Ministry of Higher Education and Scientific Research

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College of Technology And Health Sciences

Radiological Equipment Techniques

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Lecture 2: x_ray tube

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X_ ray tube

The x-ray tube is the most important part of the x-ray machine because the tube is where the x-rays are produced.

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. In contrast to other sources of ionizing radiation, X-rays are only produced as long as the X-ray tube is energized. X-ray tubes are also used in CT scanners, airport luggage scanners, X-ray crystallography, material and structure analysis, and for industrial inspection**.**

The major x-ray tube components are :

1. The support structure
2. The glass or metal enclosure.
3. The protective housing

FIGURE (1)

These tubes work by ionisation of residual gas within the tube. The positive ions bombard the cathode of the tube to release electrons, which are accelerated toward the anode and produce X-rays when they strike it**.**

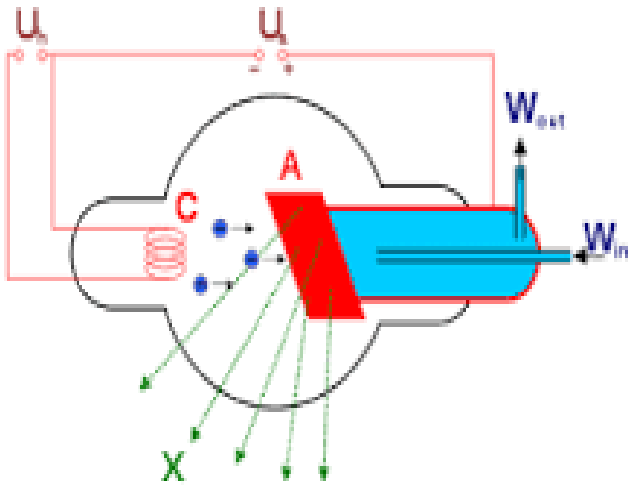

FIGURE (2)

Envelope

The entire cathode assembly and all of the anode assembly except the stator are enclosed within a glass or metal envelope commonly called the tube.

Figure 1: (A) Glass envelope. (B) Metal envelope.

- Metal envelopes are increasingly becoming more common. They prolong tube life because they eliminate the problem of tungsten vaporization

-The primary function of the envelope is to maintain the vacuum between the cathode and anode.

Protective Housing

Modern x-ray tubes must be mounted inside a protective housing (Figure 3). The housing controls leakage and scatter radiation, isolates the high voltages, and provides a means to cool the tube.

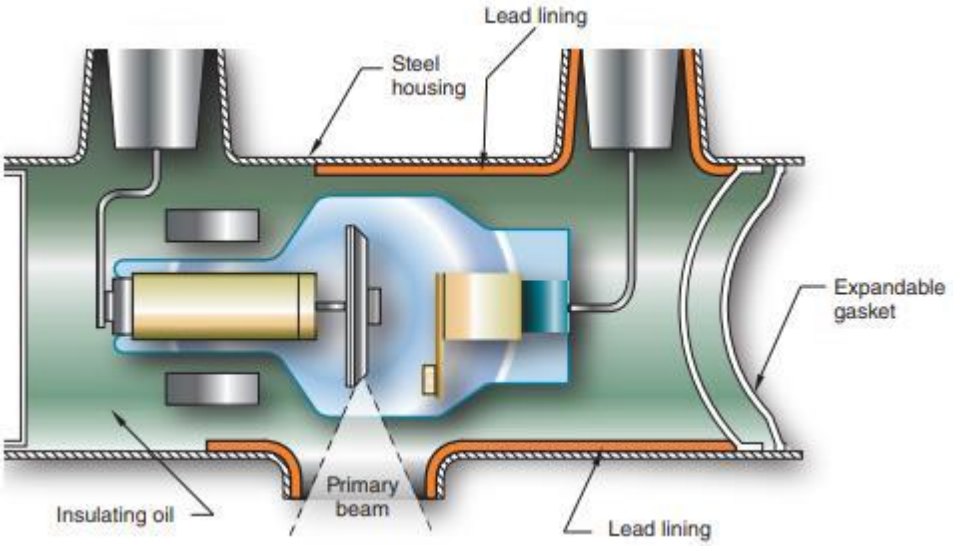

FIGURE (3) A diagnostic x-ray tube housing.

The Internal Structures of The X-Ray Tube Are:

1. The anode
2. The cathode.

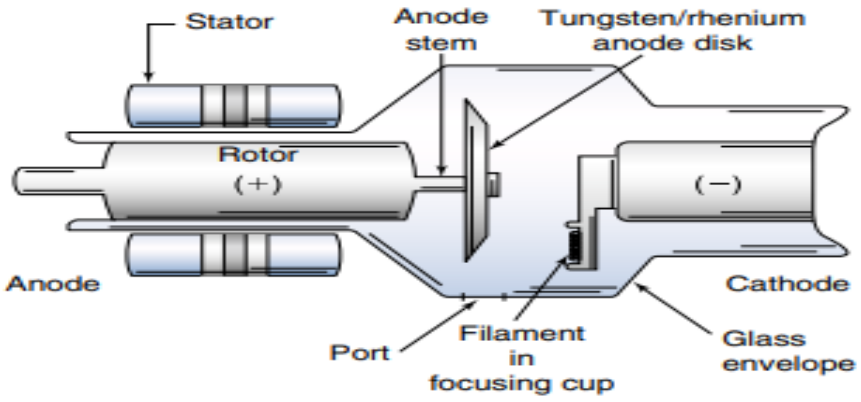

FIGURE (4) **Structure of a typical x-ray tube.**

Cathode

The cathode is the negative side of the x-ray tube; it has two primary parts, a filament and a focusing cup.
shows a double-filament cathode surrounded by a focusing cup (Its purpose is to focus the stream of electrons.).
The filament is a coiled tungsten wire, which is the source of electrons during x-ray production.

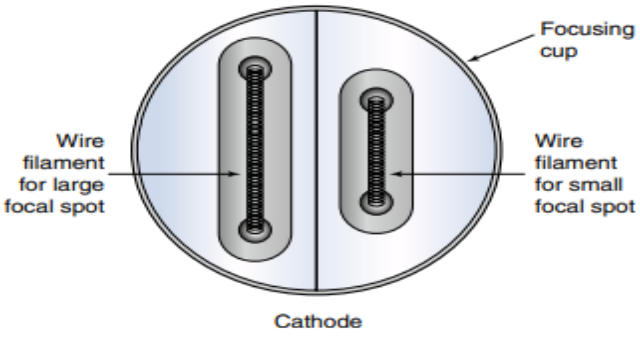

Figure 5: Dual-filament cathode

- Most x-ray tubes are referred to as dual-focus tubes because they have two filaments: one large and one small.

Anode

The anode is the positive side of the x-ray tube; it conducts electricity and radiates heat and x-rays from the target.
The target is the part of the anode that is struck by the focused stream of electrons coming from the cathode. The target stops the electrons and allowing the production of x-rays
- the anode composed of tungsten, because tungsten has a high atomic number (74) and a high melting point (3,400°C, it efficiently produces x-rays .

There are two types of anodes:
1. Stationary
2. Rotating

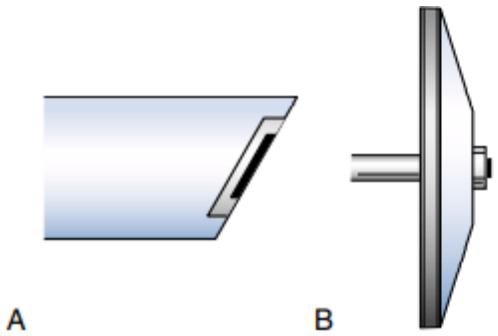

Figure 6 : Side views of a stationary anode (A) and a rotating anode (B)

- Rotating anodes can withstand higher heat loads than stationary anodes because the rotation causes a greater area, or focal track .

X-ray Production

1. The electrons are emitted from a filament in the cathode. Emission occurs when the filament is heated by passing a current through it.

2. The electrons that move from the cathode to the anode travel extremely fast, approximately at half the speed of light. The moving electrons, which have kinetic energy, strike the target and interact with the tungsten atoms in the anode to produce x-rays.

3. Electrons are accelerated by a voltage difference applied from the cathode to the anode. This voltage is supplied by a generator

4. The electron from the cathode interacts with the orbital electrons or the nuclear field of target atoms. These interactions result in the conversion of electron kinetic energy into thermal energy (heat) and electromagnetic energy in the form of infrared radiation (also heat) and x-rays.

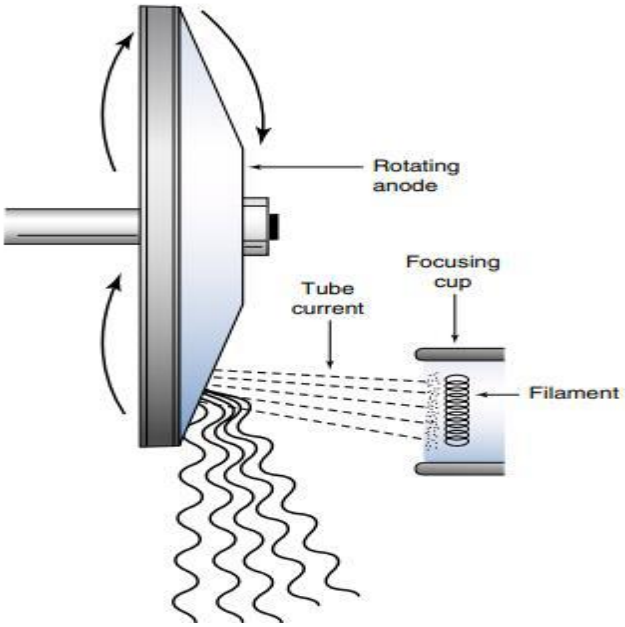

Figure (7) X-ray Production

A small percentage is converted to x-rays by two main methods

1. Bremsstrahlung Interactions

Bremsstrahlung is a German word meaning “braking” or “slowing down radiation.” Bremsstrahlung interactions occur when a projectile electron is slowed by the nuclear field (very strong electrostatic force) of a target atom nucleus. As the electron loses energy, it suddenly changes its direction, and the energy loss then reappears as an x-ray photon.

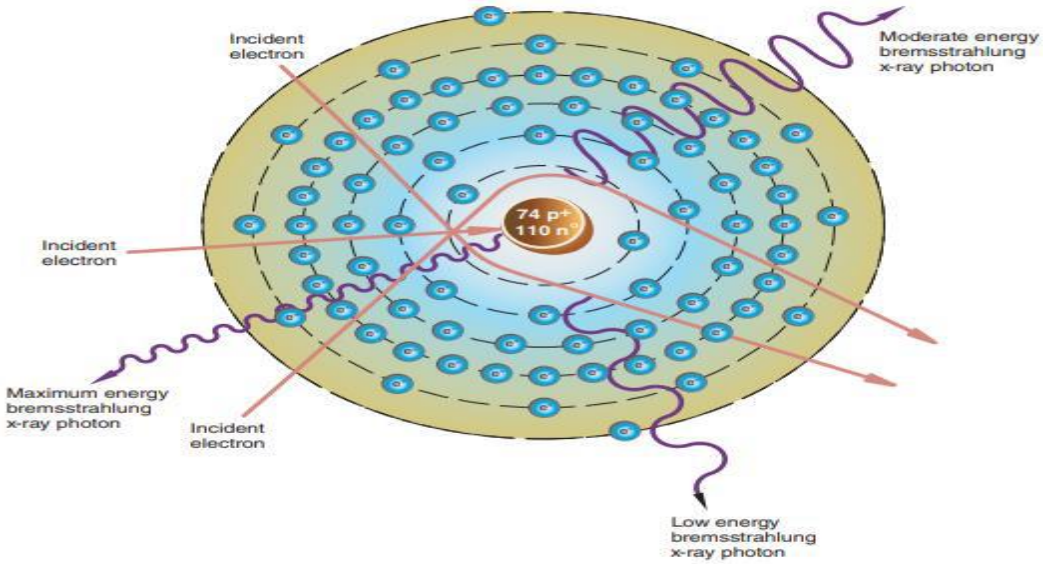

Figure 8: Bremsstrahlung interaction

- Most x-ray interactions in the diagnostic energy range are bremsstrahlung.

2. Characteristic Interactions

Characteristic interactions are produced when a projectile electron interacts with an electron from the inner shell (K-shell) of a tungsten atom.

- The electron must have enough energy to eject the K-shell electron from its orbit. Projectile electron, it must possess energy equal to or greater than 69.5 keV. When the K-shell electron is ejected from its orbit, an outer-shell electron drops into the open position and creates an energy difference.

- The energy difference is emitted as an x-ray photon

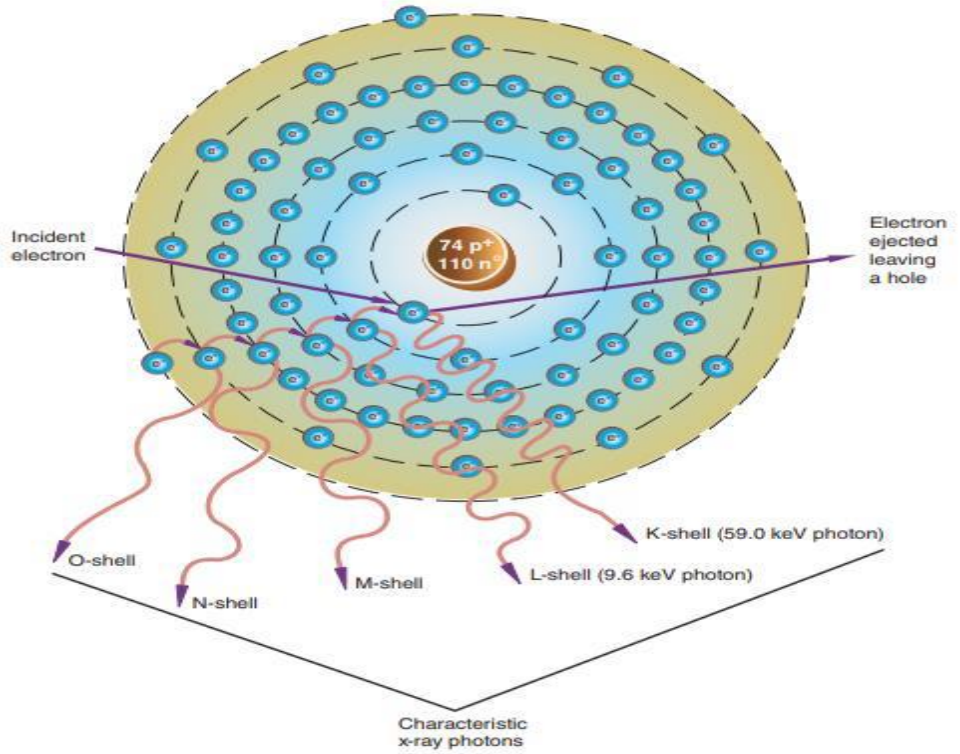

Figure 9 : Characteristic interaction.

These interactions are termed characteristic x-rays because their energies are characteristic of the tungsten target element.

Tube failure

The causes of tube failure are threefold:

1. A ***single excessive exposure*** causes pitting or cracking of the anode.
2. ***Long exposure time*** causes excessive heating of the anode,
3. Even with normal use, ***vaporization of the filament*** causes tungsten to coat the glass or metal enclosure; this eventually causes arcing.

Questions:

1- Explain x ray tube and what is The major x-ray tube components ?
2- What is The Internal Structures of The X-Ray Tube ?
3- What is anodes types ?
4- explain how X-ray Production ?
5- Explain methods that A small percentage is converted to x-rays?
6- What is the causes of tube failure?