Radiation physics-theoretical

Lec.3: **X-Ray Tube**

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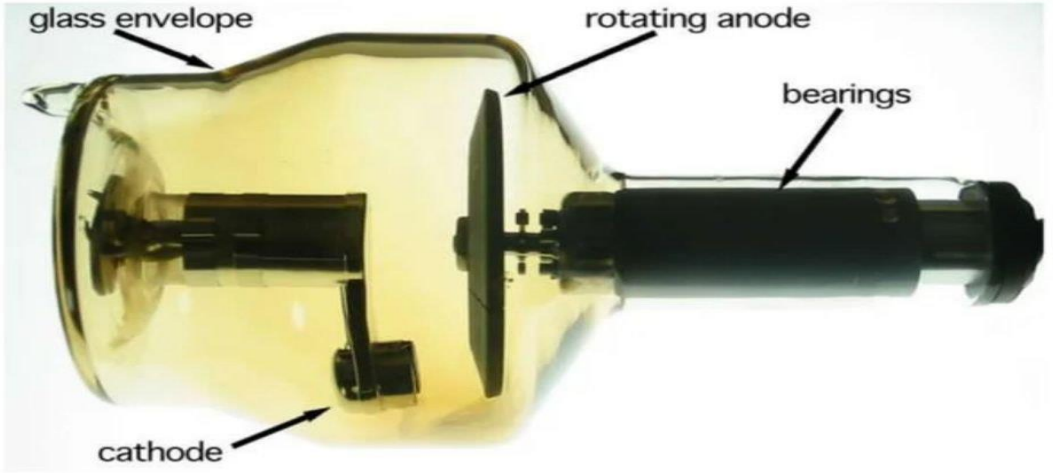
X-ray Tubes

- **X-ray tubes evolved from experimental Crookes tubes with which X-rays were first discovered on November 8, 1895, by the German physicist Wilhelm Conrad Rontgen.**

An X-ray tube is a vacuum tube that converts electrical input power into X-rays.

The availability of this controllable source of X-rays created the field of radiography, the imaging of partly opaque objects with penetrating radiation.

X-ray tubes are also used in CT scanners, airport luggage scanners, X-ray crystallography, material and structure analysis, and for industrial inspection.



For x-ray tube to function, a power supply is necessary to -

1. **Heat the filament to generate electrons**
2. **Establish a high voltage potential between the anode and cathode to accelerate the electrons.**

X-ray Tube Components:

1. Internal component

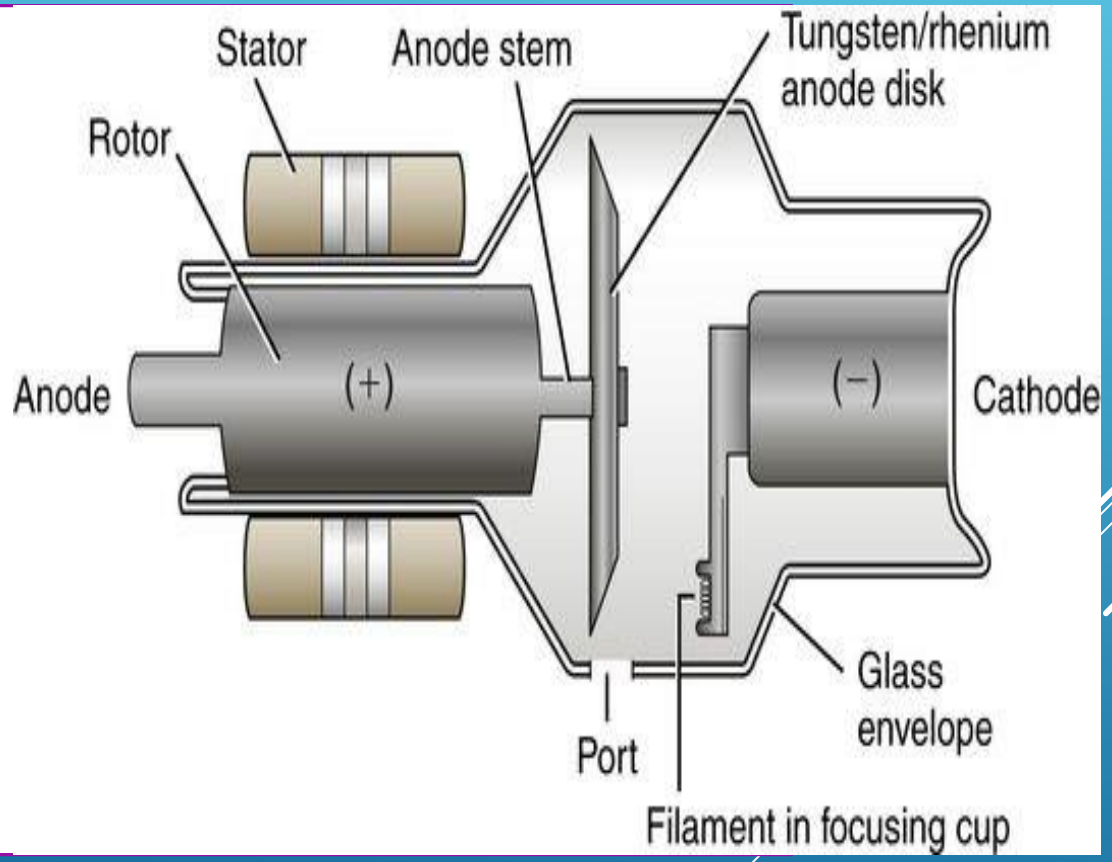
Cathode

Anode

2. External component

Glass Envelope

Protective Housing



1. Glass Envelope:

- **The anode and cathode are contained in an airtight enclosure, or envelope.**
- **The majority of x-ray tubes have glass envelopes, although tubes for some applications have metal and ceramic envelopes.**

- **The primary functions of the envelope are to**

1) **provide support mechanical**
2) **Electrical insulation for the anode and cathode assemblies**
3) **To maintain a vacuum in the tube, the presence of gases in the x-ray tube would allow electricity to flow through the tube freely, rather than only in the electron beam. This would interfere with x-ray production and possibly damage the circuit.**

2. Cathode:

The basic function of the cathode is to expel the electrons from the electrical circuit and focus them into a well-defined beam aimed the anode.

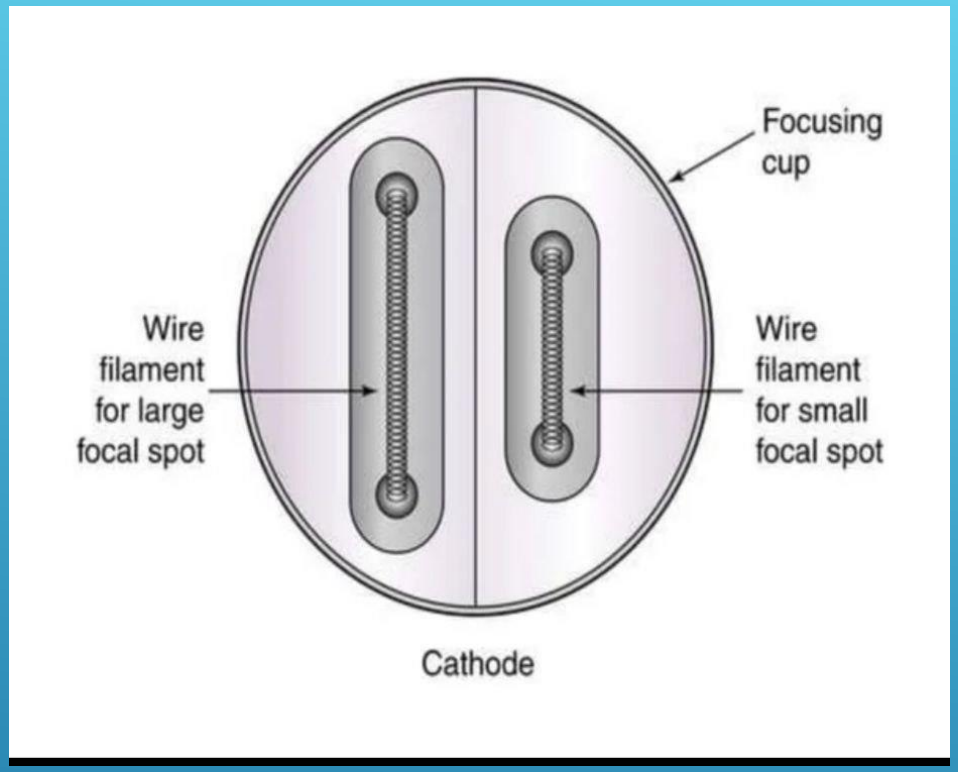
The typical cathode consists of a small coil of wire (a filament) recessed within a cup-shaped region, (the focusing cup).

A. Filament :

- It is the source of electrons within the tube.
- It is a coil of tungsten / nickel wire 2mm in diameter and 1cm in length in the small filament.
- It is mounted on two stiff wires that support it and carry the electric current, these two mounted wires lead through the glass envelope and connect to both high- and low- voltage electrical sources.
- The filament is heated by the flow of current from the low- voltage source and emits electrons at a rate proportional to the temperature of the filament.

B. Focusing Cup:

- Negatively charged, concave reflector, made of molybdenum.
- Designed to condense electron beam to small area on a focal track.
- The filament lies within the focusing cup.



the large (2 cm) filament for large part, high exposure
the small (1 cm)filament for small part, low exposure

3. Anode:

The anode is the component in which the x-radiation is produced. It is a relatively large piece of metal that connects to the positive side of the electrical circuit.

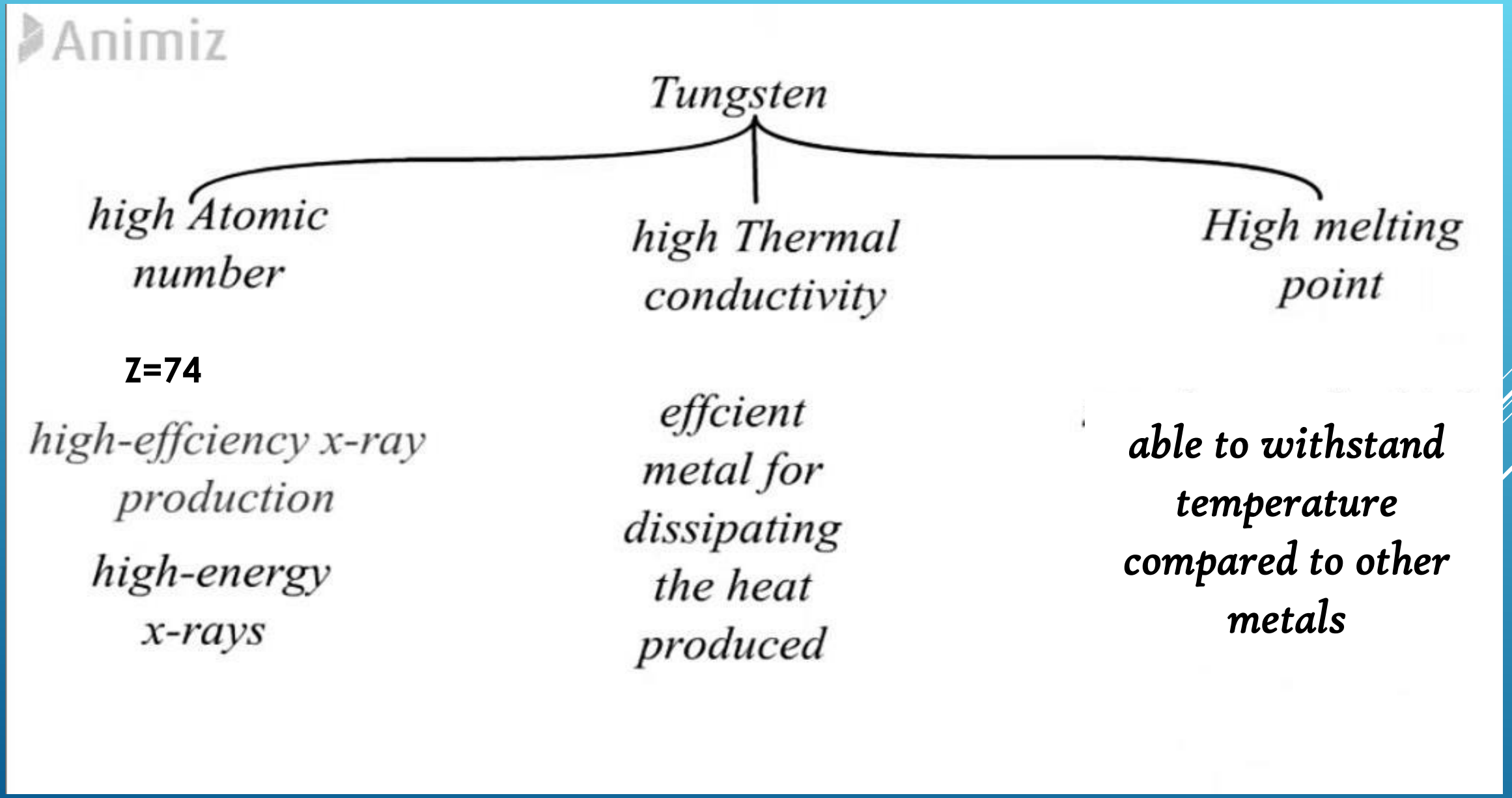
The anode has two primary functions:

(1) to convert electronic energy into x-radiation

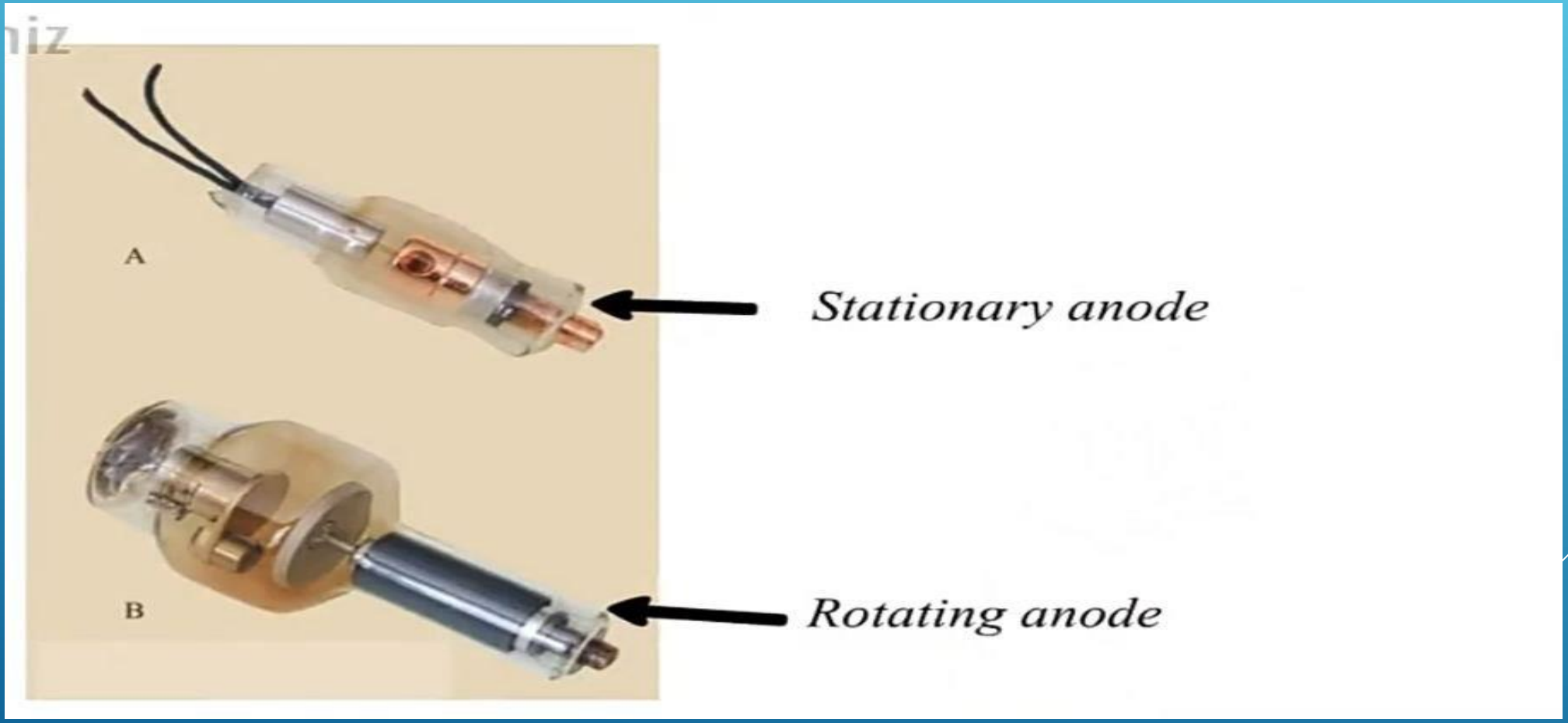
(2) to dissipate the heat created in the process.

The material for the anode is selected to enhance these functions, which is Tungsten.

The ideal situation would be if most of the electrons created x-ray photons rather than heat.


Animiz
Tungsten
high Atomic number
high Thermal conductivity
High melting point
Z=74
high-effciency x-ray production
high-energy x-rays
effcient metal for dissipating the heat produced
able to withstand temperature compared to other metals

Type Of Anode



1. Stationary Anode :A non-rotating anode in an x-ray tube so that the target surface is comparatively small.

- **It is a solid bar of copper with an inset of tungsten on the face of the bar opposite the cathode filament.**
- **The advantages of it : 1. They prevent the scattering of the X-ray radiation.**

2. The perfect bonding of the tungsten and copper ensures excellent heat dissipation

3. guarantees the out standing durability of the components.

2 . Rotating Anode :An x-ray tube in which the anode rotates when x-rays are being produced.

- **This means that there is a larger effective target surface of the anode which can be available to generate x-rays.**
- **Constructed of Tungsten target, Molybdenum and Graphite.**

4. Protective Housing :

Protective Housing : Designed to enclose an x-ray tube and to provide two types of protection, radiological and electrical.

- **Provides mechanical support and prevents damage.**
- **Some contain cooling fan to air-cool the tube.**
- **They reduce the level of radiation leakage.**
- **Prevents electric shock to patient and exposure.**

