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Cyclotron [contd ----]

Energy of the accelerated particle

If R is the radius of the dees, the ions attains maximum velocity when $r = R$. Thus the maximum kinetic energy of the ion emerging from the cyclotron is given by

$$T = \frac{1}{2} m v_{max}^2$$

$$= \frac{1}{2} \frac{(Bqr)^2}{m}$$

$$= \frac{1}{2m} B^2 q^2 r^2$$

$$= 2\pi^2 n^2 r^2 m \quad \text{---} (4)$$

$$\left[\because \frac{1}{2} m v^2 = \frac{B^2 q^2 r^2 \cdot 2\pi^2 m}{(2\pi m)^2} \right.$$

$$= \left(\frac{Bq}{2\pi m}\right)^2 \cdot r^2 \cdot 2\pi^2 m$$

$$\left. = 2\pi^2 n^2 r^2 m \right]$$

Cyclotrons are usually described in terms of the diameter of the pole faces of the magnet.

Relativistic limitations:- The energy with which particles can be accelerated are limited due to the relativistic increase of mass with velocity. As the speed v of the particle approaches the light of c, the mass of the particle increases and is given by the relation

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}, \text{ where}$$

m_0 = rest mass of the particle.

According to eqn (2)

$$T = \frac{\pi}{Bq} \frac{m_0}{\sqrt{1-v^2/c^2}}$$

and increases as the velocity v increases, i.e, the particle takes longer time to describe its semi-circular path and arrives too in the gap. It gets out of phase with the high frequency accelerating field and hence loses energy. Thus it is quite evident that cyclotron operates successfully only with ~~relating~~ relatively heavy particles and cannot be used to accelerate electrons.

Uses :- ~~Thy~~ ~~c~~ The cyclotron are used mainly to accelerate proton, deutron, α-particle and other heavy ions of atoms.