

# **Valves and Valve Testing**

In this years talk I shall be dealing with valves and valve testing. In the first section I'll talk about how a valve works and will demonstrate the various valve configurations and their characteristics. In the second section I'll detail what tests can be done to check if a valve is working correctly to specification. I won't be demonstrating a valve tester as there are many different types but will explain the principles behind a valve tester.

Many of you will be familiar with the Sussex Valve tester designed by the late Mike Rowe and published on the UKVRRR forum. Back in 2013 I volunteered to collate all the information from over 50 pages of posts and produced a construction and user manual. This is available from the forum and forms the basis for much of this talk.

<http://www.vintage-radio.net/forum/showthread.php?t=48853>

## **Background to The Development of The Valve**

### **The Edison Effect**

Around 1880 after Thomas Edison had perfected an electric light bulb he and his team were trying to find out why material from the filament was being deposited on the inside walls of the glass bulb. As part of the investigation he added an electrode to the bulb. He discovered that a current would flow between this electrode and the filament but only when the electrode was positive with respect to the filament. He patented his discovery, as he believed it could have some commercial application but did not understand exactly how it worked.

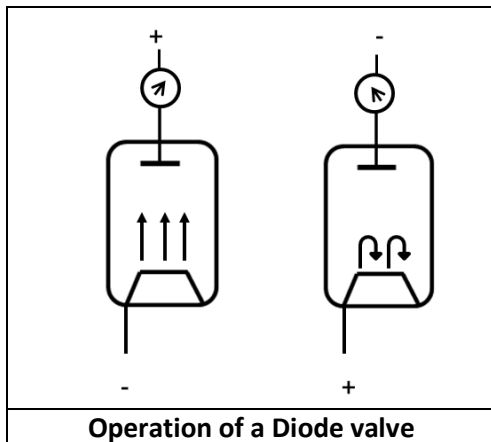
### **Ambrose Fleming**

In the early 20<sup>th</sup> century detection of radio signals was somewhat difficult with many different methods being used. Ambrose Fleming, working at University College London as an advisor for the Marconi company, revisited the Edison effect and found it suitable for detection of radio signals. This became the diode valve and formed the basis of electronics for many years until solid state devices took over.

### **Lee De Forest**

Around 1906 American Lee De Forest added a grid between the filament and anode. This allowed control of the current by varying the voltage on the grid creating an amplifier, although early versions had low gain and, due to De Forrest's insistence, had some residual gas. This was developed into the triode valve as we know it today.

## Simplified Valve Theory

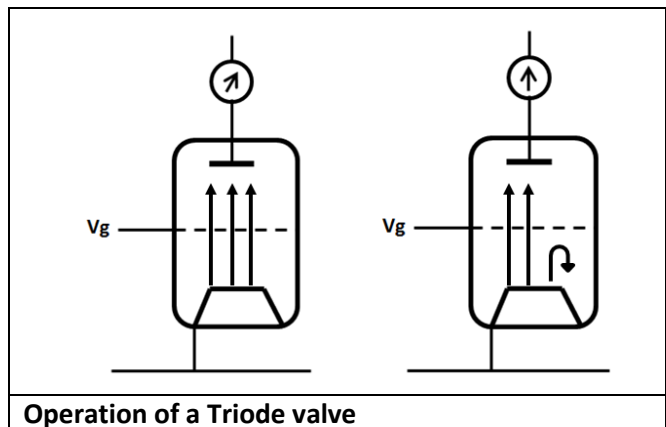


A basic diode valve comprises a source of electrons, either a directly heated filament or cathode with a separate heater and an anode. The electrons, being negatively charged, are attracted to the anode when it is positive with respect to the filament or cathode and repelled when the anode is negative with respect to the filament or cathode.

Thus a current will flow when the anode is positive, the value of which depends on the voltage applied to the anode.

A triode adds a grid between the cathode and the anode. If this grid is made negative and the anode made positive with respect to the cathode the flow of electrons and hence the anode current will be reduced.

The anode current will then be dependent on both the anode voltage and the grid voltage. If the grid voltage is varied the anode current will vary in sympathy and with a suitable resistor in the anode circuit we have the makings of an amplifier.



Extra grids can be added and we'll look at these and what advantages they have later.

### Valve Characteristics

If you look at the data for any amplifying valve, apart from the heater rating, the pin out and maximum ratings for anode voltage and current, you'll see three parameters,  $\mu$ ,  $g_m$  and  $r_a$ . What are these parameters, what do they mean and how are they derived?

Let's take an example, the ECC82 (12AU7) double triode with a centre tapped heater allowing it to be used on either a 12.6V (150mA) or 6.3V (300mA) heater supply. This was a very commonly used valve in TVs of the 1950s and 60s.

The Mullard quick reference data book and the Mazda data book show the following data on the ECC82. The data sheet shows full details of the valve including plots of the characteristics.

Mullard Databook (1968)			
Double Triode (separate cathodes)			
	Series	Parallel	
Vh	12.6	6.3	V
Ih	150	300	mA
Characteristics (each section)			
Va	100	250	V
Vg	0	-8.5	V
Ia	11.8	10.5	mA
gm	3.1	2.2	mA/V
$\mu$	19.5	17	

Mazda Data Booklet (1972)		
AF Double Triode Audio Amplifier 6.3V, 0.3A or 12.6V, 0.15A heater		
Rating (each section)		
Pa (max)	2.25	W
Characteristics (each section)		
Va	250	V
Vg	-8.5	V
Ia	10.5	mA
gm	2.2	mA/V
$\mu$	17	
ra	7.7	k $\Omega$

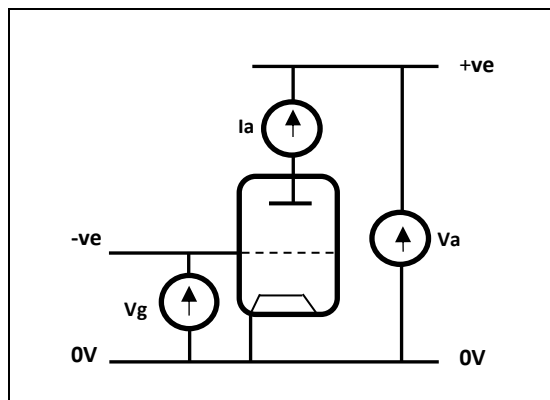


Figure 1 - Test circuit for measuring triode characteristics

If we measure the characteristics, using the test circuit shown in figure 1, we will find that the anode current ( $I_a$ ) is a function of both the control grid voltage ( $V_g$ ) and the anode voltage ( $V_a$ ).

Plotting the anode current against the anode voltage at different grid voltages we get the set of plots shown in figure 2 and plotting the anode current against control grid voltage at different anode voltages we get the set of plots shown in figure 3.

Both these plots were taken from actual measurements on one half of an ECC82.

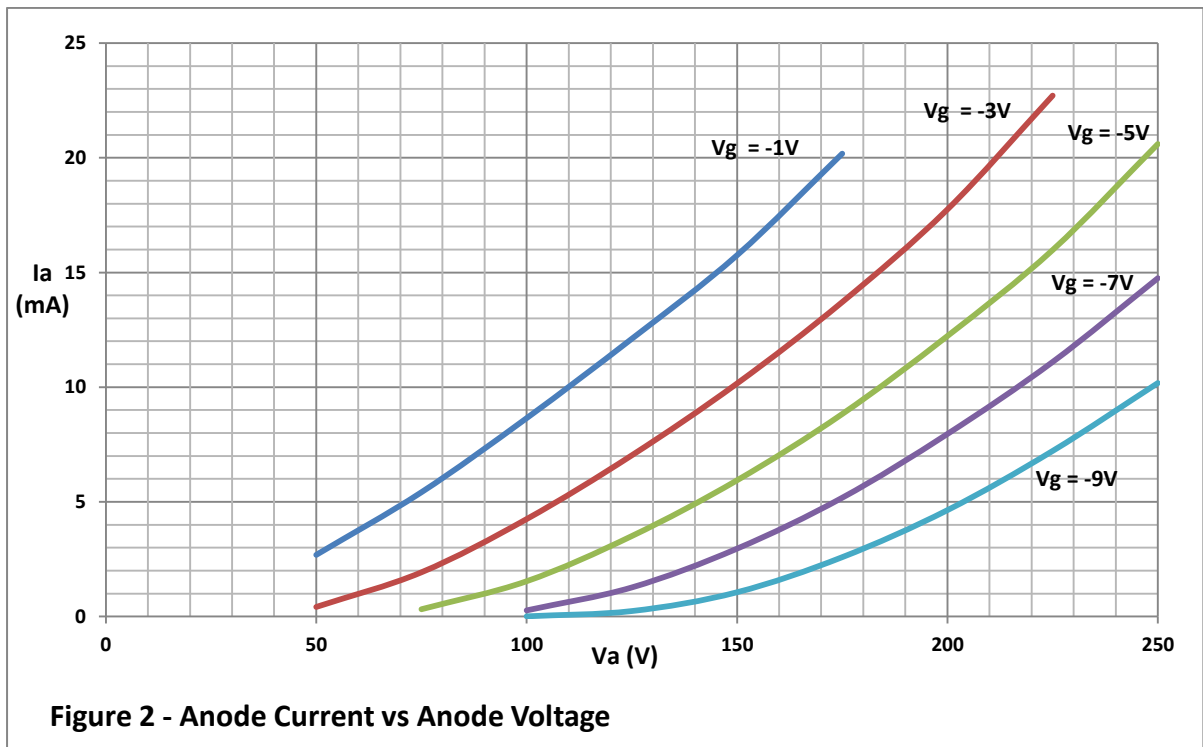
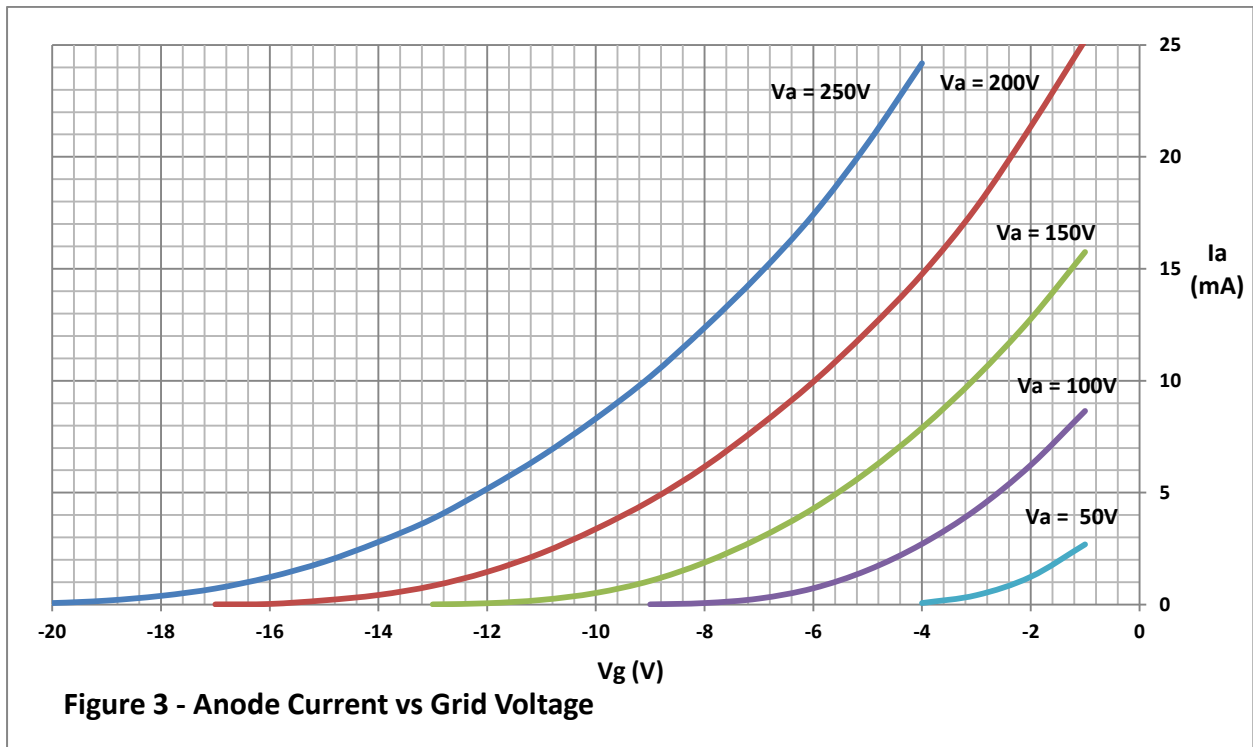


Figure 2 - Anode Current vs Anode Voltage



The first thing to note is that the characteristics are not linear meaning that the test conditions, Anode voltage and Control Grid voltage, must be specified whenever  $\mu$ ,  $r_a$  and  $g_m$  are quoted.

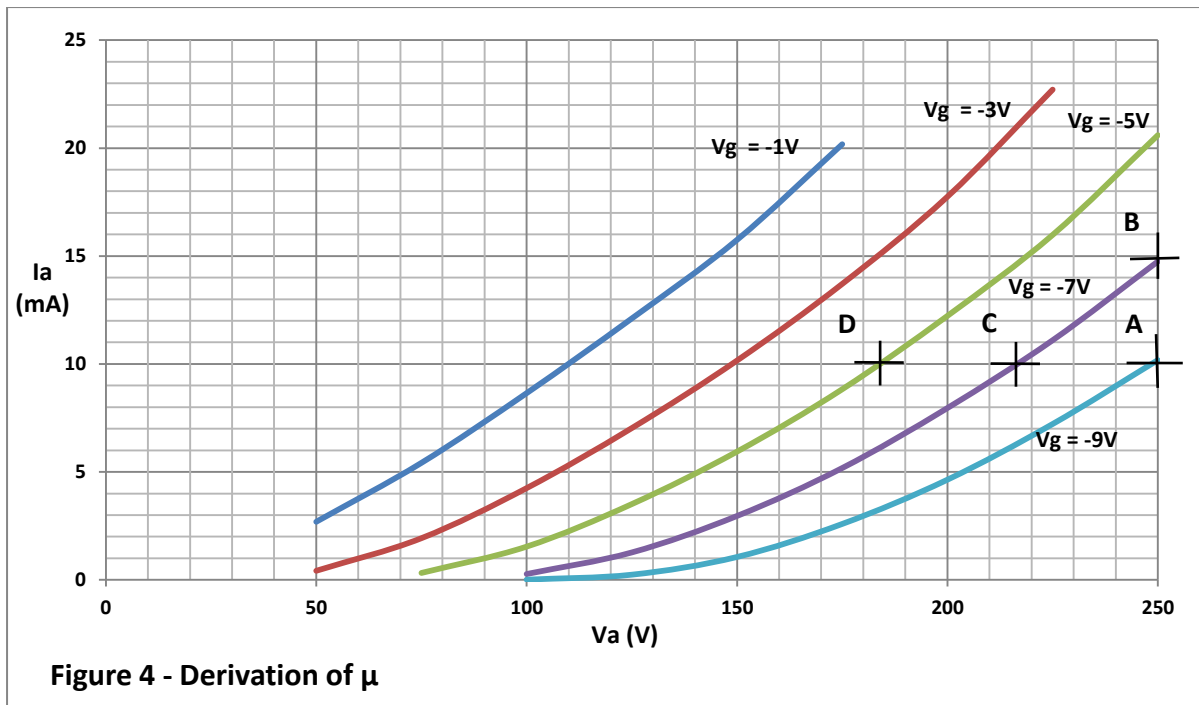
Let's take each of these parameters  $\mu$ ,  $r_a$  and  $g_m$  in turn and see how they are derived and how they are related to each other.

### Amplification Factor - $\mu$

Consider point A on the  $V_a/I_a$  plot in figure 4. The anode current is 10.2mA at an anode voltage of 250V and grid voltage of -9V. If we now change the grid voltage by 2V to -7V the anode current will increase to 14.8mA, point B. To get the anode current back to 10.2mA we have to decrease the anode voltage to 215V, point C.

Therefore, for the same anode current, the anode voltage has to change by 35V for a change in grid voltage of 2V. The ratio of these two voltages is the Amplification Factor  $\mu$ .

$$\mu = \frac{\text{Change in } V_a (\Delta V_a)}{\text{Change in } V_g (\Delta V_g)}$$



In this case  $\mu$  is  $35\text{V}/2\text{V}$  or **17.5**.

If we repeat this, changing the grid voltage from  $-7\text{V}$  to  $-5\text{V}$ , point C to D, we find  $\mu$  is  $15.5$  ( $31\text{V}/2\text{V}$ ), showing it is important to specify the test conditions when quoting  $\mu$ .

### Anode Resistance - $r_a$

As we have seen, if the anode voltage changes, keeping the grid voltage fixed, the anode current will change. This is equivalent to a resistance. In this case from point B to C the current changes by  $4.6\text{mA}$  for a change in anode voltage of  $35\text{V}$ .

The equivalent resistance is defined as the Anode Resistance  $r_a$

$$r_a = \frac{\text{Change in } V_a (\Delta V_a)}{\text{Change in } I_a (\Delta I_a)}$$

In this case it is  $35\text{V}/4.6\text{mA}$  or  **$7.6\text{k}\Omega$** .

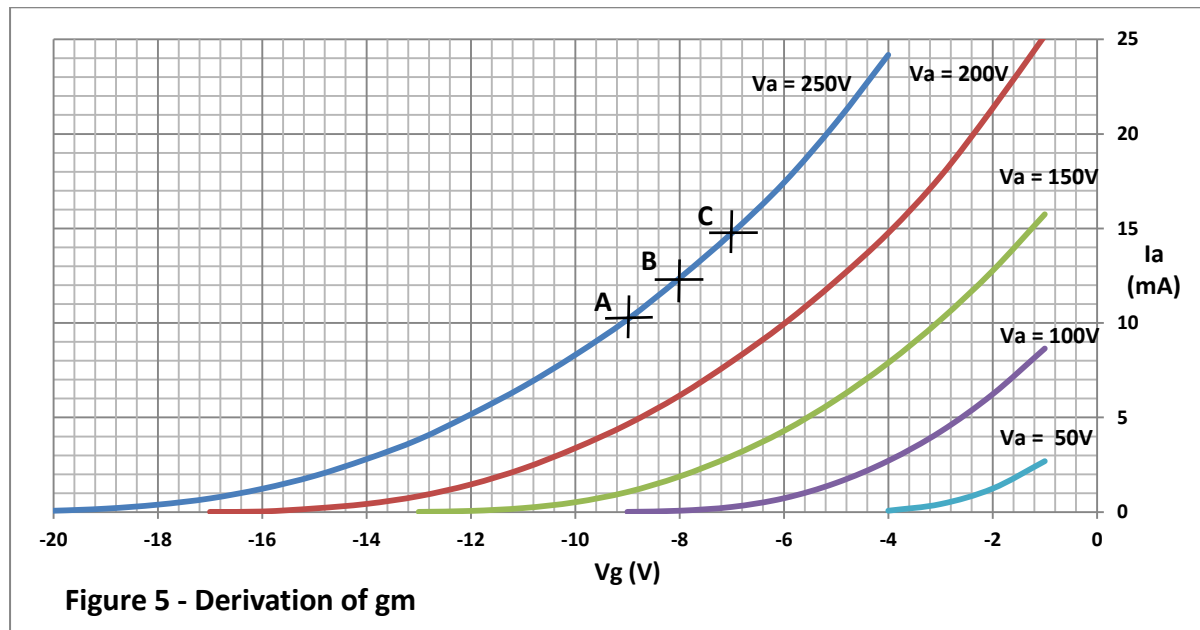
### Mutual Conductance - $g_m$

The third parameter is Mutual Conductance or  $g_m$ . This is the change in anode current for a  $1\text{V}$  change in grid voltage.

$$g_m = \frac{\text{Change in } I_a (\Delta I_a)}{\text{Change in } V_g (\Delta V_g)}$$

Looking at the  $V_g/I_a$  plot in figure 5, points A and B on the 250V  $V_a$  line represent grid voltages of -9V and -8V respectively. The corresponding anode currents are 10.2mA and 12.4mA. Therefore a change of 1V in the grid voltage results in a change of 2.2mA in the anode current giving a **gm** of **2.2mA/V**.

As with  $\mu$  the value of **gm** depends on the grid voltage and anode voltage. If we measure the **gm** from point B and C, representing a 1V change in grid voltage but a 2.4mA change in anode current, the **gm** is 2.4mA/V. As the grid voltage increases the **gm** will fall. On the 250V  $V_a$  line it drops to 1.3mA/V when  $V_g$  is -12V.



So the three parameters for this valve, at an anode voltage of 250V and grid voltage of -9V, are:-

$$\mu = 17.5 \text{ (17)}$$

$$r_a = 7.6k\Omega \text{ (7.7k}\Omega\text{)}$$

$$g_m = 2.2mA/V \text{ (2.2mA/V)}$$

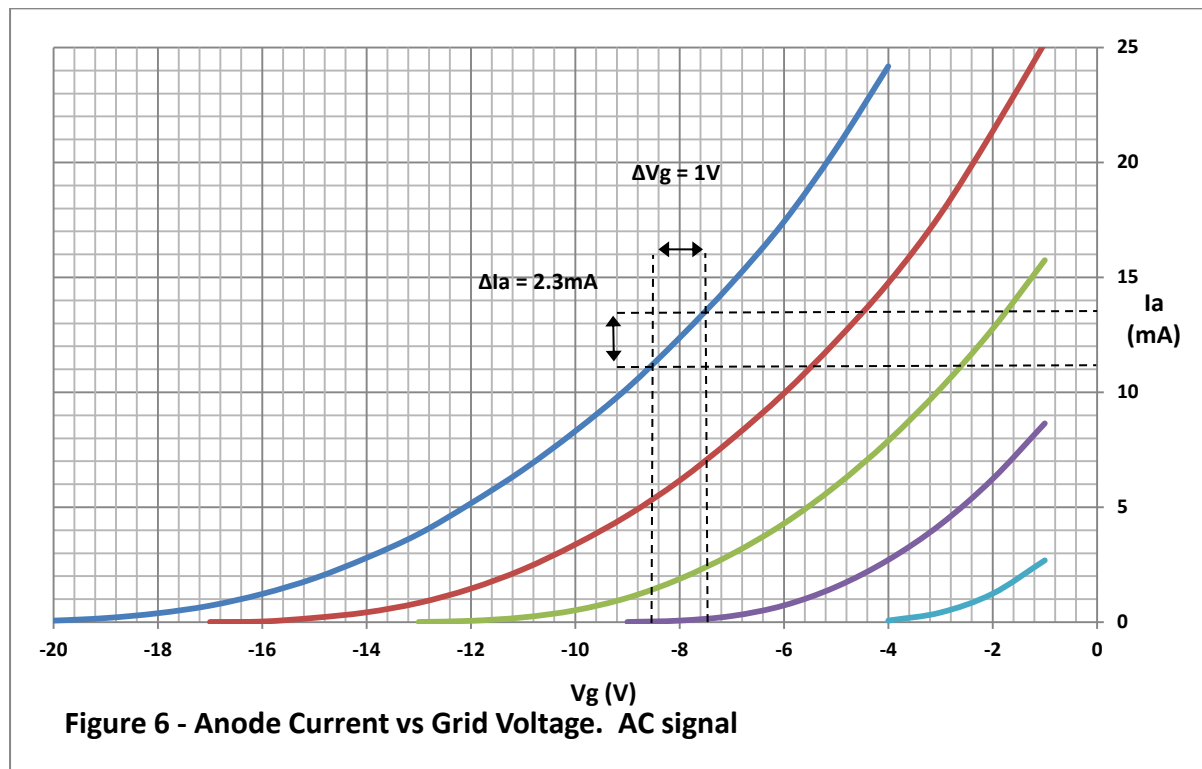
Which agree quite well with the equivalent parameters from the datasheet shown in brackets. This also indicates that the valve used for these tests is a good one.

Because the parameters are derived from the same three variables, Anode voltage, Anode current and Control Grid voltage, they are related

$$\mu = r_a \times g_m$$

Note the parameters change depending on the point of the plots they are measured as can be seen from the Mullard datasheet. Thus it is important to quote the test conditions when quoting any of these parameters.

That's covered the basic DC side of valve operation now for the basic AC side. If we couple a 1V peak to peak AC signal to the grid with a dc bias set to -8V, the anode current will vary between 11.2mA and 13.5mA (2.3mA peak to peak), figure 6.



Now for this to be useful as an amplifier this current has to be converted to a voltage by connecting a load resistor between the anode and the HT supply. You may think that the higher the value of the anode resistor the greater the alternating voltage across it and hence the higher the gain. However, as the anode current increases the voltage across the anode load resistor will increase and the anode voltage will drop and, as we have seen earlier, this voltage drop will cause the anode current to fall affecting the anode voltage. Thus calculating the voltage gain is not as straightforward as you would expect.

The detailed analysis to calculate the gain is beyond this simplified theory and to spare you the agony, the formula for the gain of this simple valve amplifier is

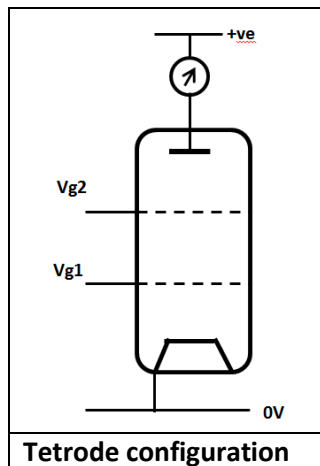
$$\text{Gain} = - \frac{\mu \times R}{R + r_a}$$

Where **R** is the anode load resistor and  $\mu$  and  $r_a$  are the Amplification Factor and Anode Resistance respectively for the valve.

The negative sign indicates the output is inverted with respect to the input voltage and the formula also indicates that the gain cannot exceed the amplification factor.

### Additional Grids

Useful as it is, the triode has limitations. In particular the anode to grid capacitance causes problems with feedback from the anode circuit to the grid circuit especially when used as an RF amplifier. This



capacitance causes feedback from the anode to the grid and can cause oscillation. To overcome this problem an additional grid, the screen grid (G2), is fitted between the grid and the anode. This grid, as its name implies screens the grid from the anode. The resulting valve is the tetrode.

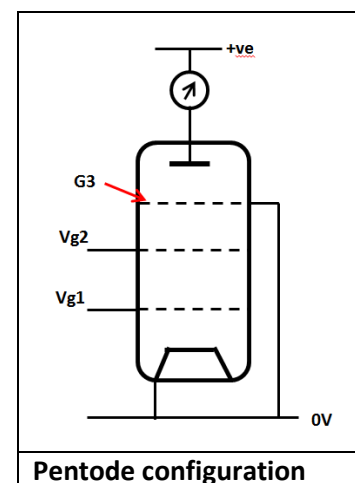
Adding this grid has the effect of increasing the amplification factor  $\mu$ , as the anode current is less dependent on the anode voltage, as well as reducing the capacitive coupling between the control grid and anode. The screen grid is normally operated at a voltage less than the mean anode voltage but if the anode voltage does drop below the screen grid voltage a flow of secondary electrons from the anode to the screen grid will cause the anode current to drop and the screen grid current to increase. This can cause increased distortion and a reduction in output

power in amplifiers.

To stop this secondary electron flow another grid, the suppressor grid (G3), is placed between the screen grid and the anode. This grid is connected to either ground or the cathode and allows larger anode voltage swings without distortion. This valve then becomes a pentode.

Philips held the patents for the addition of the third grid to form the pentode so other valve manufacturers looked for alternative methods to overcome the secondary emission. Instead of the suppressor grid plates, connected to the cathode, were added to focus the electron beam on to the anode to form the beam tetrode, sometimes known as a "kinkless tetrode".

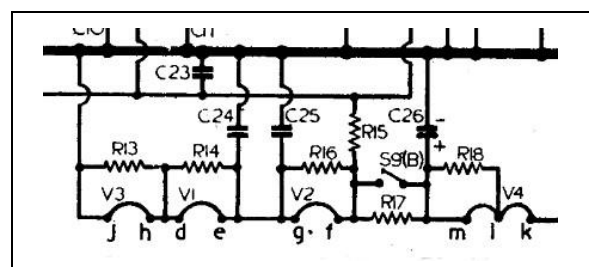
Advantages of the beam tetrode are a lower screen grid current, less third harmonic distortion and more output power than a similar pentode. Disadvantages are higher intermodulation distortion and requiring a higher input signal at the control grid for a given output power.



## Directly and Indirectly Heated Valves

In a directly heated valve the filament serves as both the source of electrons, the equivalent of the cathode, and the heater. This limits the circuit configurations as the filament generally has to have one side connected to ground. The main use of these directly heated valves was in battery radios where all the filaments are in parallel. It is possible to connect the filaments in series, as in valve mains battery radios, but resistors have to be fitted across the filaments to equalise the currents through the filaments as the anode and screen grid currents also have to pass through the filament. The biasing requirements also dictate the order of the valves in the series filament chain with the detector/ audio pre-amp valve (Generally a DAF91 or DAF96) having one side of its filament connected to ground and the audio output valve being first in the chain as it requires the highest bias voltage.

The diagram on the right shows the filament chain with the equalising resistors for a Vidor CN430 where V1 is a DK96 (frequency changer), V2 is a DF96 (IF amplifier), V3 is a DAF96 (detector and audio pre amp) and V4 is a DL96 (audio output).





## Demo Unit Pictures

The following pictures were taken using the demo unit. This can be configured to display either the anode current vs the anode voltage or the anode current vs the grid voltage. As the demo unit is fairly simple the flyback trace is not suppressed meaning there is a double trace on some of the pictures.

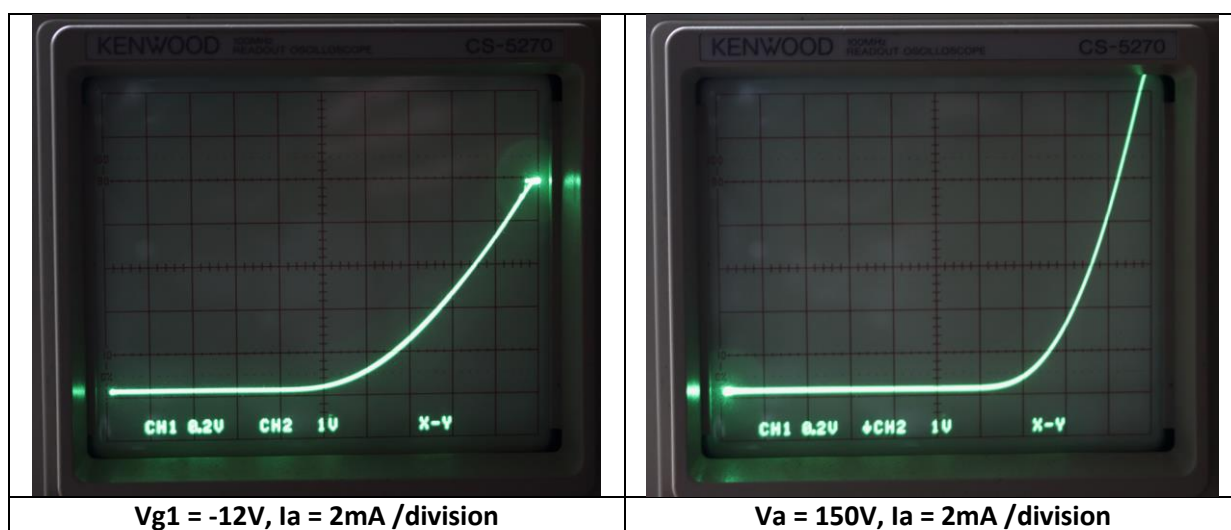
The anode current is sensed using a low value resistor equivalent to  $100\Omega$  giving an output voltage of 10mA per volt. Thus the vertical scale in the plots at 0.2V per division is equivalent to 2mA per division.

In the Anode current vs Anode voltage picture (left) the horizontal scale is approximately 30V per division and in the Anode current vs Grid voltage picture (right) the horizontal scale is approximately 2V per division.

All other voltage setting are as detailed in the individual pictures.

## Triode Characteristics

These pictures were taken using half an ECC82 and are similar to figures 2 and 3.

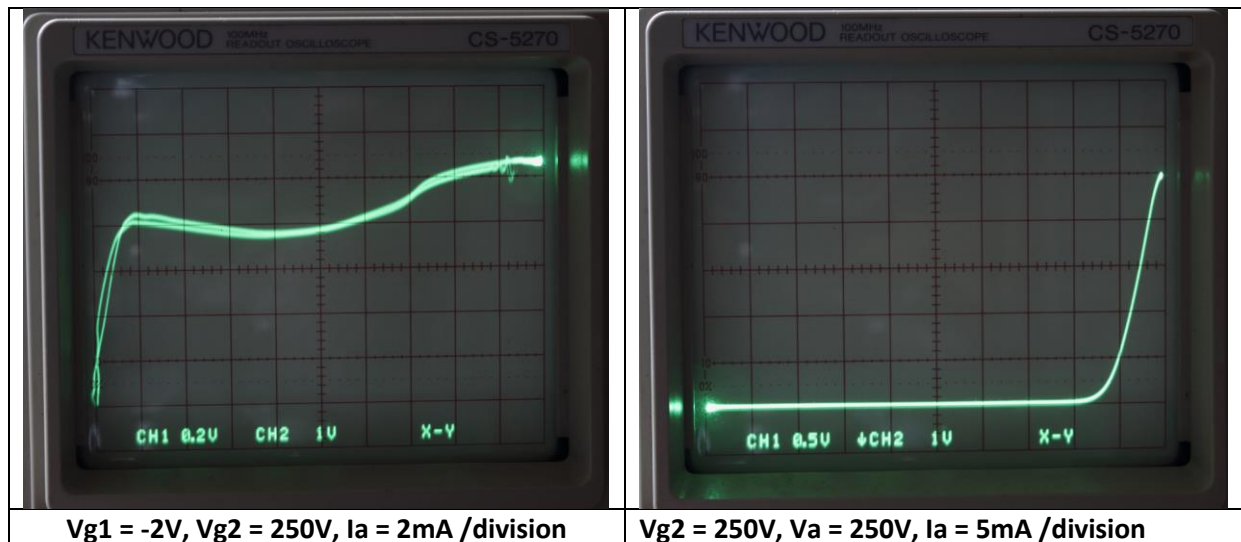


## Tetrode Characteristics

These pictures were taken using an EF91 configured as a Tetrode with G3 connected to the anode.

The grid voltage was adjusted to give an anode current of 10mA at an anode voltage of approximately 250V.

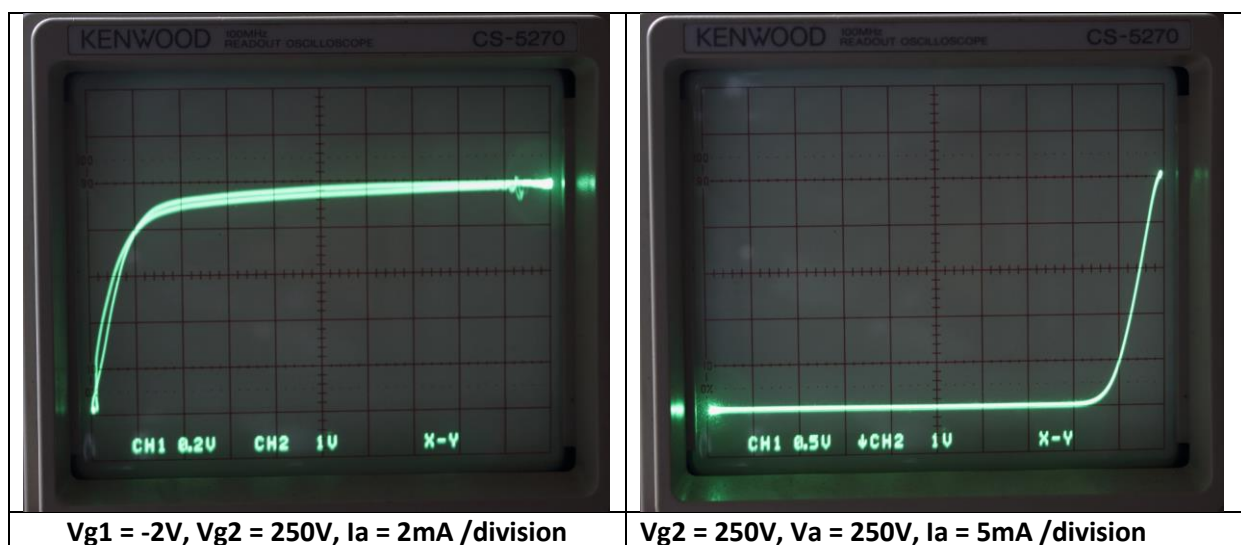
Note the “kink” in the **Ia** vs **Va** characteristic due to the secondary emission from the anode to screen grid when the anode voltage is less than the anode voltage. Note how the anode current rises from the “kink” minimum as the anode voltage approaches the screen grid voltage.



## Pentode Characteristics

These pictures were taken using an EF91 configured as a Pentode with the suppressor grid (G3) connected to the cathode.

As with the tetrode configuration the grid voltage was adjusted to give an anode current of 10mA at an anode voltage of approximately 250V.



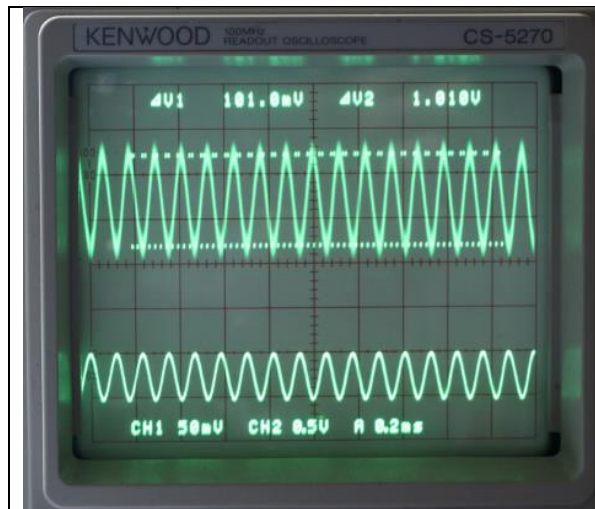
The addition of the suppressor grid removes the “kink” seen in the tetrode configuration.

Note the difference in the Anode current vs Anode voltage plots between the pentode/tetrode and the triode. The anode current in the pentode/tetrode is much less dependant on the anode voltage than the triode but the anode current vs grid voltage plots are very similar.

## Gm

For the Gm measurements a 1kHz sine wave with an amplitude of 500mV peak to peak is imposed on the grid bias voltage.

The grid bias voltage in all cases is adjusted to give an anode current of 10mA.



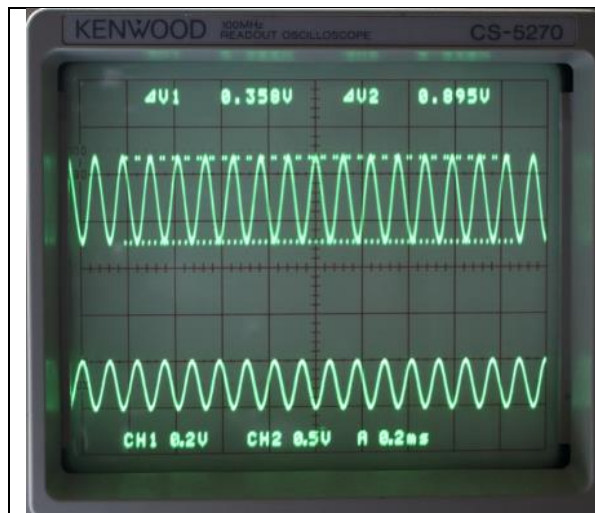
### Triode ( $\frac{1}{2}$ ECC82)

$V_a = 250V$   $I_a(dc) = 10mA$

Upper trace (CH1) -  $I_a(ac) = 1.01mA$  pk-pk

Lower trace (CH2) -  $V_{in} = 500mV$  pk-pk

$G_m = 2.02mA/V$



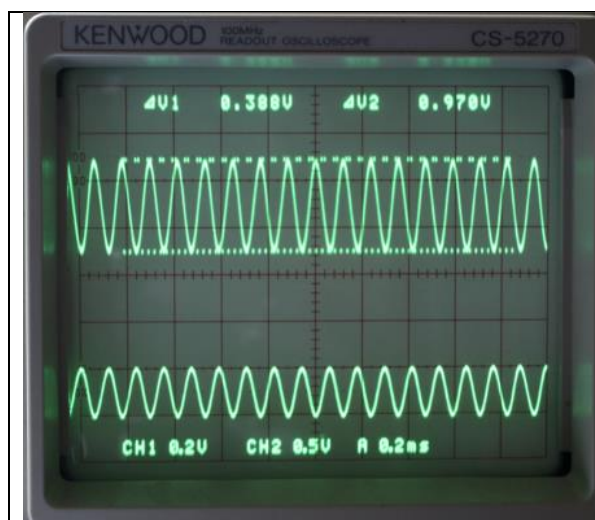
### Tetrode (EF91 G3 connected to anode)

$V_a = 250V$ ,  $V_{g2} = 250V$ ,  $I_a(dc) = 10mA$

Upper trace (CH1) -  $I_a(ac) = 3.58mA$  pk-pk

Lower trace (CH2) -  $V_{in} = 500mV$  pk-pk

$G_m = 7.16mA/V$



### Pentode (EF91 G3 connected to cathode)

$V_a = 250V$ ,  $V_{g2} = 250V$ ,  $I_a(dc) = 10mA$

Upper trace (CH1) -  $I_a(ac) = 3.86mA$  pk-pk

Lower trace (CH2) -  $V_{in} = 500mV$  pk-pk

$G_m = 7.76mA/V$

The  $g_m$  for an EF91 pentode with  $V_{g1} = -2V$ ,  $V_{g2} = V_a = 250V$  is given as  $7.65mA/V$  so the value obtained above agrees very well with the published value.

Looking at the characteristic plots shown earlier you can see that they are not linear and the parameters,  $g_m$  and  $\mu$ , will vary depending on the anode and grid dc voltages. The result is that the gain will vary with the grid dc bias. This characteristic can be exploited to control the gain in RF and IF amplifiers. Although all valves exhibit this variable gain but some valves are designed specifically to have a more controllable gain. These are vari- $\mu$  types where the control grid (G1) is wound with a variable spacing. This makes the gain more controllable with less distortion of the signal.

That covers the basic valve theory. For more detailed information on valves and the derivation of the gain formula see one of the many text books such as Foundations of Wireless by M.G.Scroggie or earlier editions of the RSGB Radio Communication Handbook.

## **Valve Numbering Systems**

Over the years many numbering systems have been developed. These will usually give some indication of the heater rating and the valve function.

Probably the most well known system, certainly in Europe, is the Pro-Electron system. This is based on a series of letters and numbers.

The first letter is the heater voltage or current.

The remainder of the letters detail the valve function or functions in the case of multiple valves

The first number details the base

The remaining numbers are serial numbers although in the case of RF pentodes an odd final number is generally a vari- $\mu$  type and an even number a normal type.

e.g. EABC80.

The first letter is the heater rating. In this case it is a 6.3v heater.

The second and subsequent letters identify the type of devices in the valve. More than one letter can be used in the case of multiple valves contained within the same envelope. In this case A is a single diode, B is a dual diode with a common cathode and C is a triode.

The first number identifies the base type. In this case it is a B9A base.

So this valve is a triple diode triode. Its intended function is as an AM/FM demodulator and audio pre-amp valve in an AM/FM radio.

More information on valve numbering is given in the following link

[http://www.vintage-radio.com/repair-restore-information/valve\\_valve-numbering.html](http://www.vintage-radio.com/repair-restore-information/valve_valve-numbering.html)

## **Testing Valves**

So what tests are needed to check a valve is working correctly and how do we achieve these tests?  
In order they are

- Heater Continuity
- Heater Cathode Leakage
- Inter Electrode Shorts
- Static Test
- Gas (Grid Current) Test
- Gm Test

### **Heater Continuity**

Here we are trying to establish that the heater is not open circuit. There is no point in conducting any further tests if the heater is not working. This is a simple continuity test but bear in mind that the resistance of the heater when cold can be up to a few hundred ohms therefore the test must be able to cope with this range of values.

This test is conducted with the heater unpowered. All other tests are conducted with the heater powered.

### **Heater Cathode Leakage**

Heater cathode leakage can be a source of hum being induced into the cathode therefore this test checks the insulation resistance between the heater and the cathode. Most valves will have a limit for the voltage between the heater and cathode. Exceed this and the insulation on the heater is at risk of breaking down. Valves intended for operation in series heater chains usually have a higher maximum voltage. The efficiency diode in a TV has a particularly high limit which is why it is the last valve to get to working temperature in a TV.

The heater of most valve rectifiers are normally fed from a separate heater winding on the mains transformer however some rectifiers, such as the EZ81, have a high heater cathode breakdown voltage which enables the heater to be powered from the same transformer winding as the other valves in the equipment.

The test is conducted with the heater powered and applies a high voltage between the heater and cathode while monitoring the current.

Note that this test is not applicable to a directly heated valve as the filament is the cathode.

### **Inter Electrode Shorts**

Before applying any test voltages to the valve under test a check is made for any inter electrode shorts, primarily any grid to grid or grid to cathode shorts. Shorts such as these can damage the equipment the valve is used in or the valve tester so it is important to check before proceeding with the test.

Once the initial tests are satisfactory it's time to apply voltages to the anode and grid and measure the anode current.

### **Static Test**

This test measures the anode current under specific dc test conditions. These test conditions, Heater voltage, Anode voltage, Control Grid voltage and Screen Grid voltage (for Tetrodes and Pentodes) are usually detailed in the valve tester manual. With these voltages set the anode current is measured and compared to the specified value. If the measured current differs significantly from this value the valve is probably faulty but there is a fairly wide tolerance on the value so if the measured value is within 50% of the specified value the valve is probably OK.

The anode current achieved in this test is also a measure of the cathode emission.

### **Gas (Grid Current) Test**

This test checks for any grid current by inserting an ammeter in series with the control grid voltage. Under normal conditions there should be no current but certain valves, such as the UL41 and other output valves, are known to have problems with grid current.

### **Gm Test**

There are two methods for measuring the Gm, one is to apply a known AC voltage to the grid and measure the resulting AC anode current. The other is to change the grid voltage by 1V and measure the change in anode current.

The Sussex tester, mentioned earlier, uses the AC method. The units for Gm are mA per volt so a sine wave is applied to the control grid. This will produce an AC anode current which is proportional to the gm of the valve.

In the AC method above the anode current sensing resistor is 100Ω. Therefore the AC voltage across this resistor will be  **$V_g \times g_m \times 100 \text{ mV}$** .

Re-arranging gives

$$G_m = \frac{V_{a(AC)}}{V_{g(AC)} \times 100}$$

Where  **$V_a$**  is in mV and  **$V_g$**  is in V (**note that this formula is only applicable to the demo unit**).

In the case of the ECC82 above  $V_a = 101\text{mV}$  and  $V_g = 0.5\text{V}$  giving the gm as 2.02

It doesn't matter whether you measure the RMS or peak to peak value provided the grid voltage and the resulting voltage across the anode load resistor are both measured as RMS or peak to peak values.

For the DC method the anode current at the specified grid voltage is measured. The grid voltage is changed by 1V and the new anode current is measured. The difference is the gm value.

If the results of the static and GM tests are close to the values in the appropriate manual then the valve is almost certainly good.

As an aside running a valve with its heater powered but no HT applied can cause the cathode to lose emission (so called cathode poisoning). This is a very common problem in AM/FM radios which have been primarily used on AM. In these sets the HT to the VHF front end is usually disconnected on AM starving the valve, usually an ECC85 or UCC85, of HT current. This can cause the set to fail when switched to VHF. One solution is to feed the VHF front end via a high value resistor, usually 100K, when the set is switched to AM. This allows some cathode current to flow, reducing the risk of the valve losing its emission. On VHF this resistor is shorted out.

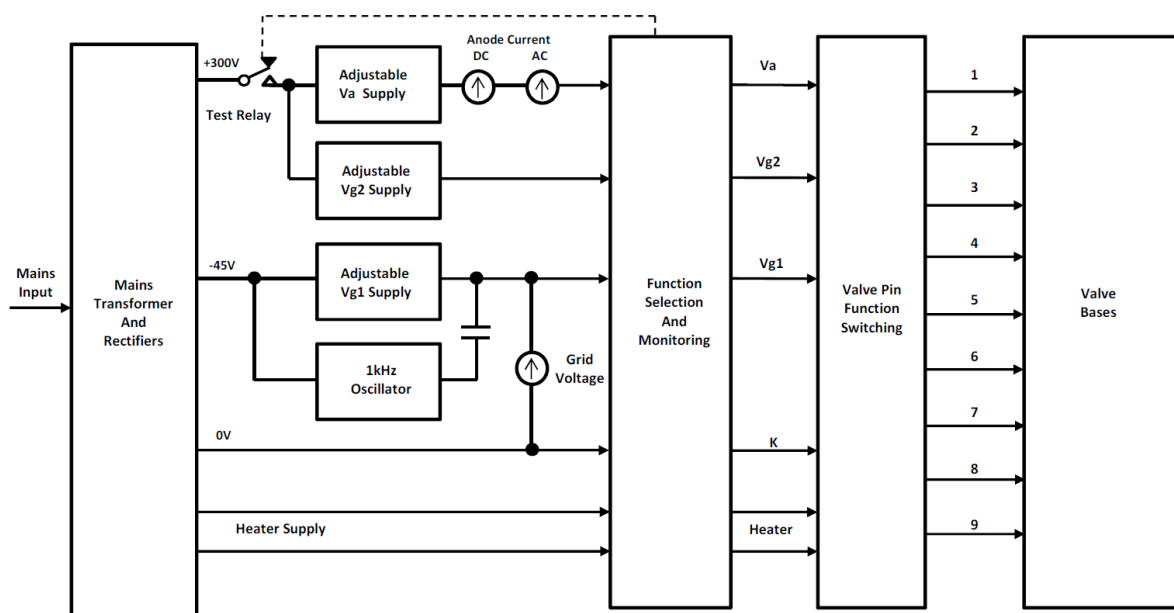
# Valve Testers

While it is possible to test a single valve by connecting appropriate power supplies and meters to the valve under test for more general use a purpose built valve tester is more useful.

## What is a Valve Tester?

The following is applicable specifically to the Sussex Valve Tester but the principles apply to most valve testers.

A typical valve tester comprises several sections as shown in the extract from the Sussex Valve Tester manual below.



**Figure 7 - SUSSEX VALVE TESTER BLOCK DIAGRAM**

The sections are

**1) A set of variable power supplies to provide.**

The Heater voltage

The Anode voltage

The Screen Grid voltage

The Control Grid voltage

**2) An AC signal to the control grid for the gm test.**

**3) Voltage and Current measurements.**

**4) Switching to select the test function.**



- 5) A set of switches to direct the power supplies and measurement connections to the appropriate pins on the valve under test.
- 6) A set of valve holders for the valve under test.

## **Power Supplies**

### **Heater Supply**

To be usable as a tester for a wide variety of valves the heater supply must be capable of supplying both AC and DC over a wide range. Typical voltages range from 1.4V (DC), for the battery valves, to 45V (AC) for a UL84. Many testers allow adjustment in 1V steps. The supply must also be rated to supply the necessary current which can be several amps in the case of some output valves.

### **Anode and Screen Grid Supplies.**

As with the heater supply these supplies must be capable of supplying a wide range of voltages up to typically 300V. Currents can range from a few milliamps to 100mA.

### **Control Grid Supply**

This has to supply a negative voltage at very low current with a typical range of up to -30V.

## **AC Source**

As the Sussex uses an AC signal to determine the gm, the output of a 1kHz sine wave oscillator is superimposed onto the dc grid bias voltage. The resulting anode current has an AC content, also a sine wave. Measuring this allows the gm to be calculated. The oscillator in the Sussex has an amplitude of 100mV and to obtain the gm the measured AC anode current has to be multiplied by 10 to obtain the correct value.

## **Voltage and Current Monitoring**

Meters are provided to monitor the control grid voltage and the anode current, both DC and AC. Not all valve testers monitor these parameters, usually just the anode current is monitored.

## **Test Function Switching**

This section directs the power supply outputs and the monitoring dependant on the function selected. There are six outputs from this section, two heater connections, the cathode connection, the control grid connection and connections to the screen grid and anode. To cope with valves with multiple sections additional switching is included to connect to the separate anodes of, for example, double triodes such as the ECC82 or double diodes such as the EB91.

## **Valve Pin Function Switching**

This section comprises a series of switches to connect each of the pins on a valve to the appropriate output from the Test Function Switching section, each pin having its own switch. Typically valves introduced up to the early 1960s had up to 9 pins. In addition to the pins some valves have a top cap for either the cathode, control grid or anode. Provision in the function switching is made to allow a top cap connection to be used instead of a connection to a pin on the valve base.

Care must be taken to ensure the correct switch settings are used to prevent damaging both the valve and the tester.

Switch settings are normally detailed in the user manual for the Valve tester. Note that the Sussex switch settings are compatible with those of the AVO CT160. This makes life easier as the user doesn't have to work out the settings for each individual valve as the CT160 manual settings run to 159 pages.

## **Valve Bases**

There are nine outputs from the pin function switching with each output assigned to a specific pin on the valve bases. Any number of valve bases can be fitted but all are wired in parallel with pin 1 on all bases connected together, pin 2 on all the bases connected together etc.

The wiring of the bases, of necessity, requires long leads. This can lead to instability problems with some high gain valves. The normal method to reduce this tendency to oscillate is to fit stopper resistors in the connection to the control grid and other electrodes. However this is not possible with a valve tester as the control grid is not always on the same pin and the pin could be used for the heater connection. The suggested alternative is to fit ferrite beads to each pin of each valve base.

Commercial testers usually have a large number bases but home built testers need only have bases for the valve types the constructor envisages testing. If necessary an adaptor can be made to plug into say the 9 pin B9A base to allow other bases to be used.

Note that in the early 1960s a 10 pin base, B10B, was introduced but only a limited number of valves such as the PFL200 and PCH200 used this base. To use this base an adapter is needed for most valve testers.

## **Burning in Valves**

Occasionally it is necessary to burn in valves before use. This may be for several reasons, for military use early failures can be weeded out and some audiophiles like to burn their output valves in before use. It should be noted that most valve testers are not rated for continuous operation at high test currents so are not suitable for burning in valves. Should you want to burn in a valve or set of valves a specific burn in rig rated for the currents used should be built or bought.