

The Vacuum Tube

A “Hollow State” Device



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What We'll Cover

- In the beginning (One element)
- Diode (Two elements)
- Triode (Three elements) and more
- Tubes today



Yesterday at the Radio Technology Unemployment Office

What's up guys?



www.huyzebladelin.com

We're still looking for a radio job



In The Beginning

“One Element”



22-Feb-18

1873: British Professor Frederick Guthrie showed a negatively-charged, red-hot, iron sphere would quickly discharge

A positively-charged sphere did not discharge as fast

In The Beginning

“One Element”



www.ieeeahn.org

1880: Edison received a patent for an electric lamp using
“... a carbon filament or strip coiled and connected to
platina contact wires ...”

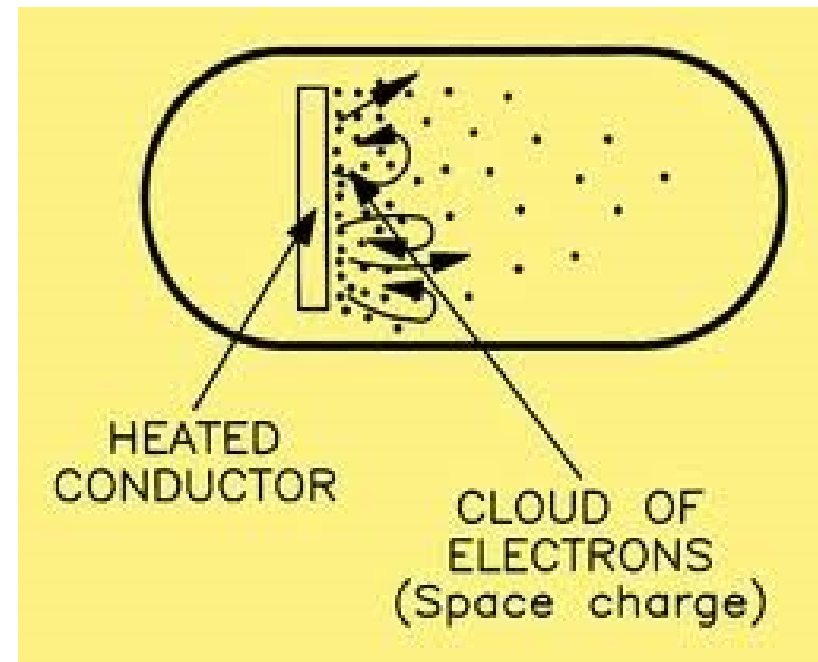
In The Beginning

“One Element”

A red hot cathode emits a cloud of electrons



www.ieeehn.org



www.r-type.org

The Diode

“Two Elements”

- **1883: The Edison Effect** - Edison thought his bulbs became dark from carbon atoms from the filament hitting the glass
- Tried a second, positively-charged element in the bulb to attract the negative atoms away from hitting the glass
- A positive charge relative to the filament caused current flow in the circuit. When reversed, no current flowed



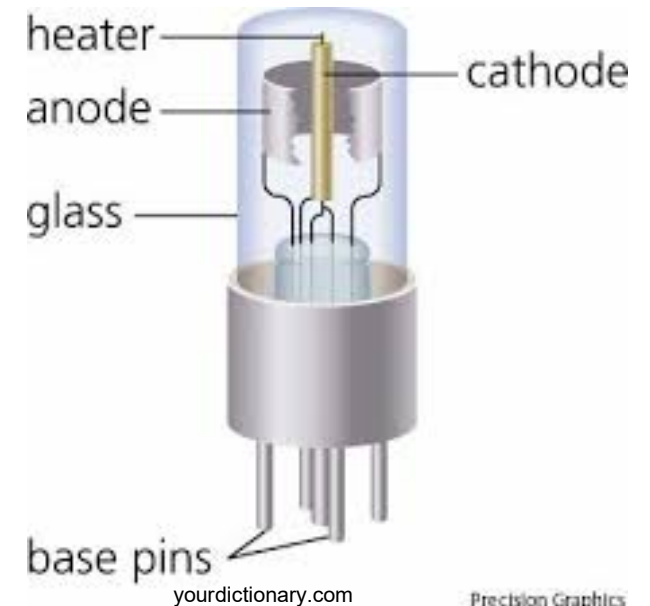
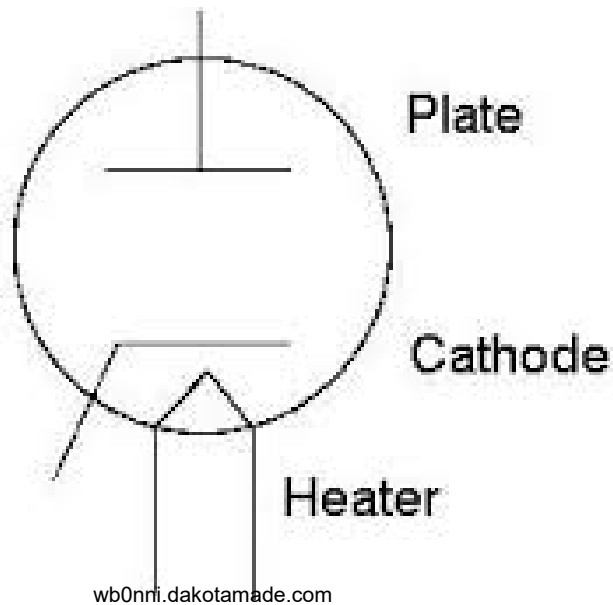
The Diode

“Two Elements”

1904: The Fleming Valve – John Fleming, using some Edison bulbs, observed that if he applied alternating current (AC) to the bulb, only one half of the cycle passed. It was rectifying the AC to produce a pulsed direct current (DC)



Science Museum/Science & Society Picture Library

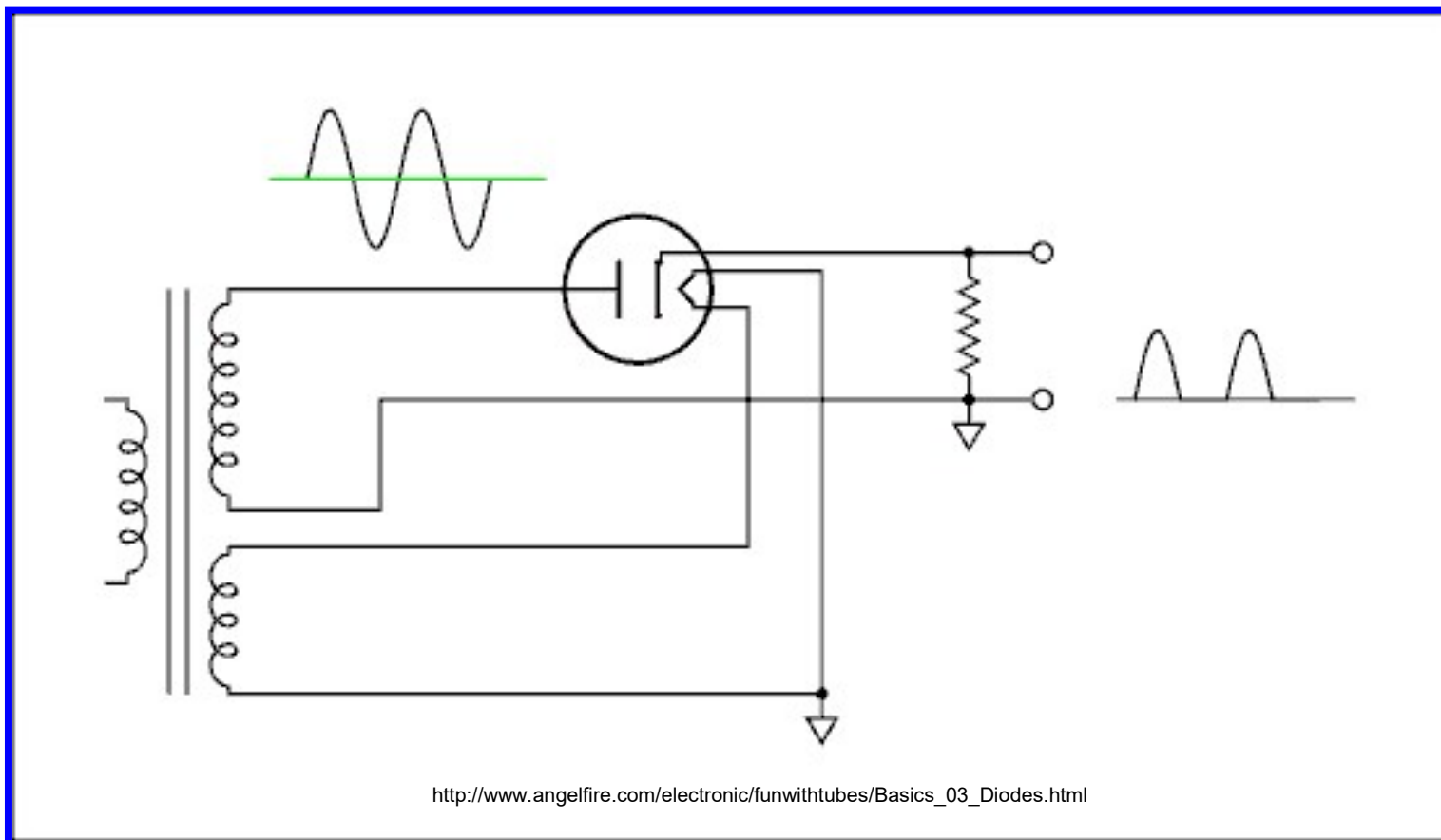


Precision Graphics

The Diode

“Two Elements”

Plate current only flows when plate is positive relative to the cathode



The Triode

“Three Elements”

1906: Robert von Lieben filed for a patent for a cathode ray tube. It could amplify audio signals for telephony (“von Lieben Valve”)

He went on to refine the triode vacuum tube



The Triode

“Three Elements”



1907: Lee De Forest filed for a patent for a three-electrode version of his Audion tube for use as an electronic amplifier in radio communications

The triode was born



<http://history-computer.com/ModernComputer/Basis/audion.html>

The Triode

“Three Elements”

Adding an electrode between the filament (cathode) and plate (anode), results in the ability to amplify signals

A negative voltage (relative to the cathode's voltage) applied to control grid (E_g) created a negative electrostatic field in near the cathode reduced the plate current (I_p).

A small change in E_g made a large change in I_p and led to a much larger voltage change at the load.

Voltage and power amplification is now available

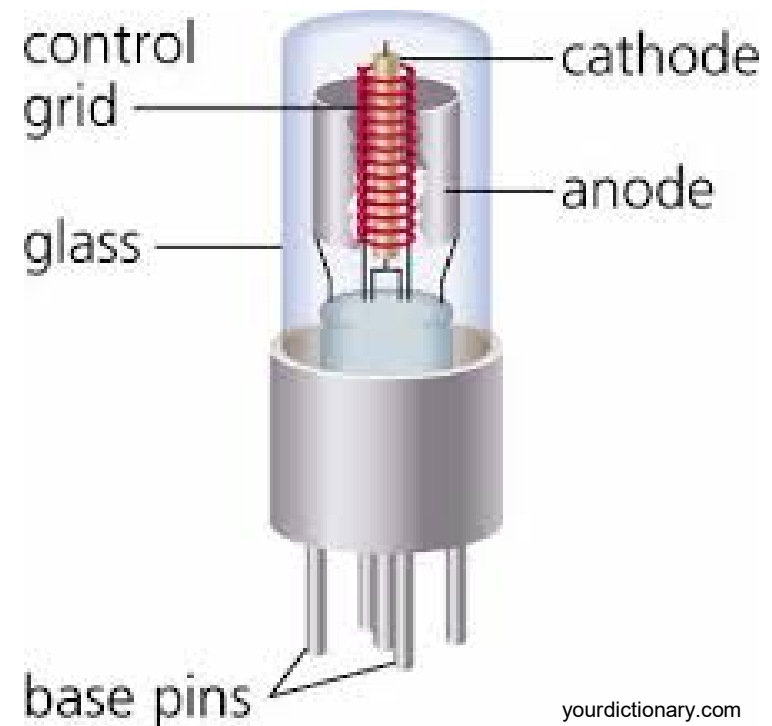


<http://history-computer.com/ModernComputer/Basis/audion.html>

The Triode Circuit

Triode: 3 elements (Cathode, **Control Grid**, Plate)

- Close to Cathode
- Like a water valve
- Try to avoid excessive I_g
- Control (bias) voltage (E_g) sets amplifier class (A, B, C)



yourdictionary.com
Precision Graphics

The DeForest "Audion" tube

http://www.ibiblio.org/kuphaldt/electricCircuits/Semi/SEMI_13.html

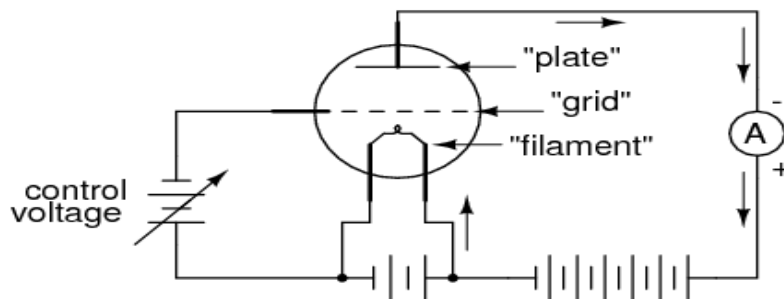
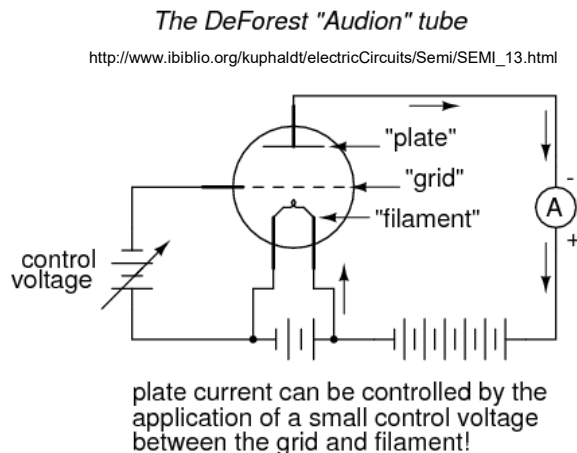


plate current can be controlled by the application of a small control voltage between the grid and filament!

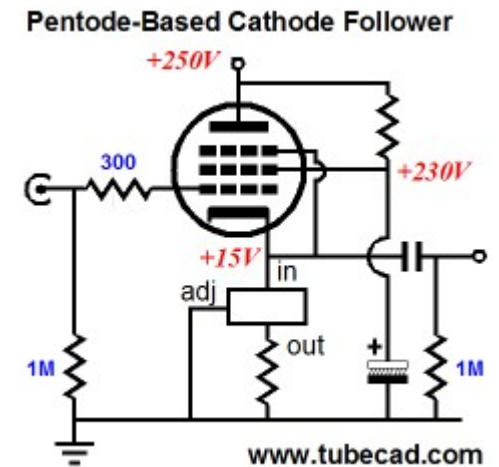
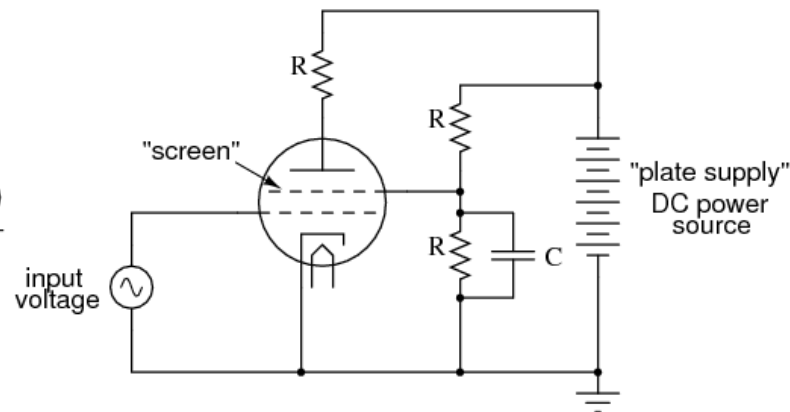
The Triode and more

“Three + Elements”

- **Triode:** 3 el (Cathode, **Control Grid**, Plate) *von Lieben '06 & DeForest '07*
- **Tetrode:** 4 el (Cathode, Control Grid, **Screen Grid**, Plate) *Schottky 1919*
- **Pentode:** 5 el (Cathode, Control Grid, Screen Grid, **Suppressor Grid**, Plate) *Holst & Tellegen 1926*



Tetrode amplifier circuit



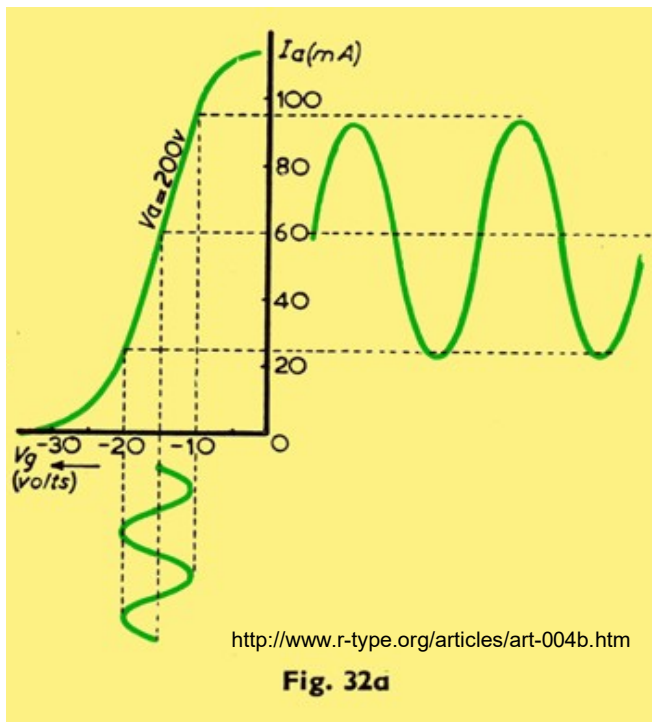
Amplifiers Have Class



Tube Amplifier - Class A

- **Class A**

- I_p flows the entire input cycle
- Inefficient, but low distortion



The DeForest "Audion" tube

http://www.ibiblio.org/kuphaldt/electricCircuits/Semi/SEMI_13.html

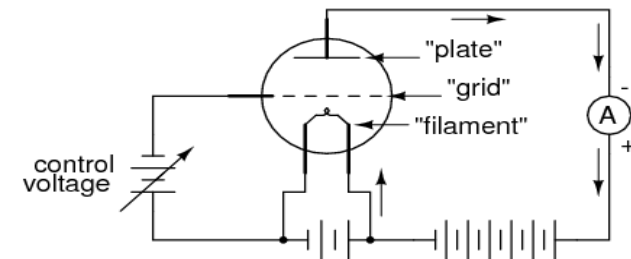
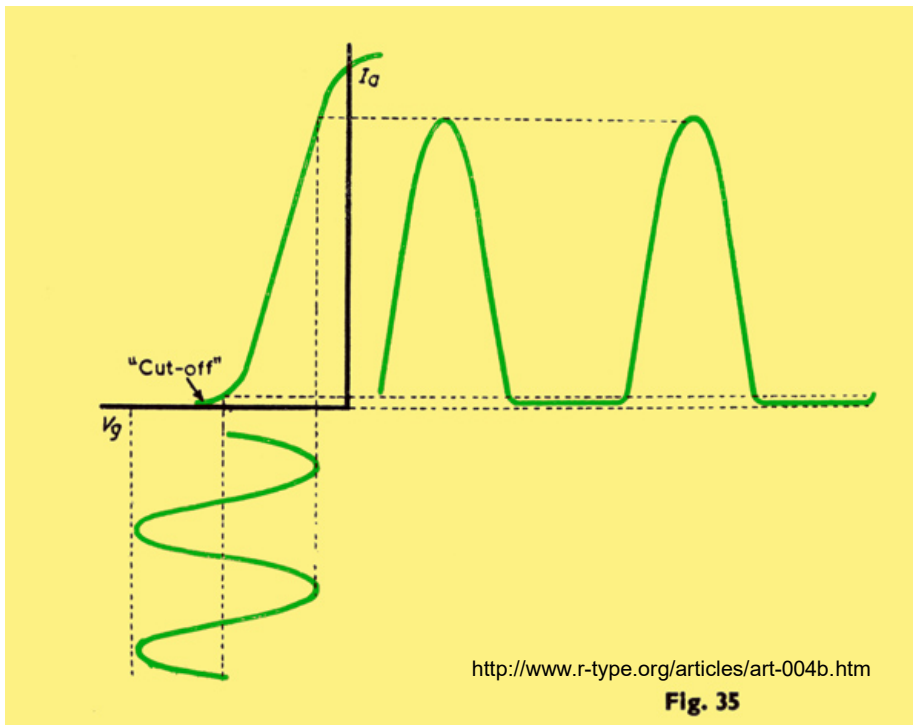


plate current can be controlled by the application of a small control voltage between the grid and filament!

Tube Amplifier Class - B

- **Class B**

- I_p flows for half the input cycle
- Biased at cutoff
- Usually implemented in push-pull circuit



The DeForest "Audion" tube

http://www.ibiblio.org/kuphaldt/electricCircuits/Semi/SEMI_13.html

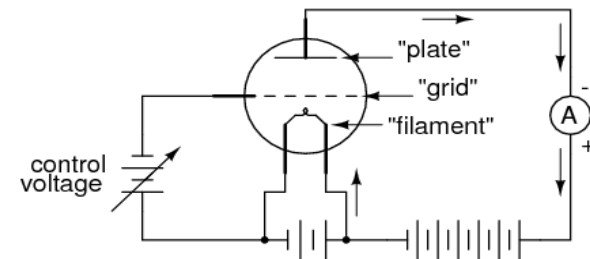
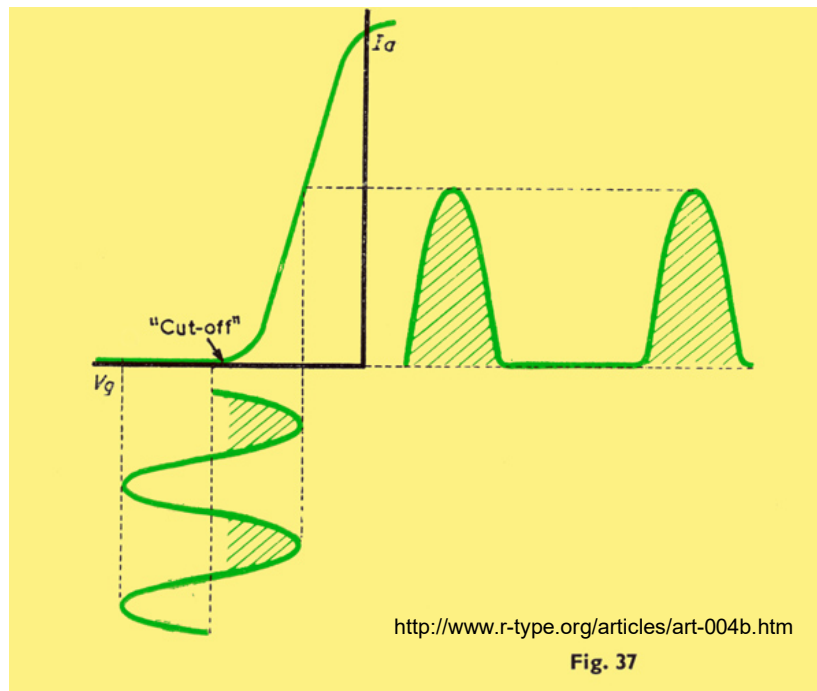


plate current can be controlled by the application of a small control voltage between the grid and filament!

Tube Amplifier Class - C

- **Class C**

- I_p flows for less than half the input cycle
- Much distortion – not for audio
- Usually only for RF amplification



The DeForest "Audion" tube

http://www.ibiblio.org/kuphaldt/electricCircuits/Semi/SEMI_13.html

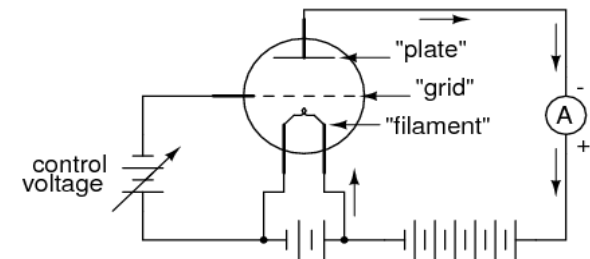
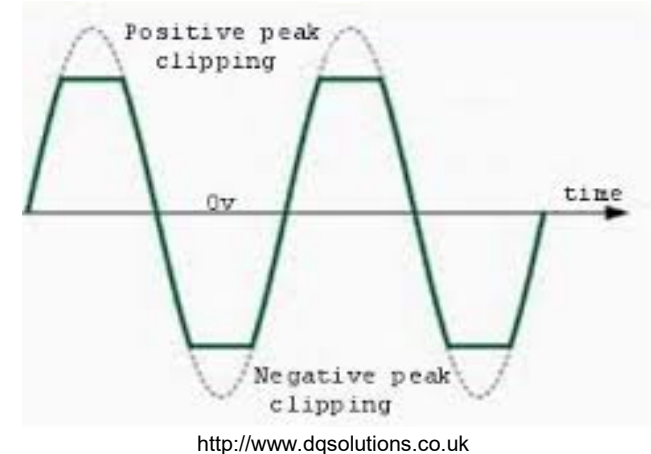
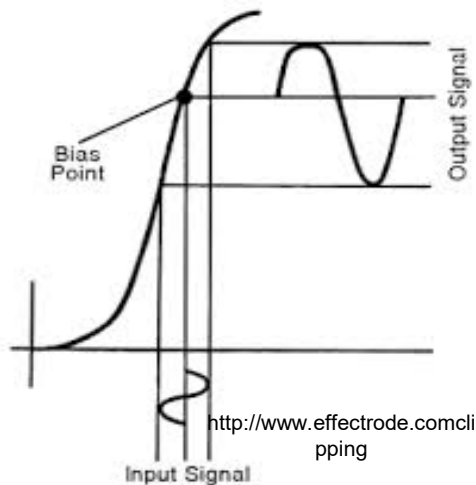
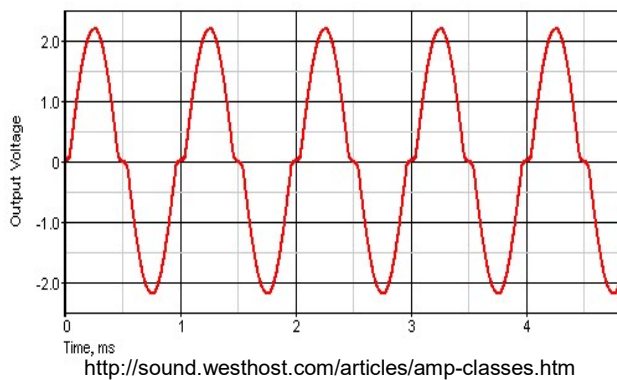


plate current can be controlled by the application of a small control voltage between the grid and filament!

Basic Distortion - Why

- **Class of operation (especially B & C)**
- **Bias point (where are you on the Eg- Ip curve)**
- **Overdriving (too much input > saturation/cutoff)**

ESP



Tubes Today

- **Cooking - Microwave oven**
- **Audiophiles - Audio quality & special distortion**
- **Broadcasting - High power**
- **Medical - Imaging (x-ray & photomultipliers)**
- **Manufacturing – Welding & industrial heating**
- **Ham Radio - High power & Vintage Operations**

Name That Tube



22-Feb-18

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Name That Tube

572B

A power triode used in class AB,
class B and class C
RF and audio amplifiers



22-Feb-18



www.radioinc.com



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Name That Tube



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Name That Tube

3-500Z

A compact power triode used in
RF amplifiers



www.w3gas.com



www.universal-radio.com



Hamradio.com

Name That Tube



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Name That Tube



gare.co.uk

3CX1500A7 / 8877

Power triode for Class AB2 or B
audio or RF amplifier,
or Class C RF amplifier



aesham.com



isquare.com

The Big Daddy



<http://www.cpii.com/docs/datasheets/81/8974.pdf>

The Eimac 8974 is a power tetrode (175 lb)
16.3V @ 600A - nearly 10 kW just to heat the filaments!
22.5kV on the plate at 125A

With 7kW drive – 2.16 MEGA watts of RF output in class C @ 30MHz

- It is shown that Robert von Lieben had designed the original vacuum tube amplifier only to increase the low-frequency electrical oscillations (telephone translation).
- The three-electrode vacuum tube created by Lee de Forest was created specifically to enhance the radio antenna received radio.
- It is noted that these inventions have different prototypes: cathode-ray tube - for von Lieben, and oscillation valve - for de Forest
- Comparing the dates of the received patents two scientists, it is obvious that priority in the invention of vacuum electronic lamp for electric signal amplification, belongs to Robert von Lieben, and radio frequency amplification belongs to Lee de Forest.