

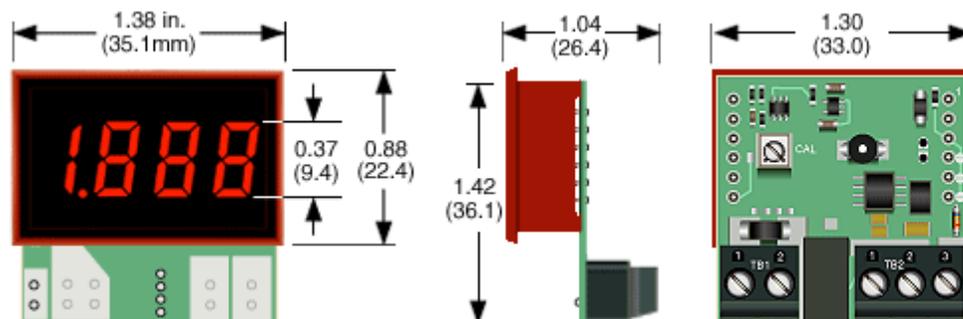
An Alpha 76A becomes "Mjollnir" (Thor's hammer)

By Matt Erickson, KK5DR



This project grew out of the failings of a previous project called "Crom". The RF deck of Crom failed due to the fact that I reused a tank circuit designed and built originally by Ten-Tec, in the Titan 425 amp, I'll never make the mistake of using anything made by Ten-Tec again. It appears that the design is of a poor construction and has begun to fail after 10 years in light service. I have decommissioned the RF deck from the Crom project and will use the far superior RF deck of an old Alpha 76A, which was on the way to a 3CX800A7 conversion anyway, and I purchased it before it was complete. I will use the still fully operational and outstanding performing home-brew outboard power supply I built to run Crom. This PSU stands ready to be connected to Thor's hammer, I must get the RF deck ready for its new life. The entire power supply and wiring harness of the original 76A is to be completely removed. I will be using my home-brew outboard power supply, which is far superior to the OEM supply in the 76A. Just how to interface it with the 76 is the hard part to this project.

Analog to digital panel meters: The meters I use are [Datel /Murata-PS DCA-20PC series](#). The exact models are DCA-20PC-1-DC4-R-C for the grid current, and a DCA-20PC-5-DC4-R-C for the plate current. The images below show the new meter and dimensions.



Here is what the new front panel looks like in the photo below. The image on the left is an angled photo to cut down on the reflected glare from the shiny surface.





The image on the right is a close up of the front panel with the LED meters powered up. They can't be seen very well, but the LED indicators below the meters are lit as well.

The front panel is not wired in this photo, that comes later in the web page. In case you were wondering, the fixtures above the switches are bi-colored LED indicators. The "Ready/Wait" indicator is red during warm-up, and switches to green for ready to operate condition. Green for condition OK for both Grid and Plate trip indicators, red for trip condition. The "input/tune" indicator gives status of the input ATU. The switch is for over-ride and by-pass of the ATU, the LED indicates status and error codes. The "Standby/Operate" indicator is dark when the T/R system is disabled, it is green when enabled, and red indicates Transmitting. The meters read 0-199mA of grid current with 0.1mA accuracy, the plate current reads 0-1.999A, with 1mA accuracy.

Why use digital meters? Well, accuracy is the first reason. Meters, regardless of whether they are digital or analog are only accurate when a carrier type transmission is made, they read inaccurate nonsense on SSB or other pulsed modes. Meters are useful only for tuning up the amp, and to read the transmit operating conditions. A bar-graph can do the same thing, but is less precise as far as tube current conditions go. These meters must be well filtered and by-passed to prevent RF from making them read erroneous indications.

The engraved front panel labels were made by [Precision Engraving and Graphics, Inc.](#) They did a nice job at a reasonable price. Loctite® Ultra gel super glue is used to stick them to the front panel, very carefully in the proper places. It is likely that I will use this company again for other projects.

Starting with a "clean slate", the chassis of the 76A is stripped of everything with the exception of the tank circuit. The tank of the 76A is one of the most reliable and most efficient made, that, along with the nice cabinet that has lots of room when it is minus the power supply, makes it an excellent RF deck for this project.

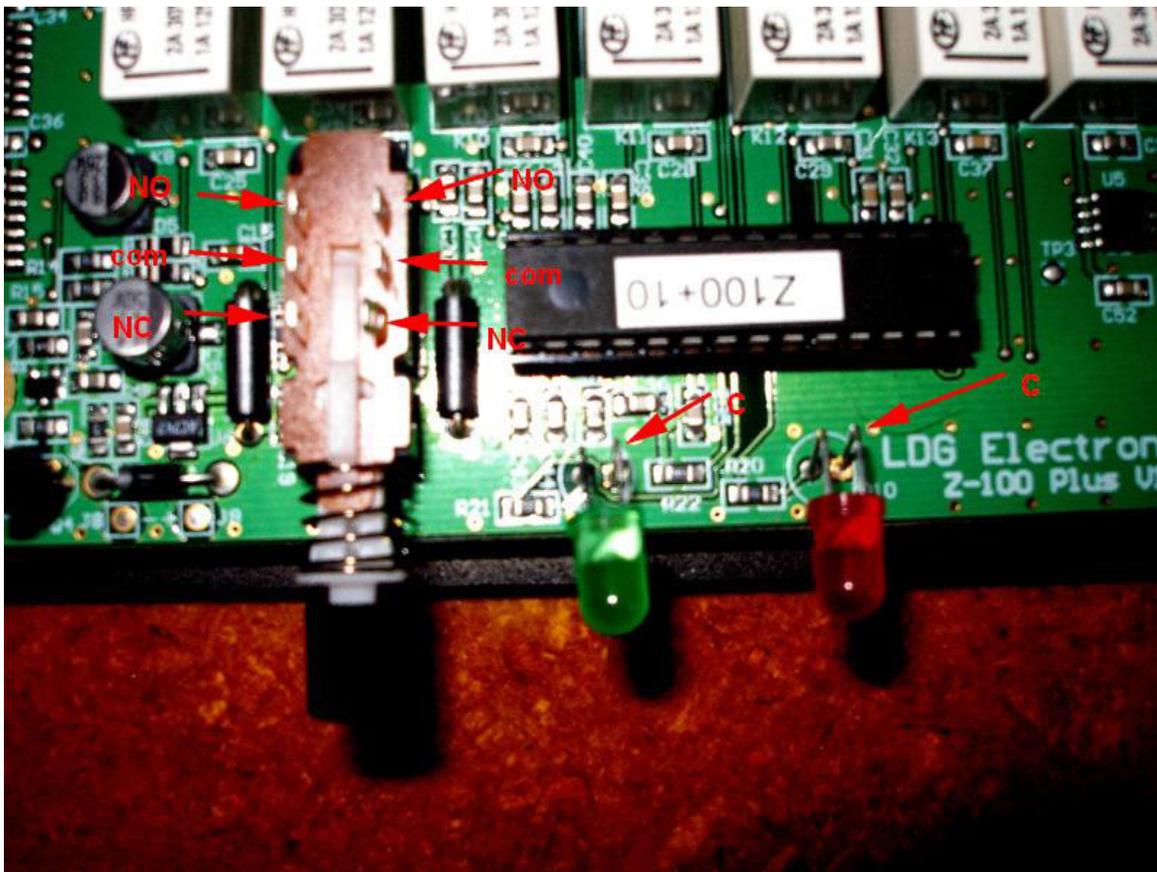


Notice the black panel connector at the top of the photo, this is the main umbilical cable from the main PSU. This cable will carry grounding, 24Vdc power, B-, 120Vac and control circuits from and to the PSU.

The input to the cathode is matched with an [LDG Z-100Plus](#), with some modifications to allow it to be mounted inside the amp cabinet and controlled from the front panel. The photos show the unmodified unit. This takes the place of a fixed tuned input, which are difficult to make and are limited in matching range, and must be re-tuned if the amp is used on a band it was not initially set up on.

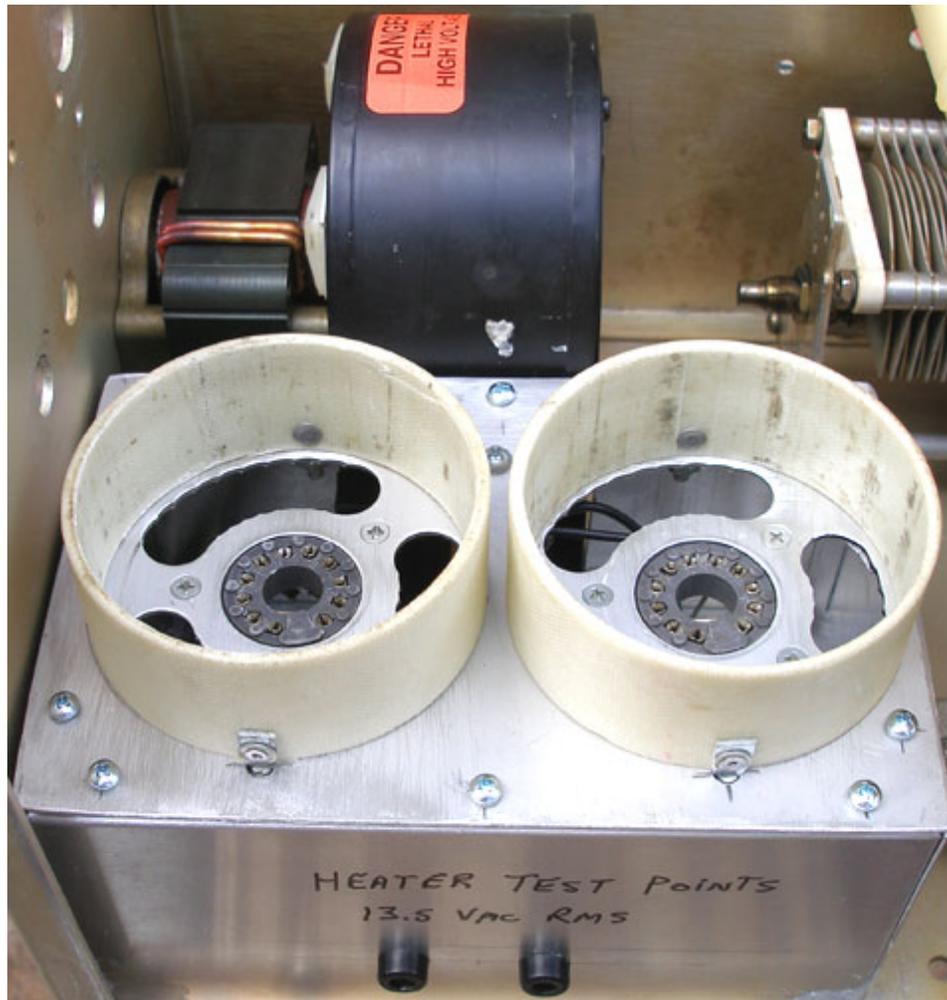


The photo below shows the modification points.



The switch is easy, there is a clip on top of it, pull back the spring, lift the clip and the plunger comes out the front of the switch. The switch has terminals on top that are easy to solder wires to, so that the wires may be run to the front panel of the amp for control with a switch there. The contacts are labeled, Normally Open, Normally Closed, and Common. Each bank of contacts are not connected to the opposed bank. The front panel switch must be a momentary contact in one direction, and normally positioned under spring load in the opposed, with the same type of contacts as the Z-100 OEM contacts. The LEDs are shown with the cathode ends marked [C]. I clipped the leads on each and soldered wires to each remaining lead. These wires are routed to the front panel LEDs. The Z-100 has "latching" relays, and does not require DC power once the unit has run a tune cycle on a given frequency. This feature removes a problem I had with the AT-100AMP boards, which was an SWR spike on each transmit, because the ATU was retuning using the parameters stored in memory. It is fast, but for me it was not fast enough, so latching relays remove this issue completely. I added an ATU DC power switch to the rear panel of the amp, should I wish to remove DC power to the ATU for any reason.

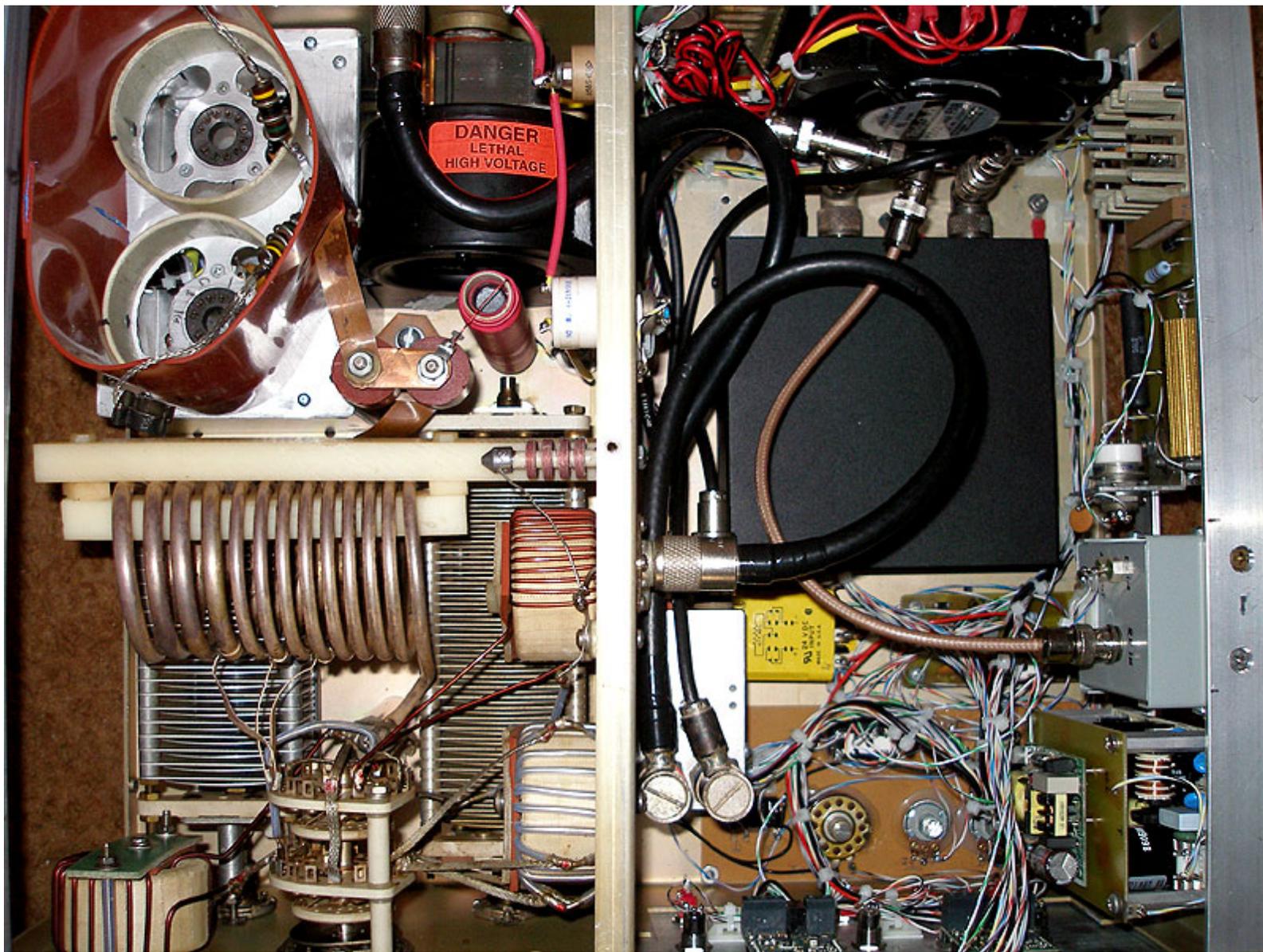
The photo below shows the new tube plenum deck I built for the project. There is very little circuitry inside the enclosure, so there will be few reasons to remove it in the future.



You will notice at the bottom of the photo there are a set of test points I installed to make it easy to check and adjust the heater voltage. Heater voltage level being fairly critical on metal/ceramic tubes, I wanted an easy way to do it. These test points can be accessed by removing the cabinet cover only. With the amp in powered up operation, the heater voltage can be measured at the socket, which is where these points are directly connected.

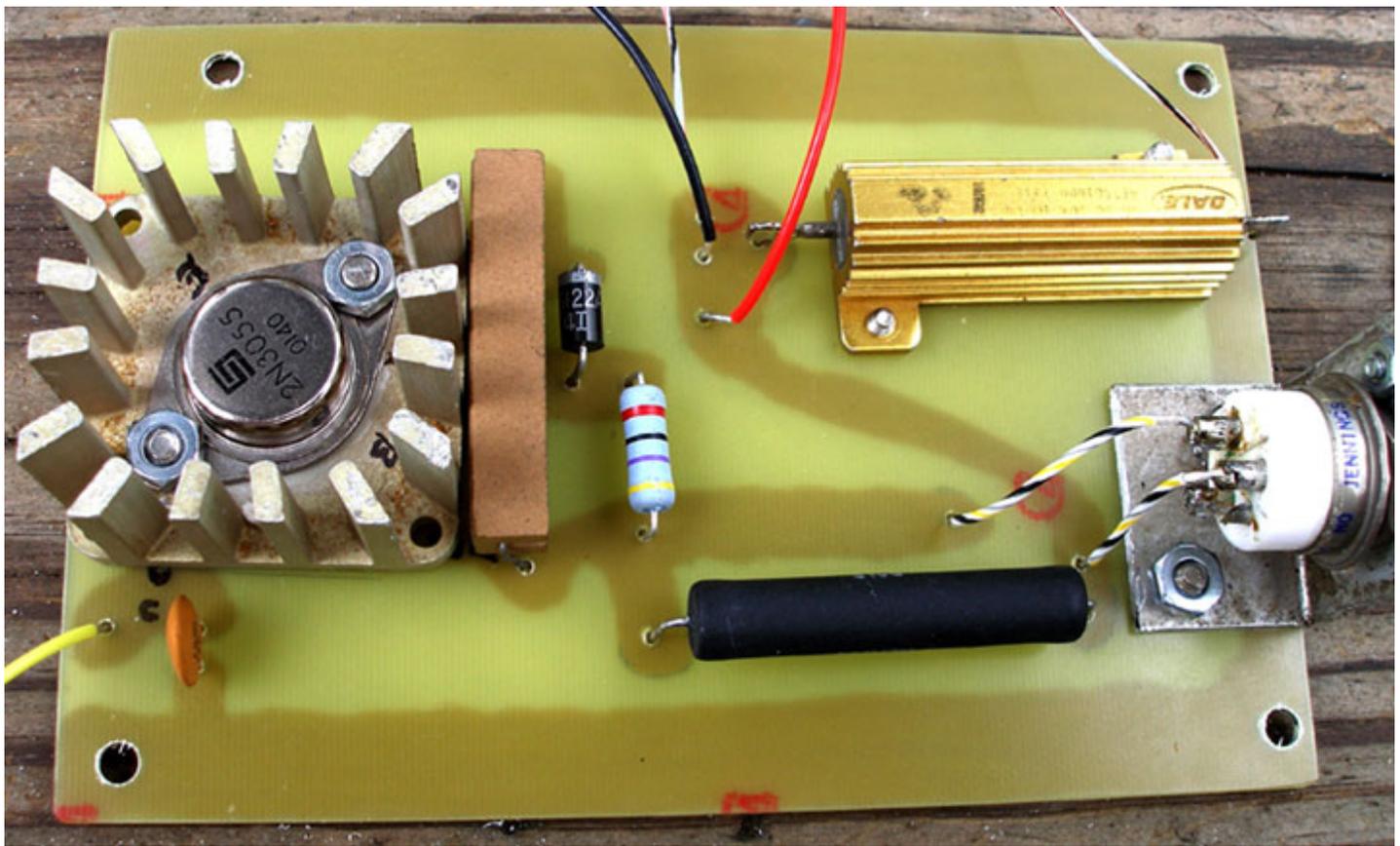
The photo above shows the routing of the RF. I used a [Dow-Key](#) transfer relay which is rated at well over 1kW at 50MHz for the T/R keying. Why didn't I use vacuum relays? Vacuum relays are OK for extremely high RF signals and rapid T/R change-over, however they do not present a clean RF impedance and they do leak RF since they are not shielded. Coaxial relays do present a nearly constant RF impedance and do not leak much if any RF, but they are much slower in change-over. Since I never use QSK in any of my amps, fast keying speed is not a priority, but good tight RF routing and a clean impedance is a priority for me. In reference to the photo above, the RF enters the amp through a BNC connector seen next to the fan on the right side. It then enters the coaxial relay and is routed through a shorted set of contacts to the output cable on the upper side of the relay for receive by-pass. During amplifier transmit condition the RF would be routed to the input side of the LDG ATU inside the box with the BNC connectors near center of the photo. The RF then exits the ATU and directly to the tube cathode through a large .01 μ F mica capacitor under the tube deck. There is a small gray enclosure mounted on the right side, this is the ALC board box. Inside is the ALC board which samples the input RF through the coaxial cable connected to it and the Tee connector on the rear of the ATU. The wire bundle can be seen exiting the ATU, where the switch was removed. The amplified RF signal comes out of the tank circuit through the SO-239 connector at the upper center of the photo, then routed to the Dow-Key relay and out to the output port which is back in the RF section of the amp on the rear panel. This system should keep all the RF where I want it and the RF impedance should stay very close to 50 ohms where I want it.

I tested my theory using my MFJ-259B and a 50 ohm dummy load. The system is flat from 1-70MHz.

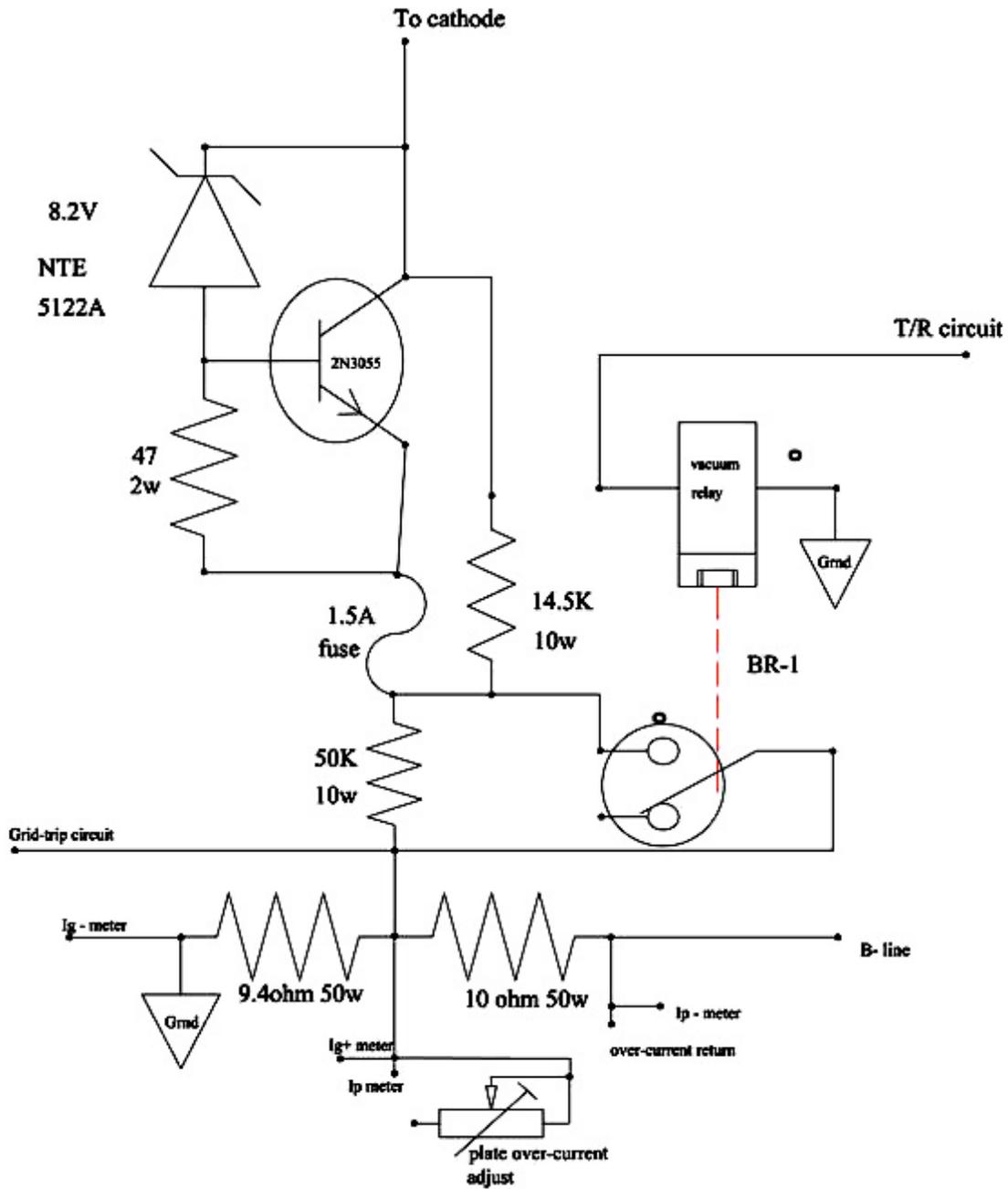


A set of small switch-mode PSUs are mounted in the lower right hand side. These PSUs are 12Vdc for the ATU, and 5Vdc for LED indicators, some relays and the T/R relay. Under the PSUs is a board with relays mounted on it, and calibration pots.

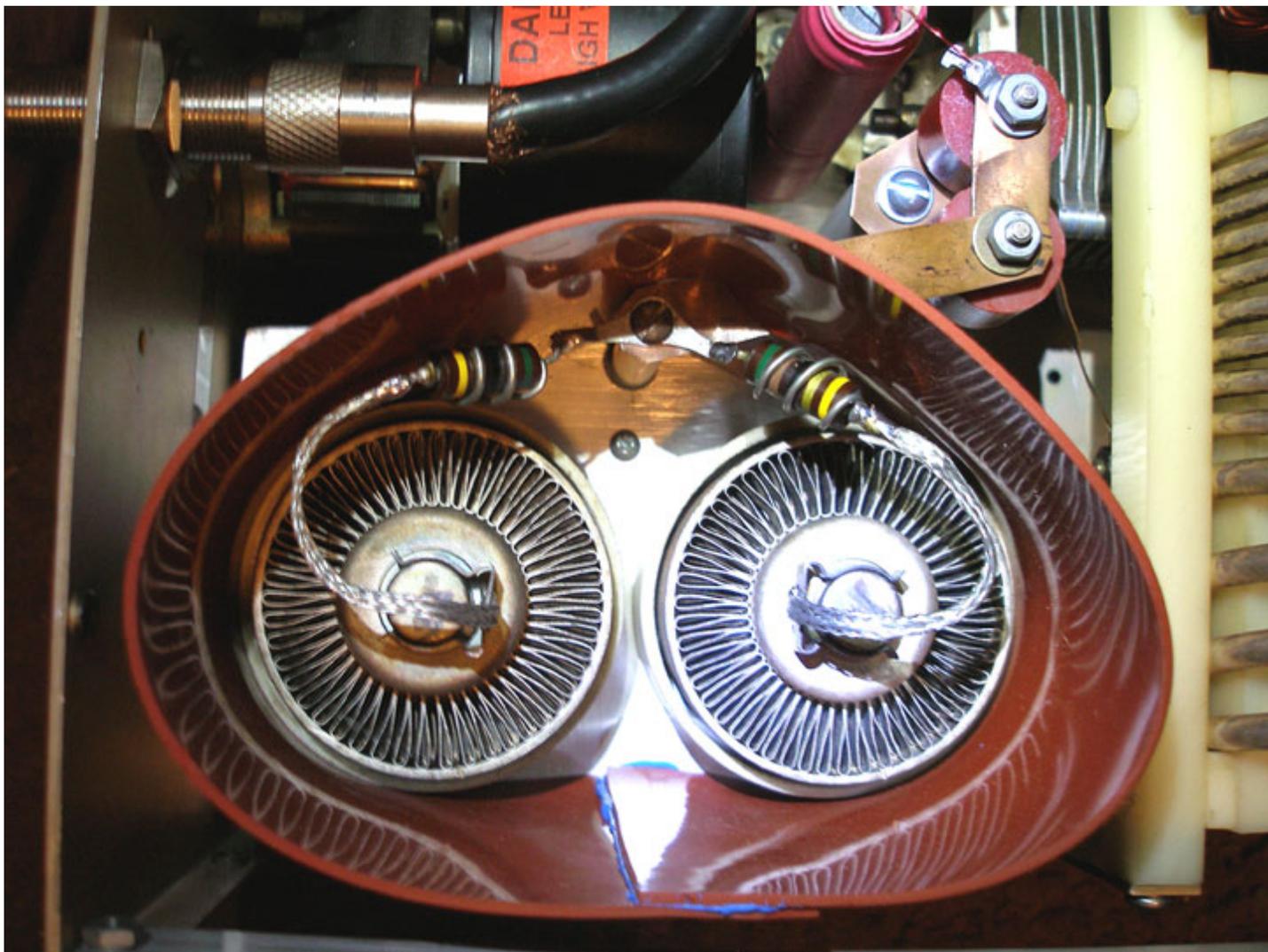
One of the most important circuits in a grounded-grid amplifier is the cathode biasing. I have built several bias PCB using the 2N3055 as a high current pass element and controlled by a small zener diode. This is the best way to bias the cathode, I favor the use of a high value resistor for cut-off bias and the pass transistor/ "power zener" circuit for operating bias. The resistor is shorted out of the circuit by a vacuum relay for operational bias. The resistor is fixed in the circuit so even if the relay fails, cut-off bias will keep the amp from operating until the relay is repaired. The photo below shows the board I built for this project.



A quick run down on the parts on the board; The black wire is the B- line input to the circuit. The red wire is the sample line for the grid-trip circuit (on a separate PCB). The large 1 ohm resistor is the grid return point, one end is grounded to the chassis the other connected to the B- line, the grid current meter samples from this resistor as well via the two smaller lines. The vacuum relay for bias switching is seen on the right side, it shorts out the black 50K ohm resistor at the bottom to send B- current to the operation bias circuit shown from center to left side. A 47 ohm resistor is seen at the center along with an 8.2V zener diode. Next to the diode is a rectangular resistor which is a 15K ohm "safety" resistor. Should the operation bias circuit fail for any reason the safety resistor will hold the cathode current to a safe level and not allow the amp to function until the bias circuit is restored. An RF bypass capacitor is shown at the lower left next to the yellow cathode line which goes to the tube cathodes through and RF choke under the tube deck. Remember, all DC current travels from negative to positive, so the current flow is from the B- line to the B+ line. The schematic for the bias circuit is shown below. The value of the control zener diode can be changed to adjust the standby/idle plate current for the desired operation, the diode in the schematic is a 12V, I used an 8.2V for this project. A fuse can be placed in the circuit to protect the amp, or can be omitted if some other method of protection is used. My amp uses plate over-current limits which remove the B+ path if an over-current condition exists, so no fuse is needed. The pass transistor is mounted in robust heat-sink, since it must be able to handle up to 50 watts of heat. With this PCB mounted in cooling air-flow, over-heating is not going to be an issue. Next to the yellow cathode line is a small .01 μ F @ 1kV RF by-pass cap to shunt RF to ground should it somehow reach this circuit. There is not supposed to be any RF in this part of the cathode line so these measures are preventative. The by-pass cap is not shown on the schematic, however it connects between the transistor output and the cathode choke, shunted to chassis ground.



The photo below shows the assembled tube deck, parasitic chokes, anode connectors, silicone rubber chimney, tank circuit connections, and plate RF coupling capacitors.

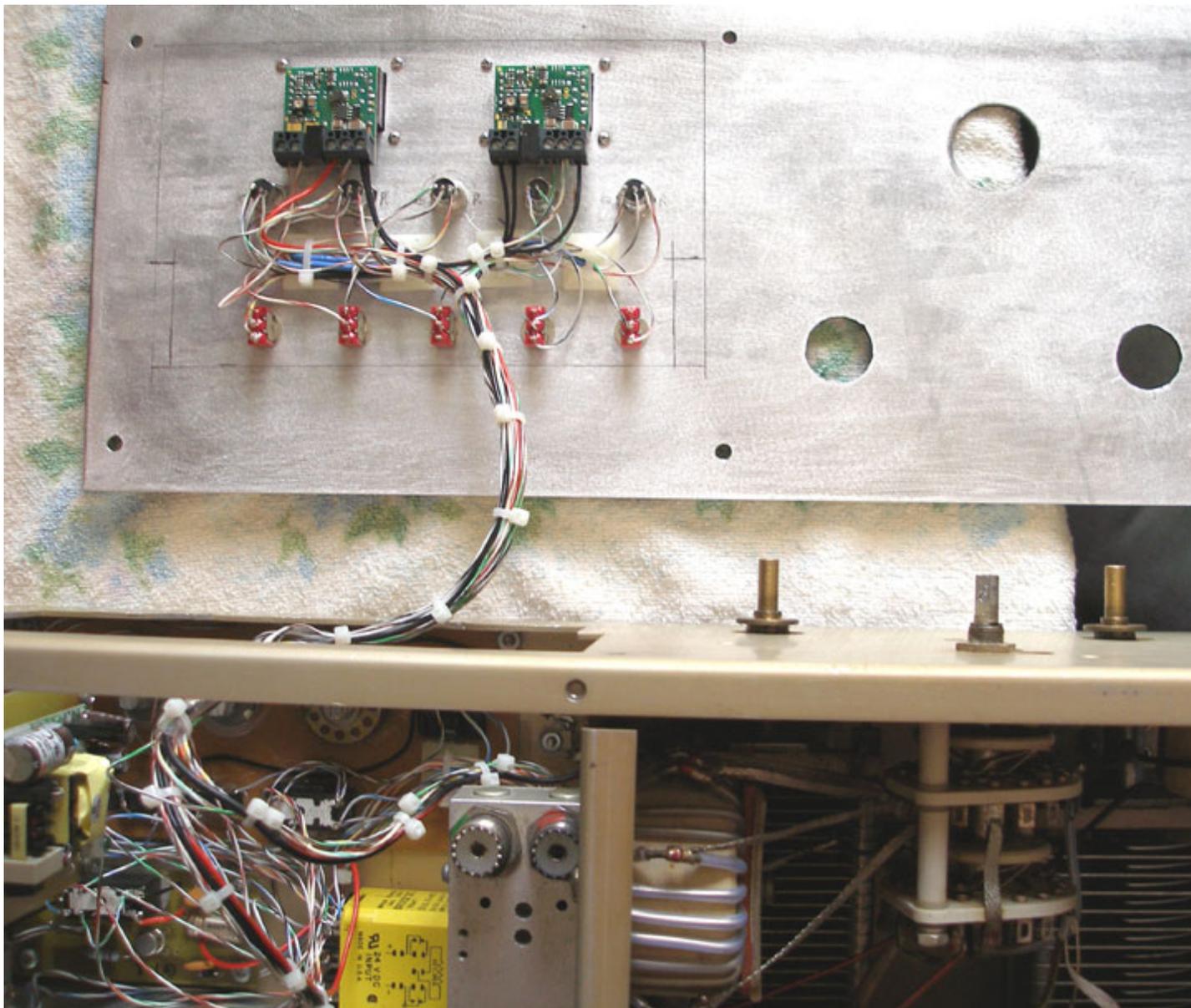


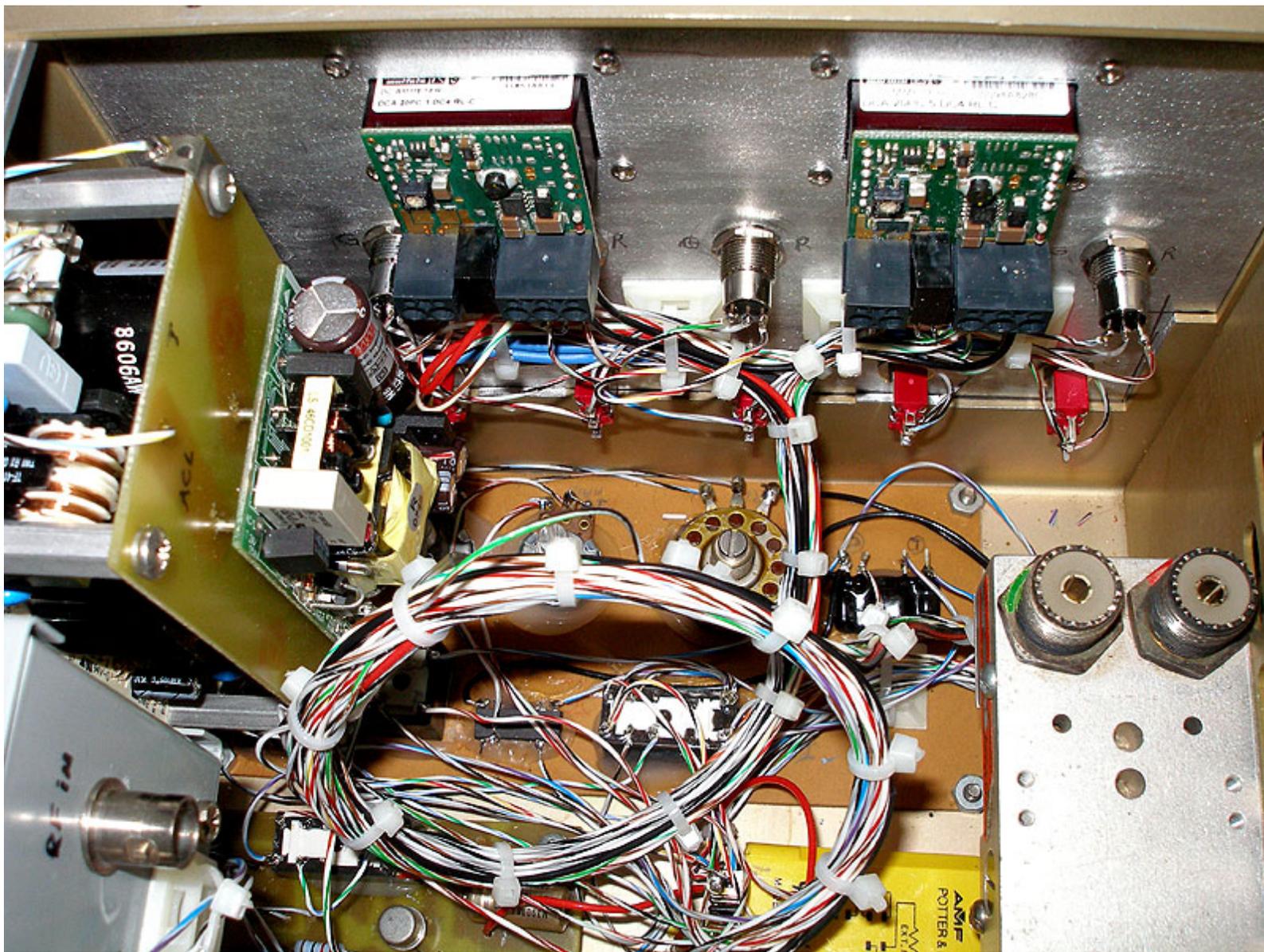
The chimney is made of .062" thick [commercial grade high temp silicone rubber](#). I used silicone [RTV by Permatex®](#) to glue the ends together, after roughing the mating surfaces with a [Dremel®](#) tool and a sanding drum attachment, I clamped the ends together in a fixture overnight for curing. The shape of the chimney is made so I can use all three of the original 76A exhaust port openings on the top cover. These openings are in a somewhat triangular configuration so the chimney nearly matches that shape. The long red cylindrical part at the top center of the photo is one of my ferrite loaded [plate chokes](#), HV/B+ is connected to this choke at its base. At the top of the choke the HV/B+ is connected to the anode line on top of the plate RF coupling capacitors. The heavy copper strap then connects to a ceramic post that anchors the connections of the strap and the parasitic chokes. I recycled the chokes from my old RF deck since they work fine. I added a length of tinned braided cable to them to make it easier to install and remove tubes without fatiguing and breaking the solid wires the chokes are made of. The plate RF coupling capacitors are .001 μ F or 1000pF each, rated at 10kV each, [door-knob type](#), mounted in parallel. The caps are secured to a large ceramic post that is anchored to the bottom of the cabinet. Nearly unseen in the photo is the copper strap that comes from the bottom of these caps and attaches to the C-1 or plate tuning capacitor at the center right side of the photo under the main Pi coils. Making the anode to tank circuit connections as short and as heavy as practical will maximize plate efficiency due to the low inductance and stray capacitance of the conductors at RF. Care must be used in the spacing of components in this section of the amp. This is because there are high levels of RF voltage and currents as well as HV. My minimum clearances are 1/2" in areas where I feel it will be fine, and much more in areas where there could be arcing under certain conditions. Plate RF coupling caps must be very robust, usually selecting them to have a voltage rating of four times the B+ peak, but never less than two times as great. Capacitance rating of these caps should be in the range of 2000-4000pF, too little and the amp will starve for RF current at low frequencies, too much and it may become a powerful oscillator. I have found that .002 μ F or 2000pF, is fine for coverage from 1.8 - 30MHz with no problems. If the builder finds that the amp loses efficiency on the 160m band, adding 1000pF to the plate coupling caps should help, if it does not, the tank circuit may need to be re-worked. The coil may not be tapped in the proper point on the coil.

The protective circuits in this amp are nearly the same as those used in [Thor](#), which you can look at to see schematics on these circuits. These will include grip over-current trip, plate over-current trip and B+ interrupt. There are circuit variations specific to this project of course. The grid trip circuit is set to trip at about 100mA. This level is used because a pair of 3CX800A7 tubes has a maximum grid current rating of

90mA, so a level of 100mA will prevent false trips. The plate trip is set to trip at 1.1A of plate current. This is the maximum level for a pair of these tubes. Each of these protective circuits also disables the T/R system and places the amp in RF by-pass mode until the trip is reset. In addition the plate over-current trip will remove B+ from the anode of the tube. There is a manual over-ride control for the B+ interrupt, located on the rear panel of the amp which can be used to remove B+ from the tubes while still having the amp powered up. This feature is handy for tube [conditioning](#) and other trouble shooting. Since these tubes need so little RF drive, the ALC is the primary protective circuit. It is a very simple envelope detect type circuit. It samples the input RF signal before it arrives at the tube cathode. It is converted to a negative DC signal and sent to the exciter to reduce RF drive to a safe level set by the threshold adjustment on the rear panel of the amp.

With the wiring harness completed, the photo below shows the front panel laying down. The photo to the right shows the front panel installed.





You will notice that there is extra cable length from the front panel to the main unit, this is to allow the removal of the front panel with enough slack in the cable to set it aside for servicing. The slack cable is coiled up inside the main unit when the front panel is installed. Something else that the reader will notice about the circuitry in the main unit, it is done in the old "dead bug" style of building. This means that the components resemble dead bugs on their backs with leg in the air. I did this because I did not want to take the time required to make etched PCB, which would have slowed me down allot, and would not make the unit anymore reliable. I simply glued the relays and pots to a piece of PCB and bolted that board to the bottom of the main unit. There are some etched boards in the amp, but most of these were recycled from the old amp.

During initial testing a found that my T/R keying voltage and current were as I designed them to be, 5 Vdc @ 5mA surge, and 0.5mA steady state in transmit mode. This amp can be keyed by any exciter without an interface relay outboard of the amp. Solid-state relays are used on the exciter key line, and these operate all the electro-mechanical relays in the chain. This amp is NOT designed for QSK/full break-in operation. The size and type of coaxial relays make that impossible, but it will last for many, many years of standard keyed operations.

June 3, 2009; Thor's hammer came to life today! I have more work to do, but it is going forward well.

Issues to work on; I ran into some issues with incompatibilities from the old OEM tank circuit and the new plate impedance I require. The original 76A was designed with a plate impedance of around 2500-2700 ohms. The plate voltage and current my new system requires calls for a plate impedance of 1350-1500 ohms. This is what is required of a pair of 3CX800A7 tubes running a full output. If I were to use the OEM PSU in the 76A with its voltage and current limitations, the 800's would not put out the same as the OEM 8874 tubes, because the 800's don't have the gain that the 8874's have at the lower plate voltage of the OEM PSU. The 800's would require more plate current to make the same output as the 8874's, but the OEM PSU can not provide such current for very long. My outboard PSU is capable of delivering the full voltage

Mjollnir (Thor's hammer) project.

and plate current the 800's need for full power output, but this will require a re-work of the OEM tank circuit.

I will re-tap the tank coils, and add some door-knob capacitors to the tuning caps to give them the range needed for the new plate impedance.

One of the issues is RFI in the meters. I think the source is from the RF section which is located directly over the vented area of the bulkhead which separates the RF section from the power supply section. The openings in the vent are large enough to allow RF current to leak into the area where the meters are. The problem; how to block the RF current, but allow the cooling air to flow into the RF section and eventually into the tube blower. My solution is to build an air-permeable Faraday shield, which will cover the vented area. The Faraday shield is built using fine mesh copper in two layers. The mesh is found at [McMaster-Carr](#) #9224T86. The shield, RF chokes and RF by-pass capacitors on the meter boards should remove the RFI problem.

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