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## (A journey of discovery for a valve novice!)

Over the past three years I have been gradually edging into 23cm, a band which has interested me for a long time. As I live in Scotland I knew I would need to generate a good signal to succeed. All of my operating is done portable from sites in the Borders and I know from experience on 70cm that a moderate amount of RF will make contacts with the South of England possible in a fairly consistent way.



I began by building a DEM transverter, followed up with a MCS "brick" 15W amplifier and DEM preamp, both of which are mountable at the mast-head. A WiMo 67 element yagi sits at the top of my 35 foot pump-up mast and has allowed me to make a lot of QSOs into the South. To date I have worked over 25 stations in 11 squares and every reason to think that this year's contest and tropo season will add to that.

My interest now lies in trying to put a stronger signal towards the continent, so I can tap into the many DLs and PAs who are QRV on 23cm. I considered a group of "bricks". Until now my equipment has been solid-state, to run from a 12v portable supply. However, the cost of 4 or more "bricks" was prohibitive and, influenced by the fact that I couldn't advance on the other VHF/UHF bands without moving into valve technology, I invested in a 240v petrol generator.



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Having never played with valves before my understanding of them was pretty sketchy and influenced by lots of 4CX250B folklore! I had an image of scary voltages, massive complexity, accurately-built metalwork and temperamental operation. No wonder I took so long to get into valves!

Chip Angle N6CA's "Quarter-Kilowatt 23cm Amplifier" article (2), showed me that a 2C39A operating in grounded-grid is very simple and has minimal power supply requirements too. The sticking-point was the cavity. I don't have access to a lathe or drill-press, or the skills to use them if I did, so accurate metal-working was out of the question.

It looked as though the idea was a dead duck until I came across an advert for a UPX-6 cavity. The UPX-6 was used in banks of 3 as the PA for IFF radar transmitters on 1090MHz. Brian Flynn GM8BJF did some work in the 80's (1) which showed that single UPX-6 cavities could be converted to 23cm by pouring molten solder into the base of the cavity to increase the resonant frequency. A couple of adjustments to the cathode circuit were then all that were necessary to get a UPX-6 running on 23cm. Brian found that by using a 7289 (a higher-spec 2C39A) with air-cooling, he was able to get 80W out for 10W of drive.

I thought I was fortunate to buy a 1.5kv PSU sight unseen from a GW8. Unfortunately, when it arrived it was so unsafely built as to be unusable: bare wires and terminals carrying HT outside of the enclosure and smoothing caps held in place (or not, in the case of some of them) with bathroom sealant were just two of the "interesting" design features. I salvaged the HT transformer and smoothing caps and binned the rest.

The first problem, building a suitable enclosure with kitchen-table metalworking facilities was solved by the use of sheet aluminium (formerly a shop sign, courtesy of Ricky GM1PLY). By cutting each panel as a separate piece of aluminium I avoided metal-folding. The panels were then attached to one another with M3 bolts and aluminium angle from B&Q. Inaccuracies in cutting the sheet aluminium are nicely disguised by the angle!

A 7289 or 2C39A in grounded grid format requires 3 supplies: HT at between 1 and 1.5kv, the heater supply of 6.0v ac and a bias supply adjustable between 8 and 20v. I based the PSU on the design used by N6CA (see above), with a few small modifications. As the HT transformer had several taps I was able to offer four switched outputs between 1.15kv and 1.75kv. I also wanted to measure the HT current drawn and pinched the anode voltmeter circuit of GW4FRX's 4CX250B PSU (3) to deliver that safely.

Building the PSU was quite time-consuming, partly because of the amount of metal-bashing involved, partly because, being new to these sort of voltages I was taking things very carefully and seeking advice at every stage! I was lucky to be able to call on the expertise of Jim MM0BQI, who fixes things that go "beep" for a living and was able to make numerous suggestions to enhance the safety, function and practicality of the PSU.



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As the PSU needed three meters and I was determined not to pay the King's ransom that new meters cost I had to use what was available and shunt them. This caused an early problem when I tied myself up in knots with the formula to calculate the shunt resistor for the HT voltmeter. (algebra was missing from the syllabus of my Medieval history degree!) I had fitted three enormous 25W resistors, with the result that the meter registered zero, despite a healthy HT voltage. Numerous members of the "Amps" e-mail reflector put me right on the calculations and pointed out that 100mA meters are *not* a good option for measuring HT! I replaced it with a 1mA one, followed the proffered advice and all was well.

Another early problem resulted from trying to use the original rectifier board the GW8 had built, as it looked ok. It might have been *mechanically* ok, but when I first powered up the HT supply the voltage hunted up and down around 800v for a while before suddenly shooting up to 1.5kv and noisily blowing one of the rectifier capacitors. Replacing the entire rectifier board cost very little apart from my time and the supply worked perfectly after that.

A different issue I sought advice on was HT connectors and I was given a variety of suggestions. Most popular from a safety point of view were PET100, but a set of them would have cost more than the rest of the PSU put together! A couple of people suggested using connectors that aren't normally used in amateur radio equipment such as TNC or C-type, to avoid risk of error. I already use TNC for 12v supplies for that reason and in the end I chose to use red-painted BNCs until something better comes along. There is little risk of error as I hate BNCs and virtually all RF in my station goes through N-type connectors. However, after Danny GM6CMQ showed me the scar on his hand from touching a BNC HT connector on the back of a PSU I also made up an insulated blanking plug, which lives on the socket when the cable is not connected and I'll be watching the rallies for some cheap PET100s.

The amplifier itself was simple enough to build. I was inspired by N6CA's design to attempt water-cooling. I had previously assumed that water-cooling would be complicated, but it turned out to be fairly simple, as well as more efficient than air-cooling. A water-jacket is made from a plumbers copper end-plug, with two pieces of quarter-inch diameter brass tube soldered into holes in the top. The air-cooling fins on the valve can be unscrewed and the jacket is araldite-ed in it's place. A pond pump in a bucket pumps water through the jacket and back the bucket via nylon aquarium tubing. As the water is in contact with HT it is important to use distilled (or de-ionised) water. As the water will ionise over time twelve inches from the valve the water return passes through a piece of brass tubing and twelve inches further on another brass tube. The latter is earthed and a milli-ammeter is wired across the two to give an indication of the conductivity of the water.

I built a similar case to the PSU (though a lot smaller) to house the cavity. It is a two-layer case, with the upper layer housing the cavity and the lower housing everything to do with cooling, so that any water leak will flow away from RF or DC power.



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Coarse tuning of the anode cavity is achieved by a 20-turn screw accessible from the top, which screws a PTFE knob in and out of the cavity. A knob at the side of the cavity turns a capacitor in the cavity to fine-tune it. When I first received my cavity it also had a brass bolt in the side of the anode cavity, which moved a 5p coin in and out. I consulted GM8BJF, who had never heard of this mod. However, in practice this turned out to provide a "very coarse" tuning control and it was impossible to tune the cavity to resonance without it. I can only assume this relates to some deficiency in the way the cavity resonance had been changed from it's original use (this had already been done when I bought it).

I tuned the cavity, using a probe made from a 47 Ohm resistor on the end of some thin coax to poke a few milliwatts of RF into the cavity. A Milliwattmeter on the RF output showed a pronounced peak when the cavity was resonant at 1296MHz. When I applied the supply voltages and then applied RF to the input there was zero RF output. which was disappointing, but a word with a couple of "oracles" soon put me on the right track.

Firstly, I had assumed that, whatever the state of tune of the input tuning, there would be some output. *Wrong!* Tuning the input circuit produced RF out, which was heartening after all that work! However, 2W in was only delivering 1W out, as the input tuning was simply incapable of properly matching the input. Tuning it had only improved the input VSWR from infinity to 8:1. The original design for converting the cavity uses very simple input tuning: basically a "T" format, with RF input via a disc ceramic capacitor on the left arm of the T, an inductor made from 3/4" of tinned wire leading to the valve on the right arm and the upright is a piston trimmer with earth at the base.

A little research showed that almost every other design of 23cm amplifier I could find used a "Pi" format, with two interacting trimmers in the two legs. An article by Robert Stein W6NBI on converting a bank of three UPX-6's to form a high-gain 40W amplifier (4) showed a slightly Heath-Robinson additional tuning circuit built outside of the first cavity. which suggests that he had the same problem.

I intend to either add a second piston trimmer to the cavity, or follow the technique used by G4FRE (5) to solve a similar problem in an EME Electronics amplifier. His amplifier had a similar input circuit and he turned the ceramic plate capacitor into one plate of an air-spaced variable capacitor by soldering a brass nut to the case and using a bolt to screw a washer (forming the other plate of the capacitor) in and out.

The next few weeks should hopefully result in a functional amplifier. The project has been a massive learning-curve for me and very enjoyable to boot. Most of my projects tend to be rushed, based on the need to have a piece of kit ready for a particular expedition or contest. The sheer scale of this project prevented that sort of thinking, which made for a more relaxing project and a much better standard of work as well. By now I'm so proud of the thing I could almost not mind if it never worked! However, DX is calling and my xyl would like her kitchen bench back, so I hope to have it finished soon and I'll look forward to reporting how I get on.



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### Thanks

I must record my thanks to Jim MM0BQI for help with testing and pointing out silly errors, Brian GM8BJF, John G3XDY and Iain GM0ONN, who have patiently answered endless e-mails seeking advice on the bl\*\*\*\* obvious. Also numberless people on the GM-23, Amps and Microwave reflectors who have also helped with much-needed advice.



### References

- (1) "A Quarter Kilowatt 23cm Amplifier". By Chip Angle N6CA, QST March 1985
- (2) "RadCom" Microwave column, February 1981
- (3) "The VHF/UHF DX Book" (RSGB), Chapter 11. By John Nelson GW4FRX
- (4) "Converting Surplus AN/UPX-6 cavities" By Robert Stein W6NBI, Ham Radio March 1981.
- (5) Improved input match for the EME Electronics 23150 P.A." By Dave Robinson G4FRE / WW2R" <http://ns1.mesh/~g4fre/emepa.html>