

## ***Introduction:***

**General radiography**, also known as **plain film radiography**, is the specialty within medical imaging that utilizes projectional radiography to examine anatomy. It is often referred to as simply 'x-ray' within medical imaging departments.

the differential absorption of X rays in tissues and organs, owing to their atomic composition, is the basis for the various imaging methods used in diagnostic radiology. the principles in the production of X rays have remained the same since their discovery. however, much refinement has gone into the design of X ray tubes to achieve the performance required for today's radiological examinations.

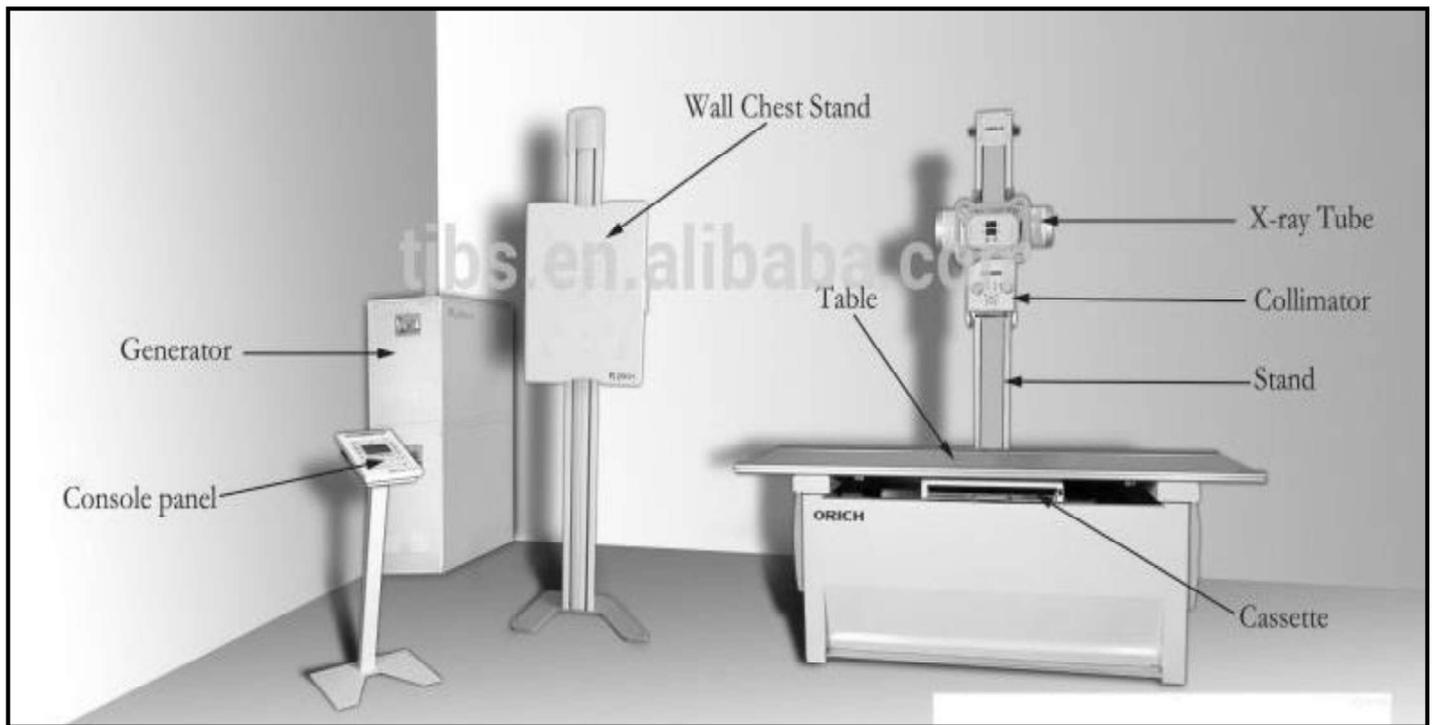
### ***X – Ray machine system***

An **X-ray machine** is a device that uses X-rays for a variety of applications including medicine, X-ray fluorescence, electronic assembly inspection, and measurement of material thickness in manufacturing operations. In medical applications, X-ray machines are used by radiographers to acquire x-ray images of the internal structures (e.g., bones) of living organisms.

#### **▲ X – Ray machine shape & size:**

The many different types of x-ray machines are usually identified according to either the energy of the x – rays they produce or the purpose for which those x – rays is identified.

The radiographic x-ray tube is attached to an overhead movable crane assembly that permits easy positioning of the tube and aiming of the x-ray beam. Regardless of the type of x-ray imaging system used, a patient-supporting examination couch is required. This examination couch may be flat or curved but must be uniform in thickness and as transparent to x-rays as possible. Carbon fiber couches are strong and absorb little x-radiation. This contributes to reduced patient radiation dose. Most patient couches are floating—easily unlocked and moved by the radiologic technologist—or motor driven. Just under the couch is an opening to hold a thin tray for a cassette and grid.



**Fig (1): illustration of x – ray system parts.**

The function of the x-ray machine is to provide a sufficient intensity of electron flow in a controlled manner to produce an x – ray beam of desired quantity and quality. Conventional x-ray radiography produces images of anatomy that are shadowgrams based on x-ray absorption. The x-rays are produced in a region that is nearly a point source and then are directed on the anatomy to be imaged. The x-rays emerging from the anatomy are detected to form a two-dimensional image, where each point in the image has a brightness related to the intensity of the x-rays at that point. Image production relies on the fact that significant numbers of x-rays penetrate through the anatomy and that different parts of the anatomy absorb different amounts of x-rays.

### ▲ X-Ray Machine System Types

#### By Mobility/Installation:

**Fixed X-ray Systems:** High-power, stationary units in dedicated rooms, often floor-mounted or ceiling-mounted.

**Mobile X-ray Systems:** Motorized, wheel-based units for in-ward imaging.

**Portable X-ray Machines:** Compact, lightweight, and hand-carried units for field use.

**By Technology:**

**Traditional/Analog:** Uses traditional, non-digital film.

**Digital Radiography (DR):** Uses digital sensors for immediate image acquisition.

**Computed Tomography (CT) Scanners:** Produces 3D, cross-sectional images.

**By Function/Application:**

**Fluoroscopy Systems:** Provides real-time, continuous X-ray imaging.

**C-arm Systems:** Mobile fluoroscopy machines used in operating rooms.

**U-arm Systems:** Versatile, motorized systems with the tube and detector mounted on a rotating U-shaped arm.

**Mammography Systems:** Specialized, low-dose systems for breast imaging.

**Dental Systems:** Includes intraoral (inside the mouth) and extraoral (panoramic/cephalometric) machines.

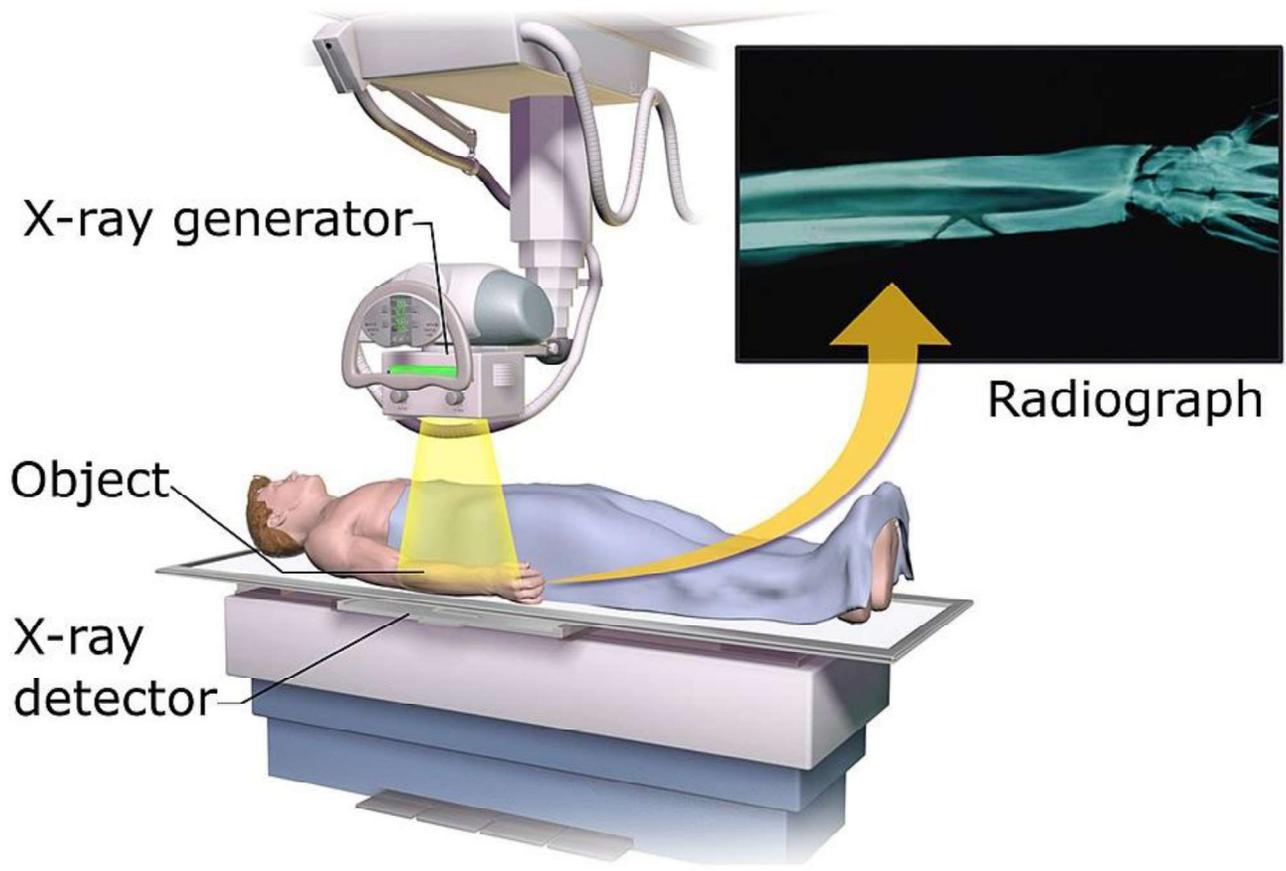
**DEXA Scanners:** Used to measure bone mineral density.

**▲ Principle parts of X – ray machine:**

Every x-ray machine, regardless of its design, has three principle parts :

- The control console
- The high – voltage generator
- The x – ray tube

In of x-ray apparatus, such as dental and portable machines, these three components are housed compactly. Most, however , have the head of the x-ray tube located in one room , the control console in an adjoining room, and a protective barrier separating the two.

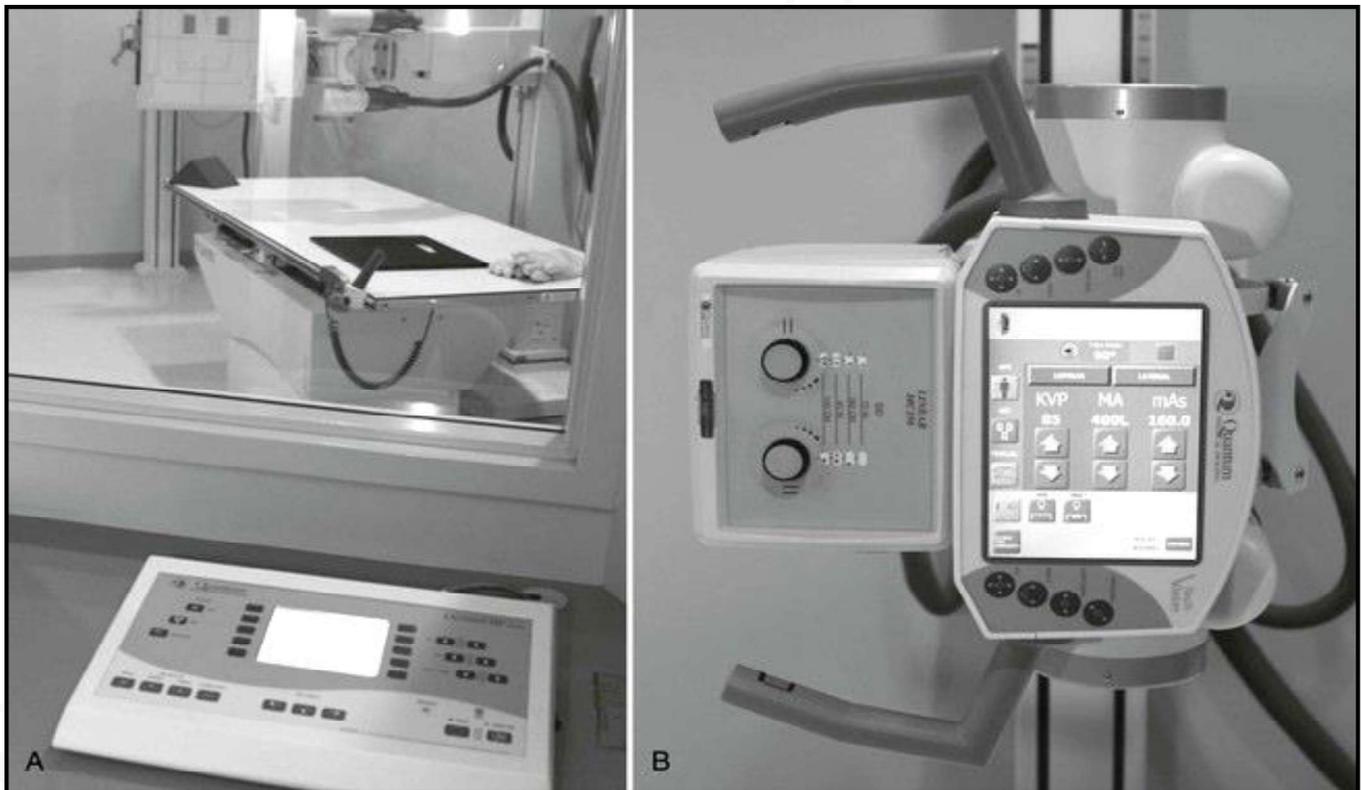


**Fig (2): Principal parts of X – ray machine.**

## *The operating console*

In medical imaging applications, an X-ray machine has a control console that is used by a radiologic technologist to select X-ray techniques suitable for the specific exam, a power supply that creates and produces the desired kVp (peak kilovoltage), mA (milliamperes, sometimes referred to as mAs which is actually mA multiplied by the desired exposure length) for the X-ray tube, and the X-ray tube itself.

The operating console is the technician's "cockpit", allowing control of X-ray tube voltage (kVp), current (mA), and exposure time to determine beam intensity and penetration. The console allows a technologist to establish an x-ray beam of adequate quantity (number of x-ray photons) and quality (effective energy of x-ray photons)



**Fig. (3): Operating console components.**

The console usually provides control of line compensation, kVp, mA, and exposure time. It is a separate unit connected electrically to the X-ray machine. Control of x-ray energy and quantity is attained through adjustments of the voltage potential in kilovolts (kV), the x-ray tube current in milliamperes (mA), and the exposure time in seconds (s), by meters and switches contained in the operating console to select kVp, mA and exposure time, respectively. Several electrical circuits and voltage transformers within the x-ray generator assembly provides this capability. Figure 3 & 4 illustrates the major x-ray operating console components.

↳ **Voltage compensator control (Line Compensation):**

The line compensation compensates the incoming voltage so that a constant voltage may be used during exposure and not a varying voltage. Most x-ray machines are designed to operate on a 220 V power source, although some can operate on 110 V or 440 V. Unfortunately, power companies are not capable of providing 220 V accurately and continuously. Because of variations in power distribution to the hospital and in power consumption by the various sections of the hospital, such variation in input voltage results in larger variation in x-ray output, which is unacceptable if high-quality radiographs are to be consistently produced.

The line Compensator incorporates a voltmeter to measure the voltage provided to the unit and a control to adjust that voltage to precisely 220 V. The control is wired to the autotransformer shown in (Fig. 4). In most machines these days such a system is automatic.

↳ **Kilovoltage selector:**

It allows precise selection of desired kV. In some machines, this control is automatically linked to a certain milliamperage (mA) value. In such a case, a high kVp is available at a relatively low mA and vice versa. In the modern type of X-ray apparatus and in those operating on a pre-determined milliamperage, the kilovoltage control will be directly calibrated, so that the described value can be easily selected.

## The effect of kilovoltage

As already stated, it is the passage of a high voltage current across an x-ray tube which results in a production of X-rays. The higher the kilovoltage employed for this purpose, the more rapidly the electrons travel, the greater the amount of energy released on impact and the shorter the wavelength of the X-rays produced.

↳ x-rays of short wavelength (high frequency) are sometimes described as " hard X-rays " while those of longer wavelength (low frequency) may be spoken of as " soft ".

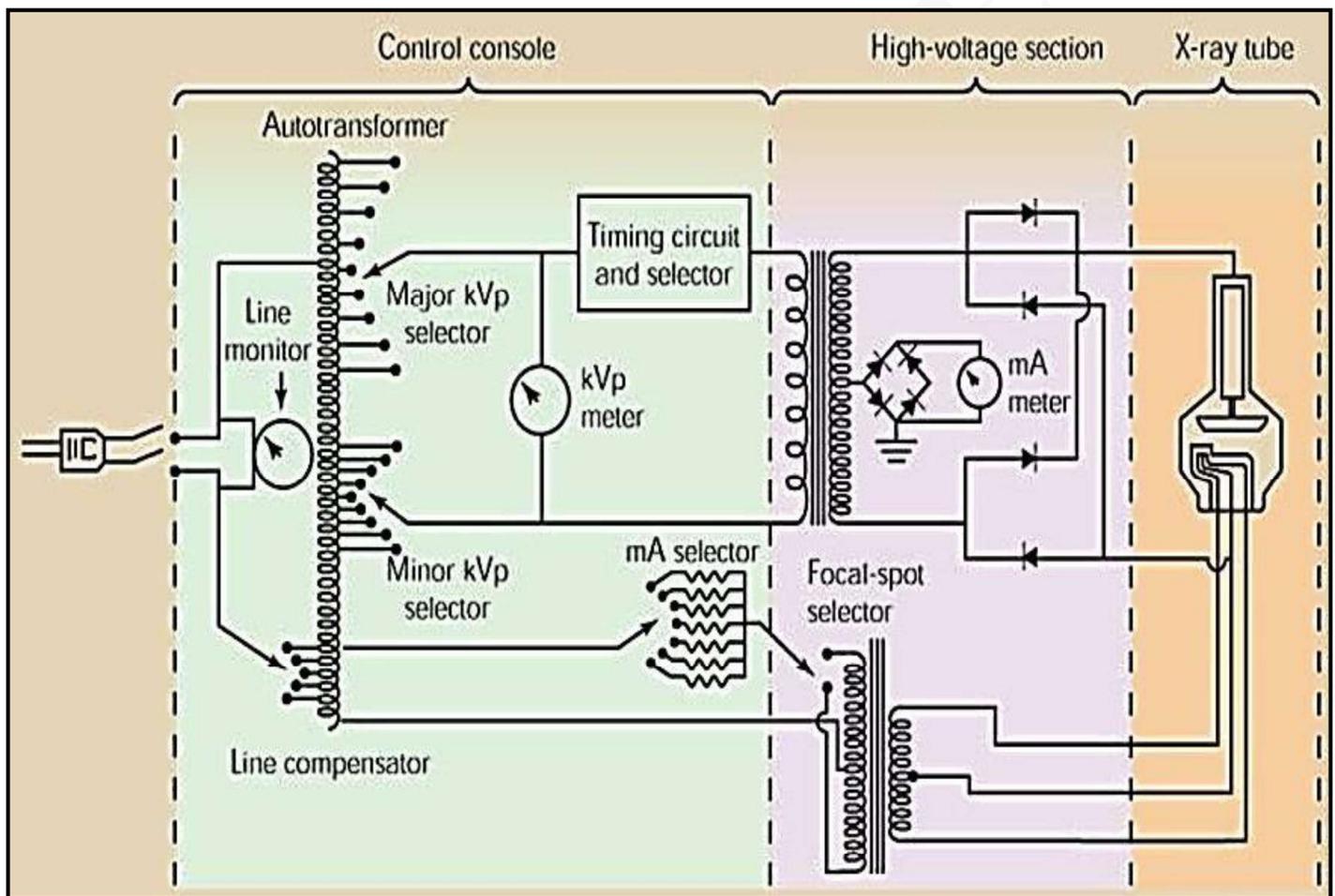


Fig. (4): components of x-ray machine.

### **↳ Milliammeter and milliamperage selector:**

X – Ray tube current is controlled through a separate circuit called filament circuit. It indicates the current passing through the tube during an actual X-ray exposure. The voltage of the filament circuit is provided from taps of the autotransformer.

The significance of the milliamperage is that it affects the amount of X-rays produced, and a level has to be selected which is sufficient to produce an easily recognizable image on the X-ray film. However the amount of radiation is also controlled by the length of the exposure and is best expressed in milliamperage-seconds (i.e., the milliamperage multiplied by the time in seconds).

### **The effect of Milliamperage:**

The amount of current which travels across an X-ray tube during an exposure depends on the number of electrons available to carry that current, which in turn varies with the current supplies to the filament in the cathode. The tube current (measured in milliamperes) is directly related to the amount of X-rays produced.

\*The above effect is often summarized by stating that kilovoltage affects the quality and the milliamperage (more correctly the mAs) the quantity of the X-ray produced by a particular apparatus.

### **↳ Timer and exposure button:**

X-ray exposure timers are critical components in the high-voltage circuit that control the duration of radiation emission, regulating the total number of photons produced. They ensure precise, safe imaging by controlling the length of time (measured in seconds, ms, or pulses) that current (mA) flows through the tube, which directly impacts image receptor exposure.

In any given radiographic examination, 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. *Exposure timing circuitry* starts and ends the application of high voltage across the x-ray tube electrodes. The timer is located on the control console and is electrically connected to the exposure switch.

**Exposure duration**, defined as the time of x-rays that being produced for image formation, varies depending on the diagnostic imaging procedure and modality being used.

For radiography, exposure durations are extremely short, typically 100 ms, combined with large tube current (200 –1,000 mA) to achieve high photon fluence. The electronic timer provides an accurate control of exposure, which can reduce voluntary and involuntary patient motion artifacts and preserve image quality.

**There are five basic types of timing circuits:**

- 1- Mechanical timer
- 2- Synchronous timers
- 3- Electronic timers
- 4- mAs timers
- 5- Automatic exposure control timers (AEC) (phototimers)

⇒ **Mechanical timers:**

The mechanical timer operates by clockwork. A preset exposure time is dialed by turning a knob that winds a spring. When the exposure button is depressed, the spring is released and unwinds. The time required to unwind corresponds to the exposure time. Mechanical timers are inexpensive, but not very accurate. now rarely used due to poor precision.

⇒ Synchronous timers:

Is a precision device that driven by a synchronous motor which operates at 60 revolutions per second. Used in older machines.

⇒ Electronic timers:

The most expensive, most complicated and most accurate of the x-ray timers. Consist of complex circuitry based on the time required to charge a capacitor through a variable resistance. They allow for a wide range of intervals that can be used to make serial exposures.

⇒ mAs timers:

Special kind of electronic timer called a mAs timer, monitors the product of mA and time and terminates the exposure when the desired mAs is attained.

⇒ Automatic exposure control timers (AEC) (phototimers):

A phototimer is a device that measures the quantity of radiation reaching the image receptor and automatically terminates the exposure when sufficient radiation to provide the required optical density has reached the image receptor.