turn, thus varying the output voltage which is measured between the first turn of the coil and the selector contact.

The rheostat is a variable resister, *i.e.* a coil of wire wound on some cylindrical object with a sliding contact to introduce as much resistance in the circuit as desired and thus vary the voltage in a continuous manner. It may be mentioned that, whereas there is appreciable power loss in the rheostat because of the resistance of the wires, the power loss is small in the case of the inductance coil since the wires have low resistance.

The voltage input to the high tension transformer or the x-ray transformer can be read on a voltmeter in the primary part of its circuit. The voltmeter, however, is calibrated so that its reading corresponds to the kilovoltage which will be generated by the x-ray transformer secondary coil in the output part of the circuit and applied to the x-ray tube. The tube voltage can be measured by the *sphere gap* method in which the voltage is applied to two metallic spheres separated by an air gap. The spheres are slowly brought together until a spark appears. There is a mathematical relationship between the voltage, the diameter of the spheres, and the distance between them at the instant that the spark first appears.

The tube current can be read on a milliammeter in the high voltage part of the tube circuit. The meter is actually placed at the midpoint of the x-ray transformer secondary coil which is grounded. The meter, therefore, can be safely placed at the operator's console.

The alternating voltage applied to the x-ray tube is characterized by the peak voltage and the frequency. For example, if the line voltage is 220 V at 60 cycles/sec, the peak voltage will be $220\sqrt{2} = 311$ V, since the line voltage is normally expressed as the root mean square value. Thus, if this voltage is stepped up by an x-ray transformer of turn ratio 500:1, the resultant peak voltage applied to the x-ray tube, will be $220\sqrt{2} \times 500 = 155{,}564$ V = 155.6 kV.

Since the anode is positive with respect to the cathode only through half the voltage cycle, the tube current flows through that half of the cycle. During the next half-cycle, the voltage is reversed and the current cannot flow in the reverse direction. Thus, the tube current as well as the x-rays will be generated only during the half-cycle when the anode is positive. A machine operating in this manner is called the *self-rectified* unit. The variation with time of the voltage, tube current, and x-ray intensity[1] is illustrated in Fig. 3.4.

3.3 VOLTAGE RECTIFICATION

The disadvantage of the self-rectified circuit is that no x-rays are generated during the *inverse* voltage cycle (when the anode is negative relative to the cathode) and therefore the output of the machine is relatively low. Another problem arises when the target gets hot and emits electrons by the process of

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[1] Intensity is defined as the time variation of energy fluence or total energy carried by particles (in this case, photons) per unit area per unit time. The term is also called energy flux density.

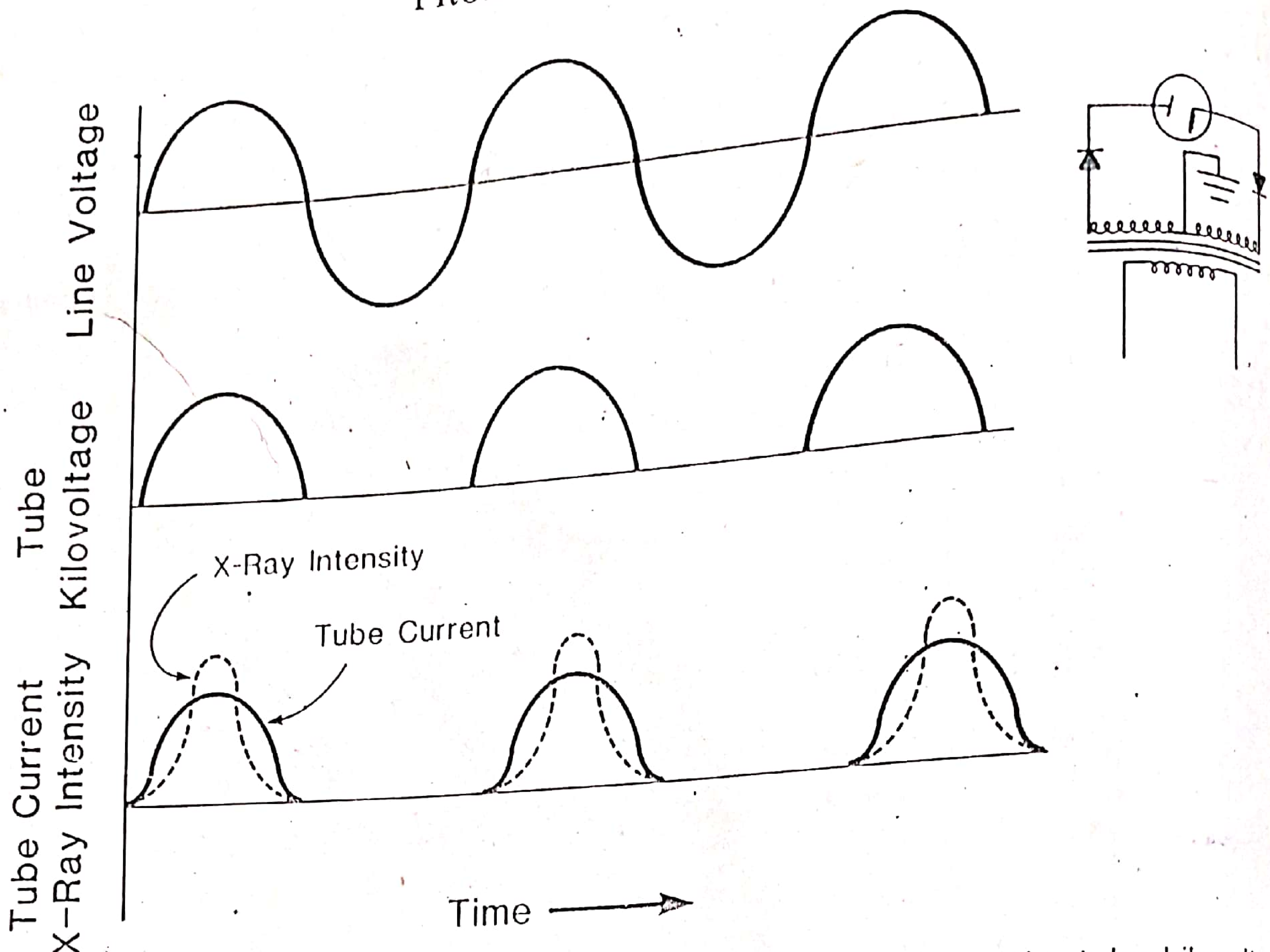

Figure 3.4. Graphs illustrating the variation with time of the line voltage, the tube kilovoltage, tube current, and the x-ray intensity for self- or half-wave rectification. The half-value rectifier circ is shown on the right. Rectifier indicates the direction of conventional current (opposite to the flow electrons).

thermionic emission. During the inverse voltage cycle, these electrons will flow from the anode to the cathode and bombard the cathode filament. This can destroy the filament.

The problem of tube conduction during inverse voltage can be solved by using voltage rectifiers. Rectifiers placed in series in the high voltage part of the circuit prevent the tube from conducting during the inverse voltage cycle. The current will flow as usual during the cycle when the anode is positive relative to the cathode. This type of rectification is called *half-wave rectification* and is illustrated in Figure 3.4.

valve rectifier

The high voltage rectifiers are either valve or solid state type. The valve rectifier is similar in principle to the x-ray tube. The cathode is a tungsten filament and the anode is a metallic plate or cylinder surrounding the filament. The current[2] flows only from anode to the cathode but the valve will not conduct during the inverse cycle even if the x-ray target gets hot and emits electrons.

A valve rectifier can be replaced by solid state rectifiers. These rectifiers consist of conductors which have been coated with certain semiconducting

[2] Here the current means conventional current. The electronic current will flow from the