Chapter 4

Commonly Used Valves

Glass triodes

Glass tetrodes and pentodes

High gain ceramic triodes

Russian ceramic triodes

Ceramic tetrodes

COMMONLY USED VALVES

Glass triodes

1 811 used in the Collins 30L1, Linear Amp Ranger and the Ameritron 811

2 572B used in the Yaesu FL2100, FL2100B and FL2100Z, Heathkit SB200, KW1000 and LA UK Pioneer

3 3-500Z/ZG used in the Kenwood TL922, Heathkit SB220, Linear AMP UK Explorer and Hunter 750

Glass Tetrodes and Pentodes

4 4-400 used in homemade amplifiers and marine transmitters

5 813 Pentode used in the KW500 and many home brew HF amplifiers.

High Gain Ceramic Triodes by Eimac

6 Introduction - Eimac 3CX series

7 3CX400A7/8874 used in older Alpha amplifiers, and some 2/6m amplifiers

8 3CX800A7 used in many 1500w HF amplifiers using a pair, or a single valve at VHF

9 3CX1200A7 only used in the Ameritron AL1200

10 3CX1500A7/8877 used in the Linear Amp UK Challenger, Ameritron AL 1500 and the Alpha 9500

Russian Ceramic Triodes

11 Introduction - Russian Triodes

12 GI7b/GI46 300- 400 watt valve used up to 1296 MHz in home made amplifiers

13 GS31 used in the Linear Amp UK 1 KW 2m, 4m, and 6m and 70cm models.

14 GS35b used in the Linear Amp UK HF Challenger and 2m and 6m 1500 watt amplifiers.

Ceramic Tetrodes

15 Return of the tetrode

16 4CX250B 4CX350 used in many early VHF and UHF amplifiers to give 300 – 400 watts output.

17 4CX800 or GU74 used in the Acom 1000 and 2000.

18 4CX1000A used in the Collins 30S1 and a pair in the latest Alpha 8410.

19 GS23b used in the latest OM-1500 watt tetrode amplifier

The 811, Glass Triode

The 811 has been one of the popular valves used in Ham radio since the 1960s. The first amplifier to use the 811 was the Collins 30L1 to go along with the rest of the Collins S line. A group of 4 x 811 will give around 800 watts output. The gain is around 10 dB so you will get almost 10 x your drive power. 4 x 811 are a very stable design and easy to match the input and output. Originally made by GE and now only made in China and for a short time in Russia.

Amplifiers to use the 811
Collins 30L1
Ameritron 811
Linear Amp UK Ranger 811

Specification HT voltage range 1600 to 1800 volts

Plate Dissipation	65 watts
Heater voltage	6 .3 volts @ 4 amps volts
Gain	9 -10 dB
Base	4 pin ceramic
Grid Bias / cathode	- 3 volts
Standing current	25 mA per valve
Drive	25 watts per valve
Cooling	Low power axial fan
Max Freq	30 MHz
Typical output	200 watts
Cost	£ 25 USA$35
Pin connections	
Top cap	Anode
Pins 1 and 4	Heater
Pin 3	Grid
Pin 2	N/C

The 572b Glass Triode

The 572b Triode has been one of the most popular valves since the late 1960s. It was used in the Heathkit SB200, the Yaesu FL2100, FL2100B and FL2100Z models and also the British built KW1000. The valve can be fitted into amplifiers using the 811 i.e. the Collins 30L1 or the Linear Amp Ranger 811 as a more robust alternative having larger anode dissipation.

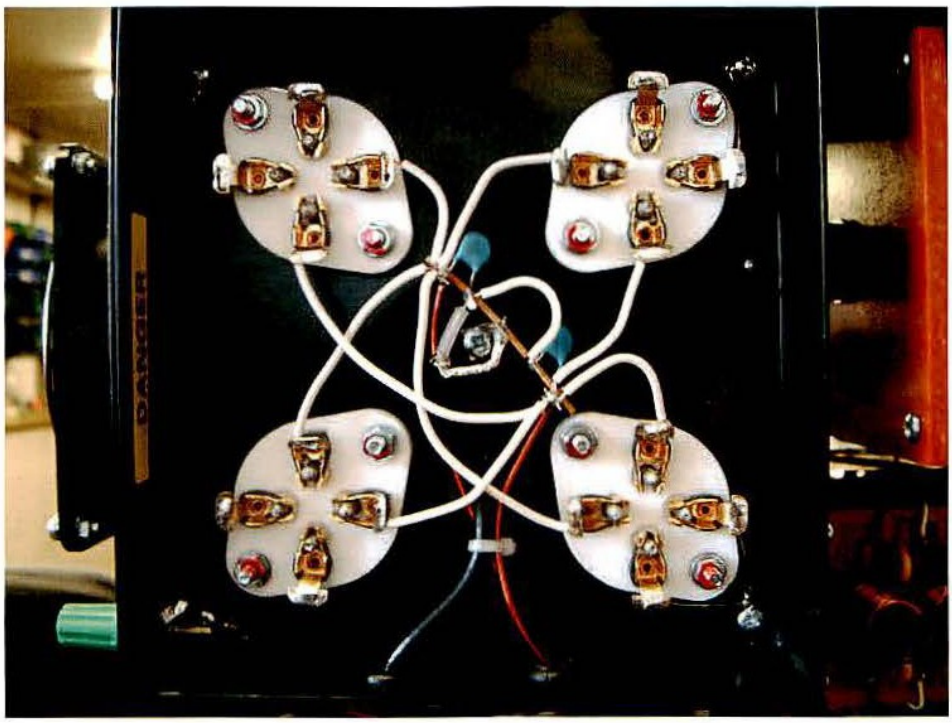
You will not get any more power output using the same HT but the valve will run cooler as it has a larger carbon anode. Originally made by Cetron but now made in China and badged under many different labels including Golden Dragon and Taylor. Also made in Russia and badged under the name of Svetlana.

Normally used in a pair to deliver around 700 watts with a drive of 100 watts. All designs use the valve in grounded grid driving the cathode.

Specifications

DC Plate Voltage	2400 DC
Plate Dissipation	160 watts
Bias on Grid	-2
Heater voltage	6.3 volts @ 4 amps, 25 watts
Zero signal current	45 mA
Single Plate current	250 mA
Drive power	up to 50 watts per valve
Single Tone useful O/P	300 watts
Base	4 pin Ceramic
Max freq	30 MHz
Cooling	low power axial fan
Cost	UK £45 USA $60

Top cap	Anode
Pins 1 and 4	Heater
Pin 3	Grid
Pin 2	N/C



Bottom view showing 4 x 572b or 4 x 811 bases

The 3-500 Z and 3-500ZG Glass Triode

The 3-500Z has been the powerhouse of many of the early 1kW amplifiers to give the USA legal limit of 1000 watts, now increased to 1.5kW. The classics have been the Heathkit SB220, Drake L4, L7, plus the single valve version the Drake L75, the Kenwood TL922 and the first Linear Amplifier UK, Explorer 1000. With most transceivers having a power output of 100 watts, a pair of 3-500 will comfortably deliver well over 1000W RMS output. All 3-500Z amplifiers use a grounded grid and drive the cathodes.

Articles have been written about the 3-500Z and its related amplifiers. In practice I have found the 3-500Z stable and long lasting, if not over driven. Each valve heater runs at 5 volts at 15 amps, though the cold switch-on current can be many times this, it is a good idea to fit step-start on switch on. This limits the inrush current of the valve. Cooling to the valve pins is also very important. I have known many valves desolder themselves inside their own pins due to overheat. This is due to the heater itself taking 75 watts plus the heat from the anode making the temperature very high unless adequately cooled. With an input power of around 2000 watts into the two valves, it is worth having the step-start as part of the HT circuit which helps limit the input switch-on current.

The 3-500Z was a classic Eimac tube made for many years until Eimac decided to stop production of all glass tubes. The 5 pin base has 2 pins for the heater and the other 3 pins strapped together for the grid. The tetrode equivalent, the 4-400 and 4-250 will also work in the same valve base. The heater pins and voltage are the same as the 3-500Z. Having 2 grids rather than one they both get grounded and work as a triode.

A pair of 4-400 will give around 800 watt compared with over 1kW from a pair of 3-500Z working with the same HT voltage. Of course the 4-400 is really designed to be grid driven and a very low drive of 20 watts

or less would drive a pair to over 1kW output in a passive grid circuit. The 4-400 was used in many ship transmitters and commercial long distance communications.

Eimac ceased production of all glass valves, this caused quite a vacuum in the supply of the 3-500Z. To my knowledge the Russians have never made the 3-500Z. I started to use the Amperex 3-500ZG made in France. While I was producing the Explorer 1200, I was experiencing a real production problem with the Amperex valve. The reliability was poor and I got many changed FOC! I stopped buying them and this was before the Chinese ones came available. For this one reason I stopped production of my very popular Explorer 1200 amplifier.

Later the Chinese 3-500ZG came available and now I think it is the only one made in the world. There are still many thousands of 3-500Z amplifiers working every day by radio amateurs. Like other valves they come badged with different labels including Taylor and other brands, but all are made in China.

The Chinese valves when I first started using them were not that reliable. Now the quality and reliability is much improved and I would recommend them. The 500 watt dissipation is much more conservative now from a pair running 1000 watts output. The Z type would run between red and bright red (do not drive into white hot). Two 3-500ZG will run 1000 watts output with no sign of getting overheated in either ICAS or SSB operation. Cooling can be vertical through a pyrex chimney but more commonly with amateur amplifiers the whole of the glass is cooled horizontally.

A single 3-500ZG as used in the Linear Amp UK Hunter and also the Drake L75 will give 600 to 700 watts output from a single valve. A pair as used in the TL922 and the SB220 just cruises along at 1kW with no stress. This is similar to a 2000cc car doing 70 mph on the motorway compared with a 1000cc car doing the same. Some manufacturers push a single 3-500ZG to 1000 watts output, twice the anode dissipation! The tube will suffer sooner and will need replacing. After all the difference from 700 watts to 1kW is no more than 1dB which will not make the difference between working a DX station or not!

Specifications

Plate Voltage	3000 volts typical
Grid dissipation	20 watts
Plate Dissipation	500 watts
Freq Max	110 MHz
Cooling	Radiation or forced air
Heater	5.0 volts at 15 amps thoriated tungsten
Base	5 pin special SK 410
Mounting	Vertical
Gain	up to 12 dB
Typical Output	700 to 800 watts
Typical Drive	70 watts
Top cap	Anode
Pins 1 and 5	Heater
Pins 2, 3 and 4	Grid

The 4-400 Glass Tetrode

Glass tetrodes have never been used in commercial Ham Radio amplifiers to my knowledge. The 4-400 was widely used in Marine transmitters because of their high gain. The driver was either a synthesized transmitter or a crystal controlled transmitter which would only have a power output of 10 to 20 watts. Driving a tuned input circuit of a glass tetrode would give a very high gain and a good power output. You would typically get over 1000 watts from a pair of 4-400 and often known as the QY4-400 where the Q depicts the tetrode version. These valves became very popular in amateur homebrew amplifiers. There was large release of the new surplus valves coming onto the market when commercial amplifiers were being changed for the more modern ceramic tubes.

Many homemade amplifiers with the 4-400 were made, either by using grounded grid or the classic G2DAF design were you rectify some of the drive and feed it onto Grid 2. A very good design was published in the ARRL Handbook of 1982. This was the basis of my very first grounded grid HF amplifier, using no tuned input as the input is low impedance. In 1982 all radios had a valve PA so a normal Pi network would easily drive the cathodes with just a simple coupling capacitor. With 100 watts of drive you would get 800 watts of RF into your aerial - quite nice for 1982.

Specifications 2 to 50 MHz

HT Voltage	3400 DC
Input Current	270 mA
Anode Dissipation	400 watts
Screen Dissipation	35 watts
Grid Dissipation	10 watts
Drive	5 watts in Passive (Grid Driven), 60 watts cathode driven
Heater	5 volts @ 14.7 amps approx 75 watts
Bias	8.2 volts in grounded grid
Output	630 watts
Max Freq	110 MHz
Cooling	Horizontal or vertical with a SK - 406 cooling system
Type of operation	Grid driven or cathode driven grounded grid.
Base	5 Pin - Special
Top cap	Anode
Pins 1 and 5	Heater
Pins 2, 3 and 4	Grids when used in grounded grid

The 813 Glass Pentode

In the 1960s to 1980s the 813 was an iconic valve, just like the 4CX250B was for VHF. It was used widely in HF power amplifiers for amateur radio.

From memory the first transmitter in the UK to use the 813 was the famous Lab Gear LG300 which gave 100 watts AM. KW electronics made the KW 500 designed by Rowley G8KW. This was the first 400 watt PEP amplifier to use the 813 Pentode. The most common way of driving it is in grounded grid, you do not get the gain compared to running it in passive grid but the circuitry is simpler. This valve has quite a large internal capacitance which limits its upper operating frequency especially when using a pair of 813.

Specifications

HT Voltage	2500 VDC
Screen voltage	750 VDC
Grid Voltage	-95 volts
Plate Current	360 mA
Drive	60 watts in grounded grid
Power Out	650 watts
Max Freq	30 MHz
Heater/Cathode	10 volts @ 5 amps
Base	5BA
Mounting	Vertical

Eimac 3CX Series of Ceramic Triodes

Introduction

The 3CX series of valves are the best triodes ever made. Having a gain of x40, a drive of 10 watts will give an output of 400 watts and 25 watts, 1 kW. This is more what would you expect from a grid driven tetrode without all the complications of regulated screen and bias supplies. These valves have an external anode so the cooling air can be pushed directly through the metal anode. This gives a far better cooling than the old type glass triode.

In practice the 3CX series of valves are the most reliable I have known, although expensive to buy.

The design of the valve is beam focusing, beaming the electrons on to the anode like a sharp torch. These valves are extremely reliable and I used a pair of 3CX800A7 in my first Challenger I to deliver 1500 watts.

There are a few variations of the normal valves. The 3CPX version is made for pulse transmission often used in NMR (Nuclear Magnetic Resonance) MRI body scanner. I used 4 x 3CPX800A7 in an amplifier for scanning soil sampling. It delivered pulses of 20 kW at 500 kHz.

The 3CPX series have a strengthened cathode for the higher pulse operation and the base is usually a few millimetres longer. Pulses are only a few milliseconds long and each valve can operate up to 10 x its normal anode dissipation. A 3CPX800A7 will happily pulse at 8000 watt.

The group available for Ham Radio service include the 3CX400A7, 3CX800A7, 3CX1500A7. Larger ones are available for commercial service. The 3CX15000A7 will produce 29.6 kW with 8000 volts DC on the anode and a drive of 1750W.

The 3CX400A7/8874 also have a sister called the 8875, this is horizontally cooled and only requires a small amount of air in comparison. The 8875 was used in the Heathkit SB230 and Dentron MLA2500. Unfortunately these two valves are not made anymore.

The 3CX400U7, 3CX600U7, 3CX800U7, 3CX1500U7, 3CX5000U7 can been used for operation up to 1000 MHz but are more expensive.

3CX400A7/8874 Ceramic Triode 500 watts

The 3CX400A7 is the smallest of all the 3CX series valves. It has a very low profile and so an amplifier can be made a very low, small and compact for a power output of 500 watts. The Alpha 76 uses 3 x 3CX400A7 to make a very low profile neat amplifier to give 1500 watts.

The 3CX400A7 has a sister valve, the 8875, two are used in the Dentron MLA 2500 and one in the Heathkit SB230. Both valves are basically the same except for their anode coolers. The 8875 employs horizontal cooling compared with the vertical anode cooler of the 8874. Both valves must be the most difficult to purchase and replace.

I recently managed to swap an 8875 to the 8874 by altering the cooling system. The base is just the same and requires no change.

The valve works very well on 2m and 6m, but rarely used, as the 3CX800A7 is twice the power and is normally the same price or cheaper.

If you have a faulty 3CX400A7 and you cannot get hold of one, which is likely, you have a few choices. A 3CX800 will work well, but you will have to make the chimney larger and also change the heater supply to 12.8 volts. Another option is to use the Russian GI7b or GI46b. These are a similar size and have similar outputs. Both are triodes and can be used for normal grounded grid operation. The only snag, there is NO valve base, like the GS31 and GS35 they mount directly into a hole in the chassis and the grid is clamped down to earth. This is not a big job and is very well worth the modification rather than spending maybe over 1000 dollars, approximately 600 pounds/euro, on two valves. The heater on the GI7b is 12.8 volts so you would have to add a small transformer to give the 12.8 VAC supply.

A UHF version is available and useable up to 1000MHz (3CX400U7)
The base is a Johnson special called the SK 1900, 11 pin or Jedec E11-81
Recommended Chimney is the SK 696
Max freq operation 500 MHz

Specifications

Heater Voltage	6.3 volts at 3 amps
HT Anode	2200 VDC
Grid dissipation	5 watts
Cooling	Forced air
Power out	550 watts
Drive	25 watts

Valve pin connections

Top Cap	Anode
Pins 5 and 6	Heater
Pins 4, 7 and 11	Grid
Pins 1, 2,3,8,9 and 10	Cathode

3CX800A7 Ceramic Triode 1000 watts

The 3CX800A7 and the 3CX1500A7 are my all time favourite valves. Both have style and power when required, such fantastic classics of all valves. Turn the steam on and they give you fantastic power, very stable and useable to 350MHz and the 3CPX800A7 to 500MHz. The only drawback to the 3CX800A7 is its price.

When I first used the 3CX800A7 the price was only £200 each plus £25 each for the base. Unfortunately the price went up and up, and then the Chinese started to make the 3CX1500A7 for about the same price or lower!

The 3CX1500A7 is twice the power and for about same price, the base is an old type ceramic QQV06-40 valve base which can be bought for a few pounds. It made more sense to use one 3CX1500A7 instead of the 2 x 3CX800A7 that I used in the first Challengers and 2m and 6m Discoveries.

The 3CX800A7 operates at a relatively low HT voltage of 2200 volts for a valve that delivers 1000 watts. Output is very good, as low as 25 drive watts can deliver 1000 watts.

Other users of the 3CX800A7 have been Alpha, Ten-Tec Titan, Henry and Command Technology, that's just a few that I can think off!

A really great valve, but a pity about the price!

Specifications

Heater voltage	13.5 Volts at 1.5 amps, 20 watts
HT Anode	2200 VDC
Max Freq.	350MHz
Grid Dissipation	4 watts
Cooling	Forced air
Power out	1000 watts
Anode dissipation	800 watts
Drive	25 watts
Valve pin connections	
Top Cap	Anode
Pins 5 and 6	Heater
Pins 4, 7 and 11	Grid
Pins 1, 2, 3, 8, 9 and 10	Cathode

Eimac 3CX1200A7 Triode

The 3CX1200A7 is the black sheep of all the 3CX family. It is a very robust HF valve but not like the 3CX400/800 and 3CX1500A7 which will work above 2m, the 3CX1200A7 has a top frequency of only 100 MHz so it is fine up to 6m at its full rating. The 3CX1200A7 is more like a metal 3-500Z but it will deliver twice the power of a 3-500Z. The output is well over 1500 watts from one valve due to the metal anode and the efficient external cooler making it far superior to a 3-500Z. For a ceramic valve the gain is also down, where a 3CX800A7 has a gain of x 40, the 3CX1200A7 has a gain of around x 15. A 3CX800A7 which will deliver over 1000 watts only takes 3 amps or 40 watts on its heater current, but the 3CX1200 takes 21 amps at 7.5 volts some 160 watts, just about 4 times the heater current in comparison. The big advantage, like a 3-500Z, it has instant warm up but a soft start circuit is highly recommended as the inrush current could be 4 or 5 times the normal heater current at switch-on. This all depends on how much voltage sag there is from the heater transformer on switch on which is the limiting factor. I have only used the valve once to build an amplifier which ended up with my friend, G3YQA, in a Hunter amplifier which normally uses a single 3-500Z. I put a couple of more turns on the toroidal heater transformer to raise it to the 7.5 volts required. This made it into a very compact 1000 watt amplifier. It would have been a lot more if the core of the transformer had been of a larger VA rating. In many ways this is a good valve, but has never really taken off with the larger manufacturers, only Ameritron, to my knowledge, used it in their large AL 1200. As I write this I have one in for repair and the cost of a replacement 3CX1200A7 from RF parts is quoted at 1550 dollars plus import tax, 20% VAT and delivery, this is as much as the amplifier is worth. Unfortunately there is no similar valve except the 3-500Z which would really be a big downsize on a very good amplifier. The 3CX1500A7, in comparison, is a smaller valve with a much higher gain and a heater which is indirectly heated and only takes 10 amps at 5 volts some 50 watts. When a heater is directly heated it takes 3 minutes to warm up, but there is no stress on the heater. It is operated more like an electric fire compared with a light bulb as in the 3-500 or 3CX1200A7.

A good valve but do stay away due to cost and availability, unfortunately not made by the Chinese.

Eimac 3CX1200A7 Triode continued

Specifications

Plate Dissipation	1200watts	
Grid Dissipation	50 watts	
Freq for Max ratings	100MHz	
Cooling	Forced air	
Voltage	7.5 volts	
Current	21.0 amps	
Base	5 pin special	
Recommended Air system socket	SK – 410	same as a 3-500Z
Recommended Air chimney	SK – 436	
Maximum Seal & Anode Temp	250 °C	
Typical output with 80 watts of drive	1500 watts	

Valve pin connections

External Metal Cooler	Anode
Pins 2, 3 and 4	Grid pins
Pins 1 and 5	Valve heater

The 3CX1500A7/8877 Ceramic 1500 watts Triode

The 3CX1500A7 is the largest of the 3CX series used in amateur radio service. With 3500 volts on the anode it will deliver around 2500 watts with 80 watts of drive. I used the Eimac version in my Challenger 2 before the price went crazy to £700!

The 3CX800A7 and 3CX1500A7 have been my very favourite valves available for amateur radio use. Made and designed by Eimac and introduced in 1970.

The Chinese started importing their version of 3CX1500A7 around 1996. When the Chinese ones arrived for a third of the price I had to try them. In the early days the reliability was not that good, but now I think the quality is good and as reliable as the Eimac 3CX1500A7.

Besides the Challenger 2 and 4, the Ameritron AL1500, Alpha 9500 and Henry have all used the 3CX1500 with great success.

The next in size is the 3CX3000A7 and 3CX5000A7 delivering some 5 KW and 8 KW, which would be difficult to use on a normal household mains supply but I am sure someone has!

Using the 3CX1500A7 is a dream and easy to tune. It is very stable and usable up to 250 MHz. The only weakness is the grid though I have never known one get damaged with proper use and care. Considering the price of the valve, fitting a grid protection circuit is a must. The maximum grid current is 120 mA. The grid current swing can be quite large while tuning at higher powers. Delivering 1500 watts on SSB or CW the exhaust temperature is just a nice steady warm temperature. Nice for warming the shack in the long dark winter DX sessions!!

The base is the same as the old Mullard QQ- VO6-40 the number is a SK-2210

A Great Valve and nice to use!

The 3CX1500A7/8877 Ceramic 1500 watts Triode continued

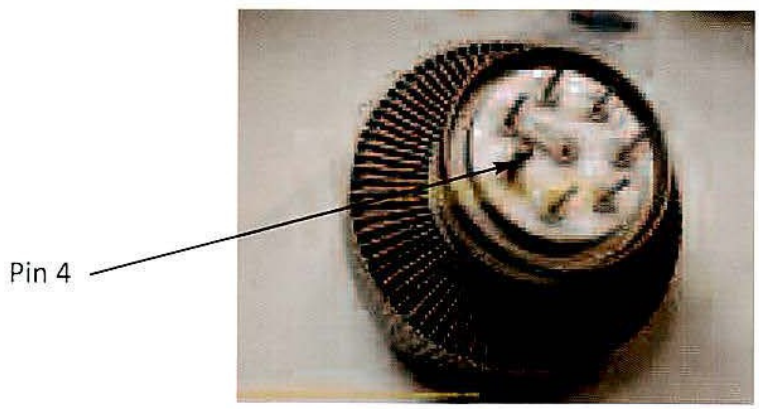
Specifications

Heater voltage	5 volts @ 10 amps 50 watts
HT Voltage normal	3500 VDC
Max Freq	250MHz
Grid Dissipation	25 watts
Cooling	Forced air
Power Out	1500 to 2500 watts depending on drive and the HT supply.
Drive	65 watts

Valve pin connections

Top Cap	Anode
Pins 1 and 5 are the	Heater
Pins 2, 3, 4, 6 and 7	Cathode

Metal ring is the grid and must be earthed with fingers to earth
The large pin at 8 o clock is pin 4



Bottom view of 3CX1500A7

Introduction of Russian Triodes

My introduction to the Russian valves starts with my yearly pilgrimage to the Friedrichshafen Ham Radio show some 20 years ago. I had a booth for selling my amplifiers into Europe. At this time I was not using any Russian valves except for maybe the odd 811. After looking around the show I was astonished by how many dealers were selling these Russian valves that not many people knew about. By chance I saw a very good little book by a German Ham, Karl Weiner DJ9HO called UHF – Applikation. He had spent a lot of time making VHF/UHF amplifiers using the Russian valves. I do not think the book is sold outside of Germany but it is a host of really good information, and of course mainly in German.

I started making VHF amplifiers initially using the 4CX250B. Later I moved over to the Eimac 3CX800A7. The temptation for a good cheaper alternative was born. The Russian valves filled this gap well.

The main valves that were available were the GS35, GS31, GI7b triodes and the GU74b tetrode. The GU74b is also known as the 4CX800A for the Western market. When I first looked at the GU74b at Friedrichshafen they were only €25 each. This was before the Acom 1000/2000 and Alpha 91b and many other users latched on to them, now you could pay close to £200 for one.

Russian triodes and tetrodes are a bit of an oddity. You cannot buy them from normal trade outlets. Of course you can buy them from people selling on the Web and at some European Ham Radio Shows.

Russian Ceramic Triodes in Operation

Russian Triodes are great to use and are quite different from most Western valves. The first difference is that they do not necessarily need a valve base. The outer ring of the valve is the grid ring and hence you can fasten it directly into your chassis. Normally, most Eimac valves need an expensive de-coupling ring to ground the grid. The other two rings are the cathode / heater. It is easy to fasten a clamp round. Russian valves also have a detachable anode cooler locked on with a large locking nut. This is very useful for fitting a half-wave line on the GI7b and GS31 for 70cm.

A valve will always operate on HF frequencies. Its upper limit is always due to the internal capacitance of the valve. Most Russian triodes have a low internal capacitance and will operate happily at 70 cm and the GI7b/GI46b will also operate very well at 1296 MHz.

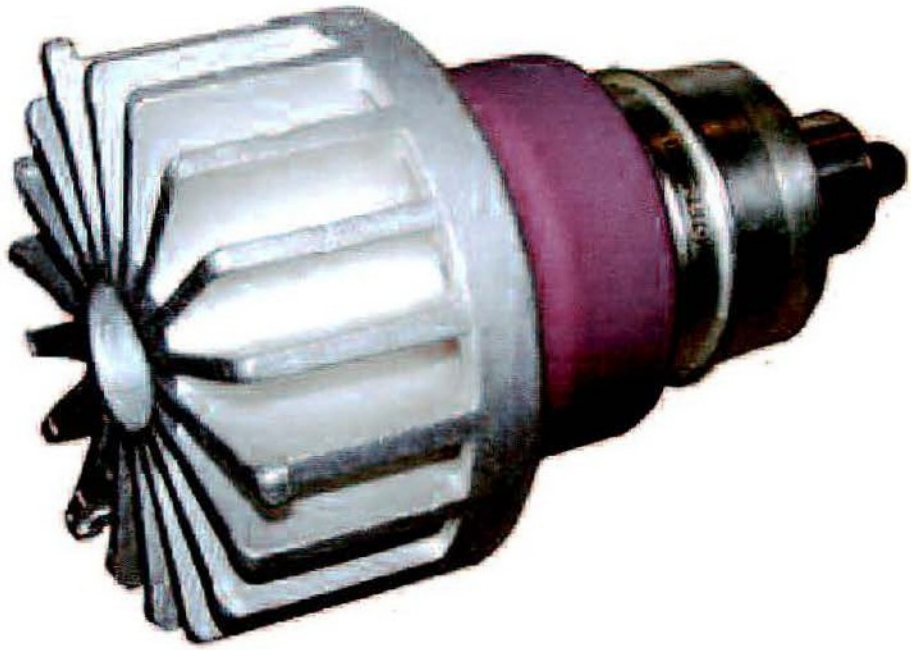
In practice, you will find at 70cm and 23cm you will experience thermal drift in frequency. You will need to do a small amount of re -tuning. On SSB or CW when you go to transmit you will be down by around 20%. The power will soon recover and come up to its full operating power in about 15 seconds. I do not have an answer to solve the problem other than to just accept it. I have tried extra cooling and a much thicker half-wave line to sink the heat better, but nothing makes any difference. I believe the movement is due to a stretching of the grid when hot, this changes the internal capacitance of the anode

Nearest equivalent Western valves to the Russian GS series

GI7b	400	watts	=	3CX400A7
GI46b	500	watts	=	3CX400A7
GS31b	1200	watts	=	3CX800A7
GS35b	1500 to 2500 watts depending on HT and Drive = 3CX1500A7			

For a comparison the GS31b will give a similar output to the 3CX800A7, though the gain is less. For 1kW output, a GS31 will need 80 watts of drive, a gain of 12dB, whereas the 3CX800A7 will only need 25 watts drive, for a gain of 16dB, for the same output power. Grid current is also much different, a 3CX800A7 will draw a maximum of 60 mA where the GS31 is happy to take 200 - 300mA with no damage. Grid protection is highly recommended for all the ceramic triodes.

GI7b Ceramic Triode.



Base connections are the same as the GS35

This valve is the least used in Amateur Radio. If you want 300 watts at 1296 MHz the GI7b would be an ideal choice though it is not used in any commercial amplifier. They can be bought for as little as €15 each and at HF you could use as many in parallel as you would like to, so 3 would give you almost 1000 watts for the price of €45. Furthermore, the operating voltage is only around 1800VDC, they are in good supply and would make a good simple amplifier - simple to build with minimal cost for either HF, VHF or UHF operation.

Specifications at 70cm

HT Voltage	1000 to 2000 VDC
Input Current	400 mA
Drive	10 – 18 watts
Heater	12.6 volts @ 2. 5 amps
Bias required	+ 15 volts
Output	330 watts at 2kV
Max Freq	1300MHz
Type of operation	Grounded Grid, Cathode driven
Cooling	Forced air cooled with a snail fan

GI46b Ceramic triode

Base connections are the same as the GS35

The GI46b is the closest Russian valve to the Eimac 3CX400A7 which is not made any more. If you can find a 3CX400A7 they carry a very premium price. Amplifiers such as the Alpha 76A use 3 x 3CX400A7, I believe they will convert and give a similar output to the original valves. Some people think that the 4CX400 or 4CX800 are like the GI46b but they are tetrodes not triodes hence a complete change of circuitry would be required. The only main consideration would be the heater voltage and you would have to change it as the GI46b has a 12 volt heater.

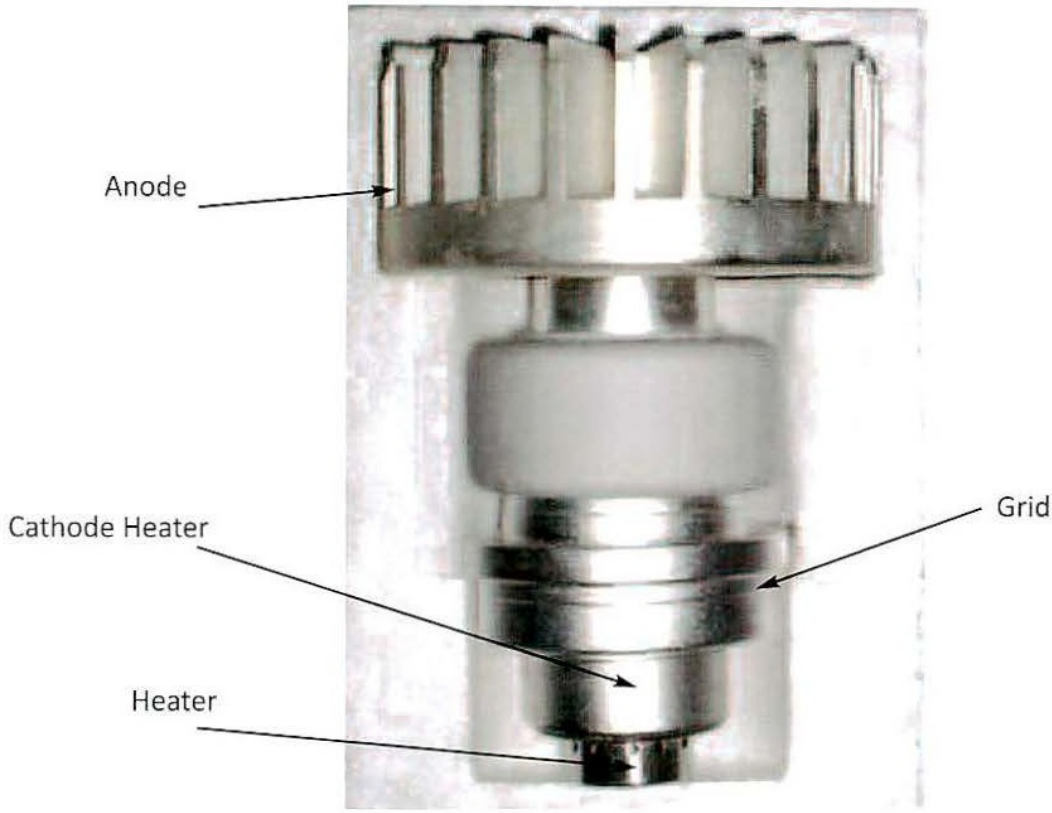
The GI46b is a slightly better version of the GI7b but both are very similar in performance and output.

The GI46b would make a very good HF or VHF/UHF amplifier, 3 valves could be used to deliver 1200 watts on HF

Specifications at 70cm

HT Voltage	2000VDC
Input Current	400 mA
Drive	10 to 20 watts
Heater	12.6 volts @ 2.6 amps
Bias Required	+ 15 volts
Output	400 watts
Max Freq	1300 MHz
Type of Operation	Grounded Grid, Cathode Driven
Cooling	Forced air cooled with a snail fan.

The Russian GS31b Ceramic Triode



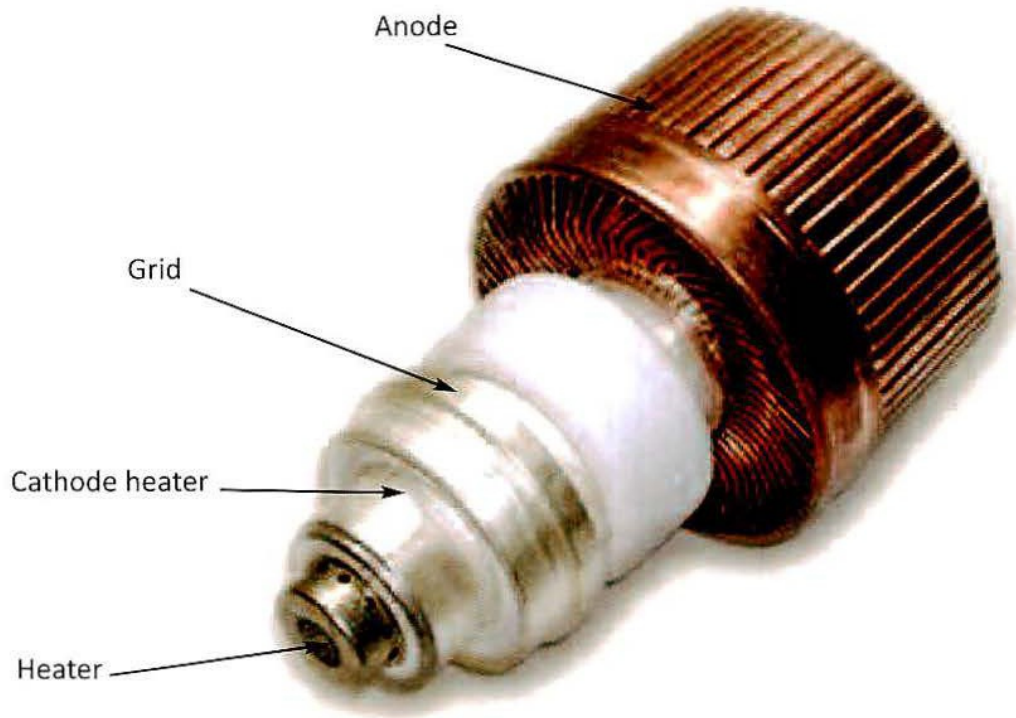
The GS31b is one of my favourite Russian valves. It will give 1200 watts from 160m to 2m and around 800 watts on 70cm. This is quite something for a valve that costs less than €100. It is a very robust triode and very easy to mount in a hole. For 70cm the anode cooler can be taken off and a half-wave line fastened directly between the anode and the anode cooler.

The GS31b has a gain of around 13dB, and 10dB when you get to 70cm, all depending on the amplifier build quality! I have used the GS31b in amplifiers for 2m, 6m and 70cm with great success. A single valve would also make a very easy to build 1000 watt amplifier for HF. The circuit you could use would be the same as my Challenger amplifier employing a GS35b.

Specifications at 144MHz

HT Voltage	2800 VDC
Plate Current	800 mA
Heater	12.6 volts @ 3.4 amps
Drive	100 watts
Bias required	+28 volts
Output	1200 watts
Max Freq	1000 MHz
Anode Dissipation	1000 watts
Grid Dissipation	22 watts
Type of Operation	Grounded grid, cathode driven
Cooling	Forced air cooled with a snail fan.

The Russian GS35b Ceramic Triode



The GS35b is the largest available of the Russian Triodes. Like the other valves I have just described availability is getting harder. Suppliers seem to have good stocks like QRO parts and on the Web. All mainly sent from the Ukraine and Russia, the numbers at Friedrichshafen are now lacking compared with 10 years ago.

The GS35b is quite a heavy valve at 2.8 Kg /6.2lbs. I have used it from HF up to 70cm with great success. If you want a cheap 1500 watt valve this is the one with a good specification. You should be able to pick up a GS35b for around £100/$150, compared with a 3CX1500A7/8877, a new one from RF Parts, listed at $1160 for similar specification.

You can take the main anode cooler off. The main valve body splits into two, undo the fixing nut by 2 turns, hold the large copper cooler in one hand then tap the large nut with a hammer, and it will then easily slide off. You can fasten the main body of the valve into a hole in your amplifier using 4 'L' shaped brackets. Clamp the grid ring down to the chassis of your amplifier with the 4 L brackets. The GS35b is indirectly heated so it must have approximately 3 minutes warm up time before drawing anode current. It is perfectly alright to apply the HT supply when you switch on the heaters but do not key the cathode until 3 minutes have passed.

The GS35b does not have the gain of a 3CX1500A7 but it will deliver the power when driven by a 100 watt radio. You will get 1500 watts with a 100 watt driver and HT of 3600VDC. I read, with interest, an article by a German Amateur who used a GS35b with 4000 volts on it and a drive of 200 watts to give 3000 watts on 2 metres, presumably for EME!!

The GS35b has not been made since the 1970s and all have been in cold store for many years. Buying them is strange as the Russians do not seem to have surplus sales like we do in the West. They all seem to be 'acquired' and appear at flea markets. I find them superb, especially good for 2m and 6m amplifiers. When new it is worth running the heater for an hour or two to warm the getter. This makes sure the vacuum inside the valve is 100%. When the valve is running with RF going through it the ceramic part of the valve normally glows a nice fluorescent blue and modulates as you speak on SSB and CW.

Generally the valve is good and robust, especially if you fit grid protection.

Specifications

HT Voltage	3600 VDC
Input Current	1 amp
Drive	100 watts
Anode Dissipation	1500 watts +
Grid Dissipation	26 watts
Bias required	+36 volts
Output	1500 watts
Max Freq	1000 MHz
Type of Operation	Grounded Grid, Cathode Driven
Cooling	Forced air cooled with a snail fan
Weight	2.8kg / 6.2 lbs.

The Return of the Tetrode after a gap of 40 years

If I was starting to make amplifiers now, rather than 40 years ago, I would definitely be choosing a tetrode. My life with triodes has been good, but now there is a nice choice of Russian and Chinese tetrodes. Yes, there are disadvantages, like you need a good regulated screen supply and a stable variable bias supply. It is now very easy to make the required circuits by using one of the many circuits available, or you can purchase one of Ian White, GM3SEK, Tetrode boards. It does everything you would need to run a modern Tetrode amplifier including protection, screen, bias supplies as well as a timer and all the metering and LED outputs. It comes very well documented, how to set it up and understand how it works.

My first venture into tetrodes was like many others who used the 4CX250BB to give me 300 watts on 2metres. The 4250B was actually introduced in the early 1950s, when 2m radios only gave 10 watts like the old FT221 and the Trio TS700G, so the gain of a ceramic tetrode was unbelievable. In fact, the 4CX250B could be driven to 300 watts with only 3 or 4 watts if the grid load resistor was kept to a high value. In those days the gain of the tetrode was used to its optimum.

Now the low level drive is not required any more as most VHF and HF radios all deliver 100 watts or more. A 50 ohm load resistor across the grid input makes a tetrode very stable and gives a medium gain compared with a tuned input circuit which would have been used years ago for a high gain amplifier.

With around 50 watts of drive you will have enough voltage swing across the grid to drive the amplifier to full output.

Advantages

Modern tetrode amplifiers will work on ten amateur bands. This is easily done by not needing tuned input circuits. The modern way is to drive the valve grid across a 50 ohm non inductive load resistor. This means the input of the amplifier is flat across its entire spectrum. This avoids having to make tuned input circuits for each band, which takes time winding all the individual tuned circuits.

When I first started making amplifiers we only had five HF bands where high power was allowed. We did not have high power on 160m nor did we have the WARC bands or the new 60m band. On top of all this we did not have the 6m band which is now a standard on almost all modern HF amplifiers. Having a low current heater is an advantage prolonging the heater life compared with directly heated valves.

Disadvantages

There are few disadvantages with a tetrode. You do need a more complex control board to supply the screen and bias supplies. Protection is a must as the grid parts of the valve are the most delicate. The heater is indirectly heated so you have to wait 3 minutes for the timer to come in. Having a low current heater is an advantage which helps prolong the life of the heater.

6 meters

The problem getting an HF Amplifier to work on 6m is C1, the tune capacitor, is too large! It is normally around 200 pF in size. This can be done mechanically by splitting the capacitor 80% and 20%, which gives 40pF and 160pF. The two parts are linked together for all the lower bands. Just 40pF is needed on 6m. Alternatively you could fit a 50pF fixed door knob capacitor in series with the 200pF tune capacitor. Short it out on all the lower bands. This will give a maximum capacitance of no more than 45pF.

The load capacitor C2 needs to be around 200 pF. Most HF amplifiers have a load capacitor of around 1000pF. Fortunately these are made in 3 sections and just one section can be used for 6m band to give 330pF which is ideal.

The 4CX250B Ceramic Tetrode

In 1948 Eimac introduced the 4X150A tetrode and later, in the mid 1950s, the improved 4CX250B arrived. They seem to have been around for ever for HF, VHF and UHF. It started off as a glass valve with an external anode cooler. Then it was improved into the 4CX250B which has a ceramic centre like the one above. Many companies took a licence on the Eimac 4CX250B which included Mullard, Plessey, Siemens, RCA and many others. It was such a popular valve for the high power transmitters and amplifiers.

They have been used as a single valve or up to 4 in parallel to give 1500 watts. You can easily obtain a gain of 20dB. I have seen commercial amplifiers using 10 x 4CX250B in a broadband design which gives 1000 watts with no tuning for 2 to 30Mhz.

Delivering around 300 to 400 watts with a fantastic gain, what a valve!

This is good all round valve and good for HF, VHF and UHF.

A perfect match for the Kenwood Trio TS700G and the Yaesu T221R

Most radios in the 1970s only produced about 10 watts to go to 300 – 400 watts with a single valve was fantastic.

In the 1970s a few European and Japanese companies manufactured 2m and 70cm amplifiers. These included the German Dressler D200S and the Japanese Nag using the odd 4CX350F.

I built the Heatherlite 2m Explorer using a 4CX250B to deliver 300 watts. In the 1970s and 80s 2m SSB DX was very popular before we acquired the 6m band.

I must admit I had a lot to learn about power tetrodes and amplifiers!

Many Marine Transmitters used 4 x 4CX250B to deliver 1500 watts, this has never been a popular design in Amateur Radio as a single 4CX1000B will do the same job with much less wiring.

The 4CX250B has many different versions which include the 4CX250B, 4CX250R 4CX250BM and 4CX250F and also the 4CX350B and F. Some have more rugged cathodes than others and also have different heater voltages i.e. 6V or 26V mainly for aircraft and mobile communication use.

In Europe in the late 60s the CW requirement was dropped. This created the class B G8 licence which was only VHF/UHF. Many amateurs were very happy to use 2m or 70cm with the expertise it brought. When a VHF opening came the band would be alive from top to bottom with signals from all over Europe and Scandinavia. Distances of 2000 – 3000km were easily obtainable with a good yagi and 300 watts. Of course the power helped and every radio ham in the 60s and 70s had to go to a radio rally to look for a 4CX250B and a matching base. Many articles were written about the 4CX250B and its different versions. The 4CX250B has a special base which improves stability and decouples the valve for VHF/UHF operation. I am sure many hams have bought a 4CX250B with the full intention of building an amplifier, but many were placed on a shelf like a good ornament.

The K2RIW 600 watt 70cm amplifier using 2 X 4CX250B

Finally I must mention the famous K2RIW amplifier. This amplifier was described by Ian White, GM3SEK, and John Norman, GW4FRX, in the 1995 RSGB VHF/UHF hand book.

It uses two 4CX250B to deliver around 500 to 600 watts, a great power for those days for the 70cm band. This would be enough power for serious DXing, also Earth Moon Earth communication, when feeding a good aerial array.

Employing a half-wave tuned line for the output circuit which was capacitance coupled to the output. The input is a tuned brass line which is also directly coupled by a coupling capacitor.

In those days there was not a lot of choice of valves to give high power on 2m and 70cm.

Now the availability of the Russian GS series of valves gives a good choice of valve for VHF and UHF frequencies.

Specifications HF to 500 MHz

Anode Dissipation	250 watts
Typical Output	300 to 400 watts
Drive	< 10 watts
Heater	6 volts @ 2.4amps, 15 watts
Cathode	Oxide- coated Uni potential
Operating position	any
Plate Voltage	2000 VDC
Screen Voltage	300VDC
Base	9 pin Special SK-600
Chimney	Special SK 606
Cooling	Forced air cooled e.g. snail fan.
Top Anode Cooler	Anode
Valve base centre pin	Grid 1
Pin 1	Screen/Grid 2
Pins 2, 4, 6 and 8	Cathode

The Russian GU74b/4CX800 Ceramic Tetrode

The most popular tetrode is the GU74b made around 1980 later called the 4CX800A and must be one of the most used tetrodes in the Amateur radio field. I do not know how many were made but it seems like tens of thousands, the supply never seems to dry up. They have not been made for almost 30 years. Supplies of the GU74 are now getting low and the price is going up from the 25 euro I paid at Friedrichshaven. The GU74b has been rebadged for the west as the 4CX800 to come in line with Eimac numbering similar to the Eimac 4CX1000.

Original Russian GU74b have a dull finish, almost like lead colour, but many went for re-silvering and came back looking like a new 4CX1000. This was all done by George Badger W6TC, who was ex-Eimac.

The Russian valves were made 30 years ago with the name of OTK on them, in their factory in St Petersburg, Russia. Described as a high μ tetrode, it is ideal to be grid driven using a 50 ohm input load resistor eliminating any other input circuitry like grounded grid amplifiers need. George Badger W6TC realised its potential and saw the opportunity of using the Russian valves. He created the name Svetlana to market the newly found tetrodes into the west. All the GU74b valves we use now are NOS, new old stock.

Some Amplifiers that use the GU74:-

Alpha 91β, Acom 1000 and 2000 Auto, Emtron DX1 and DX2, Alpin amplifiers

The Russian GU74b/4CX800 Ceramic Tetrode continued

Specifications HF and VHF amplifiers

Anode dissipation	800 watts
Typical output	800 to 1000 watts
Drive	60 watts into a 50 ohm load resistor
HT	2200 VDC
Screen	300 to 350 volts dissipation @ 15 watts
Max Freq	250 MHz
Warm up time	3 min
Cooling	Forced air e.g. snail fan
Heater	12.6 volts @ 3.6 amps, 45 watts
Pins 3 and 7	Heater
Pins 2, 4 and 6	Cathode
Pin 1	Grid 1
Pin 5	Screen grid 2

The Eimac 4CX1000A Ceramic Tetrode

The Eimac 4CX1000A is a fantastic 1500 watt tetrode. A valve that was probably the most used valve in commercial high power amplifiers in the 1960 to the 80s. It was brought out by Eimac in 1957 and used in the classic Collins 30S1. I have also seen them used in VHF Police Transmitters using several frequencies from one valve to give several 200 watt channels multiplexed from one aerial.

In the UK most Hams did not consider it, with a legal limit of only 400 watts using a 4CX1000A in the 70s and 80s would have been frowned upon. We still had inspections by the 'Man from the Post Office', later the RA and now OfCom. That is a thing of the past now and everyone is left to police themselves. Many manufacturers started using Russian tetrodes like the GU74/4CX800 but now with them getting rarer and more expensive the 4CX1000A are becoming popular again. The new Alpha 8410 uses two instead of a pair of 4CX800. The Chinese make them and appear under the name Taylor (RF Parts) and other badged labels, but all are made in China, unless specified Eimac, which are still made in the USA.

I think if I was still making amplifiers, this would be my first choice. The modern idea of using a 50 ohm load resistor to feed your transmitters into is so simple and requires much less wiring. You do not have any tuned input circuit but a Pi-L network is necessary in order to keep the harmonic content to an acceptable level.

The Eimac 4CX1000A Ceramic Tetrode continued

Specifications up to 110 MHz

HT Supply	3000VDC
Screen Voltage	325VDC
Anode Dissipation	1000 watts
Screen Dissipation	12 watts
Heater	6 volts @ 9 amps, 54 watts
Max Frequency	110 MHz at full CW rating.
Mounting	Horizontal or vertical
Base	Special SK-800B
Cooling	SK-806 air chimney, with snail type fan.
Weight	0.77 kg
Drive	50 watts with 50 ohm Grid load resistor.
Typical output	1630 watts

Top Cap	Anode
Top ring	Screen
Pin 3	Grid
Pin2	Heater /Cathode
Pin 1 Bottom Ring	Heater

GS23b Ceramic Tetrode

The GS23b is the latest tetrode to be used by Western manufacturers. You would think by its number it would be a triode but it is actually a tetrode.

I first ran across the GS23b in the OM 1500. The valve also has a western number of the 4CX1600U. It has a very high specification as it can give 1000 watts on 70cm. It is also is useful at 1296 MHz with reduced ratings. It is built as a coaxial valve to keep everything symmetrical for its UHF properties.

Specifications HF - UHF

HT Voltage	3000 VDC
Screen	500 VDC
Grid	- 150VDC
Output	1500 watts
Heater	6.3V @ 6.25 amps
Anode Dissipation	1500 watts
Max Frequency	1000 MHz full rating, 1300MHz at a reduced rating
Cooling	Forced air cooling e.g. snail type
Typical gain	15 dB using a 50 ohm input load.
Base	UHF special