

432 MHz PA

Utilizing GS35b triode

The following pages is not a complete description of the amplifier, merely a general discussion on some of the important points on how I implemented some of the NUMEROUS ideas that are available on the net for implementing a GS35b as a 432 MHz amplifier. With the right power supply, this tube will deliver 1500W PEP on 432MHz. As such it just "loafs" along at the VK limit of 400 W PEP. A substantial amount of planning and construction went into the amplifier, but at the end of the day it cost FAR less then any comparable commercial amplifier, and as an added bonus gave me the immense satisfaction that only comes from "rolling your own". If you are planning on building a similar amp then the QRO site is a must read!

*****DISCLAIMER*****

**WARNING: WORKING
WITH HIGH VOLTAGE
EQUIPMENT IS
DANGEROUS.**

IT CAN KILL YOU!

**If you are not experienced at
working with high voltages**

DO NOT attempt to build an amplifier such as this.

If you decide to build a similar amplifier, I cannot be held responsible for the outcome. This description is merely intended to illustrate how I implemented someone else's design. BE CAREFUL around HIGH VOLTAGE. !!!

General Construction:

Having completed a 250 W PEP SSPA (utilizing 1 driving 4@ MRF646 transistors) the quest for more power on 432MHz began. In VK the regulations allow for 400W PEP as a maximum power level. I also wanted a QRO amplifier that I could use for EME after obtaining the necessary permits.

My choices were to 1. Build 2 of the 200W models and combine them, or 2. Use a valve. I chose to use a valve!

My previous experiences with valve amplifiers were with modest (QRP!) output valves such as the 06/40, 6146, 8072 and 572b varieties....hardly QRO capable! Upon searching the web, I decided that I would try my hand at a GS35b on 432MHz. The GS35b is a Russian made triode. There are many different views on whether triodes or tetrodes are "better". Without entering into the arguments, the design of a triode amplifier is undeniably simpler with respect to the power supply requirements when compared with a tetrode. The main drawback is that compared with a tetrode, triodes require far more drive. No problems I had 200W from my SSPA! As tests later show, you only require somewhere between 30-40W drive (depending on the static conditions of the tube) for full VK output (400W). Many commercial transceivers offer this on 70cm nowadays. The GS35b were available quite readily from a number of sources. The ratio of Cost/Power-out is exceptional when compared with semiconductor devices. The tubes I acquired (1 spare!) were old but unused. It is very important when dealing with such tubes that they are "run-in" correctly. Many designs exist on the web for utilizing a GS35b as a 432MHz amplifier. If you are contemplating building an amplifier like this, I suggest checking out the QRO site. The PA3CSG design impressed with it's subtle simplicity and ease of reproduction. As such the decision was made to copy this amplifier deck.

Nothing more than hand tools and patience was required to build this particular amplifier deck. A number of hours were spent "bashing" out the metal work. The RF Anode and Grid compartments are made of 3mm Aluminium with Aluminium angle for the junctions. Several schemes for cooling the tubes adequately have been described, but I chose to use a reasonable blower (equivalent to the blower in an AM17 which uses 2 @ 4CX250bs) to cool the anode and separate "muffin fans" for the grid compartment. It is also possible to blow air from the anode compartment into the grid with the 1 blower, or alternatively blow from the grid compartment into the anode. The Gs35b has a very large anode dissipation rating, BUT ONLY if the recommended airflow is achieved! This is the main reason why I settled upon a dedicated blower for the anode compartment. Air is blown in through a screened inlet in the bottom half of the anode compartment and pressure is achieved with a piece of PCB (etched both sides!) that divides the anode compartment into 2. In this way, air is forced to escape over the fins of the anode cooler, and a screened outlet is provided immediately above the anode cooler. Whilst I have not yet incorporated it, a pressure sense switch can be implemented that provides a means of shutting down the amp immediately should the airflow cease, thereby protecting the tube. From the pictures you can see that the remainder of the RF deck is fairly "standard".

An important point that I should state at this point is that the length of the copper pipe used for the anode line is such that the total anode length is 120mm, NOT 100mm as indicated in the original design by PA3CSG. I used this length without actually trying 100mm upon the recommendation of a friend (David VK3HZ) whom had only recently built his RF deck and found that 120mm worked better at achieving resonance. I'm certain that the right combination of anode to Ground capacitance and loading would allow 100mm to work just as effectively. Whilst on it, the anode tuning is a "Flapper" made from a piece of Phosphor bronze and it is insulated from its control using a block of Teflon and blank PCB material. The loading flapper is fabricated in the same way and both controls are controlled via a "gear reduction motor". (I may actually change these for Stepper Motors thus allowing the option of "smart tuning", more later). I decided quite early on in the construction that I wanted the amplifier to be an in-shack, desk-top unit, and as such to make it more "presentable" I wanted all controls to come out on to the front panel. No problems for the input tuning and loading, but the output controls needed to be on opposite sides of the anode compartment. I did see several designs utilising "fishing line" techniques but due to the very high RF fields present, problems are often reported, and it seemed simple enough to implement an arrangement as I have. Consequently all controls are on the "front" face and I am sure many would find intriguing and clever ways of utilising stepper motors.

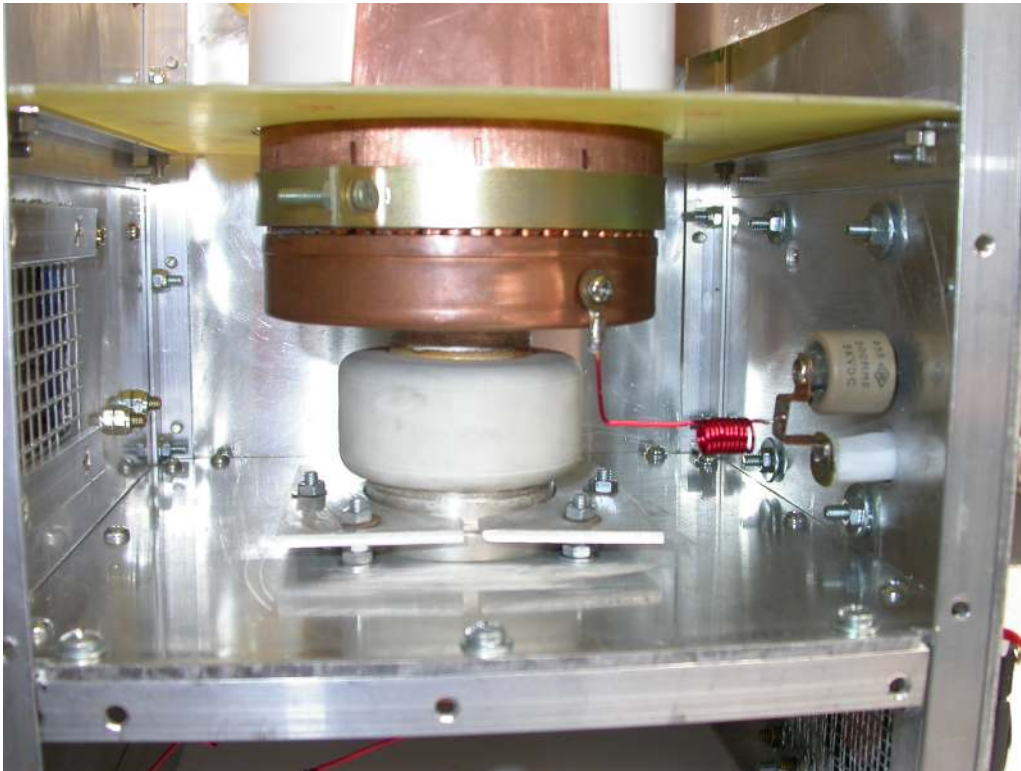
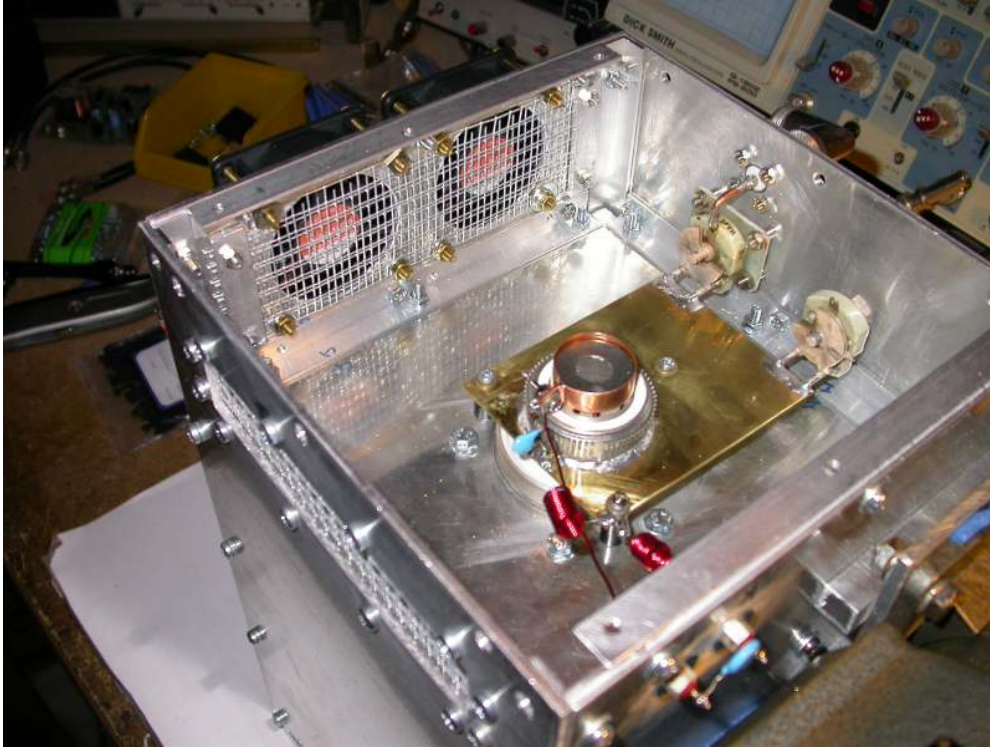
My power supply consisted of a voltage doubler configuration. These tubes work best with over 3kV on the plate. The transformer I had was quite large but it supplied only

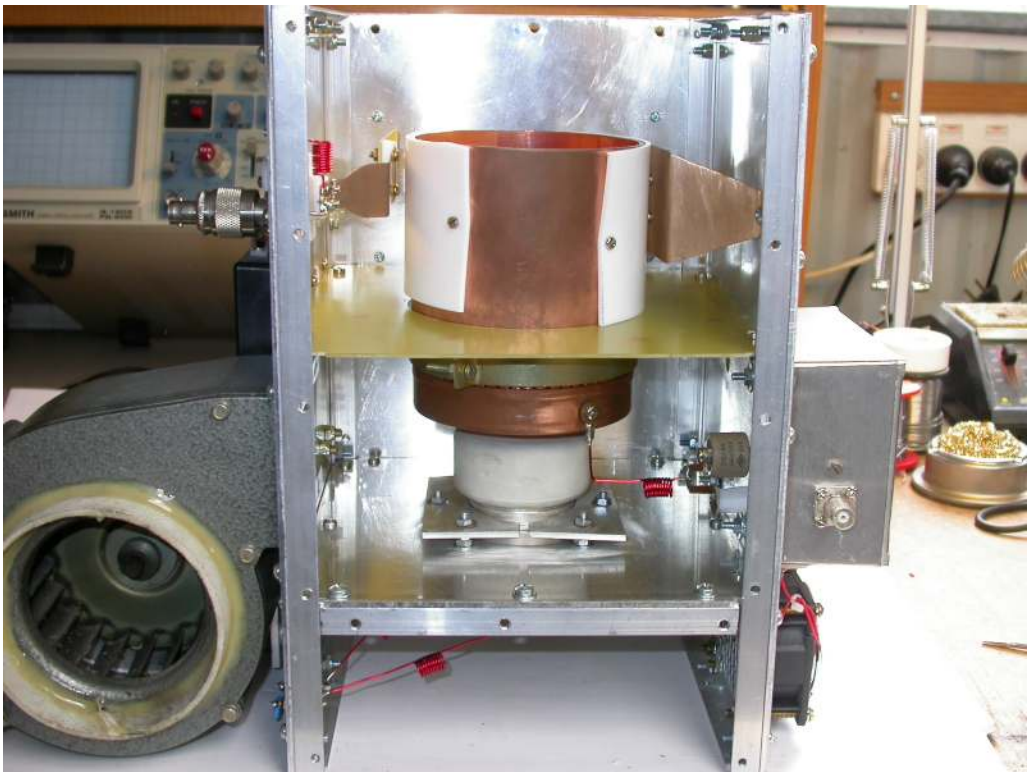
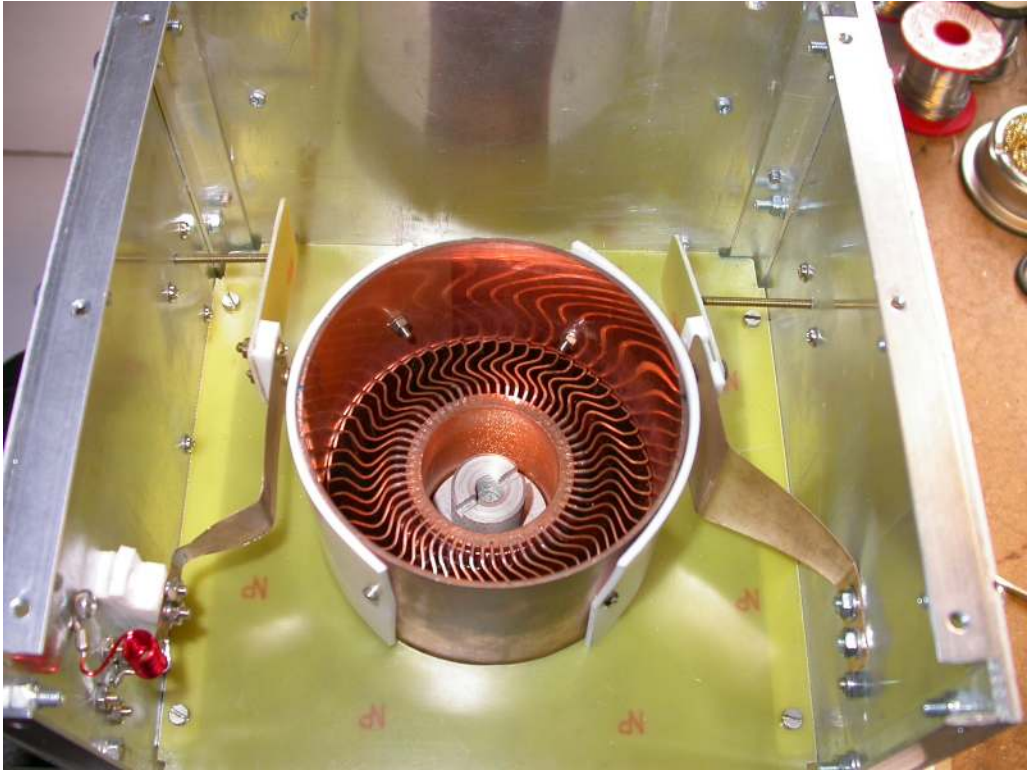
900 odd volts at about 2 amps. continuous. With a capacitive input filter (rated at 4kV) I was able to produce 3250kV with no load, dropping to 3000V @ 1 amp.: Reasonable regulation. The grid supply can take on many forms. Most designs on the net use Zener diodes, But I decided to use an active Bias arrangement as it tends to provide "stiffer" regulation. The grid supply is housed in the amplifier deck with the anode supply in a separate chassis.

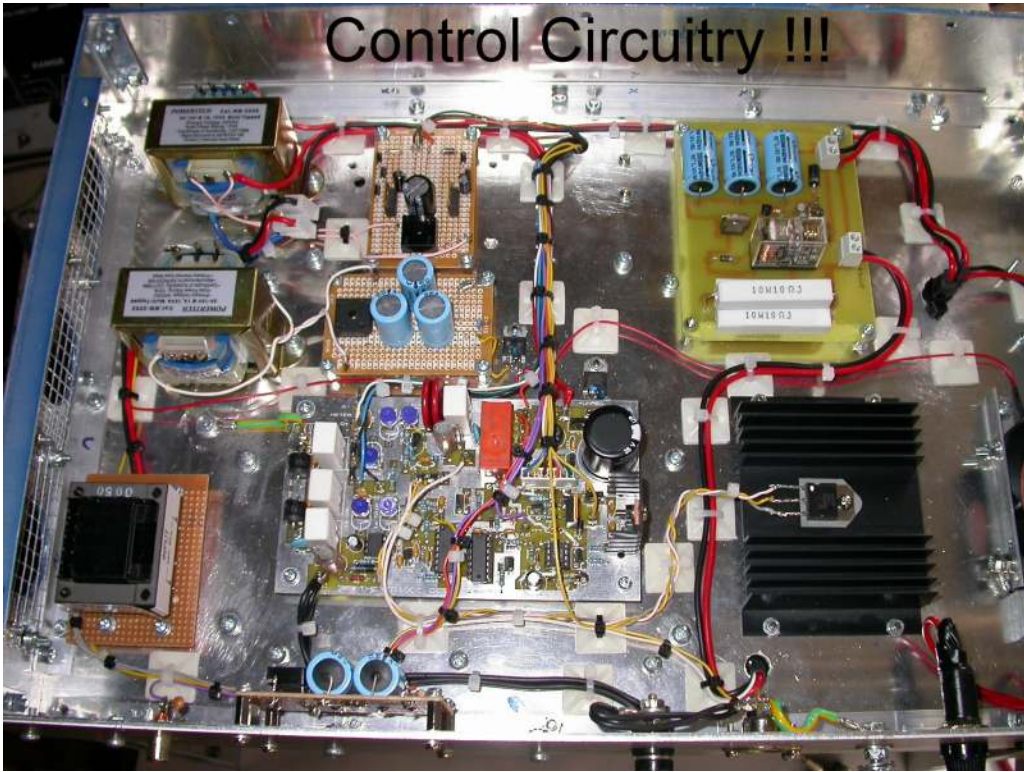
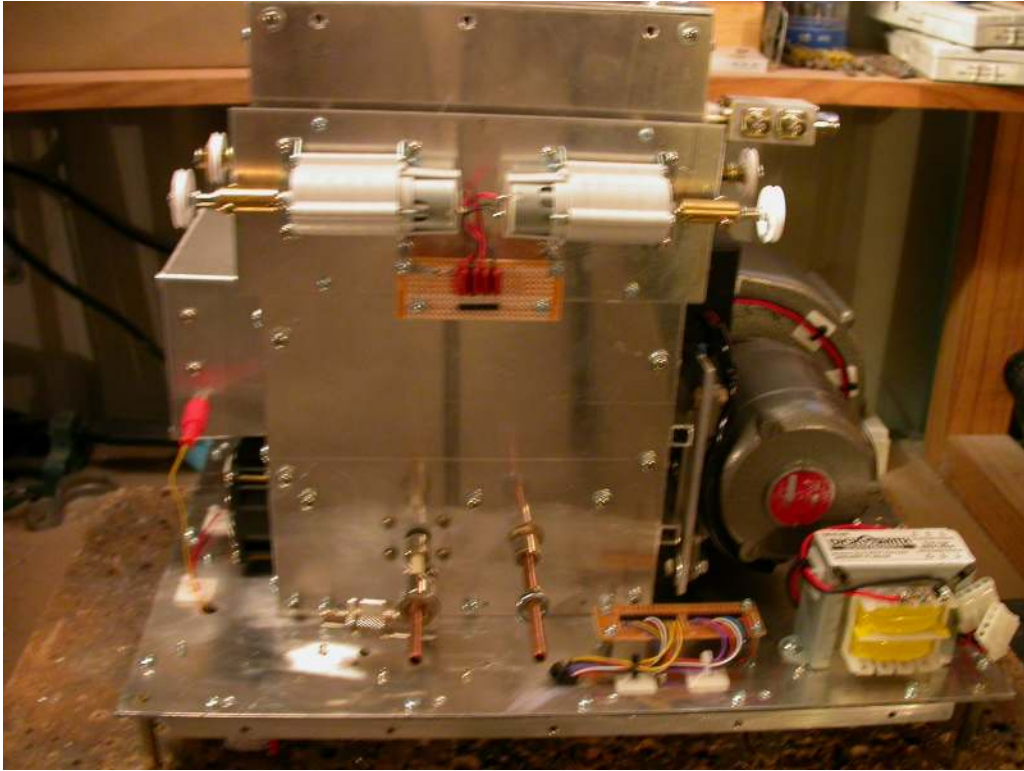
The anode supply features soft start and has a control interlock from the RF deck. The supply unit weighs 26Kg. and consequently resides under the operating desk! How to get the HV DC to the amplifier deck?.....Well only one way:....Coaxial cable with specialised HV BNC connectors. I had a few in the junk box (courtesy of a junked T37 amplifier, from which also came the HV transformer). These connectors are also available via "Rojone" in Sydney Australia, but they are pricey. When dealing with HV and amps I would suggest reading the "authorative" VHF-UHF Dx Handbook. A seperate chapter is devoted to Anode supplies and designing them with safety as the paramount factor. The concepts and methods described in this, are relevant for all HV work, be they 500V or 5kV ! Having followed the guidelines in this book closely, the anode current metering is accomplished in the B- rail which is closely tied to "deck" (ground) via a chain of high surge rated diodes and a resistor. Three chassis ground connections exist between the power supply and the RF unit: 1.A dedicated multicore ground strap (rated at 120A, 2. The outer braid of the coaxial cable carrying the HV+ line and 3. an additional ground in the control cable. Anode current and voltage metering is present in the supply (should it be used for another amplifier) and also anode current metering on the RF unit.

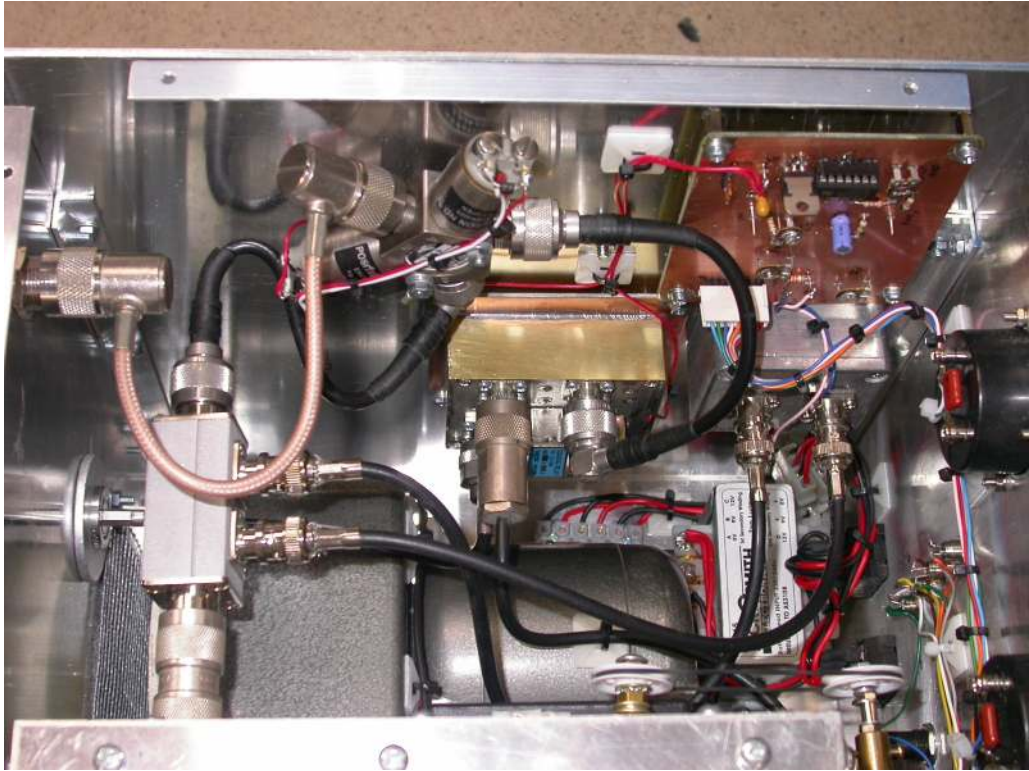
Once I had the power supply sorted, Anode and Grid supplies, it was time to begin a little live testing.

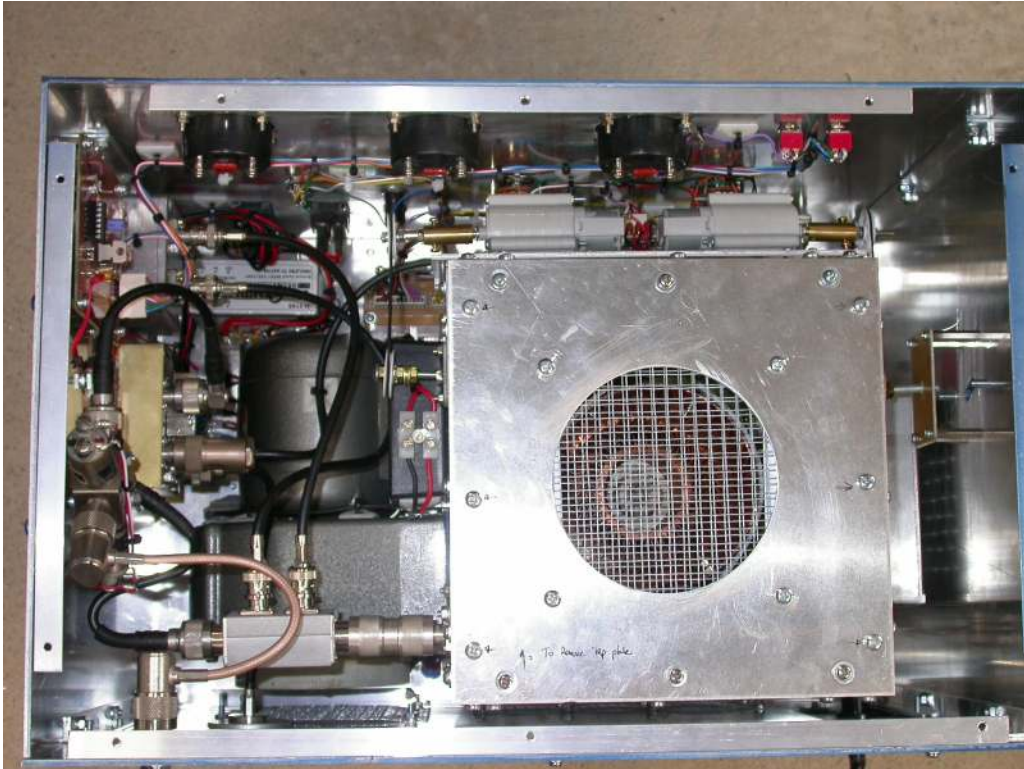
Pictures











Preparing the tube.

The GS35b I acquired was unused, but had been sitting around for quite some time on the shelf. In this state, there is a real chance that it had become "Gassy" and also the grid material was "corrupted". The QRO site has a number of links to methods on regenerating old tubes, and ones that have been "sitting" around. This is what I did.

1. With **BLOWER ON**, I ran Filament Voltage for 22 hours continuously.
2. Anode Volts were applied through a VARIAC at 1000 V. Bias was set for 50mA and initial tune up with 10 W drive into a Dummy load for 30 mins(about 100W output)
3. Anode volts were brought up to 2kV, reset the bias and reduced drive..still 100 W out for another 30 mins.
4. Anode volts was brought up to full (3250V) and reset bias and 100 W out for another 30 mins.
5. Then full steam. As the drive power is changed the operating conditions change (and thermal effects) thus requiring retuning. I was able to run 100W in for 1kW out in short bursts (5-10 sec. carrier).

By bringing everything on slowly, none of the components are overly stressed and it gave me confidence that the tube was behaving properly. No flashovers occurred, but the anode current protection tripped once as the tuning was off.

I feel my power supply is the only reason why I have not been able to produce more than 1kW output with key-down.

I was able to run 30 mins continuous at the 400 W level, with only a slightly noticeable increase in airflow temperature!

Control :

Several features needed to be built into the amplifier in order to ensure correct operation within specifications and as a form of safety.

The main control features required are:

- Anode Current metering
- Grid Current metering
- Shut down of amp if preset Anode Current exceeded
- Shut down of amp if preset Grid Current exceeded
- Warm Up timer..... 90-180 sec required for GS35b
- Filament Soft Start
- shut down in event of flashover
- If amp shut down PTT inhibit and unable to be reactivated until fault condition fixed and reset of control
- PTT inhibit if HV fail
- Fault indicator
- Fwd power detector
- Rev power detector

All of the above with the exclusion of the Fwd and Rev pwr indication was accomplished with the "TRIODE BOARD" by G3SEK. This was bought as a kit from Tom's Tubes in the USA and is easily customised to an individual requirement. I will not rehash any of the documentation and implementation except for a couple of very important points.

- Because I used 2 different Anode Current sensing resistors and meters in the B-line I had to use a total of 5 diodes in parallel to ground so the current would read correctly. This makes sense when you examine the circuit and decide on using the back to back safety diodes on the B- rail to ground.
- The Anode trip point was set to 1.2 A

- The grid trip point was set to 400mA
- The warm up timer was set to 90sec.

For the Fwd and Rev power monitoring, a directional coupler is used and a detector assembly was fabricated to indicate both Fwd and Rev, in either Avg. or PEP levels on a front panel meter. It is planned in the future to add an SWR integration circuit, so the amplifier will be automatically shut down when SWR becomes excessive.

Thermal drift and Tuning:

A fair bit has been written about and many have hypothesised as to why this occurs. I certainly noticed a change in the tuning point to maintain Max. output with a key down at high power. The tuning drifts a little after about 5 sec or so of key down, but seems to hold quite stable after this. As such I tune for Maximum Output after about 5 sec of key down and this seems to hold quite well for CW and SSB. The best description I have read as to the cause of this effect is that the Grid heats and expands and as such the input capacitance changes. The output tuning and input tuning are VERY closely inter-dependent. Changing drive power requires a retuning of both anode and input tuning controls. It was interesting to note that the input coupling and output loading have very little need for retuning at all drive levels once their initial tuning position is established! My plan in the future is to use stepper motors to actuate the tuning controls. It may be possible then to use a PicAxe microprocessor to automatically track the thermal drift or perhaps allow a self tune! (When I get some time!).

Acknowledgements:

Many thanks to David VK3HZ whom was also working on a similar amp and helped with initial dimensions that differed from the original PA3CSG design, for helping out with some HV decoupling capacitors in the anode compartment and for the loan of his variac and HT probe.

Thanks also to Dr. Alex Gavarrin, for providing the tubes from the Ukraine in "mint" condition.

.....and of course thanks to all the amateur operators whom share their amplifier construction projects and findings with ALL of the Amateur community.
