90. CYCLOTRON

Ques:- Describe the principle and construction of a cyclotron. Discuss its limitation and how they are overcome?

Ans:- The cyclotron derived by Lawrence in 1932 is the most familar device for accelerating particles ions by r.f. field the ions moves in Spiral Path of application of constant and uniform magnetic field. The mechanic accelerator the positive ions to energy of few million electron volts. This instruments was some time also called on the principle of resonance between the applied electric and magnetic field.

Construction:-

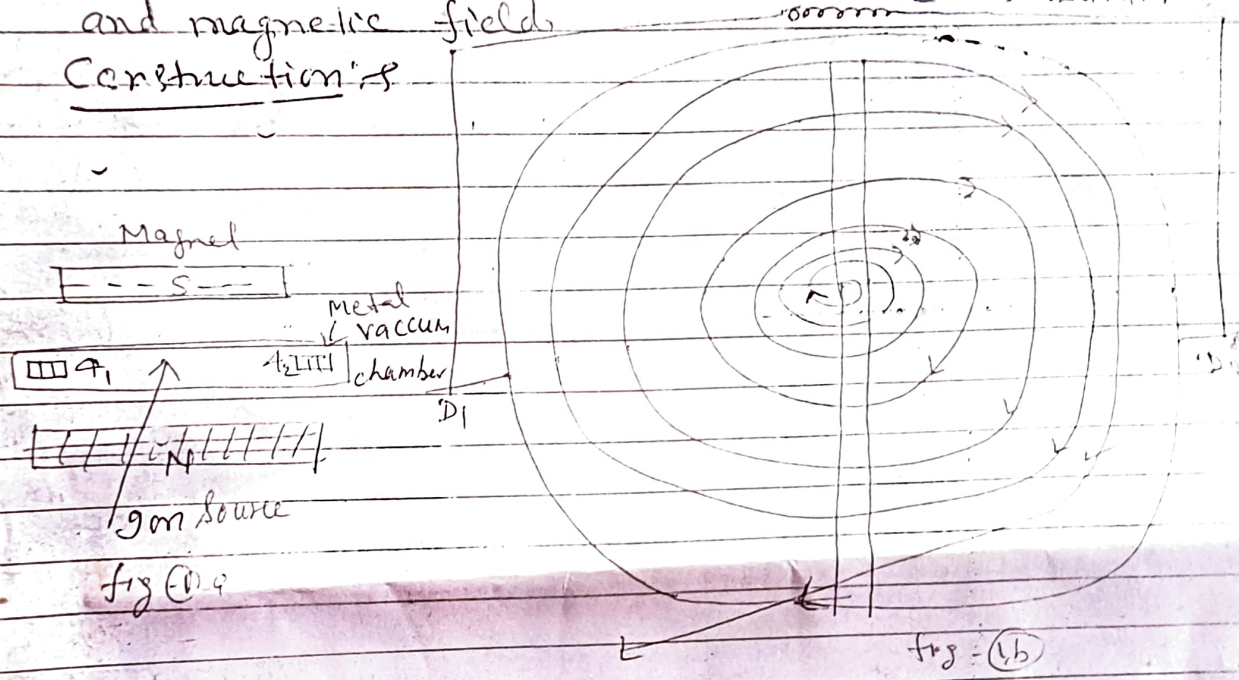

fig (1a)

fig (1b)

fig (1) Cyclotron (a) Sketch
(b) principle of action

The cyclotron consists of two flat semi circular hallow metal boxes called does the hollow chamber have their diametric edge parallel and slightly separated from each other. These does are surrounded by a closed vessel, containing gas like hydrogen hydrogen hellium, deuterium of low pressure and the whole apparatus is placed between the poles of a strong electromagnetic which provides a magnetic field perpendicular to the plane of the the dees.

A radio frequency alternating potential of the order of mega cycles/second is applied between the dees which acts as electrodes. The positively charged ions are produced at the centre between two dees as shown. The accelerated ions are extracted one of the dees with the help of a negatively charged electrode with potential at 50 K.V. In fig (1.5)

Principle:-

In this accelerator positive aquire energy from r.f. field when they cross the gap between field. Ion source between electrodes is so that the field is always in a phase to accelerate the ions when they cross the gap between the two dees and thus aquires energy much higher than the equivalent peak accelerating voltage.

Principle of operation:-

Suppose a positive ion is produced in an ion source is and alternating potential is in the direction with makes D_1 and D_2 negative. A positive ion starting from the source will be attracted by the dee D_2 and becomes of the proces of uniform magnetic field B, it waves in a circular path governed by eqn

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

$$\therefore r = \frac{mv}{BQ} \quad \text{---} (1)$$

Where, m, v, and Q are mass, velocity and charge of ion respectively r is the radius of a circular path in the presence of magnetic field B.

The ion after traversing half a cycle comes to the edge of D_2 if in the mean time the potential difference between D_1 and D_2 has changed direction so that D_2 now positive and D_1 negative, the positive ion will receive an additional acceleration while going across gap between dees. and then travel in a circular path of larger