ARRL Handbook CD

Template File

Title:	50-W Power Amplifier
Chapter:	17
Topic:	An HF 50-W Linear Amplifier

Template contains:

Additional text.

Mechanical drawings.

Component layout drawings.

Photos.

PC board etching patterns.

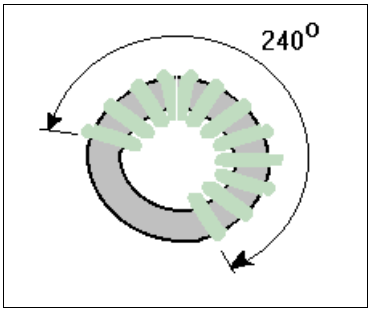
An HF 50-W Linear Amplifier -- Template Package

1995 *Handbook* Errata:

- R19--connects directly from pin 1 to pin 6 of U3 (correct on component layout and etching pattern, incorrect on schematic).
- R14, R20 & R32 are 470 Ω.
- R15 & R16 are 2200 Ω.
- The parts designators on the forward and reflected branches of the directional coupler circuit (the lower half of p 17.95) should be transposed from R25 and R27 through terminals F and G. That is, transpose R25 and R27, D6 and D7, C51 and C52 and so on.

Construction

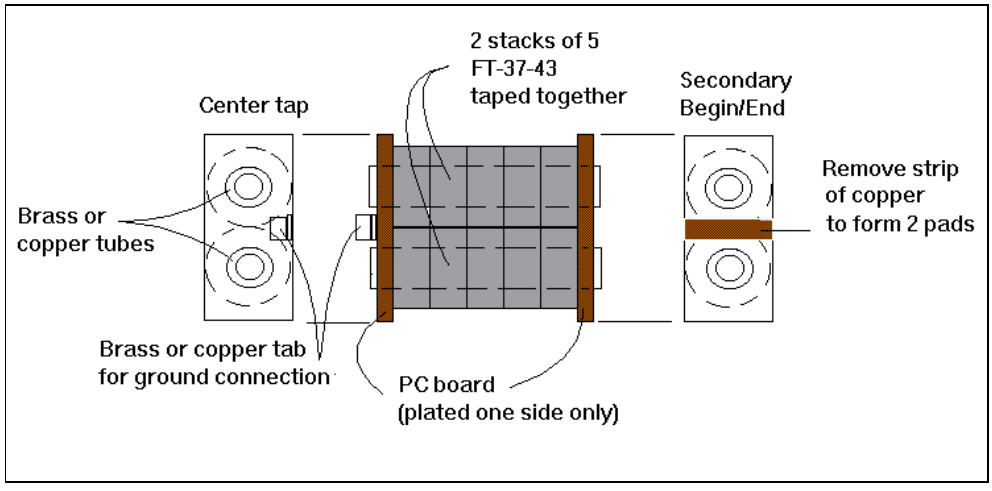
Low-pass Filter Boards



Wind all of the toroids as described in Table 1. The angle given is the arc covered by the winding. Space the turns evenly across this perimeter. Observe the winding direction. Keep the wire taut while winding so that the turns lie snug against the core, but take care not to damage the wire insulation. Mount each coil to the circuit board immediately after winding (to prevent mix ups). Fig 6 provides layout information for both low-pass filter boards. Trim and form the leads so they are short and direct when mounting components to the boards.

Trim and form the silver mica capacitor leads, double check the value of each, and solder it to the board.

Input Transformer T1



T1 can be fabricated if the builder does not choose to buy the ready-made unit. Make the core by taping two stacks of 5 FT37-43 ferrite toroid cores together (10 total). The low-impedance secondary may be made by inserting two brass or copper tubes through each core stack and connecting the ends on one side with flashing copper to form the center tap. Be sure to leave a tab on the center tap for connecting to the circuit board. Make two similar tabs for the secondary connections on the other end of the cores. Wind three complete turns through both cores with Teflon insulated AWG #22 stranded wire. The wire ends should extend out of the core end with the center tapped secondary.

DC Feed Transformer T2

Wind six turns of bifilar or twisted pair AWG #28 enameled magnet wire on the FT50B-43 ferrite core. Observe the phasing dots shown in the schematic when connecting to the circuit board. The

feedback winding is a single turn of insulated wire through the core and connected directly to the tops of R21 on one side and R23 on the other side. The resistors are mounted in a vertical position to allow the shortest possible length of wire in the feedback winding, to serve as a terminal post supporting the feedback winding and the compensation capacitor C10.

Output Transformer T3

This transformer may be constructed identical to T1 except each of the two stacks of cores are made with six FT37-43 toroidal cores.

Directional coupler transformers (T4 & T5)

Wind 32 turns of AWG #22 enameled wire on two stacked T68-10 (Red) cores for each transformer. Windings will be close spaced on the inside of the core. Space the wire evenly on the outside of the core. Observe the winding direction shown by polarity dots in the schematic. When mounting the cores to the main board, observe that the grounded end of the winding proceeds around the bottom of the core. It is also very important to follow the correct winding sense otherwise the directional coupler will not function correctly. The inductance of the windings will be approximately 11.7 μH.

Prepare two pieces of miniature Teflon coax as shown in Fig 8B & 8C, and install in the toroid transformers as shown in Fig 7. Observe the Faraday shield grounding. Ground only the shield ends shown in the schematic and Fig 7 for proper operation. If the transformers are constructed properly, the coupling will be very close to 30 dB and the directivity approximately 20 dB in the HF band.

Special Meter-Shunt Resistor

R5 is constructed by cutting exactly 4.13 inches of AWG #22 enameled wire and stripping the ends for 1/8-inch. Wind the wire around a 1/8-inch drill bit. Adjust the winding until the ends are in the proper position for mounting to the PC board. Do not allow the ends to protrude through the PC board excessively. The resistor thus constructed will be 5.667 milli-Ohms. Connect the wires going to the meter to the legs of R5 immediately above the hole in the printed wiring board. Check the accuracy of the current meter with a known calibrated dc ammeter and adjust the length of wire in R5 accordingly if the readings do not agree.

A Wattmeter Scale for the Meter

The front of the Radio Shack Meter is easily removable. Be extremely careful to not touch the needle or meter movement mechanism. Wattmeter calibration marks may be carefully made with a fine tip permanent ink pen and a steady hand. Here is the data for the scale markings:

RF Power	10 W	20 W	30 W	40 W	50 W	60 W	70 W	80 W	90 W	100 W
Meter Scale	3.85	5.93	7.24	8.61	9.78	11.02	12.52	13.24	14.09	15.00

Main Amplifier Board Assembly

Mount the two relays first because some modification of their mounting holes may be necessary due to variations in the mounting tolerances. Next mount all parts except for the Q1, Q2, U1, T4 and T5. Double check that all components are properly located and soldered. Check that all ground leads are soldered both top and bottom. Check for solder bridges or solder "splashes." These will spell disaster later if not cleaned off now.

The following components are lap soldered to top of the circuit board with an absolute minimum lead length: C2, L3, R1, R2, C3, L4, R4, and R3. Resistors R21 and R23 are mounted in a vertical position and lap soldered to the board. Silver mica capacitors C1 and C9 are soldered directly to the secondary of transformers T1 and T3 respectively with an absolute minimum of lead length. Resistor R32

has one end lap soldered to the +12 V pad near R5; the other end connects to the anode of the power on LED, D8.

Install jumper wires as shown on the layout.

Diode D2 must be mounted with its cathode lead cut very short and soldered to a small solder lug. The solder lug is then mounted under the 6-32 screw that mounts Q2 thus grounding D2 cathode and ensuring good thermal coupling to the diode. D2 tracks the temperature of Q2 and temperature compensates the base bias current to the RF transistors.

Chassis Assembly

The amplifier is designed around the Hammond 1590E die cast aluminum box. This box is rugged, RF tight, and is easy to drill accurately. Follow the dimensions given in Figs 2, 3, and 4 to drill the front, rear, and side of the box. Note that the locations are given from specific points of reference since the box sides are tapered. No mechanical dimensions are given for the top since it is preferable to use the main PC board as a template to locate the mounting holes. Drill the four corner mounting holes to 1/8-inch diameter for no. 4 screw. Install the connectors on the rear panel. Check the main board for fit in the chassis and correct any problems. Install the directional coupler toroids. Trim all protruding leads on the ground plane side of the board off flush. Next solder Q1, Q2, and U1 (the TO-220 devices) to the board and temporarily mount the board in the chassis. Mark the mounting holes for these three semiconductors and drill 9/64-inch diameter holes for no. 6 screws.

Install the main board in the chassis with 4-40 screws at the four corners using no. 6 hex nuts to space the board off the chassis. This prevents shorting out protruding component leads. One or two large flat aluminum or copper washers must be used under Q1, Q2, and U1. Use thermal grease sparingly on the chassis, both surfaces of the washers and the bottom of the power devices.

Bandswitch Assembly

Assemble the band switch per Fig 5. Install the bandswitch and connect the LPF boards. Color coded wire will help identify the bands and their connections via the band switch. Install 2-inch leads on the input and output pads on each low-pass filter board. Assemble the bandswitch using a 3/16-inch spacer between the detent and the first switch wafer. Use the white washers at each end of a ceramic spacer in the switch. Install the first wafer with the contacts away from the detent. Next, mount 2 ea. 9/16-inch and 2 ea. 1-inch ceramic spacers with washers on each switch screw and then mount the second wafer again with the contacts pointing away from the detent.

Note that both wafers must be mounted with their common terminal located in the 9 o'clock position when the switch is viewed from the knob end with the locator tab held in the 12 o'clock position. Refer to Fig 5. Contact no. 6 for band 6 is defined as located at approximately the 10 o'clock position. Going clockwise, contact 1 is next, then contact 2, and so on. Measure the knob shaft depth and cut the switch shaft to length and likewise the switch assembly screws. Hold the waste end of the shaft and screws in a vise when cutting to avoid damage to the delicate switch mechanism.

Low-pass Filter Assembly

Assemble the two low-pass filter boards with the 3/16-inch hex post spacers. Use 1/2-inch spacers mounted to the corners next to the band 6 filter. Insert a solder lug between the post and the 2-inch post extending to the opposite board holes near the band 1 filter. The hex posts on the other side are composed of two each 1 1/4-inch posts or other combinations to achieve a 2 1/2-inch total length.

Temporarily insert the bandswitch into the center of the filter assembly and insert the whole thing into the chassis to check for fit. Use no. 8 hex nuts for spacers between low-pass filter board #1 and the chassis side wall. Snug the switch mounting nut. Next position the leads from each low-pass filter to their proper switch terminal and trim to length. Solder all accessible leads then remove the entire assembly from the chassis to complete wiring the bandswitch. The solder lugs on the hex posts should be

positioned approximately 1/2-inch from the common terminal of each switch wafer. Check that none of the switch wafer terminals touch the hex posts.

Mount the meter selector switch. This switch is an eight position switch of which only the first six positions are used. The unused terminals also happen to slightly interfere with the edge of low-pass filter board #2. Cutting these contact lugs down will alleviate the mechanical interference. Mount and wire the meter switch, meter, main board and rear panel connectors. Lastly, install the completed low-pass filter assembly and connect the input and output coax cables to the ground lugs and the common terminals of the switch wafers. Fig 8a. details dimensions of the coax cable between the PA output and the low-pass filter input.

Initial Check-Out and Adjustments

Connect a signal generator to the filter assembly input and a 50-Ohm load and RF voltmeter to the output. Check for low loss in the pass-band (less than 0.5 dB) of each band. Test for the pole frequencies given in Table 1 for each filter. The elliptic function filters will exhibit a sharp peak in stop-band attenuation at the pole frequencies. The filters will each have two pole frequencies except band 4 will have three. The first pole frequency listed is due to the first parallel resonator (closest to the filter input); the second frequency is associated with the second resonator.

If the measured pole frequencies are not within a one or two percent of the correct frequency, the associated resonator does not have the correct value of capacitance and/or inductance. If you are off a little on bands 5 or 6, some tweaking of the turns spacing on the toroid may be required (assuming the capacitor value and toroid turns are correct). Do not attempt to detect incorrect values of the shunt capacitors until you are sure all parallel resonators are tuned to the correct pole frequencies. Otherwise you can get caught in a confusing "chicken-and-the-egg" situation.

After initially checking for shorts with an ohmmeter, connect a 12 V supply to the amplifier. Initially set R7 (Bias Adj) and R17 (Reflected power protection threshold) both fully counter-clockwise. Ground the PTT line (J3) and observe that both K1 and K2 relays operate satisfactorily and that no current is displayed on the meter.

Next connect an external 50 to 100 W HF transmitter through a wattmeter to RF input (J1) and a wattmeter and dummy load to the RF output (J2). Do not allow the PTT line to ground during this initial high power test of the low-pass filters and the directional coupler. Operate the test transmitter and the low-pass filter in all of the nine ham bands and verify that the filters and internal wattmeter are functioning properly. The input SWR should be very low, the insertion loss should be very low, and the internal directional coupler forward power meter should agree closely with the power measurement from the external test transmitter.

Disconnect the high power test transmitter and substitute the normal 1-2 W QRP transceiver. Without drive, key the PTT line and adjust R7 for a just barely perceptible increase in collector current. Adjust R17 for +3.0 V on U3-1 measured with an external VOM. Start with the low bands first. Key the amplifier by grounding the PTT line and drive the amplifier. Output of 50 W should be achieved on each band with no more than 2 W of drive. Collector current should be 8-10 Amps at 50 W output. Care should be taken not to overdrive the amplifier beyond 50 W as linearity will degrade.

The amplifier is designed for intermittent SSB voice operation. If it is desired to operate the unit in contests or RTTY, then a finned heat sink should be added to the top to the chassis. Be sure to coat both the heat sink surface and the chassis top with thermal grease to in sure good thermal conductivity. The mounting screws for Q1, Q2, and U1 should extend completely through to the finned heat sink.

TABLE 1 LOW-PASS FILTER COIL DATA

Notes:

1. All inductors wound with AWG #22 enameled wire
2. Toroidal Cores: Red = T-68, μ=10
   Black = T-68, μ = 6
3. Number of turns refers to the numbers of times the wire passes through the center of the core.
4. The coverage angle refers to the arc of core circumference occupied by the winding; that is 90° means that one quarter of the core is covered by the winding, with the turns evenly spaced within that area.
5. Inductance is given in μH.
6. The wound cores are mounted with the winding away from the board ground plane.

Ref	*L(μH)*	*core*	*turns*	*coverage*
L11	4.68	Red	28	300°
L12	3.94	Red	25	270°
L13	2.40	Red	19	270°
L14	1.97	Red	17	250°
L15	1.34	Red	14	200°
L16	1.12	Red	11	150°
L17	0.579	Black	11	250°
L18	0.435	Black	9	180°
L19	0.371	Black	8	180°
L20	0.450	Black	9	90°
L21	0.375	Black	8	180°
L22	0.320	Black	6	60°
L23	0.260	Black	5	45°

STOP-BAND POLE FREQUENCIES (FREQUENCIES WITH HIGH PEAK ATTENUATION):

Band	*F1 (MHz)*	*F2 (MHz)*	*F3 (MHz)*
1	4.06	6.78	
2	7.76	12.3	
3	15.7	19.7	
4	20.3	25.3	36.9
5	41.7	68.8	
6	54.2	78.0	

Figure List

Fig 1--The schematic shown in *The ARRL Handbook.*

Fig 2--Chassis box front panel layout.

Fig 3--Chassis box back panel layout.

Fig 4--Chassis box left side layout.

Fig 5--Low-pass filter drawing, front view.

Fig 6--Low-pass filter component layout (2 boards: LPF #1 and #2, both drawn 4/5/95).

Fig 7--Component Layout, Main Amplifier board, Rev A (drawn 4/5/95).

Fig 8--Coaxial cable Dimensions (revised 4/5/95).

Fig 9--PC board cutting pattern (Rev A 6/12/94)

Note: All photos show the original, not Rev A as published. They do not exactly match the Rev A schematic and component layout, yet they may be helpful with some construction details.

Photo A--Interior of chassis box with main amplifier board in place. The filter assembly is not yet in place. J2 is at the upper right. T5 is immediately below J2, and T4 is slightly below and to the left of T5.

Photo B--Same as Photo A, but with the filter assembly in place. The LPF1 board is at right. The mounting screws are not shown here. The 4-40 screws pass through the box wall, a single 6-32 nut (used as a spacer) and the LPF PC board before threading into the 4-40 hex spacers that secure LPF1 to LPF2.

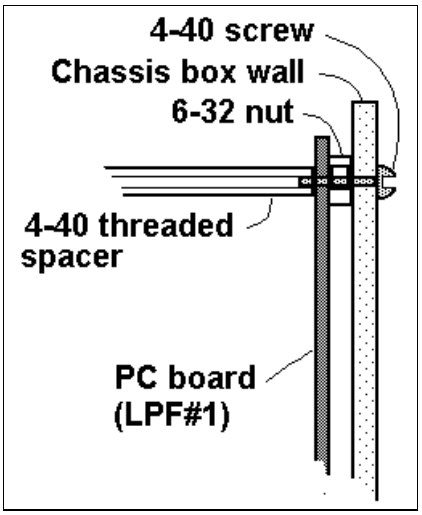


Photo C--View of filter assembly from the front (knob) end. Note that the left PC board (LPF #1) is loose from the spacers. That board will be held in place by the assembly mounting screws.

Photo D--Rear view of filter assembly. LPF #1 is on left.

Photo E--Top view of filter assembly.

Etching Patterns:

Main Amplifier board (component side)

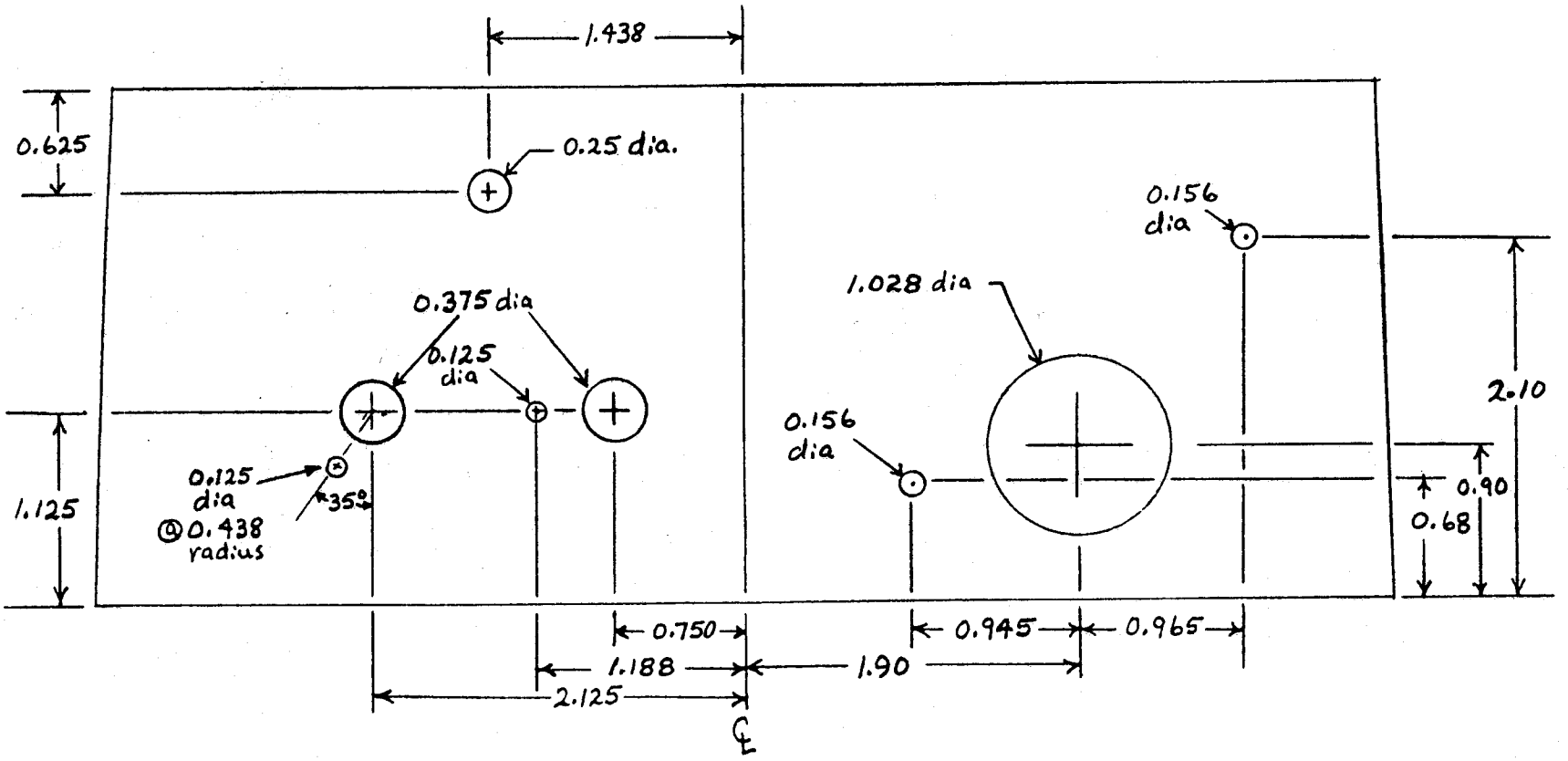
Main Amplifier board (ground plane).

LPF #1 (component side)

LPF #1 (ground plane)

LPF #2 (component side)

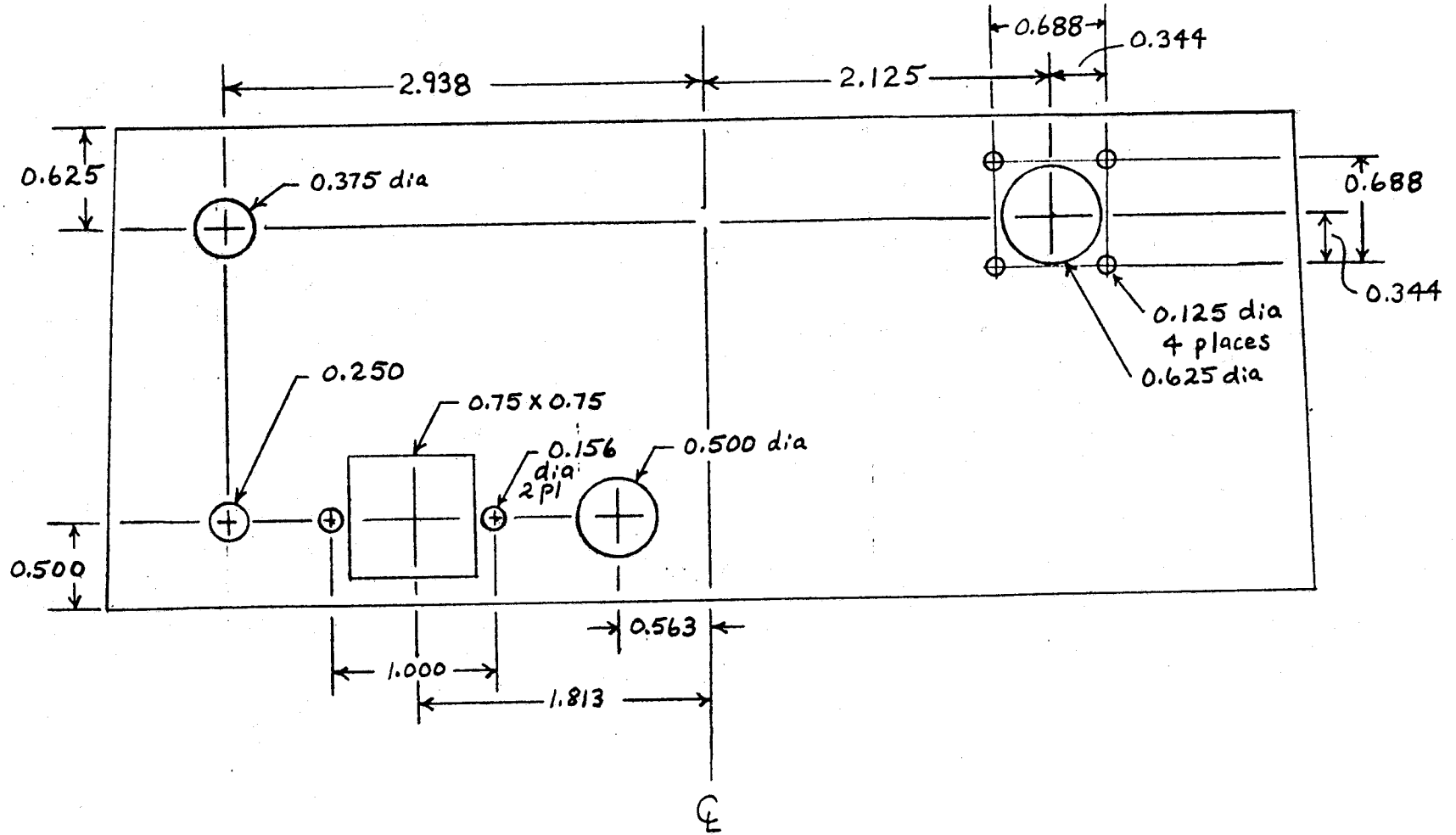
LPF #2 (ground plane)



INCHES

Figure 2, Chassis Front
(open end down)

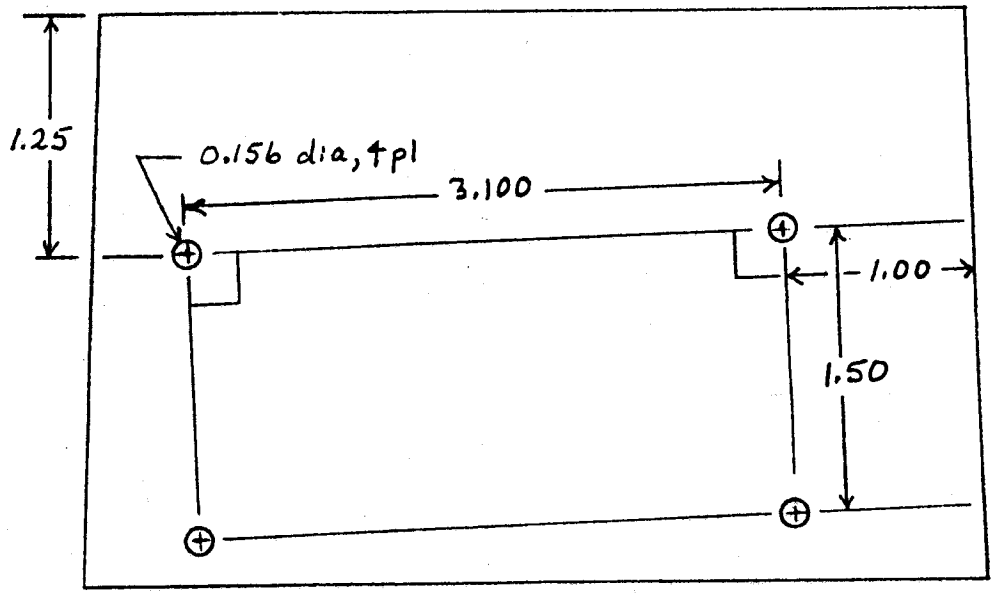
50 Watt PA



INCHES

Figure 3, Chassis Rear
(open end down)

50 Watt PA



Rear

Front

Figure 4, Chassis Left View
(open end down)

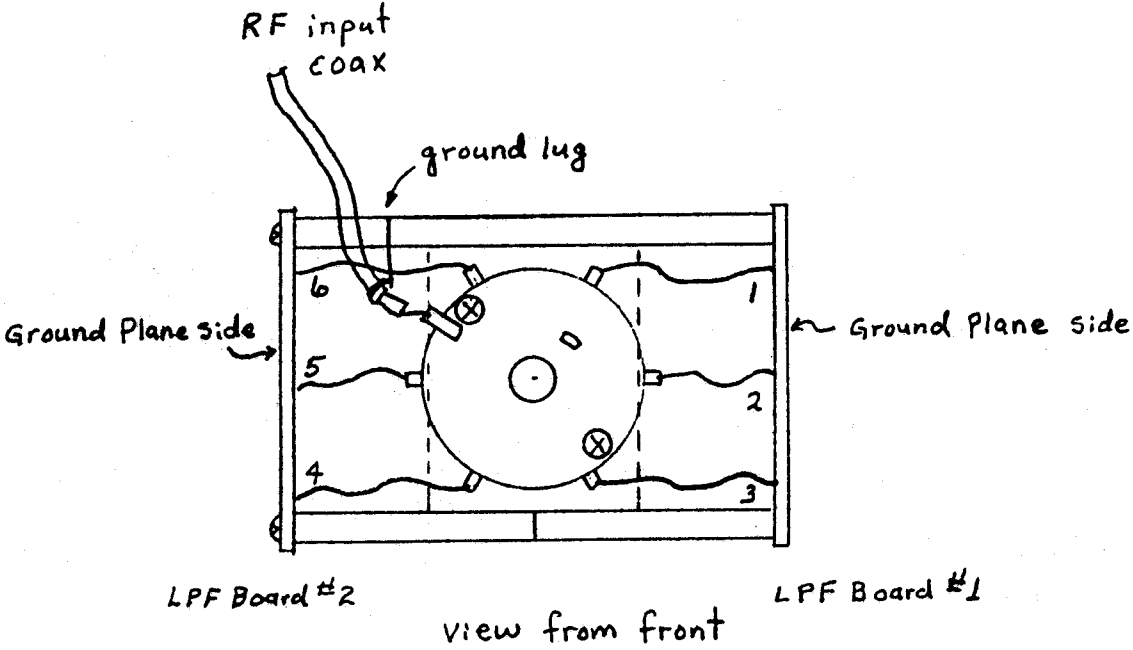
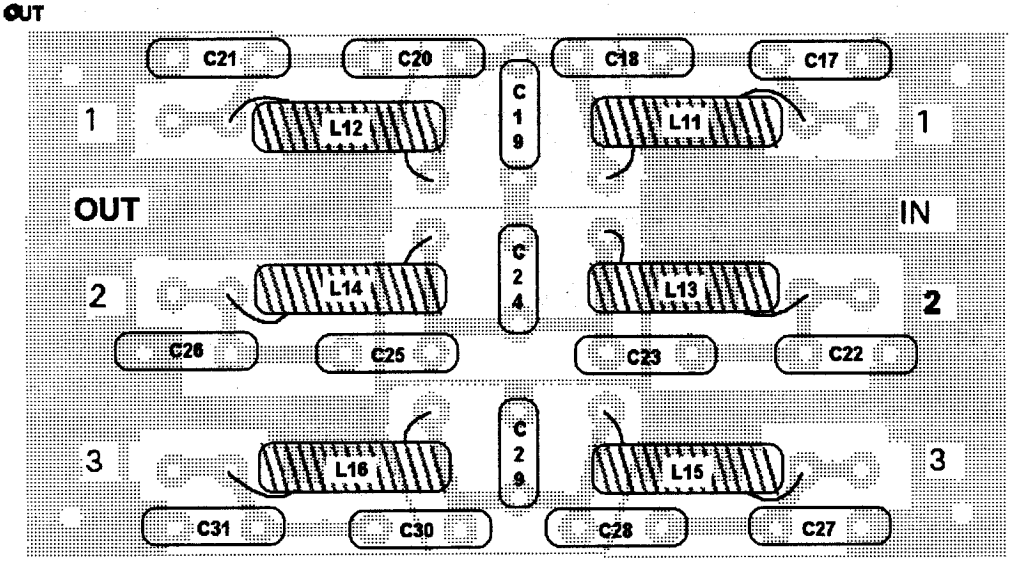
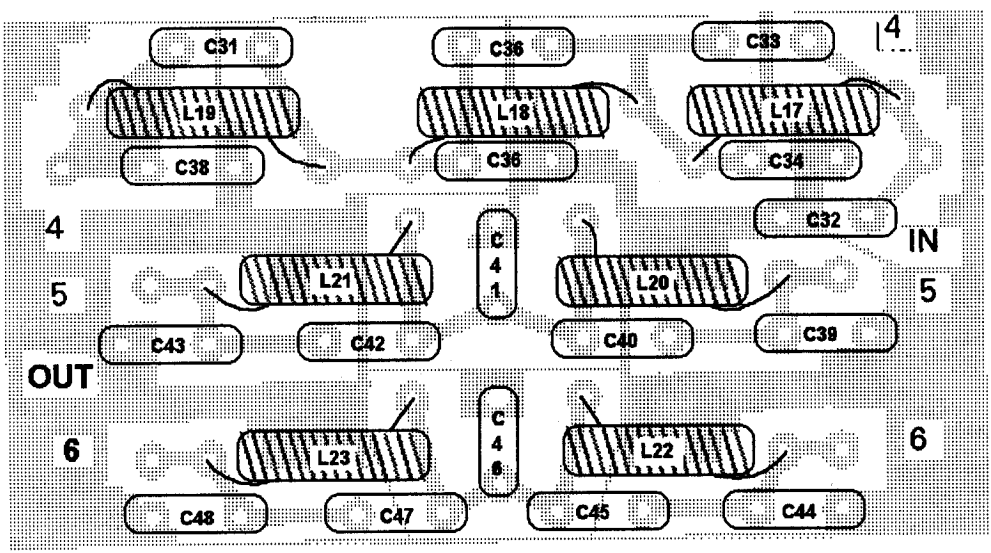


Figure 5, Low Pass Filter Assembly Details



LPF #1 (drawn 4/5/95, KU7G)



LPF #2 (drawn 4/5/95, KU7G)

Figure 6, Component Layout, Low-Pass Filters

50-W PA

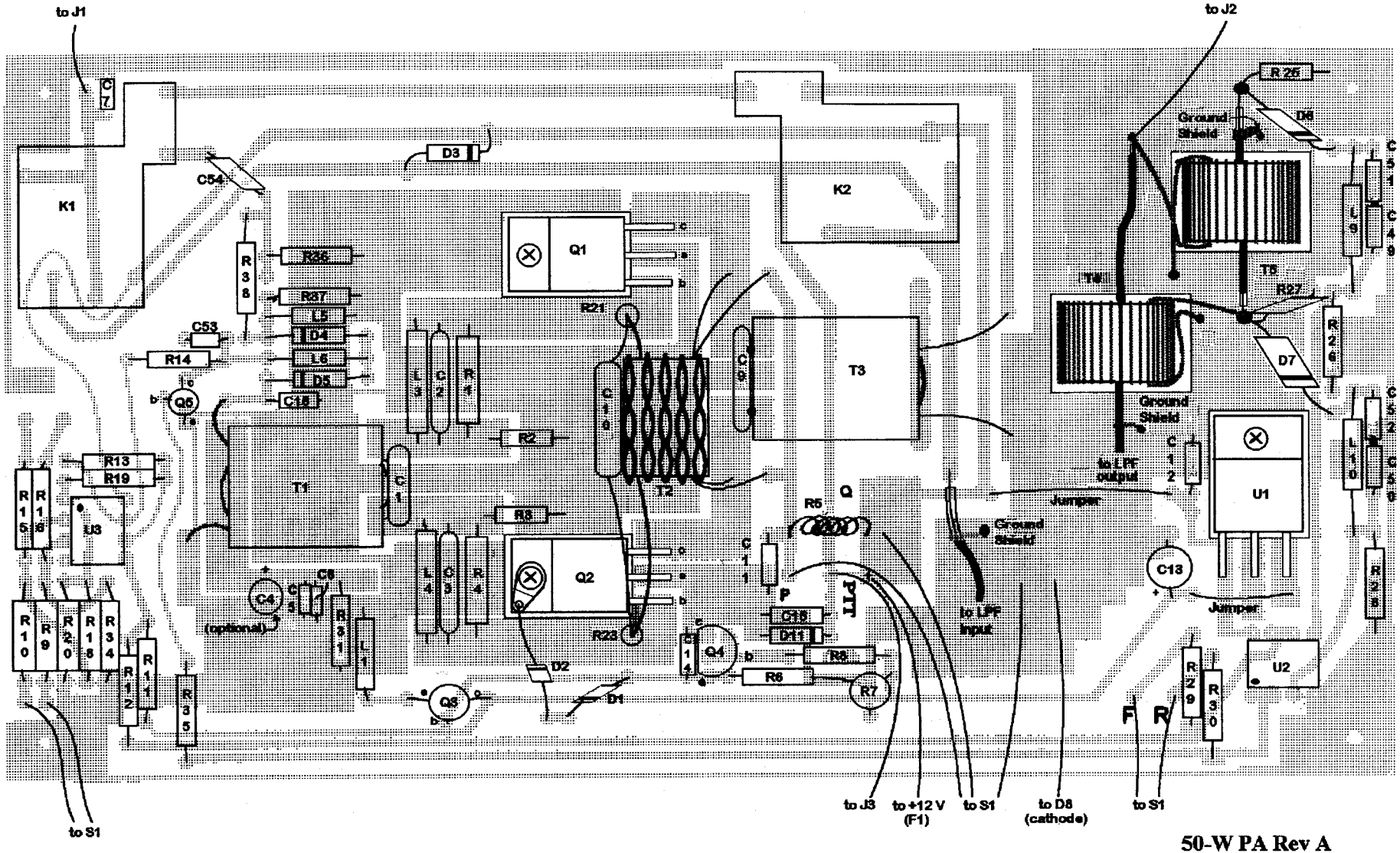


Figure 7, Component Layout, Main Amplifier Board

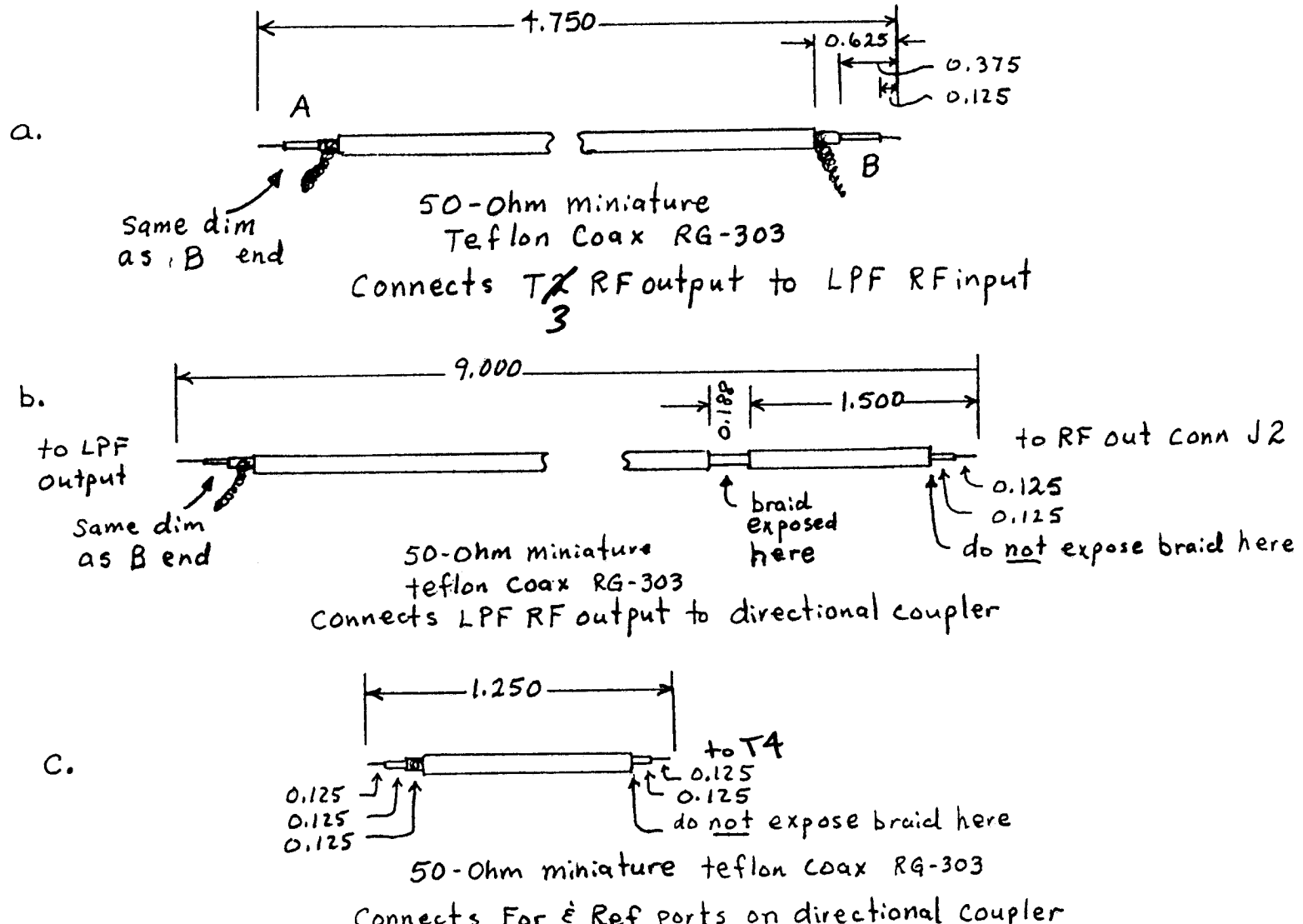


Figure 8, Coax cable Dimensions

Revised 4/5/95 KU7G

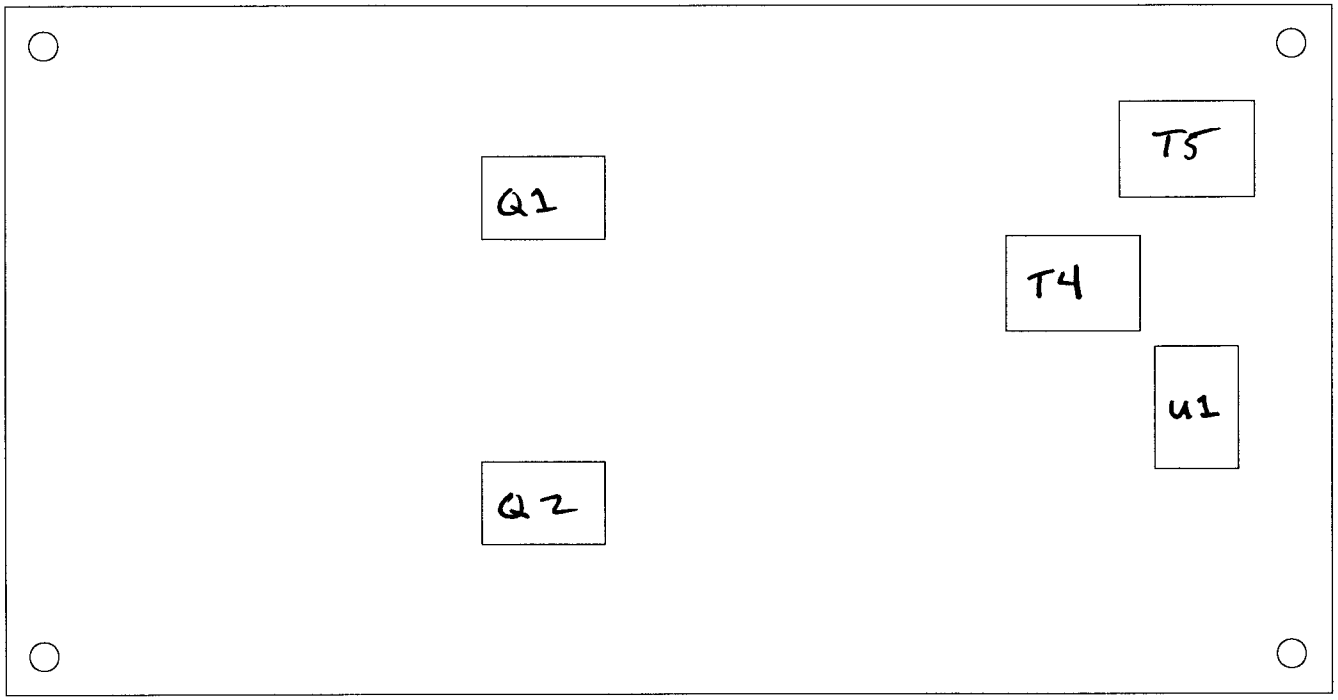


Figure 9,
PC Board cutting pattern

50 Watt PA
Rev A
June 12, 1994

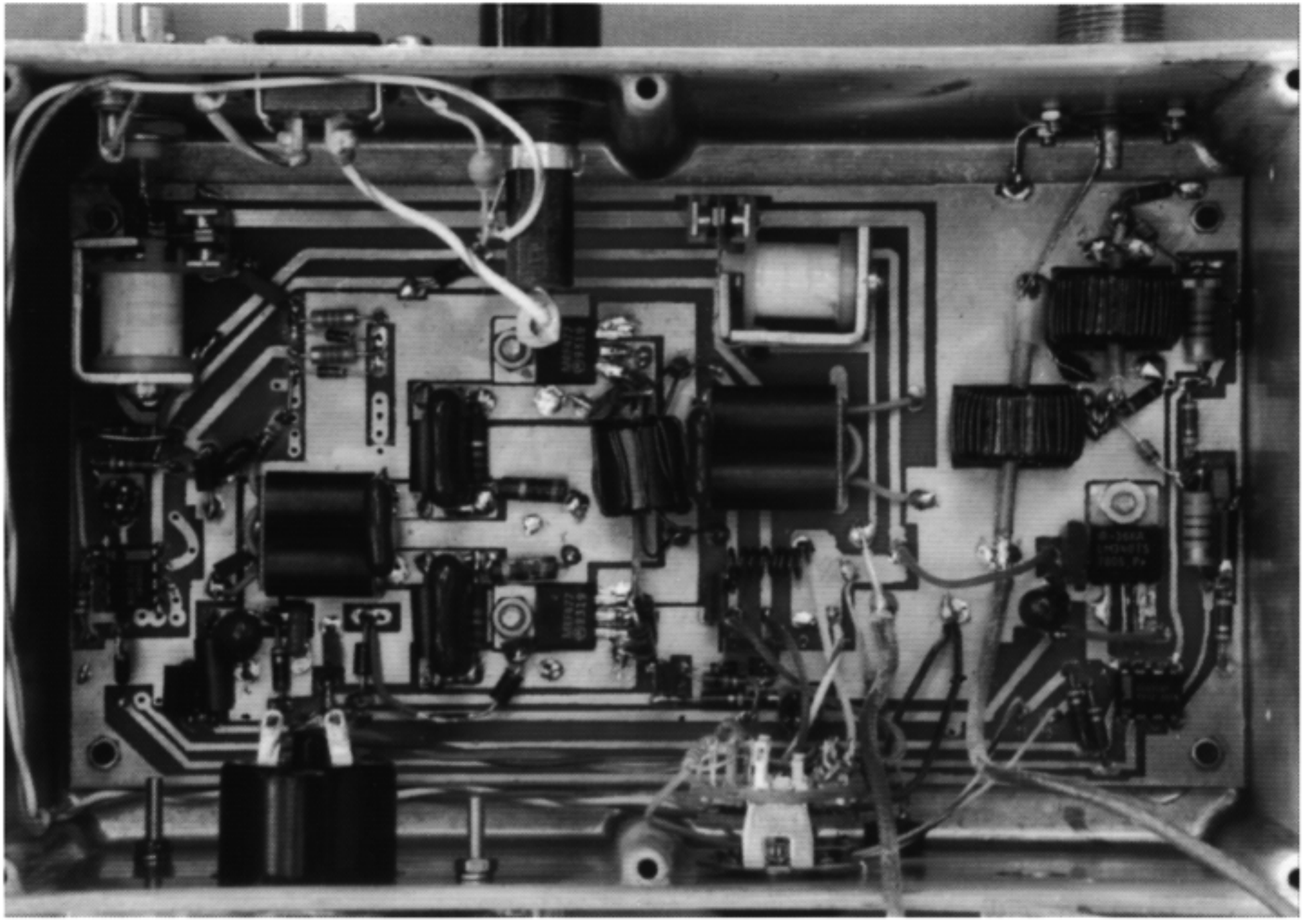


Photo A: ARRL HANDBOOK 50-W PA (HF) NOT REV. A

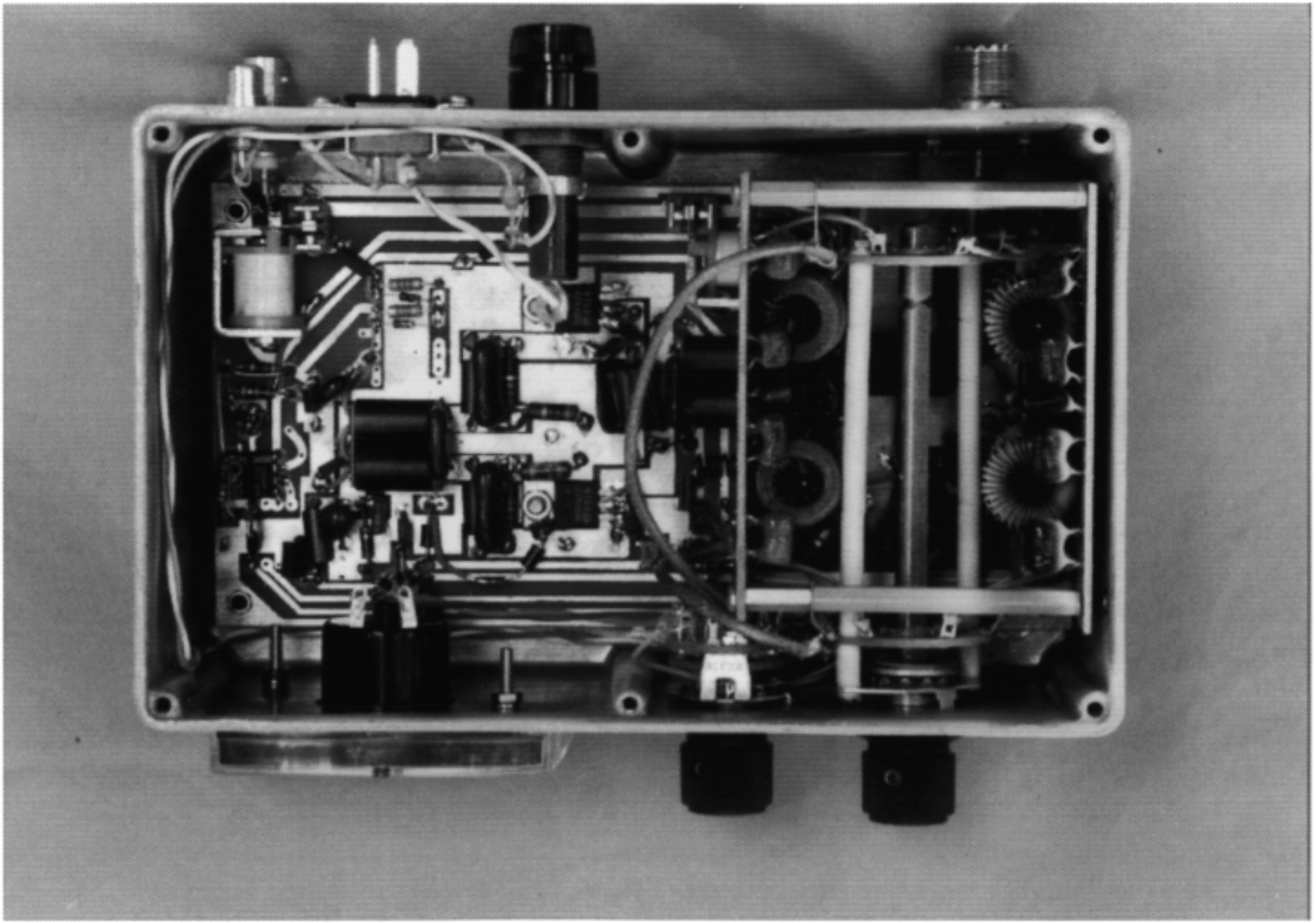


Photo B: ARRL HANDBOOK 50-W HF PA NOT REV. A

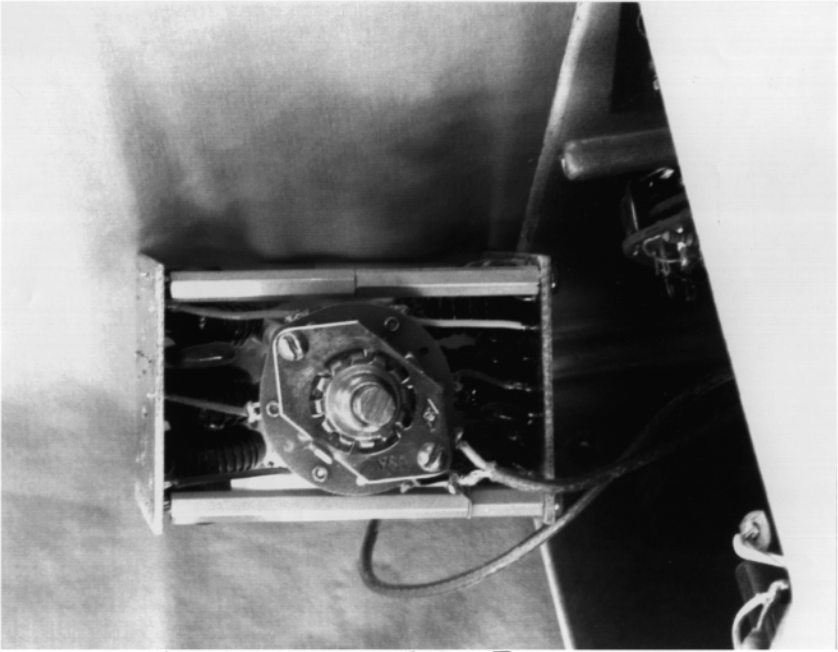


Photo C: ARRL HANDBOOK 50-W HF PA NOT REV. A

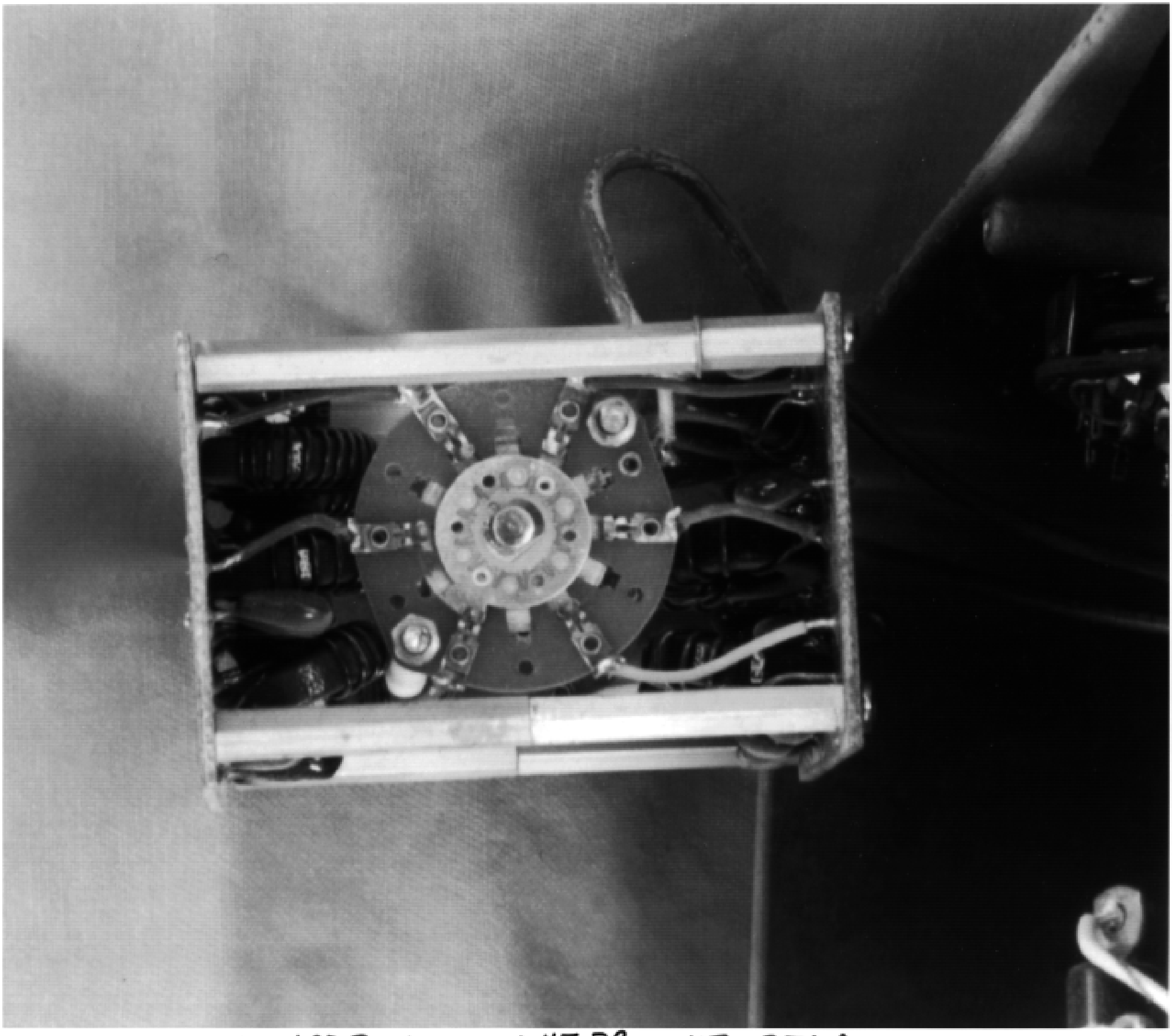


Photo D: ARRL HANDBOOK 5D-W HF PA NOT REV. A.

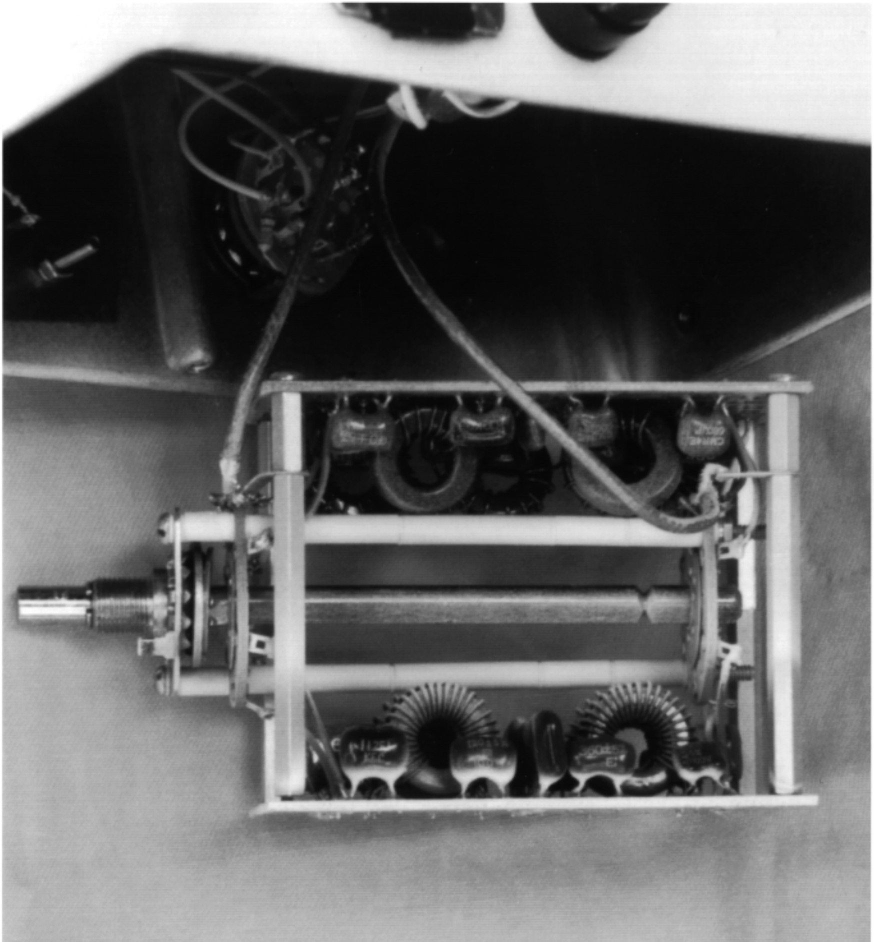
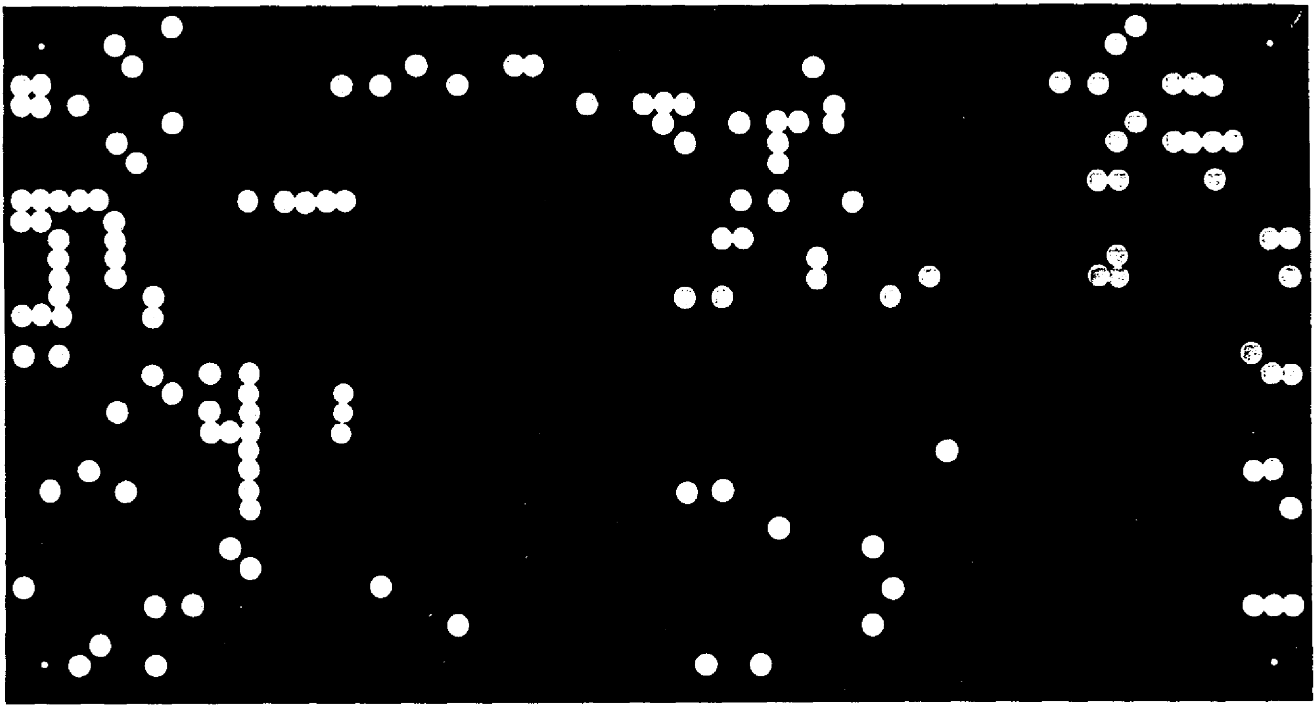
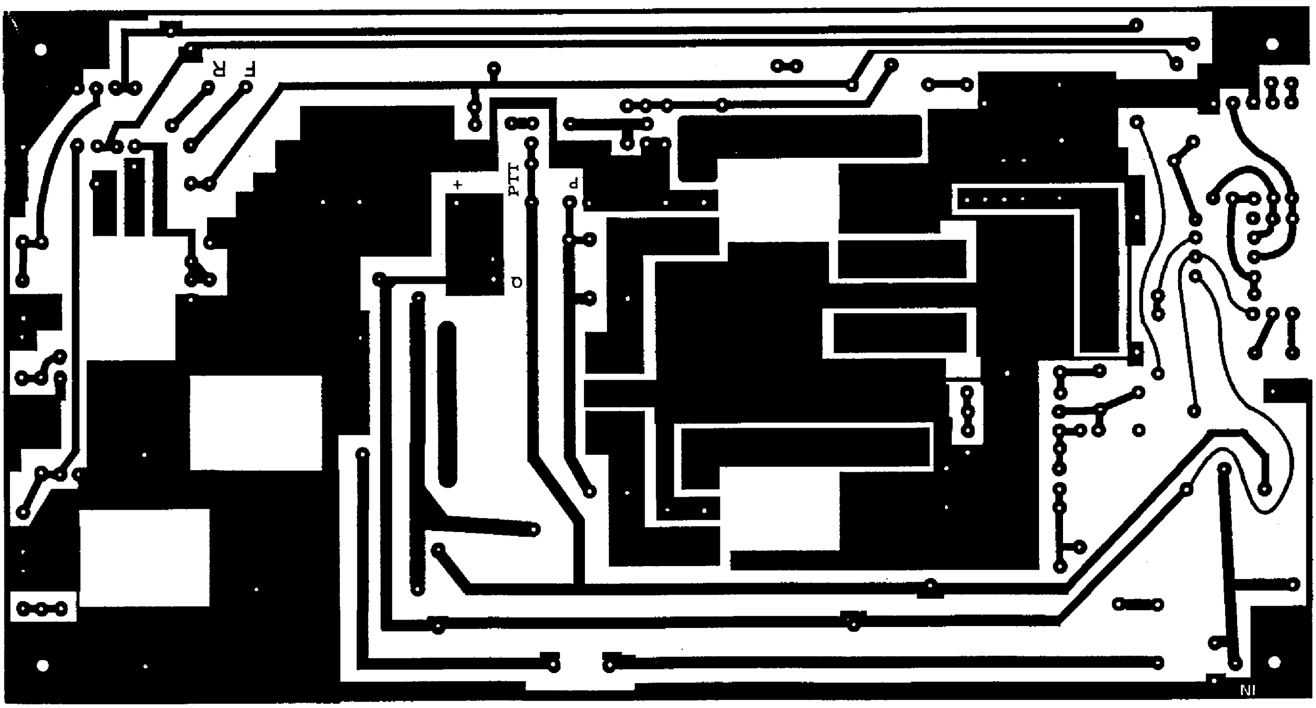


Photo E: ARRL HANDBOOK 50-W HF PA NOT REV. A



ARRL HANDBOOK 50-W HF PA REV. A MAIN BOARD



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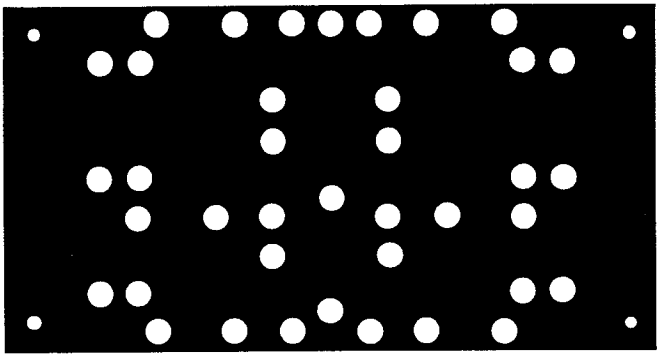
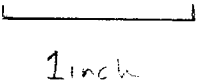
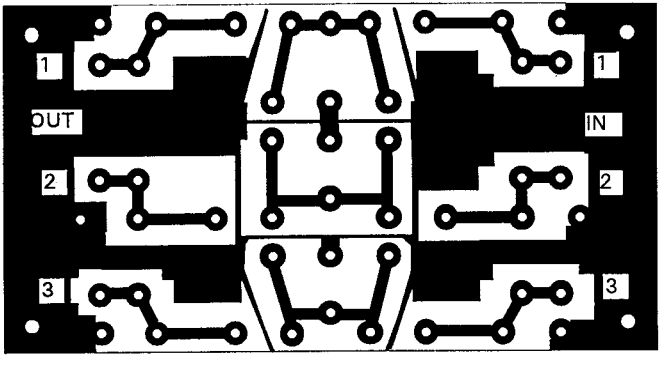




LPF #1



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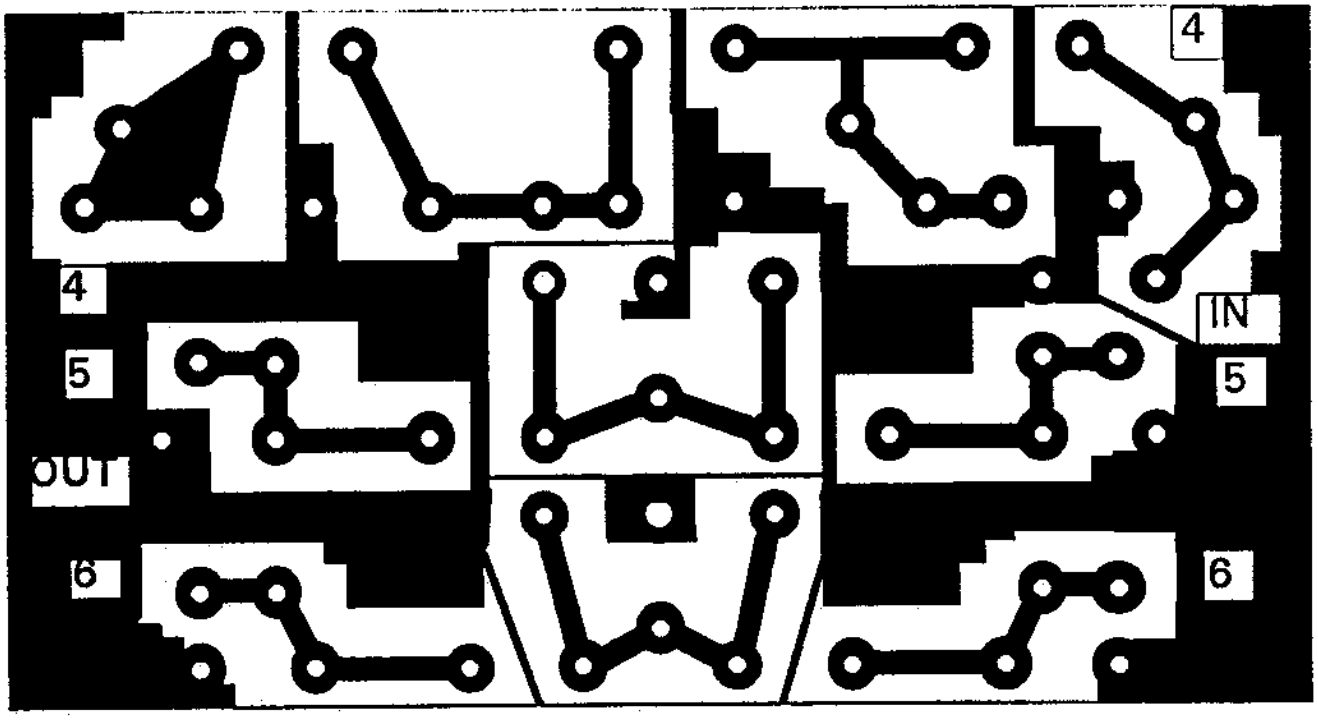
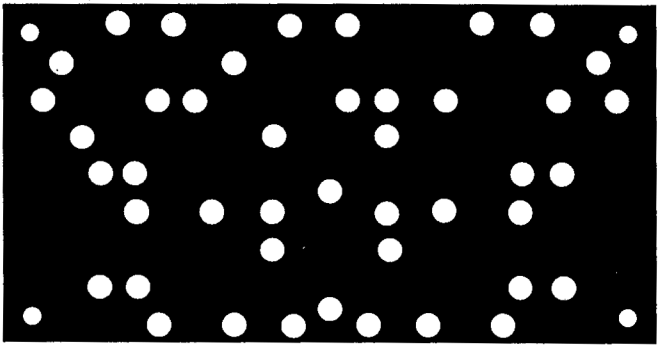
LPF BOARD #1



1 inch

LPF #2



1 inch

LPF #2