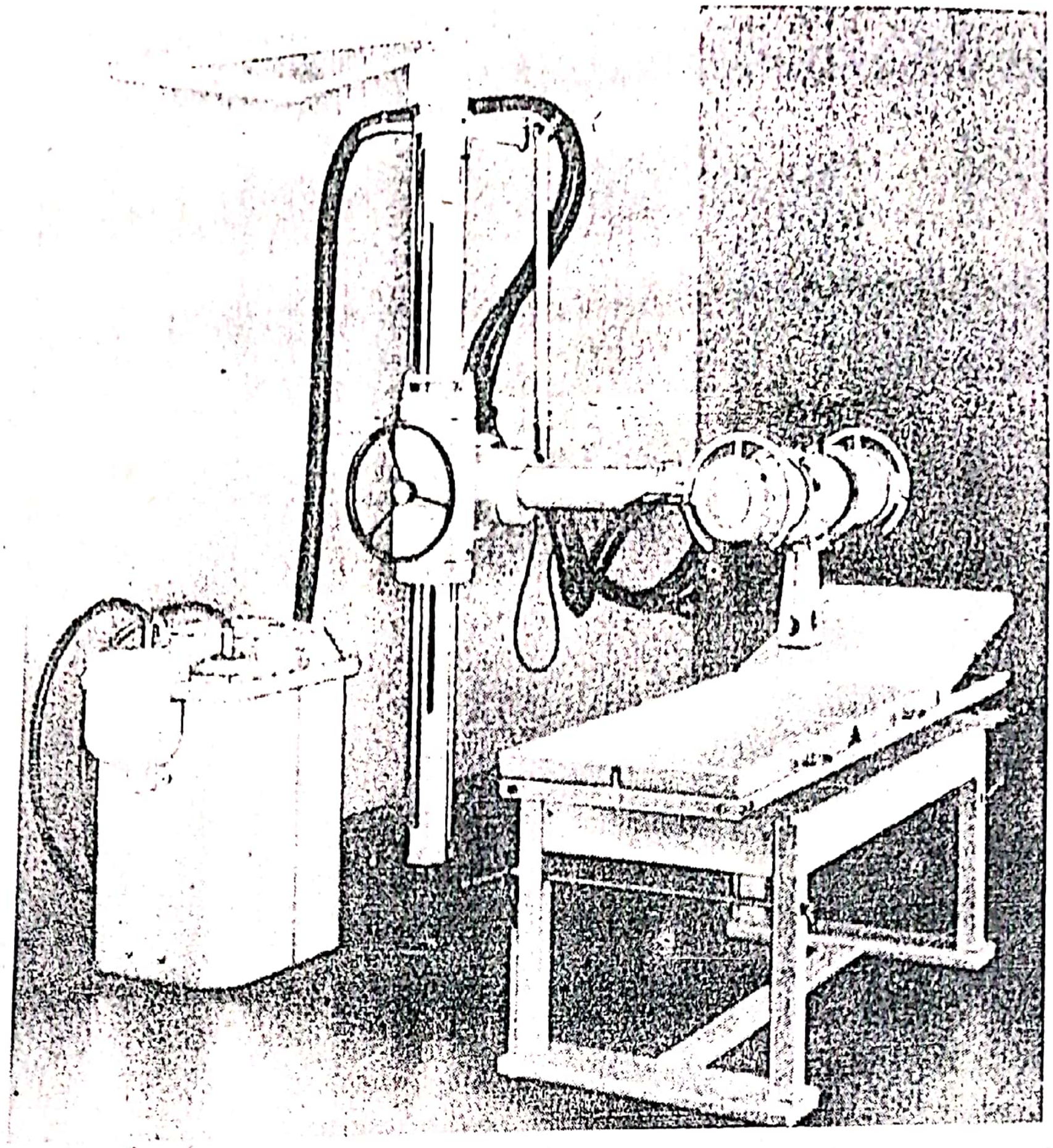

**Figure 4.2.** Photograph of Sieman's Stabilapan.

overriding concern in the orthovoltage era. With the availability of cobalt teletherapy, the *skin-sparing* properties of higher energy radiation (see Fig. 4.1e) became the major reason for the modern trend to megavoltage beams.

Although skin dose and depth dose distribution have been presented here as two examples of the limitations posed by low energy beams, there are other properties such as increased absorbed dose in bone and increased scattering that make orthovoltage beams unsuitable for the treatment of tumors behind bone.

## E. Supervoltage Therapy

X-ray therapy in the range of 500–1000 kV has been designated as "high voltage therapy" or "supervoltage therapy." In a quest for higher energy x-ray beams, considerable progress was made during the postwar years toward developing higher voltage machines. The major problem at that time was insulating the high voltage transformer. It soon became apparent that conventional transformer systems were not suitable for producing potential much above 300 kVp. However, with the rapidly advancing technology of the times, new approaches to the design of high energy machines were found. One of

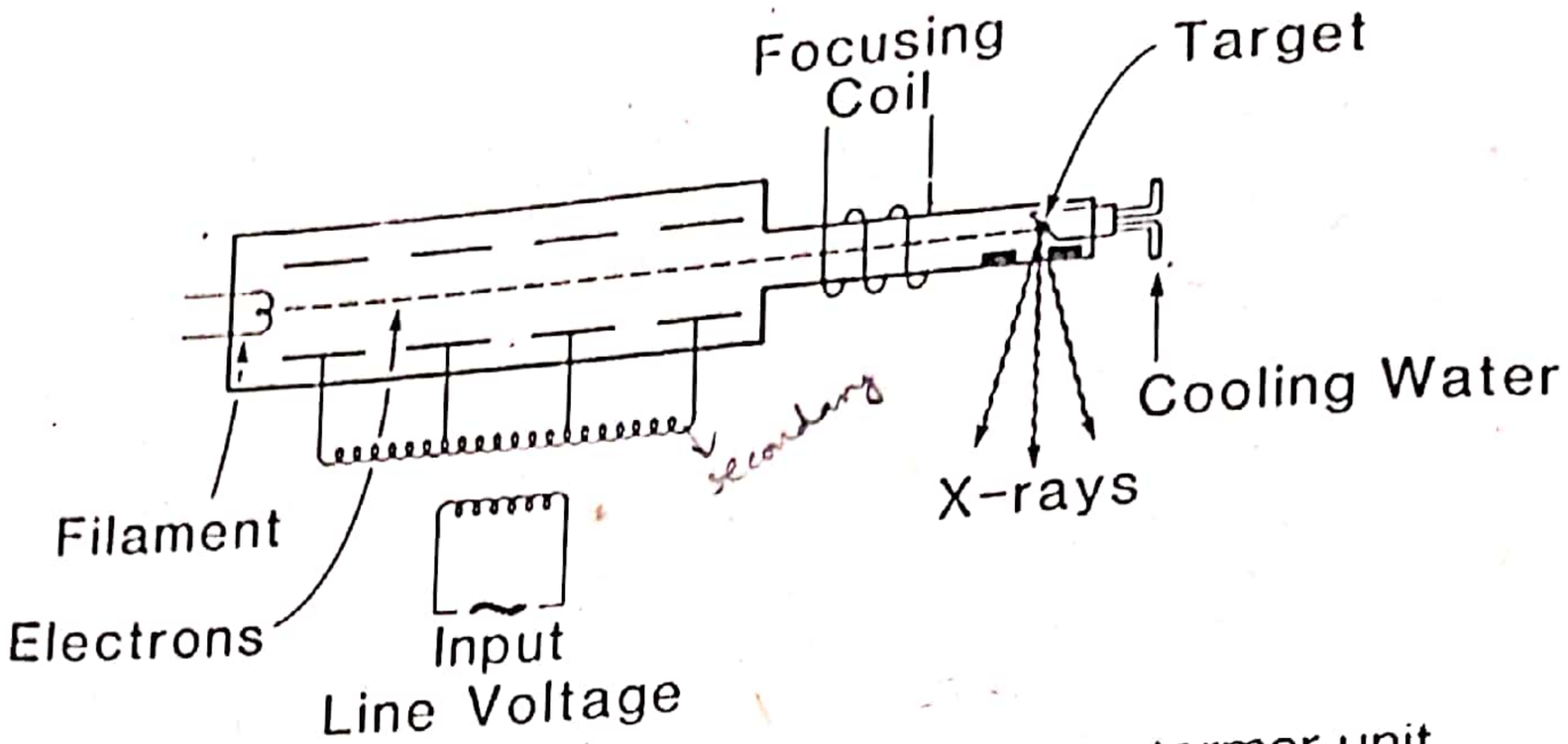


**Figure 4.3.** Diagram of a resonant transformer unit.

these machines is the resonant transformer, in which the voltage is stepped up in a very efficient manner.

## E.1. RESONANT TRANSFORMER UNITS

Resonant transformer units have been used to generate x-rays from 300 to 2,000 kV. The schematic diagram of the apparatus is shown in Fig. 4.3. In this apparatus, the secondary of the high voltage transformer (without the iron core) is connected in parallel with capacitors distributed lengthwise inside the x-ray tube. The combination of the transformer secondary and the capacitance in parallel exhibits the phenomenon of resonance. At the resonant frequency, the oscillating potential attains very high amplitude. Thus, the peak voltage across the x-ray tube becomes very large when the transformer is tuned to resonate at the input frequency. Since the electrons attain high energies before striking the target, a transmission type target (Section 3.4) may be used to obtain the x-ray beam on the other side of the target. The electrical insulation is provided by pressurized Freon gas.

## F. Megavoltage Therapy

X-ray beams of energy 1 MV or greater can be classified as megavoltage beams. Although the term strictly applies to the x-ray beams, the $\gamma$ ray beams produced by radionuclides are also commonly included in this category if their energy is 1 MeV or greater. Examples of clinical megavoltage machines are accelerators such as Van de Graaff generator, linear accelerator, betatron and microton, and teletherapy $\gamma$ ray units such as cobalt-60.

## 4.2 VAN DE GRAAF GENERATOR

The Van de Graaf machine is an electrostatic accelerator designed to accelerate charged particles. In radiotherapy, the unit accelerates electrons to produce high energy x-rays, typically at 2 MV.

Figure 4.4 shows a schematic diagram illustrating the basic principle of a Van de Graaf generator. In this machine, a charge voltage of 20–40 kV is applied across a moving belt of insulating material. A corona discharge takes

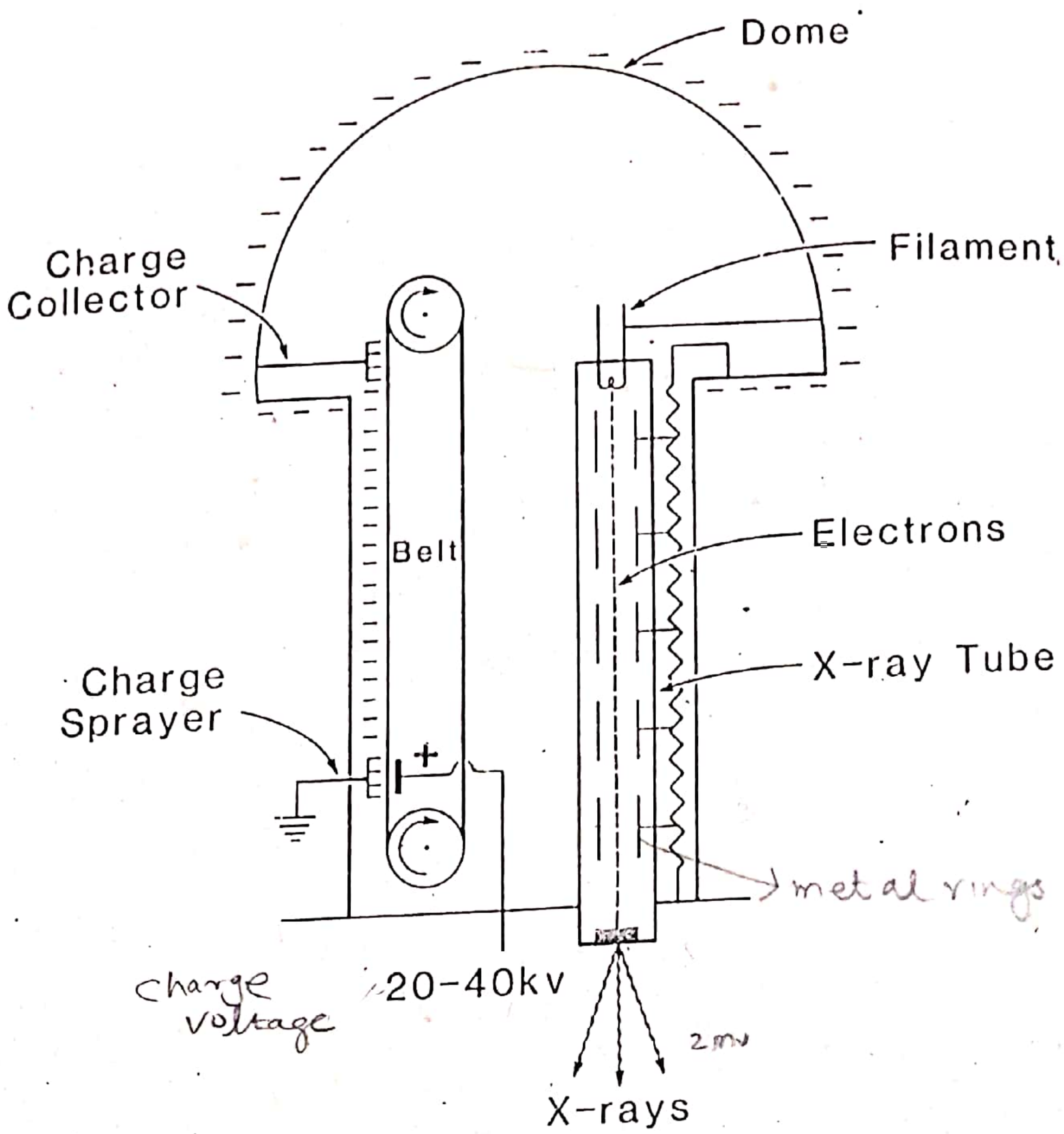


**Figure 4.4.** A Van de Graaff generator.

place and electrons are sprayed onto the belt. These electrons are carried to the top where they are removed by a collector connected to a spherical dome. As the negative charges collect on the sphere, a high potential is developed between the sphere and the ground. This potential is applied across the x-ray tube consisting of a filament, a series of metal rings and a target. The rings are connected to resisters in order to provide a uniform drop of potential from the bottom to the top. X-rays are produced when the electrons strike the target.

Van de Graaf machines are capable of reaching energies up to 10 MV, limited only by size and required high voltage insulation. Normally the insulation is provided by a mixture of nitrogen and $CO_2$. The generator is enclosed in a steel tank and is filled with the gas mixture at a pressure of about 20 atmospheres.

Van de Graaf and resonant transformer (Section 4.1E) units for clinical use are no longer produced commercially. Only about 20 units of this type still remain in operation in the United States. The reason for their demise is the emergence of technically better machines such as cobalt-60 units and linear accelerators.

## 4.3 LINEAR ACCELERATOR

The linear accelerator (linac) is a device which uses high frequency electromagnetic waves to accelerate charged particles such as electrons to high