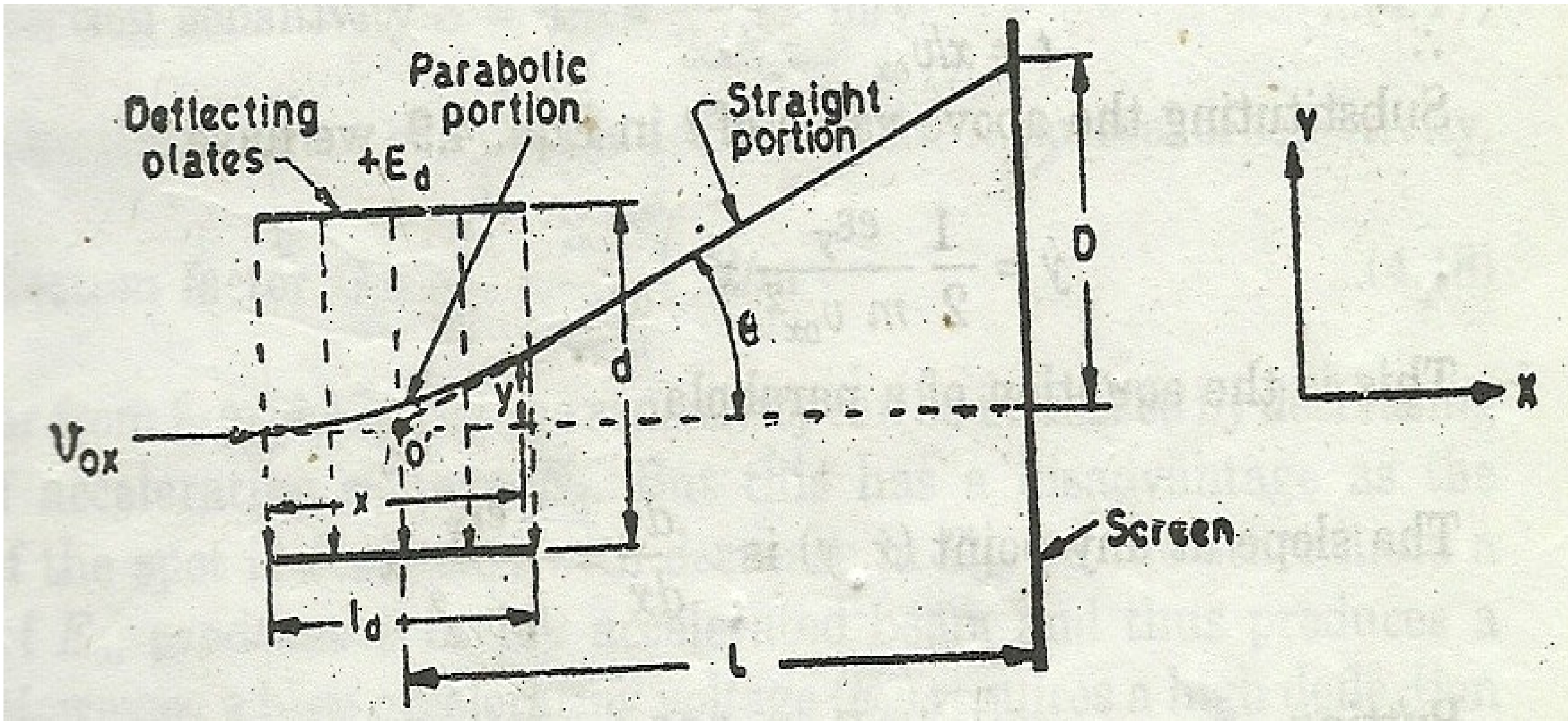
Electrostatic Deflection



Electrostatic Deflection

E_0 = voltage of pre-accelerating anode ; V,

e = charge of an electron ; C,

m = mass of electron ; kg,

v_{ox} = velocity of electron when entering the field of deflecting plates ; m/s,

E_d = potential between deflecting plates ; V,

d = distance between deflecting plates ; m,

l_d = length of deflecting plates ; m,

L = distance between screen and the centre of the deflecting plates ; m,

D = deflection of electron beam on the screen in Y direction ; m.

Electrostatic Deflection

- The loss of potential energy when the electron moves from cathode to accelerating anode

$$P.E = eE_a \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

- The gain in K.E. by an electron

$$K.E = (1/2)mv_{ox}^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where m = $9.109*10^{-31}$kg

Equating two energies,we have

$$v_{ox} = (2eE_a/m)^{1/2} \ldots\ldots(3)$$

$$\epsilon_y = E_d/d \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$F_y = e\epsilon_y = eE_d/d \ldots\ldots\ldots\ldots\ldots(5)$$

$F_y = ma_y$

$$a_y = e\epsilon_y /m \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

No initial velocity in the Y direction the displacement y at any instant t in the Y direction is:

$$y = \frac{1}{2} a_y t^2 = \frac{1}{2} \frac{e\epsilon_y}{m} t^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

As velocity in X direction is constatnt , the displacement in X direction is given by:

$$x = v_{ox}t \ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\therefore t = x/v_{ox} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Electrostatic Deflection contd…..

- Substituting the above value of t in eqn.(7) we have:

$$Y = \frac{1}{2}\frac{e\epsilon_y}{mv_{ox}^2}x^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

This is the eqn.of parabola

The slope at any pt(x,y) is $\frac{dy}{dx} = \frac{e\epsilon_y}{mv_{ox}^2}x \ldots\ldots\ldots(11)$

putting $x = l_d$ in eqn (11),we get the value of tan θ

$$\tan\theta = \frac{e\epsilon_y l_d}{mv_{ox}^2} = \frac{e E_d l_d}{mdv_{ox}^2} \quad \ldots\ldots\ldots(12)$$

The straight line of travel of electrons is tangent to the parabola at $x = l_d$ & this tangent intersects the X-axis at pt O' .The location of this point is given by:

$$x = \frac{y}{\tan\theta} = \frac{e\epsilon_y l_d^2}{2\,mv_{ox}^2} / \frac{e E_d l_d}{mv_{ox}^2} = ld\ /2 \ldots\ldots\ldots(12)$$

The deflection D on the Screen is given by:

$$D = L\tan\theta = \frac{Le E_d l_d}{mv_{ox}^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

Substitute the value of $v_{ox}^2 = 2e\,Ea/m$ in eqn.(13) we get:

$$D = = \frac{L l_d E_d}{2d E_a} \quad \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

Electrostatic Deflection

Deflection Sensitivity:-The deflection sensitivity of a CRT is defined as the deflection of the screen per unit deflection voltage.

$$S = D/E_d = Ll_d/2dE_a \text{ m/V}$$

Deflection Factor:-It is reciprocal of sensitivity.

$$G = 1/S = 2dE_a/Ll_d \text{ V/m}$$

Post Deflection Acceleration

- After electrons pass beyond the deflection plates,they may or may not experience additional acceleration.
- This depends primarily upon on the maximum frequencies to be applied to CRT.
- For good sensitivity E_a should be low below 4 kV but reduces brightness,which can be seriously impaired at high frequencies.
- Below 10 MHz ,monoaccelerator may be used.
- If signals of frequencies higher than 10 MHz are to displayed,post deflection acceleration tubes(PDA) or post accelerators is necessary to increse the brightness of the trace which otherwise would be dim.

Graticule

- The graticule is a grid of lines that serves as a scale when making time and amplitude measurements.

Aquadag

- The bombarding electrons ,striking the screen ,release secondary emission electrons.these secondary electrons are collected by an aqueous solution of graphite called **Aquadag** which is connected to the second anode,collection of secondary electrons is necessary to keep the CRT screen in a state of electrical equilibrium.