PROFESSIONAL(SPECIAL) ENGLISH COURSE

NUCLEAR ENERGY

Chapter 8 Particle Accelerators (粒子加速器)

- A device that provides forces on charged particles by some combination of electric and magnetic fields and brings the ions to high speed and kinetic energy is called an accelerator. Many types have been developed for the study of nuclear reactions and basic nuclear structure, with an ever-increasing (持续增长) demand for higher particle energy. In this chapter we shall review the nature (性质) of the forces on charges and describe the arrangement (结构) and principle of operation of several important kinds of particle accelerators.

8.1 ELECTRIC AND MAGNETIC FORCES (电磁力)

- Let us recall how charged particles are influenced (感应) by electric and magnetic fields. First, visualize (想象) a pair of parallel metal plates separated by a distance *d* as in the sample capacitor (电容器) shown in Fig. 8. l.

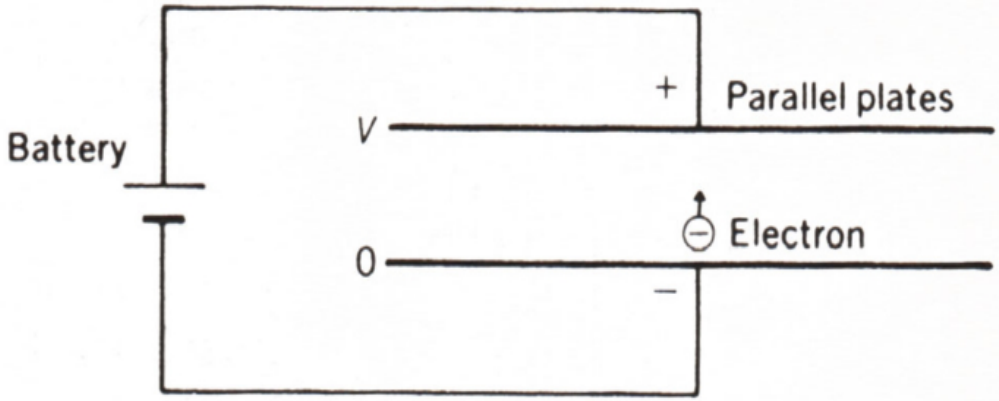

Fig. 8.1. Capacitor as accelerator.

P73第二段第三行中

- **A potential difference (势差) *V* and electric field *E=V/d* are provided to the region of low gas pressure by a direct-current (直流电) voltage supply such as a battery (电池). If an electron of mass *m* and charge *e* is released at the negative plate (阴极板), it will experience a force *Ee*, and its acceleration will be *Ee/m*. It will gain speed, and on reaching the positive plate (阳极板) it will have reached a kinetic energy $mv^2/2 = Ve$.**

- **Next, let us introduce a charged particle of mass *m*, charge *e*, and speed *v* into a region with uniform magnetic field (均匀磁场) *B*, as in Fig.8.2.**

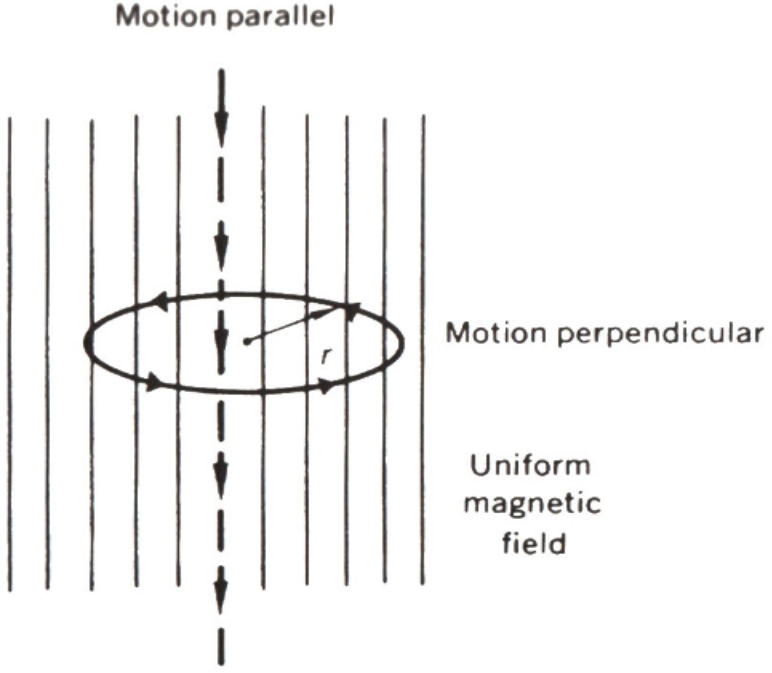

Fig. 8.2. Electric charge motion in uniform magnetic field.

P73末行尾

- **If the charge enters in the direction of the field lines (场力线), it will not be affected, but if it enters perpendicularly (垂直地) to the field, it will move at constant speed on a circle. Its radius, called the radius of gyration (旋转), is $r = mv/eB$, such that the stronger the field or the lower the speed, the smaller will be the radius of motion. Let the angular speed (角速度) be ω (omega), equal to v/r. Using the formula for r, we find $\omega = eB/m$. If the charge enters at some other angle, it will move in a path called a helix (螺旋状) , like a wire door spring (金属丝制的门弹簧).**

P75首段

- **Finally, let us release a charge in a region where the magnetic field *B* is changing with time. If the electron were inside the metal of a circular loop (圆环) of wire of area *A* as in Fig.8.3, it would experience an electric force induced by the change in magnetic flux (磁通量) *BA*. The same effect would take place without the presence of the wire, of course.**

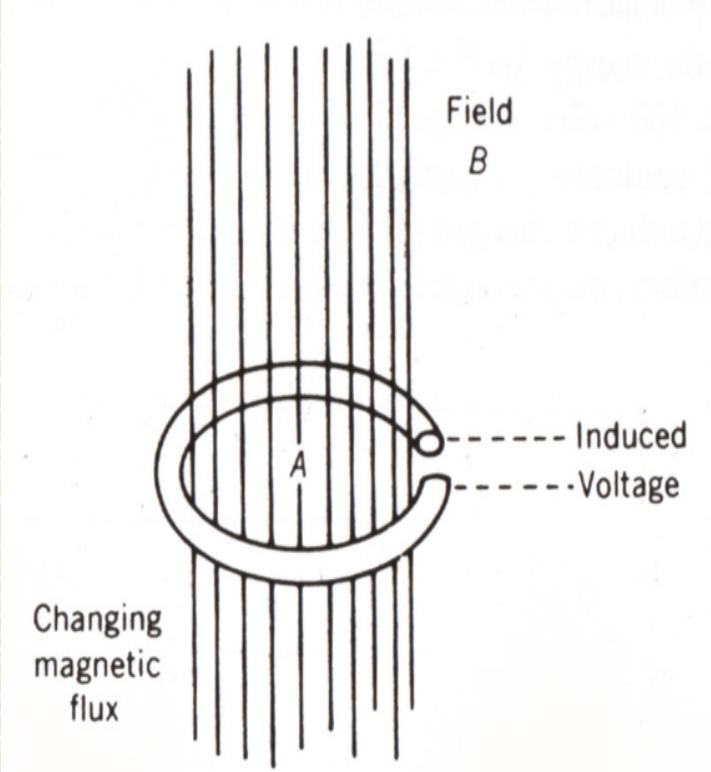

Fig. 8.3. Magnetic induction.

8.2 HIGH -VOLTAGE MACHINES (高压设备)

- One way to accelerate ions to high speed is to provide a large potential difference between a source of charges and a target. In effect, the phenomenon of lightning (闪电), in which a discharge (放电) from charged clouds to the earth takes place, is produced in the laboratory. Two devices of this type are commonly used. The first is the voltage multiplier (电压倍增器) or Cockroft-Walton machine.

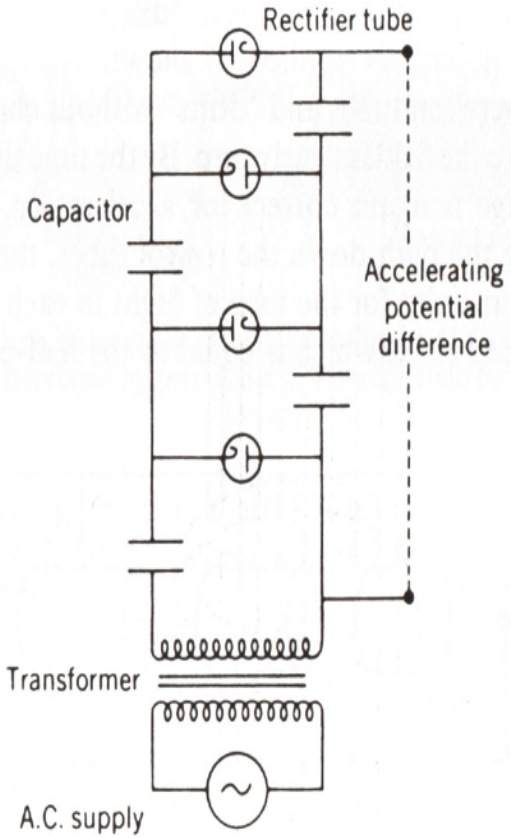

Fig. 8.4. Cockroft–Walton circuit.

- **The second is the electrostatic generator (静电发生器) or Van de Graaff accelerator (Fig. 8.5). An insulated (绝缘的) metal shell is raised to high potential by bringing it charge on a moving belt (传动带), permitting the acceleration of positive charges such as protons or deuterons. Particle energies of the order of 5MeV are possible, with a very small spread in energy.**

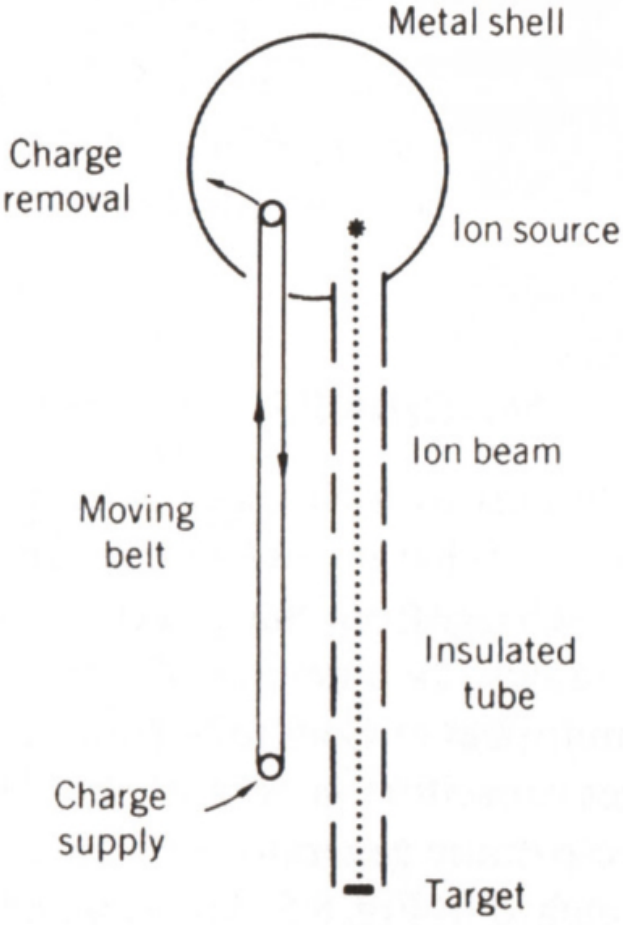

Fig. 8.5. Van de Graaff accelerator.

8.3 LINEAR ACCELERATOR (直线加速器)

- **Rather than (胜于) giving a charge one large acceleration with a high voltage, it can be brought to high speed by a succession of (一连串) accelerations through relatively small potential differences, as in the linear accelerator, sketched in Fig- 8.6.**

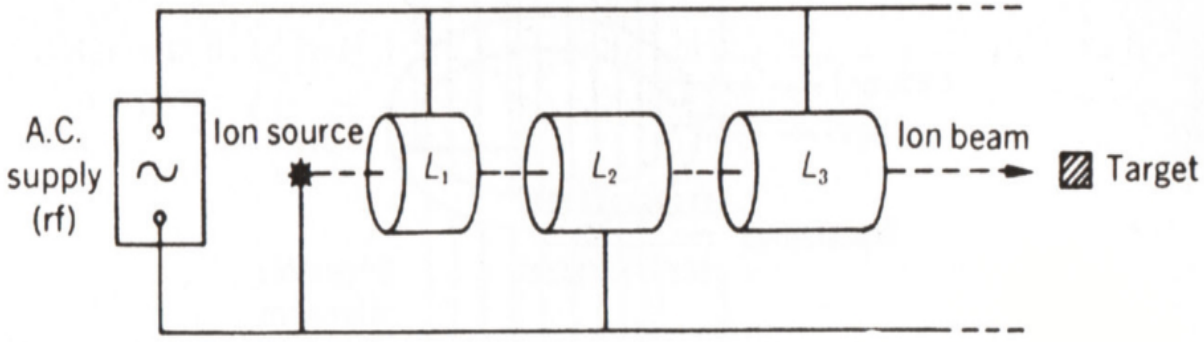

Fig. 8.6. Simple linear accelerator. (From Raymond L. Murray and Grover C. Cobb, *Physics: Concepts and Consequences*, ©, 1970. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey.)

P73第三行末

- It consists of a series of (一连串的) accelerating electrodes (电极) in the form of tubes with alternating electric potentials applied as shown. An electron or ion gains energy in the gaps between tubes and "drifts (漂流)" without change of energy while inside the tube, where the field is nearly zero. By the time the charge reaches the next gap, the voltage is again correct for (做…的校正) acceleration.

8.4 CYCLOTRON AND BETATRON
(一) CYCLOTRON（回旋加速器)

- Successive electrical acceleration by electrodes (电极) and circular motion (圆周运动) within a magnetic field are combined in the cyclotron. (Fig. 8.7)

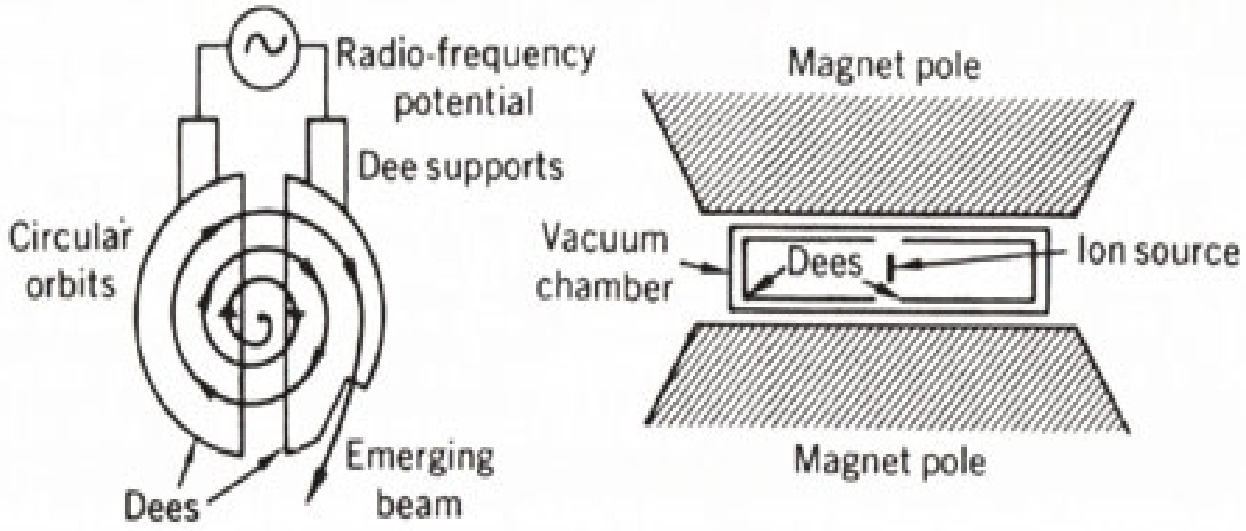

Fig. 8.7. Cyclotron. (From Raymond L. Murray and Grover C. Cobb, *Physics: Concepts and Consequences*, © 1970. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey.)

P77第四行末

- Two hollow (空的) metal boxes called "dees (D字盒)" (in the shape of the letter D) are supplied with alternating voltages (交流电压) in correct frequency and opposite polarity (极性). In the gap between dees, an ion gains energy as in the linear accelerator (直线加速器), then moves on a circle while inside the field-free region (无电场区), guided by the magnetic field. Each crossing of the gap with potential difference V gives impetus (推动力) to the ion with an energy gain Ve, and the radius of motion increases according to $r = v/\omega$, where $\omega = eB/m$ is the angular speed (角速度).