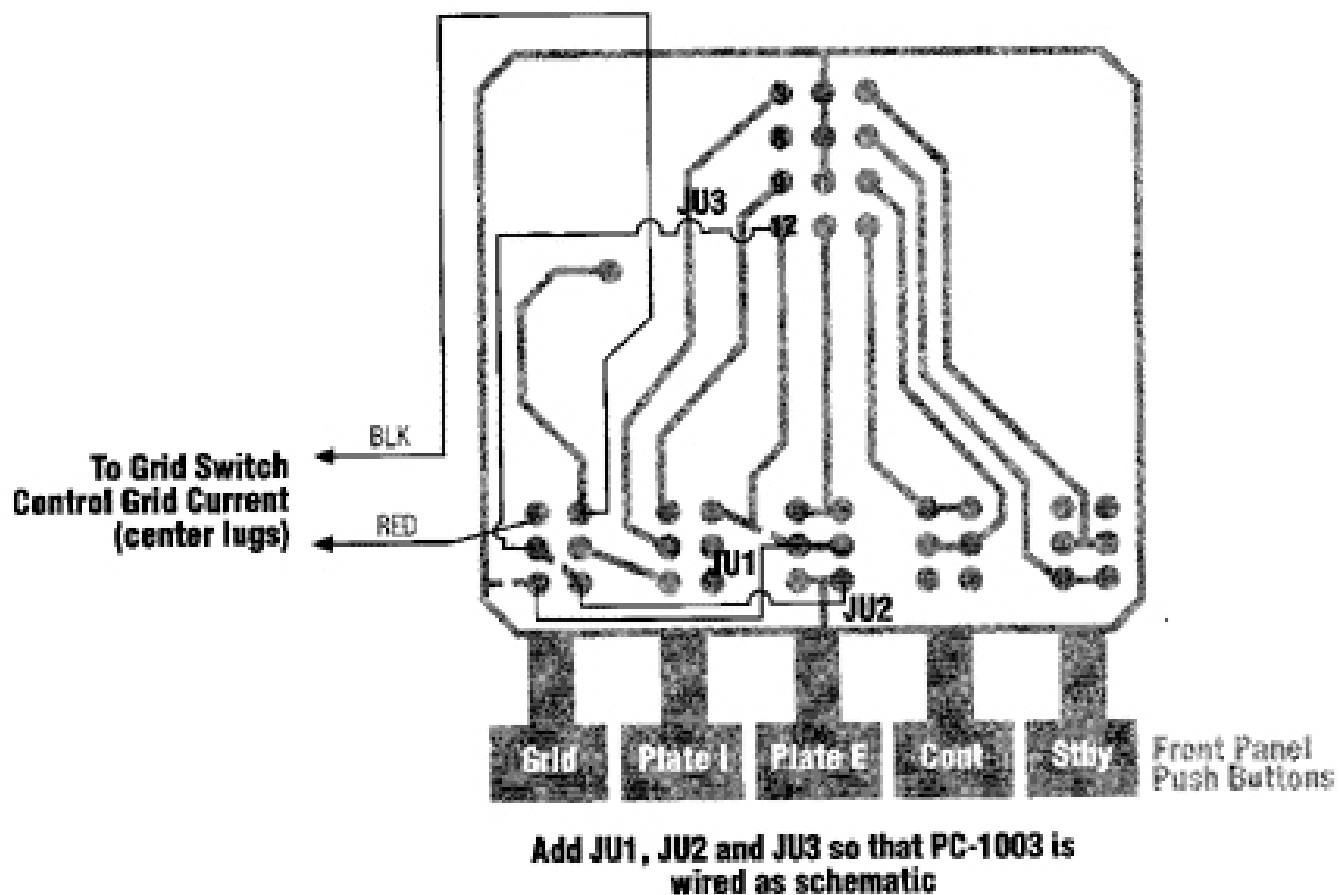
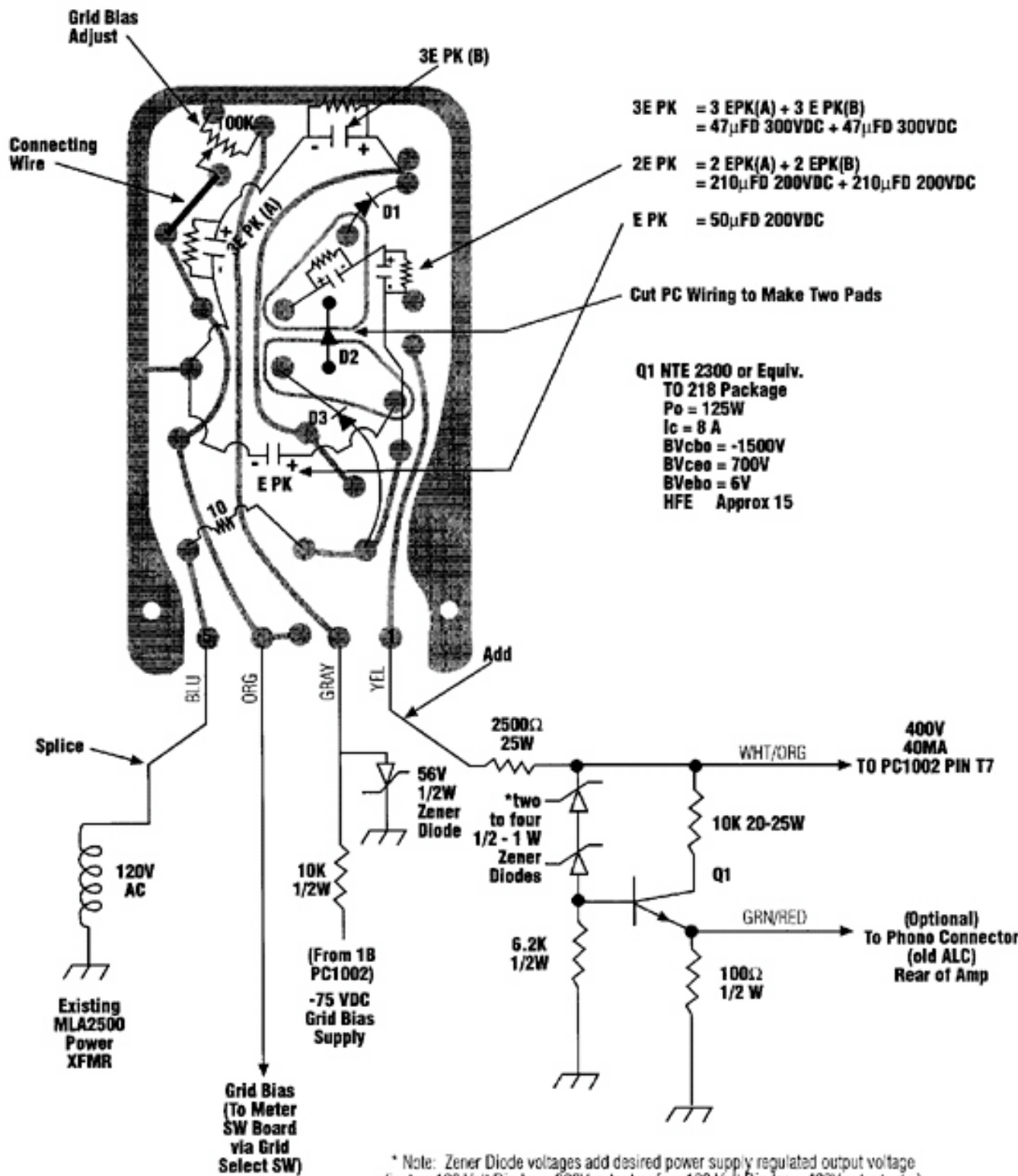


Fig 3B. Modified PC1003 meter switch board



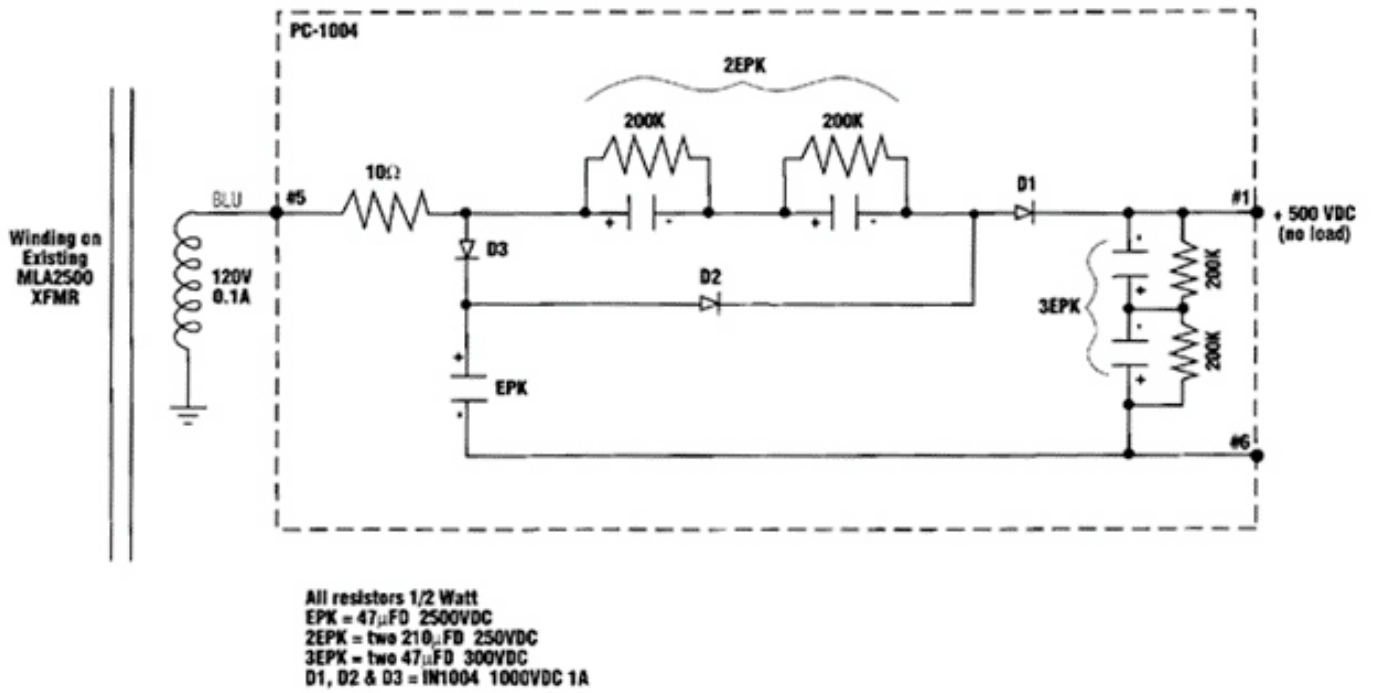


Figure 4B. Screen power supply tripler circuit

Figure 4C
PC-1004

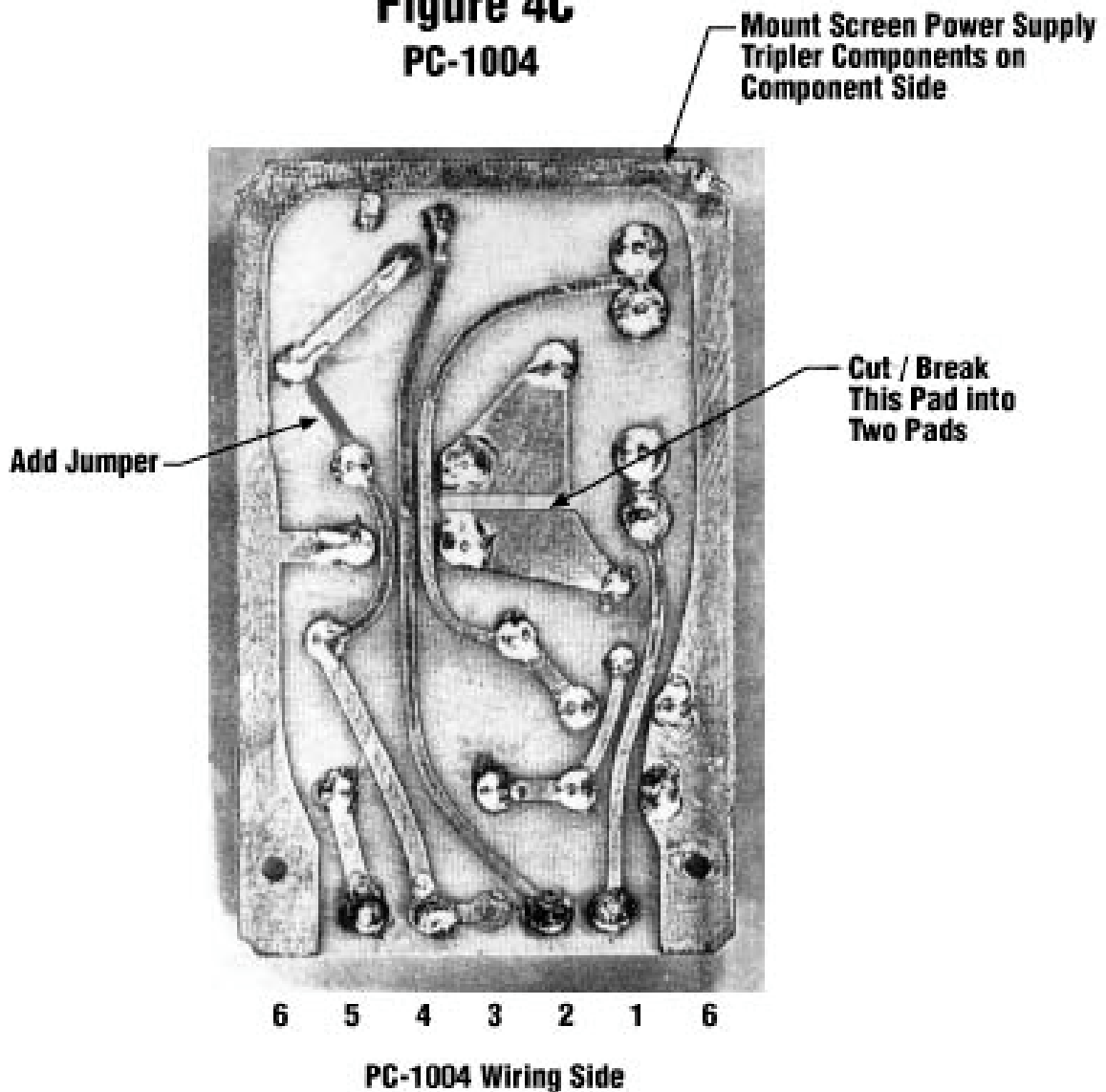
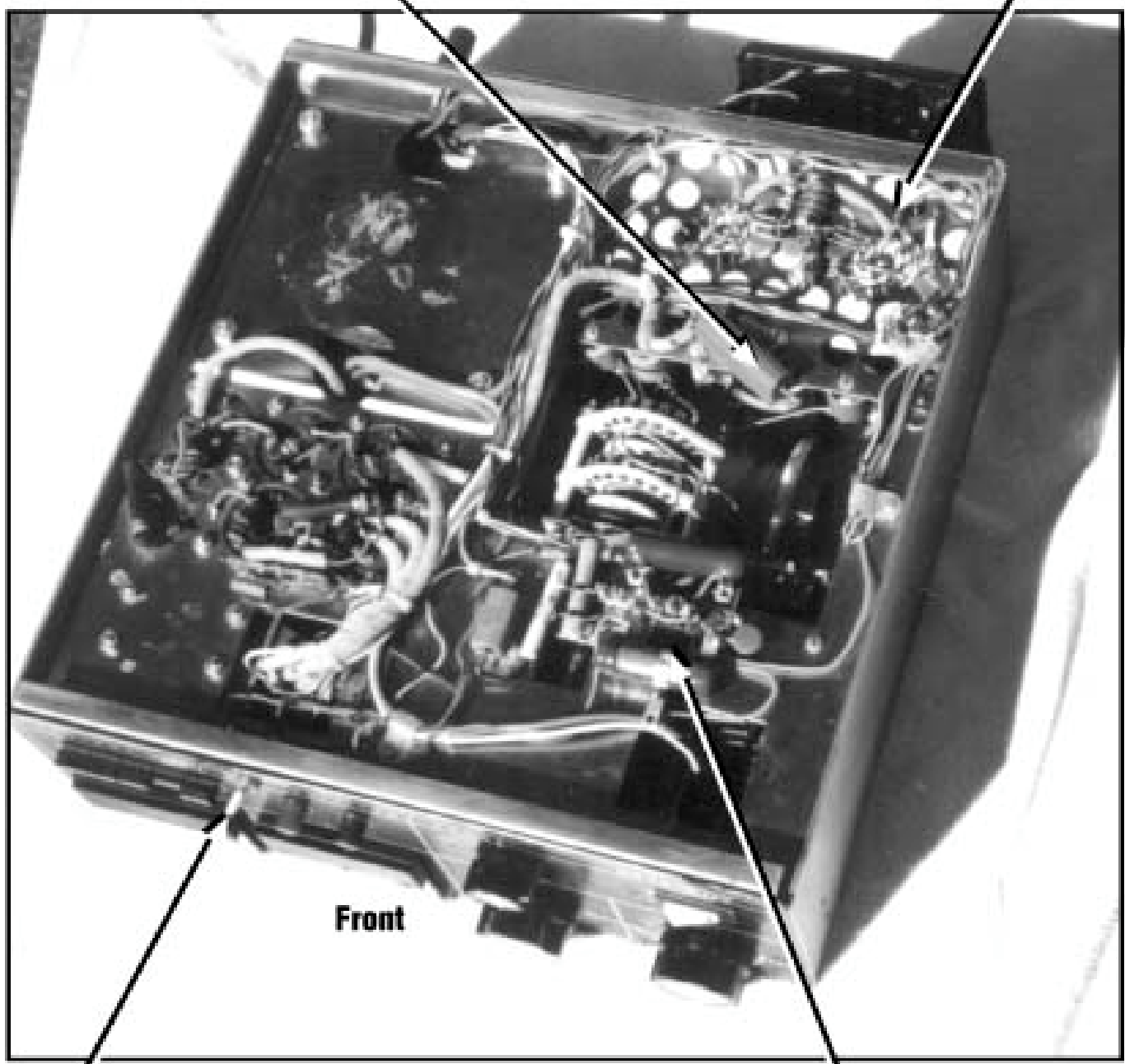


Figure 5
Modified MLA2500
Bottom View

**B+ 50Ω 50W
Current Limiting
Resistor**

SK2A Socket



Front

**DPDT
Grid Switch
(Front Panel Mounting)**

**Q1
Shunt Regulator**

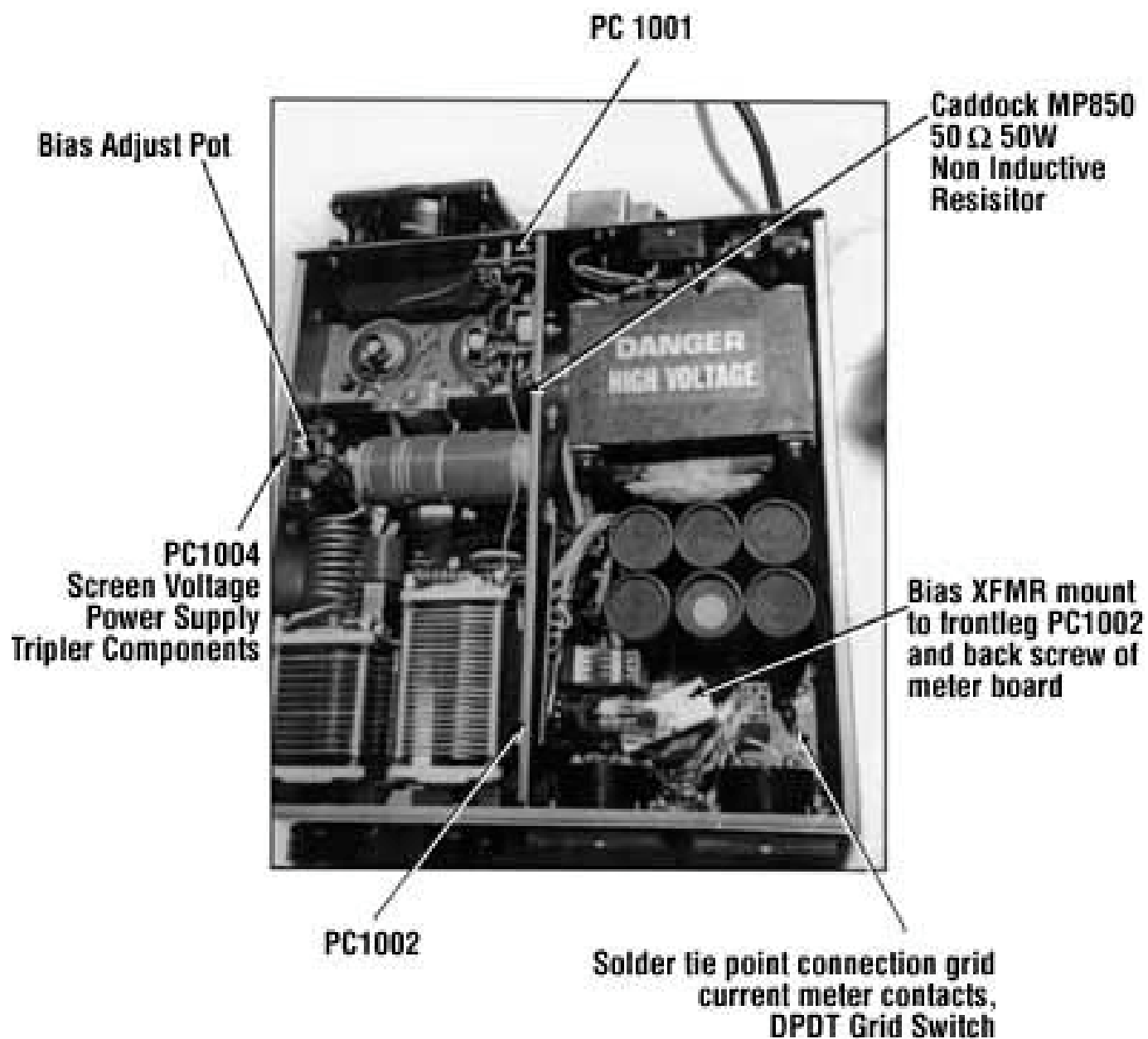


Figure 6. Top view of modified MLA-2500