X-Ray machine

X-rays are a form of electromagnetic radiation, similar to visible light. X-rays have higher energy and can pass through most objects, including the body.

Medical x-rays are used to generate images of tissues and structures inside the body. Photographic films are used to visualize the output. X ray picture is called a radiograph.

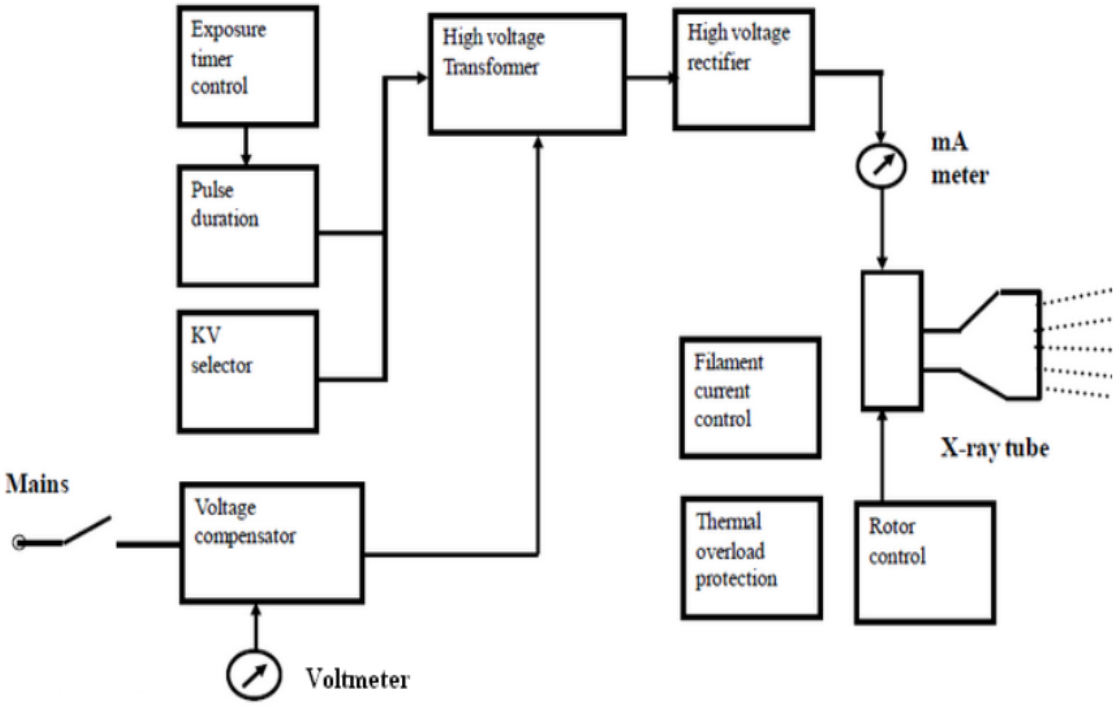
Generation of X rays

X-rays are produced when the electrons are suddenly decelerated upon collision with the metal target. They are generated inside high vacuum X ray tube. The tube has an electrode pair- cathode and anode. The cathode is a heated filament. The machine passes current through the filament, heating it up. The heat releases electrons off of the filament surface. The positively-charged anode, a flat disc made of tungsten, draws the electrons across the tube. X rays arise from the anode and are focused using collimators.

The high-impact collisions involved in X-ray production generate a lot of heat. A motor rotates the anode to keep it from melting. A cool oil bath surrounding the envelope also absorbs heat.

The entire mechanism is surrounded by a thick lead shield. This keeps the X-rays from escaping in all directions. A small window in the shield lets some of the X-ray photons escape in a narrow beam. The beam passes through a series of filters on its way to the patient.

Block Diagram



The system has two parts- One to produce high voltage and the other to control the heating of X ray tube filament.

High Voltage Generator

These produce high voltages to the HV transformers for a specified time. The transformers produce 20KV – 200 KV at the output. High ratio step up transformers are used. The voltage produced determines the contrast of the image. Higher the voltage, higher the contrast.

High Voltage Rectifier

This rectifies the HV produced by HVT and supplies to the anode of the X ray tube. Usually either a bridge or solid state rectifier is used.

Thermal overload protection

The heat of the X ray tube should not exceed a specified range. If it does exceed, the protection system turns off the machine.

High tension Cable

Highly insulated cables are used as connection to generators. These cables have 3 conductors individually insulated for low filament voltages. They are surrounded by semi conducting and non conducting rubber.

Collimators and Grids

These limit the X -ray beams to a specified area of interest. They are placed between X ray tube and patient. It is made of lead with circular r rectangular holes.

Grids are inserted between patient and film cassette to reduce the loss of contrast due to scattered radiation.

Kilovoltage selector

It allows precise selection of desired kV.

Voltmeter and voltage compensator control

Most X-ray machines are designed to operate on a 220 voltage power source. A voltmeter measures the voltage of electric current and voltage compensator allows adjustment of voltage.

Timer and exposure button

The quantity of X-rays reaching the film is directly related to the X-ray tube current and the time for which the tube is energized i.e. the exposure time.

The range of exposure time in available machines is large with minimum setting being as short as 0,001 second. An exposure device mostly consists of a two-stage exposure button of which first half depression rotates the anode and a complete depression, after a short pause, causes actual radiographic exposure.

Computed Tomography/ CT

Computed tomography (CT) is a diagnostic imaging test used to create detailed images of internal organs, bones, soft tissue and blood vessels.

The term tomography comes from the Greek words tomos (a cut, a slice, or a section) and graphein (to write or record).

In CT, the picture is made by viewing the patient via X ray imaging from numerous angles, by mathematically reconstructing the detailed structures and displaying the reconstructed images on a video monitor.

Principle

It involves the determination of attenuation characteristics for each small volume of tissue in the patient slice which constitute the transmitted radiation intensity recorded from various irradiation directions.

These calculated tissue attenuation characteristics compose the CT image

$I_t = I_o e^{-\mu x}$

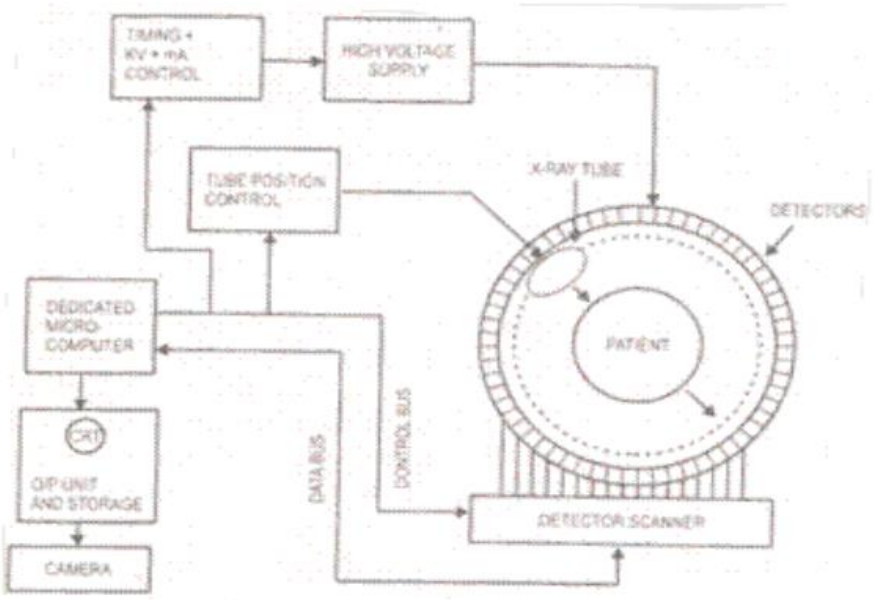
I_t – Transmitted intensity

I_o – Incident radiation intensity

x – thickness of tissue

μ - Attenuation coefficient of tissue

Block Diagram



The basic three components of a CT scanner are an X-ray tube, an object (patient) and a detection system.

Computer controls the timing, anode voltage and beam current supply.

High voltage DC supply drives the X ray tube which can be rotated around the patient in gantry.

X ray passes through the patient get absorbed and remaining transmitted photons fall on the 1000 radiation detectors fixed around the gantry.

When the photons strike the detector, they are converted into scintillations.

The computer samples the output of the detector parallel to the X ray tube. Calculations are also done by the computer.

Output unit produces a visual image on the CRT.

Scanning system

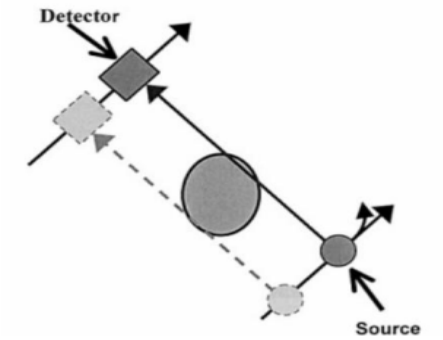
First generation

Detectors: one

Type of beam: pencil-like X-ray beam

Tube-detector movements: translate-rotate/transverse and index arrangement

Duration of scan (average): 25-30 mins



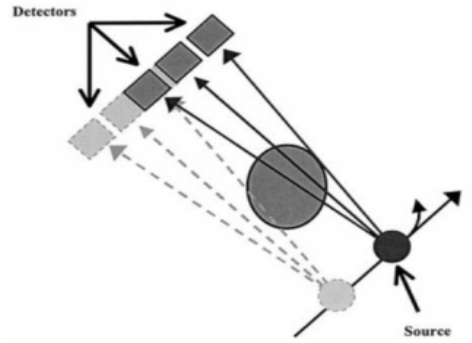
Second generation

Detectors: multiple (up to 30)

Type of beam: fan shaped x-ray beam

Ttube-detector movements: translate-rotate

Duration of scan (average): less than 90 sec



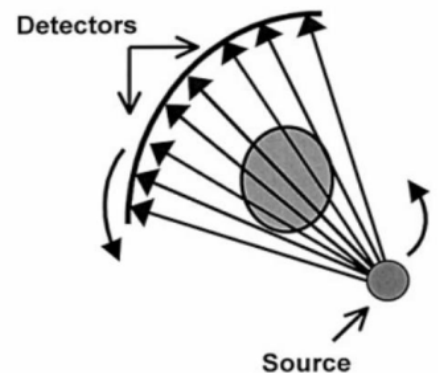
Third generation

Detectors: multiple, originally 288; newer ones use over 700 arranged in an arc

Type of beam: fan shaped x-ray beam

Tube-detector movements: rotate-rotate

Duration of scan (average): approximately 5 sec



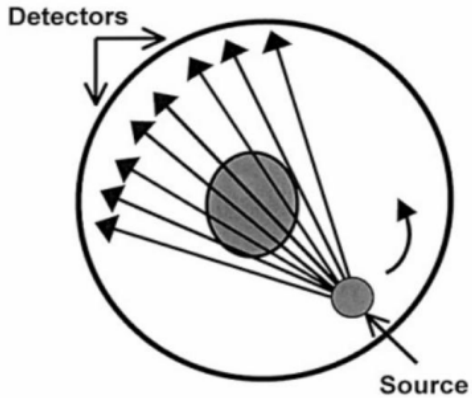
Fourth generation

Detectors: multiple (more than 2000) arranged in an outer ring which is fixed

Type of beam: fan shaped x-ray beam

Tube-detector movements: rotate-fixed

Duration of scan (average): few seconds



Fifth Generation

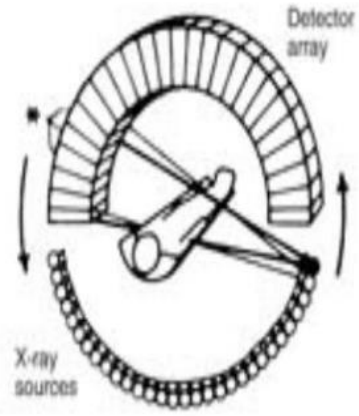
X-ray tube is a large ring that circles patient, opposed to detector ring.

X - rays produced = high - energy electron beam

No moving parts to this scanner gantry

It is capable of 50 - millisecond scan times and can produce 17 CT slices/second

Stationary/stationary geometry



Sixth Generation

Slip-ring gantry designs

Very high power x-ray tubes

Interpolation algorithms to handle projection data