radius is same as equation ⑪
The pitch of the helical path is given by

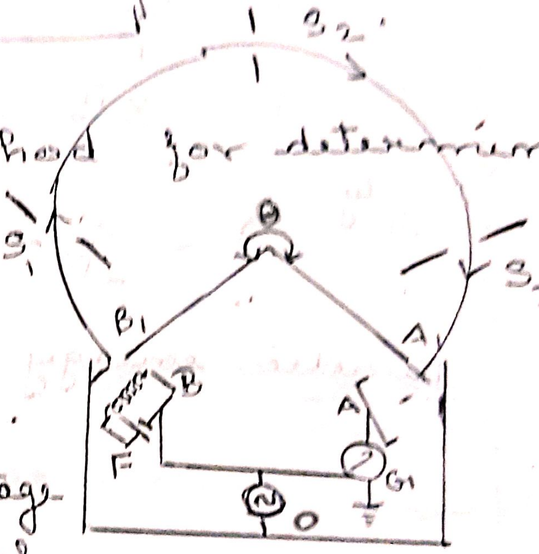
Pitch = Time period × velocity along x axis

$$P = T v_x$$

$$P = \frac{2\pi m}{qB} v\cos\theta \quad \text{from } (V)$$

$$\boxed{P = \frac{2\pi m}{qB} v\cos\theta} \quad — ⑨$$

## Dunnington's method for determining e/m



The apporatus is shown in Fig. An alternating voltage at a constant high frequency produced by a crystal oscillator O is applied simultaneously to the two pairs of electrodes $AA_1$ and $BB_1$. Electrons from the hot filament F are accelerated towards $B_1$ during the positive half-cycle, and emergy through a fine opening in $B_1$. The electron are then bent into a circular path by a magnetic field B applied normal to the plane of the figure. The radius of curvature r of the circular path is defined by the slits $S_1$ $S_2$ and $S_3$. Then only those electrons whose velocity satisfies the relation

$$Bev = \frac{mv^2}{r}$$

can pass through the slits $S_1$, $S_2$ and $S_3$ is

∴ the speed of the electron in its circular path

$$v = \frac{Ber}{m} \quad — ①$$

After the electrons are turned through an angle θ, they enter the Faraday chamber A through a grid $A_1$ and produce a deflection in the galvanometer G. The electrodes and the slits are enclosed in an evacuated glass envelope. The grid $A_1$ is connected to the same oscillator which accelerates the electrons. Suppose the time taken by the electrons to be turned through the angle θ is the period $1/f$ of the oscillator or an integral multiple of it. say $n/f$. Then the electrons will lose all their energy in overcoming the opposing PD between $A_1$ and A and will just fail to reach A. The galvanometer indicates zero deflection. when this condition is satisfied. This can be brought about by varying the intensity of magnetic field B.

Now, distance travelled by the electron in going from $B_1$ to $A_1 = r\theta$. The time taken for travelling this distance $= n/f$.

$$\therefore v = \frac{\text{distance}}{\text{Time}} = \frac{r\theta}{n/f} = \frac{r\theta f}{n} \quad ②$$

① + ②

$$\frac{Be\cancel{r}}{m} = \frac{\cancel{r}\theta f}{n}.$$

$$\frac{e}{m} = \frac{\theta f}{nB}$$

θ is measured using microscope. The built into the apparatus. The determined magnetic field (B) can be measured accurately. f can be measured with an accuracy of one part in one million. This method is, therefore, a precision one. Thus e/m is calculated.

## Magnetron method:

Consider a long straight filament of radius r and a coascial cylindrical plate of radius $R_x$ constituting a diode. The cylindrical plate ~~of radius~~ is maintained at a positive potential v with respect to the cathode.

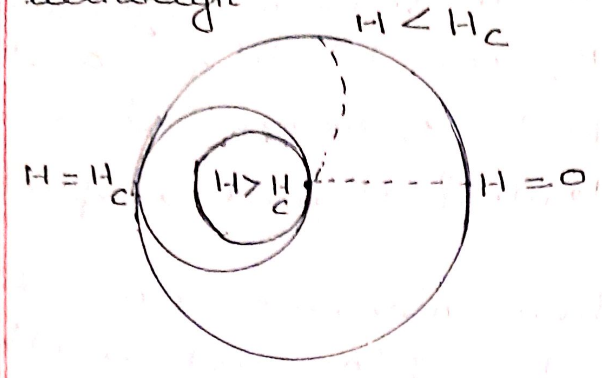
Let us further assume that the electrons leave the filament with zero initial velocities. A magnetic field parallel to the ascis of the diode filament is superposed upon the electric field. This becomes the so-called magnetron arrangement first introduced by Hull. This longitudinal magnetic field along the ascis of the filament may be obtained by placing the diode inside a long straight solenoid such that its ascis is coincident with the filament, the strength of the magnetic field may be varied by controlling the current through the solenoid.

Let us now investigate the electronic paths. Suppose to begin with, the magnetic field is zero. The electrons, each of mass m and charge e, are accelerated towards the plate by the electric field. The velocity v acquired by the electrons under a potential difference v is given by. the relation.

$$\frac{1}{2} m v^2 = V.e \times 10^8$$

$$v = \sqrt{\frac{2Ve}{m} \times 10^8}$$ — ①

If a weak magnetic field is present, then due to lorentz force the electron path will be curved although the electron will strike the plate.



As the field is further increased, the path becomes more and more curved until a critical value of the field $H_c$ is reached. When the path of the electron is tangential to the anode. For fields greater than $H_c$, the electrons does not strike the plate at all but returns to the filament. Thus for fixed anode potential $V$, if the anode current is studied as a function of $H$, the applied magnetic field, the plate current should be unaffected for values of $H$ less than the critical value $H_c$. whereas for values of $H$ greater than the critical value of $H_c$, the anode current should reduce to zero. The equilibrium equation for the critical field is given by

$$H_c e v = \frac{mv^2}{\rho}$$ where $\rho$ is the radius of the circular path, which for $H_c$ equals half the radius of the cylindrical anode ie,

$$\rho = \frac{R_c}{2}$$ thus

$$H_c e v = \frac{2mv^2}{R_a}$$

$$v = \frac{H_c e R_a}{2m} \quad \text{———} \quad (2)$$

equating (1) and (2)

$$\frac{H_c e R_a}{2m} = \sqrt{\frac{2Ve}{m} \times 10^8}$$

$$\left(\frac{H_c e R_a}{2m}\right)^2 = \frac{2Ve \times 10^8}{m}$$

$$\frac{H_c^2 \cancel{e}^2 R_a^2}{4m\cancel{m}} = \frac{2V\cancel{e} \times 10^8}{\cancel{m}}$$

$$\frac{e}{m} = \frac{8V\,10^8}{H_c^2\,R_a^2} \text{ emu/gm}.$$

The value of $H_c$ is calculated using the relation.

$$H_c = \frac{4\pi n I_c}{10} \cos\theta.$$

where

n - number of turns of the coil / cm length of the solenoid.

$I_c$ is ~~cc~~ critical current in the solenoid for cut off. and the factor cos θ takes the finite length of solenoid.

$$\cos\theta = \frac{L/2}{\sqrt{R^2 + \left(\frac{L}{2}\right)^2}}.$$

where L is the length of the solenoid and R its radius.

## Properties of Cathode Rays.

1). The rays travel in straight lines

2) The rays emerge normally from the cathode.

3) The rays can penetrate small thicknesses of matter such as sheets of aluminium foil .

4) The rays carry negative charge and so they are deflected by electrostatic and magnetic fields. This property is used in determining the ratio of the charge (e) to the mass (m) of the electron. The ratio e/m is known as the specific charge of the electron. It is found to be a universal constant.

5). cathode rays carry momentum and KE.

6) They ionize gases.

7) They produce fluorescence in the glass of walls of the tube.

8) They produce heat when they fall upon matter

9) when cathode rays are suddenly stopped by a target, the target becomes a source of x-rays.

— x —