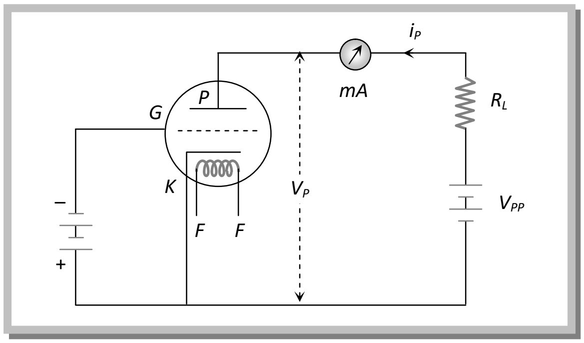
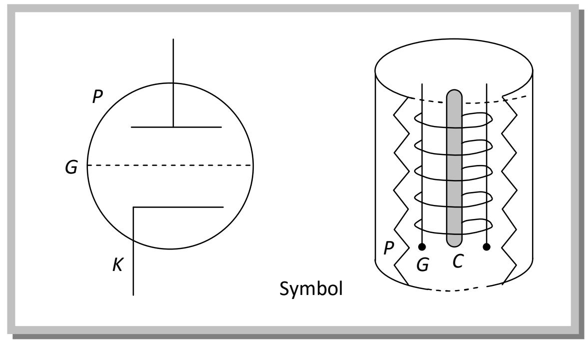
Triode Valve.





Inventor: Dr. Lee De Forest

Principle: Thermionic emission

Number of electrodes: Three

Grid: Is a third electrode, also known as control grid, which controls the electrons going from cathode to plate. It is kept near the cathode with low negative potential.

Working: Plate of triode valve is always kept at positive potential w.r.t. cathode. The potential of plate is more than that of grid. The variation of plate potential affects the plate current as follows $i_p = k\left(V_G + \frac{V_p}{\mu}\right)^{3/2}$; where μ = Amplification factor of triode valve, k = Constant of triode valve.

When grid is given positive potential then plate current increases but in this case triode cannot be used for amplifier and therefore grid is normally not given positive potential.

When grid is given negative potential then plate current decreases but in this case grid controls plate current most effectively.

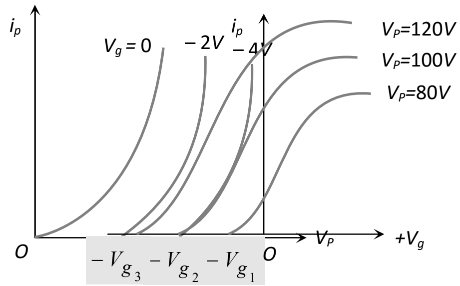
(1) **Cut off grid voltage:** The valve of V_G for which the plate current becomes zero is known as the cut off voltage. For a given V_p, it is given by $V_G = -\frac{V_p}{\mu}$.

(2) **Characteristic of triode:** These are of two types

Static characteristic	**Dynamic characteristic**

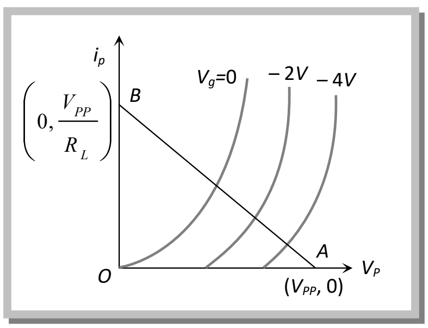
Graphical representation of V_p or V_g and i_p without any load	Graphical representation of V_p or V_g and i_p with load

Note: Both static and dynamic characteristics are again of two types-plate characteristics and mutual characteristic

Static plate (or anode) characteristic	Static mutual (or trans) characteristics
Graphical representation of i_p and V_P at constant V_g. 	Graphical representation of i_P and V_G when V_P is kept constant

Load line

(a) It is a straight line joining the points (V_{pp} , 0) on plate voltage axis and $(0, V_{pp} / R_L)$ on plate current axis of plate characteristics of triode.



(b) In graph, AB is a load line and the equation of load line is:

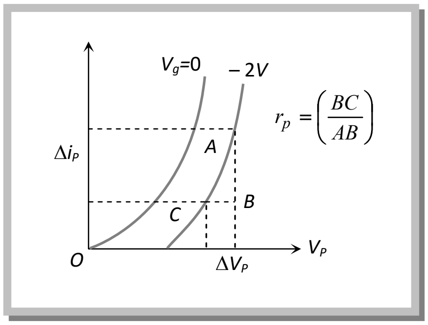
$V_{pp} = i_p R_L + V_p$ or $i_P = -\frac{1}{R_L} V_P + \frac{V_{PP}}{R_L}$

(c) The slope of load line $AB = \frac{di_p}{dV_p} = -\frac{1}{R_L}$

(d) In graph, $OA = V_{pp}$ =intercept of load line on V_P axis and $OB = V_{pp} / R_L$ =intercept of load line on i_p axis.

(3) **Constant of triode valve**

(i) **Plate or dynamic resistance (r_P):** The slope of plate characteristic curve is equal to $\frac{1}{\text{plate resistance}}$ or it is the ratio of small change in plate voltage to the change in plate current produced by it, the grid voltage remaining constant. That is, $r_p = \frac{\Delta V_p}{\Delta i_p}, V_G = \text{constant}$.

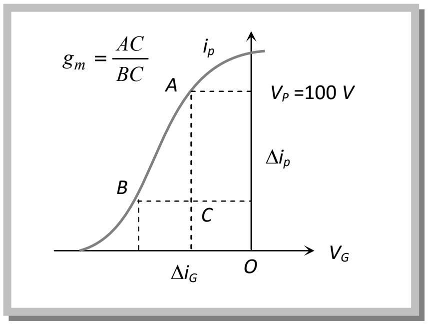


It is expressed in kilo ohms (KΩ). Typically, it ranges from about 8 KΩ to 40 KΩ. The r_p can be determined from plate characteristics. It represents the reciprocal of the slope of the plate characteristic curve.

If the distance between plate and cathode is increased the r_p increases. The value of r_p is infinity in the state of cut off bias or saturation state.

(ii) **Mutual conductance (or trans conductance) (g_m)**

(a) It is defined as the ratio of small change in plate current (Δi_p) to the corresponding small change in grid potential (ΔV_g) when plate potential V_p is kept constant i.e. $g_m = \left(\frac{\Delta i_p}{\Delta V_g}\right)_{V_p \text{ is constant}}$



(b) The value of g_m is equal to the slope of mutual characteristics of triode.

(c) The value of g_m depends upon the separation between grid and cathode. The smaller is this separation, the larger is the value of g_m and vice versa.

(d) In the saturation state, the value of $\Delta i_p = 0$, $g_m = 0$

(iii) **Amplification factor (μ) :** It is defined as the ratio of change in plate potential (ΔV_p) to produce certain change in plate current (Δi_p) to the change in grid potential (ΔV_g) for the same change in plate current (Δi_p) i.e. $\mu = -\left(\frac{\Delta V_p}{\Delta V_g}\right)_{\Delta I_p = \text{a constant}}$; negative sign indicates that V_p and V_g are in opposite phase.

(a) Amplification factor depends upon the distance between:

- Plate and cathode (d_{pk})
- Plate and grid (d_{pg})
- Grid and cathode (d_{gk})

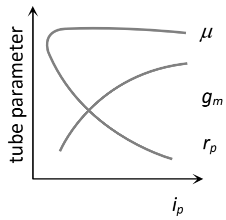
Also $\mu \propto d_{pg} \propto d_{pk} \propto \frac{1}{d_{gk}}$

(b) The value of μ is greater than one.

(c) Amplification factor is unit less and dimensionless.

Note: The triode constants are not independent of each other. They are related by the relation.

$\mu = r_p \times g_m$



The r_p and g_m depends on i_p in the following manner.

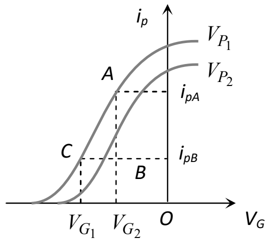
$r_p \propto i_p^{-1/3}$, $g_m \propto i_p^{1/3}$

μDoes not depend on i_p. The variation of triode parameters with i_p are shown in figure.

Above three constant may be determined from any one set of characteristic curves.

$r_p = \frac{V_{P1} - V_{P2}}{I_{PA} - I_{PB}}$,

$g_m = \frac{I_{PA} - I_{PB}}{V_{G1} - V_{G2}}$,

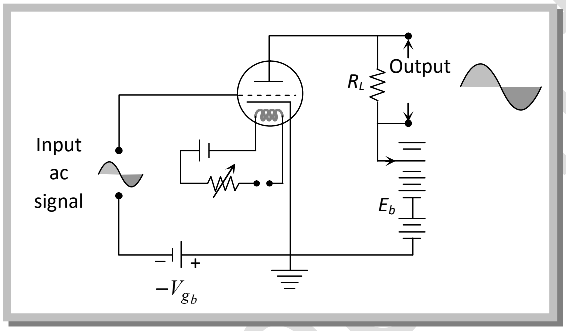


$$\mu = -\frac{V_{P1} - V_{P2}}{V_{G2} - V_{G1}}$$

(4) **Triode as an Amplifiers**

Amplifier is a device by which the amplitude of variation of ac signal voltage / current/ power can be increased

(i) **Principle and circuit diagram:** The amplifying action of the triode is based on the fact that small change in grid voltage produces the same change in the grid voltage as due to a large change in the plate voltage. A circuit for triode as an amplifier



(ii) **Working:** First of all the mutual characteristic curves of a triode to be used as an amplifier are plotted and the grid potential $-Vg_b$ corresponding to the mid-point of straight portion of characteristic curve is noted.

This negative grid potential is applied on grid and is known as grid bias. The AC signal to be amplified is connected in series with this grid bias $(-Vg_b)$. Let the input signal be represented as $e_g = e_0 \sin \omega t$.

The net input grid voltage $= -Vg_b + e_0 \sin \omega t$, varies between $-Vg_b + e_0$ and $-Vg_b - e_0$. The corresponding amplified output current shown in fig. The output voltage is taken across load resistance R_L. If e_g (or ΔVg) is the input signal voltage and $\Delta V_L = R_L i_p (= R_L \Delta i_p)$ is the consequent voltage change across load R_L, then

Voltage gain $= \frac{\text{output voltage}}{\text{input voltage}} = \frac{\Delta V_L}{\Delta V_g} = \frac{\Delta V_p}{\Delta V_g} = \frac{\mu R_L}{R_p + R_L}$

or $A = \frac{\mu}{1 + R_p / R_L}$

The maximum voltage gain is obviously equal to μ for $R_L = \infty$.