Chapter 1

Transmitting

1.1 K2RIW Amplifier Modifications

Joe Reisert W1JR - March 1975

This amplifier has been a real breakthru for generating high power at 432 MHz, using reasonably priced tubes. However many builders have experienced problems such as instability and lower output than expected. I have not built one of these amplifiers myself. I have discussed these problems with the author and have worked with many other builders. In the process I have compiled a list of recommendations which hopefully will cure many of the problems incurred.

1. The grid tank mechanical dimensions have often been misinterpreted (see QST, July 1972, pg. 47). The 4 3/4 and 2 1/4" dimensions are from the left edge, not the centerline of the screw hole.

2. The input capacitors, C2 and C3, may in some cases be too low a value. Furthermore, some have not been able to obtain a good input VSWR into the amplifier. If this is experienced it is recommended that you experiment with the capacitors and the point where they tap to the grid tank, L2.

3. The plate line, L1, should be as shown in the photos. Failure to round off the corners may make it difficult to resonate the output circuit. Some builders have reduced the length of the plate line by 1/8 to 1/4" and claim more tuning range.

4. Lower than expected output (with sufficient drive) may be due to the output loading capacitor value C4. Tune the final for maximum power output (input power fixed) with the loading at maximum. Then tune the same way with minimum loading. If the output is the same or greater at minimum, reduce the width of C4 by 1/8" and repeat until the correct combination is obtained.

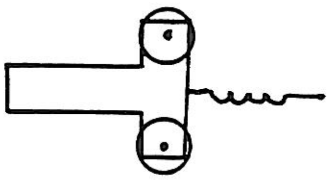
5. This amplifier design may be slightly regenerative if Eimac SK610 tube sockets are used. One cure is to use Eimac SK620 or SK630 type sockets. The latter are preferred. If the SK610's are used and instability is experienced it may be possible to neutralise it out by bending the screen grid contacts from the socket either in or out to change the screen inductance on the return. One method is to slide a 1 5/8" ID Nylon ring over the contacts (a household sink drain bushing available in most hardware stores). This will lower the inductance. If this fails it may be advantageous to raise the inductance by decoupling one or more of the contacts. This can be easily done by bending one of the contacts at a time away from the tube and/or putting a small Teflon insulator between the fingers and the tube.

6. The high-voltage Feedthru, C7, may not be available since it is a company part number. A substitute home-made capacitor is described in part II of the article.

7. The control grid supply has been a major source of problems such as instability and run-away plate current. First off the supply itself should be heavily loaded such as a 1000 ohm power resistor. Also the 10000 ohm, 2 W resistor between the supply and the shunt regulator (if this circuit is used) should be lowered. A 3000 ohm 5 to 10 W value is recommended. A better solution would be to build a supply with a 1000 ohm variable output load resistor which would be used to adjust the control grid voltage.

8. At least one builder reduced regeneration by moving the point where the control grid RF choke, RFC3, connects to the grid line, L2. See below for recommended contact point.

Figure 1–1: K2RIW Grid Line



9. Plate tuning and output drift has sometimes been experienced. There are several possibilities. The main one is insufficient air (cooling) due to obstructions or too small a blower. Another reason could be low output efficiency (see #4 above) which would in turn increase plate dissipation and hence raise the tube temperature. It goes without saying that the mechanical strength etc. must be carefully evaluated in your own model.

1.2 2 kW Amplifier using 7213

Paul Snyder Jr. K2CBA - July 1981

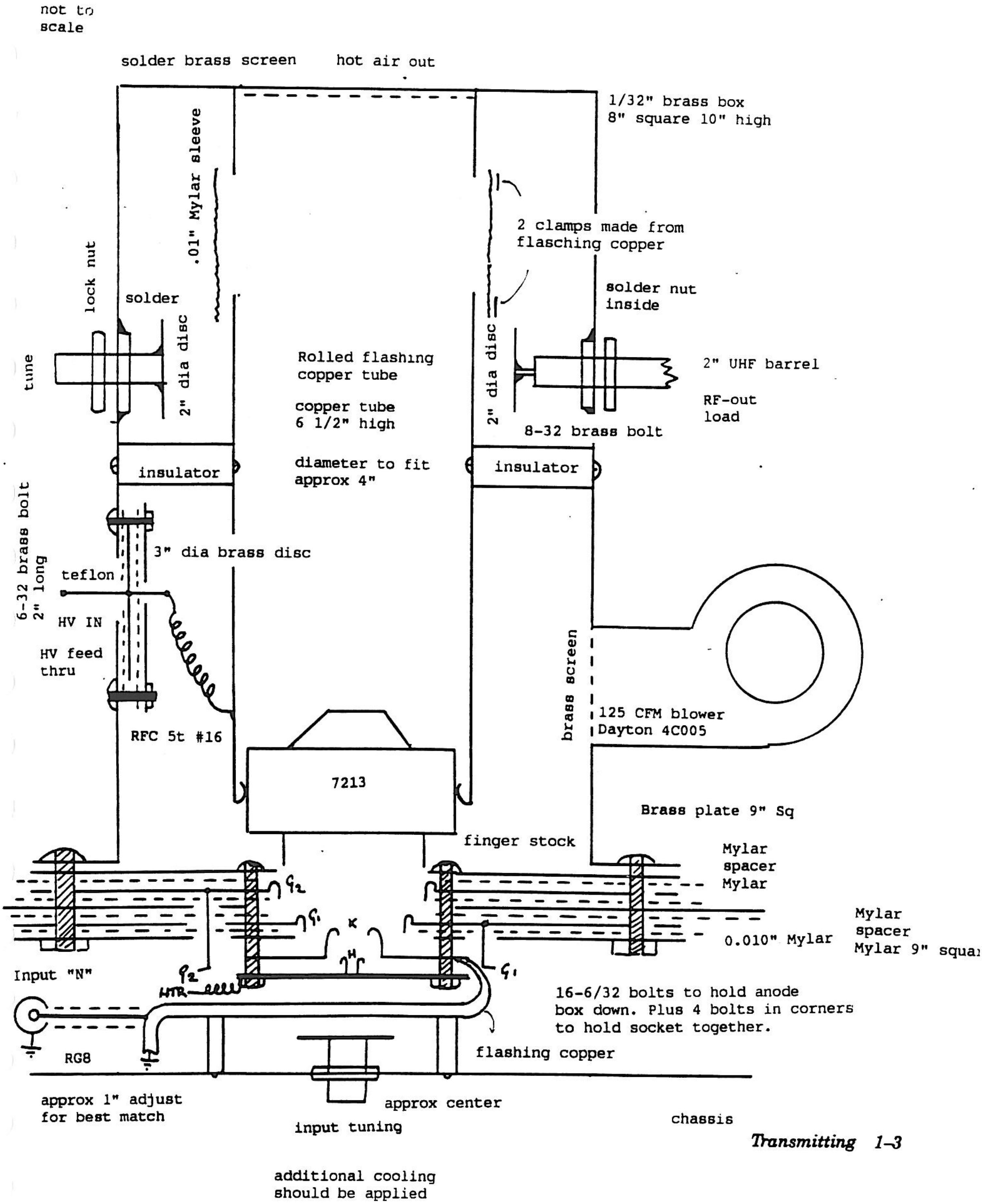
Judging from the mail, there seems to be a number of 7213 type tubes available on the surplus market. This tube is capable of 2 kW output on 432. (It is not recommended for use on 1296). Although some fellows have located surplus cavities for the 7213/7214, very few of these units are around. The following page shows the mechanical details of K2CBA's 7213 final. The plate circuit is a rectangular box 8" on each side and 10" high. The tube is mounted in a homebrew socket, constructed from four 9" square brass plates (and finger stock) separated by 0.010" sheets of Mylar. The cathode circuit (the amp is cathode driven) is a 9" by 1" strip of copper flashing. Jud runs 2 to 5 kV on the plate, 325 V on the screen and a variable supply (to -150 V) on the grid. He has had excellent results with this design. The final has been in use for more than 15 years and it really putout the juice.

1.3 Crawford Hill 1296 Two Tube Amplifier

The Crawford Hill EME group W2CQH, W2CCH, W2IMU - August 1981

I added the diagrams of a two tube 1296 amplifier developed originally by W2CQH, W2CCY and W2IMU. I use it to drive my UPX-4. A water-cooled version of this amplifier, capable of producing 250-300 W, appeared in the W2IMU EME notes. An air-cooled version was described in detail in March 1970 Ham Radio Magazine. Although this amplifier is very popular in the North East U.S., it is not as well known in other parts of the world. It has greater efficiency than the WB6IOM amplifier and is relatively easy to construct. More recently Hans OZ9CR has developed another 2 tube amplifier design. This new

Figure 1–2: 2 kW Amplifier Using a 7213



design is being used as a driver by VE7BBG, G3WDG and ZE5JJ. I will be running diagrams of Hans' amplifier in a future NL.

1.4 Two Tube Amp for 1296 MHz

Hans Lohmann Rasmussen OZ9CR - November 1982

The figures on the following pages are the long promised details of OZ9CR's two tube driver amplifier. Hans has even sent us a more detailed drawing which we will include in another newsletter. (never published ed.)

1.5 7650 1kW Final Details

Allen Katz K2UYH - February 1983

In Figure 1–5 K2UYH shows the construction details of his 7650 432 MHz Amplifier.

1.6 High Voltage Current Trip Circuit

Stuart Jones GW3XYW - March 1983

This circuit in Figure 1–6 is a way to avoid fuse blowing etc., when tubes are flashing over.

1.7 UPX-4 Modifications

J. Gannaway G3YGF & D. Williams G4CVN - April 1983

A number of UPX-4 six valve amplifiers (either home-built or ex OZ9CR) are known to be operational in the UK. A number of users of this amplifier have reported in problems achieving the power output of which this amplifier is capable. The main reason for this seems to be that the output link as originally specified is not optimum. The use of a slug tuner (See microwaves June 1981) can help considerably, but a better solution is to use a modified output loop. G3YGF and G4CNV have developed a new output loop so that the amplifier can deliver full power, into a well matched load, without needing a slug tuner. Details of their modified loop are given in Figure 1–7a. When optimising the penetration and angle of the loop for optimum power output, it will be found that there are two possible penetrations for best performance, one with the loop barely in the cavity, the other with the loop well into the cavity. To prevent possible flash over problems the position with the loop only just into the cavity is preferable. G4YGF and G4CNV also found that it was possible to increase the gain of the amplifier by changing the input coupling to a loop, details of which are given in Figure 1–7b. The angle and penetration are adjusted for maximum drive, but care should be taken to avoid instability which can result if the loop is

Figure 1–3: Crawford Hill 1296 Two Tube Amplifier

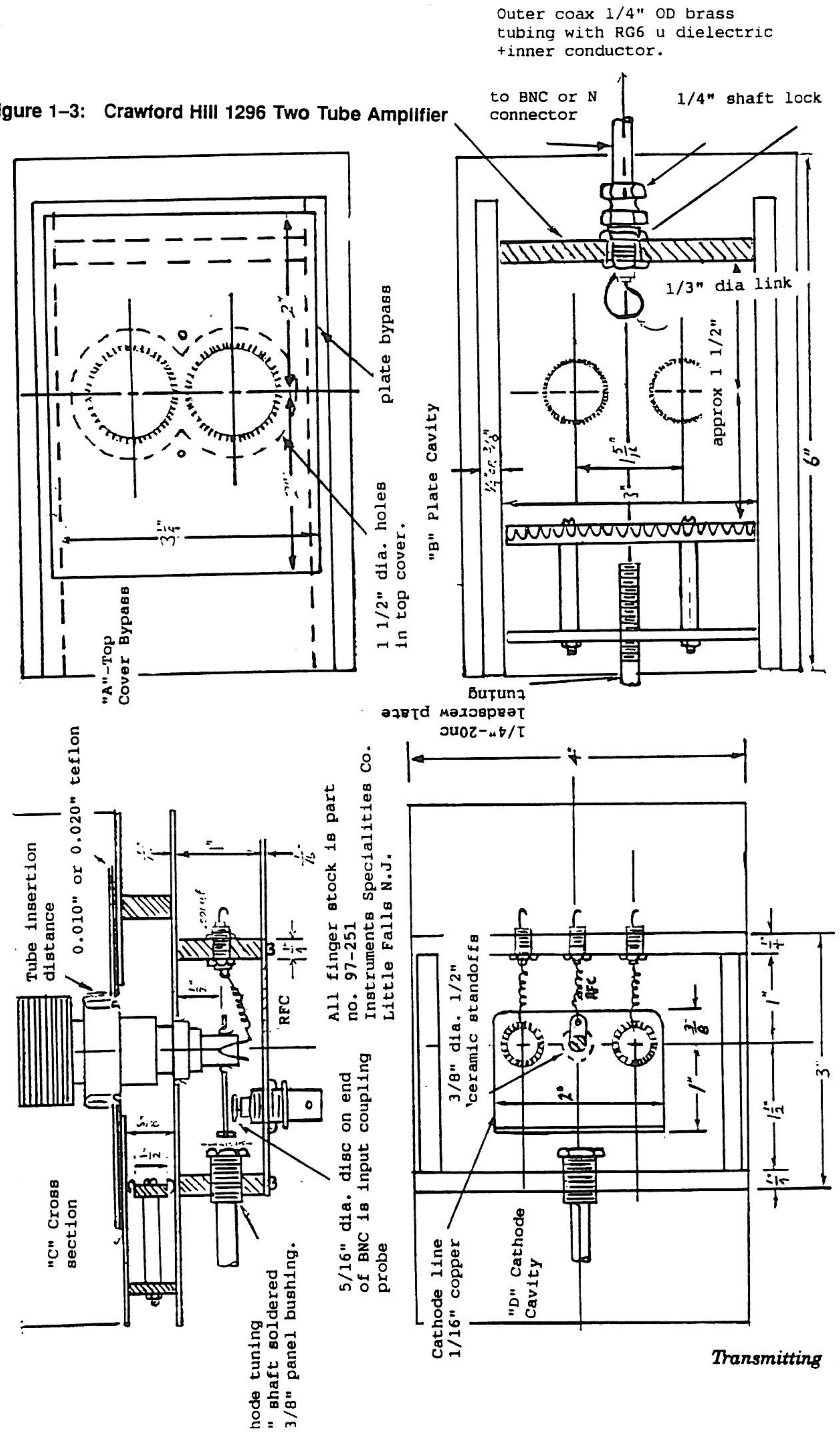


Figure 1–4: Two Tube Amp for 1296 MHz

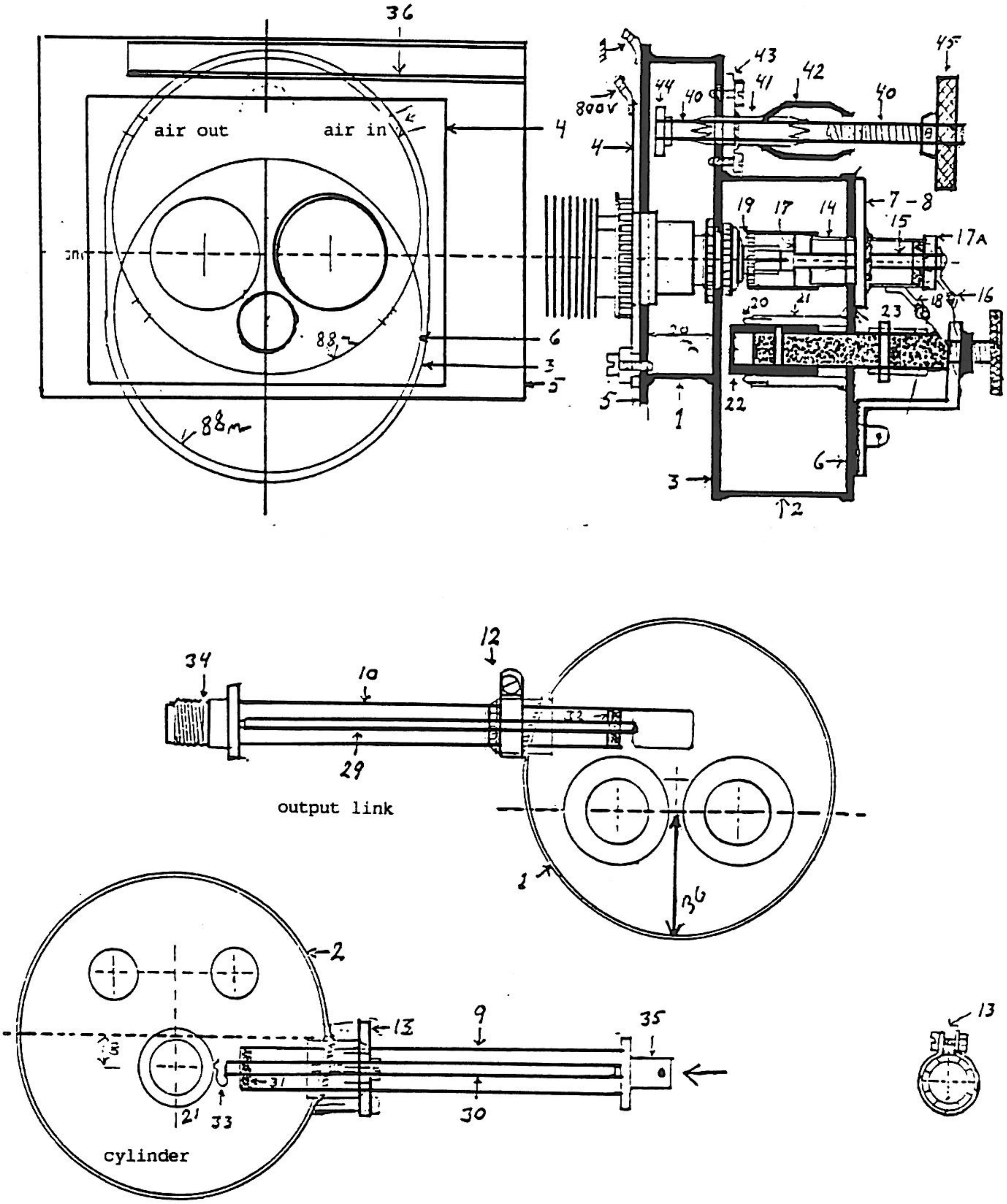
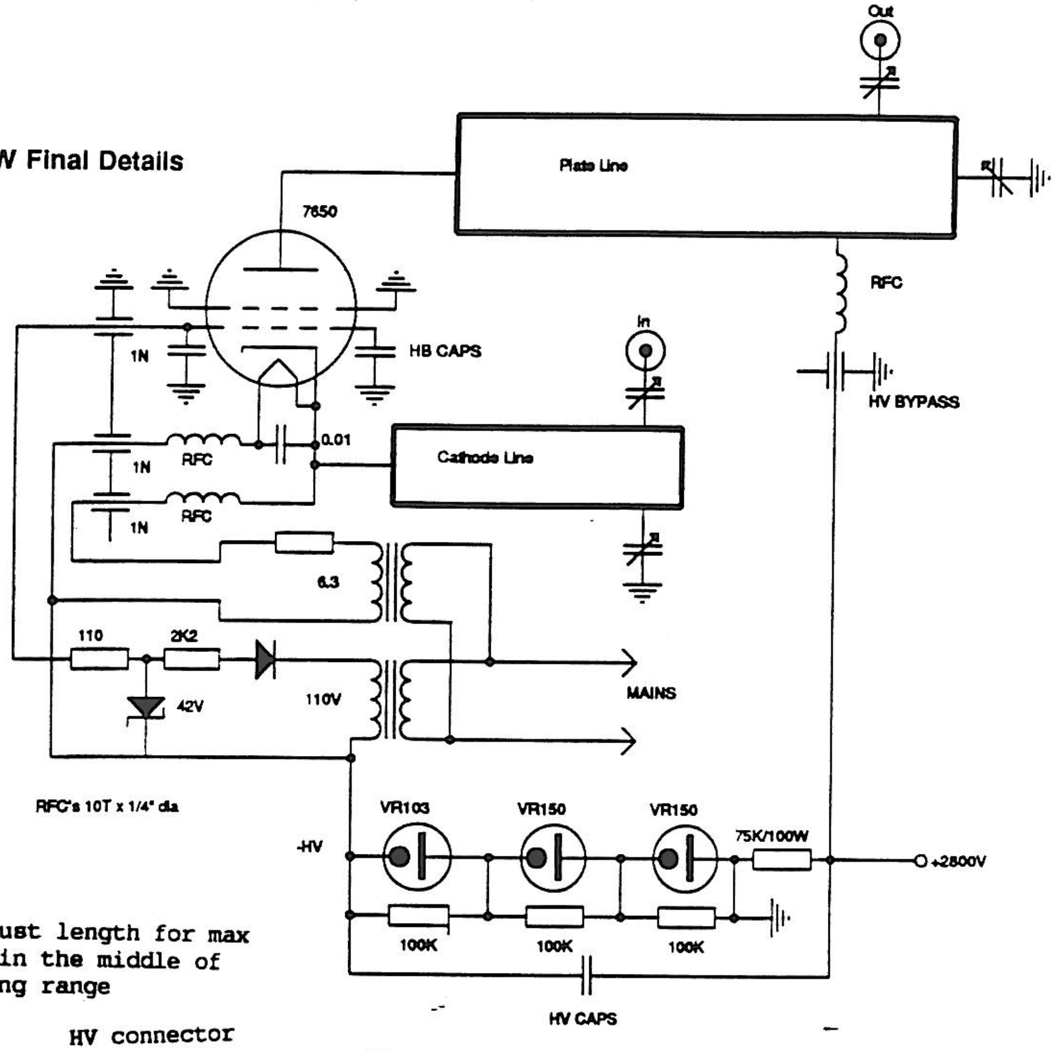
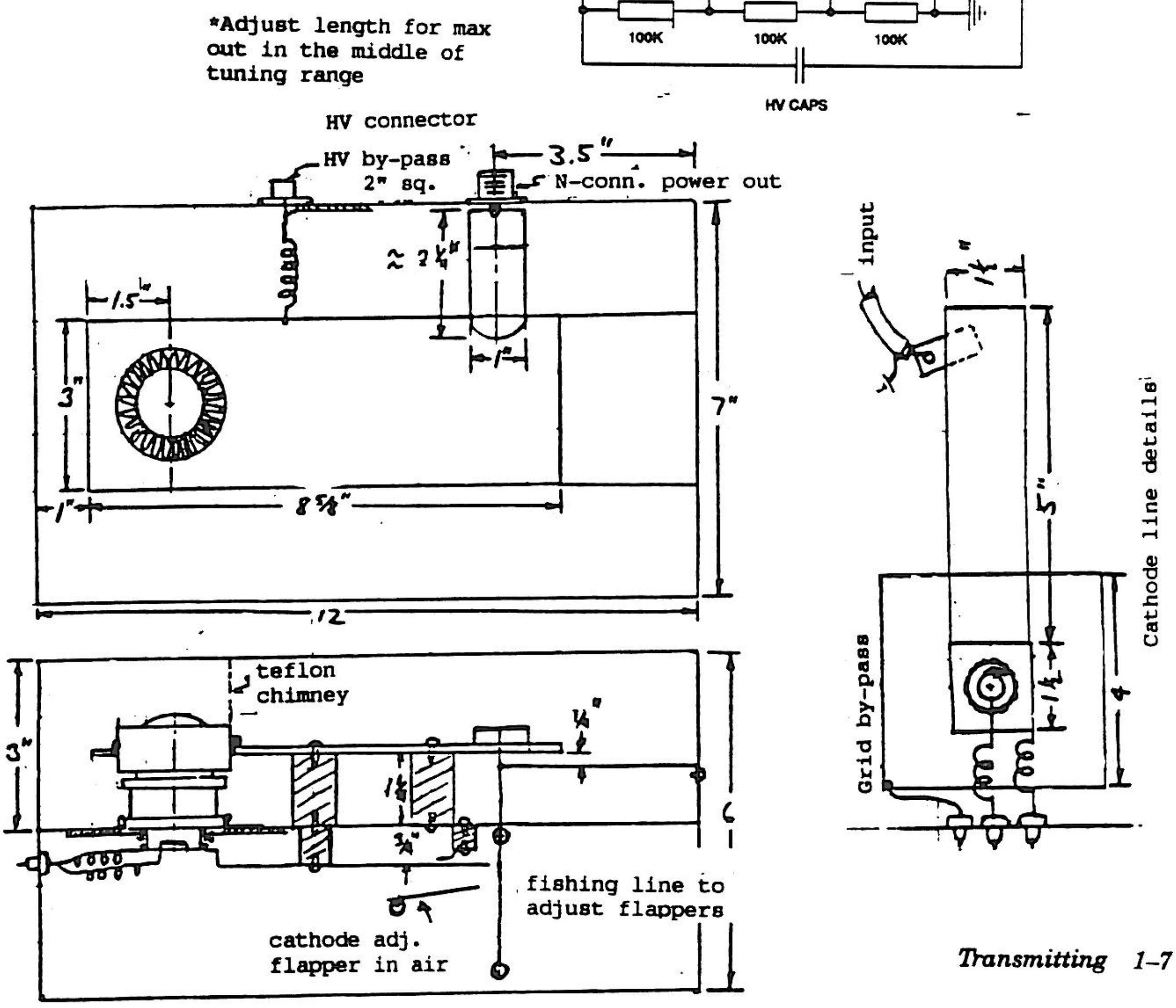


Figure 1–5: 7650 1kW Final Details





Notes: Bolt top and bottom plates down many places

Figure 1–6: E.H.T. Current Trip

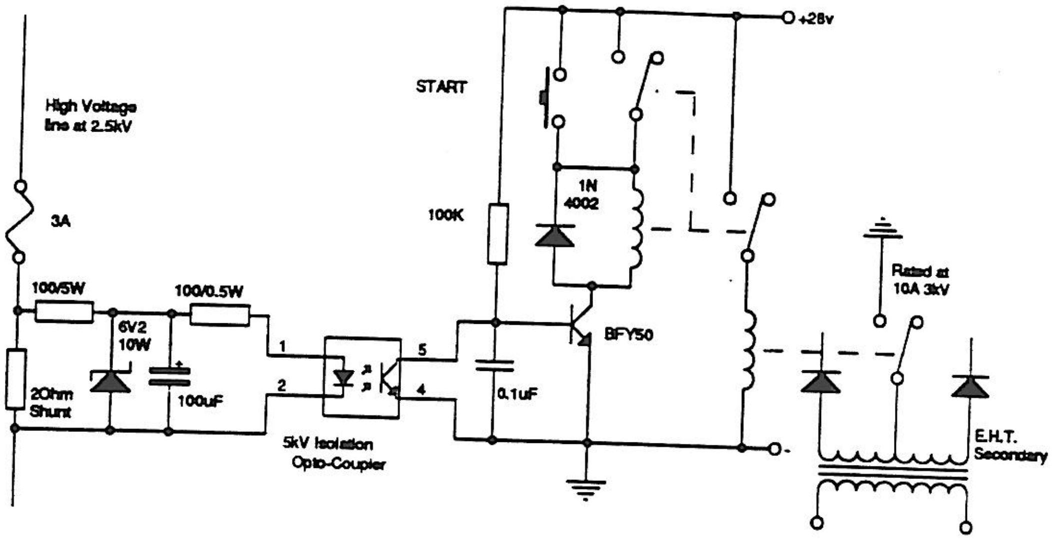
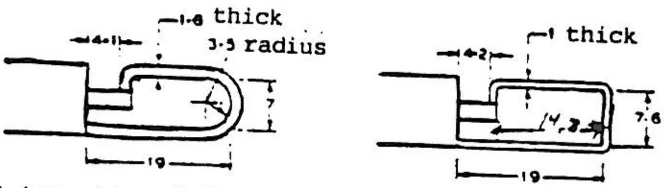


Figure 1–7: UPX-4 Modifications



Material 7.4mm wide x 1.8mm thick copper strip.
(A)

Material 7.9mm wide x 1mm thick copper strip.
(B)

Fig. 2. (a) modified output loop for UPX-4 amplifier. (b) modified input coupling

too far out (i.e. the coupling is too light). After these modifications, and with an on load anode voltage of 1.5 kV, it was possible to achieve 13 dB gain (at 25 W drive).

1.8 200 Watt Amplifier for 1296 MHz

Drago Dobricic YU1AW - July 1983

This 1296 MHz amplifier uses a YD1270 and delivers 234W RF output with a minimum gain of 13 dB. DC specifications:

Ug1	-10 V	Ia-max	250 mA
Ia0	35 mA	Ig1-max	30 mA
Ua	2 kV	Pin	500 W

Figure 1–8: YU1AW 1296 MHz Amplifier

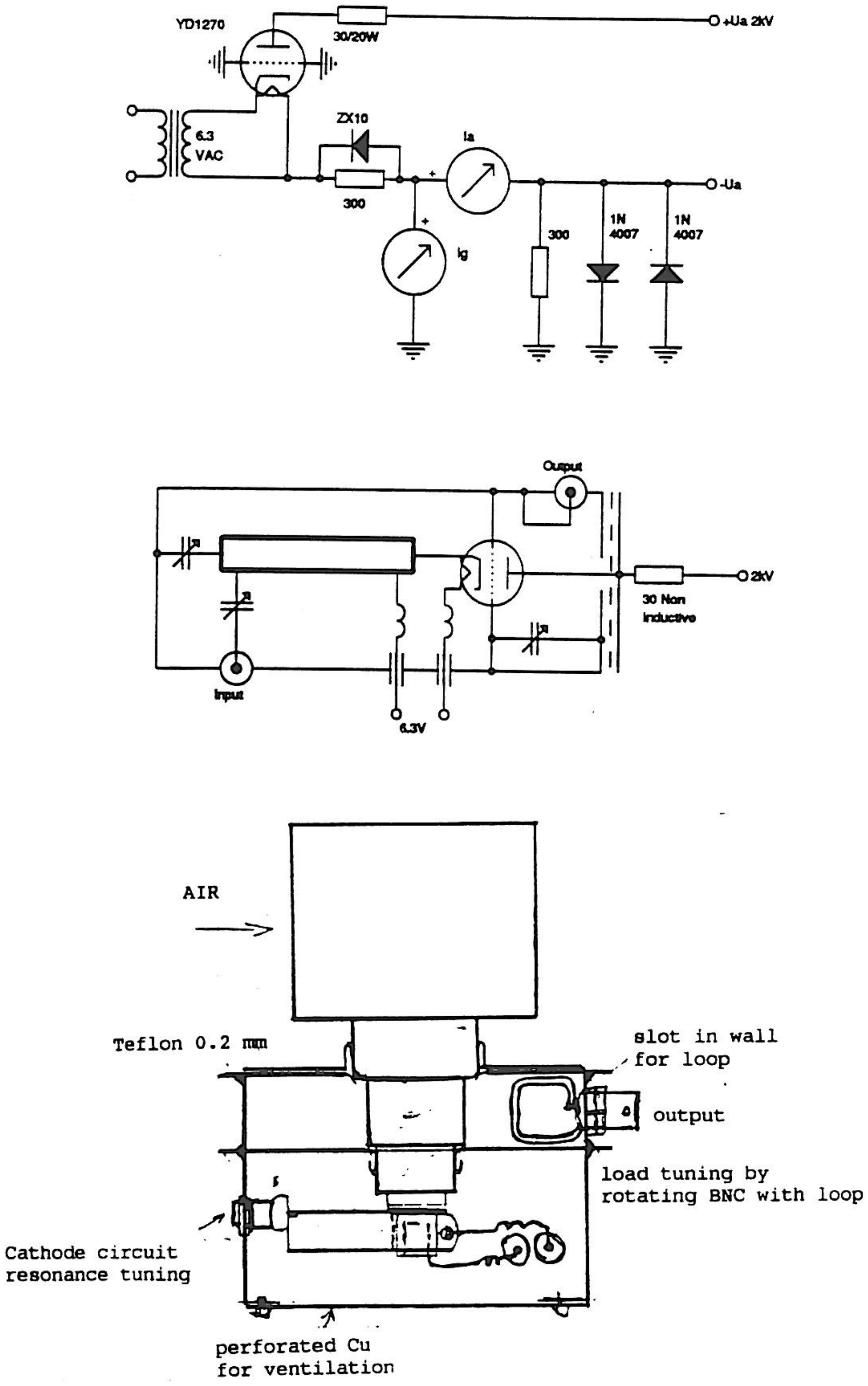
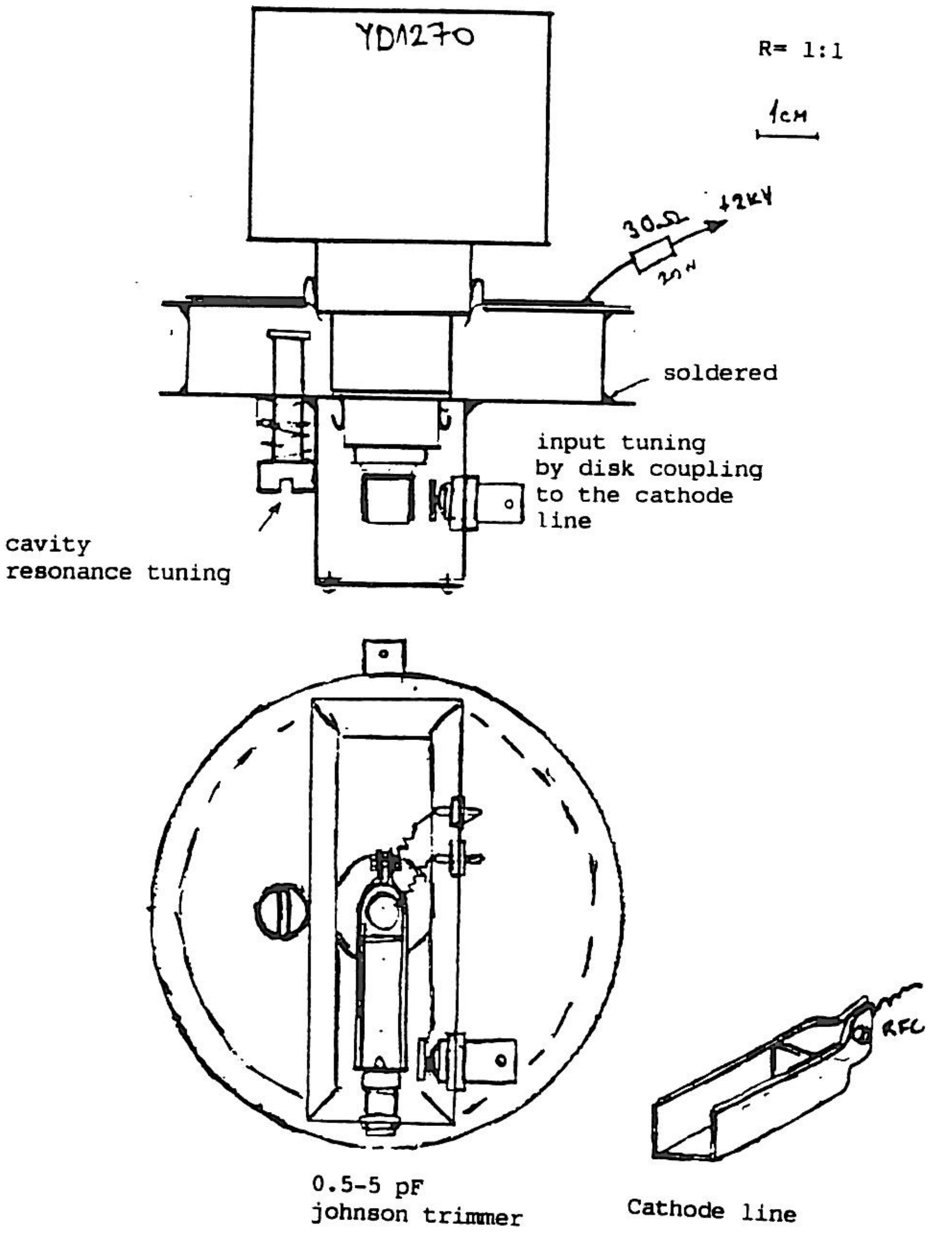


Figure 1–9: YU1AW 1296 MHz Amplifier Construction

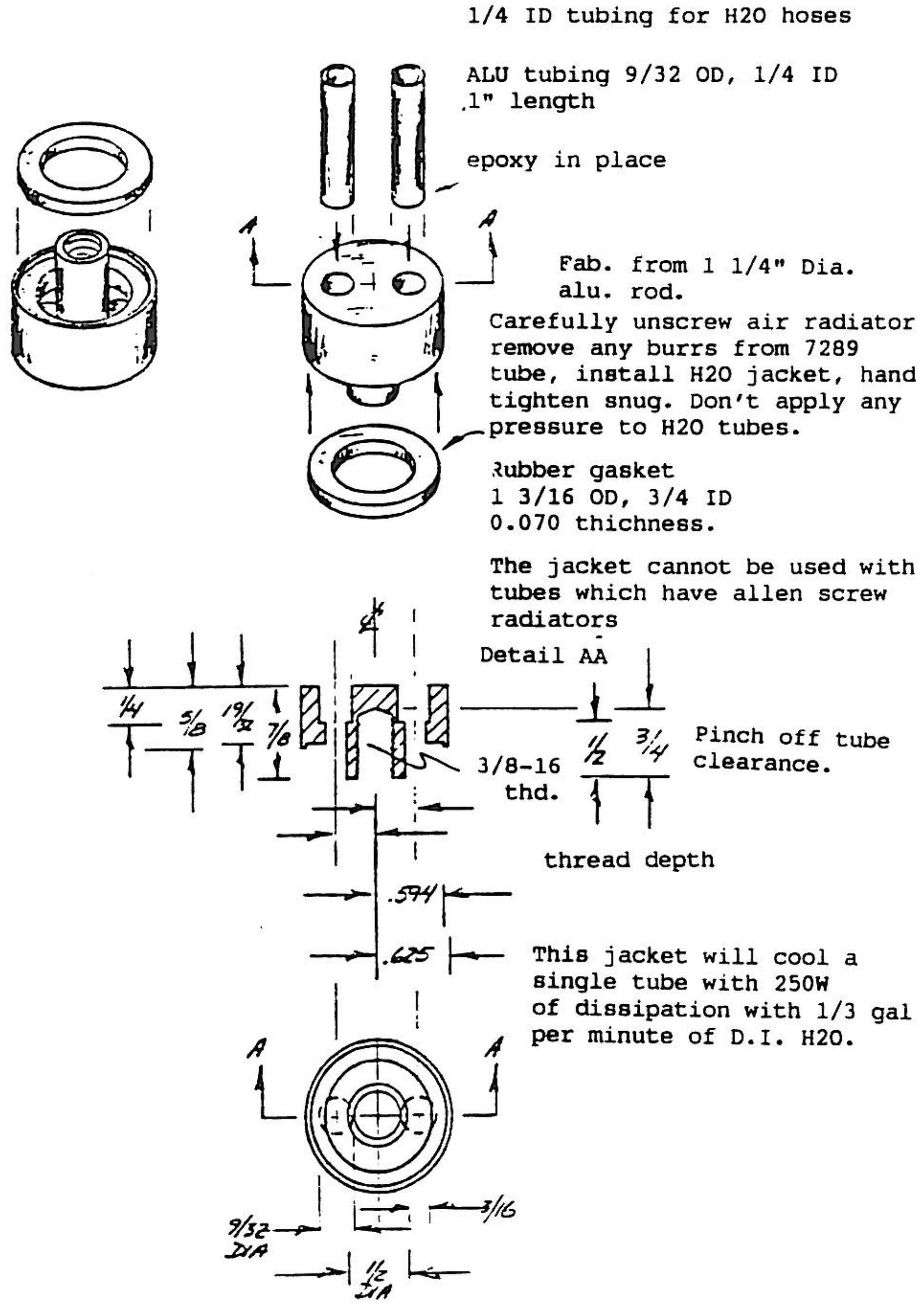


1.9 Water Cooled Anode for the 7289

Chip Angle N6CA - November 1983

Figure 1–10 shows Chip's way of water cooling 7289 type tubes.

Figure 1–10: 7289 Water Cooled Anode



1.10 1296 MHz Power Combining

Chip Angle N6CA - February 1984

1.10.1 Principles

Basically, when a signal is applied to the input port, two equal in amplitude but opposite in phase signals will be produced at output ports 0° and 180°. The isolated port will essentially be the imbalance between the two outputs. The isolated port should be terminated in a good 50 ohm load. The electrical diameter of the ring is 6/4 wavelengths. The basic splitting and combining scheme can be seen in Figure 1–12.

1.10.2 Construction

Refer to Figure 1–11. A 3/16" diameter copper tubing is rolled around a 4 inch diameter form. This ring must be as circular as possible. If necessary make a wooden cylinder on a lathe for bending the tubing. Tightly wrap the tubing while on the form. Wind several turns of tubing on the form and secure so it won't unwind. With a file, mark a line across all the turns of tubing. This will accurately set the length. Now cut the tubing into individual rings. Chamfer the ends as they will be butt-joined and soldered. Carefully remove the pitch and "spring-out" of the rings by bending. Check diameter and circularity by placing it back on form. The rings must also be flat. After this is done, then solder the butt joint of each ring.

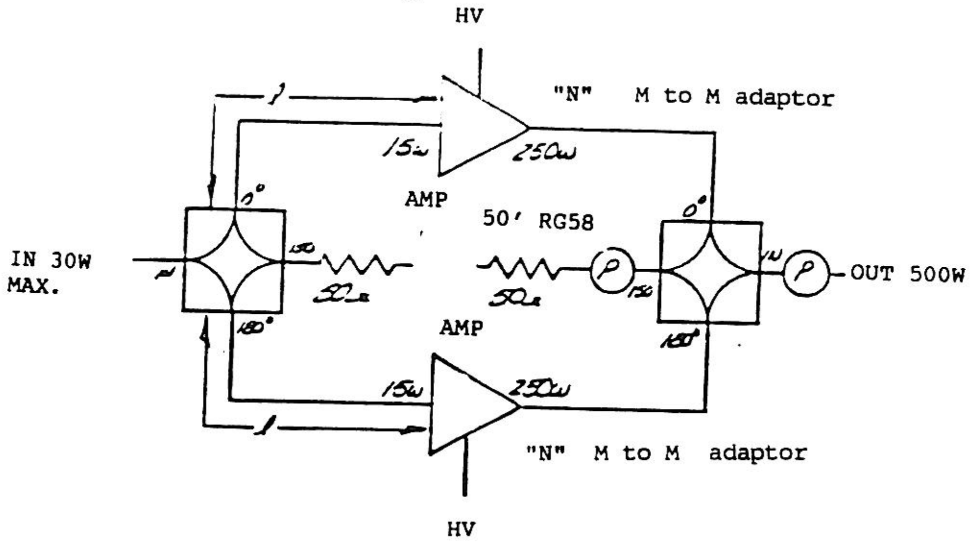
1.10.3 Mounting plate

As accurately as possible using a compass, mark the cover plate for your selected enclosure. This will serve as a template. Drill all 1/8" holes only. Position the copper ring with tape to the inside of the plate and mark the connector centre pin positions on the ring (four places). Accurately centre punch the ring at these four places and drill the 1/8" holes through the ring. Now the connector holes can be opened up on the plate to 1/2" diameter.

1.10.4 Assembly

Once all parts are made, check alignment before soldering. Mount spacers and connectors to enclosure. Position ring on the connectors to enclosure. Position ring on the connector centre pins. Clean and tin all parts. Temporarily install 1/16" spacers under the ring to set ring height above the ground plane. Install "N" male adapters on all female connectors, to assure good alignment of the centre pins. Now solder all ring-pin points. Remove the 1/16" spacers and clean all solder joints. Install cover on box. The unit is ready for testing.

Figure 1-11: 1296 MHz Power Combining

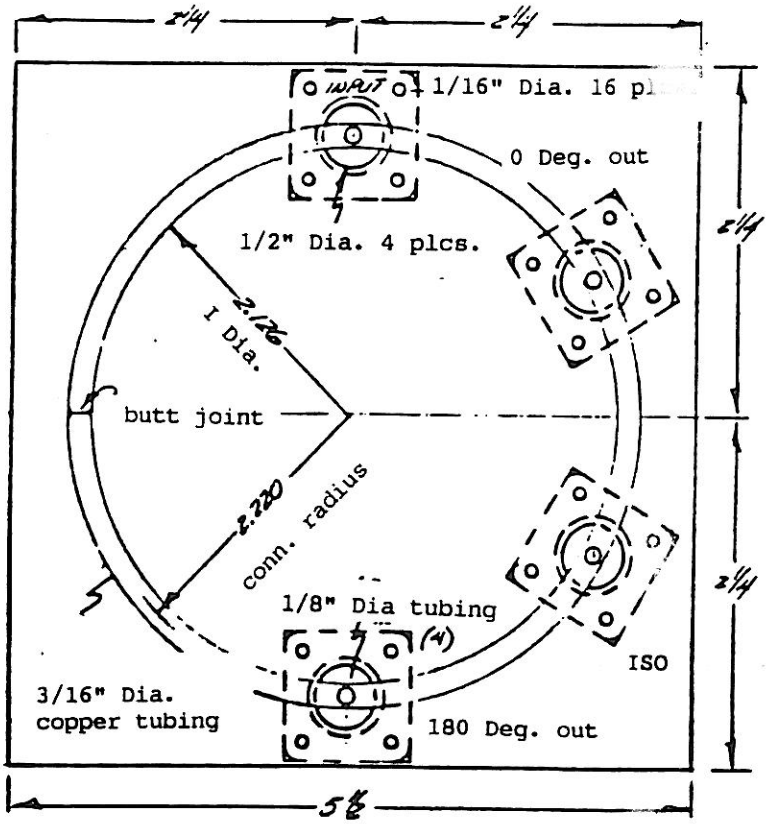


1.11 Y730 1kW Amplifier for 1296 MHz

Peter Riml OE9PMJ - October 1984

The amplifier shown was designed by OE9PMJ (of OE9XXI) for ham radio use in the frequency range from 1250-1320 MHz. The plate cavity is a 3/4 wavelength coaxial cavity and the cathode is fed through a 5/4 wavelength line. Using a Varian Y730, the amplifier is capable of a PEP output power of up to 1 kW with an anode voltage of 2100 Volts. It has a gain of 14 dB and a efficiency of almost 50%. The Thomson TH308 is capable of working in this circuit and generating 800 Watts with a gain of 12 dB and an efficiency of around 42%. Other tubes can also be used with similar results: TH328, TH294, F6007, and Y831 (above 1kW). Peter OE9PMJ is willing to provide more details to anyone interested. He has an extensive design package available (more than 10 sheets). He will supply this package to anyone sending him $3.00 to cover the cost of duplication and postage.

Figure 1–12: Construction 1296 MHz Power Combiner



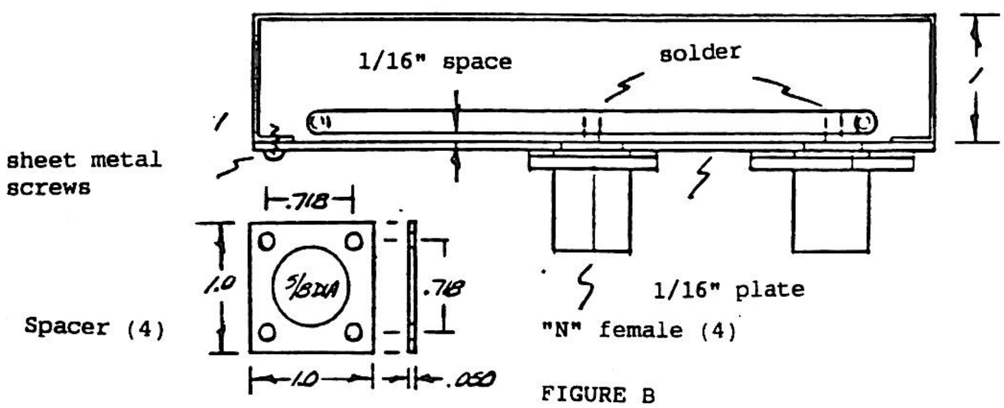
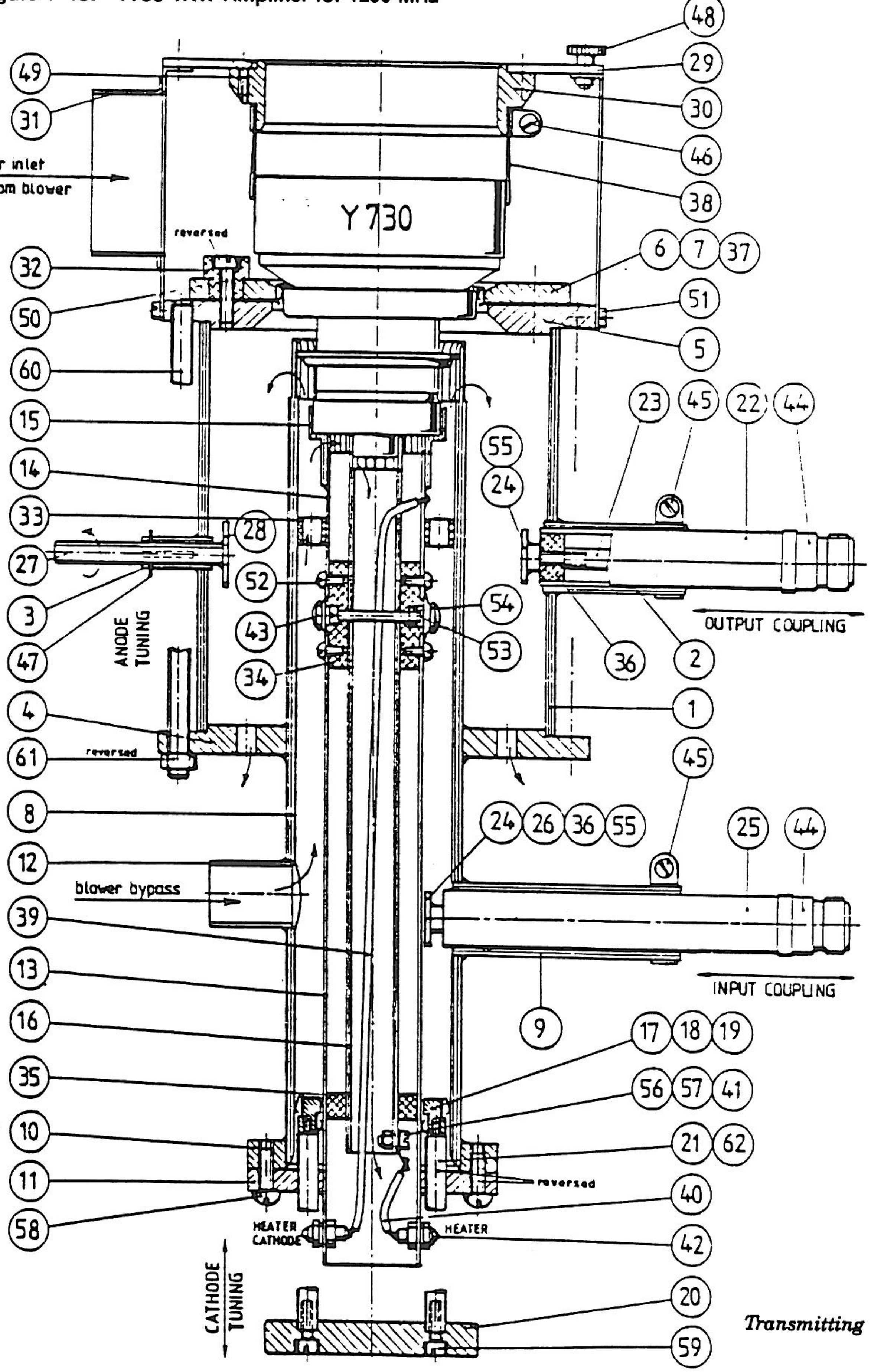


FIGURE B

Figure 1–13: Y730 1KW Amplifier for 1296 MHz



1.12 432 MHz Power Tube Comparison

Steve Powlishen K1FO - June 1985

Steve produced an extensive list of the most used tubes for high-power amplifiers. See Table 1–1.

Table 1–1: 432 MHz Power Tubes

Tube	Cost	Clean Pout.	Linear Eff.	IMD	Surplus Avail	Drive	Notes
2x4CX250B	$100	600W	55%	-23	yes	10W	sockets $160
2x4CX250R	$180	850W	55%	-28	yes	10W	sockets $160
2x3CX400	$625	1000W	60%	-35	rare	50W	coaxial base
2x8874	$400	1100W	53%	-35	rare	60W	N ratings
2x3CX800	$550	1500W	55%	-35	no	50W	rat.exceeded
4CX600B	$900	900W	63%	-38	rare	10W	hard to
4CW800B							stabilise
7650	$950	950W	60%	-30	yes	10W	rat.exceeded
4CX1000	$575	1000W	35%	-25	yes	25W	socket $600
8877	$500	1000W	35%	-40	yes	100W	low gain
7213	$1200	1500W	55%	-30	yes	20W	rat. exceed
4CX1500	$1000	1500W	55%	-40	no	10W	new tube
8938	$700	1500W	50%	-44	rare	80W	coaxial base

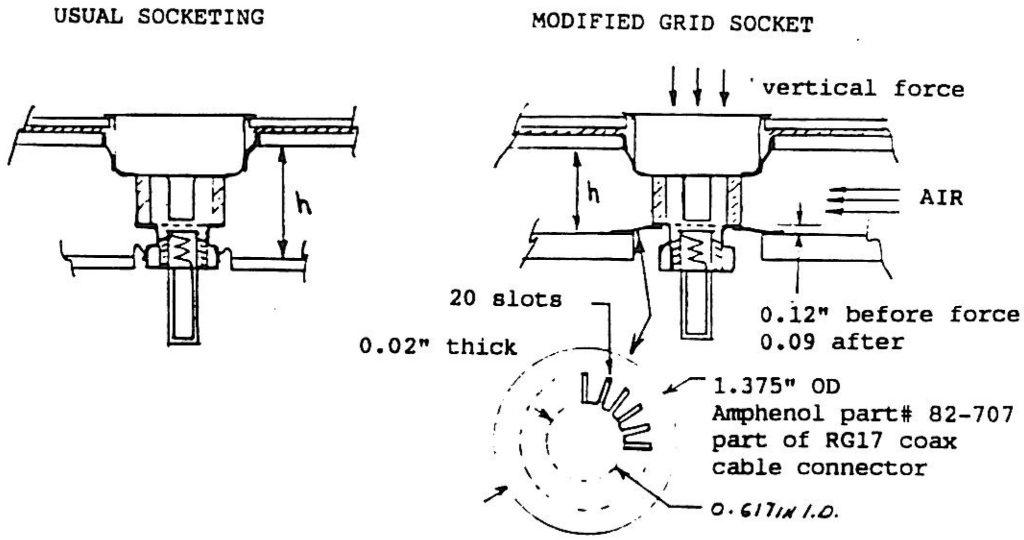
1.13 Modified Grid Socket for 2C39 type Tubes

Dick Turrin W2IMU - September 1985

If you are considering building or modifying a UHF power amplifier using the small planar triode of the type 2C39B 3CX100A5 or 7289, here is a modified grid socket method which should improve the grid thermal properties and may also improve RF-efficiency.

This modified grid socket provides tight connection directly to the grid ring itself for maximum heat transfer to a heavy cavity wall heat sink. An axial force of 3 to 5 pounds per tube is required to maintain the tight grid connection. Good alignment, concentricity and registration are important, as usual, to minimise physical stress on the tube. This modified socket also results in reduced cavity height by about 0.25" and eliminates the small cylindrical section of the tube between the grid ring and the finger stock in the usual socketing method. The resulting anode cavity size (diameter) will have to be increased slightly to compensate for the missing reactance of the cylindrical section and also the lowered Zo of the cavity due to reduced height. The special grid socket piece may be obtained from Amphenol as part number 82-707 at $2.55 each. They are part of an RG17 coaxial cable connector and are made of nickel plated beryllium copper. May be obtained silver plated on request. Call local distributor or main office in Danbury, CT., 203-743-9272. This part may also be found in surplus supply in RG17 connectors.

Figure 1–14: Modified Grid Socket for 2C39 type Tubes



Comment found in the September 1985 EME-Newsletter by K4QIF and W2IMU: "Dick, W2IMU wishes to retract the technical note published in last month's NL on a Modified Grid Socket for 2C39 type Tubes". After consultation with K4QIF and the actual disassembly of a 7289, he realised that a key mechanical assumption upon his design was based is incorrect. Although the washer grid connection will work, it may actually provide poorer thermal and electrical properties than a normal grid ring.

1.14 Bias supply for the UPX-4

Rusty Holshauser K4QIF - September 1985

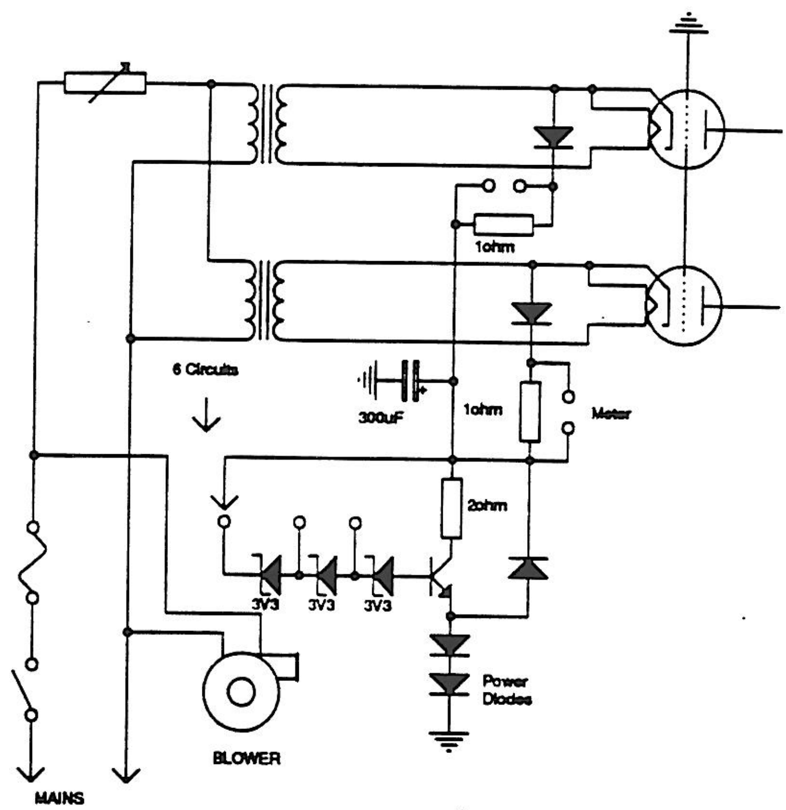
The Bias runs normal at 18 to 20 Volts. With 1kV on the plate and 900mA anode current Rusty obtains 500 Watt output. Figure 1–15 shows the final version.

1.15 1296 MHz Amplifiers using 2 x SD1599 and 4 x SD1599

Dave Mescaro WA3JUF - November 1985

Combining Class C amplifiers is easy, even on 1296. Wilkinson power dividers/combiners were used with good results. Combining 2 devices in class AB was also tried with good results, although the biasing gets tricky with more than one device when using common base transistors. Combining two stages using Sage Wire Line 3 dB hybrid divider/combiners was also tried. This is recommended for high power combining because power dissipating loads can be used on the dump ports instead of resistors. I used GC-10 pc board and 2W resistors to prove that good microwave components are not necessary for good performance at 1296 MHz. These amplifiers could have been build with Teflon PCB and microwave terminations for balancing resistors with possibly better results, but I doubt it.

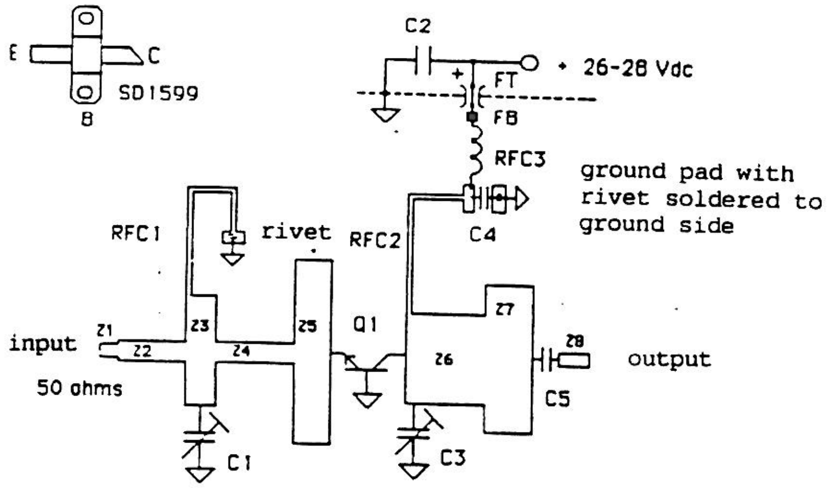
Figure 1–15: Bias Supply for the UPX-4



The two stage amplifier was built first, using devices that gave at least 10W Pout in a single stage. With 2W of drive, Pout was 22W. Power output did not change when the balancing resistors were removed. Only slight retuning was necessary. The standard carbon resistors are therefore good even on 1296 MHz. The resistors did not heat up under normal operating conditions. Four devices where then combined using 6 Wilkinson divides/combiners total, and 6 balancing resistors. With 4-5W drive, power output was 38-40W. Again removing the resistors did not effect the output very much. Blowing up one device did however make several resistors very hot. At the same time the other 3 devices still performed without damage. The balancing resistors DO work, even if they don't handle the unbalanced power very well.

The resistors are mounted in holes cut in the pc board to eliminate the lead length. Copper tape is soldered over the holes cut in the pc board for the flanges (bases) of the transistors. Heatsink compound is used between the copper tape and the heatsink. It is not used between the tape and the flange of the transistors because good RF and DC connections are needed. A suitable heatsink is of course required. The flanges of the transistors are screwed down to the heatsink with 4-40 screws. Initially the piston trimmers are adjusted to near minimum capacitance. Input drive is applied at a low level, and increased to the point where maximum power output occurs. The trimmers are alternately adjusted for maximum output. Slight tuning of the input and output can be done now using copper foil tape and an Exacto knife to add or trim the Z2 and Z6 microstrip "C" elements. Thomson CSF Semiconductor devices are available from RF Gain Ltd. The SD1599 sells for $15.00 ea.

Figure 1–16: 1296 MHz Amplifiers using 2 x SD1599 and 4 x SD1599



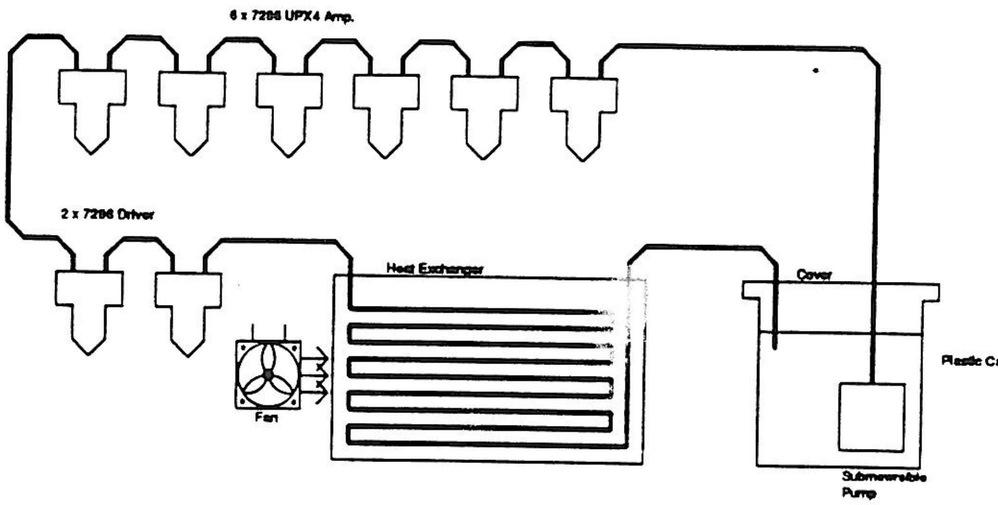
Q1	- Thomson CSF SD1599	FB	- Ferrite Bead
Board	- 1/16" G-10	Z1,8	- 0.11" wide 50ohms
RFC1,2	- 0.030 x 1.5" chokes	Z2	- 0.11" x 0.30"
RFC3	- 8 turns #28 on 0.1"	Z3	- 0.20" x 0.60"
C1	- 3pF Johanson Piston	Z4	- 0.15" x 0.45"
C2	- 10uF/35VDC	Z5	- 0.20" x 1.00"
C3	- 6pF Johanson Piston	Z6	- 0.50" x 0.60"
C4,C5	- 100pF chip cap.	Z7	- 0.50" x 1.00"
FT	- 1nF Feedthru		

1.16 Watercooling the UPX-4 Amplifier

Allen Katz K2UYH - February 1986

This system is easy to implement and well worth the effort. It has completely eliminated thermal drift and the very noisy blower which came with the original UPX-4. It also allows the plate voltage to be increased without causing the tubes to arc-over when they heat up. I am using the external anode cooling fins available from VE3CRU. 5/16" OD (3/16" id) clear plastic vinyl tubing available at many hardware stores fits snugly over the copper tubes protruding from these units and does not even require clamping. The only limitation of Hans' cooling fins is that they can only be used with tubes which have threaded anode connection. I am water cooling my dual 7289 driver (which always had a serious thermal drift problem) along with the UPX-4 and have connected all 6 tubes from the UPX-4 and the 2 tubes from my driver in series. There does not seem to be any reason to construct a manifold to feed water to the tubes in parallel. The temperature differential between the water which enters and leaves the tubes is very small. For a reservoir I am using a small plastic trash can which can hold up to about 6 gallons of water. At the bottom of the reservoir is placed a model L40-102 Little Giant Submersible pump which is rated at 120 gal/hr over a height of 5 ft. This pump is available from H&R Inc., 401 E. Erie Ave, Philadelphia, PA 19134 (tel 215 426 1708) for $38.50. 5 Gallons of distilled water, available at most supermarkets is placed in the can, and the can is covered to keep the dust out of the water. Originally water was pumped directly to the tubes and back to the reservoir. However, after several hours of operation the water became noticable warmer, although never hot enough to effect the amplifiers operation, and required more than 24 hours to cool back to room temperature. A heat exchanger (evaporation coil assembly) model #TN23K420 also available from H&R for $7.50 was placed in series with the return line and blown with a muffin fan to help keep the reservoir cool. This system has been in operation for several months with no problems observed. When ever the station is turned on, no matter what the band of operation, the pump is activated and circulates water through the 1296 MHz system.

Figure 1–17: Water cooled UPX-4



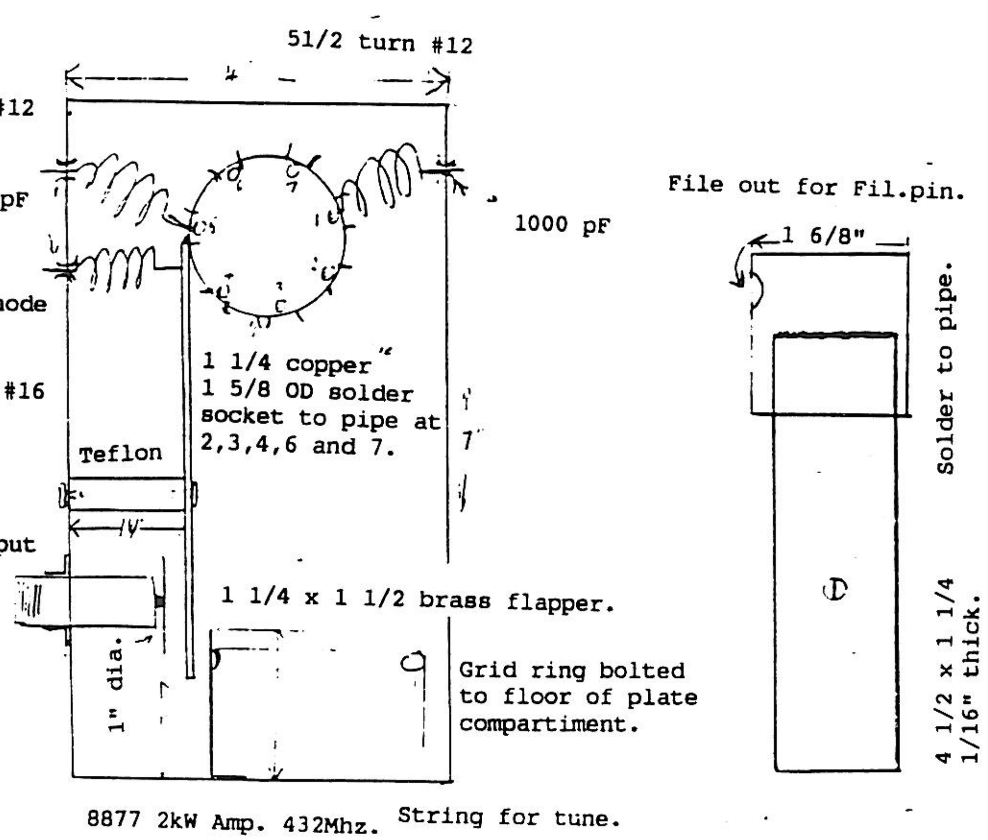
1.17 432 MHz Amplifier With 8877

Ray May K5AZU - May 1986

For the plate section please see the "Radio Handbook, William Orr, W6SAI". 2kW amplifier for 432 MHz with 8938 built by W3HMU.

The input circuit is shown here in Figure 1–18

Figure 1–18: 8877 Input circuit for 432 MHz

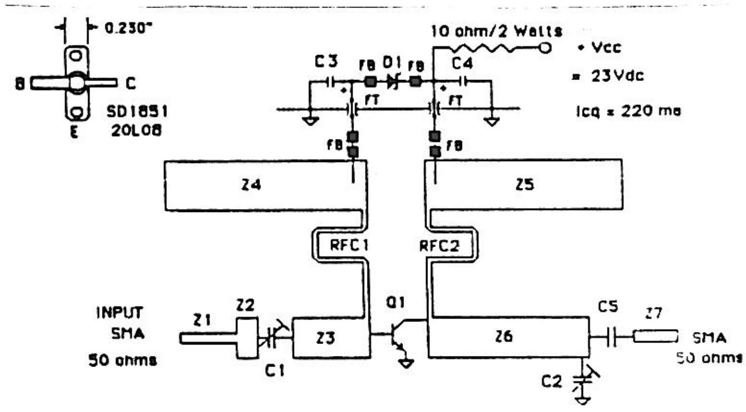


1.18 A 1.2 Watt Amplifier for 2.3 GHz

Dave Mescaro WA3JUF - May 1986

The gain of this little amplifier, presented by WA3JUF, should be greater than 8 dB, while the returnloss is 20 dB or more. Saturation point is reached at 1.2 Watts. Details are shown in Figure 1–19.

Figure 1–19: 0.6 Watt Amplifier for 2.3 GHz



Parts List:

C1	4.5 pF Johanson Giga trim cap.
C2	0.3-3.0 pF Johanson piston cap.
C3,4	10uF/ 35vdc
C5	47 pF chip cap.
D1	22V zener
FB	ferrite bead (2 on each FT) (1 on each lead of zener)
FT	Feedthru cap. 1000pF
Q1	Thomson CSF semiconductor SD1851
Z1,7	50 Ohm line 0.060" wide
Z2	0.10x0.4" (trim to tune)
Z3	0.180x0.30"
Z4,5	RF short 0.275x1.0"
RFC1,2	Choke 0.035x1.10"
Board	1/32" Teflon Er 2.5

1.19 PA Blower Protection with a Manometer

John Shorland ZL2AQE - June 1986

Figure 1–20 shows a blower protection circuit based on a Manometer. Adjust the level of water for *Go/NoGo* contact between "A" and "B" with blower ON/OFF. If there is no air there won't be 230V on the power supply.

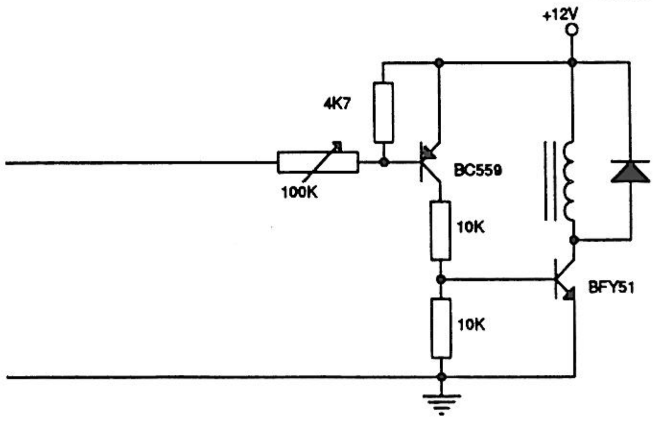


Figure 1–20: Blower Protection with a Manometer

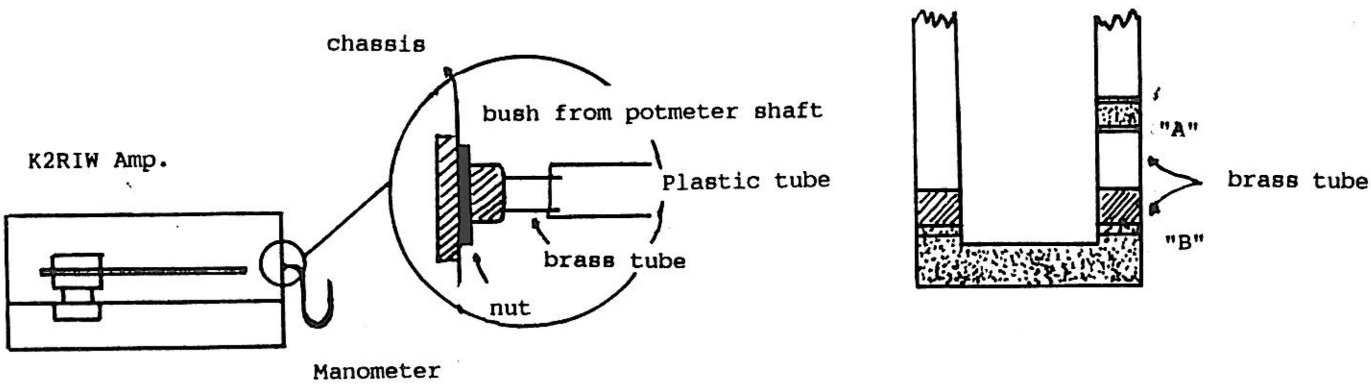
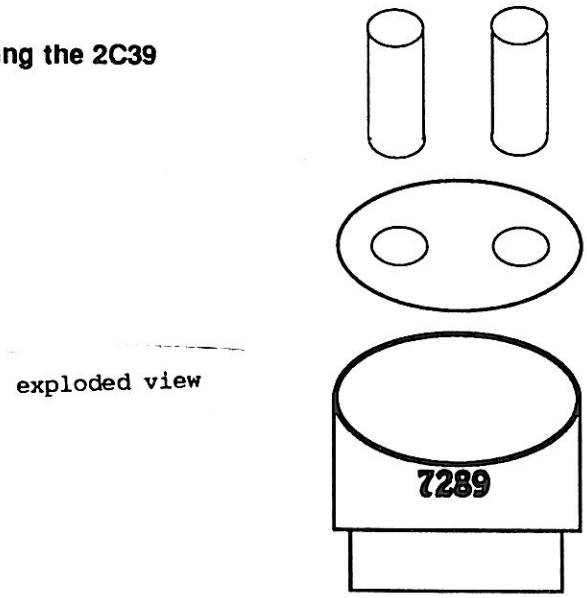


Figure 1–21: Water cooling the 2C39



1.20 Quick Method of Making Water Cooled 2C39's

Takao Sugimoto JH3EAO - July 1986

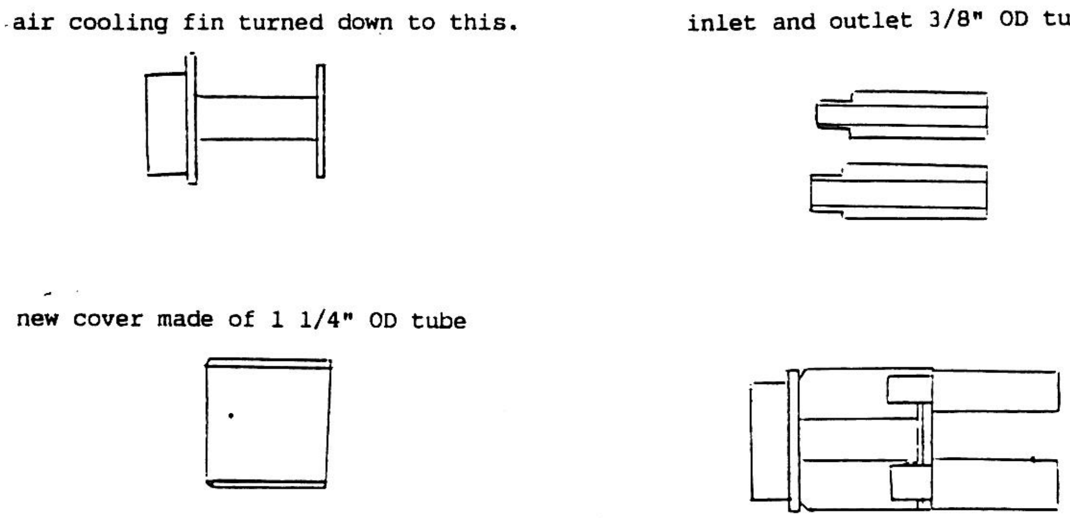
If you are looking for a quick way to cool your 2C39 type tubes, look at Figure 1–21. JH3EAO shows his method over here. There are no special parts needed, the copper pipes will be soldered directly to the tube.

1.21 The VK5MC Water Jacket

Chris Skeer VK5MC - March 1987

This construction shows how to use water cooling on 2C39 type tubes. Turn down the air cooling fins to their centre posts but leave bottom and upper plate intact. Then place a 1 1/4" OD tube and weld it to the top and bottom disk. Drill two 3/8" holes in the top disk for inlet and outlet tubes and weld them in place.

Figure 1–22: VK5MC 2C39 Water jacket



1.22 2320 MHz Amplifier

Barry Malowanchuck VE4MA - November 1987

This amplifier was created to fill an existing void in power amplifier designs for 2304 MHz. Previous designs by WA9HUV, OE9PMJ and OZ9OR have required extensive machine work or used exotic tubes. This design uses readily available materials in critical areas and can be built with simple tools. The design was developed using the principles presented by Buzz Miklos, WA4GPM in his paper Coaxial Cavity Amplifiers at the 1985 Central States VHF Conference.

1.22.1 Output Circuit

The amplifier will operate using any of the 2C39 or 7289 like tubes. The input and output circuits will accommodate the range of internal capacitances. The output circuit is a loaded 3/4 wavelength resonator while the input coaxial line is a 5/4 wavelength resonator. The input and output cavities use modified UG58A/U chassis mount N-connectors as a capacitive coupling probe. The plate tuning capacitor is a large diameter 5/16" brass "toilet flange" bolt with approximately 18 threads per inch. The plate tuning will be very sharp and a bolt with finer threads is recommended. I have used a 3/8" 24 tpi unit and found it very satisfactory. An option would be to make the anode cavity approximately 3/16" longer (overall cathode line length is unchanged but more of it will have to be inside the anode cavity) which will require less tuning capacitance. The change in capacitance for a change in length will be smaller near the outside wall.

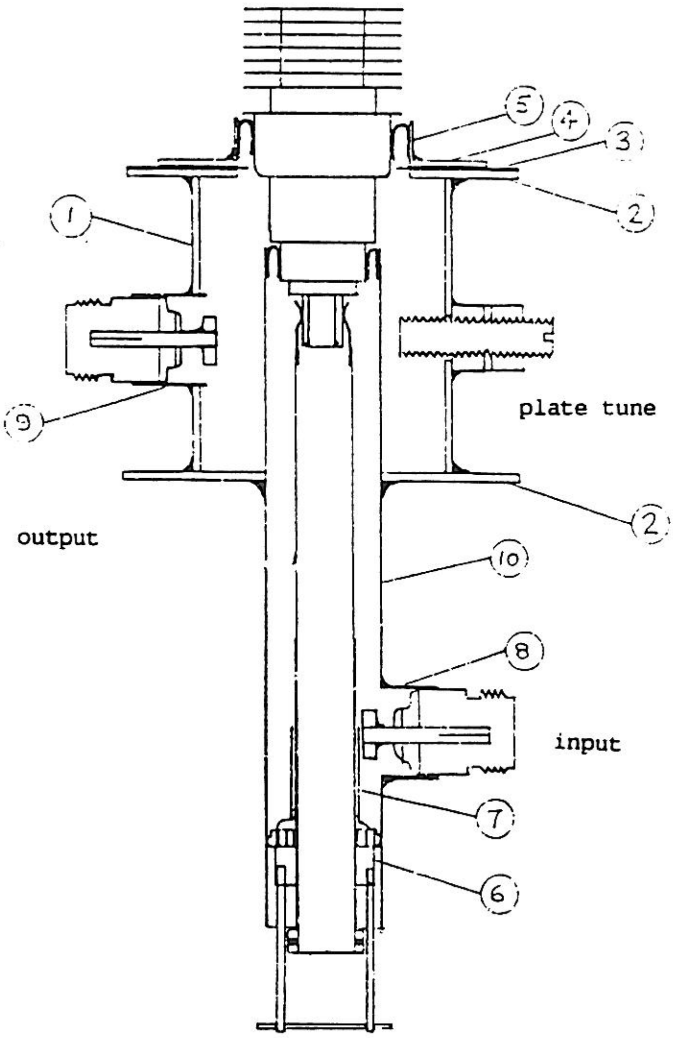
1.22.2 Input Circuit

The cathode cavity is tuned with a sliding RF short. This short uses conventional finger stock in contact with the inside of the 3/4 inch copper water pipe as the sliding coaxial quarterwave stub moves along the 7/16" OD cathode line. The bottom 2 inches of the cathode line is covered with a thin plastic sheet material. I used Teflon by Mylar tape (transparent "Magic" tape or the brown packing tape should work well. The 3/4" long piece of 1/2" OD hobby brass tubing in the RF short slides along on the tape. It should be smooth inside to prevent damage to the tape. The 1/16" brass rods extend out the bottom of the cavity to allow adjustment. The input coupling probe, like the output probe, is a UG58A/U "N" type coaxial connector with the mounting flange removed. A #8-32 brass nut is soldered to the end of the centre conductor and for the input probe, only a thin piece of Teflon or Mylar covers the end of the probe to prevent shorting out the input, when pushed all the way in. The probe will optimise within 1/16 " of the centre conductor. The copper input and output mounting sleeves were cut from a straight splice fitting for 1/2" copper water pipe. These were slotted and accept a small hose clamp to secure the coupling probes.

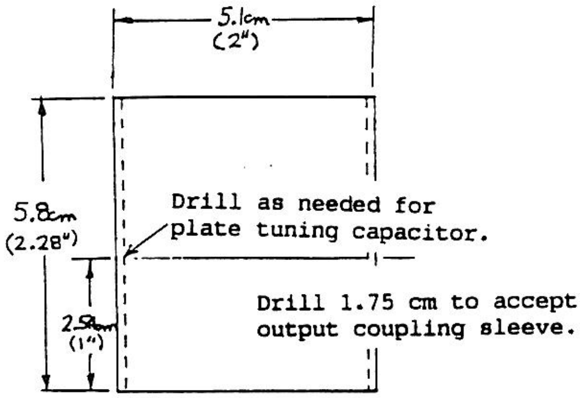
The cathode line assembly in my case was a surplus unit. The 7/16" outside dimension is important and should be adhered to, although +- 1/16" may work out allright if you adjust the dimensions of the 3/4" long piece in the RF short accordingly. The cathode line must be mechanically secured at the bottom without shorting out the cathode or filament voltage. This was achieved by securing the bottom of the cathode line to a 11/16" wide piece of epoxy board (no copper). A 7/16" hole was drilled in the centre of the 2" long board to let the cathode line pass through. The short pieces of approximately 7/16" ID tubing or 2 flat washers are soldered to the cathode line on opposite sides of the board to hold it in place. The epoxy board is secured to the outside of the 3/4" cathode line with 2 right angle brackets and a hose clamp. The push rods attached to the cathode tunable short, straddle the Epoxy board as they emerge.

Figure 1–23: 2304 MHz Power Amplifier

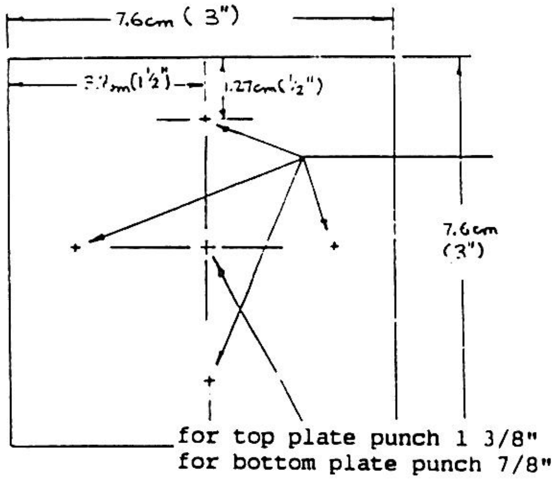
2304 MHz. Power amplifier
using 7289 or similar.



2" brass pipe with 1/16" wall

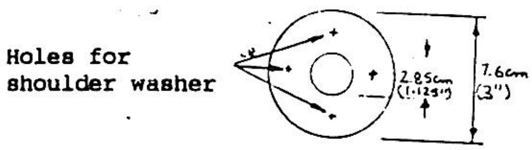


① Anode cavity
Outer conductor



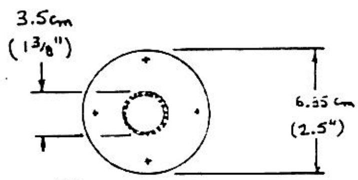
② Anode cavity top and
bottom plates

1/16" thick brass plate



0.015 teflon

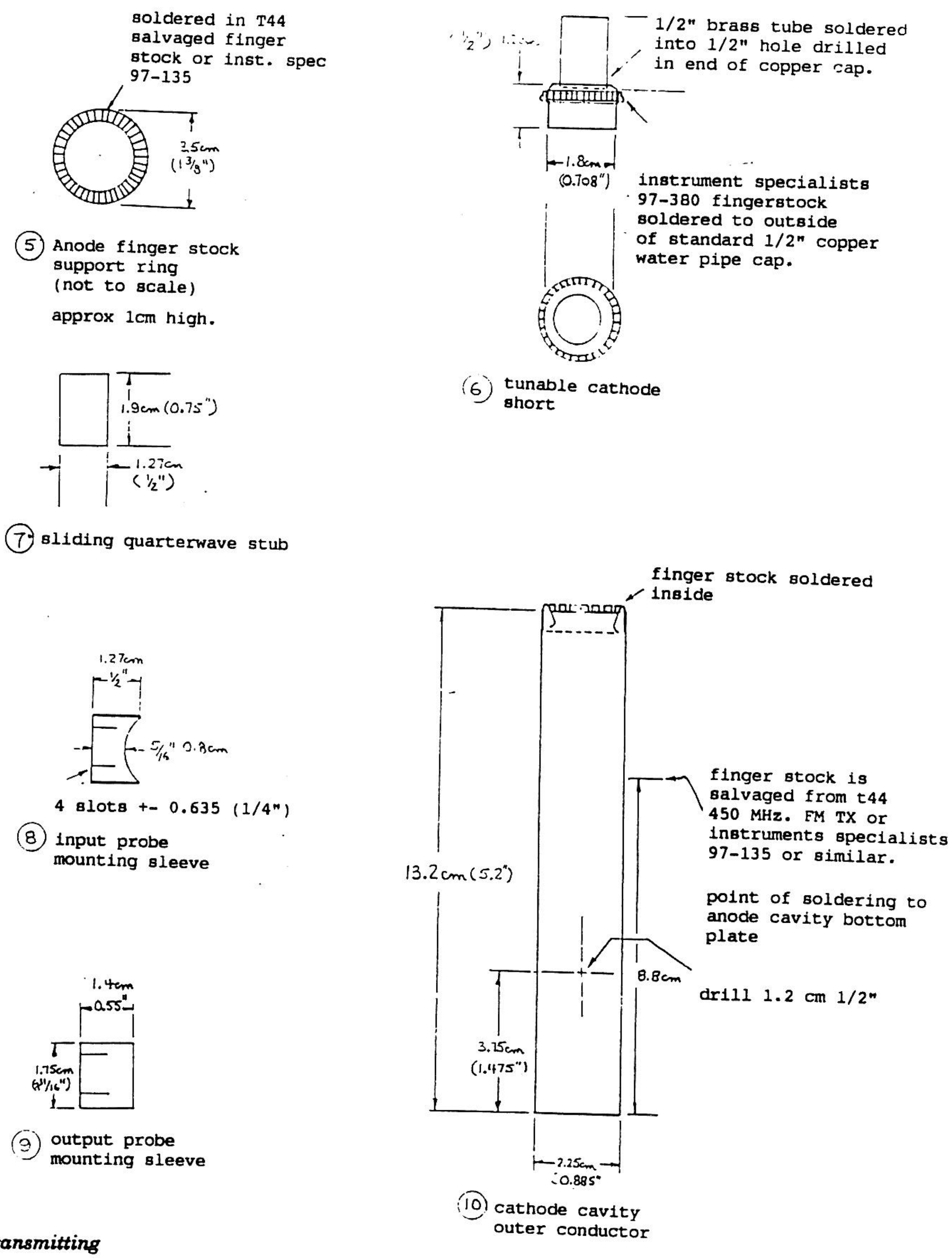
③ Plate bypass insulator
(not to scale)



④ Anode bypass plate
1/16" brass
(not to scale)

Figure 1–23 Cont'd on next page

Figure 1–23 (Cont.): 2304 MHz Power Amplifier



1.22.3 Tuneup and results

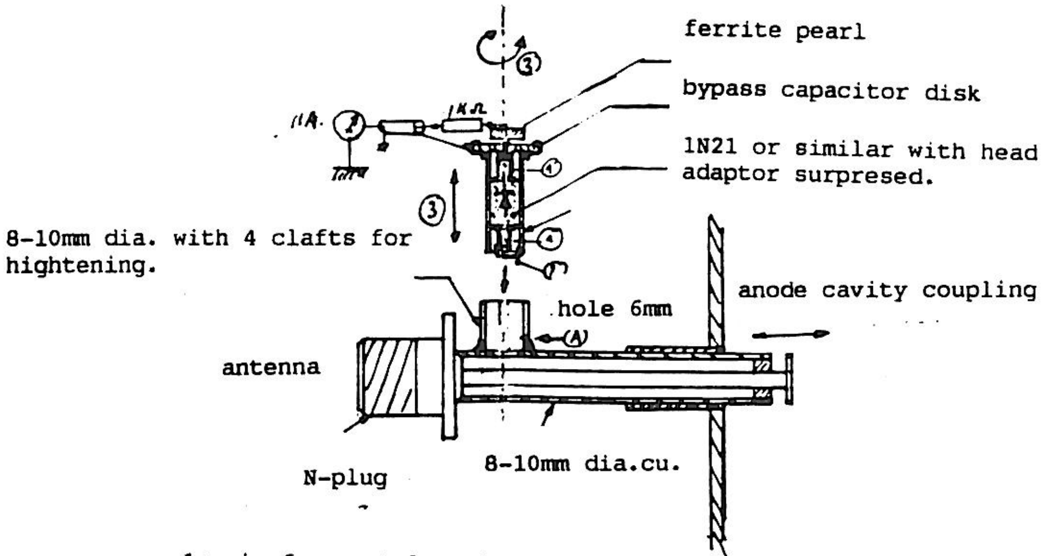
The amplifier tunes very easily and smoothly. The amplifier should tune with the probes etc. in the positions shown in Figure 1–23. Adjust the idling current for 50mA and apply a few Watts of cathode drive. Adjust the cathode short and the input probe for maximum plate current. With a suitable RF indicator, adjust the plate tuning for maximum output. It will be a very sharp peak. Then alternately adjust the output probe and tuning for maximum power. With good tubes, I have seen greater than 60W output at efficiencies near 25% and a gain of 10-13 dB. One final comment is required concerning cooling. No attempt has been made to use air cooling. My experiences on 23cm with these types of tubes is that water-cooling is the only way to eliminate thermal drift of the output power. The two versions of this amplifier I have built, have no significant drift with 7289 type tubes. A slight amount appeared with the 7211 tube but this was not enough to be concerned of.

1.23 RF Probe With Power Monitor

Philip Pierrat F2TU - December 1987

An easy way to have a power indicator from a cavity amplifier is presented by F2TU. He uses a 1N21 or similar diode with a little loop which is fixed in a piece of tubing soldered onto the RF output probe of the cavity. Sensitivity can be changed by sliding the inner tube with the diode in the outer tube. The 1N21 is fixed inside the inner tube by using a pin from an octal socket. Results obtained by F2TU on 2300 MHz are 300 uA with 70W HF when (2) is at the position of (A) as shown in Figure 1–24.

Figure 1–24: RF Probe With Power Monitor



1: pin from octal socket

2: 0.5mm wire soldered after 1N21 introduction

3: sensivity tuning

1.24 Output Probe for Annular Cavity Amplifiers

Paul Chominski SM0PYP - April 1988

Amplifiers based on UPX-4 design contain Teflon plunger for tuning, and inductive output probe from the anode cavity. My own experience was that this kind of Teflon plunger introduce losses and sometimes can even burn badly, when the amplifier is not loaded properly.

1.24.1 Construction

In the first stage I changed the Teflon to a metallic plunger. Even if arcing inside can happen, it will not cause any permanent damage. Second step was just to skip the inductive output loop using only capacitive coupling and insert this one into the metallic plunger. This should make more equal load for all tubes inside the cavity, as it is symmetrical. W2IMU came with a very good suggestion, to use a quarter wave transformer inside the output probe. This will cause larger distance inside the coupling capacitor, and will decrease the risk of arcing. The only tricky point is to achieve good electrical contact by using proper finger stocks.

Figure 1–25: Output Probe for Annular Cavity Amplifiers

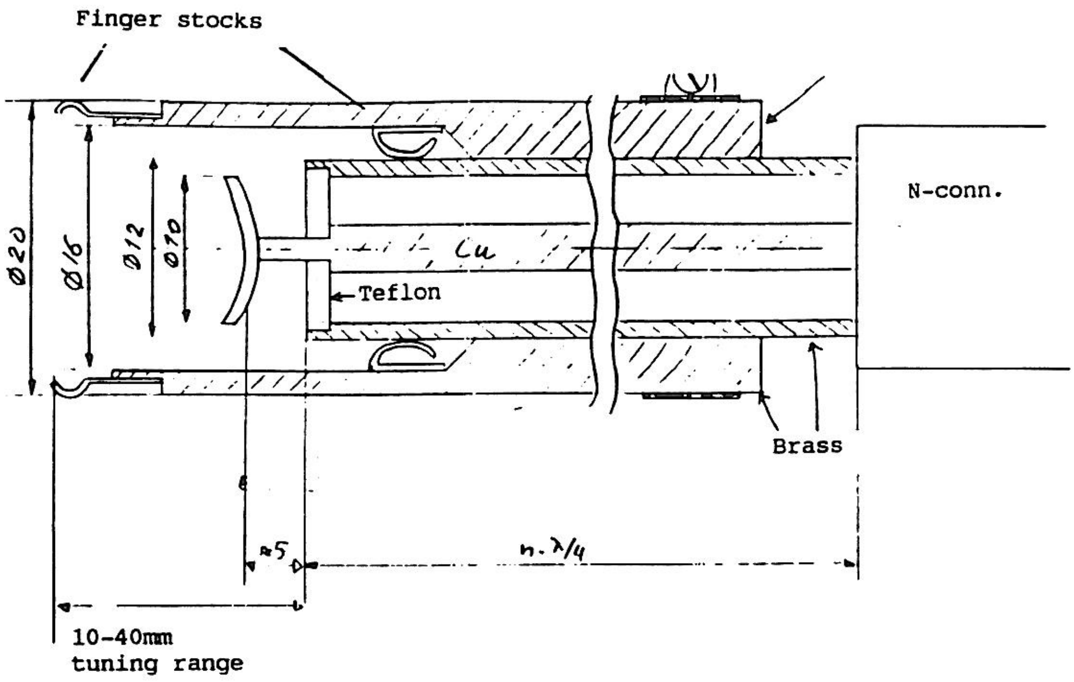
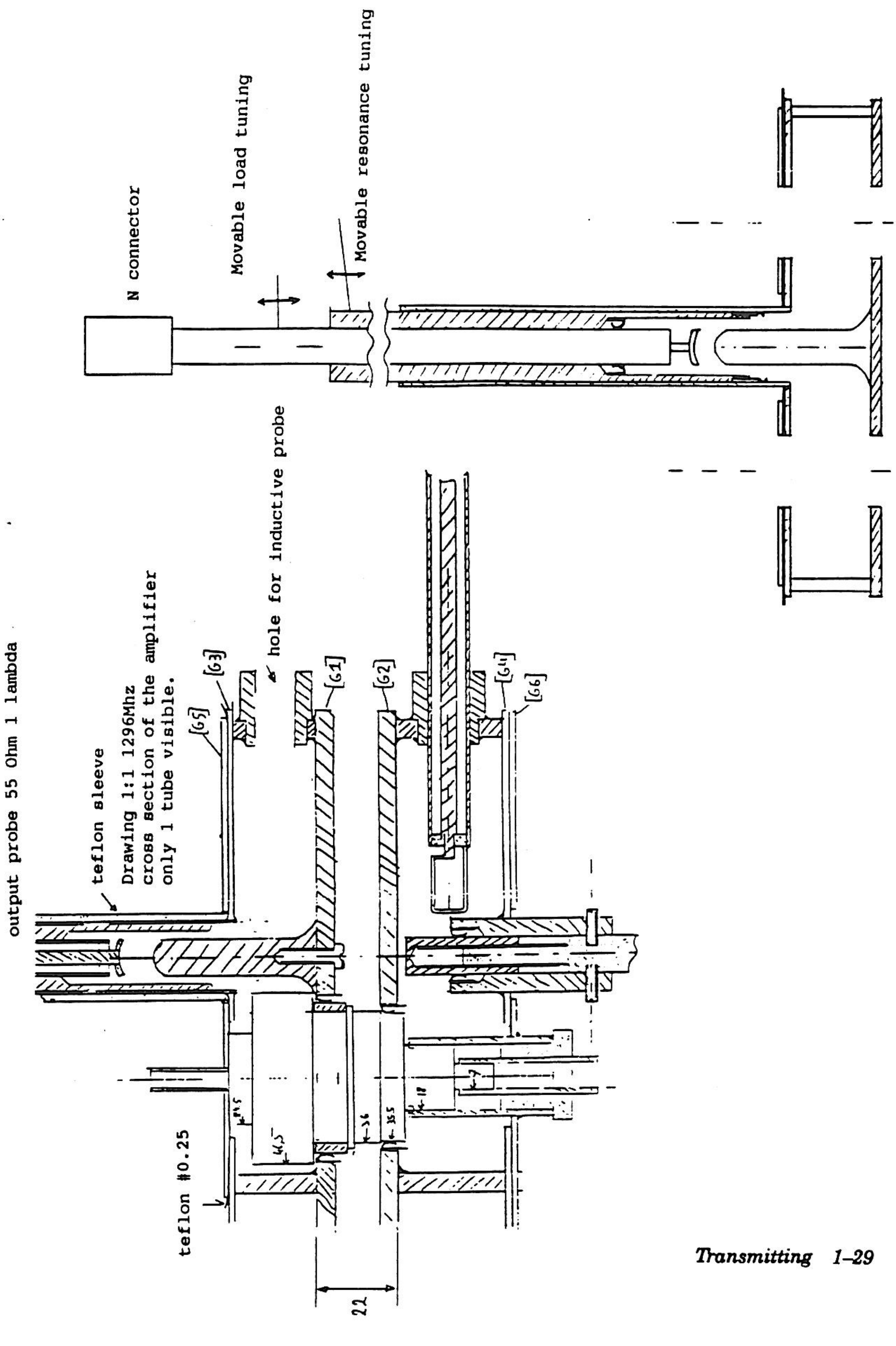


Figure 1–25 Cont'd on next page

Figure 1–25 (Cont.): Output Probe for Annular Cavity Amplifiers



1.25 The Audrey II UHF Amplifier

Russ Miller N7ART - April 1988

When I picked the 3CX800A7's for use in this amplifier it was with one thing in mind, to use tubes that would do the job but at minimal cost. The 3CX800A7's (two of them) cost less than one of the more heftier single tubes available. Incidentally, two 3CX800A7's allow you a total of 1600W plate dissipation! The Audrey II UHF amplifier utilises two grounded grid 3CX800A7's, biased for class AB2 linear operation to minimise intermodulation distortion. In AB2 operation the efficiency is approximately 56% when the amplifier is terminated in a 50 ohm non reactive load. Design centre frequency of the amplifier is 432 MHz.

It is recommended that Eimac's specification for the 3CX800A7 be followed for maximum tube life. Plate voltage should be in the range of 2000 to 2200 VDC, not to exceed 2500 VDC when unkeyed. Total plate current should be 1 ampere at specified voltages. This amounts to 500mA per tube. At 2200 VDC with 1 Ampere plate current and 56% efficiency the output should be approximately 1232W. Plate dissipation would be 484W for each tube, well below their capability of 800W dissipation per tube!

Normal operation cautions prevail! Don't operate into a high VSWR load, don't apply drive without plate voltage being present, don't apply high voltage until the heaters have warmed up for at least 3 minutes, don't shut it down without at least a 3 minute cooldown period.

When operating the amplifier with 1kW or more output you are past the point where RG8/U or RG9B/U can be used, they will melt! Some antenna relays will also not handle the high power levels this amplifier will produce.

1.25.1 Input Circuit

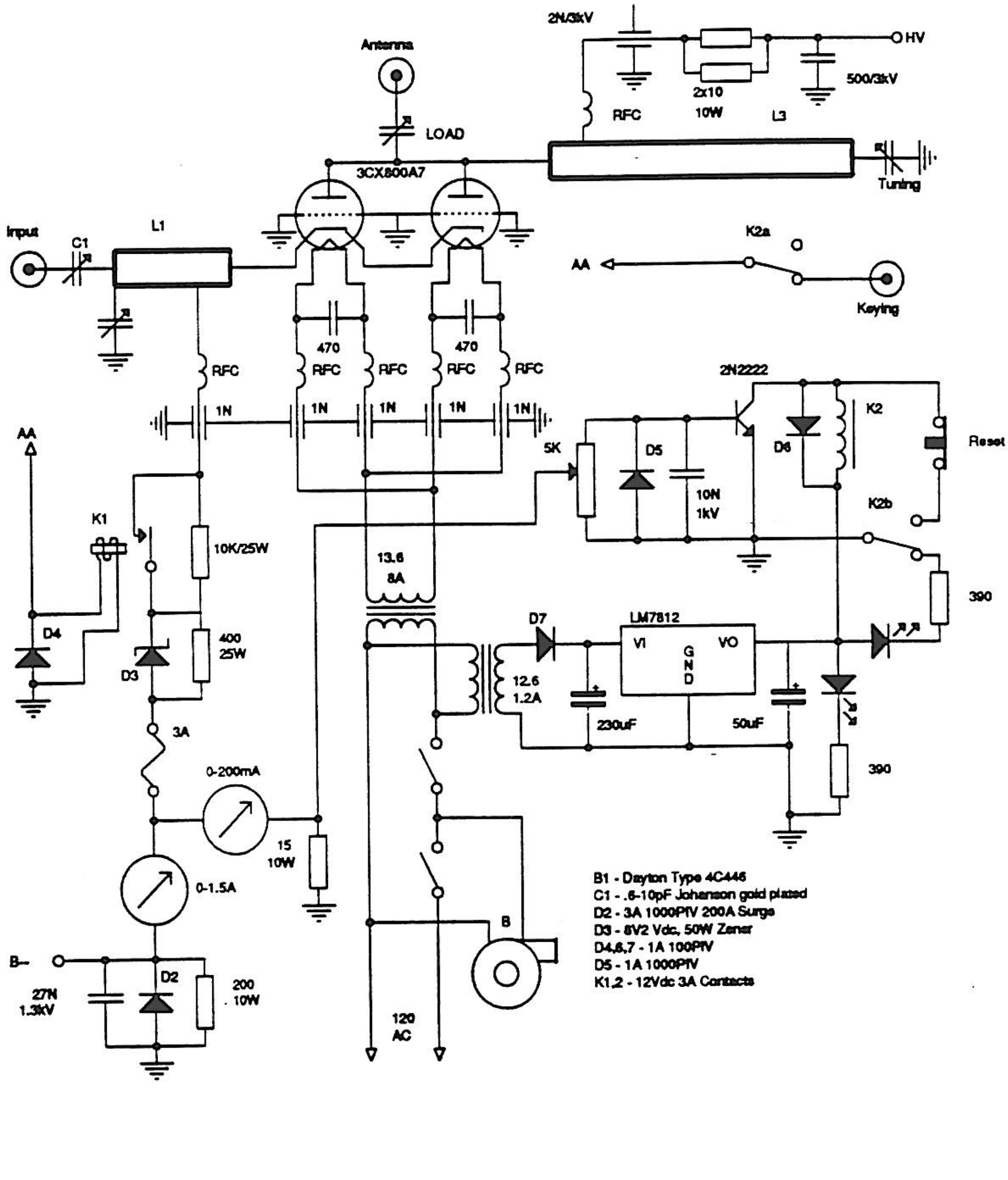
The amplifier uses a tuned cathode circuit for low intermodulation distortion, matched to a 50 ohm drive source. Cathode bias is provided by a 8.2 VDC, 50W zener diode, and cutoff bias is supplied by a 10K, 25W resistor. A 3 A fuse, in series with the cathodes, provides protection from fast overcurrents. Keying relay contacts are used to short out the 10K cutoff bias resistor to place the amplifier in transmit mode. The input tuning capacitor C2, is made from a Johnson 160 series with all the stator plates removed except 3 and all the rotor plates removed except 4. L1 is attached directly to the stator plate support rods of C2. The entire input circuit and sockets must be contained within an enclosed chassis box with all the leads leaving the box well bypassed by feed-thru's.

The 3CX800A7 uses an inexpensive 11-pin tube socket. Before mounting the sockets, bend pins 4, 7 and 11 over and solder them to the tube socket integral mounting ring. Next, using 0.005" shim stock, connect pins 1,2,3,8,9,10 (cathode connections). Drill a hole in the centre of the tie plate connecting all the cathode pins (6-32) and mount L2 at this point. Connect C1 to C2 with as short a lead as possible, C1 should be backed all the way out (adjusting screw in the centre of the capacitor). This is the starting point for setting minimum input VSWR. The grounding ring should be made from 1/16" copper and small finger stock. This is the inexpensive way to do it! The Eimac 720359 collet is a little expensive.

1.25.2 Drive Requirements

The amplifier will produce 1000 W output with approximately 52 W of 432 MHz drive. This figure will vary depending on plate voltage and differences from tube to tube. Because the amplifier requires such low drive, care must be taken not to overdrive the cathodes.

Figure 1–26: The Audrey II UHF Amplifier



1.25.3 Output Circuit

The output circuit uses a 1/2 wave stripline, made of 1/16" copper, capacitive tuning and coupling. The plate stripline is supported on two 1-3/8" x 3/4" Teflon insulators. Plate tuning is accomplished with a "flapper plate" that is in 2 parts, half of it is a 1-1/4" square brass plate soldered to the stripline, at the tube end of the line. The other half is a 1" diameter copper disk fastened to an N-fitting with that assembly being made adjustable so it can be moved to vary the coupling capacity. The plate choke and bypass capacitor, as well as all the other chokes, were designed specially so there isn't a sneak series resonant circuit that could be shock or harmonic excited causing one of those unexplained arcovers.

1.25.4 Arcover

Amplifier arcover may occur with either of two conditions, one is high load VSWR and the other is overly light loading. In these cases, the circulating tank current and stripline E field can become so intense that it will relieve itself by arcover. Protection is provided by 3 devices: The grid overcurrent board, the 3 A cathode fuse, diode D2 and the 0.027 uF capacitor across the diodes. Most normally an arcover will only fail one of the diodes. Also there are a pair of parallel 10 ohm 20 W resistors in the high voltage circuit. These may be blown if an arcover occurs. If an arcover occurs, immediately remove the RF drive.

1.25.5 Cooling

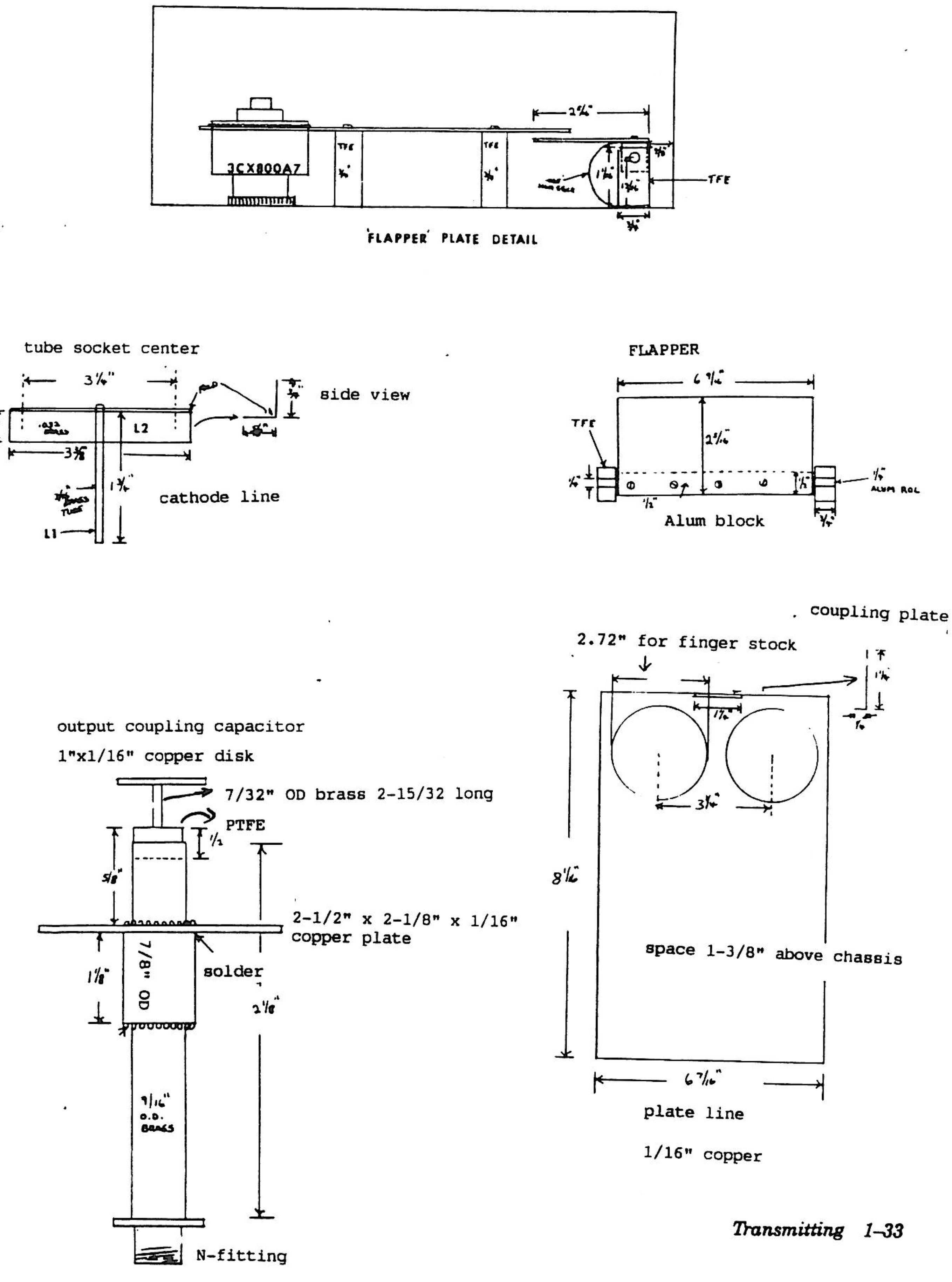
Eimac specifications recommend a minimum of 19 cfm of air flow through the anode of a single 3CX800A7, at sea level, dissipating 800 W, at a room temperature of 77°F. Two tubes require a minimum of 38 cfm. The blower recommended will provide 3 times the required cfm air flow for 2 tubes. It is suggested that 4 drilled aluminium blocks (2 holes in each block at right angles L-shaped) be used with 2 blocks mounted in the cathode compartment and directed at the cathode tie plate on each tube socket. The other blocks should be positioned to direct air at the heather pins on each socket. The holes through the blocks should be at least 1/4".

The blocks should be mounted with a 6/32 screw after drilling a 1/4" hole through into the anode compartment which is the source of pressurised air. The blower should be mounted so air is directed into the anode compartment at a point about half way between the tube and the end of the stripline where the flapper plate is located. A screen does not need to be placed across the blower opening, it is waveguide beyond cutoff anyway.

1.25.6 AC Circuits

AC power is fed through an RFI filter to a 6 A circuit breaker and then to the power switches. The RFI filter is present to provide some transient AC surge protection. The AC power switches should be wired so that the blower comes on as soon as the main AC switch is activated. The heaters cannot be turned on until the main AC switch is on. Eimac specifies that the heater voltage be 13.5 VAC +/- 0.6 VAC. To obtain this voltage it is recommended that you contact a transformer manufacturer such as Peter Dahl or Avatar Magnetics and have one wound since there aren't any commercially available. The two tubes will require a transformer that will supply that voltage with 3 A current flow. Don't worry about dropping the voltage back since most of all the operation will be in either CW or SSB mode and little back heating of the cathode will occur. It has not been a problem for me in 41/2 years of using 3CX800A7's. A quick word about the blower, it has internal thermal protection, should a winding fail or the motor freeze up. To prevent freeze up the blower must be lubricated at least once a year.

Figure 1–27: The Audrey II UHF Amplifier mechanics



1.25.7 Air Exhaust

There isn't a simple way to exhaust the heated air from the plate compartment other than to provide the least restriction after it leaves the anode. I use an Eimac SK-1906 chimney (2 of them). Saw each chimney in half, bolt one half to the plate stripline and the other half to the cover over the plate compartment. Use a piece of 0.030" Teflon sheet rolled up and fastened with a couple of 1/8" rivets as the chimney between the two halves of the SK-1906

1.25.8 Construction

The anode compartment is 12" x 9" x 4-1/2" deep, the cathode compartment is 6-1/2" x 3-7/8" x 2" deep. Placement of the cathode compartment will depend on the relationship of the length of C2 plus the length of L1. C2 has to be mounted to the wall of the compartment with the height of the stator plate support rods matched to the height of L1. The cathode compartment should have at least 3 holes drilled somewhere around the sides to exhaust the air from the drilled aluminium blocks mentioned under "Cooling" A cover is required over the cathode compartment and one over the plate compartment. The plate compartment cover has to have screws spaced no more than 2-1/2" apart to hold it down and to provide good RF seal and air seal. The tube sockets are mounted 3" from the 9" end of the plate compartment, spaced 3-1/4" apart. The sockets require a 1" hole for each. The plate tuning flapper is mounted on a 1/2" x 1/2" aluminium bar, drilled on each end for 1/4" aluminium rod that will serve as pivots in Teflon 3/4" x 1-1/16" blocks. The aluminium bar is spaced 13/16" from the chassis. A piece of 0.005 brass shim is fastened to the bar and the chassis such that spring action afforded that will push the flapper up. The flapper is 2-5/16" x 6-9/16" and is made from aluminium. The actual tuning mechanism will have to be made up by the constructor, describing it is beyond the space available here.

1.25.9 Notes

If you tackle this project you will be pleasantly surprised at how easy the amplifier works, docile too! However, this amplifier will produce a surprisingly large amount of power, sufficient to melt many things, especially coax! Whatever high-voltage supply is used will have to supply at least 1+ Amperes readily. The supply B- has to be floating above ground and a B- lead run from the power supply to the amplifier along with a ground lead that is connected to the power supply chassis ground. Keying requires 12 VDC and the source should be capable of supplying 120 mA.

1.26 Hi-Power Hybrid

Tim Pettis KL7WE - May 1988

Would you like to run the legal power limit on the VHF and UHF bands without mortgaging your home? There IS a way to make the jump to higher power without starting all over. You need not rush out and buy a brand new 8877 or equivalent! You can use what you have and just add to it.

Using hybrid rings one can combine any two amplifiers having similar characteristics. A common amplifier on 144 MHz is the K2RIW using a pair of 4CX250's. It's output is a comfortable 750 W on CW. Two of these amplifiers can be connected by hybrid rings to produce the 1500 W legal limit. For less than $25.00 worth of parts (at new prices), one can produce a pair of hybrid rings. A venerable old RIW can be purchased with power supply for less than half the price of an 8877 tube alone. I have combined a pair of 432 MHz ARCOS amplifiers using Amperex DX393A's (Eimac 8930). The combination produces 1500 W output power.

1.26.1 Theory

The ring consists of 6 electrical quarter waves as shown in the diagram. A signal at port "A" will be equally divided between ports "B" and "C". Zero power will appear at port "D" The phase relationship at port "B" is -90° and port "C" is -270°. Power arriving at port "D" from port "A" via port "C" is -360° relative to port "A".

Power arriving at port "D" from port "A" via port "B" is only -180° relative to port "A". The result is that at port "D" the signals are 180° out of phase and cancel.

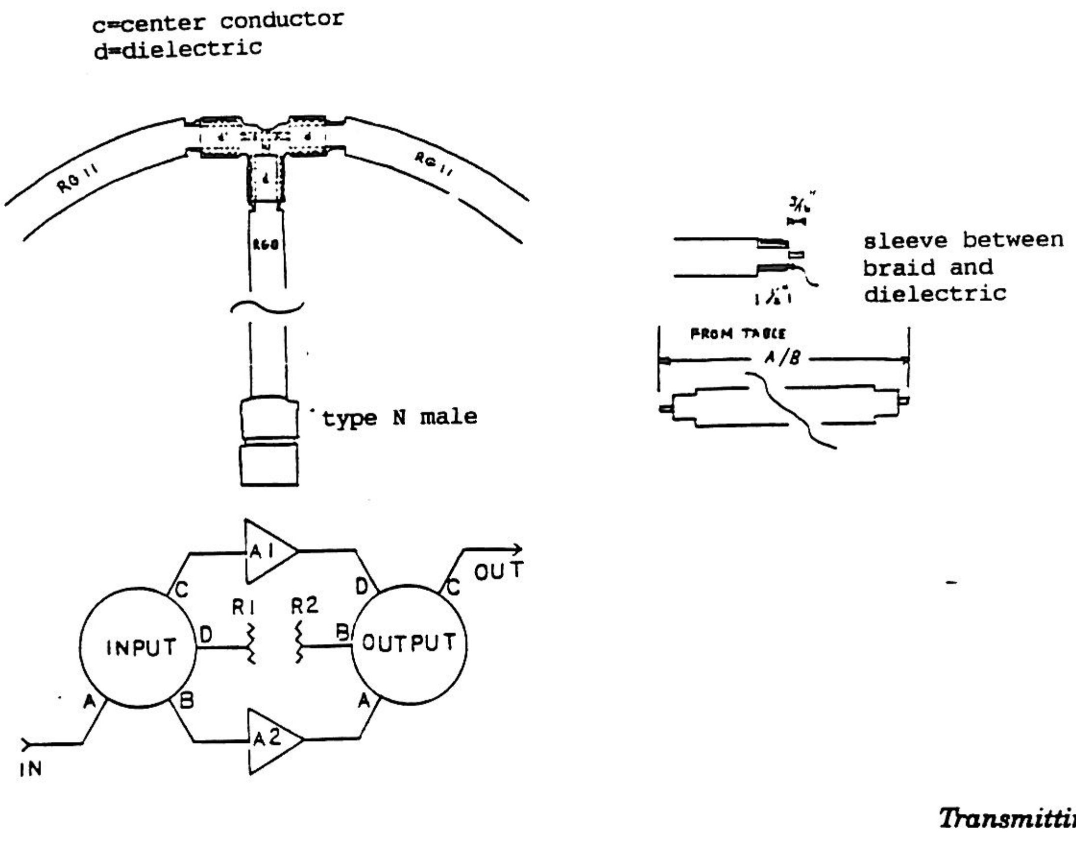
Power to the output ring is fed into port "A" and port "D". Power fed into port "A" arriving at port "D" via port "B" is 180° out of phase with that arriving via port "C". The net result is that power from one amplifier is not fed into the other. Power arrives at port "C" in phase as a result of the 180° phase difference that exists in the input ring.

The advantage of this method is that the input ports of the output ring are isolated from one another, preventing meltdown of one of the amplifiers should the other go dead.

In the event of an open at either input drive port of the output ring, one half of the drive will go to output port "C" and the other half will be sent to port "B".

For this reason the output ring termination must be capable of dissipating 50% of the power of either amplifier. That is to say that if you combine two amplifiers capable of producing 500 W each, the terminating resistor must be rated at 250 W. Port "D" of the input ring must be terminated in a load capable of dissipating 50% of the drive power. The ring itself is made of 75 ohm line. Each quarter wave section joined to the next provides a match to 50 ohm in just the same way that it is used to transform impedances in a two way power divider.

Figure 1–28: KL7WE Hi-Power Hybrid



1.26.2 Construction

The input ring can be made of high quality RG 59/U. The output ring can be made with conventional RG 11/U. The physical length of the lines can be calculated using the dielectric constant. The length for each band is given in Table 1–2. (This calculation is made for a velocity factor of 0.66.) The input ring can be constructed in a metal chassis box using BNC chassis connectors. Grounding is important! The braid should be joined as close to the end of the coax sections, and hence the connectors, as possible.

Table 1–2: Sizes for Hi-Power Hybrid

Band	Length A	Length B
432 MHz	4.5"	13.55"
220 MHz	8.86"	26.58"
144 MHz	13.50"	40.60"

Sizes are for a velocity factor of 0.66

A word of caution is in order. One might be tempted to try to construct the ring using coaxial T-connectors. **Don't do that !!** First, it is difficult to determine the velocity factor of that combination. Second, the impedance of most T-connectors I've found is unpredictable, and a good match is not possible, especially at 432 MHz . . .

It is necessary to get the phase relationships in the output ring as close as possible or there will be power transferred from one amplifier to the other. To join the 1/4 wave and 3/4 wave, RG11 sections of the ring to RG8 pigtails in a practical and repeatable manner took a little thought. The problem is solved by using copper water pipe T-connectors. 1/4 inch fittings have about the right inside diameter. The ring can therefore be connected to amplifiers antenna and termination without incurring extra losses. This is especially critical at 432 MHz and higher.

Begin construction by cutting 3 lengths of RG11 coax to dimension "A" and one end to dimension "B". Take care to blunt cut the end so that the strands of centre conductor remain together. Remove 3/16 inch of outer jacket, braid and dielectric from each end of the sections. Remove 1/2 inch outer jacket. Select a convenient length for the RG8 pigtails and cut 4 equal lengths. This should be not more than 18" at 432 MHz. Prepare one end as described above for the RG11. Install a type N male connector on the other end.

Cut 12 sleeves of 9/32 inch thin wall hobby shop brass tubing 1/2 inch long. Carefully slip the tubing between the braid and the dielectric. Smooth the braid down over the tubing and solder the braid to the brass. Be sure to use a low wattage iron for this purpose to avoid distorting the dielectric. Use of excess solder will prevent slipping the coax into the water pipe T-connector. Drill a 1/4 or 5/16 inch access hole in the top of the waterpipe T-connector. Be sure to deburr the inside of the hole. Slip two RG11 ring segments and a RG8 pigtail into the T-connector so that the 3 centre conductors meet exactly in the middle of the connector. Use the natural curvature of the coax to help form a ring. Use some means of holding the work in place. Heat the body of the T-connector allowing solder to flow inward around the circumference of the braid. You will find that the underlying brass sleeve will extend outside of the T-connector providing rigidity and a means of containing the solder. Solder the three centre conductors together. Make sure that you have a good connection here. Cover each joint with heat shrink tubing as you go. Repeat to complete the ring.

1.26.3 Testing

Each ring should be tested to insure symmetrical power division. This is best done with low power. Power division between ports "B" and "C" should equal and result in negligible loss of power. Next connect the rings together without the amplifiers. The total loss through the combined setup should also be negligible. For a 10 W signal, the total loss through both rings should be on the order of less than 0.05 W. Finally check the power of port "D" of each ring. Again more than 0.05 W out of the isolation port would indicate possible trouble. If you have access to a sweep generator, you can measure the symmetry and isolation of the hybrid by inserting a signal at port "A" and detecting the output at port "D". At the design frequency and only the design frequency, the power at this port should be in the order of 27 dB down. Multiple notches at this port indicate lack of symmetry (measure lengths carefully). For comparison the isolation of the input Combiner made of RG59 had better than 27 dB isolation from 400 to 440 MHz rising to 26 dB at 450 MHz.... The output ring exhibited similar characteristics.

When finally connecting the amplifiers, remember that the connecting lines between the amplifiers and both the input and output rings must be the same length. This assumes that both the internal input and output circuitry of the amplifiers is the same. Some amplifiers may use a short section of coaxial cable to connect from the RF input connector to the actual grid circuit, or equivalent. Especially in home-brew amplifiers this cable length may vary. This is not a problem. The internal lines can be made the same length, or the external lines can be made longer or shorter to compensate. All checks having been made, you are ready for final connection.

1.26.4 Final Thoughts

I had been reluctant to commit to the use of other than air dielectric line for the output ring for reasons of efficiency and possible component failure. However the temporary output ring has been in service for over 150 EME contacts during a 4 month period. Although there is some heating at the output port "C" after prolonged operation, it is not seemed serious enough to expect a failure at this junction. All others are cool. The caveat applied here is that the load (antenna) connected to the output of the ring be reasonable close to 50 ohm. I would also not expect one to use this ring for continuous service. SSB and CW provide no threat unless you are prone to lay a brick on the key to tune up. I suggest sending a series of 'dits' at 40 WPM.

1.27 A Bias Circuit for 7289 or 2C39 alikes

Rusty Holshouser K4QIF - June 1988

This circuit provides protection from thermal/detuning run away in terms of limiting the cathode current that may be drawn by any tube in the lineup. Also, cathode bias increases with drive cathode current. This will improve efficiency especially with high power CW operation. The circuit will have to be duplicated for each tube in the amplifier with the exception of the transmit enable relay and metering switch. The +25 V and 50 VDC supplies can also be common and do not have to be capable of much current. Q1 is the cathode current limiter. It is saturated until it becomes starved for base current at which level, its emitter to collector voltage increases and drives the cathode bias up. Q2 sets the bias level at the idle current.

Table 1–3: Operating conditions 6 tube UPX-4 Amplifier

Filament	5.5 VAC
Plate voltage	1750 V
Plate current	900 mA
Ik max per tube	200 mA
Idle per tube	30 mA
CW power out	800 W

Under these conditions with a good set of tubes, the amplifier will run key down for long periods of time. Higher power outputs can be obtained with a duty cycle less than 100 percent. One word of caution many problems with UPX-4 amplifiers originate from over driving them. To achieve the above conditions, only about 40 W of drive are required.

1.28 432 MHz Amplifier using 2 x 7650

Bernd Wilde DL7APV - November 1988

Bernd runs this amplifier at 2.5 kV at no load and 2 kV under load conditions. To reach an output of 2 kW he needs 150 W of drive power, thus the amplifier has a gain of approximately 11 dB. The screen voltage which is used is 560 V, while the heather requires 6.5 A at 6 V. All dimensions of the construction details in Figure 1–30 are in millimetres.

Figure 1–29: A Bias Circuit for 7289 or 2C39 alikes

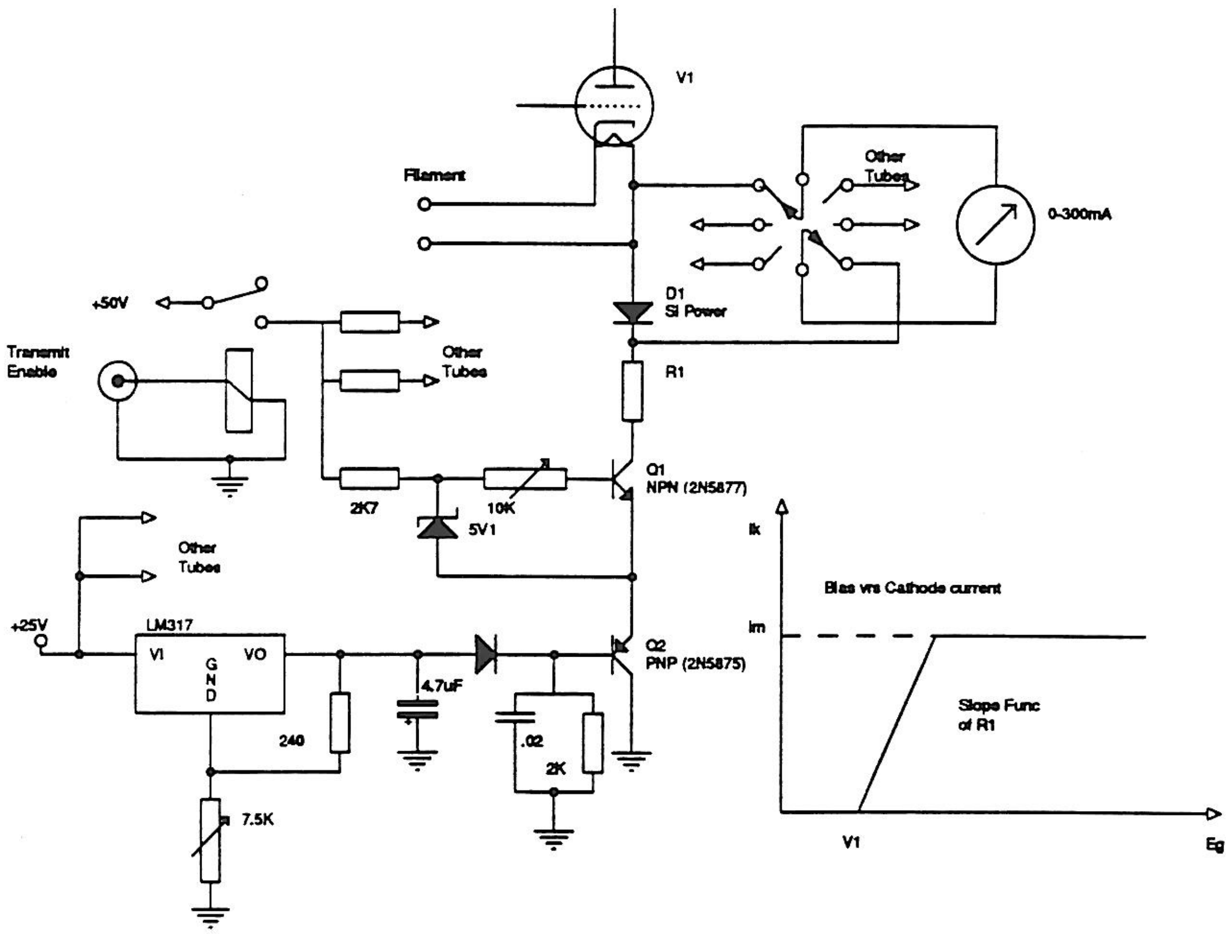
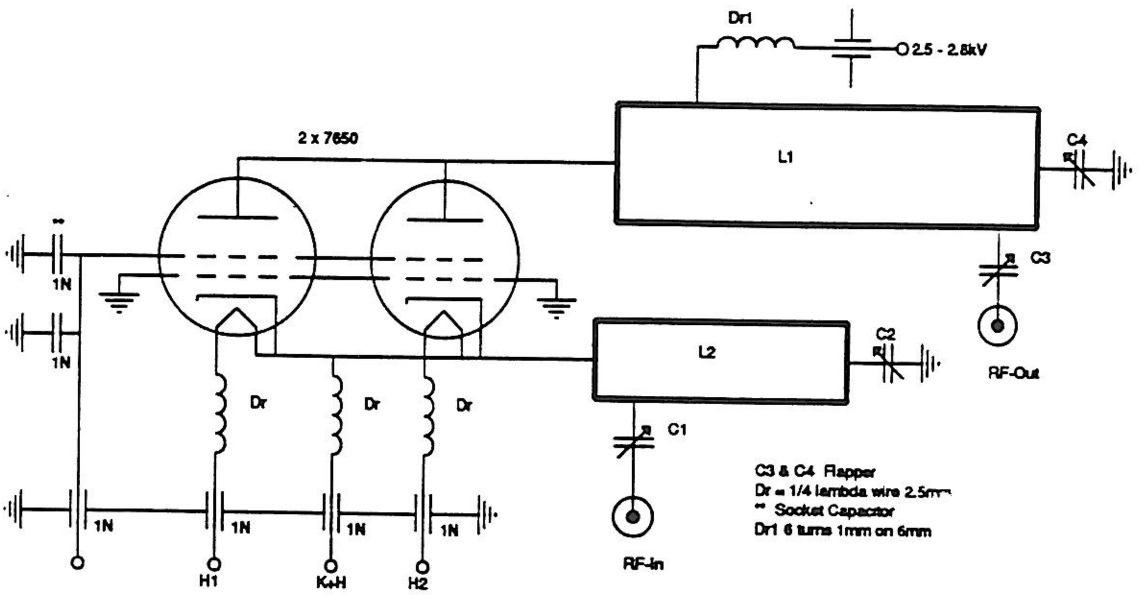


Figure 1–30: DL7APV 432 MHz Amplifier



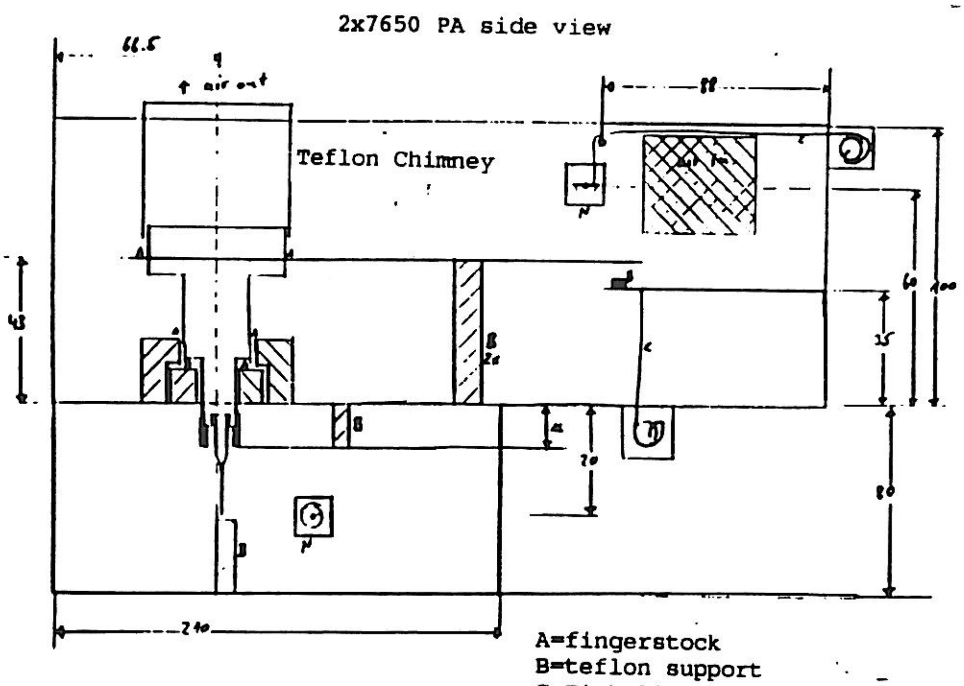
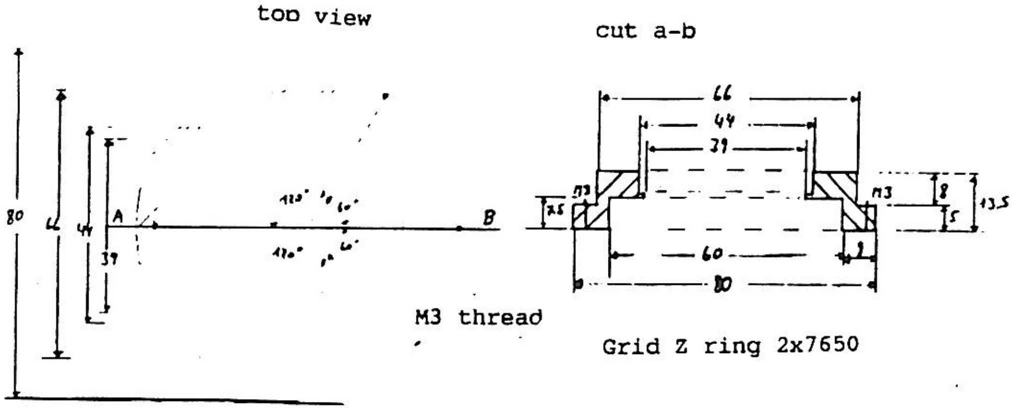
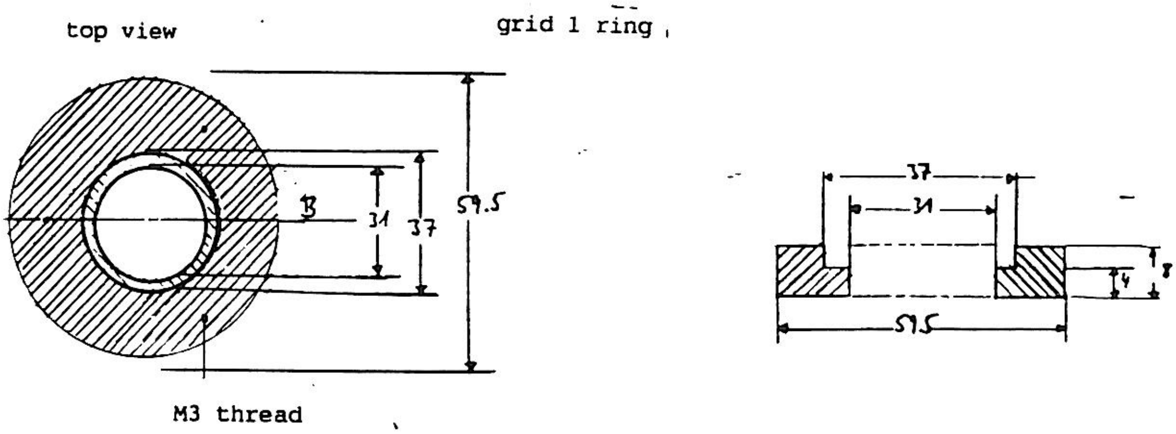
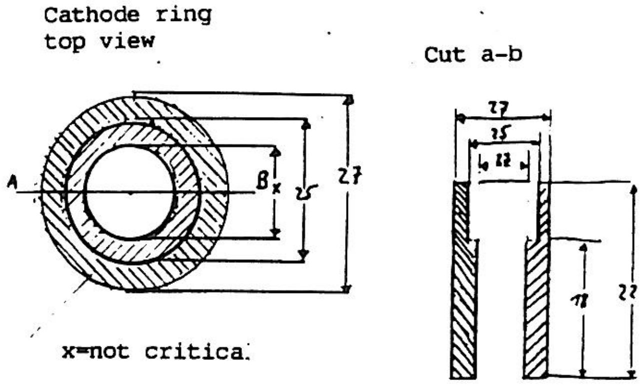


Figure 1–30 Cont'd on next page

Figure 1–30 (Cont.): DL7APV 432 MHz Amplifier







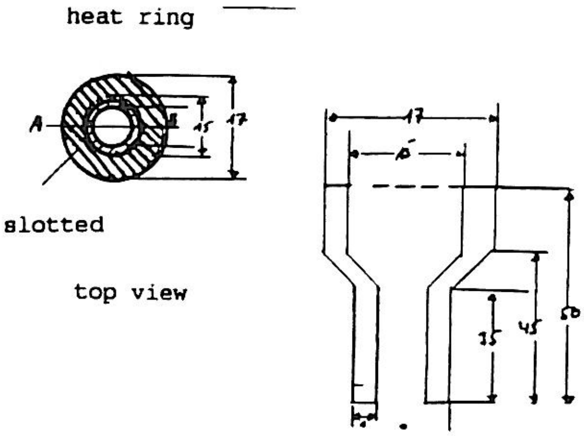
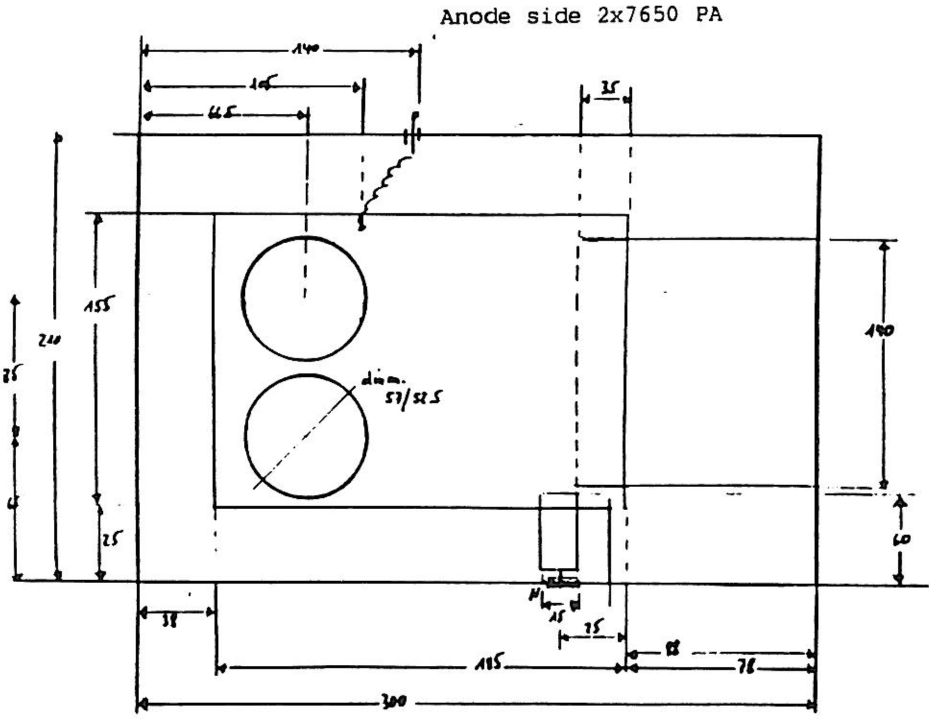
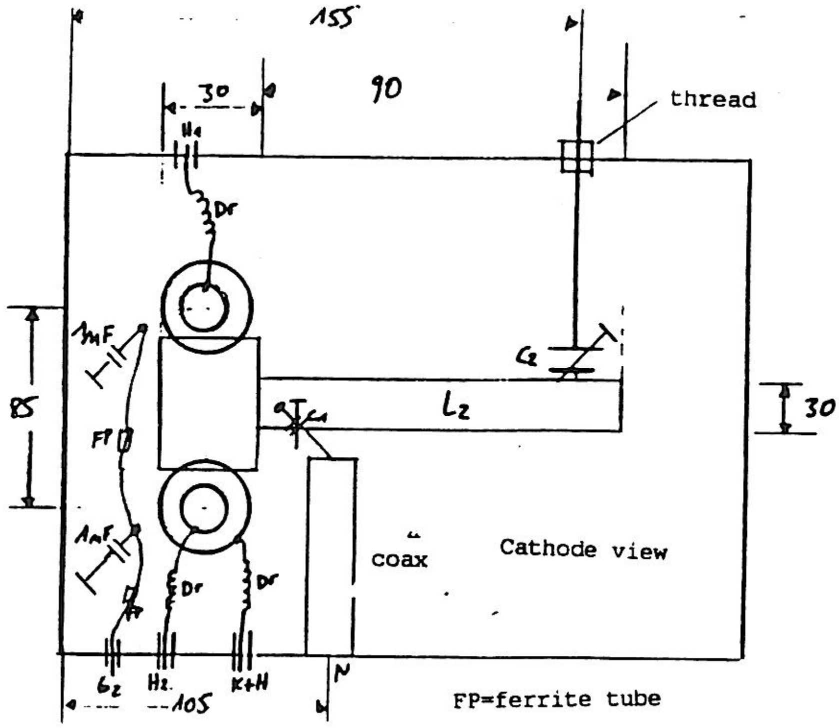


Figure 1–30 Cont'd on next page

Figure 1–30 (Cont.): DL7APV 432 MHz Amplifier





1.29 YU-129 Modifications

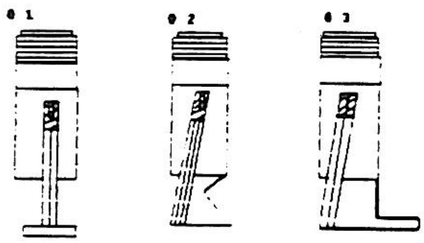
Tom Ellis WB0QMN - December 1988

Tune the cavity at about 3 W drive and about 2000 V on the plate, tune for max output, now check the grid meter and see if the peek output and 0 grid peek at the same time. If so increase the the drive to about 30 mA of grid and you will get about 550 W output.

1. Is a stock coupler as comes in the cavity. This will run 300 W output at about 33%.
2. 1/16" strap and centre pin cocked to one side and the strap bent as shown in #2. This will run 600W at about 46%.
3. This connector loads down the cavity heavier and hasn't arced yet and I am running it at 550 W output.

As you can see it is easier to change the output loading connector rather than redesign the cavity. I believe there is still room for improvement, but I am close. And the amplifier runs cool for a 2.5 minute key down for EME work. Please beware you are on your own. If you load the amplifier wrong it will arcover inside the tube, so be sure to load the amplifier on the heavy side.

Figure 1–31: YU-129 Modifications



1.30 Increasing Capacitance for 2C39 Cavities

Paul Chominski SM0PYP - January 1989

In Figure 1–32 Paul suggests a way to increase the plate capacitance of a 2C39 type cavity by adding an extra plate to the HB Teflon capacitor.

Figure 1–32: Double Capacitance for 2C39 Cavities