

# OPERATING & TECHNICAL MANUAL

## ALPHA 86 HF LINEAR POWER AMPLIFIER



**EHRHORN TECHNOLOGICAL OPERATIONS, INC.**  
4975 NORTH 30TH STREET  
COLORADO SPRINGS, CO 80919

COPYRIGHT 1990 BY E.T.O., INC.

# OPERATING & TECHNICAL MANUAL

## ALPHA 86 HF LINEAR POWER AMPLIFIER

### NOTE

The schematic diagrams and text in this manual describe the latest production version of the *ALPHA 86* amplifier, including early units which have been factory-modified.

Minor design changes (which do not affect overall circuit design, specifications, capabilities, or operating procedures) typically are made on a continuing basis over the life of the product. Thus most *ALPHA 86*'s will vary to some degree from details shown herein.

**We strongly recommend that you retain for reference and comparison the schematic diagrams originally provided for your *ALPHA 86*.**

Please contact ETO *ALPHA* products customer service if you need further information.

# CONTENTS

|                  |                                      |    |
|------------------|--------------------------------------|----|
| <b>GENERAL</b>   | Service Assistance                   | 1  |
|                  | Initial Inspection                   | 1  |
|                  | 10 and 12 Meter Operation            | 1  |
| <b>SECTION 1</b> | Introduction                         | 2  |
|                  | General Description                  | 2  |
|                  | Specifications                       | 2  |
| <b>SECTION 2</b> | Preparation for Operation            | 3  |
|                  | Transformer Installation             | 3  |
|                  | Shipping Hardware Removal            | 3  |
|                  | 120 Volt Modification                | 4  |
|                  | Transformer Installation - Pictorial | 5  |
| <b>SECTION 3</b> | Transceiver Connection               | 6  |
|                  | Transceiver Connection - Pictorial   | 7  |
| <b>SECTION 4</b> | Operation                            | 8  |
|                  | Control Functions                    | 8  |
|                  | Switches                             | 8  |
|                  | Metering                             | 8  |
|                  | Tune-Up Procedure                    | 8  |
|                  | High and Low Power Tune-Up           | 10 |
|                  | Reflected Power Protection           | 11 |
|                  | ALC                                  | 11 |
|                  | Initial Control Settings – Table 1   | 12 |
| <b>SECTION 5</b> | Operating Notes                      | 13 |
|                  | Panel Lamp Replacement               | 14 |
| <b>SECTION 6</b> | Troubleshooting Tips                 | 15 |
|                  | Receive Fuse Replacement             | 17 |
| <b>SECTION 7</b> | Theory of Operation                  | 18 |
| <b>SECTION 8</b> | Schematics                           | 23 |

## **GENERAL**

### **SERVICE ASSISTANCE**

To help you secure technical assistance without wasted long distance calls, ETO has established a special SERVICE telephone line which will be answered only when a qualified technician is available to help you immediately.

The special service number is (719) 599-3861 (599-ETO1). If your call is not answered, it means that no qualified technician is free to talk with you at the moment. Please wait a few minutes and try again. Our business hours are from 8:30AM to 4:30 PM Mountain Time Monday through Friday. If your call does not relate to service or other technical matters, our business office staff will be happy to help you at our main office telephone number, (719) 260-1191.

### **INITIAL INSPECTION OF YOUR ALPHA 86**

When you remove the top cover to install the power transformer (see p. 5) make sure the tubes are firmly seated in their sockets and the tube anode connectors (silver strap rings) are firmly attached to the tube plate caps. If the connectors are not attached the tubes may be irreparably damaged immediately upon application of RF drive to the amplifier.

The red silicone rubber chimneys installed on the 3CX800A7 tubes are absolutely essential parts of the cooling system. Make sure the chimneys are straight (vertical) and firmly installed. The bottom edge of each chimney must be flush against the tube deck, completely covering the airflow slots. Tube cooling air must exit through the tube anode fins; it must not be allowed to escape around them. Failure to ensure adequate and proper cooling airflow will result in severe tube damage not covered under warranty!

### **TEN METER OPERATION**

FCC rules permit appropriately licensed amateurs to modify their own amplifiers for operation on 12 and 10 meters. We strongly recommend that you contact ETO customer service before attempting any modification. If a photocopy of your amateur radio operator's license is sent with the warranty registration card, easy-to-follow instructions will be sent to you at no charge. We are not permitted to perform this modification for you at ETO.

## SECTION 1 – INTRODUCTION

### 1.1 General Description

The *ALPHA 86* is a self-contained, HF linear power amplifier capable of continuous operation at a power output of 1500 watts PEP, keyed CW, SSTV, RTTY, or AM, with no time limit (rated for continuous commercial service, "CCS"). Units delivered within the USA and its territories and possessions are manually tunable over the frequency range of 1.8 to 22 MHz. They may be user-modified to extend coverage to 29.7 MHz. Units delivered elsewhere cover 1.8 through 30 MHz. Performance is optimized for amateur bands.

The *ALPHA 86* is capable of high-speed, full break-in CW (QSK) when used with a suitably-designed transceiver. **Note:** the term "transceiver" includes suitable transmitter-receiver combinations, such as the Collins S-Line and Drake R4C-T4XC, etc. The *ALPHA 86* is fully compatible with CW, AMTOR, or PACKET modes.

### 1.2 Specifications

- 1.2.1 Frequency Coverage: 1.8 - 22 MHz (domestic units); 1.8 - 30 MHz (export units).
- 1.2.2 Power Output: 1500 watts all modes including continuous carrier, CCS.
- 1.2.3 Drive Power: 50 to 70 watts nominal for rated output.
- 1.2.4 Power Gain: approximately 15 dB, equivalent to a power increase of thirty times.
- 1.2.5 Input Impedance: 50 ohms nominal, unbalanced VSWR < 2:1; switched pi-networks for each band.
- 1.2.6 Output Impedance: 50 ohms unbalanced.
- 1.2.7 Maximum Load VSWR: 2:1 at full rated power output.
- 1.2.8 VSWR Trip: automatic for reflected power of  $\geq 200$  watts.
- 1.2.9 Intermodulation Distortion: 35 db below rated output.
- 1.2.10 Harmonic Output:  $\leq -55$  dBc amateur bands;  $\leq -50$  dBc elsewhere.
- 1.2.11 CW Break-in (QSK): PIN diode T/R switching, 4 millisecond maximum switching time.
- 1.2.12 Tube Complement: two Eimac 3CX800A7 ceramic-metal triodes.
- 1.2.13 Cooling: full cabinet ducted forced air using cushion-mounted centrifugal blower.
- 1.2.14 Automatic Level Control (ALC): negative-going (from zero) DC voltage derived as a function of grid current. May be used to limit exciter output to prevent amplifier overdrive.
- 1.2.15 Primary Power: 220-240 volts AC, 60Hz (50-60 Hz export and non-type accepted models), fused at 20 amperes. May be field-modified for 110-120 volt operation at reduced power (maximum fuse size 20 amperes).

- 1.2.16 Power Transformer: Tape-wound Hipersil<sup>®</sup> core, 3.5 kVA CCS.
- 1.2.17 Protective Devices: primary and step-start fuses, primary AC interlock, high voltage crowbar, plate overcurrent trip, T/R mis-sequence trip, and reflected power trip.
- 1.2.18 Status Indicators: operate, standby, wait (initial turn-on time delay), overdrive (excessive grid current), SWR (reflected power tripout), and T/R fault.
- 1.2.19 Metering: full-time LED bargraphs display forward and reflected power and grid current; selectable plate voltage, plate current, and tune function.
- 1.2.20 Size: 7.5" H x 17" W x 15" D (19 x 43 x 38 cm).
- 1.2.21 Weight: 66 lb. (30 Kg) net, 70 lb (32 Kg) shipping in two cartons.

Note: ETO reserves the right to change design and/or specifications without notice or obligation.

## SECTION 2 – PREPARATION FOR OPERATION

### 2.1 Transformer Installation

Remove the top cover. **CAUTION: Do not remove the two screws in the center of perforated areas of cover!** Install the power transformer in the amplifier chassis. Note orientation of transformer wires as shown in drawings 1 through 4, page 5. **USE CAUTION!** The power transformer will damage wires or components if allowed to rest on them. Lift the transformer just high enough to clear the right side chassis lip and then move it sideways into the chassis. The transformer base plate must clear all components and wiring and, in some units, the two RCA type jacks on the back chassis wall. It must slide underneath these two RCA jacks and not pinch the chassis wiring. Four tapped bolt holes are provided in the transformer base plate. Mounting hardware is supplied with the power transformer. This hardware is inserted into the base plate from underneath the chassis. Mate transformer wiring connectors per Figure 1, page 5.

### 2.2 Inspection - Tubes & Chimneys

While the top cover is removed, make sure the tubes are firmly seated in their sockets and the tube anode connectors (silver strap "rings") are tightly attached to the tube plate caps. If the connectors are not attached the tubes may be irreparably damaged immediately upon application of RF drive to the amplifier.

The red silicone rubber chimneys installed on the 3CX800A7 tubes are absolutely essential parts of the cooling system. Make sure the chimneys are straight (vertical) and firmly installed. The bottom edge of each chimney must be flush against the tube deck, completely covering the airflow slots. Tube cooling air must exit through the tube anode fins; it must not be allowed to escape around them. Failure to ensure adequate and proper cooling airflow will result in severe tube damage not covered under warranty.

### 2.3 Shipping Hardware Removal

The blower motor is secured to the back chassis wall for shipment. The shipping hardware should be removed for quietest blower operation. Follow the instructions printed on the label directly beneath the blower bearing cutout (round hole) on the back wall. The hardware should be reinstalled whenever the amplifier chassis is packed for shipment.

## **2.4 Primary Power – 120 Volt Modification**

The *ALPHA 86* is factory set up for operation from a 220-240 volt source. It is fused at 20 amperes. A dedicated branch circuit to the amplifier, using #10 AWG copper wire or equivalent (with a current capacity of at least 30 amps) is recommended for best results. To reconfigure the *ALPHA 86* for 110-120 volt operation, locate the six screw terminal block to the right of the center partition on the back chassis wall. As shipped from the factory lugs 2 and 3 (numbered from the left) are jumpered. Move the strap to jump lugs 1 and 2. Another strap (supplied with the spare fuse kit) is installed across lugs 3 and 4, and a third across lugs 5 and 6. Note that 120 volt operation from a typical 20 ampere household circuit (with no other loads connected to it) may limit amplifier power output to around 1000 watts.

## **2.5 Replacing Cover**

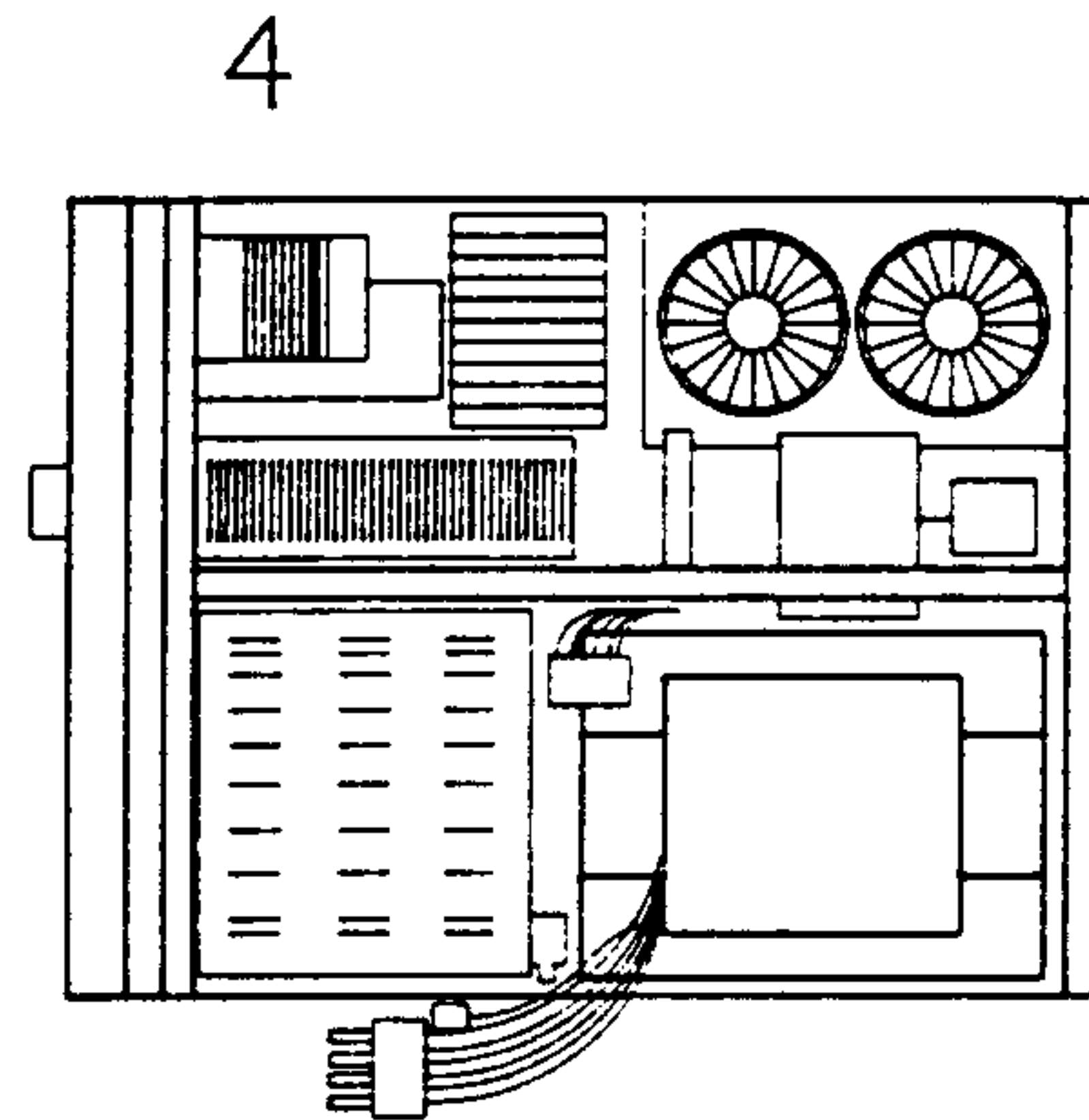
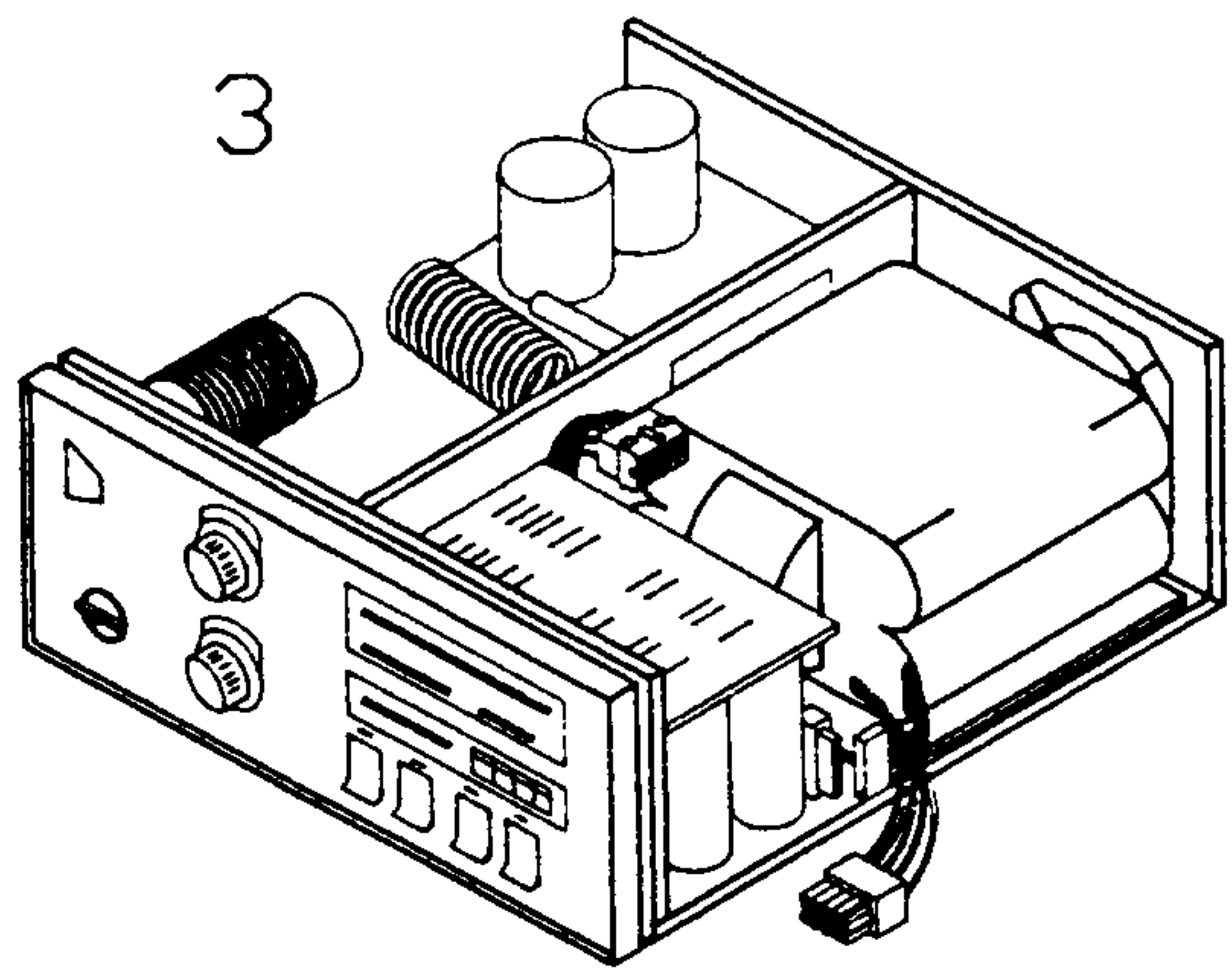
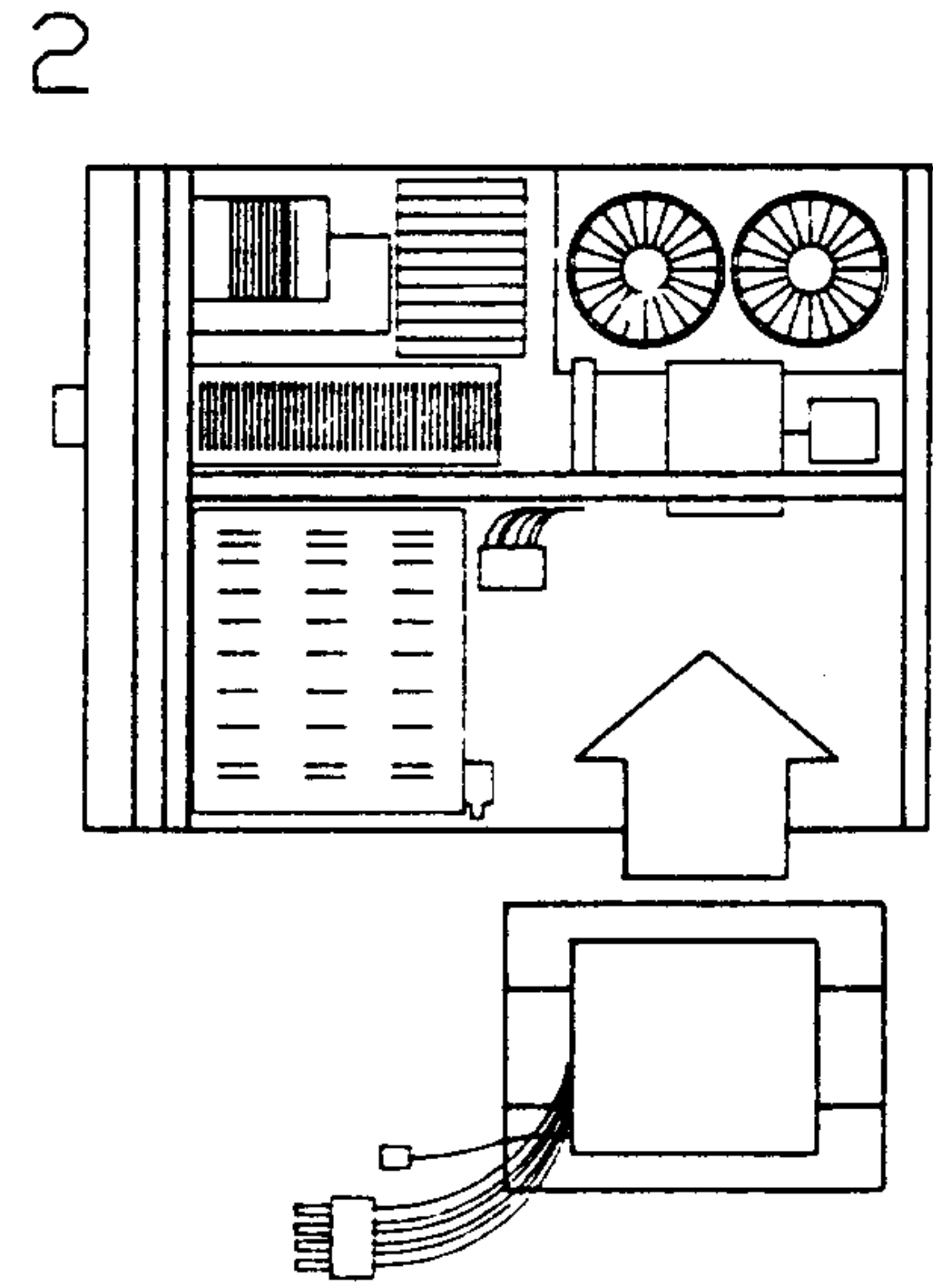
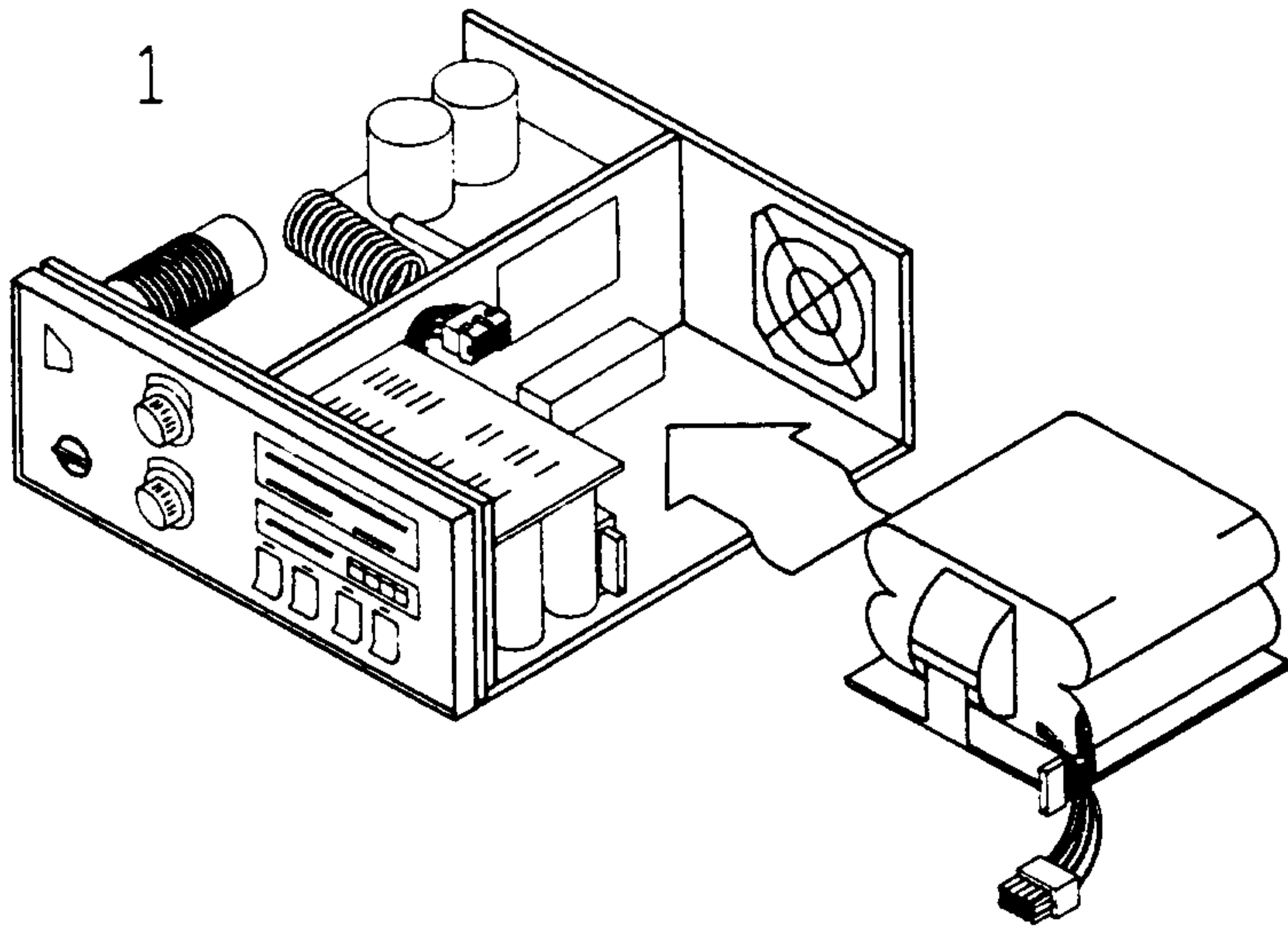
Tilt the top cover down slightly at the front to allow its front edge to slide underneath the front panel trim piece. Slide the cover over the chassis and align the screw holes. The chassis may warp slightly after the power transformer is installed. *Do not tighten any of the screws until all are started.*

## **2.6 240 Volt Primary Connections & Amplifier Grounding**

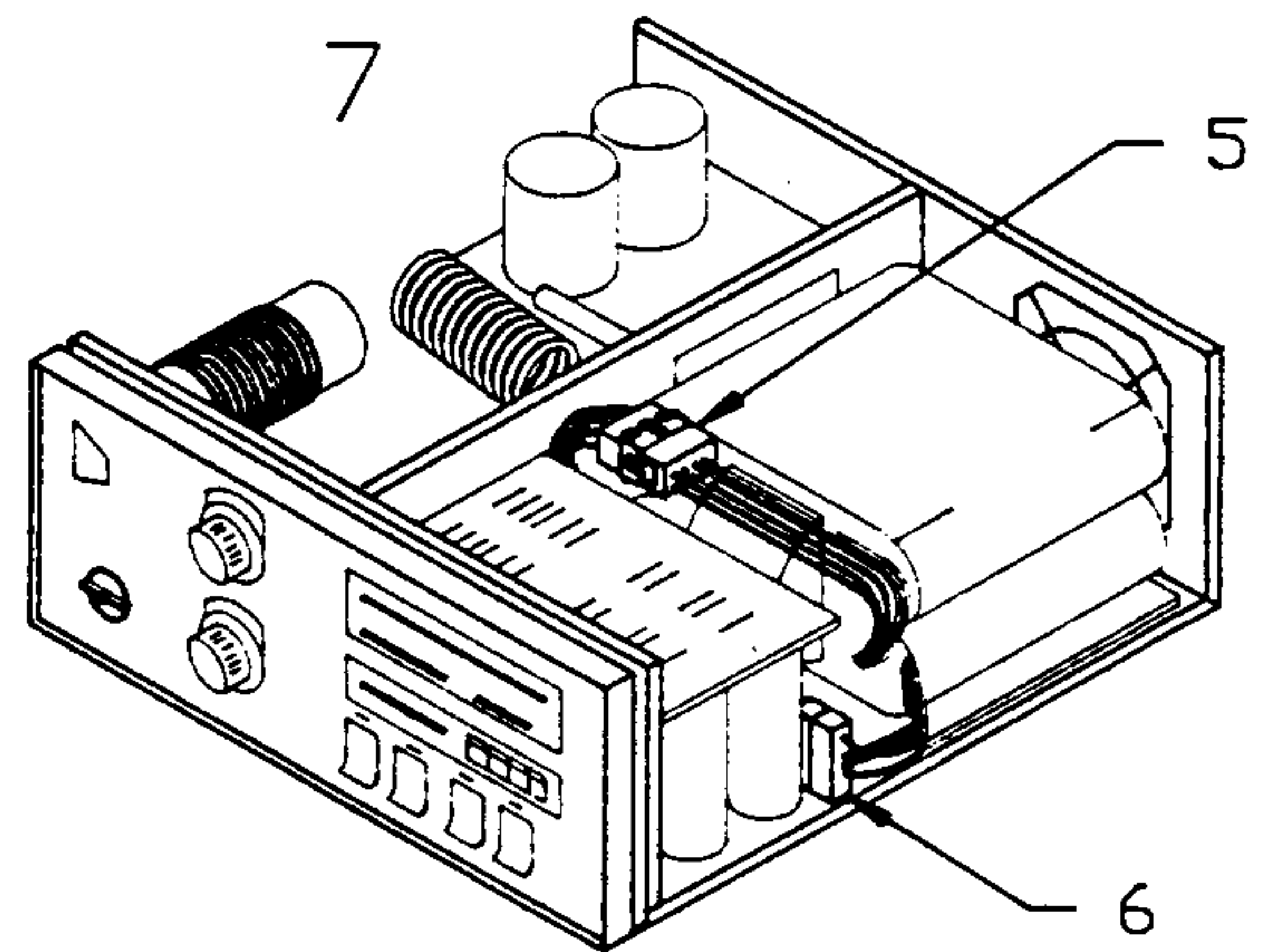
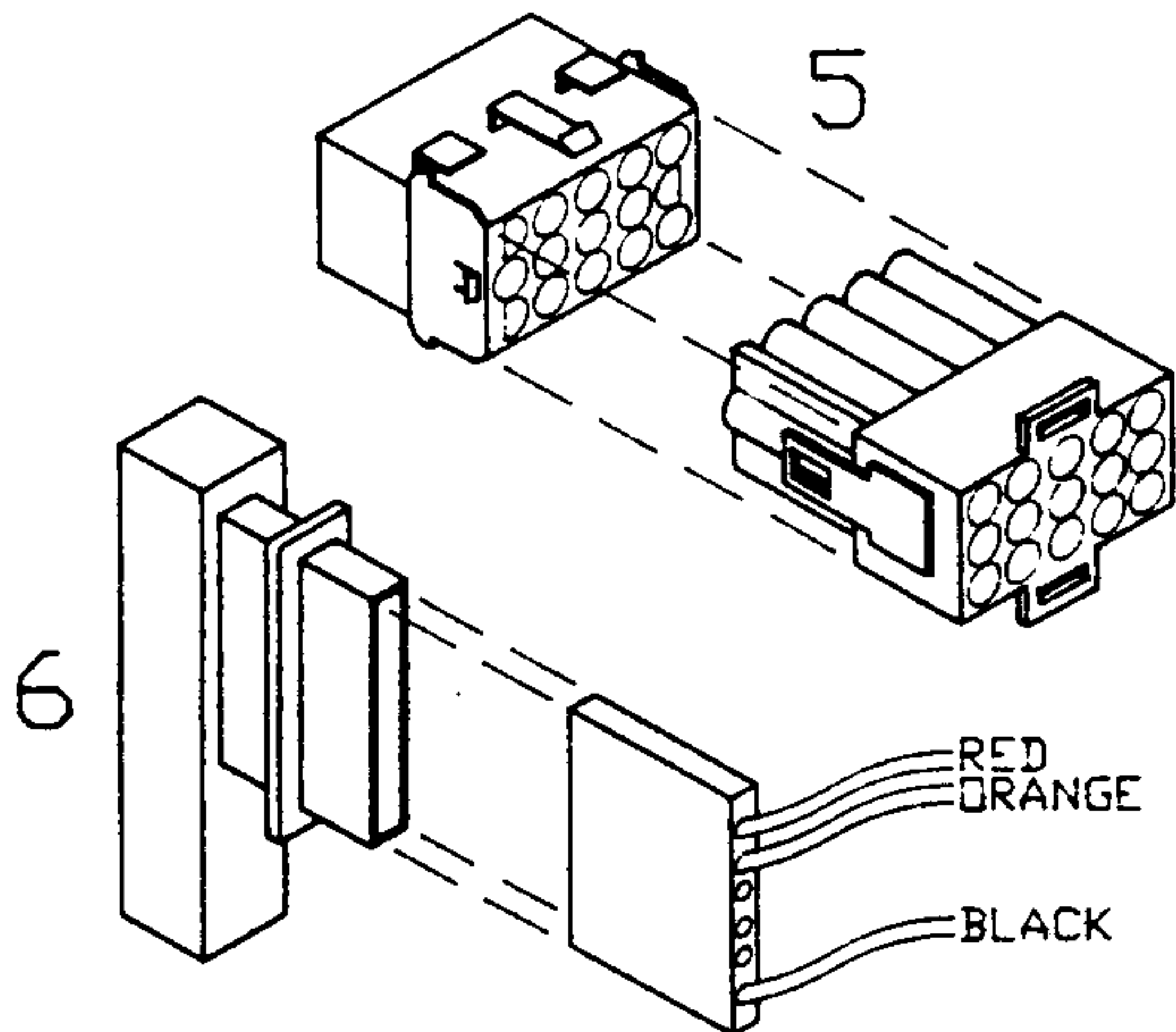
The *ALPHA 86* chassis is directly connected to the green power cord conductor. The green conductor must be connected to the power plug safety "ground" (or neutral) pin. The black and white power cord wires connect to the two 240V "hot" blades of the AC plug (either wire to either blade is okay).

A separate ground lug (with wing nut) is provided on the rear of the chassis. Connection at this point should be made to a good RF earth ground such as a copper water pipe or driven rod, via heavy braid or strap.

**FIGURE 1**  
**TRANSFORMER INSTALLATION**



WIRES OMITTED FOR CLARITY





## SECTION 3 – CONNECTION TO THE TRANSCEIVER

*ALPHA 86* interconnections to the station transceiver are shown in figures 2 and 3 on page 7.

### 3.1 Coax Types & Connectors

Connect the transceiver RF output to the *ALPHA 86* RF input with 50 ohm coaxial cable—type RG-58C/U or equivalent. Coaxial cable used between the *ALPHA*'s RF output and antenna should be type RG-8A/U, RG-213/U, or equivalent high quality type. Type RG-8X cable is *not* recommended. Suggested connectors are Amphenol 83-1SP male UHF type (with reducing fitting type UG-175 for use with RG-58C/U).

### 3.2 T/R Switching

For transmit/receive switching the *ALPHA 86* requires a relay contact closure on transmit across its RELAY jack (center pin to chassis). This control function is supplied by the transceiver, usually from a dedicated relay that is normally open in receive and closes in transmit.

The relay contact must close before RF drive is applied. The *ALPHA 86* protective circuitry will not allow the amplifier to "hot switch" with RF drive applied. Attempting to force a hot switch will cause protective circuitry to lock out the receive to transmit change over. If this happens the "T/R" fault LED will illuminate. It may be reset by removing drive, unkeying the transceiver, and switching the *ALPHA* from operate (OPR) to standby (STBY) and back to operate (OPR).

A few (mostly older model) transceivers may generate an RF transient (spike) when keyed. This spike may activate the *ALPHA 86*'s excessive grid current protection, in which case modification of the transceiver will be necessary. For specific instructions contact the ETO customer service department.

Figure 2 should be used with late model transceivers such as those listed below, and will allow the full capabilities of the *ALPHA 86*, including break-in (QSK) operation, to be enjoyed. Suitable transceivers include at least these (as of 9/90):

Kenwood TS-940S, TS-950S/D, TS-440S, and later production versions of the TS-930S and TS-430S  
Icom IC-735, IC-751, IC-751A, IC-761, IC-765, and IC-781  
Yaesu FT-757, FT-767, FT-1, and FT-1000

Figure 3 shows a switching arrangement that may be used to facilitate changing from conventional SSB/VOX or PTT to CW break-in operation with older transceivers that have inappropriate T/R sequencing. The desired mode of operation is selected by the external DPDT switch. QSK-capable transmitters of older design may also require connection per Figure 3.

For transceivers or transmitters not mentioned above, try connection per Figure 2 first. If T/R faults occur, try Figure 3.

### 3.3 ALC

The *ALPHA 86* generates a grid-current-derived, negative-going (from zero) DC control voltage that can be fed back to most transceivers to avoid overdrive. To take advantage of ALC, connection must be made to the *ALPHA 86* rear panel ALC jack.

Any grid current excursion above approximately 70 mA will "trigger" the ALC. At about 100 mA, ALC output is nominally -10 VDC. If the transceiver requires less voltage a 100 kohm potentiometer may be connected across the center pin of the ALC jack to chassis. The potentiometer wiper will provide an adjustable "feed" to the transceiver. While driving the amplifier the potentiometer can be adjusted to limit transceiver output to keep the amplifier grid current less than 100 mA.

**FIGURES 2 & 3**  
**CONNECTION TO THE TRANSCEIVER**

FIGURE 2. ALPHA 86 Interconnections for Normal VOX, PTT, AND QSK Operation.

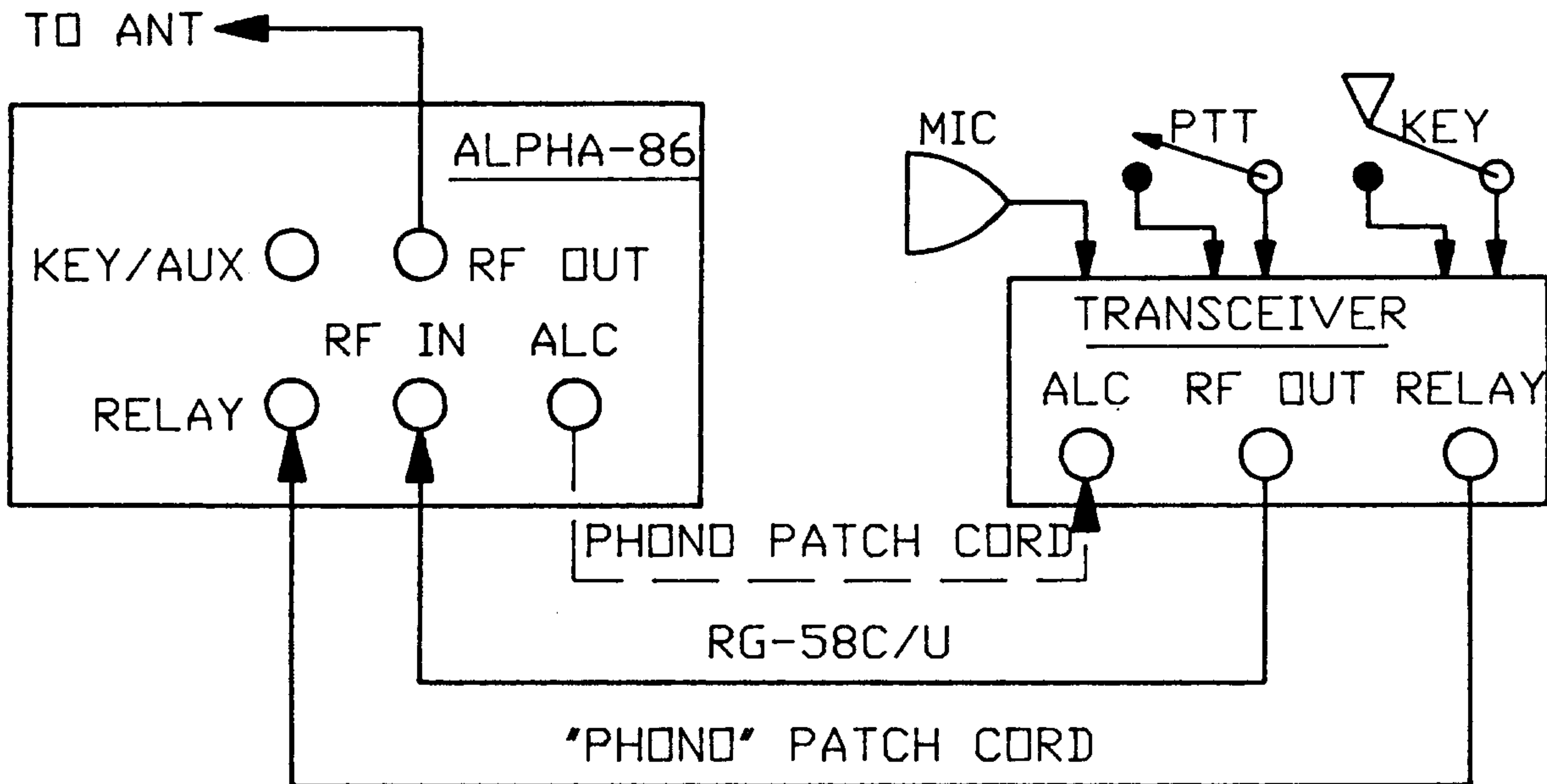
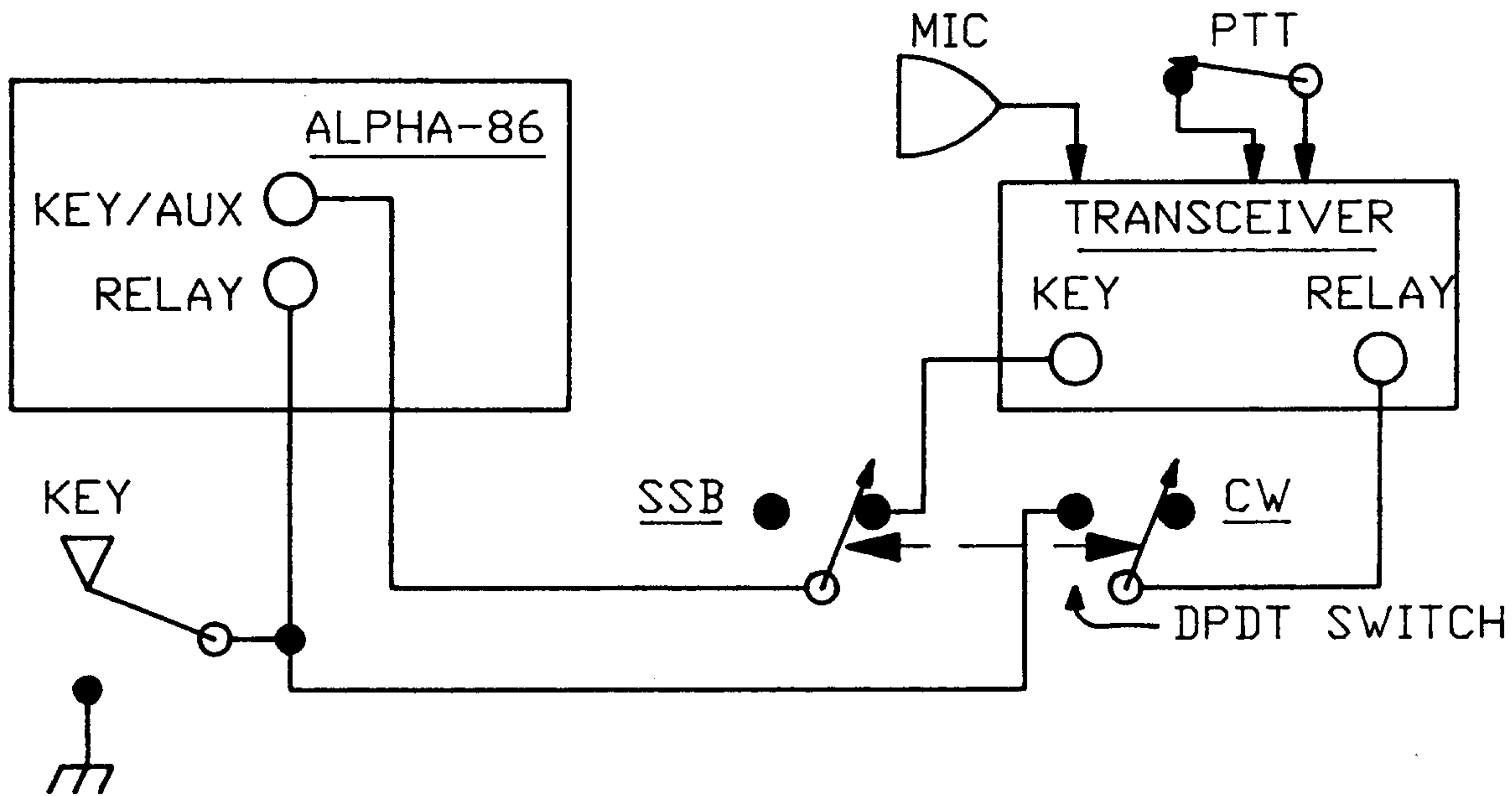


FIGURE 3. Alternative Method for Switching Between Conventional SSB PTT or VOX and CW Break-in-See text



## SECTION 4 – OPERATION

### 4.1 Tune-Up Control Functions

**BAND** - Selects tuning range; scale indicates principal amateur band covered. Frequency ranges in MHz are displayed on commercial models.

**TUNE** - Selects operating frequency. In general, higher frequency bands tune toward the "0" end of the dial scale, while lower bands tune toward the "50" to "100" end.

**LOAD** - Sets amplifier plate loading and determines the power input level at which best efficiency and linearity are achieved. In general, loading is heavier at greater scale settings and higher frequency bands load toward the "50" to "100" end of the vernier dial scale. Lower bands load toward the "0" end.

### 4.2 Switches

**POWER ON:** Depress momentarily to apply primary AC power to the amplifier, or to "reset" power if the plate overcurrent relay has tripped.

**POWER OFF:** Depress momentarily to remove primary AC power.

**OPR - STBY:** Operate (OPR) places the amplifier in line to the antenna. With the amplifier turned off, or in Standby (STBY) and during warm up (before the WAIT LED goes out), the amplifier remains bypassed, with the exciter connected directly through to the antenna.

**HI - LO:** LO selects reduced plate voltage for tuning or low power operation to about 1000 watts output. HI selects high plate voltage for full power operation.

### 4.3 Metering

Separate LED bargraphs provide instantaneous full-time display of peak RF OUTPUT (to 2.3 kW), GRID CURRENT (to 150 mA), and REFLECTED POWER (to 250 watts).

A fourth, switch-selected LED bargraph monitors these additional functions:

**TUNE:** Facilitates amplifier tune-up. Tuning is optimized when one of three center LEDs is illuminated. ( See subsection 4.)

**Ip:** Plate current, 1.5 amperes full scale (approximately 75 mA per segment).

**HV:** Plate voltage, 3000 VDC (150 V per segment).

### 4.4 Tune-up Procedure

#### 4.4.1 Objective

The objective of tune-up is to adjust the amplifier (and the drive applied to it) to obtain maximum efficiency and linearity at the desired output power (or in rare cases with the maximum available drive power, if that is the limiting factor).

When the amplifier is adjusted for maximum attainable RF output with a specific fixed level of drive power, it inherently yields the best combination of efficiency and linearity possible *at that particular drive level*. If a greater drive level than that used for tune-up is applied, the result will tend to be flattopping, off-frequency "splatter," and excessive amplifier grid current.

#### 4.4.2 Grid Current

Grid current falls off rapidly when drive power is too low and rises abruptly when drive power is too high. **GRID CURRENT IS THE SINGLE BEST INDICATOR OF PROPER AMPLIFIER OPERATION.** In the *ALPHA 86*, grid current should never exceed 70 to 80 mA under normal CW/SSTV/RTTY carrier or SSB peak conditions. If the grid current reaches 80 mA before the desired value of plate current is obtained, do not increase drive further! When operating voice SSB, grid current should peak in the range of 30-50 mA.

The threshold of the O'DRV (overdrive) indicator LED is set at 120 mA grid current. If this indicator flashes at any time *reduce* transceiver output immediately!

Excessive drive creates excessive grid current. Either reduce drive or increase amplifier loading to take advantage of this excess drive to produce more output power.

#### 4.4.3 ALC

The *ALPHA 86* generates ALC as a function of grid current rather than RF drive. This provides positive tube protection against possible damage, as any excessive grid current excursion will be self-limiting. This protection will be provided for the tube grids *only* when an ALC connection is made from the *ALPHA 86* to the transceiver. The ALC voltage generated by the *ALPHA 86* is not applied internally and cannot control the amplifier itself.

#### 4.4.4 Initial Tune-Up

**IMPORTANT:** The forward and reflected power LED bargraphs are peak-reading. All other bargraphs display averaged readings.

**BEFORE INITIAL TUNE-UP, MAKE SURE A SUITABLE ANTENNA OR DUMMY LOAD IS CONNECTED TO THE ALPHA 86!** Leave the amplifier turned off or in standby, and use *exciter power only* for a forward versus reflected power check. If reflected power is less than ten percent of forward power, the VSWR is lower than 2:1 and it is safe to proceed.

### Turning on the *ALPHA 86*

- 1) Select LO plate voltage (HI-LO switch).
- 2) Place the OPR-STBY switch in STBY (standby).
- 3) Depress Power ON.

If any of the following does *not* occur, depress power OFF switch immediately and investigate before proceeding:

- 1) The blower starts.
- 2) The multimeter bargraph automatically displays HV; it should indicate 1.6 to 1.9 KV.
- 3) The STBY and WAIT LEDs come on.

**IMPORTANT: EXHAUST AIR MUST BE DETECTABLE FROM THE TOP VENTS:** If not, TURN OFF the amplifier and verify that the 3CX800A7 rubber exhaust chimneys are properly positioned.

When the warm up delay is complete (about three minutes), the WAIT indicator will go out. The *ALPHA 86* is now "ready".

## Tune Up For 1,500 Watts Output

- 1) All initial control settings must match those in Table 1, page 12. Set BAND, TUNE, and LOAD controls to their proper positions. The final settings will vary somewhat with operating frequency, antenna characteristics, and drive level.
- 2) Reduce transceiver carrier output control to ZERO.
- 3) Depress HI on HI-LO switch
- 4) Depress OPR on OPR-STBY switch. The OPR LED should light.
- 5) Select TUNE function on multimeter bargraph.

IF AT ANY TIME IN THE FOLLOWING PROCEDURE THE AMPLIFIER FAILS TO RESPOND AS DESCRIBED, REMOVE DRIVE IMMEDIATELY!

- 6) Switch transceiver to "tune" or CW "lock-key" and increase its carrier output until the RF OUTPUT bargraph indicates approximately 500 watts.
- 7) Adjust TUNE control to deflect TUNE LED maximum left.
- 8) Adjust LOAD control to center the illuminated LED.
- 9) Repeat steps 7 and 8 above.
- 10) Increase transceiver output until *ALPHA 86* output is 1,000 watts.
- 11) Adjust TUNE to deflect TUNE LED maximum left.
- 12) Adjust LOAD to illuminate center LED.
- 13) Repeat steps 11 and 12.
- 14) Increase transceiver output until *ALPHA 86* output is 1,500 watts.
- 15) Touch up TUNE for maximum power output.

NOTE: Illumination of the first red LED on the RF OUTPUT bargraph indicates output has exceeded 1,500 watts.

The *ALPHA 86* is now correctly tuned for approximately 1,500 watts output on SSB, CW, FSK, SSTV, and FM. On AM, decrease exciter carrier output until the *ALPHA 86* output drops to 375 watts.

## Reduced Power Operation (800-1000 Watt Nominal Output)

- 1) Set the BANDswitch, TUNE, and LOAD control to initial settings.
- 2) Reduce transceiver carrier output to zero.
- 3) Depress LO on HI-LO switch.
- 4) Depress OPR on OPR/STBY switch. The OPR LED should light.
- 5) Select TUNE function on multimeter bargraph.
- 6) Switch transceiver to "tune" or CW "lock-key" and increase its carrier output until the RF OUTPUT bargraph indicates approximately 500 watts.
- 7) Adjust TUNE control to deflect TUNE LED maximum left.
- 8) Adjust LOAD control to illuminate center LED.
- 9) Increase transceiver output until *ALPHA 86* output is 800-1000 watts.
- 10) Repeat steps 7 and 8.

The *ALPHA 86* is now correctly tuned for reduced output.

When operating at high (1,500 watt) or low (800 watt) powers it is normal for the TUNE LED to shift slightly left or right of center under voice modulation or keying.

#### 4.4.5 Reflected Power Protection

While operating check the reflected power bargraph to ensure that it remains below 150 watts (equal to a 2:1 VSWR when the amplifier output is 1,500 watts). Variations in reflected power may indicate a problem in the feedline or the antenna. If reflected power exceeds approximately 200 watts the *ALPHA 86* will immediately switch to standby. The entire REFLECTED POWER bargraph and SWR LED will illuminate, indicating that the VSWR protection circuitry has "tripped". To reset, remove exciter drive and switch OPR-STBY from OPR to STBY and back to OPR.

#### 4.4.6 ALC

Grid current peaks greater than approximately 70 mA will "trigger" the ALC. At 100 mA ALC voltage is nominally -10VDC. If the transceiver requires less voltage, a 100k ohm potentiometer may be wired across the jack so that the control wiper provides an adjustable "feed" to the transceiver. When driving the amplifier the potentiometer can be adjusted to limit transceiver output to keep grid current within safe bounds. A VOM can be used to measure and "set" the correct *peak* ALC voltage level to the transceiver. Late model Kenwood and Yaesu transceivers should work well between -8 and -10 VDC. Icom transceivers require lower peak ALC voltages, typically -2 to -3 VDC. In place of a potentiometer a fixed resistor voltage divider can be used.

**TABLE 1 — INITIAL CONTROL SETTINGS**

| BAND           | FREQUENCY | TUNE | LOAD |
|----------------|-----------|------|------|
| 160            | 1.80      | 81   | 11   |
| 160            | 1.90      | 58   | 32   |
| 160            | 2.00      | 42   | 56   |
| 80             | 3.55      | 62   | 53   |
| 80             | 3.75      | 53   | 65   |
| 80             | 3.95      | 43   | 77   |
| 40             | 7.05      | 52   | 47   |
| 40             | 7.20      | 48   | 48   |
| 30 (band "C")  | 10.12     | 19   | 67   |
| 20             | 14.20     | 40   | 78   |
| 17 (band "15") | 18.10     | 67   | 76   |
| 15             | 21.25     | 31   | 84   |
| 12 (band "10") | 24.90     | 46   | 82   |
| 10             | 28.10     | 22   | 87   |
| 10             | 28.50     | 19   | 87   |
| 10             | 29.00     | 18   | 88   |
| 10             | 29.60     | 12   | 89   |

Note: The settings above are a COMPOSITE based on average ALPHA 86 performance characteristics. The settings you observe may vary — this will not indicate a problem with your amplifier but rather normal tolerances. All factory testing is done with the amplifier tuned to 1500 watts output and terminated in a 50 ohm dummy load.

## SECTION 5 – OPERATING AND MAINTENANCE NOTES

### 5.1 Tubes

The 3CX800A7 tubes used in the *ALPHA 86* are very rugged and normally operate with a large margin of safety. They generally deliver outstanding service for many years if not damaged by misuse — especially by excessive grid current — or blockage of the intake or exhaust cooling airflow. Keep the air intake and exhaust vent areas completely clear. Allow *at least* twelve inches (31 cm) unobstructed clearance around the air intake and exhaust ports. “Stacking” equipment is not recommended unless provision is made for adequate cooling.

Never allow key-down plate current to exceed 1.2 amperes for more than one or two seconds. Do not allow grid current *ever* to exceed 120 mA; normal operation requires only 50 to 80 mA maximum.

On-off AC power cycling may lead to shorter tube life-time. It is better to leave equipment turned on for several hours than to cycle it repeatedly, on-off-on-off, over the same period.

### 5.2 Interlocks

The *ALPHA 86* is equipped with an interlock switch intended to remove primary power from the amplifier and a crowbar to short-circuit the high voltage to chassis whenever the cover is lifted. These interlocks are designed to protect against dangerous electric shock resulting from accidental contact with the potentially lethal voltages inside the amplifier. However, never depend on the interlock switches alone for protection.

#### **WARNING!**

**CONTACT WITH LETHAL VOLTAGES EXISTING INSIDE THE ALPHA 86 MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH FROM ELECTROCUTION!**

**ALWAYS DISCONNECT THE AC LINE CORD FROM ITS WALL OUTLET BEFORE REMOVING THE COVER!**

**THE AMPLIFIER SHOULD NEVER BE TURNED ON WITH INTERLOCKS DEFEATED EXCEPT BY THOROUGHLY KNOWLEDGEABLE SERVICE PERSONNEL!**

### 5.3 Fuses

Except in rare instances of component failure, blowing one or both of the primary line fuses indicates that the maximum safe average power capability of the amplifier has been substantially exceeded. USE ONLY 20 AMP 250 VOLT RATED (ceramic) FUSES.

The slow blow fuses, F3 and F4, located above the primary line fuses, prevent damage to the step-start resistors and HV rectifiers in the event of abnormal turn-on conditions or HV faults. NEVER substitute a fuse of different size or rating.



## 5.4 Plate Overcurrent Relay

This relay will turn off the amplifier quickly in the event of a fault in the high voltage circuitry or grossly excessive plate current. The relay will not prevent damage from either short- or long-term overdrive or improper tuning. Setting safe tuning and operating conditions, including drive level, is the operator's responsibility. Should the overcurrent relay trip, removing all AC power from the amplifier, it is essential to determine and correct the cause before turning the *ALPHA 86* on again.

## 5.5 Preventive Maintenance

The amplifier interior, particularly high voltage DC areas, should be cleaned frequently enough (with a soft bristle brush and vacuum cleaner) to prevent visible accumulation of dust. In extremely dusty conditions it may be advisable to secure a thin plastic air filter, of the type used for window air conditioners, across the air intake area on the rear panel. Appropriate filters are available from ETO. The ETO accessory cooling fan should also be installed to compensate for reduced airflow.

There are no lubrication points within the amplifier. Do not apply oil or grease to any of the components.

The exterior of the *ALPHA 86* can be cleaned with Fantastik<sup>®</sup>, Formula 409<sup>®</sup>, or similar household liquid detergents. Do not use chemical solvents as these may severely damage the front panel plastic overlay and the cabinet finish. Never use abrasive cleaners or pads!

## 5.6 Front Panel Lamp Replacement

Type #85 bulbs provide illumination for the TUNE and LOAD control dials. To replace these bulbs it is necessary to remove the front panel:

- 1) Remove the top cover
- 2) Remove the BANDswitch, TUNE, and LOAD knobs.
- 3) Five machine screws mount the front panel to the front sub-panel. These screws are inserted from the rear of the sub-panel and are located in the upper and lower left and right corners and in the upper center. Remove the five screws.
- 4) Carefully slide the complete front panel off the control shafts.
- 5) The bulbs are located directly behind the dial skirts.

Reverse the above steps to replace the front panel.

## SECTION 6 – TROUBLESHOOTING TIPS

A) Will not turn on: nothing happens when ON switch is depressed.

- 1) External AC wiring, fuse or circuit breaker open.
- 2) Amplifier cover not in place; cover safety interlock open.
- 3) Fuse F1-F4 open or missing.
- 4) Voltage dropping resistor R8 open.
- 5) Step-start resistor R6 or R7 open.

Resistors R8, R6 and R7 are mounted vertically on the chassis floor between the HV power supply filter capacitors and the power transformer.

B) Amplifier turns on but no HV indication on the multimeter bargraph.

- 1) Possible HV fault.
- 2) HV multiplier resistor(s) R19, R20, or R21 on HV power supply may be open.

C) Amplifier turns on but no multimeter indications; other bargraphs appear operative.

- 1) 28 or 5 volt power supply problem.
- 2) Defective source-select IC on control board.

D) Amplifier turns on but time delay will not complete; WAIT LED does not turn off and STBY LED does not come on.

- 1) Timing transistor on display board (Q3).
- 2) Time constant capacitor on display board (C9).

E) Amplifier turns on, time delay completes, STBY LED comes on, but amplifier will not transmit.

- 1) Open control line from transceiver to RELAY jack.

F) Amplifier will transmit; grid current is excessive.

- 1) Amplifier overdriven; reduce transceiver output and/or increase loading.
- 2) ALC line to transceiver open or not connected.
- 3) Load VSWR too high and/or plate tuning misadjusted.

G) Amplifier will transmit; grid and plate current low, transceiver does not seem to be able to drive amplifier to 1500 watt output.

- 1) Insufficient drive
- 2) ALC control voltage to transceiver too high; add potentiometer at ALC jack (see section 4.4.6, ALC Provision).
- 3) Input tuning circuitry damaged.
- 4) Bias switch transistor Q5 on control board damaged or defective.

H) Amplifier appears to transmit, grid current and all other functions normal but no indication of plate current.

- 1) Plate current pickup transformer T2 on HV power supply board defective.

I) Receive signals disappear or are severely attenuated when switching from STBY to OPR.

- 1) RELAY control cable from transceiver is shorted.
- 2) Transceiver locked in transmit.
- 3) Receive fuse open (see page 17, Receive Fuse Replacement).
- 4) Damaged receive PIN diode.

J) Plate current indication when amplifier in STBY or receive.

- 1) 3CX800A7 tube(s) with heater to cathode leakage or short.
- 2) Tube bias supply or transistor bias switch Q5 faulty.

K) T/R fault LED comes on whenever transceiver is keyed with amplifier in OPR mode.

- 1) Transceiver attempting to hot switch amplifier; see page 6. To reset, switch from OPR to STBY and back to OPR.

L) Distorted SSB output signal with possible severe television interference (TVI).

- 1) Excessive RF drive from transceiver and/or insufficient amplifier loading.
- 2) Flashover in amplifier RF compartment from component to component or to chassis.
- 3) Coaxial connector, coax feedline, antenna balun, or antenna trap arcing on voice peaks.
- 4) RF feedback from antenna into transceiver via the AC power cord, microphone or key line cable, or other unshielded station patch cables.
- 5) Poor RF station ground.

M) TUNE and/or LOAD dial illumination failed.

- 1) Illuminating bulb open; see page 14, Front Panel Lamp Replacement.

## Receive Fuse Replacement

The PIN diode T/R circuit board has a fuse which may blow in the event of a control or circuit fault. If the fuse opens received signals will be lost when the OPR (operate) switch is depressed.

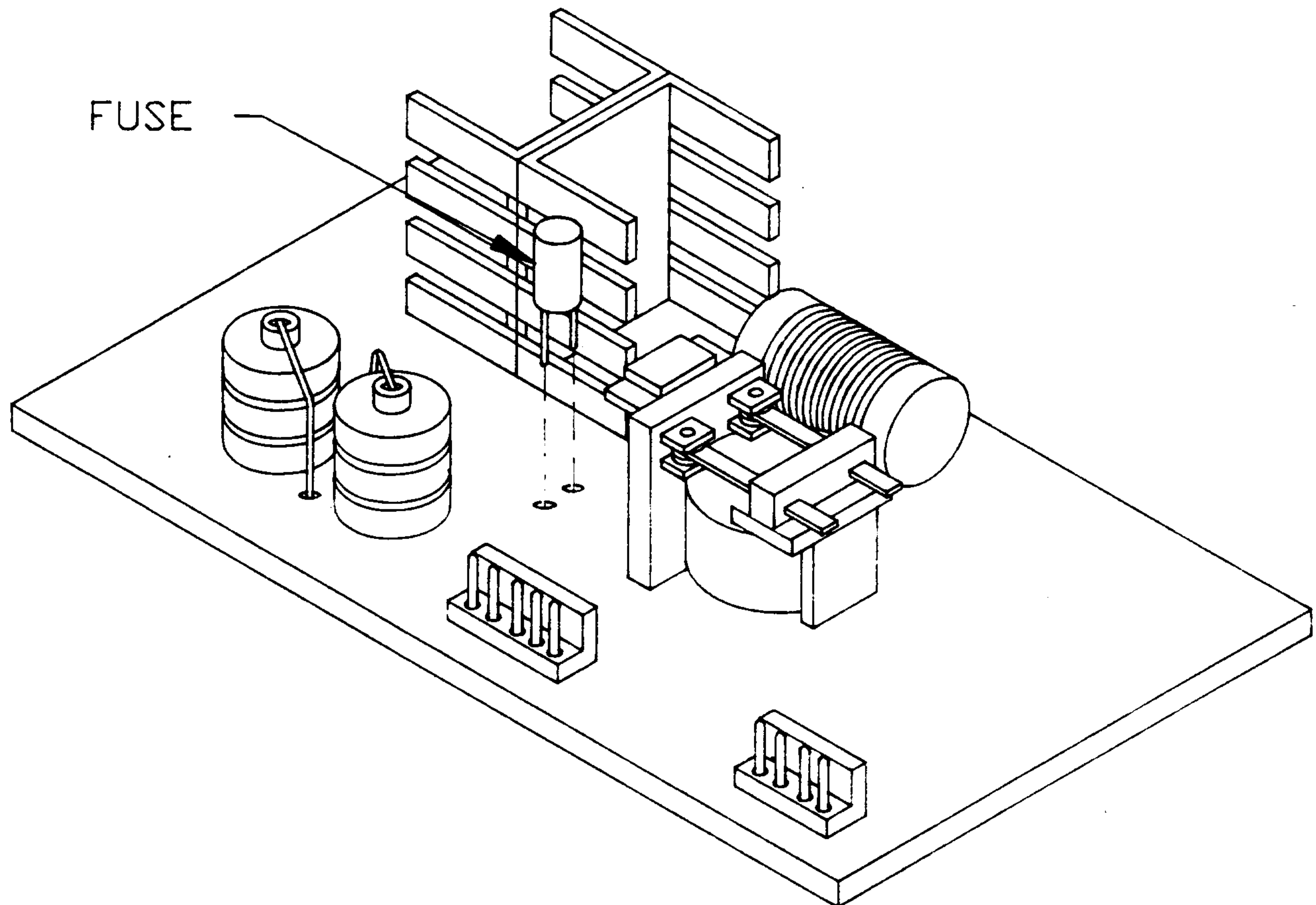
**WARNING: THE AMPLIFIER MUST BE TURNED OFF AND THE POWER CORD UNPLUGGED FROM THE WALL RECEPTACLE BEFORE REMOVING THE TOP COVER AND ATTEMPTING FUSE REPLACEMENT!**

The circuit board is mounted on the back wall directly behind the 3CX800A7 tubes. The drawing below shows the major board parts. The fuse is adjacent to the large black finned heatsink.

The fuse unplugs from the board. A continuity check with an ohmmeter will determine if the fuse is open. If necessary replace the fuse with the supplied spare. Warning! Do not substitute a larger size fuse or wire jumper. The exact replacement part must be installed or serious equipment damage not covered under warranty may occur. **REINSTALL THE TOP COVER BEFORE TURNING ON THE AMPLIFIER!**

Refer to Figure 4 below.

**FIGURE 4  
RECEIVE FUSE REPLACEMENT**



## SECTION 7 – THEORY OF OPERATION

### 7.1 Power Supply and Control

Refer to Figure 5.

When the ON rocker switch is momentarily depressed (closed), the AC power control circuit is completed through contact 1 of P4, F1, the ON switch, S3 (normally closed OFF switch), R4, S5, K14, K11 coil, F2, and contact 2 of P4. K11 latches closed, completing the circuit to the transformer primaries via P4, R7, F4, F3, R6, and F2. (Depressing OFF opens the control relay circuit, turning off the amplifier.)

(For 120 volt operation the transformer primary windings must be parallel-connected and R4 shorted.)

At turn-on, the discharged high voltage (HV) filter capacitor bank C1-C7 appears as a momentary short circuit across the output of the HV rectifiers, D1-D4. Primary in-rush current is limited to 12 amperes by "step-start" resistors R6 and R7. After a period of less than a second, the HV and other DC power supplies reach nearly full output. Relay K12 closes, shorting out R6 and R7 so that full voltage is applied to the transformer primary.

In the event of an HV fault, the overcurrent relay and/or fuses F3 and F4 will open, turning off the amplifier.

The power transformer supplies all necessary voltages for amplifier operation:

- 1) 13.5 volts AC for tube filaments
- 2) 7 volts AC for the 5 volt DC supply
- 3) 50 volts AC for the 28 volt DC supply
- 4) 1250 or 1785 volts AC for the HV plate supply

The 7 volt winding feeds full wave rectifier D3-D4. The nominal 5 volt output powers control, transmit/receive (T/R), and PIN diode switching circuits.

The 50 volt winding feeds full wave rectifier D1-D2. 36V output from this supply provides tube bias and also is regulated at 28 volts by regulator U1 which powers control, switching relay, and T/R circuitry.

Voltage from the 28V regulator to the coil of step-start relay K12 is appropriately delayed by RC time constant components associated with Q1 and Q2.

Refer to schematic diagram Figure 6.

Relay K13 selects the "low" or "high" tap of the high voltage winding and applies it to HV bridge D1-D4. The HV supply negative terminal is floated above chassis ground for purposes of tube biasing and grid current monitoring. Plate current is monitored by passing transformer HV secondary current through current transformer T2. The voltage induced in its secondary is proportional to the HV supply current and is processed for display by the Ip function of the multimeter bargraph. Filter capacitors C1-C6 are a matched set. Their total capacitance is nominally 50  $\mu$ F. Bleeder resistors R1-R14 equalize voltage distribution across the capacitors.

HV output is applied to the tube anodes and to the PIN diode bias circuitry shown in Figure 7. R16 in the HV return lead limits fault current in the event of an HV arc or short. The voltage drop across R16 is applied to the coil of plate overcurrent relay, K14. When K14 activates, its contacts open the coil circuit of K11 and disconnect primary power from the amplifier. R18 and D6 protect K14 from excessive voltage.

R19-R21 are HV meter multipliers; R22 provides a return path to limit open-circuit voltage.

AC interlock S5 operates in conjunction with the HV crowbar. When the top cover is lifted approximately 1/4 inch, S5 opens, turning off all AC power. Lifting the cover further causes the HV crow-bar to discharge the filter capacitor bank.

Cutoff bias from the 36 volt supply is applied to the tube cathodes via R17. When the amplifier is keyed into the transmit mode by the transceiver, T/R circuitry grounds the anode of zener diode D7, thus dropping the bias to its operating value of 8-9 VDC.

NOTE: During the three minute tube warm-up period, the amplifier cannot be switched into the transmit condition described above. See Figure 12 for details of T/R switching circuitry.

## 7.2 RF Signal Routing

Refer to schematic diagrams Figures 12 and 5.

When the amplifier is off, or on but in STANDBY, RF is routed between transceiver and antenna (from J2 to J1) via the normally closed contacts of relay K1.

When the amplifier is in OPERATE, K1 is energized and RF routing is controlled by the amplifier T/R system.

In RECEIVE, signals from the antenna pass through to the transceiver via AMP OUT connector J1, T1, K1, C3 and C4, safety fuse F1, forward biased PIN diodes D13 and D12, C33, D11 C27, K1, and the AMP IN connector, J1. PIN diodes D1, D2, and D10 are back biased and turned off.

In TRANSMIT, the drive signal is routed via J2, K1, C27, forward biased PIN diode D10, and C26 to the input tuning networks. The drive signal sampled at K1 by R11 is rectified and fed to the control circuits. PIN diode D11 is back biased and turned off.

Output from the plate tuning network passes through PIN diodes D1 and D2, C1-C4, K1, T1, and the AMP OUT connector. T1 is part of the RF wattmeter, whose output is displayed on respective LED bargraphs as the forward and reflected power. Receive PIN diodes D13, D12, and D11 are back biased and turned off.

## 7.3 RF Power Amplification

Refer to Figures 5 and 14.

Drive RF from the PIN diode T/R board is routed via coaxial cable to the input matching network circuit board underneath the tube deck. A pi-network selected by the bandswitch transforms the load presented by the 3CX800A7 tube cathodes to the nominal 50 ohms required by the transceiver.

The two Eimac 3CX800A7 ceramic metal tubes are parallel-connected in grounded grid. The tubes operate class AB2 for high linearity and efficiency.

Refer to Figure 5.

RF drive is applied to the tube cathodes via DC blocking capacitors C4 and C5. The cathode HV return is RF decoupled by choke L7 and C8. An RF voltage sample is taken at the tube cathodes for use by the TUNE meter. See schematic diagram Figure 5 for additional detail. A voltage sample is similarly taken from the tube plates.

L1-R1 and L6-R2 are plate parasitic suppressors.

The tap on plate shunt feed choke L2 is selected by K4 to provide efficient operation over the full frequency range. Additional HV decoupling is provided by R3, C12, C16, C17, L8, C13, C14, and C15.

RF from the tube plates is coupled to the output network via DC blocking capacitors C10 and C11.

The nominal 50 ohm load is transformed to an appropriate plate load resistance by the bandswitched pi-L network.

L9 provides a safety DC return to ground in the event of HV leakage or flashover across the blocking capacitors.

## 7.4 Control and Metering

Refer to schematic diagram Figure 13.

When the amplifier is initially turned on, all control functions are locked in STANDBY. The standby light emitting diode (LED), D63, is switched on by transistor Q6. The wait LED is controlled by switching transistor Q1. A three minute time delay is provided by R21 and C9. After sufficiently charging C9, the programmable unijunction transistor (PUT) Q3 fires, which in turn switches on SCR Q2.

When Q2 switches on, Q1 turns off and the wait LED is extinguished. When the OPERATE switch is depressed, the STBY LED turns off, the OPRLED turns on, and the RF bypass relay K1 is activated.

At turn on, the multimeter circuit automatically displays HV. Integrated circuit U8A triggers U8B and U10C. The HV pushbutton assembly, D66, is illuminated. The HV sample from the power supply is decoupled by R38 and C21 and passes via U10C to the multimeter LED driver bus and to U5 and U6. U5 and U6 are configured to drive successive LED's as their input driving voltage increases. This "stair step" illumination of LED's D39 thru D58 provides a linear display.

Pressing multimeter buttons TUNE or Ip similarly selects those functions.

Separate, dedicated bargraphs monitor amplifier grid current and forward and reflected RF power. (Pre-conditioned "samples" of these parameters are provided by the control/ALC/tune circuit board.)

The grid current sample from the control board is applied to LED driver U3. A sample is taken from the 120 ma LED output of U3 and applied via R32 to Q7. Transistor Q7 is configured as an emitter follower; when it triggers, Q8 turns on. Resistor R35 and capacitor C10 comprise a fast attack/slow release circuit which discharges thru Q8, allowing the overdrive LED, D72, to turn on quickly and fade slowly as the grid current peak diminishes. Repetitive peaks will continue to charge C10; D72 remains on and provides a warning as long as the overdrive condition exists.

The forward power sample from the control board is applied to LED drivers U1 and U2.

The reflected power sample from the control board is applied to LED driver U4. A sample from the 150 mA LED output of U4 is applied via D73 and R8 to transistor Q4. If a VSWR fault occurs, SWR fault LED D60 illuminates. Either fault will switch the amplifier to standby; faults can be cleared by switching the MODE switch from OPR to STBY and back to OPR. If the fault does not clear, the appropriate status LED(s) will remain illuminated and the amplifier will remain locked in STBY.

## 7.5 Function Control/ALC/Tune

Refer to schematic Figures 9, 10, and 11.

Basic amplifier function control is straightforward. Two logic inputs must agree before the amplifier can be switched into the transmit mode.

- 1) The three minute time delay must be completed.
- 2) No RF may be present at the RF input detector; i.e. there is no incoming RF drive from the transceiver.

When these conditions are satisfied the amplifier can be switched to transmit.

A T/R lockout will occur if the transceiver attempts to "hot switch" the amplifier. (Hot switching occurs if drive RF is present before the T/R system is in transmit.) The amplifier requires the following control sequence when switching from receive to transmit:

- 1) T/R relay closure signal (center pin of RELAY jack shorted to chassis ground).
- 2) RF drive follows approximately 5 milliseconds later.

When switching from transmit to receive:

- 1) RF drive level decays approximately 1mW.
- 2) T/R relay "open" signal (center pin of RELAY jack open circuit to chassis ground).

If these conditions are violated so that the transceiver attempts to hot switch, a T/R "inhibit" occurs and causes the bypass relay to drop out; the amplifier remains in STBY. Any RF applied to the RF IN jack will bypass the amplifier and appear at the RF OUT jack. The T/R fault LED will illuminate. The fault can be cleared by removing RF drive and then toggling the mode switch from OPR to STBY and back to OPR.

Provision is made for an alternative T/R control hookup with transceivers that may attempt to hot switch. Basically, the amplifier itself is T/R keyed and it, in turn, keys the transceiver via reed-type keying relay, K2. K2 closes under these conditions:

- 1) Time delay is complete.
- 2) The amplifier is in the OPR mode.
- 3) No RF is present at the amplifier RF IN jack.
- 4) The RELAY jack center pin is shorted to chassis.

If the amplifier is in off or in STBY, any keying or PTT control signal applied to the RELAY jack will be passed via K1 to the KEY OUT jack. Relay K2 follows the input keying.

When the amplifier is properly (not hot-) switched, in transmit, and being driven, RF at the post T/R detector is sampled and applied to the logic driver. A logic "high" turns on Q6. When Q6 is turned on the tube cathode bias is reduced from +36 VDC to +9 VDC. Plate current does not flow through Q6. Grid current, however, does pass through this device and voltage drop across R24 is sampled and fed to the GRID ALC circuit. The grid current sample also is routed to the display board via D22, R29, and R28.

A reflected power sample from the T/R board is monitored by the control logic. The reflected power trip threshold is adjusted by variable resistor RP1 which sets the turn-on point of Q9. If Q9 turns on, the output of U5B changes state and T/R board input relay K1 drops out. This switches the amplifier back to STBY and turns on the SWR fault LED. The fault can be cleared by removing RF drive and toggling the mode switch from OPR to STBY and back to OPR.

The forward and reflected power samples from the T/R board are calibrated by variable resistors RP2 and RP3, then amplified by operational amplifiers U5A and U5B and routed to the display board.

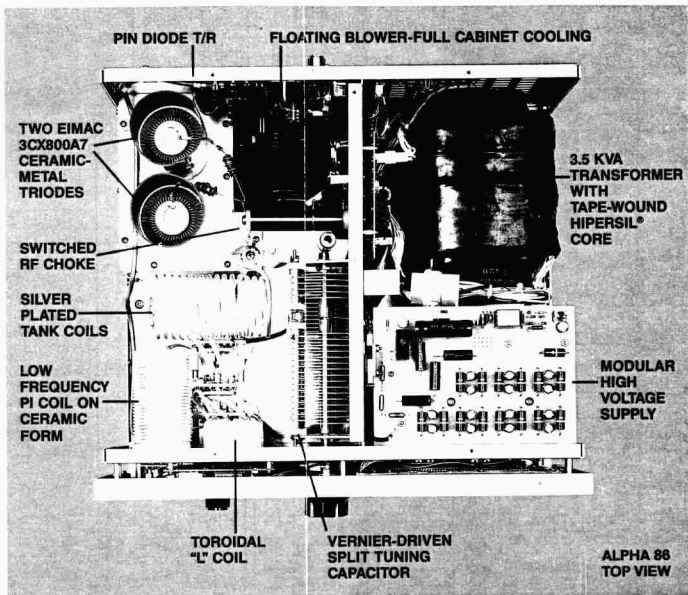
Power supplies providing  $\pm 15$  volts are shown in Figure 9.



Refer to Figure 11

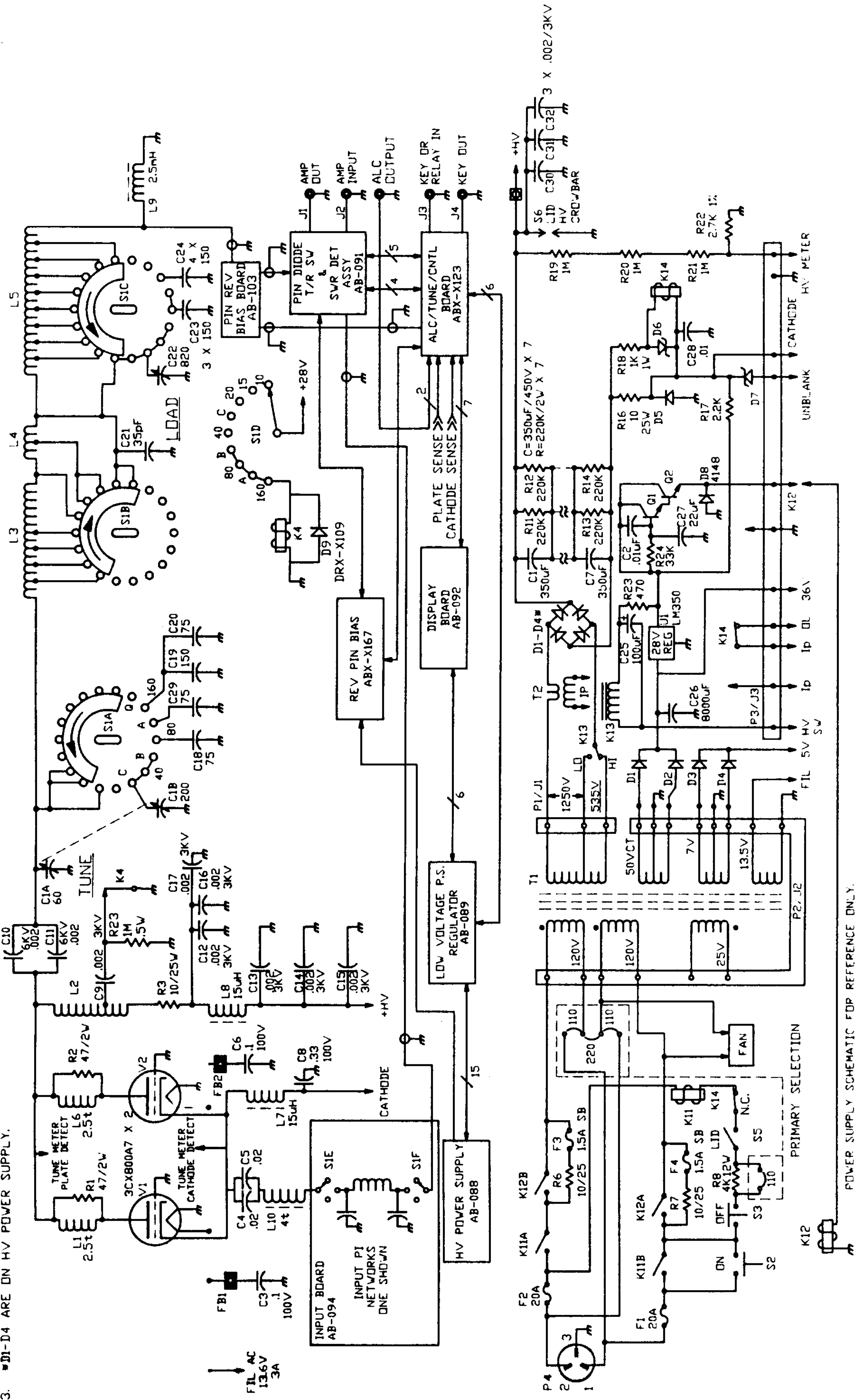
ALC is derived as a function of amplifier grid current. A grid current sample from R24 is amplified and inverted by U5C/D. The negative-going output is available for control of transceiver RF peak output.

The TUNE meter circuitry determines amplifier gain by comparing detected RF voltages at the cathodes and plates of the 3CX800A7 power tubes. Each voltage sample is amplified (U6A and U6B, respectively) then applied to U6A. If the voltage ratio is correct, the output will illuminate a single LED at or near the TUNE bargraph center. If the ratio is incorrect, the illuminated LED will be proportionately to the left or right of center.



NOTES:

1. ALL SWITCHES SHOWN FULL CLOCKWISE POSITION.
2. CAPACITOR VALUES ARE PF IF WHOLE NUMBERS AND OF IF DECIMAL NUMBERS, UDS.
3. #D1-D4 ARE ON HV POWER SUPPLY.

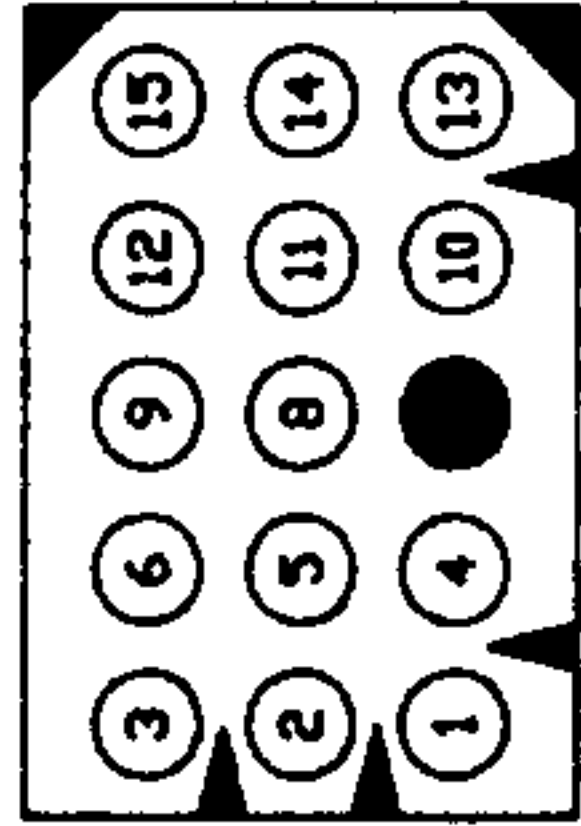


POWER SUPPLY SCHEMATIC FOR REFERENCE ONLY.  
REFER TO HV/PS & LV/PS BOARD SCHEMATICS FOR DETAIL.

FIGURE 5  
SIMPLIFIED CHASSIS DIAGRAM

NOTE: ALL DECIMAL CAPACITANCE VALUES ARE IN  $\mu\text{F}$ ; DISC CERAMIC

D8-11=1N270  
 R1-14=220K/2W  
 C1-7=350 $\mu\text{F}$ /450V



J3 PINS AS VIEWED FROM TOP OF BOARD

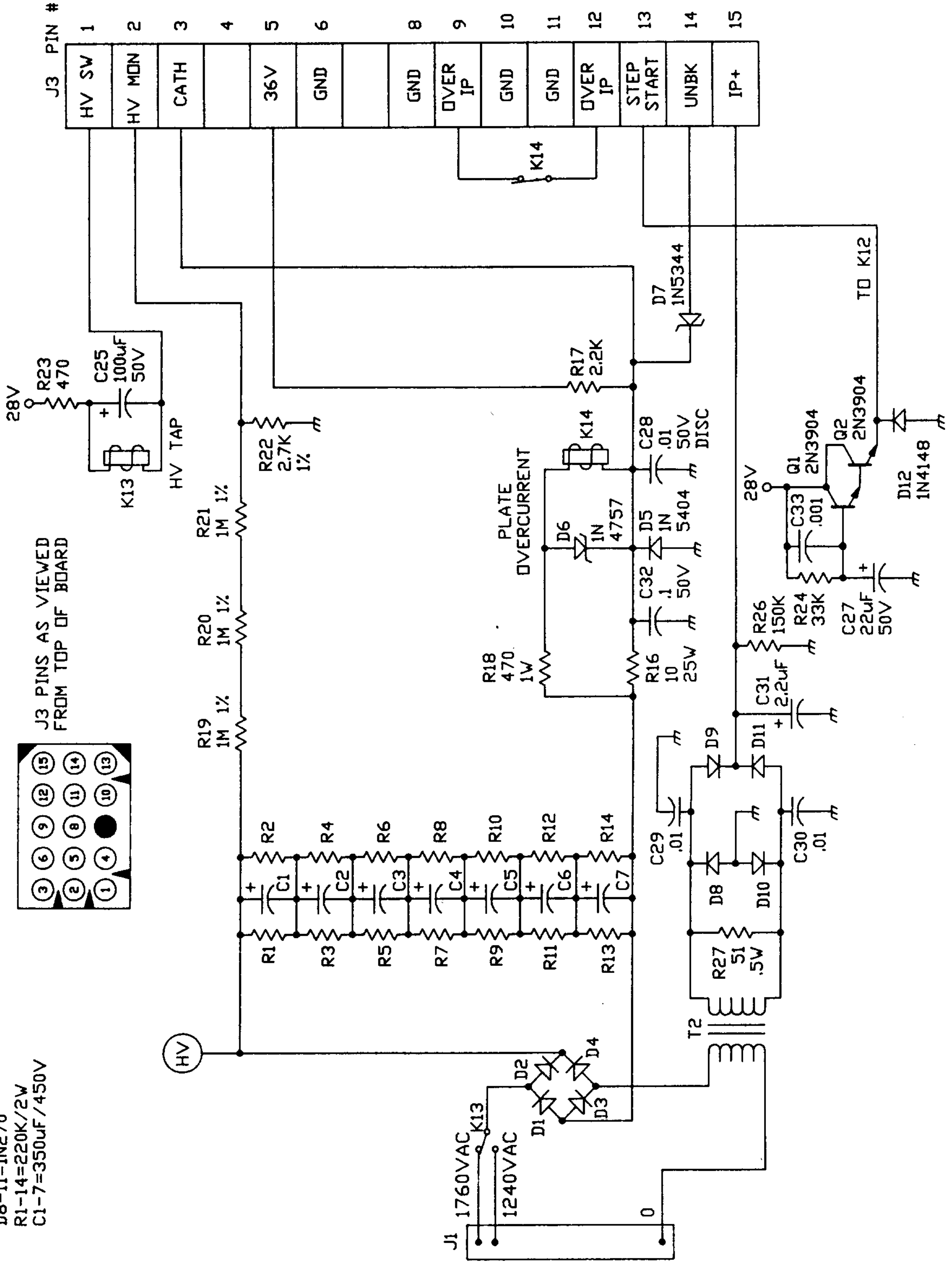
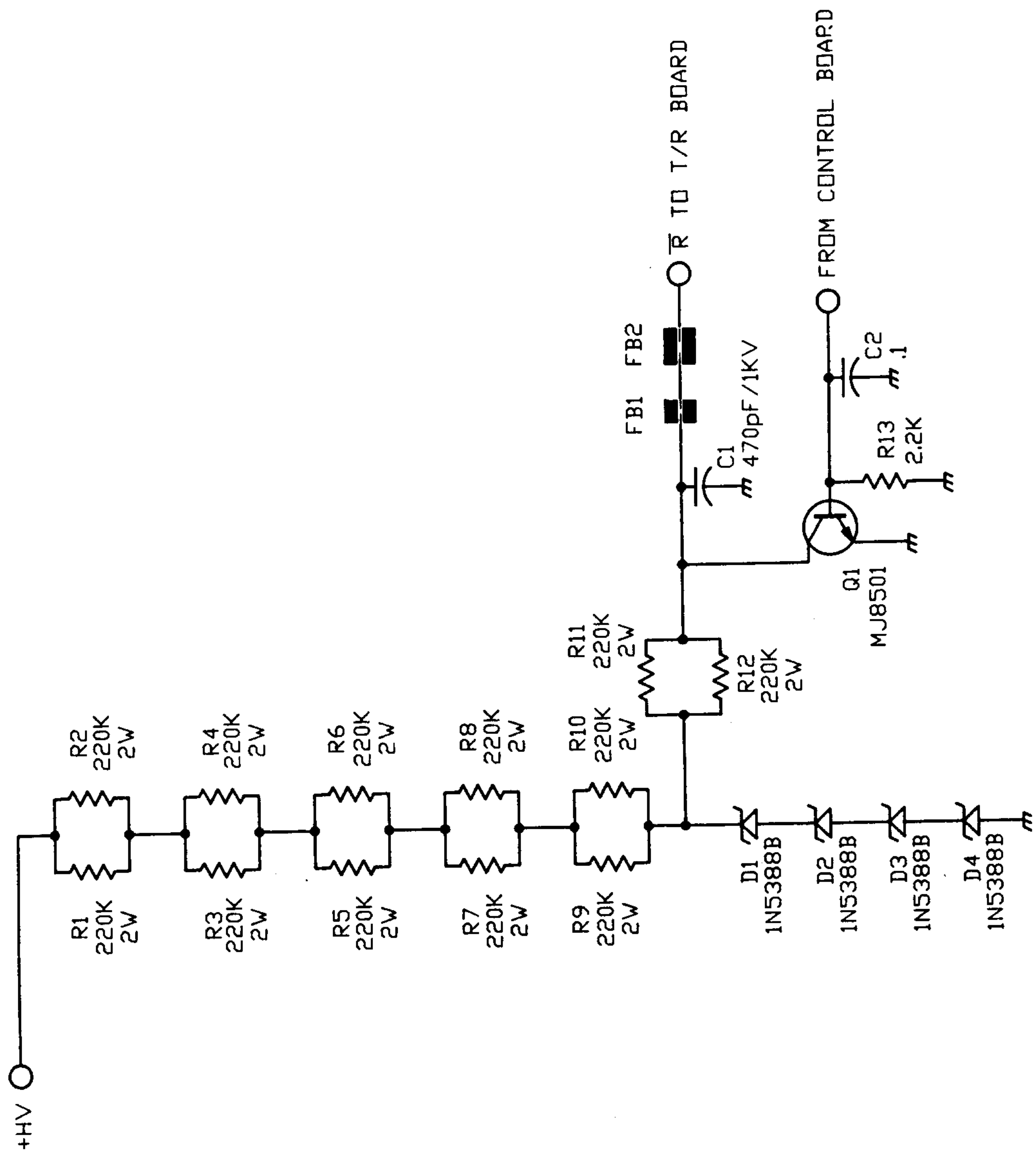
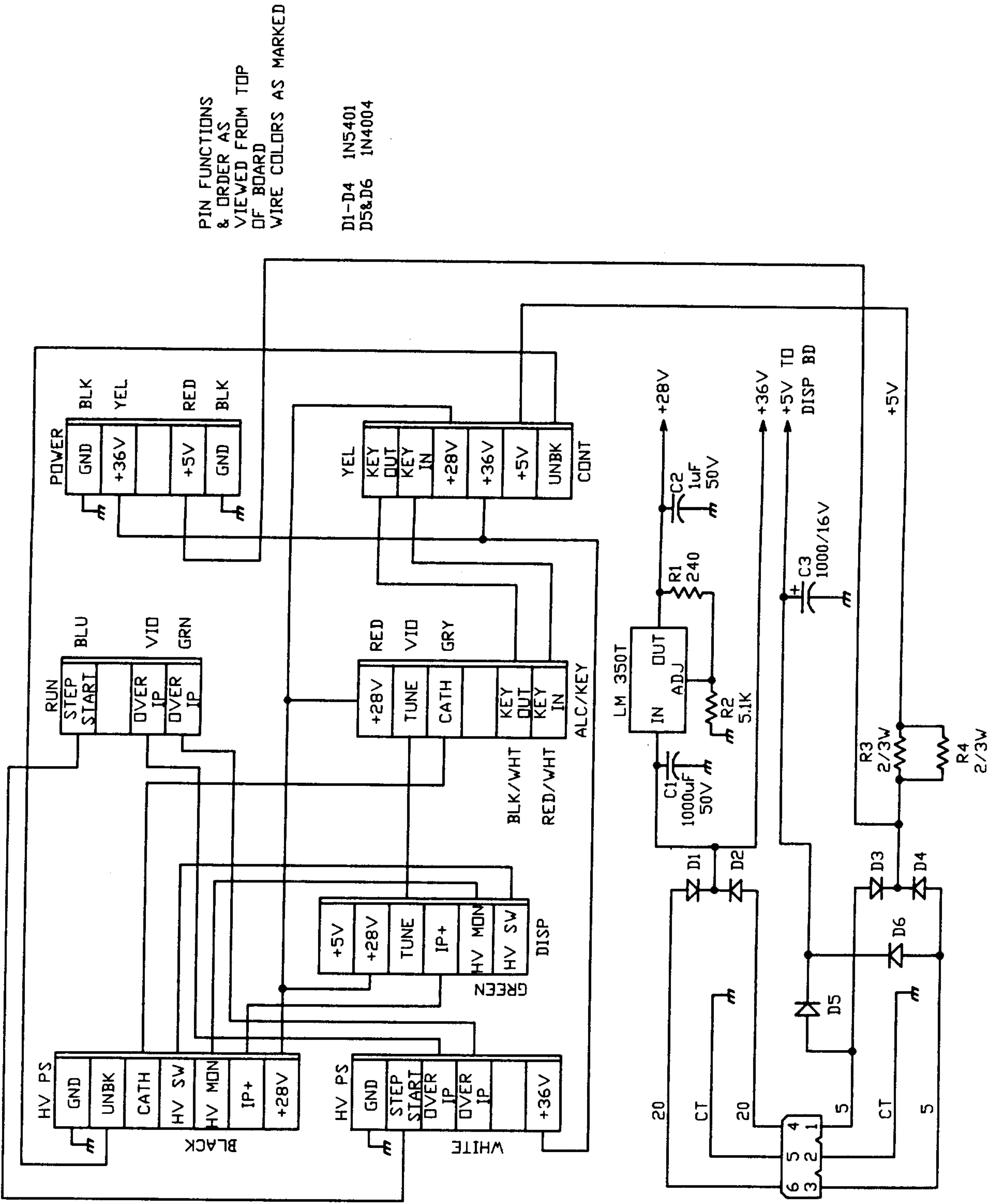


FIGURE 6  
 HIGH VOLTAGE POWER SUPPLY



**FIGURE 7**  
**RECEIVE PIN BIAS**

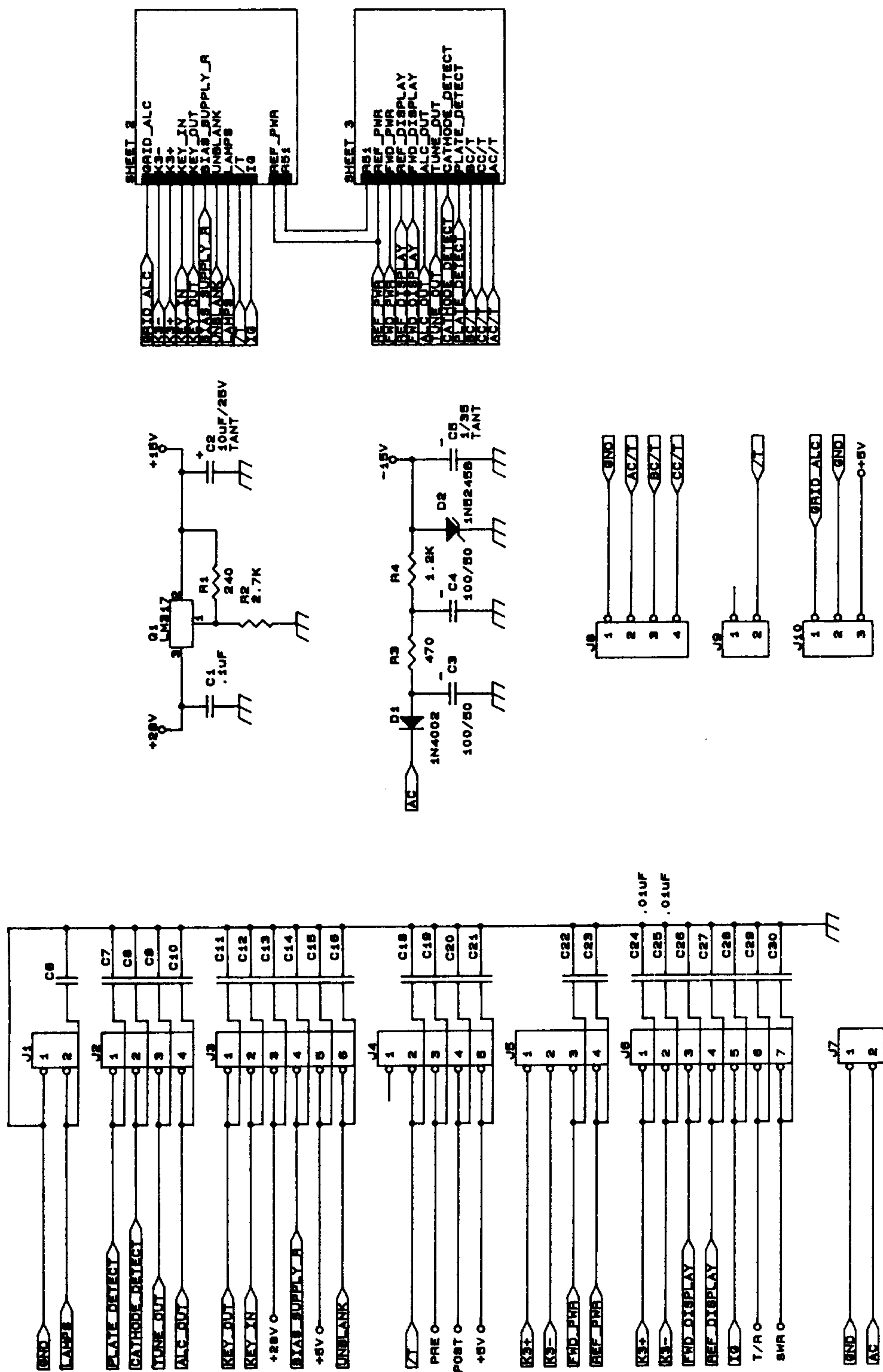


PIN FUNCTIONS  
& ORDER AS  
VIEWED FROM TOP  
OF BOARD  
WIRE COLORS AS MARKED

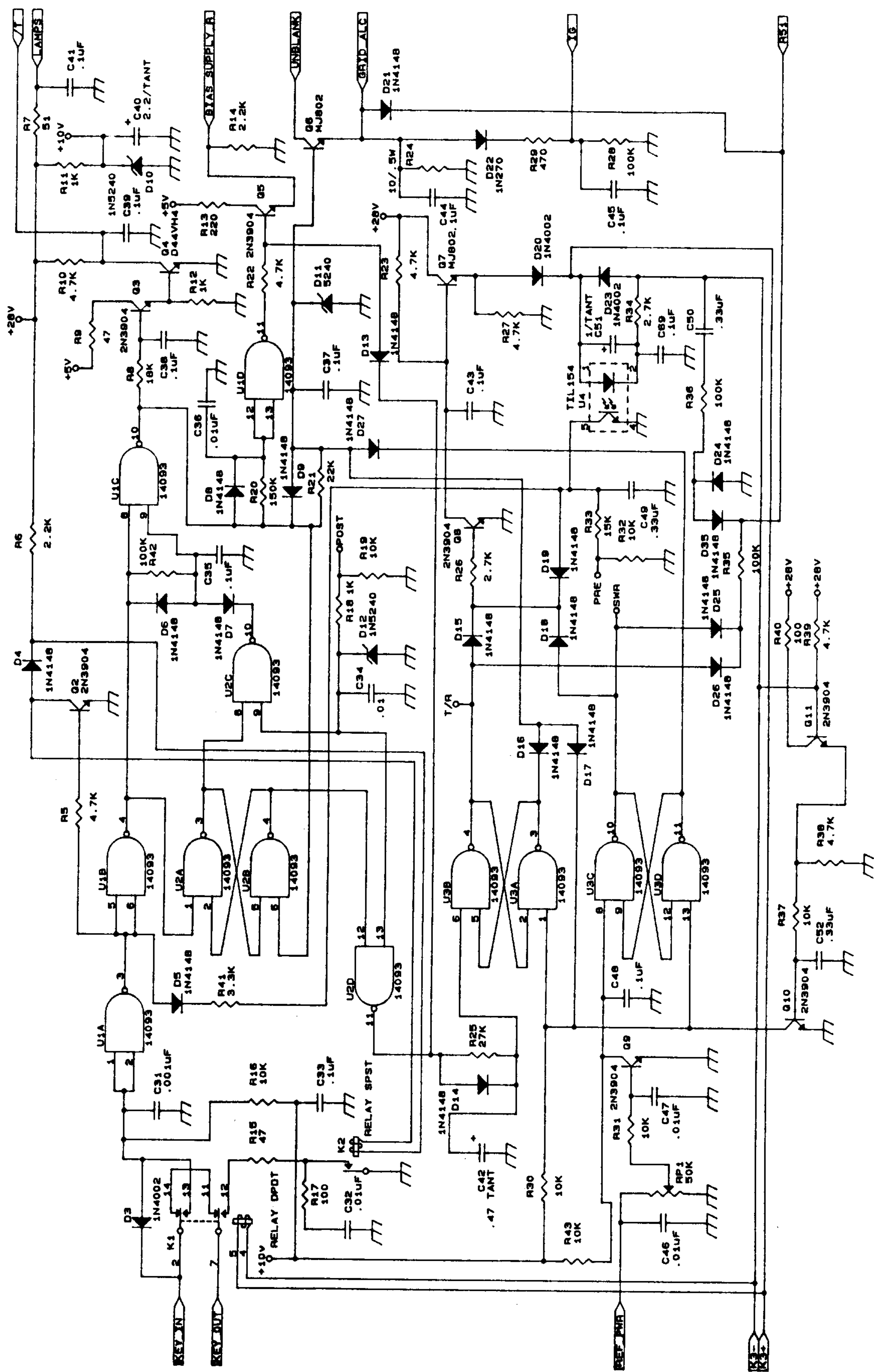
D1-D4 1N5401  
D5&D6 1N4004

**FIGURE 8**  
**Low Voltage Power Supply**

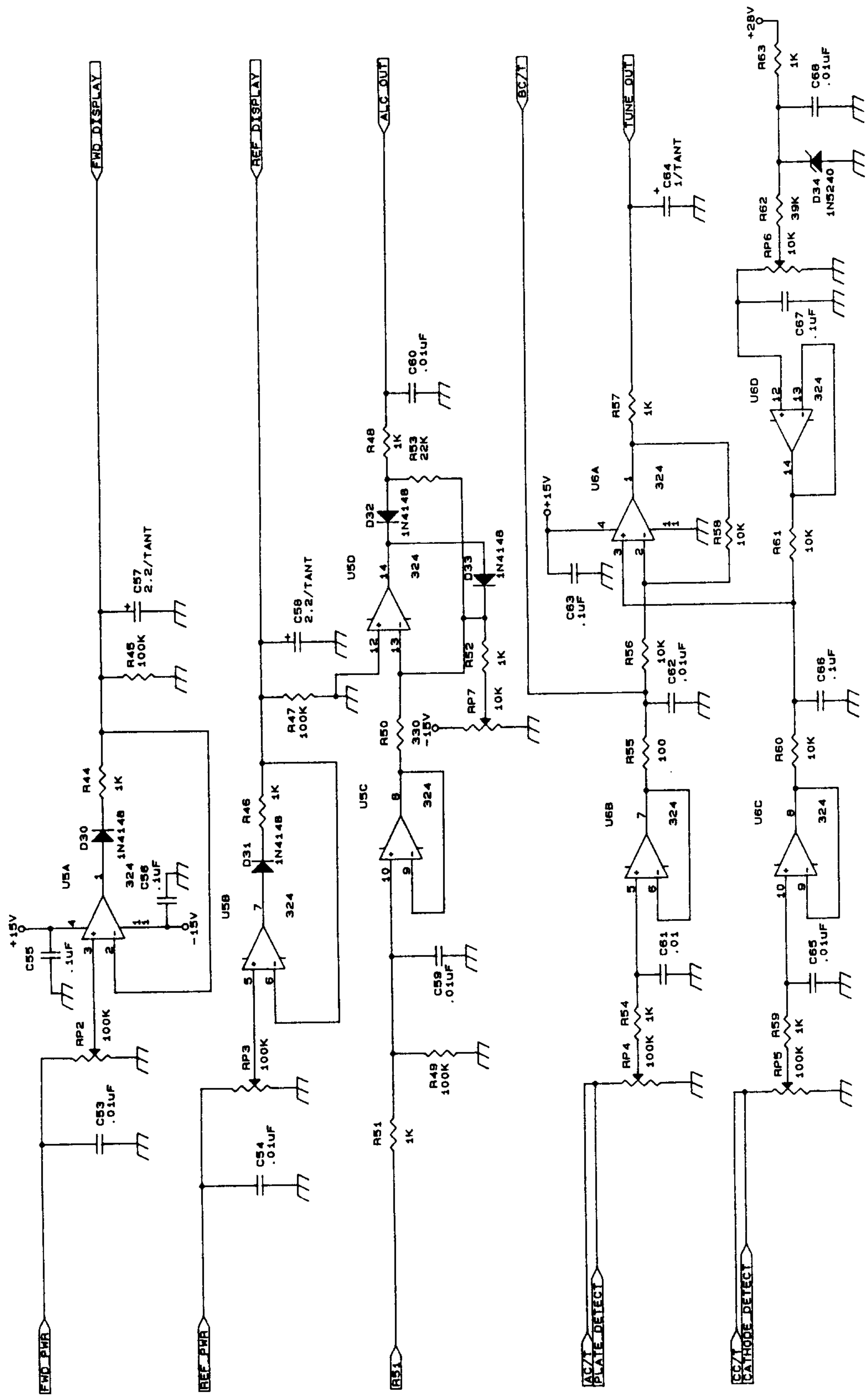
FIGURE 9  
CONTROL BOARD  
(SHEET 1 OF 3)



NOTE: ALL CAPACITOR VALUES 0.1uF UNLESS OTHERWISE INDICATED



**FIGURE 10**  
**CONTROL BOARD**  
**(SHEET 2 OF 3)**



**FIGURE 11**  
**CONTROL BOARD**  
**(SHEET 3 OF 3)**



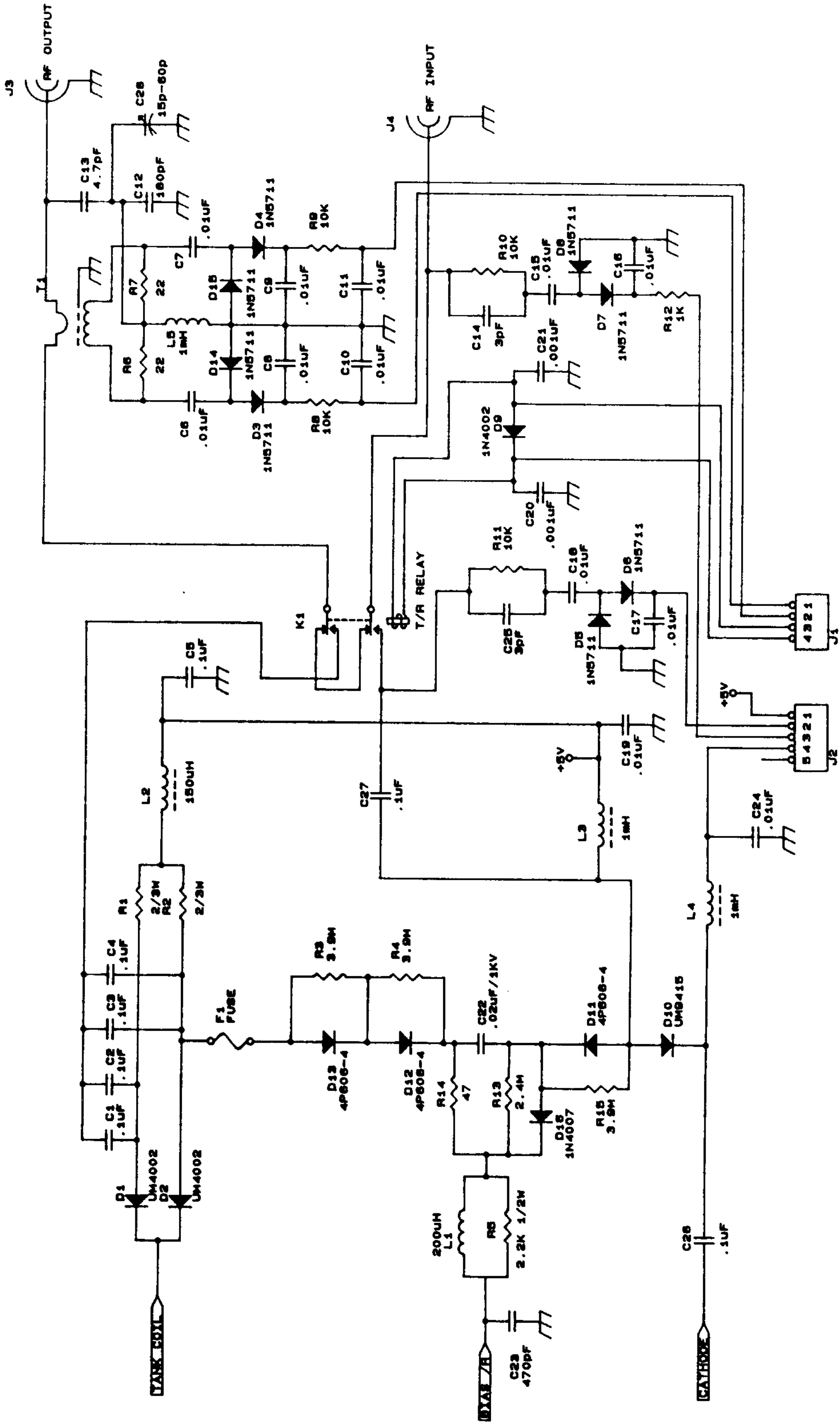
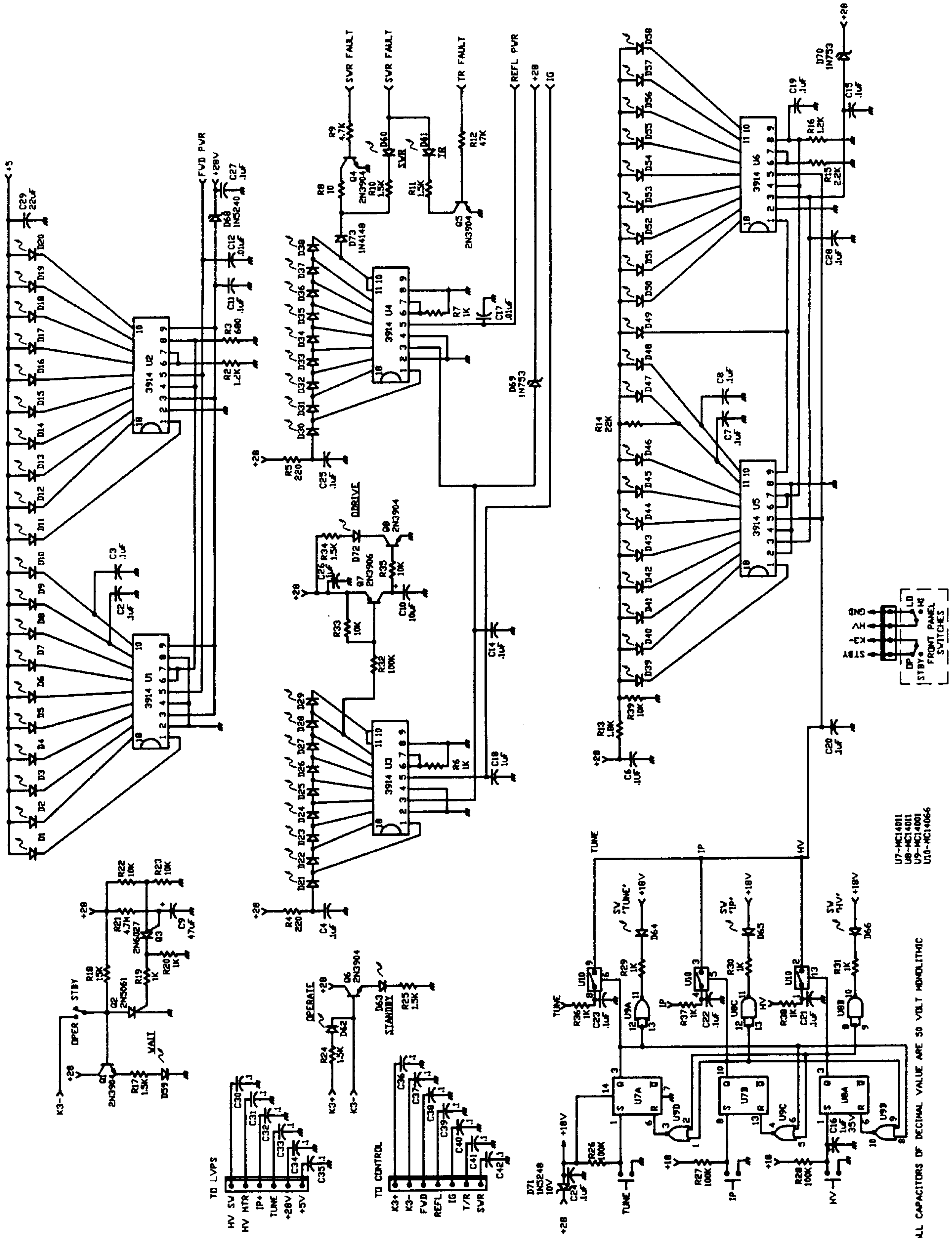


FIGURE 12  
T/R BOARD



U7-MC14011  
 U8-MC14011  
 U9-MC14001  
 U10-MC14066

ALL CAPACITORS OF DECIMAL VALUE ARE 50 VOLT MONOLITHIC

FIGURE 13  
 DISPLAY BOARD

NOTES:  
 1. 10M POSITION AVAILABLE ON EXPORT MODEL ONLY.

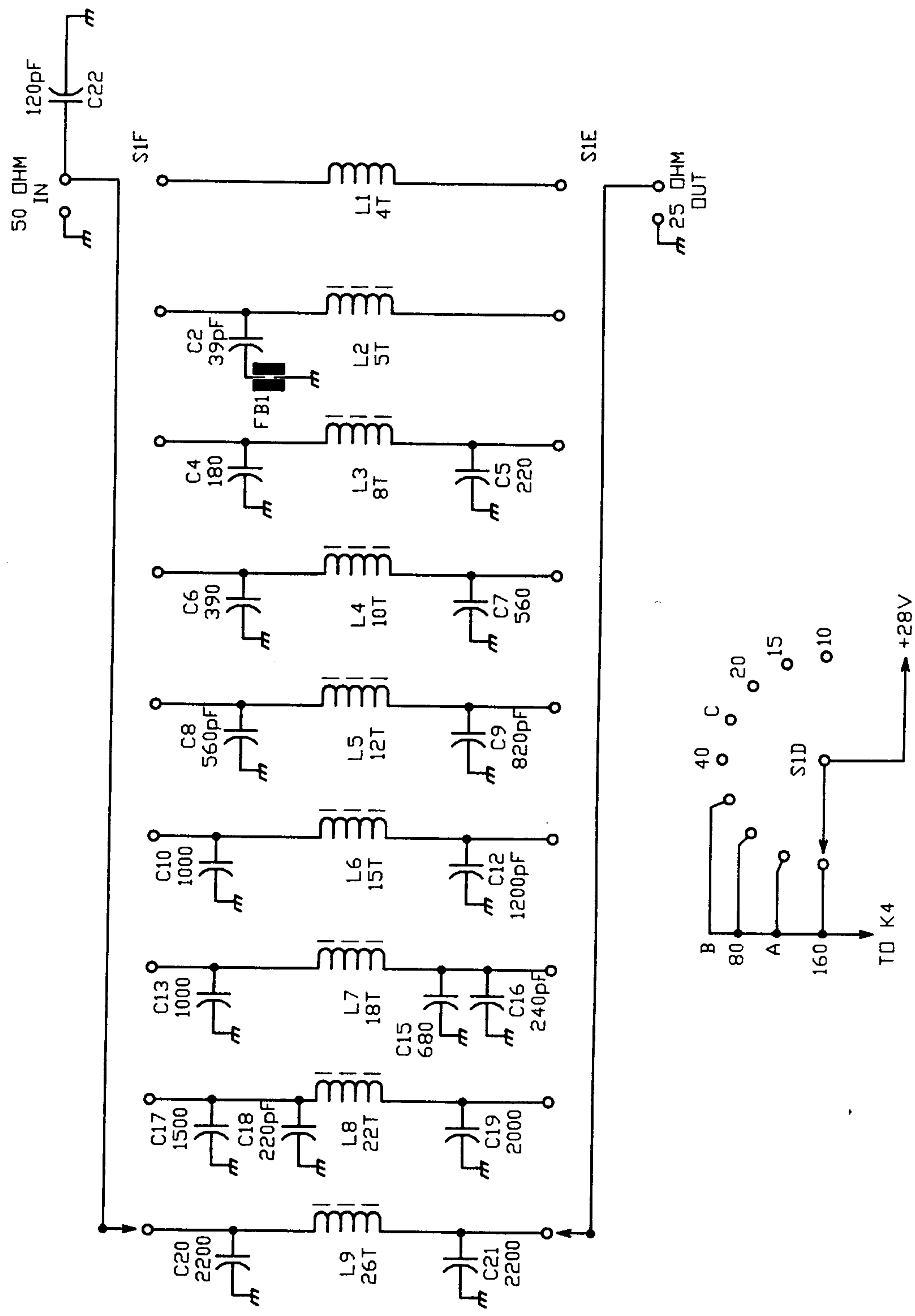


FIGURE 14  
 INPUT MATCHING NETWORK

# **K4XL's** **BAMA**

This manual is provided **FREE OF CHARGE** from the "BoatAnchor Manual Archive" as a service to the Boatanchor community.

It was uploaded by someone who wanted to help you repair and maintain your equipment.

If you paid anyone other than BAMA for this manual, you paid someone who is making a profit from the free labor of others without asking their permission.

You may pass on copies of this manual to anyone who needs it. But do it without charge.

Thousands of files are available without charge from BAMA. Visit us at <http://bama.sbc.edu>