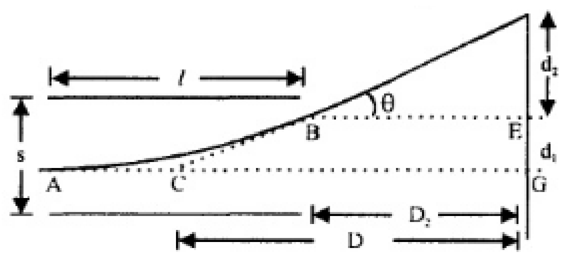
ELECTRIC STATIC DEFLECTION

The electro static deflection system is used in the cathode ray tube. This cathode ray tube is heart of cathode ray oscillator (CRO). CRO is an laboratory test instrument to observe and measure the wavefroms of voltage, current, frequency and phase angle.

The electric static deflection system uses two pairs of deflection plates. One pair of deflection plates are used to move the beam horizontally and they are called horizontal deflection plates but they placed vertically i.e., ($\perp' r$ to plane). There is another pair of deflection plates are used to move the electron beam vertically and are called vertical deflection plates but they are kept horizontally (parallel to plane).



The length of deflection plates $= l$

Separation between the plates $= d$

Potential applied between the plates $= V_d$

The cathode k emits the electron which flows towards anode by potential ‘Va’. Those electrons which are not collected by anode pass through the small anode hole and enters the region of deflection plates with initial velocity v_{0x}, the electrons strikes the fluorescent screen (inner side of screen is coated with phosphorous material) with high velocity then a spark of light is produced which is visible to human eye. Since there is no electric field between the region from anode to point ‘0’ the electrons will move with constant vel. v_{0x} in stright line path.

The vel. v_{0x} of an electron on entering the field of deflecting plates

$$v_{0x} = \sqrt{\frac{2eV_0}{m}} \qquad - \qquad (1)$$

In the region between the plates the electrons will move in a parabolic path

$$y = \frac{1}{2}\left(\frac{a_y}{v_{0x}^{\;2}}\right)x^2 \qquad - \qquad (2)$$

There is a straight line path from point 'M' at edge of deflection plates, to point p on screen, since this region is field free region. This st.line path (MP) is tangent to parabola at point 'M'.

Slope of the line at point 'M' is given by

$$\tan\theta = \frac{dy}{dx}\int_{x=l}$$

Differentiating eq(2) w.r.t. 'x'

$$\frac{dy}{dx} = \frac{1}{2}\cdot\frac{a_y}{v_{ox}^{\;2}}(2x)\Big|_{x=l}$$

$$= \frac{a_y l}{v_{0x}^{\;2}}$$

$\therefore m = \tan\theta = \dfrac{ay.l}{v_{ox}^{\;2}} \qquad - \qquad (3)$ is the slope of line at point 'M'

When st. line $'MP''$ is extended backward it intersects the x-axis at point '0' (centre of deflecting paltes$= \dfrac{l}{2}$). The point '0' is called virtual cathode because the electron appears to be emerge from this point and move in a straight line to point P', through the electron really started from the cathode. The st. line $'MP''$ also passing through the $(x_1, y_1) = \left(\dfrac{l}{2}, 0\right)$

The eq. of st. line passing through the point (x_1, y_1) with slope 'm' is

$$y - y_1 = m(x - x_1)$$

$$y - 0 = \frac{a_y \cdot l}{v_{ox}^{\;2}}\left(x - \frac{l}{2}\right) \qquad from\ eq(3)$$

$$\Rightarrow y = \frac{a_y \cdot l}{v_{ox}^{\;2}}\left(x - \frac{l}{2}\right) \qquad - \qquad (4)$$

This is the eq. of st. line MP'

If we substitute $x = l$, then

$$y-0=\frac{a_y\cdot l}{{v_{ox}}^2}=\frac{1}{2}\frac{a_y\cdot x^2}{{v_{ox}}^2} \qquad (parabola\ eq.)$$

At the point P', $y=D$ i.e., Deflection on screen

And $x=L+\frac{l}{2}$

$$L=x-\frac{l}{2}$$

From eq(4) $y=\frac{a_y\cdot l}{{v_{ox}}^2}\cdot L$

$$y=D=\frac{a_y\cdot l\cdot L}{{v_{ox}}^2}$$

But $a_y=\frac{-e\varepsilon}{m}$

$$\varepsilon=\frac{-V_d}{d}\Rightarrow a_y=\frac{eV_d}{md}$$

And ${v_{ox}}^2=\frac{2eV_a}{m}$

$$\therefore D=\frac{\frac{eV_d}{md}}{\frac{2eV_a}{m}}\cdot l\cdot L$$

$$=\frac{1}{2d}\cdot l\cdot L\cdot\frac{V_d}{V_a}$$

$$D=\frac{lLV_d}{2dV_a} \qquad - \qquad (5)$$

The deflection on screen of CRT is directly proportional to deflecting voltage (voltage between parallel plates) applied between the plates

Deflection sensitivity :

The elector static deflection sensitivity of CRT is defined as the deflection on screen per volt of deflecting voltage.

$$S_E = \frac{D}{V_d}$$

$$S_E = \frac{D = lL}{2dV_a} \qquad - \qquad (6)$$

Where ‘l’ is the length of deflecting plates

‘L’ is the distance between centre of deflecting plates to the screen

‘d’ is the distance between the paltes

‘V_a’ is anode potential

The units for deflection sensitivity is mt/volt or mm/v or cm/v the deflection sensitivity is inversely proportional to anode potential i.e.,

$$S_E \alpha \frac{1}{V_a}$$

Force in magnetic field :

Force on a moving charge in a magnetic filed is given by motor’s law. If a conductor of length ‘L’ carrying a current I situated in a magnetic field intensity ‘B’ then force acting on this is given by

$$F_M = BIL \qquad - \qquad (1)$$

Where F_M is force in Newtons

B is magnetic flux density wb/m^2 (or) Tesla

I is current in amperes

L is length of conductor in mts.

The direction of I and B are perpendicular to each other, the direction of force F_M is perpendicular to BI plane i.e., they are mutually perpendicular which are directed along advance of right hand rule.

If the particle is a +vely charged particle then current ‘I’ direction is to be taken along direction of motion of particle so I and v^+ both are in same direction. This is called conventional current (it is due to flow of +vely charge particle).

If the particle is a -vely charged particle then current 'I' direction is to be taken along opposite to direction of motion of particle i.e., I and v^+ in opposite direction. This current is called electronic current.

Conventional current direction is opoosite to electronic current.

Let N be the no. of electrons in a conductor and

'L' is the length of conductor and T be the time taken by electron to travel a distance of 'L'. the no. of electrons passing through any cross-section in unit time is given by

$$= \frac{N}{T}$$

From the relation $q = it$

$$\Rightarrow i = \frac{q}{t}$$

$$current = \frac{charge}{\sec}$$

Total charges passing per second $= \frac{N}{T} \cdot e$

$$I = \frac{Ne}{T} \qquad - \qquad (2)$$

Substitute eq(2) in eq(1)

$$f_m = BIL$$

$$= B\left(\frac{Ne}{T}\right)L$$

Where $\frac{L}{T}$ is called drift velocity [vel. acquired by external voltage/force]

$$\therefore f_m = BN_e v$$

Force due to mag. Field per electorn, $f_m = Bev$