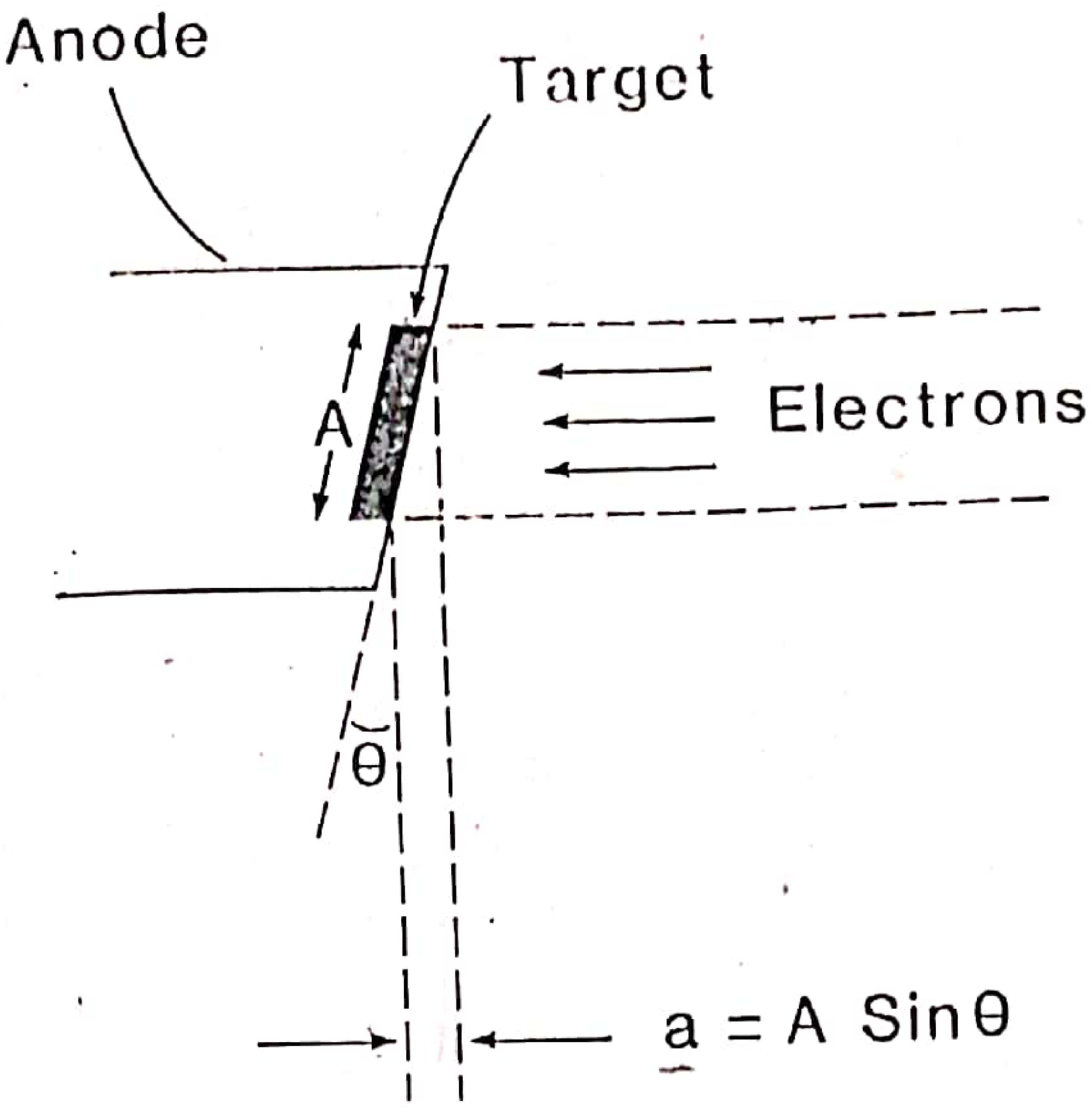

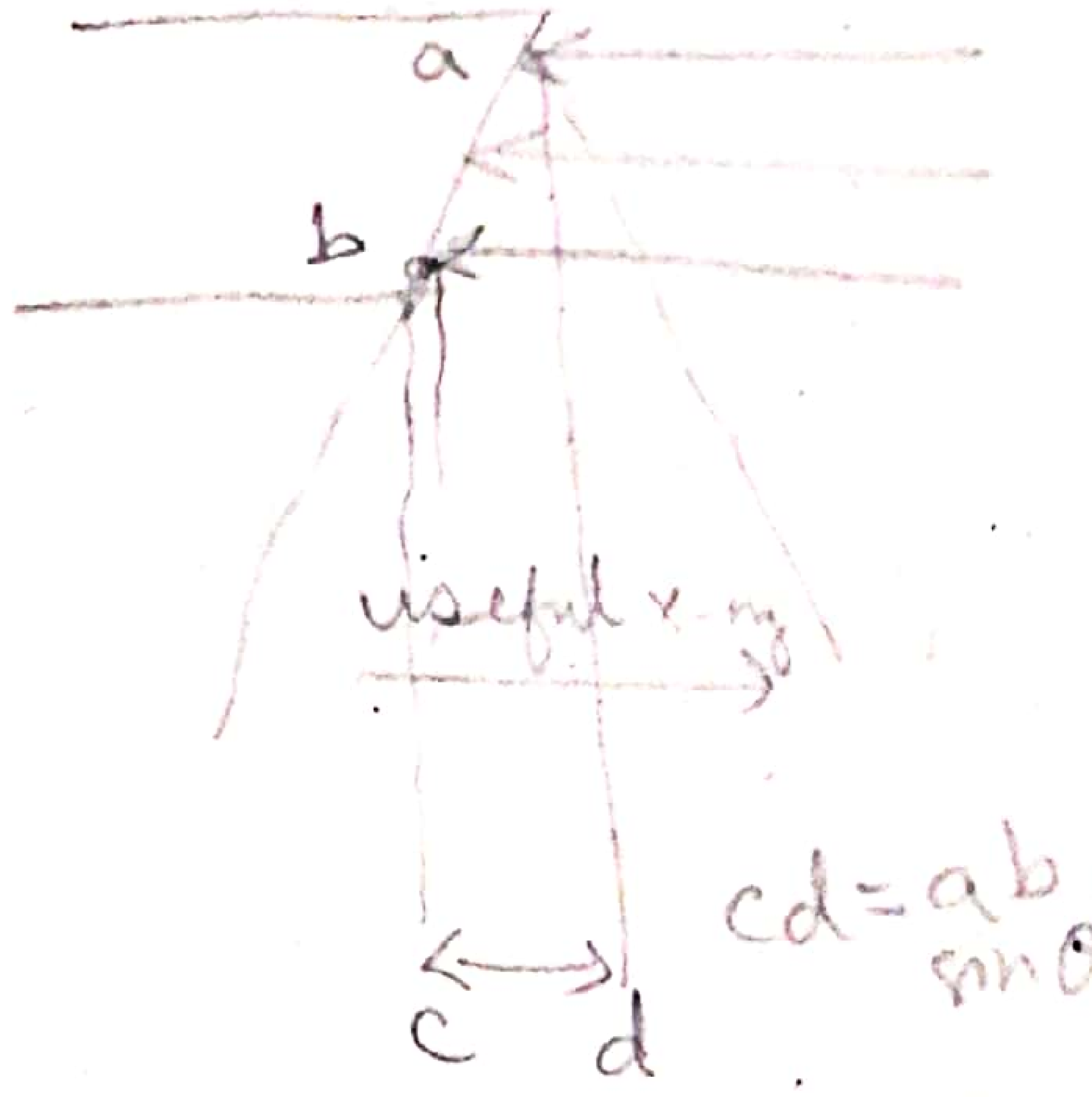

igure 3.2. Diagram illustrating the principle of line focus. The side A of the actual focal spot is educed to side a of the apparent focal spot. The other dimension (perpendicular to the plane of the aper) of the focal spot remains unchanged.

length remains the same as the original. The dimensions of the actual focal spot are chosen so that the apparent focal spot results in an approximate square. Therefore, by making the target angle θ small, side a can be reduced to a desired size. In diagnostic radiology, the target angles are quite small (6°–17°) to produce apparent focal spot sizes ranging from 0.1 × 0.1 to 2 × 2 mm. In most therapy tubes, however, the target angle is larger (about 30°) and the apparent focal spot ranges between 5 × 5 to 7 × 7 mm.

Since the x-rays are produced at various depths in the target, they suffer varying amounts of attenuation in the target. There is greater attenuation for x-rays coming from greater depths than those from near the surface of the target. Consequently, the intensity of the x-ray beam decreases from the cathode to the anode direction of the beam. This variation across the x-ray beam is called the *heel effect.* The effect is particularly pronounced in diagnostic tubes because of the low x-ray energy and steep target angles. The problem can be minimized by using a compensating filter to provide differential attenuation across the beam in order to compensate for the heel effect and improve the uniformity of the beam.

B. The Cathode

The cathode assembly in a modern x-ray tube (Coolidge tube) consists of a wire filament, a circuit to provide filament current and a negatively charged focusing cup. The function of the cathode cup is to direct the electrons toward the anode so that they strike the target in a well defined area, the focal spot. Since size of focal spot depends on filament size, the diagnostic tubes usually have two separate filaments to provide "dual-focus," namely one small and one large focal spot. The material of the filament is tungsten which is chosen because of its high melting point.

3.2 BASIC X-RAY CIRCUIT

The actual circuit of a modern x-ray machine is very complex. In this section, however, we will consider only the basic aspects of the x-ray circuit. For more detailed information the reader is referred to the literature.

A simplified diagram of a self-rectified therapy unit is shown in Fig. 3.3. The circuit can be divided into two parts: the high voltage circuit to provide the accelerating potential for the electrons and the low voltage circuit to supply heating current to the filament. Since the voltage applied between the cathode and the anode is high enough to accelerate all the electrons across to the target, the filament temperature or filament current controls the tube current (the current in the circuit due to the flow of electrons across the tube) and, hence, the x-ray intensity.

The filament supply for electron emission usually consists of 10 V at about 6 A. As shown in the diagram, this can be accomplished by using a step-down transformer in the AC line voltage. The filament current can be adjusted by varying the voltage applied to the filament. Since a small change in this voltage or filament current produces a large change in electron emission or the current (Fig. 3.10), a special kind of transformer is used which eliminates normal variations in line voltage.

The high voltage to the x-ray tube is supplied by the step-up transformer, as shown in Fig. 3.3. The primary of this transformer is connected to an *autotransformer* and a *rheostat*. The function of the autotransformer is to provide a stepwise adjustment in voltage. The device consists of a coil of wire wound on an iron core and operates on the principle of inductance. When an alternating line voltage is applied to the coil, potential is divided between the turns of the coil. By using a selector switch, a contact can be made to any

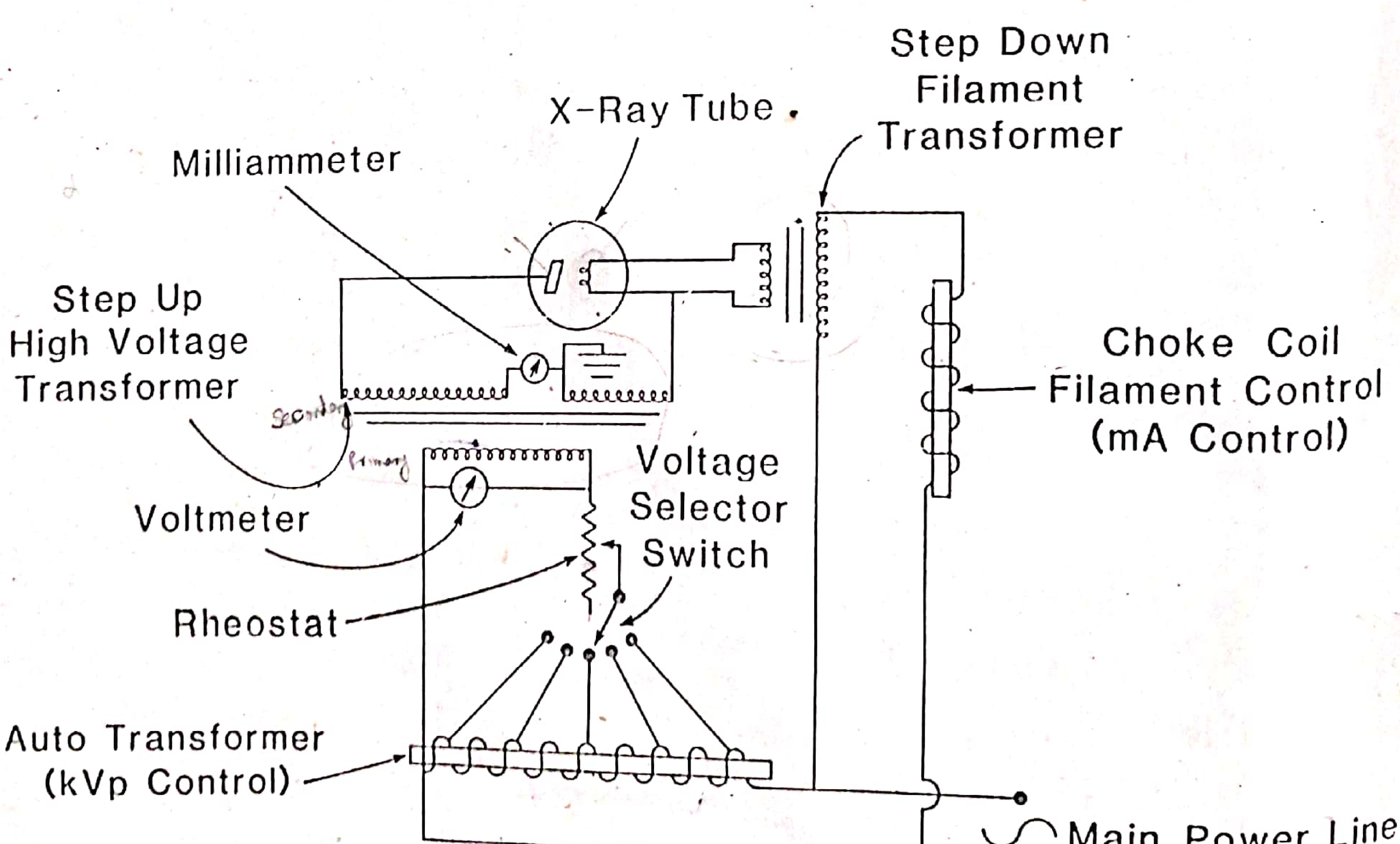

Figure 3.3. Simplified circuit diagram of a self-rectified x-ray unit.