DENTAL RADIOLOGY

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Radiation

- **It is the process of emission and propagation of energy through space or substances in the form of waves or particles.**

Radiology

- Science that deals with diagnosis, therapeutic and researches application of high energy radiation.

Roentgenology

- Science that deals with application of X-ray on any field

Dental radiology

- **It is the branch of science that deals with the use of radiation in diagnosis of dental diseases.**

Dental radiography

- It is the art of producing an image or picture for intra- or extra-oral structures on a dental film using X-ray.

Radiograph

It is the shadow features (image) received on a radiation-sensitive film emulsion by exposure to ionizing radiation directed through an area or region or substance of interest, followed by chemical processing of the film.

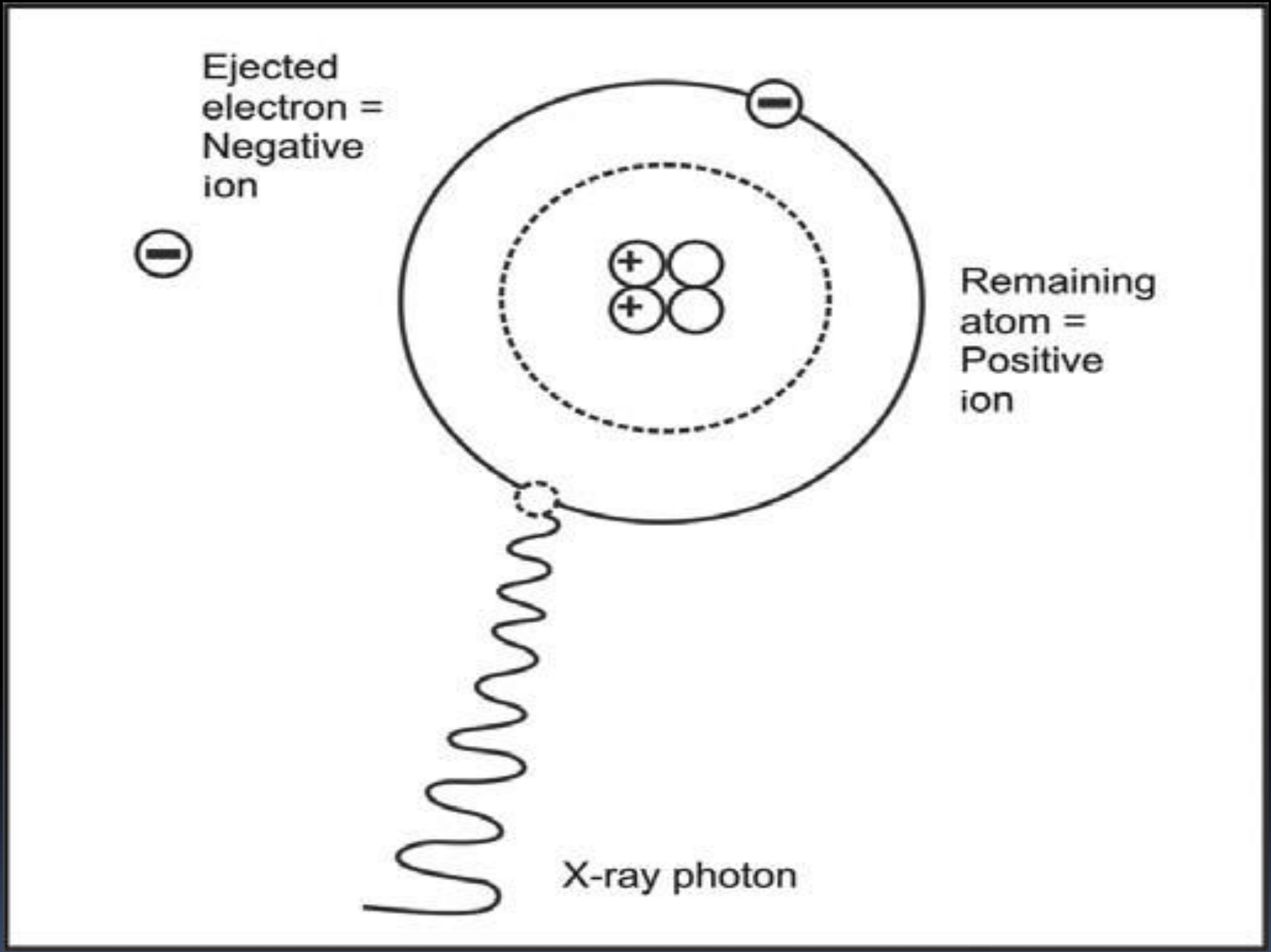
- It is basically dependent on the differential absorption of radiation directed through heterogeneous media.

X radiation

- X rays make up x radiation, are defined as weightless package of pure energy(photons) that are without electrical charge and that travel in waves along a straight line with a specific frequency and speed.
- It is a form of electromagnetic radiation having wavelength ranging from 0.01 to 10 nm, and energies in the range of 100 eV to 100 keV.

Ionization

- **Ionization** or **ionisation**, is the production of ions, or the process of converting atom into ions.
- It is the process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons, often in conjunction with other chemical changes.
- The resulting electrically charged atom or molecule is called an ion.


Ejected
electron =
Negative
ion
Remaining
atom =
Positive
ion
X-ray photon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I think I lost an electron!!!
Are you sure?
Ya…I'm positive

Ionizing radiation

- **Ionizing radiation** (**ionising radiation**) is defined as the process by which certain unstable atoms or elements undergo spontaneous disintegration or decay, in an effort to attain a more balanced nuclear state.
- Ionizing radiation is made up of energetic subatomic particles, ions or atoms moving at high speeds (usually greater than 1% of the speed of light),and electromagnetic waves on the high-energy end of the electromagnetic spectrum.

- **IONIZING**
- Gamma rays
- X rays
- Higher ultraviolet part
- **NON IONIZING**
- Lower ultraviolet part
- visible light(including nearly all types of laser light)
- Microwaves
- Infrared
- Radio waves

Ionizing radiation hazard symbol

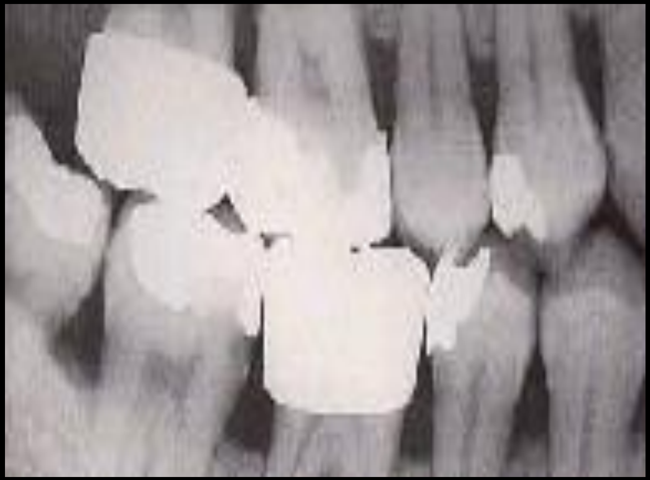
- 2007 ISO radioactivity danger symbol intended for IAEA[international atomic energy agency]Category 1, 2 and 3 sources defined as dangerous sources capable of death or serious injury

Radiolucent

- Objects that permitting the passage of radiant energy with relatively little attenuation by absorption and appear black on the film, such as silicate restoration, pulp tissues, gingiva, and carious lesion.
- Another definition; Objects partly or wholly penetrable by roentgen rays; the image of such a material on the film ranges from dark gray to black.


Radiopaque

- Objects that absorb X-rays and appear white on radiograph, such as amalgam restoration, enamel, and bone.
- Another def.: Objects that not freely penetrable by radiation.
- OR Objects highly resistant to penetration by roentgen rays; the image of such a material appears on the film within range of gray to white.



HISTORY

X-ray

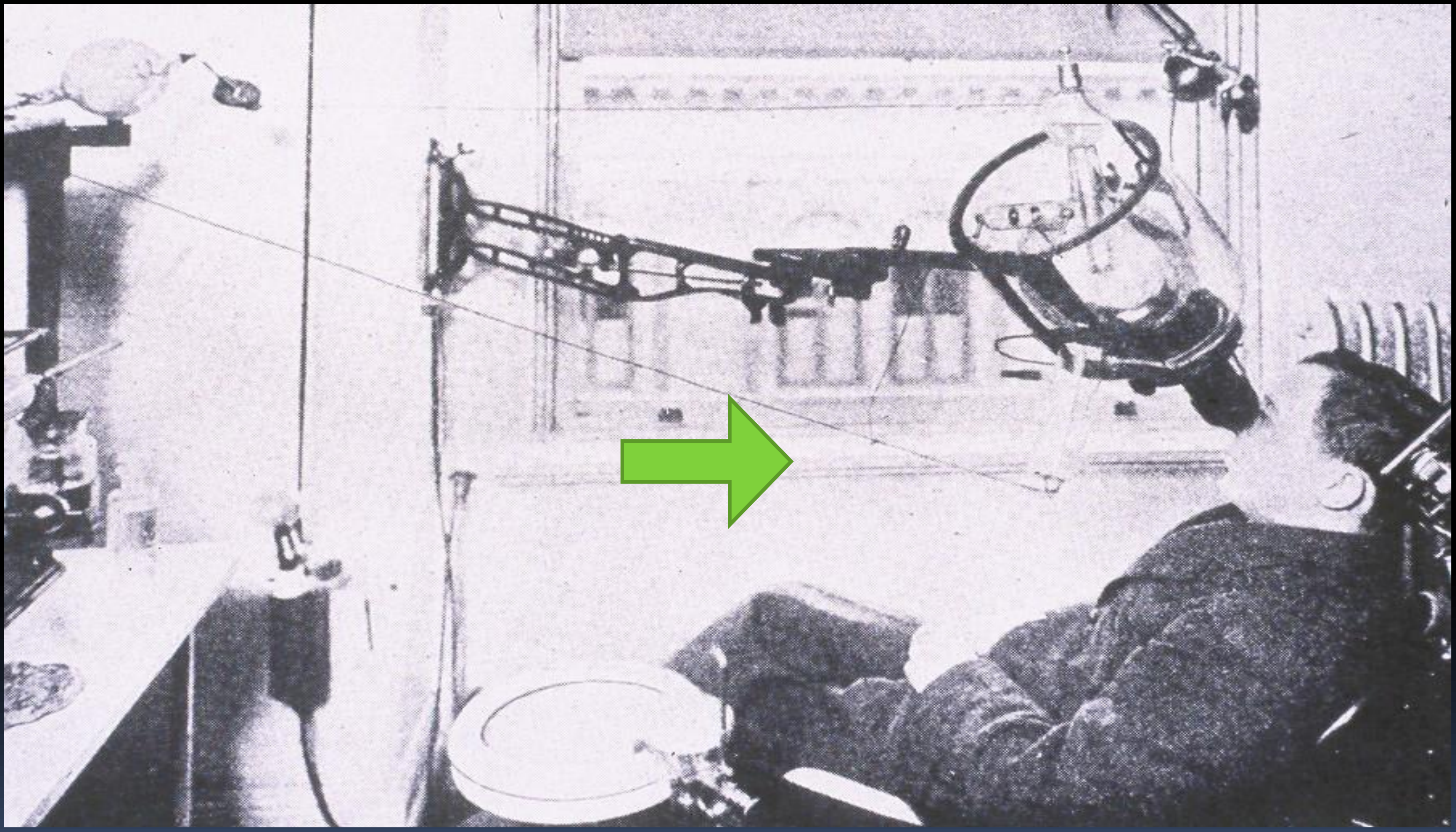
- X-rays were first discovered in 1895 by Wilhelm Conrad Roentgen, the professor of physics and director of the physics institute at the University of Wurzburg in Bavaria.
- Hence the term ROENTGEN RAYS often applied to mechanically generated x-rays.
- He won a Noble prize for his discovery
- Roentgen called them X-rays after the mathematical symbol X for unknown.

- Roentgen soon found that photographic plates were sensitive to the newly discovered rays.
- He convinced his wife to participate in an experiment.
- Roentgen placed her hand on a cassette loaded with a photographic plate.

He then aimed the activated cathode ray tube at her hand for fifteen minutes.

- When the image was developed, the bones of her hand and the two rings she wore were clearly visible.

- Within 2 weeks after Roentgen was made his discovery public, the first dental radiograph was made by German dentist Otto Walkoff, who placed small glass photographic plates wrapped in rubber dam in his own mouth and exposed them for 25 minutes.



Early x-ray machine. Arrow points to "live" electrical wire.

X ray tube

- Various x ray tubes are:

  gas tube

  regulator tube

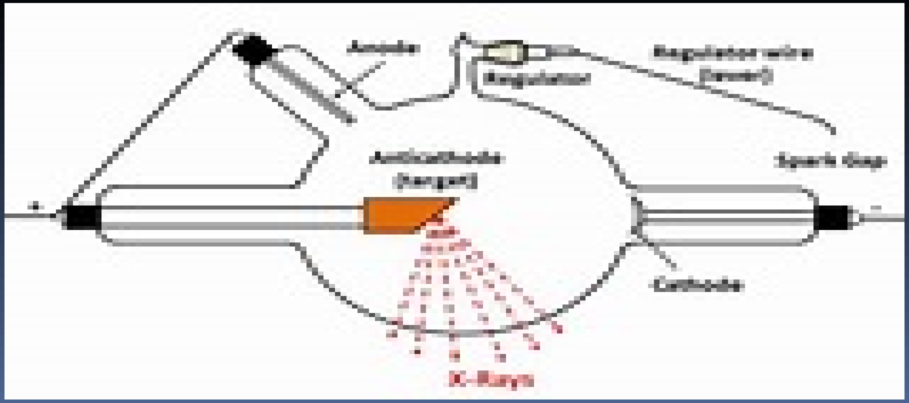
  vaccum tube

  self regulating tube

Gas tube

- The gas molecules combined with vaporized residue from the anode and cathode which gradually increase the vaccum.

- When the vaccum become too high, no x ray were produced and the tube was considered to be “cranky”.
- This cranky tube could be heated by an alcohol lamp to drive gas molecules from its walls which maintains continuous production of x rays.



Regulator tube

- To facilitate alteration of vaccum, an accessory bulb was added to the main bulb and chemicals placed in the accessory bulb were heated to produce gas which reduce the vaccum in the tube.
- When the vaccum in the tube became too high, resistance increased and the current supplying the tube was diverted to the low vaccum accessory bulb by means of adjustable wire.

- This resulting in heating of the caustic potash, which produces gas and causes the vaccum in the main tube to be lowered sufficiently to produce x rays again.

Vaccum tube

- J.E.lilienfield develop this to eliminate gas
- The electrons were extracted from the cathode by using a high potential across the tube.
- To increase the drain of electrons from the cathode, the electrons were ejected by pointed cathode.

- The operation of such a cold cathode tube was described as ‘ticklish’.
- Due to the use of curved cathode, charges become so crowded on the curved part that they easily leak (lilienfield effect).
- So to increase the drain of electron from the cathode, the electrons were ejected from pointed cathode.
- Disadvantage: he can’t heat the cathode enough

Self regulating tube

- Developed by H.L.Sayew(1897)
- Has a second pair of electrons embedded in potassium carbonate.
- When the vaccum is too high, the current would arc between the electrodes. Automatically heating the potassium carbonate, which release little gas and restore the efficient operation of x ray tube.

William Coolidge & X-Ray Tube

- William Coolidge invented the X-ray tube popularly called the Coolidge tube.
- His invention revolutionized the generation of X-rays and is the model upon which all X-ray tubes for medical applications are based.
- Other inventions of Coolidge: invention of ductile tungsten

- Golden age of radiology-1913- due to invention of hot cathode tube by william david coolidge.
- He uses coil of tungsten filament as a cathode which permit

  1.greater flexibility in the quality and quantity of x ray

  2.greater tube stability during the production of x ray

3. Smaller tube size

4. Longer tube life

5. Direct operation from transformer

- Disadvantage:

  was conduction of heat away from tungsten target.

- To overcome this, tungsten anode was backed by copper to dissipate heat rapidly.
- In 1916, he self rectified his old model, this tube was capable of operating with good efficiency when unrectified AC voltage was applied between the anode and cathode.

Panoramic Radiography

- Dr H Numata was the first to propose (1933) and experiment (1934) this method of panoramic radiography.
- Numata placed a curved film in the mouth lingual to the teeth and used a slit or narrow X-ray beam that rotated around the patient's jaws to expose the film

Dr H. Numata. First to take panoramic radiograph of teeth in 1933

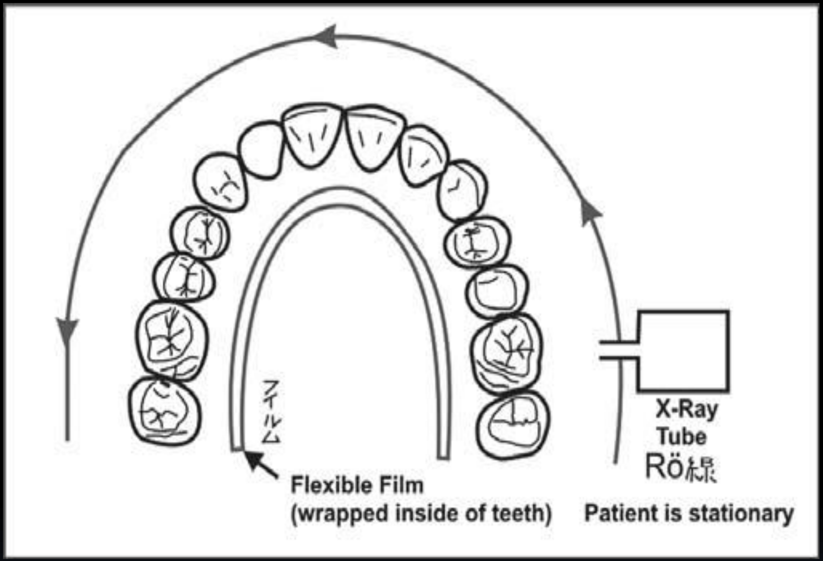


Diagram of panoramic technique used by Dr Numata

- Twelve years later, in 1946 Y.V. Paatero ,of the Institute of Dentistry, Finland, proposed (1946), experimented (1948) and demonstrated a **slit beam method** of panoramic radiography for the dental arches (1949).

Dr. YV Paatero. The Father of Panoramic Radiography

Inventor of the Cat-scan

- Robert Ledley was the inventor of CAT-Scans a diagnostic x-Ray system.
- Robert Ledley was granted patent #3,922,552 on November 25th in 1975 for a "diagnostic X-ray systems" also known as CAT-Scans.

Digital radiography

- The very first system that was introduced in digital radiography in dentistry was Radio-visio-graphy (RVG) by Trophyin France in 1987.
- Digital radiography refers to a method of capturing a radiographic image using a solid-state technology sensor, breaking it into electronic pieces, and presenting and storing the image using a computer.

- There are currently three types of digital radiography systems available for use in dental imaging:
- (1) CCD-Charge-Coupled Device (direct system);
- (2) CMOS-Complementary Metal Oxide Semiconductor (direct system); and
- (3) PSP-photo-stimulable phosphor (indirect system).

COMPUTED TOMOGRAPHY

- The first commercial computed tomography (CT) scanner was developed in 1972 by Sir Godfrey N. Hounsfield, an engineer at EMI, Great Britain.
- Is a sophisticated, powerful x ray that take 360 degree picture of internal organs, the spine and the vertebrae.
- It shows bone better than MRI.

Original "Siretom" dedicated head CT scanner, circa 1974

MRI

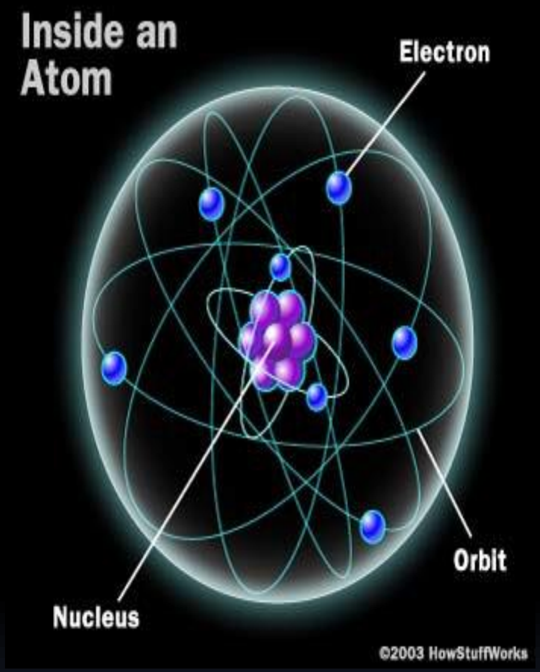
- **Raymond Vahan Damadian** is an American physician, medical practitioner, and inventor of the first MR (Magnetic Resonance) Scanning Machine.
- Damadian's research into sodium and potassium in living cells led him to his first experiments with nuclear magnetic resonance (NMR) which caused him to first propose the MR body scanner in 1969.

- MRI combines a powerful magnet with radio waves(instead of x rays) and a computer to manipulate these magnetic elements and create highly detailed images of structures in the body.

RADIATION PHYSICS

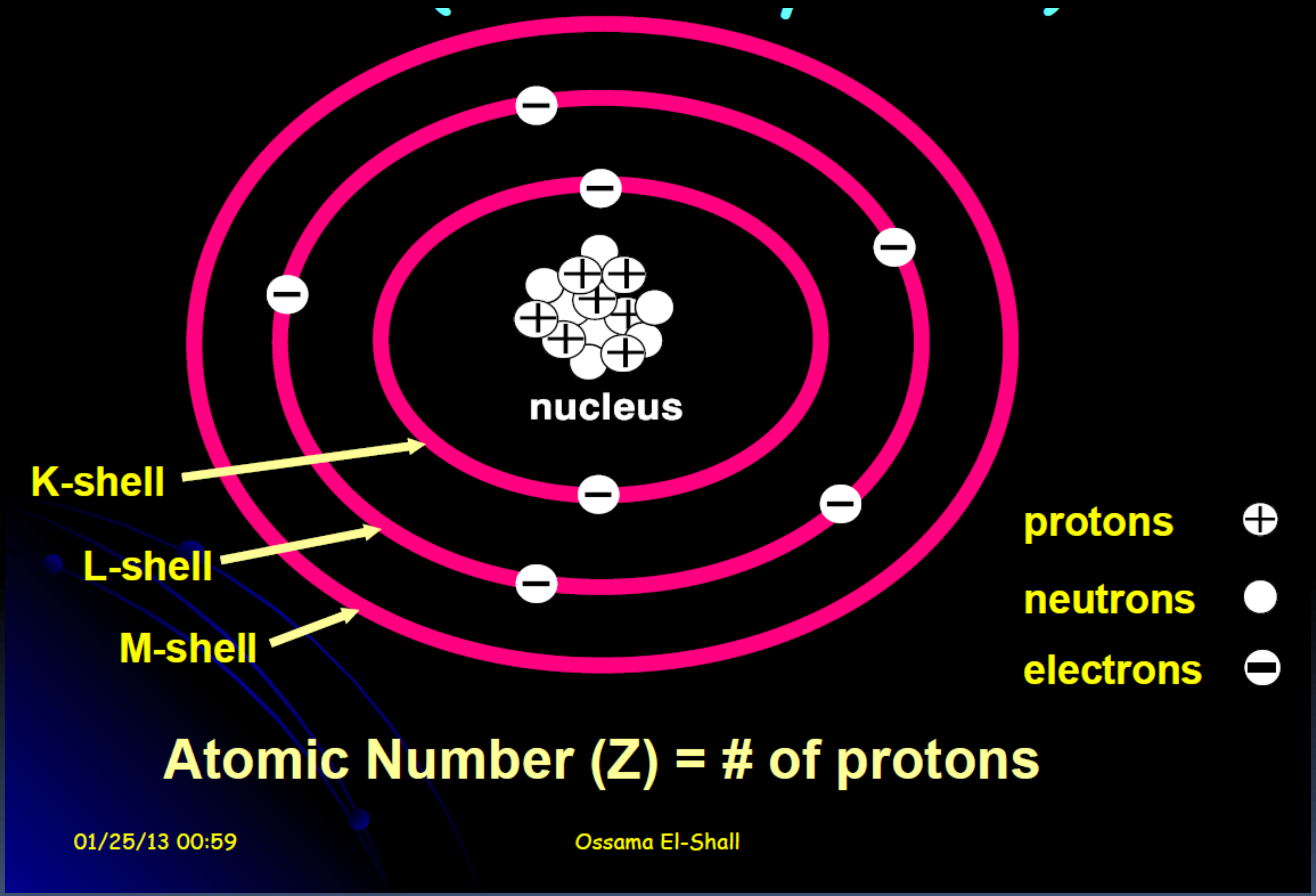
Atomic structure

- 1- Atom is the fundamental unit of any particular element, i.e. the basic unit of an element.
- 2- It is composed of a central nucleus and outer orbits which spaced at a definite distance from the nucleus and are identified by letters, K, L, M, N, O, P, Q.



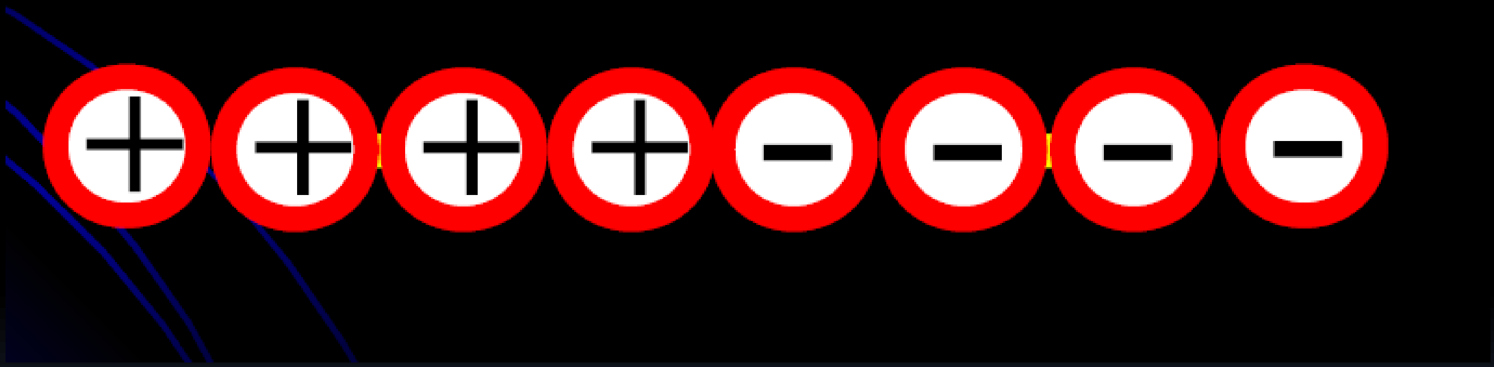
- 3-Electrons are negatively charged particles that orbiting shells.
- 4-The central nucleus is composed of two kinds of particles, proton, +ve charged and neutrons with no charge.
- 5-Since neutrons have no charge; the magnitude of the charge of the nucleus will depend on the number of protons (Atomic number), which are equal to the number of electrons.

Atom (electrically stable)



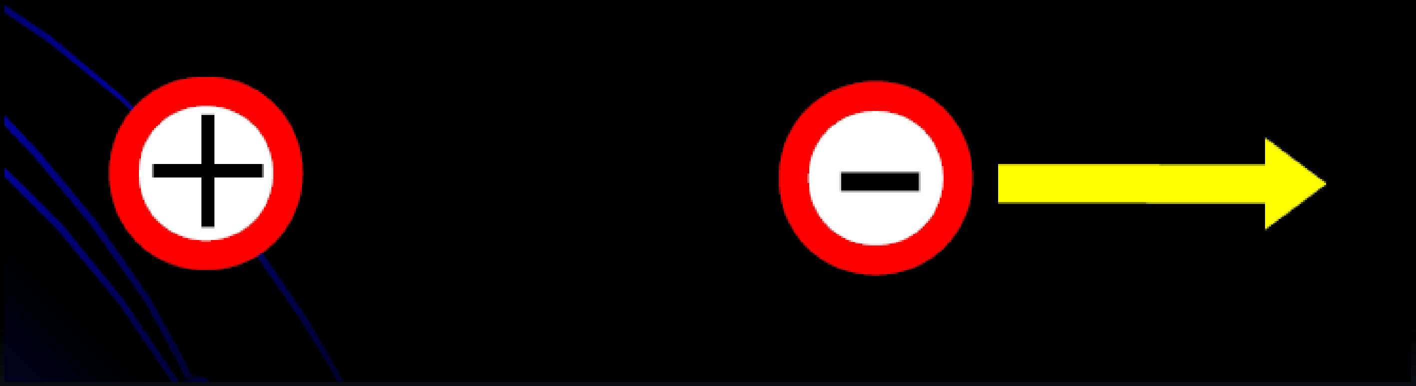
ELECTROSTATIC FORCE

- **Attraction between protons and electrons**

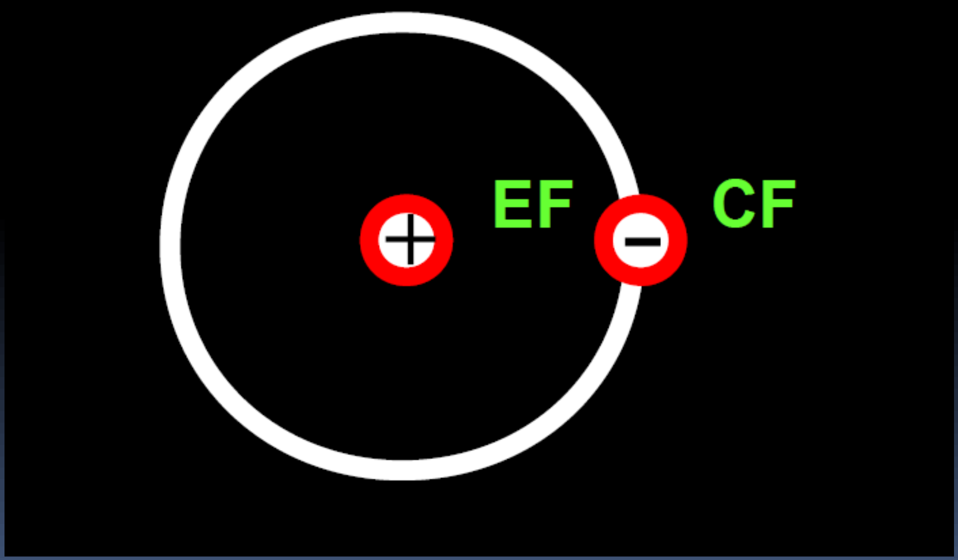


CENTRIFUGAL FORCE

- **Pulls electrons away from nucleus**



- Balance between electrostatic force and centrifugal force keeps electrons in orbit around nucleus



Nature of radiation

- Radiation may be either

Corpuscular radiation

Electromagnt ic radiation

Corpuscular or particulate radiation

- **1- It is that type of radiation given off from radium, radioisotopes, and during splitting of the atom.**
- **2- It is composed of solid subatomic particles having mass and charge.**
- **3- It travels in straight lines and is not used in dental diagnostic field but in therapeutic means.**

- 4.types:
  1.electrons
  2.alpha particles
  3.protons
  4.neutrons

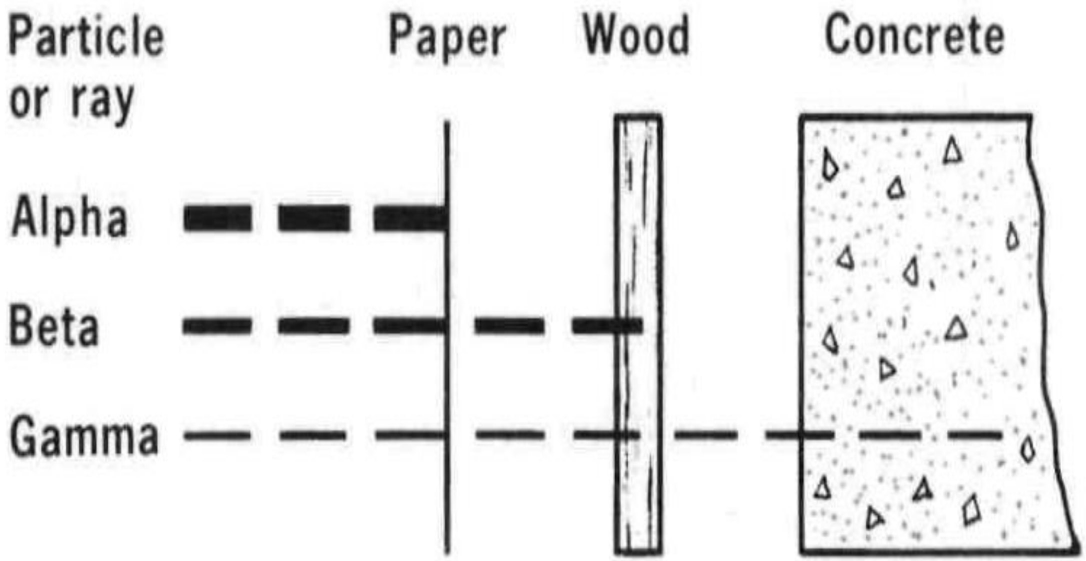
- ELECTRONS: classified into

  1.beta particle- fast moving electrons emitted from the nucleus of radioactive atoms

  2.cathode rays- streams of high speed electron that originate in the x ray tube
- ALPHA PARTICLE- emitted from the nuclei of heavy metals and exist as 2 protons, neutron without electron

- PROTONS- accelerated particles, especially hydrogen nuclei with a mass of 1 and charge of +1
- NEUTRONS- accelerated particles with the mass of 1 and no electric charge

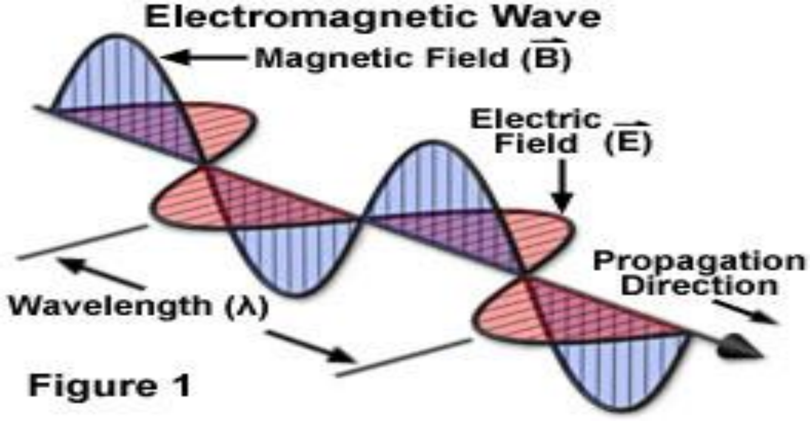
Property	Alpha particles	Beta$^-$ particles	Gamma rays	Beta$^+$ particles
Nature	Particulate — two protons and two neutrons	Particulate — electrons	Electromagnetic radiation — identical to X-rays	Particulate — positron, interacts very rapidly with a negative electron to produce 2 gamma rays — *annihilation radiation* — properties as shown in adjacent column
Size	Large	Small	Nil	
Charge	Positive	Negative	Nil	
Speed	Slow	Fast	Very fast	
Range in tissue	1–2 mm	1–2 cm	As with X-rays	
Energy range carried	4–8 MeV	100 keV–6 MeV	1.24 keV–12.4 MeV	
Damage caused	Extensive ionization	Ionization	Ionization — similar damage to X-rays	
Use in nuclear medicine	Banned	Very limited	Main emission used	PET



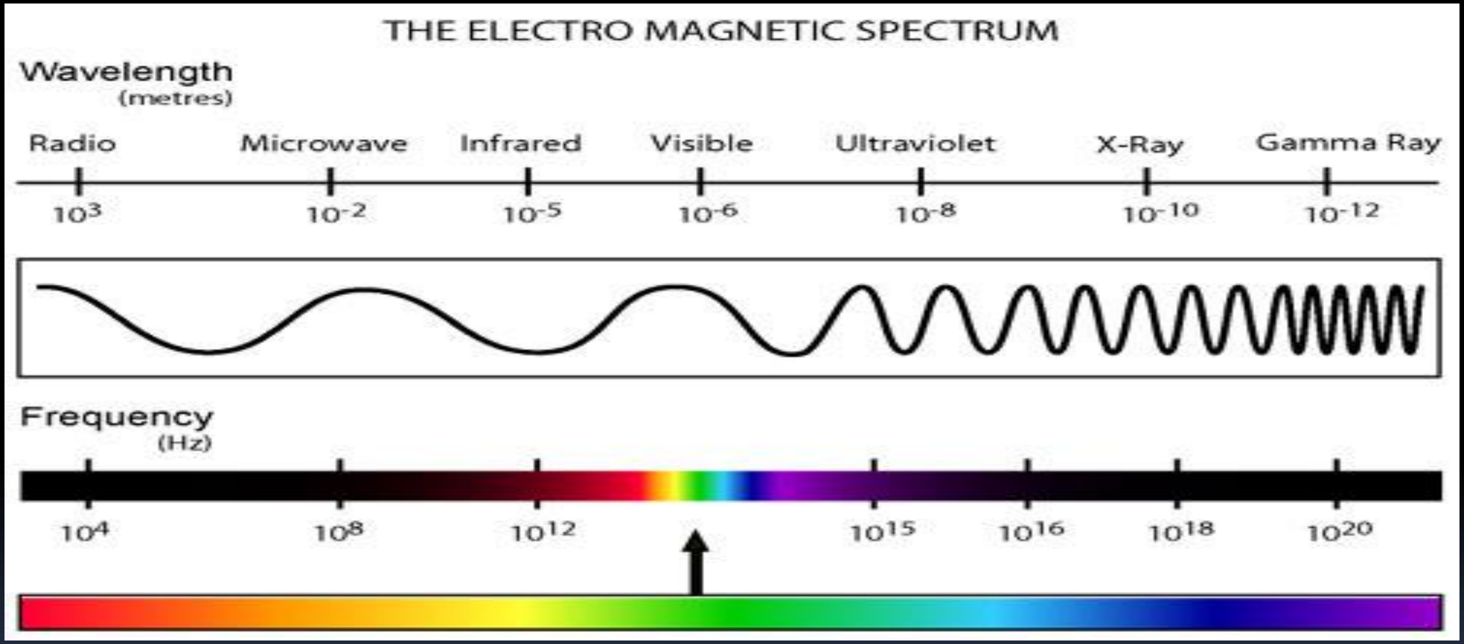
Relative penetration of alpha, beta, and gamma radiation.

Electromagnetic radiation

- **Electro magnetic radiation-**defined as the propagation of wave like energy(without mass) through space or matter.
- **Electro magnetic spectrum-** electromagnetic radiations are arranged according to their energies in what is termed electromagnetic spectrum.

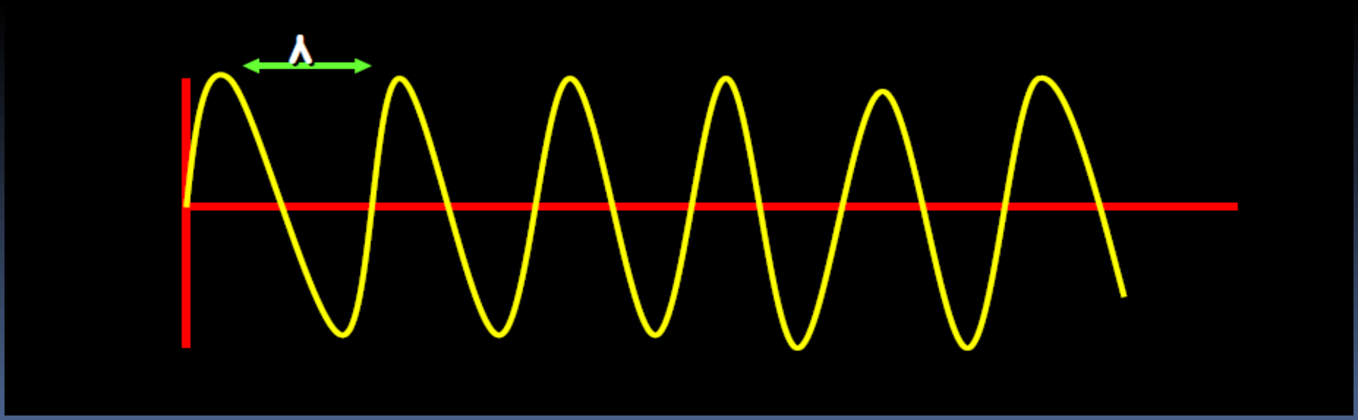


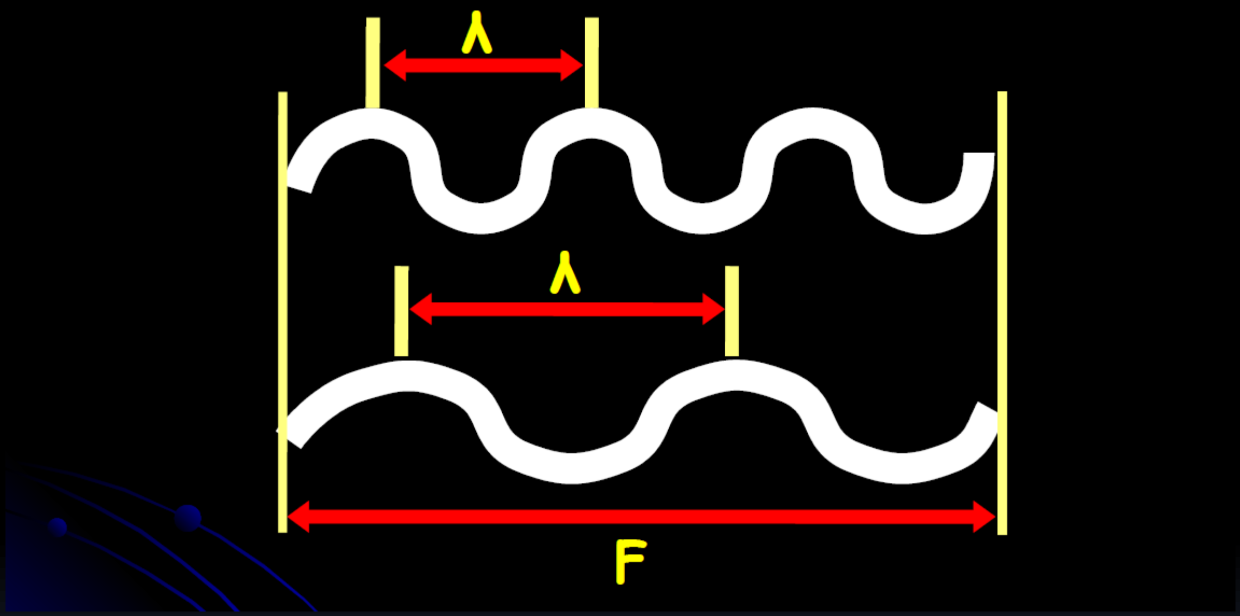
Electro magnetic spectrum



- 1-It is that type of radiation formed of units of pure energy, which are propagated in the form of waves as a combination of electric and magnetic fields.
- 2-It is made of pure energy propagate in a form of waves with no mass or charge.
- 3-It is generated when the velocity of an electrically charged particle is altered.
- 4-They travel in straight lines with the same speed of light (3x108 meter/sec.)
- 5-As they propagate in a form of waves, they have a wavelength (λ) and frequency(ν)

- Wavelength (λ) is the distance between 2 crests or bottoms of 2 successive waves.
- Frequency (ν) is the number of waves that pass a given point in a certain amount of time.





Wavelength x Frequency = Speed of wave

According to the wavelengths, radiations can differ in their properties.

- Radiation may be of

Short wavelength

Long wavelength

The short wavelength

increased frequency increase the energy accompanied with it

increase the power of penetration, the rays will termed Hard radiation which characterized with low power of absorption into matter and low ionization.

The long wavelength

↓

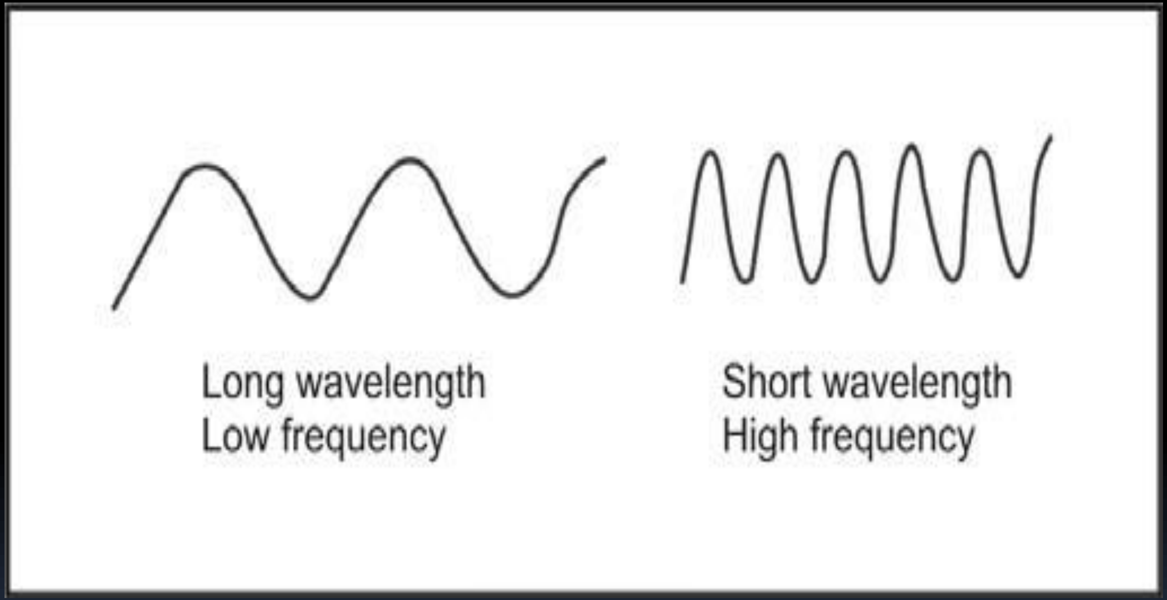
Decreases frequency

↓

decrease the energy accompanied with it

↓

Decrease the power of penetration ,the rays are termed Soft radiation which characterized with high power of absorption into matter and high ionization effects.


Long wavelength
Low frequency
Short wavelength
High frequency

Properties of electromagnetic radiation

- 1.travel through space in a wave motion along a straight line
- 2.have neither mass nor weight nor electrical charge
- 3.travel at speed of light in a vaccum - 3*$_{10}$8m/sec or 1,86,000 miles/sec
- 4.tranfer energy from place to place in quanta
- 5.in passing through the matter the intensity of radiation is reduced(attenuation) both because energy is taken up by the material(absorption) or some energy is deflected from its original path(scattering)

- 6.as they travel through space they give off an electric field at right angle of propagation and magnetic field at right angle to both
- 7.obey inverse square law, I=K/D2
- 8.have measurable but different temperature and energy
- 9.invisible to naked eye, except those within the visible spectrum

Examples of electromagnetic radiation

- arranged in an ascending order according to their wavelength:

1-Cosmic rays.

2-Gamma Ray

3-X.Ray. wavelength = 0.1-1Ao, Ao = 10-10 m

4-Ultraviolet rays.

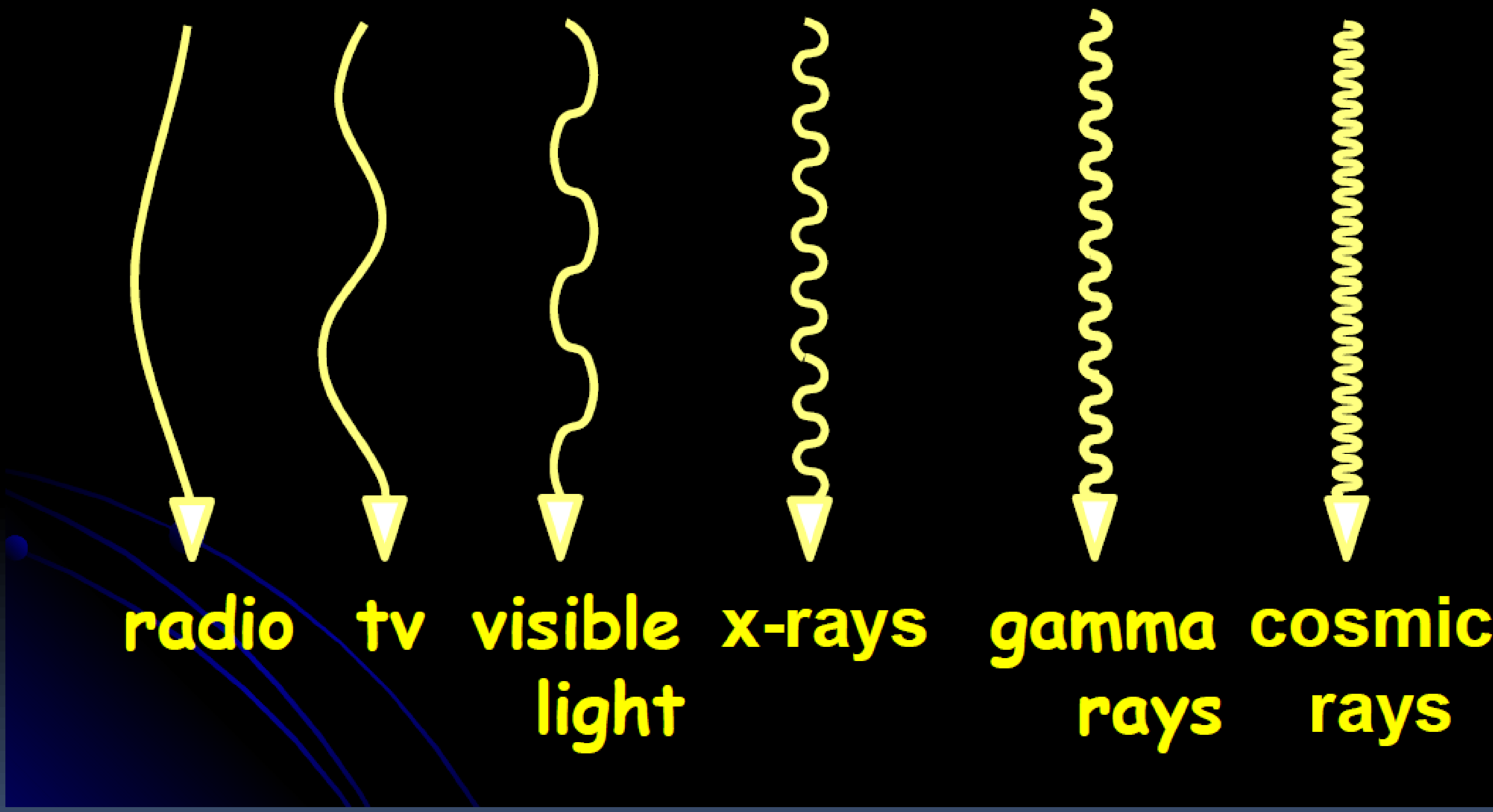
5-Visible light.

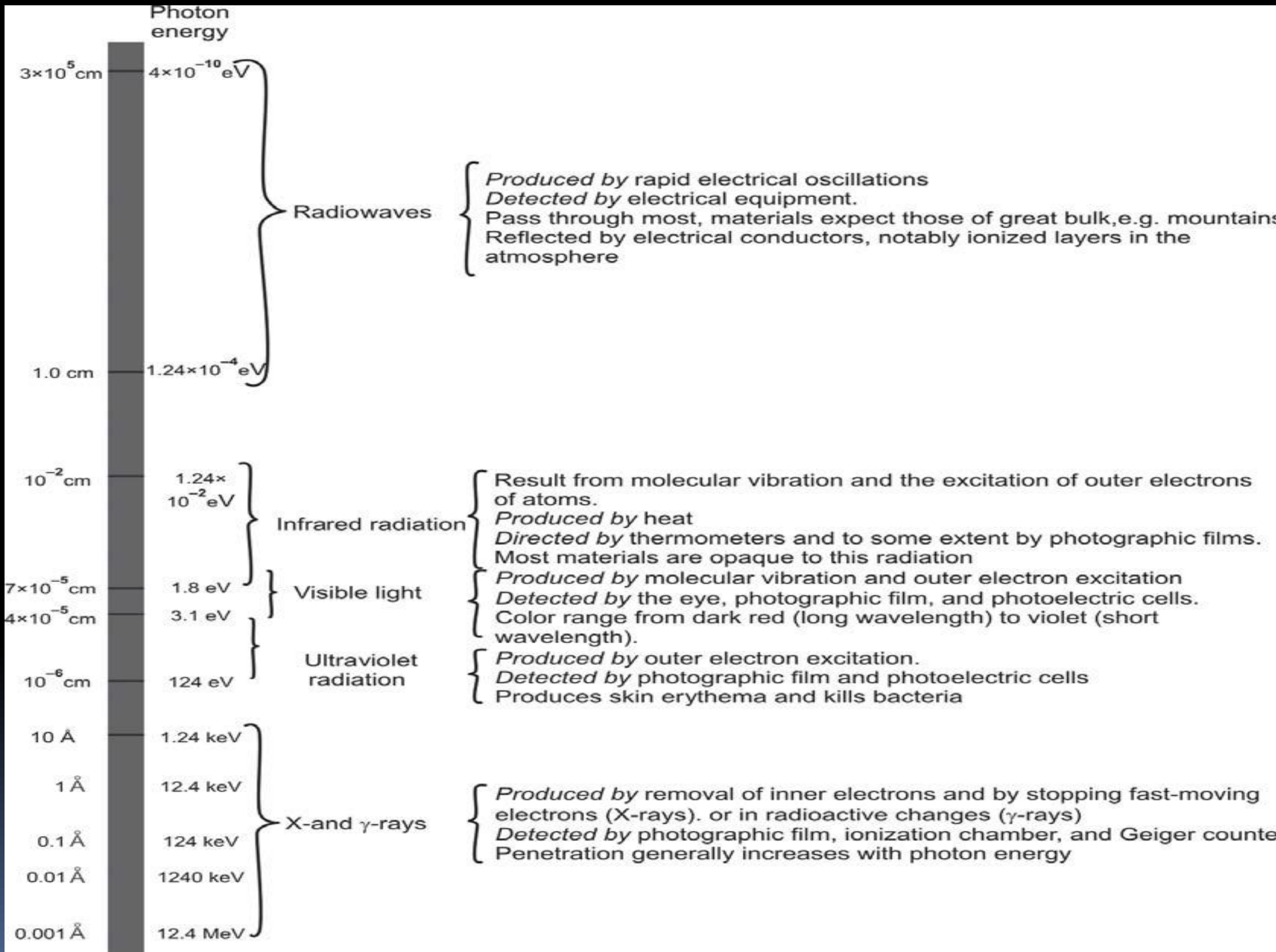
6-Infra-red.

7-Microwaves.

8-Radio, radar, T.V waves.

Electromagnetic Spectrum





Photon energy
3×10^5 cm
4×10^-10 eV
1.0 cm
1.24×10^-4 eV
Radiowaves
Produced by rapid electrical oscillations
Detected by electrical equipment.
Pass through most, materials expect those of great bulk,e.g. mountains
Reflected by electrical conductors, notably ionized layers in the atmosphere
10^-2 cm
1.24× 10^-2 eV
Infrared radiation
Result from molecular vibration and the excitation of outer electrons of atoms.
Produced by heat
Directed by thermometers and to some extent by photographic films.
Most materials are opaque to this radiation
7×10^-5 cm
1.8 eV
Visible light
Produced by molecular vibration and outer electron excitation
Detected by the eye, photographic film, and photoelectric cells.
Color range from dark red (long wavelength) to violet (short wavelength).
4×10^-5 cm
3.1 eV
10^-6 cm
124 eV
Ultraviolet radiation
Produced by outer electron excitation.
Detected by photographic film and photoelectric cells
Produces skin erythema and kills bacteria
10 Å
1.24 keV
1 Å
12.4 keV
0.1 Å
124 keV
0.01 Å
1240 keV
0.001 Å
12.4 MeV
X-and γ-rays
Produced by removal of inner electrons and by stopping fast-moving electrons (X-rays). or in radioactive changes (γ-rays)
Detected by photographic film, ionization chamber, and Geiger counter
Penetration generally increases with photon energy

Radio waves or communication waves

- Wavelength-10^{13} A-10^{8} A
- Uses in medicine- used to transmit the pattern of heartbeat through the monitor at patient's home to a near by hospital
- Other uses:

  1.used to convey information from one place to others applied in transmission of radio, tv, and radar

  2.used for navigation of ships and air crafts

  3.various remote controlling device like rocket are activated by radio signals
- Side effects-affect reproductive system

Microwaves

- Wavelength-3*10-2m to 3*10-4 m
- Uses in medicine:

1.treatment of sinusitis

2.selected case of cancer therapy

3.in oral surgery, to reduce postoperative swelling and trismus arising from traumatic procedure

- Other uses:

  1.transmit information to satellite

  2.used in microwave oven and mobile phones

  3.can penetrate tissues and cause moisturized molecules in cells to vibrate resulting in internal friction and increase the temperature of affected cells.

Infrared waves

- Wavelength-40000 A to 1,00,000 A
- Uses in dentistry:

  1.for tooth vitality testing

  2.surgical diathermy

  3.altering properties of dental materials like wax, gutta percha and acrylic

- Other uses:

  1.to study cloudy structure

  2.to determine temperature of distant object

  3.infra red astronomy

  4.medicinal uses like simple heat lamp to technique of thermal imaging or thermography.

Visible light

- Wavelength-4000 A to 7700 A
- Range of colour is called VIBGYOR
- USES:

  1.used in dental photography

  2.operative field illumination
- Other uses:

  1.in optical fibres

Ultraviolet light

- Wavelength-1000 A to 2000 A
- Biological effect produced by UV rays:

  1.photo erythema(sun burn)

  2.photo pigmentation(sun tan)

  3.photo chemical cornification of skin and skin carcinoma(malignant dermal changes)

  4.bactericidal effect

  5.aging of skin

  6.productio of vit D

  7. eyes are sensitive to UV rays which can cause cataract or keratitis

- UV rays are divided into 3 group based on wavelength:

  1.short or germicidal UV rays-200 to 290 nm-cause genetic mutation, altered reproductive cycle and cell death

  2.middle or erythemel UV rays-290 to 320nm-cause skin erythema

  3.long or black light UV rays-320 to 380 nm-not damage on its own but used with sensitizing chemicals cause extensive biological damage.

- Uses in dentistry:

  1.disclose plaque or unclean surface of fluorescence

  2.photo polymerization of composite used for fissure sealing

  fixing orthodontic practise

  splinting teeth

  placing pontics in temporary bridge work

  restoring teeth

  reparing facings

- Other uses

  1.used in photography, as it can darken photographic emulsion

  2.it has the property of fluorescence so it is used in paints, lights and dyes.

X rays

- Wavelength-1 to 2 A to 0.001 A
- Types according to wavelength:

  1.Grenz or super soft x ray: 1-2 A – used to treat superficial lesions

  2.soft rays: 1-0.5A – used in contact therapy

  3.medium rays: 0.5 to 0.1 A – used in diagnostic and superficial therapy

  4.hard rays: 0.1A – used for deep x ray therapy and industrial roentgenography

- Uses:

  1.fluroscopic examination and intensifying screen in extra oral radiography

  2.to take radiograph and monitering film badges.

  3.to sterilize commercial item in bulk

Gamma rays

- Wavelength-0.001A
- USES:

  1.due to their shorter wavelength and greater penetration power used in treatment of tumors eg. radon needles or seeds which implanted at the tumour site

Cosmic rays

- Wavelength-0.0001A
- A cosmic ray is a high speed particle-either an atomic nucleus or an electron-that travels throughout the milky way galaxy, including solar system.
- They affect the earth magnetic field
- Play a critical role in scientific study of atomic nucleus and its components

LASER

- LASER- Light Amplification by Stimulated Emission of Radiation
- Is a devise which can operate in the infra red, visible or ultra violet region of spectrum and which amplifies electromagnetic waves by stimulated emission of radiation

Characteristic of laser

- Highly directional and travels in a narrow beam, the sides of which stay almost parallel
- Produce coherent light, that it has only one frequency
- Single colour
- Very bright, powerful with very high intensity

- In dentistry two types of lasers are used:

  1. Soft Tissue Laser (800-990 nm), e.g. Argon soft tissue laser, CO_2 Laser.

  2. Hard Tissue Laser (2500-3000 nm), e.g. Er:YAG Dental laser system, Erbium hard tissue laser

Hard tissue laser

Soft tissue laser

Dental Applications:

- 1. Surgical excision of benign tumors and small soft tissue growths (e.g. Epulis).
- 2. Frenectomy.
- 3. Nerve regeneration.
- 4. Sleep apnea (LAUP—Laser Assisted Uvula Palatoplasty).
- 5. Cavity detection.
- 6. Viewing of tooth and gum tissue (Optical coherence tomography).
- 7. Treatment of Cold sores—low intensity lasers used to reduce pain.

- 8. Treatment of Temporomandibular joint for reduction of pain and inflammation.
- 9. Treatment of ulcerative lesions.
- 10. Oral biopsies
- 11. Treatment of gummy smile
- 12. Treatment of tooth sensitivity
- 13. Treatment of melanin pigmented gingiva.
- 14. Local anesthesia free cavity preparation.

- 15. Hard tissue roughening or etching.
- 16. Enameloplasty, excavation of pits and fissures for placement of sealants.
- 17. Osseous crown lengthening.
- 18. Cutting, shaving and contouring of oral osseous structures.
- 19. Ostectomy
- 20. Apicectomy
- 21. For early detection of dysplastic cells (optical coherence tomography)

Advantages:

- 1. Causes less pain thereby reducing need for anesthesia.
- 2. Minimizes bleeding and most surgical procedures done with lasers do not require sutures, because the high-energy light beam aids in clotting (coagulation) of exposed blood vessels thus inhibiting blood loss.
- 3. Bacterial infections are minimized and wound heals faster. The high energy beam sterilizes the area worked on.
- 4. Damage to surrounding tissue is minimized. Wounds heal faster.

ThankYou

Properties of X-rays

- The properties of X-rays may be classified into four broad categories:

  A. Physical

  B. Chemical

  C. Biological

  D. Physiochemical.

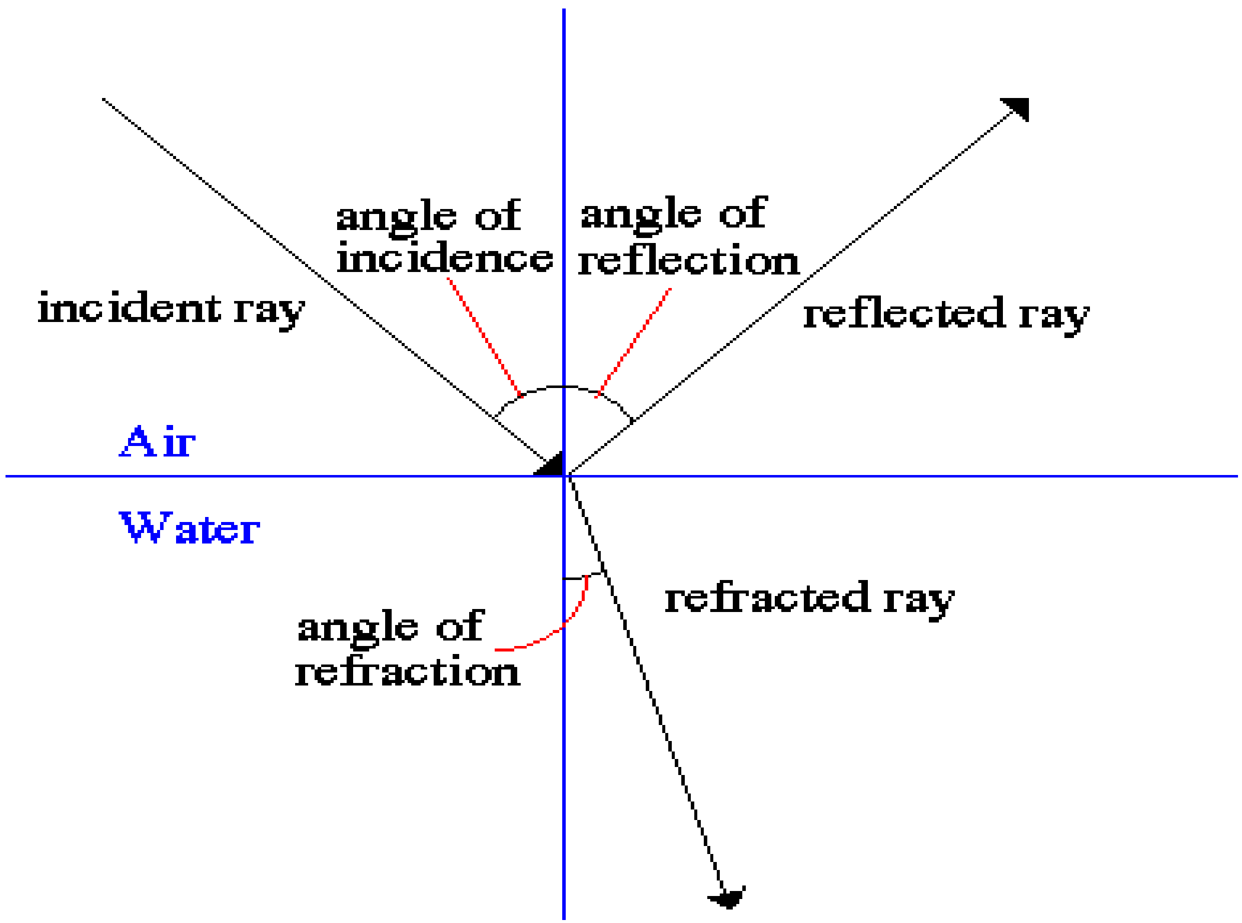
PHYSICAL PROPERTIES:

- 1.wavelength between 10 Å and 0.01Å.
- 2.travel through space in a wave motion.
- 3. In free space they travel in a straight line.
- 4. travel with the same speed as that of visible light (i.e. 1,86,000 miles per second).
- 5. As they travel through space, they can produce an electrical field at right angles to their path of propagation and a magnetic field at right angles to the electric field.
- 6. invisible to the eye and cannot be seen, heard or smelt

PHYSICAL PROPERTIES:

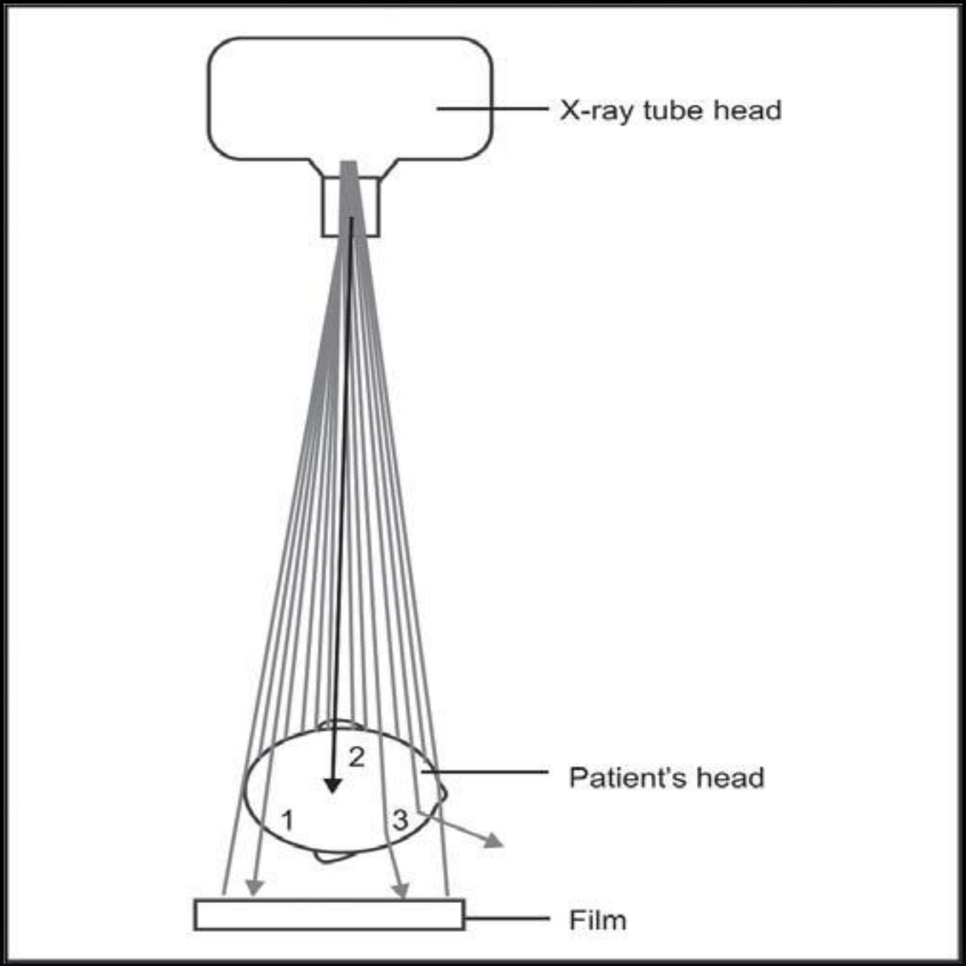
7. cannot be focused by a lens.
8. cannot be reflected, refracted or deflected by a magnet or electric field as they do not possess any charge.
9. show the properties of interference, diffraction and polarization, similar to that of visible light.
10. do not require a medium for propagation.
11. X-rays are pure energy, no mass and they transfer energy from place to place in the form of quanta
12. obey the inverse square law, I ~ 1/d2 or I = k/d2
13. X-rays are produced by the collision of electrons with tungsten atoms.

Reflection and Refraction



PHYSICAL PROPERTIES:

14. X-rays can penetrate various objects and the degree of penetration depends upon the quality of the X-ray beam, and also on the intensity and wavelength of the X-ray beam.
15. Property of attenuation, absorption and scatter
16. can release photoelectrons from the metals, when allowed to fall on them.
17. Heating effect: The production of heat is one of the initial results of the slowing down of the primary electrons, it also arises as an end product of the chemical reactions induced by radiations.
18. Fluorescence: When X-rays fall upon certain materials, visible light is emitted called fluorescence
19. Ionization: This is a process of converting atoms into ions



Three types of radiation interactions with the patient, may occur,

1. The X-ray photon may pass through the patient without interaction and reach the film,
2. Photon may be totally absorbed,
3. The photon may be scattered onto the film or away from the film

CHEMICAL PROPERTIES

- 1. induce color changes of several substances or their solutions.

  i. Methylene blue gets bleached.

  ii. Sodium platinocyanide which is apple green turns to darker shades, then light brown and finally dark brown.

- 2. bring about chemical changes in solutions which are otherwise completely stable. This is because X-rays produce the highly active radical 'OH' in water, which reacts with the solutes.

  i. This brings about molecular changes in biological molecules.

ii. Organic compounds get oxidized to carbon dioxide with release of hydrogen when exposed to radiation, because water in organic substances undergoes oxidation and reduction reactions when irradiated.

iii. X-rays can cause oxidation of ferrous sulphate to ferric sulphate and this is used as a method of measuring X-ray dosage (Frickle Dosimeter).

- 3. X-rays can cause destruction of the fermenting power of enzymes,

BIOLOGICAL PROPERTIES:

- When X-rays are incident on an atom, one of the reaction it produces is 'excitation.' *This state of 'excitation' in biological materials enable it to take part in a chemical process into which in the normal state it would not enter. This is an important cause of biological* damage produced by radiation.

  i. This property of excitation is used in the treatment of malignant lesions.

  ii. X-rays also have a germicidal or bactericidal effect and are used for sterilization and preservation of food.

BIOLOGICAL PROPERTIES:

The biological effects of X-rays may be classified into two types:

I . *Somatic effect: This ranges from a simple sun burn* to severe dermatitis, to changes in the blood supply and/or malignancy. The effect is cumulative and depends upon the type of tissues and intensity of the radiation.

ii. *Genetic effect: This effect is due to radiation* induced mutation of genes and chromosomes. These effects are usually seen in the off-springs of the irradiated parents.

The fetus is more sensitive to radiation in the early stage of development.

PHYSIOCHEMICAL PROPERTIES

photographic effect:

photographic paper or film when exposed to X-ray radiation and then developed will be found blackened.

The irradiation effects the silver salts in the emulsion, so that after the chemical process called developing, the radiograph metallic silver is released and the film or paper appears blackened.

- This blackening is known as 'film density' and difference between the degree of density is known as 'film contrast.'
- depends upon:

I . Amount of radiation.

ii. Quality of radiation.

iii. Characteristic of a film.

iv. Concentration and age of developing solution.

v. Length of developing time.

vi. Use of intensifying screens.

Diagnostic Properties of X-rays

- 1. X-rays travel in a straight line.
- 2. *Penetration: X-rays can penetrate liquids, solids and gases.*
- 3. Absorption: X-rays are absorbed by matter, the absorption depends on the atomic structure of the matter and the wavelength of the X-ray.
- 4. *Ionizing capability: X-rays interact with materials they penetrate and cause ionization, dissociate silver ions in film* emulsions.
- 5. *Fluorescence: X-rays can cause substances to fluorescence or emit light radiation in longer wavelengths. (e.g. visible* light or ultra-violet light).
- 6. *Effect on films: X-rays can produce an image on a photographic film.*
- 7. *Effect on living tissues: X-rays cause biological changes in living cells.*

PRODUCTION OF X-RAYS

X-ray Machine

- The dental X-ray machine is made up of three parts or components:

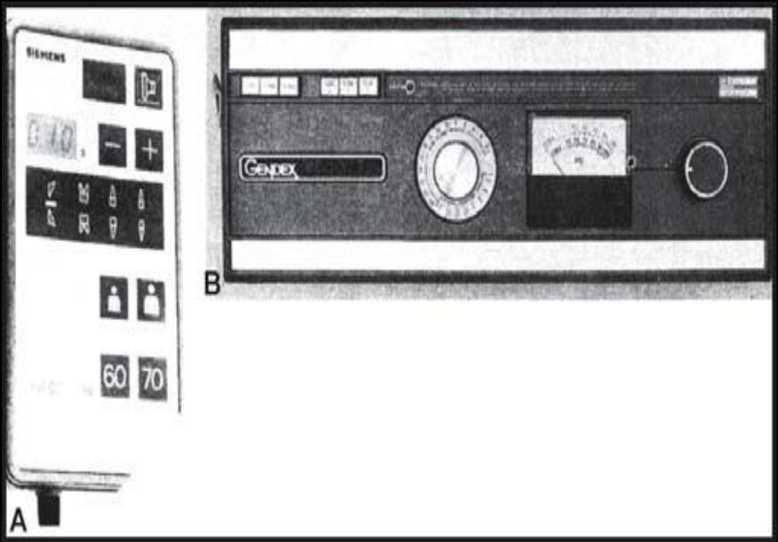
  I . Control Panel

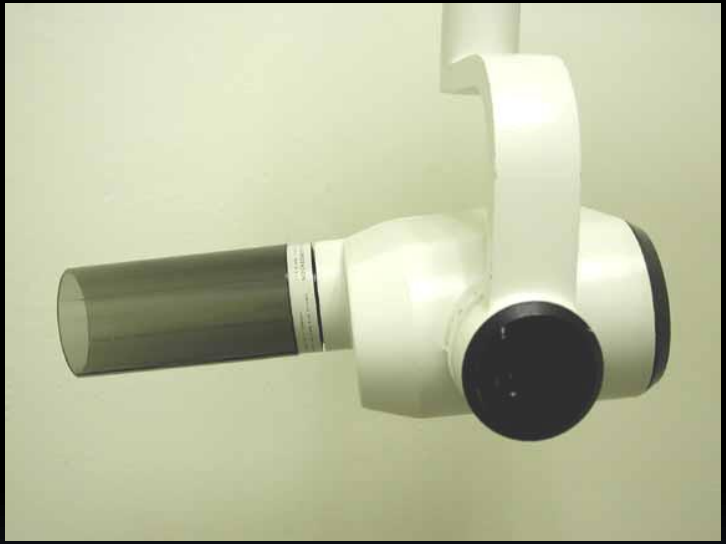
  ii. Extension Arm

  iii. Tube Head.

1. Control panel– switch ,indicator light.
2. Extension arm—suspends the x-ray tube head.
3. Tube head—is a tightly sealed heavy metal housing that contains x-ray tube which produces dental X-rays.

- Tube head consists of:
  1. Metal body of the tube head which surrounds the x-ray tube.
  2. Insulating oil.
  3. X-ray tube : Cathode & Anode
  4. Transformer- a device alters the voltage of incoming electricity.

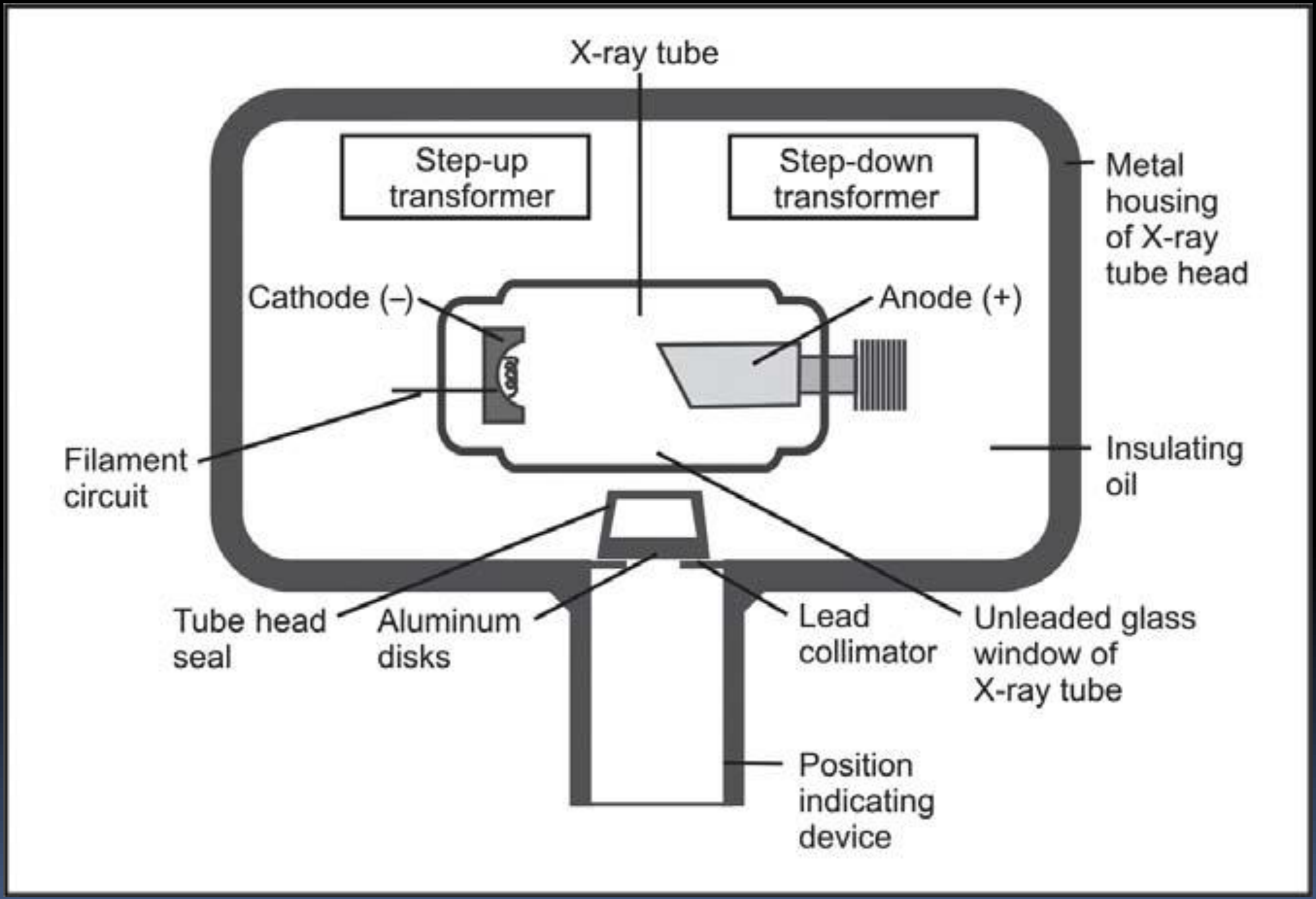




A. The helodent MD control panel,
B. The gendex—1000 Control panel

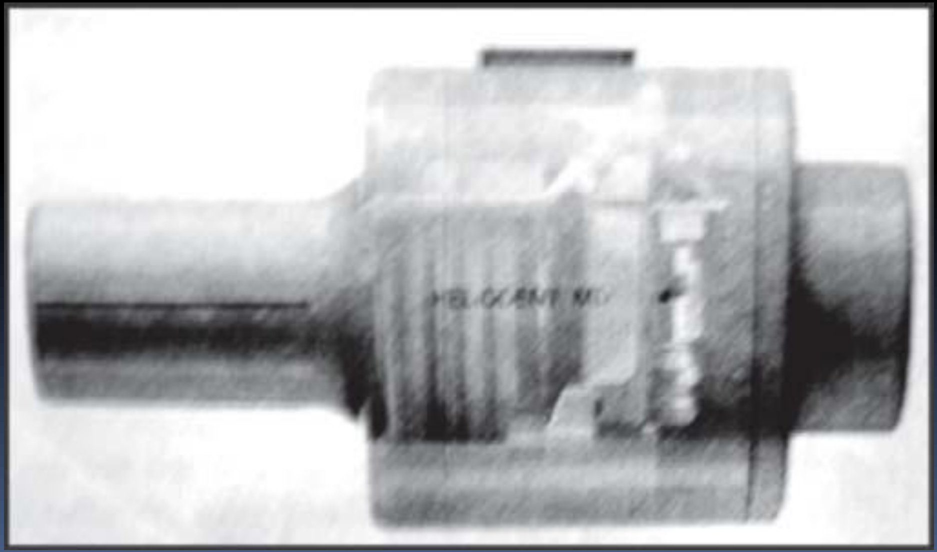
X-ray Tubehead

Schematic diagram of the dental X-ray tube head



Metal housing:

- This is the metal body of the tube head that surrounds the X-ray tube and transformer and is filled with oil, it protects the X-ray tube and grounds the high voltage component.



Insulating oil:

- It is that which surrounds the X ray tube and transformer inside the tube head, it prevents over heating by absorbing the heat created by the production of X-rays.
- The surrounding oil maintains the insulation properties of the glass envelope and also insulates the tube from the metal shield.
- With rise in temperature the oil expands and occupies a greater volume. It is essential in any such tube that there should be no air bubbles within the space surrounding the glass.
- The problem therefore, is how to provide for expansion of oil without having any bubbles in the tube case when cold.
- This is solved by inserting *metal bellows, which extends as the* heated oil expands, simultaneous acting as a safety device.
- If the bellows expand beyond a certain point then they operate a micro switch which prevents operation of the tube until the oil has cooled sufficiently.

Tube head seal

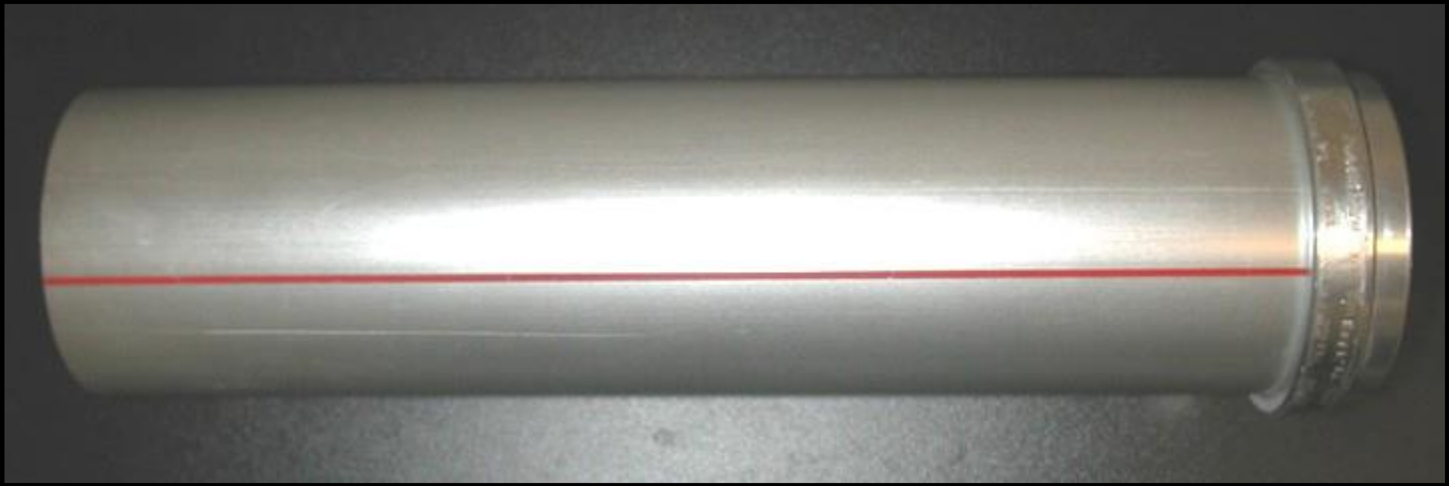
- **Aluminum or leaded glass** of the tube head that **permits the exit of X-rays** from the tube head, it **seals the oil in the tube head** and acts **as a filter** to the X-ray beam.

Aluminum filtration

- The sheets of 0.5 mm thick aluminum is placed in the path of the X-ray beam.
- They filter out the non-penetrating, longer wave-length X-rays, resulting in a higher energy and more penetrating useful beam, which is less harmful to the patient (decreased skin dose).
- In the dental X-ray tube head there are two types of filtration:

  a. Inherent filtration.

  b. Added filtration.

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Inherent filtration

- Inherent filtration takes place when the primary beam passes through the glass window of the X-ray tube, the insulating oil and the tube head seal.
- In the dental X-ray machines the inherent filtration is approximately equivalent to 0.5 to 1 mm of aluminum.
- This amount of filtration usually does not meet the standards regulated by the state and federal law (in USA) and therefore added filtration is required.

Added filtration

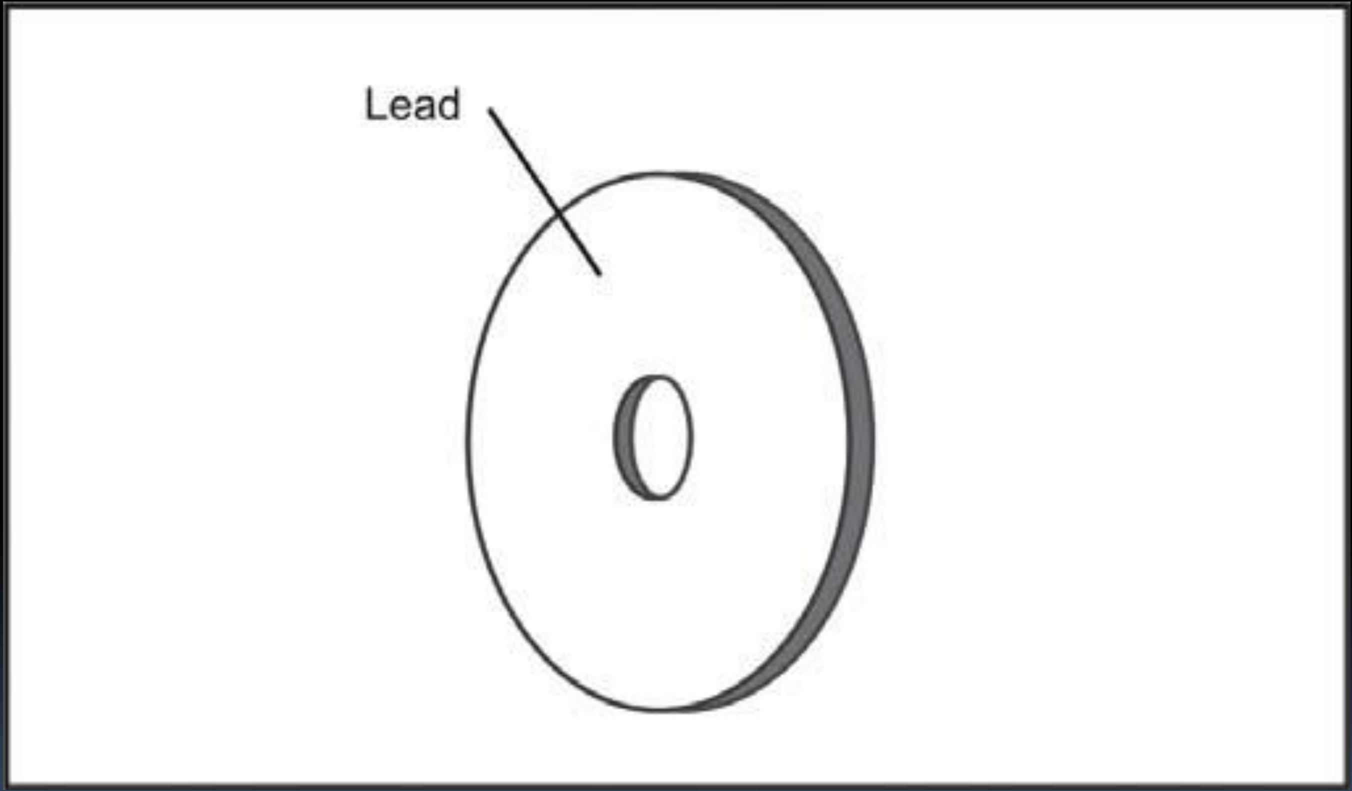
- Added filtration refers to the placement of aluminum disks in the path of the X-ray beam between the collimator and the tube head seal in the dental X-ray tube head.
- Aluminum disks may be added in 0.5 mm increments.
- Total filtration (inherent + added filtration) is regulated by the state and federal law (in USA).
- Dental machines operating:
  - At or below 70 kVp require a minimum total filtration of 1.5 mm of aluminum thickness.
  - Above 70 kVp require a minimum total filtration of 2.5 mm of aluminum thickness.

Lead collimator

- It is a lead plate with a central hole that fits directly over the opening of the metal housing where the X-rays exit.
- Collimation is used to restrict the size and shape of the X-ray beam and thus reduce exposure to the patient.
- Collimators are of two types:

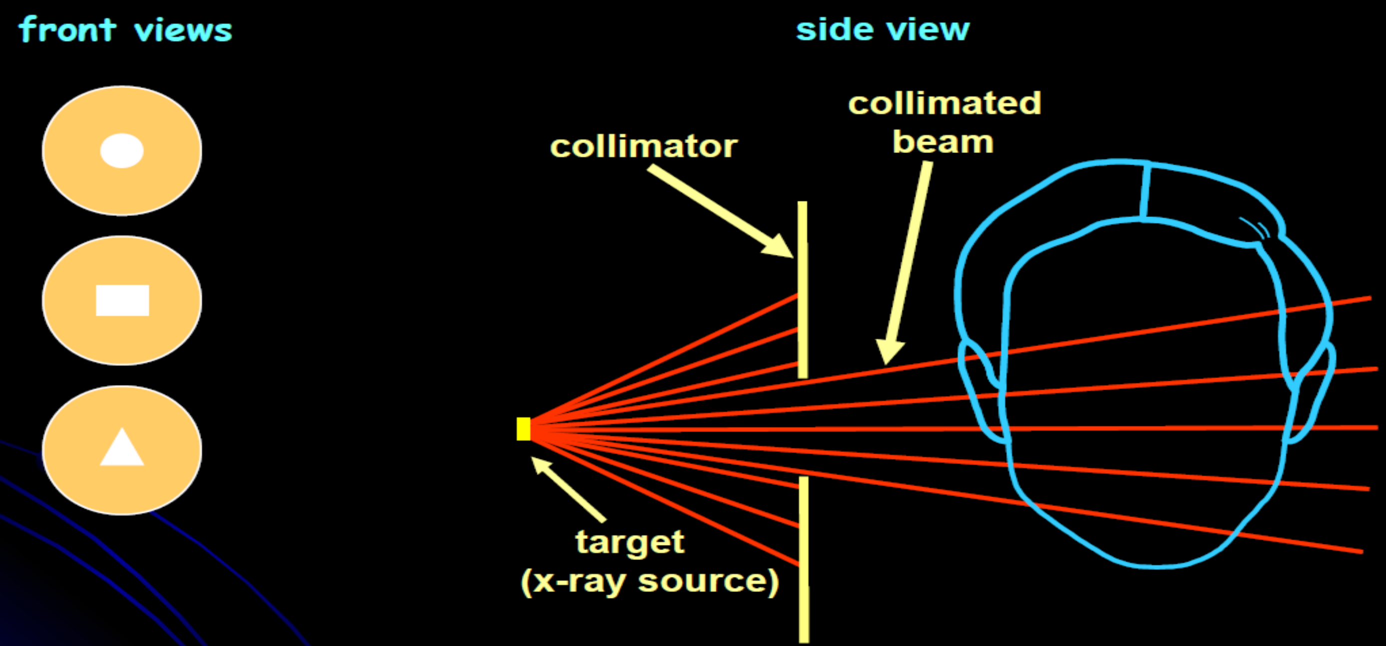
  a. Fixed.

  b. Adjustable.


Lead

- In the dental X-ray machine usually the fixed collimators are used, they may either have a round or rectangular opening.
- A rectangular collimator restricts the size of the X-ray beam to an area slightly larger than a size 2 intraoral (normal adult intraoral periapical films) and thus significantly reduces the patient exposure.
- A circular collimator produces a cone shaped beam that is 2.75 inches in diameter and is considerably larger than the size of two intraoral periapical films, and thus leads to an increased skin dose to the patient.

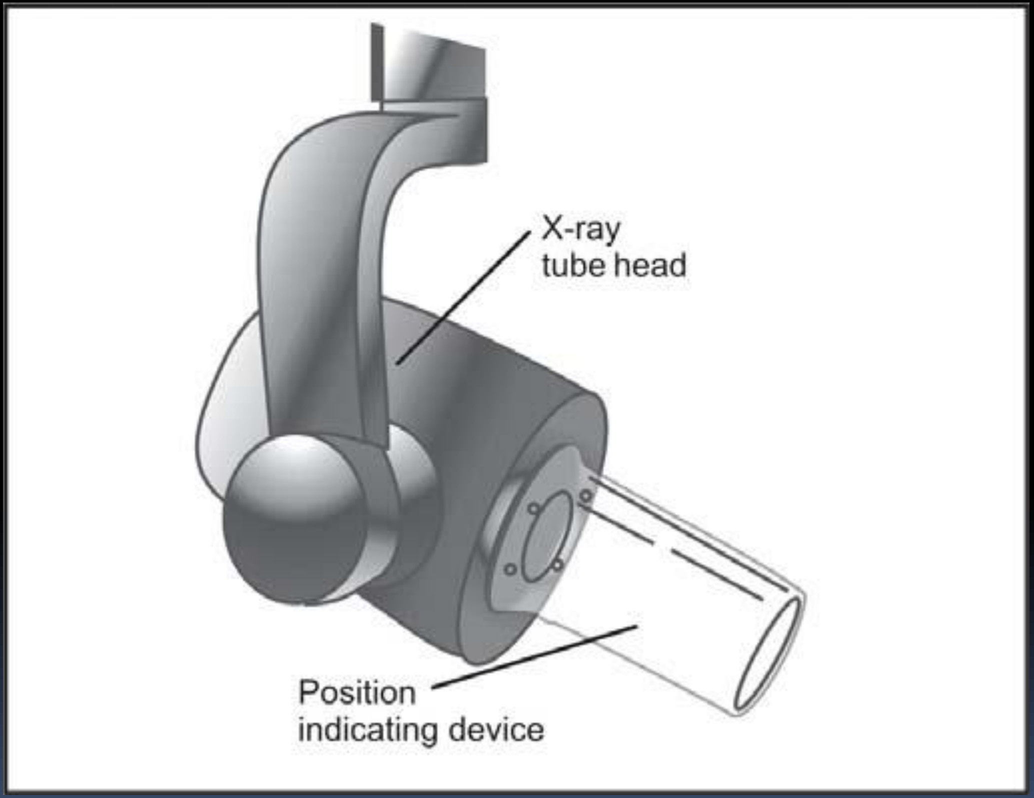
Collimation



2.75 inches (7 cm) = maximum diameter of circular beam or maximum length of long side of rectangular beam at end of PID.

Position indicating device (PID)

- open ended lead cylinder, that extends from the opening of the metal housing of the tube head also called the **"cone".**
- The PID appears as an **extension of the tube head** and it **aims and shapes** the X-ray beam.


X-ray
tube head
Position
indicating device

- There are three types of PIDs:

  i. conical

  ii. rectangular

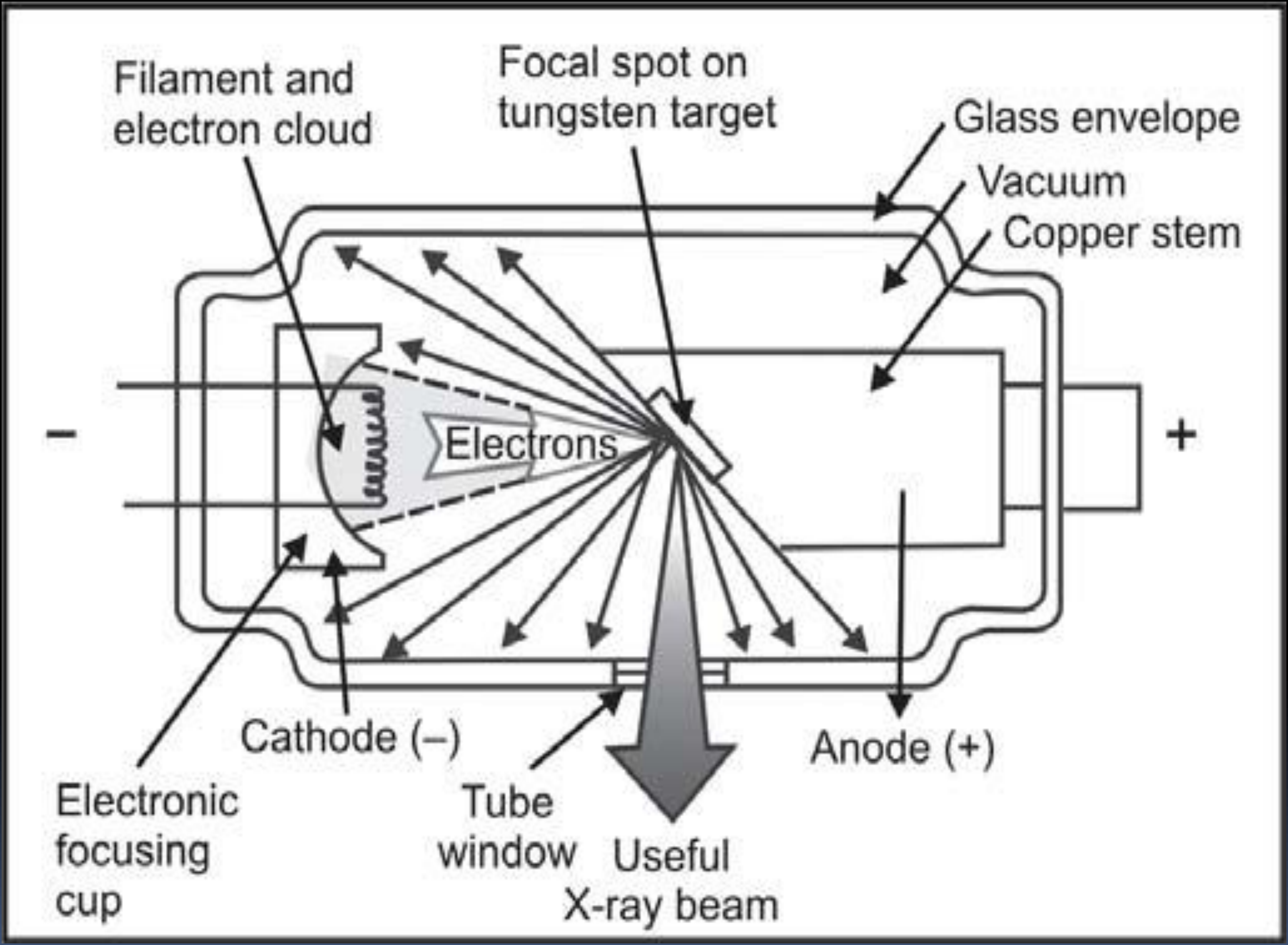
  iii. round.
- The conical PID appears as a closed, pointed plastic cone and when X-rays exit they penetrate the plastic and produce scattered radiation .
- Nowadays lead lined rectangular or round PIDs are preferred as they do not produce scattered radiation.
- Both rectangular and round PIDs are available in two lengths:

  I . short (8 inches)

  ii. long (16 inches).
- The long PID is preferred because less divergence of X-ray beam occurs. The rectangular type is most effective in reducing patient exposure.

X-ray tube

- heart of the X-ray generating system.
- The component parts of the X-ray tube consist of:
- a. A leaded glass housing
- b. A negative cathode
- c. A positive anode.


Filament and electron cloud
Focal spot on tungsten target
Glass envelope
Vacuum
Copper stem
–
Electrons
+
Cathode (–)
Electronic focusing cup
Tube window
Useful X-ray beam
Anode (+)

leaded glass housing

- It is a leaded glass vacuum tube that prevents X-rays from escaping in all directions (radiation leakage).
- One central area of the leaded glass tube has a "**window**" that permits the X-ray beam to exit the tube and directs the X ray beam towards the aluminum disk, lead collimator and PID

Negative cathode

- It is principally composed of two parts:

    I . filament.

    ii. focussing cup.

Filament:

- The filament is the source of electrons in the tube, it is made up of a coil of tungsten wire (atomic number 74, melting point 3380oC),

  approximately 0.2 cm in diameter,

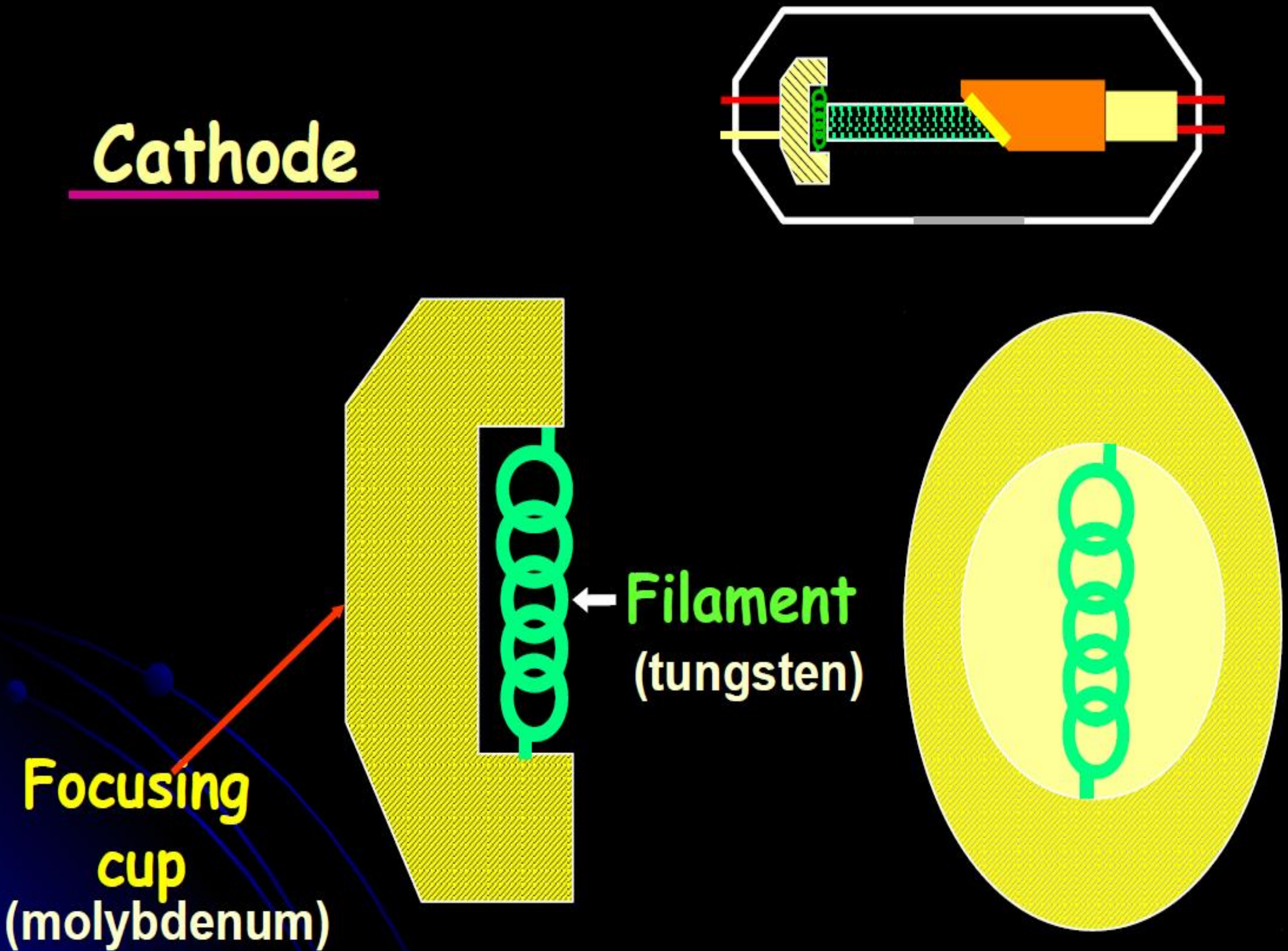
  1-2 mm wide,

  0.1-0.2 mm thick and

  7 to 15 mm in length.
- It is mounted on two strong stiff wires, that support it and carry the electric current.

- Vaporization of the filament occurs over a period of time.
- *'sunburning'* or *'sun-tanning' of the tube.*
- *'arcing' and ultimate tube* failure.
- Thorium (a radioactive metallic element) is added to the filament material to make the tube last longer.
- Other materials used for the filament are; Rhenium (melting point-3,3700C), Molybdenum (melting point-2,6200C)

Cathode



The focusing cup

- is a negatively charged concave reflector cup of molybdenum or nickel and houses the filament.
- focuses the electrons emitted by the filament into a narrow beam, directed at a small rectangular area in the anode—the focal spot.
- high negative charge placed on the cathode which repels the electrons in the electron cloud towards the anode which has a high positive charge.
- This is achieved by applying a high voltage circuit between the anode and the cathode.

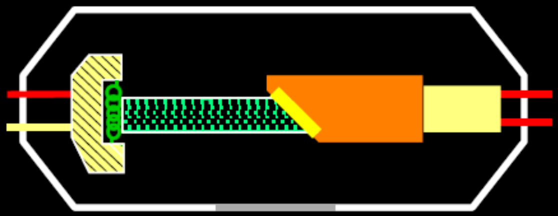
positive anode:

- It consists of a

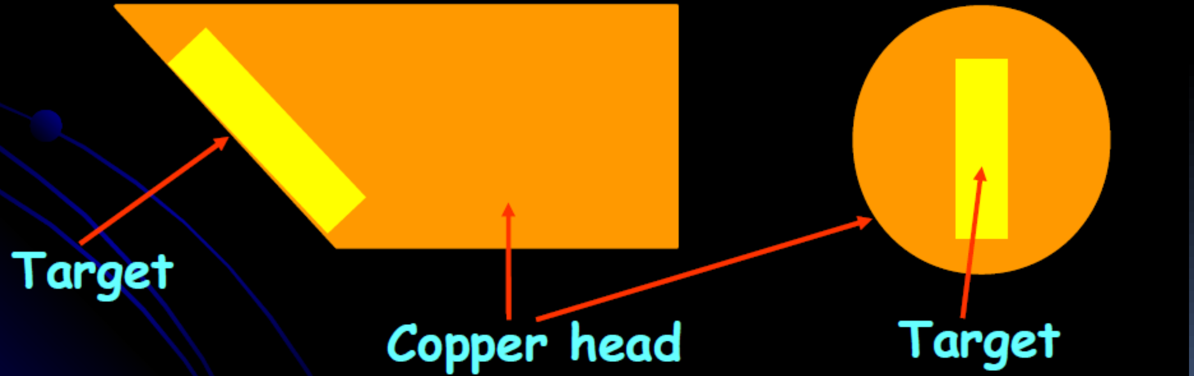
  1. wafer thin tungsten plate (target) embedded in a solid

  2. copper stem.

- The purpose of the target is to convert the kinetic energy of the electrons generated from the filament into X-ray photons.



Anode



features of an ideal target material

- *1.High atomic number:* atomic number 74
- *2.High melting point: 33800°C*
- *3. Low vapor pressure*
- *4. High specific heat (conduction of heat):* to facilitate dissipation of heat, but tungsten is a poor conductor of heat.
- Therefore, the tungsten target is embedded in a copper block which is a good thermal conductor

- The methods of heat dissipation are:

  I . Conduction: through the copper stem.

  ii. Convection: through the oil surrounding the tube.

  iii. Radiation: through the radiator device attached to the copper stem.

  iv. Rotating anode.

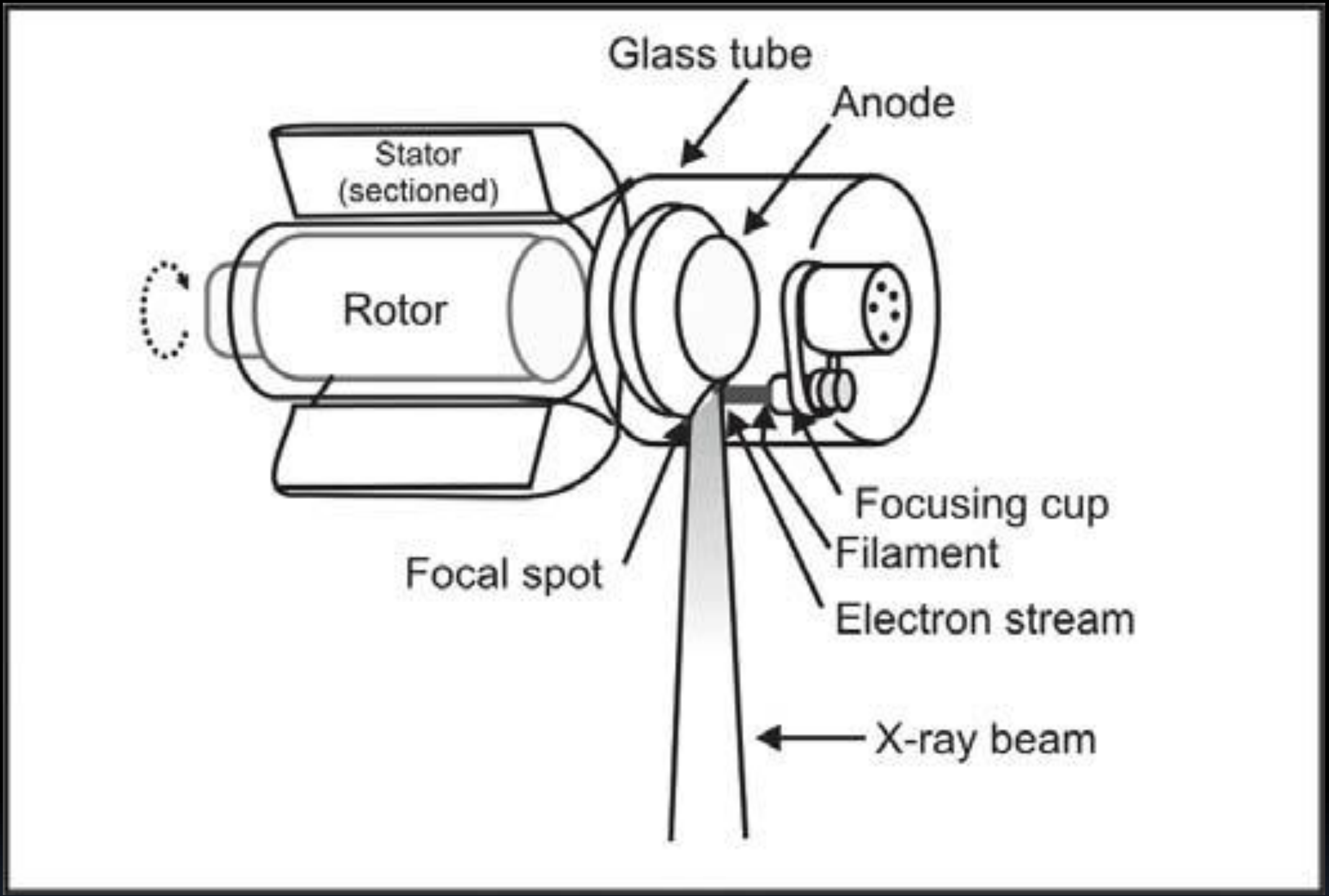
types of anodes:

- There are two types of anodes:

  1. Stationary or fixed anode.

  2. Rotating anode: This type of anode is used to help dissipate heat from a small focal spot

- Rotating anodes are not used in conventional dental X-ray machines, but may be used in cephalometric or extra oral X-ray machines.



X-ray tube with a rotating anode, which allows head at the focal spot to spread out across a large surface area

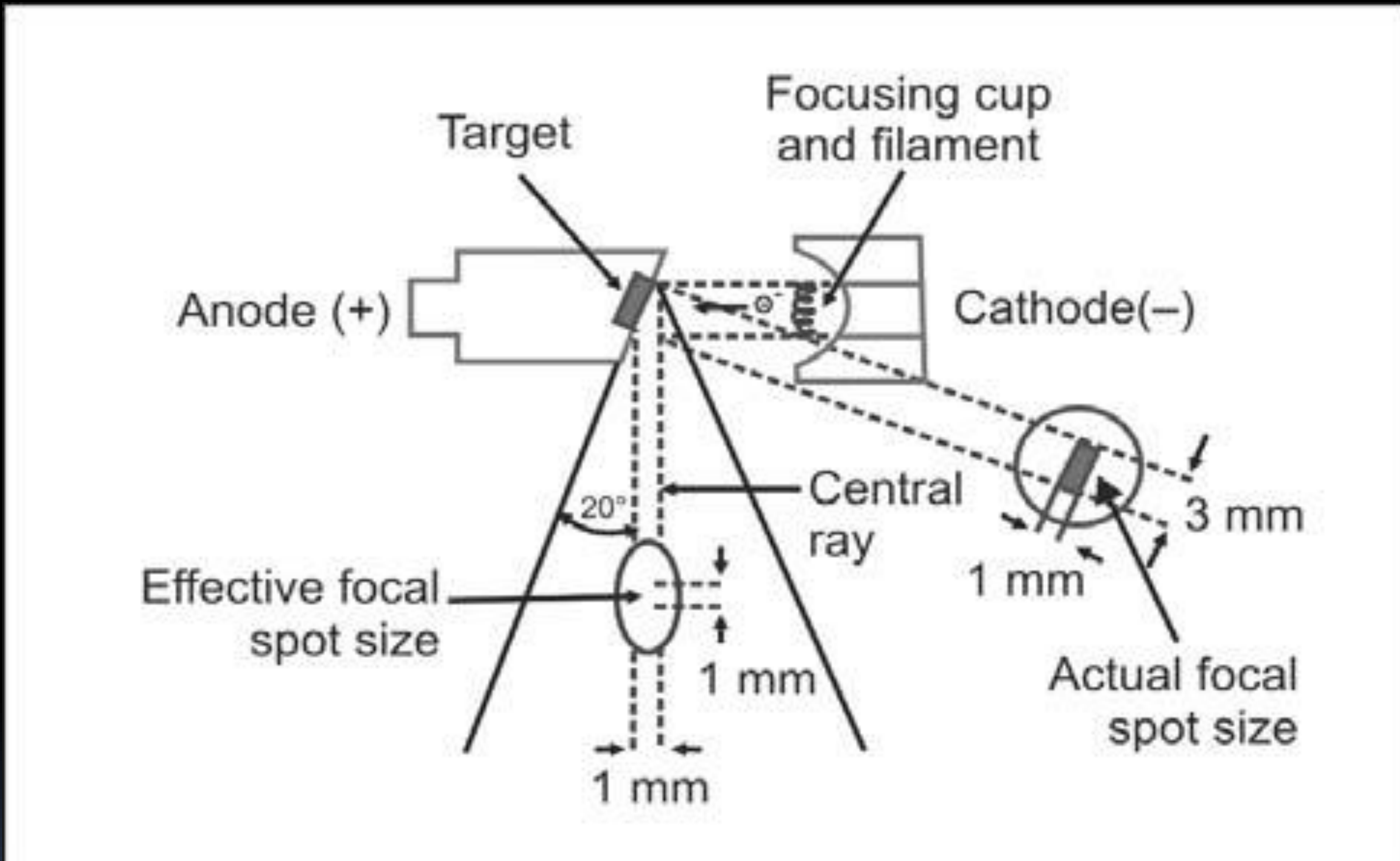
Target size:

- Sharpness of the radiographic image increases as the size of the radiographic source (that is focal spot) decreases.

focal spot

- The focal spot is the area on the target onto which the focusing cup directs the electrons from the filament.
- As the focal spot becomes smaller, heat generated per unit target area becomes greater.
- The effective focal spot will be smaller than the actual size of the focal spot that is projected, perpendicular to the target

- In practice the target is inclined at an angle of 20° to the central ray of electrons. This causes the *effective focal spot to be 1 mm × 1 mm, in contrast to* 1 mm × 3 mm of the *actual focal spot size.*
- This results in a smaller source of X-rays and sharper image with a larger actual focal spot for effective heat dissipation.
- This is known as "*Line focus principle" and the twenty degree angle is called as "the angle of truncation"*

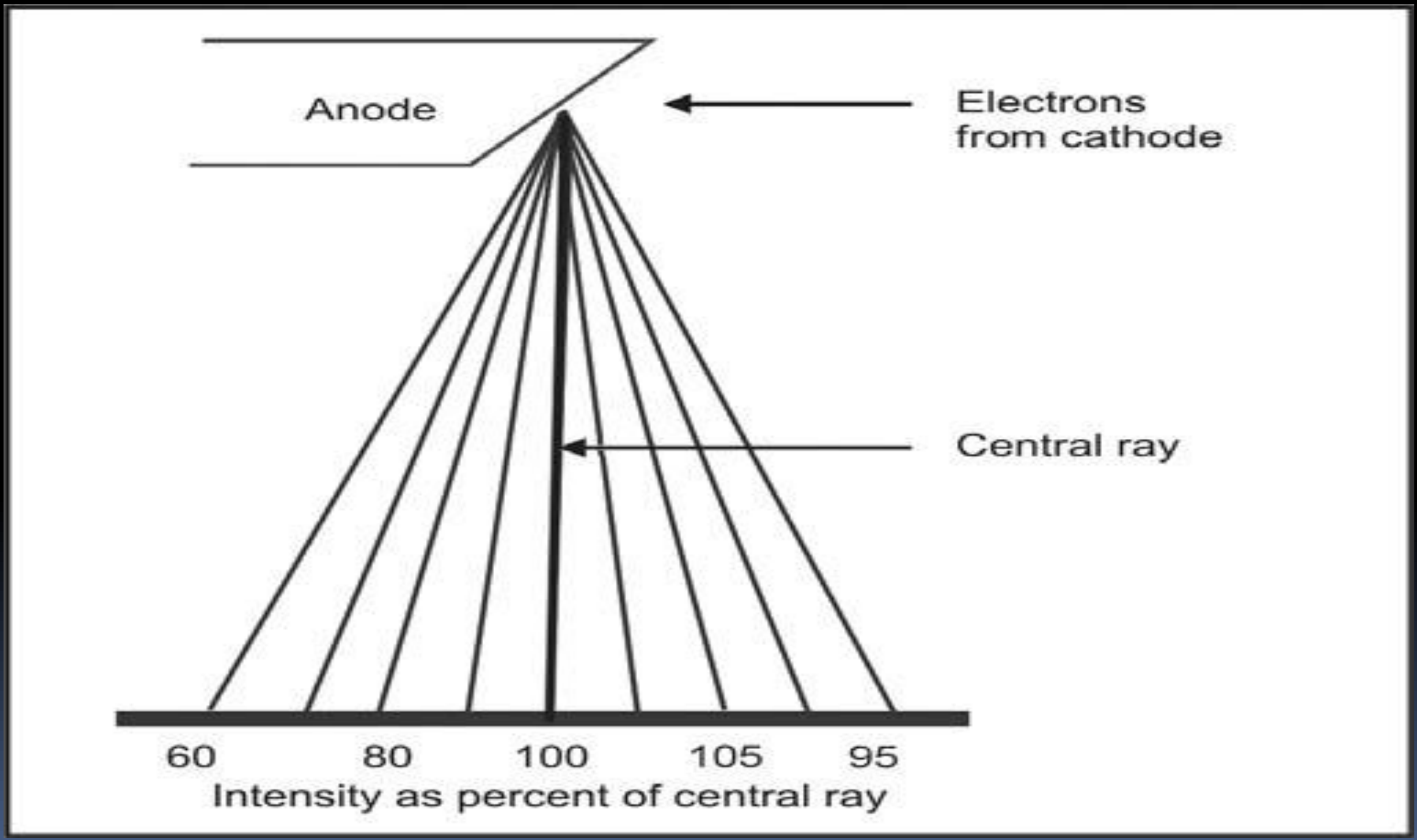


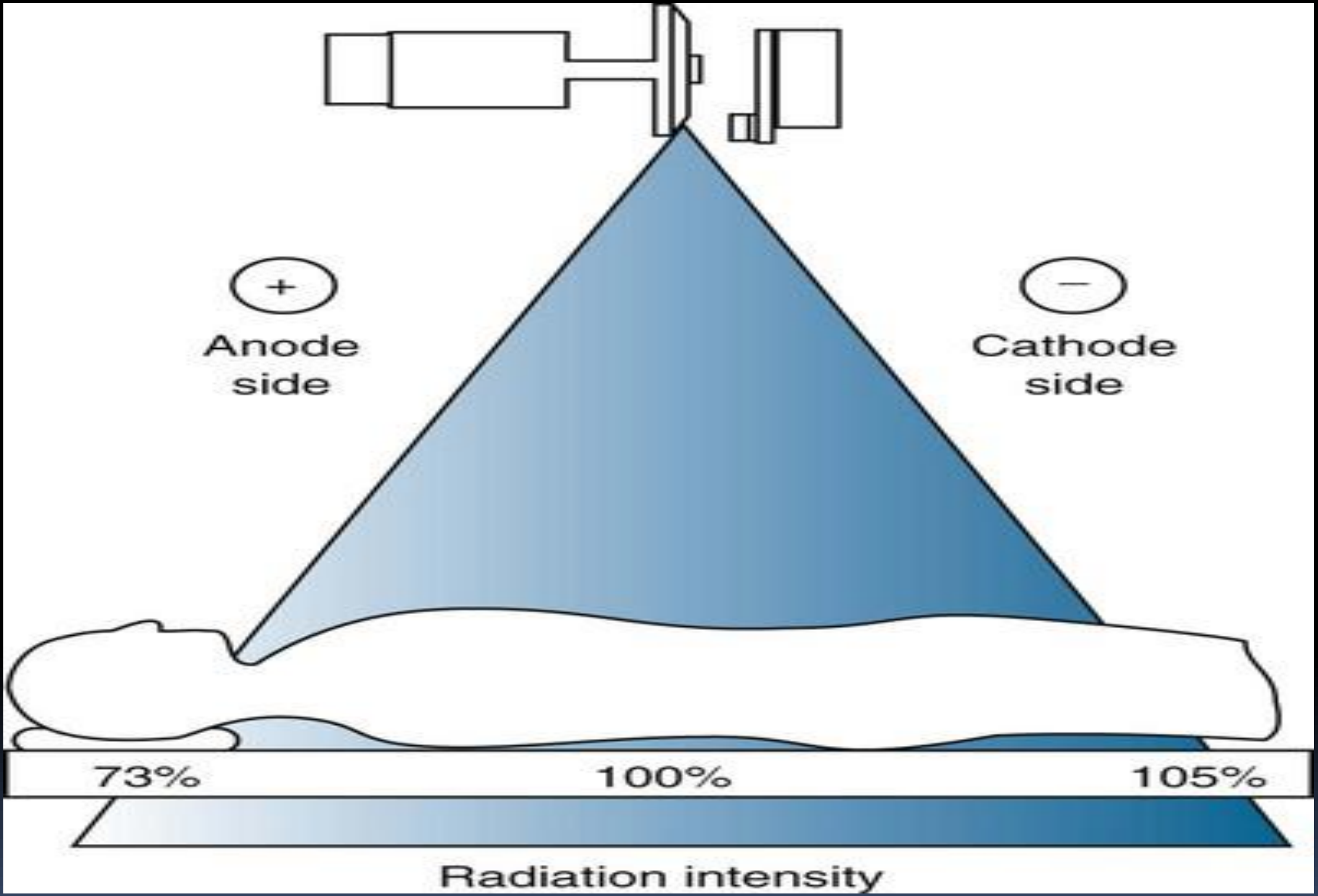
The angle of the target to the central ray of the X-ray beam has a strong influence on the apparent size of the focal spot. The projected effective focal spot is much smaller than the actual focal spot size

heel effect:

- *The **intensity of the beam** is not uniform across the **exposure field**, because the distance from the anode to a point on the **film** away from the perpendicular is greater than the center of the exposure field. (Inverse Square Law).*
- *This **non uniform distribution of photons** contributes to the heel effect and is accentuated as the angle of the target is reduced.*
- ***In dentistry as the size of the film is relatively small ,the heel effect is not seen.***

heel effect:


Anode
Electrons
from cathode
Central ray
60
80
100
105
95
Intensity as percent of central ray



+
Anode
side
−
Cathode
side
73%
100%
105%
Radiation intensity

Electricity and Electric Currents

- *Electricity: It is the energy that is used to produce* X-rays.
- *Electrical energy: It is the flow of electrons through a* conductor and is also called ‘Electric Current
- Electric current may be:

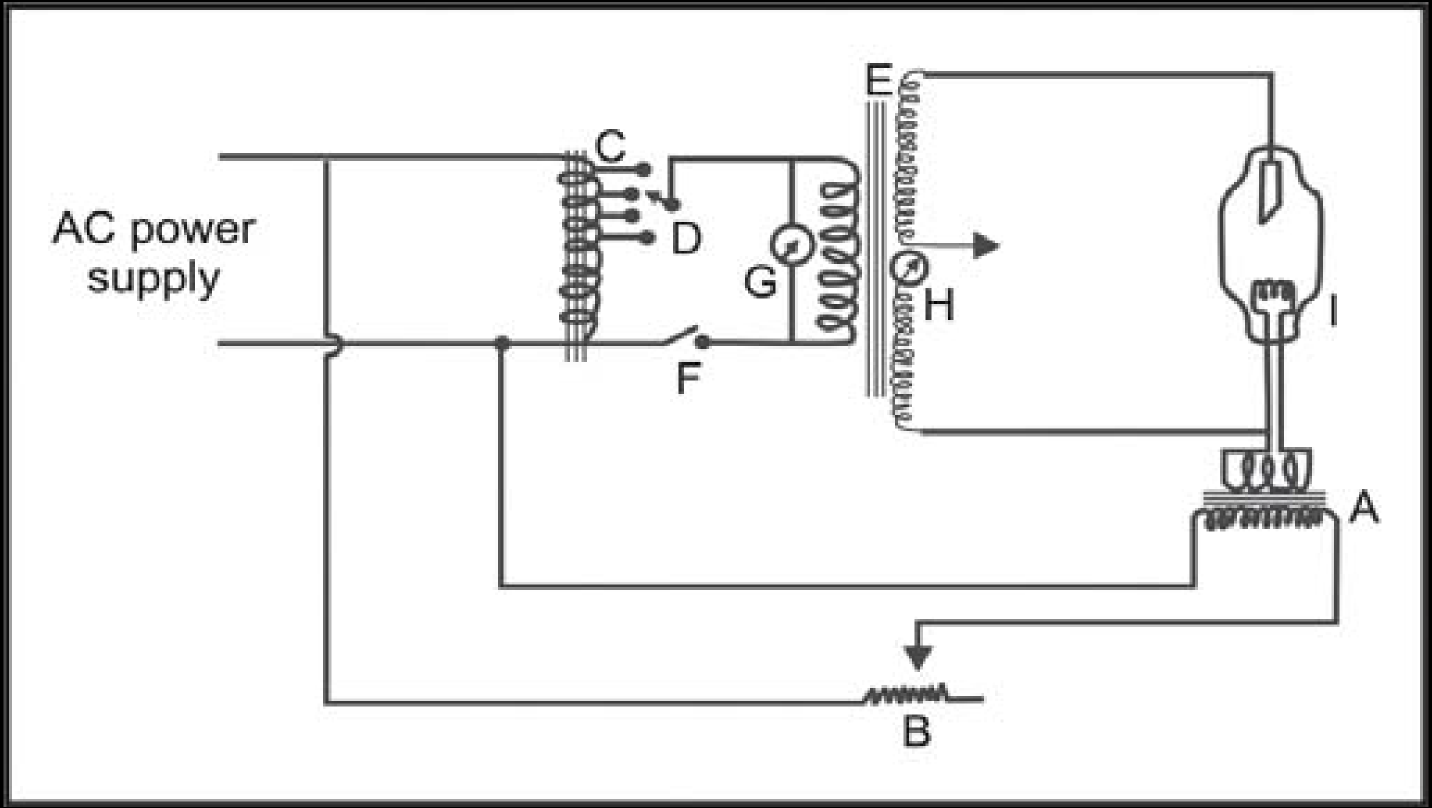
  I . *Direct current (DC): When electrons flow in one* direction only.

  ii. *Alternating current (AC): Describes a current in* which the electrons flow in two opposite directions.

- *Rectification: It is the conversion of alternating current* to direct current.
- The dental X-ray tube acts as a self rectifier, in that it changes AC to DC while producing X-rays.
- *Amperage: It is the measurement of the* ***number of*** **electrons** moving through a conductor.
- *Current is measured in Amperes (A) or Milli amperes* (mA.) If the milli amperes (mA) increases, the **number of electrons** passing through the cathode filament increases.
- *Voltage: It is the measurement of* ***electric force*** *that* causes electron to move from a negative pole to a positive one. It is measured in Volts (V) or kilovolts (kV). If there is increase in kilovoltage **wavelength is decreased, penetration will increase.**

Circuit:

- It is a **path** of electrical current.
- In the production of X-ray, two circuits are used
- I . *Filament circuit: It is **low voltage** (3-5 volts) and* regulates the flow of electrical current **to the filament** of the X-ray tube. It is controlled by the **mA setting in the Control Panel**.(cathod)
- ii. *High voltage circuit: It uses 65,000 to 1,00,000* volts, providing a **high voltage** required to **accelerate electrons to generate X-rays in the X-ray tube**. It is controlled by the **kVp setting** in the Control Panel.(anode)



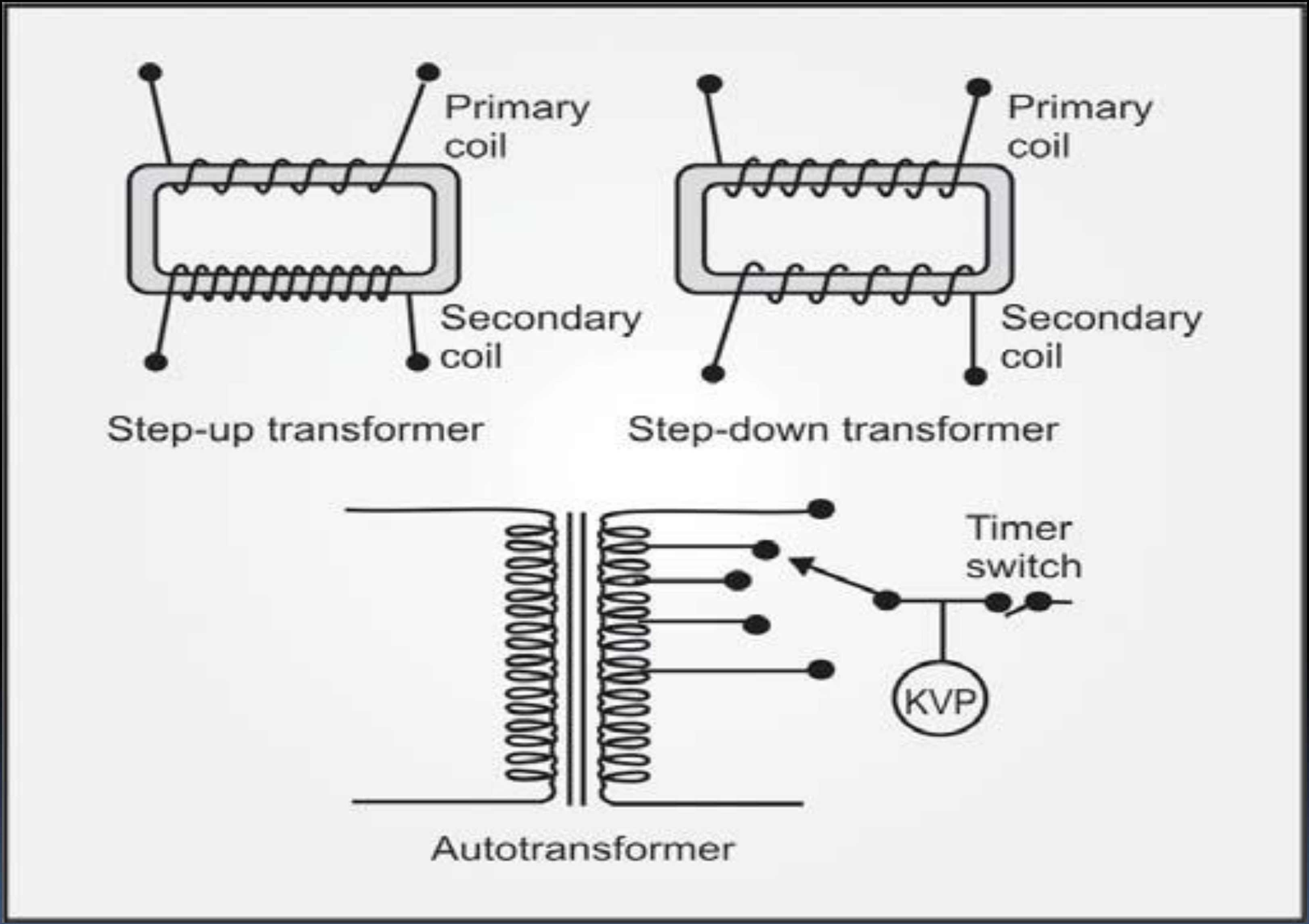
Dental X-ray machine circuit, with the major components labeled,
A. Filament step down transformer,
B. Filament current control (mA switch),
C. Auto tranformer;
D. kVp selector Dial (switch); E. High voltage Transformer;
F. X-ray Timer (switch); G. Tube Voltage indicator (volt meter);
H. Tube current indicator (Ammeter); I. X-ray tube

Transformer:

- It is a device that is used to **either increase or decrease the voltage** in an electrical circuit.
- It alters the voltage of the incoming electrical current and then routes the electrical energy to the X-ray tube.

Types of transformer:

- In the production of X-rays three transformers are used:
- I . *Step down transformer: It is used to decrease the* voltage from the incoming **110-220 line voltage to 3-4V** as required for the filament circuit. (This transformer has **more coils in the primary coil** than in the secondary coil).
- ii. *Step up transformer: It is used to increase the* voltage from the incoming 110-220 line voltage to 65,000-1,00,000 volts as required by the high voltage circuit.
- iii. *Auto transformer: This serves as a voltage* compensator that **corrects the minor fluctuations in the current.**


Primary
coil
Secondary
coil
Step-up transformer
Primary
coil
Secondary
coil
Step-down transformer
Timer
switch
KVP
Autotransformer

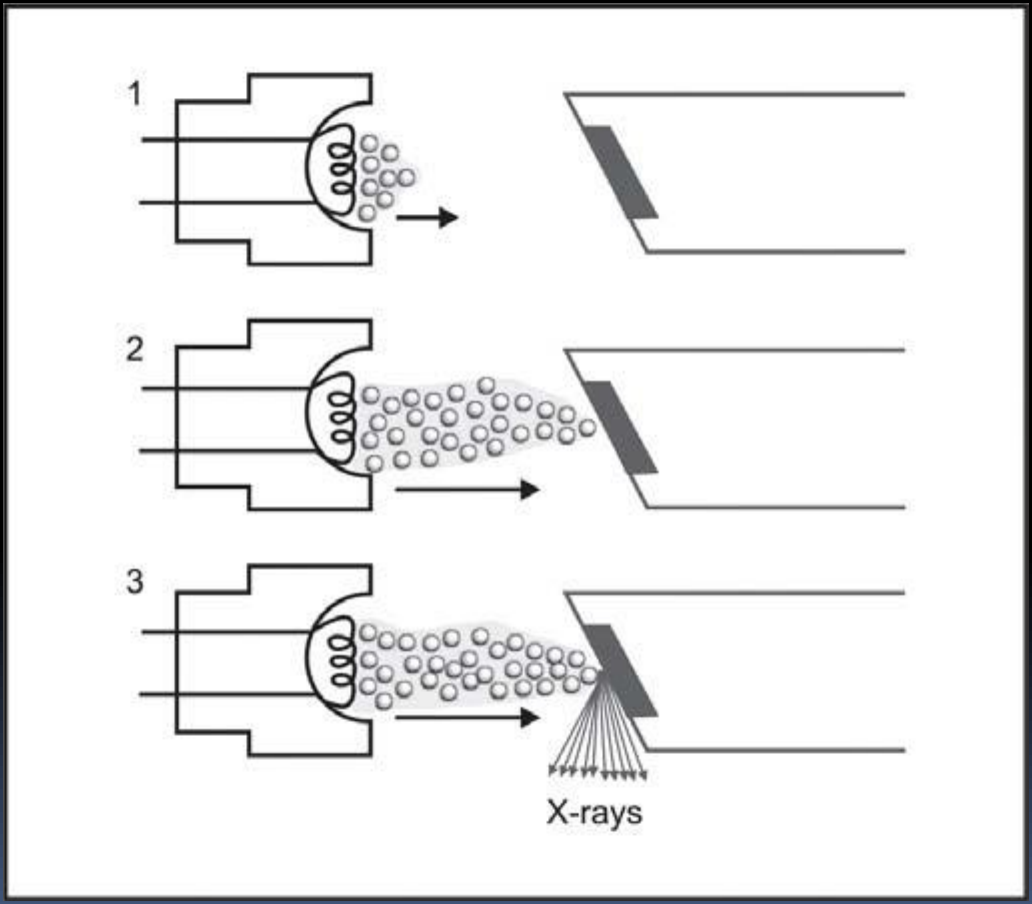
Timer:

- A timing control device, used to control X-ray **exposure time**.
- Two type:
  - Manual and elctrical
- It is included in the primary high voltage supply.
- The timer completes the circuit with the high voltage transformer thereby controlling the time that the high voltage is applied to the tube and thus the time during which the tube current flows and X-rays are produced.


28 impulses
28
Exposure time
Seconds
Pulses
70KVp 7mA
CAUTION
X-RAYS
ATTENTION
RAYONS-X
Gx-770
WARNING:

Manual Timer

Production of X-rays



Steps:

- 1. Electricity from the wall outlet supplies the power to generate X-rays.
- When the X-ray machine is turned on, the electric current enters the control panel, via the plugged in cord and from there to the tube head via electrical wires in the extension arm.
- 2. The current is directed to the filament circuit through the step down transformer, which reduces the 110-220 voltage to 3-5 volts.
- 3. The filament circuit uses the 3-5 volts to heat the tungsten filament. **Thermionic emission** occurs, which results in the release of electrons from the tungsten filament, which form an *'electron cloud'.* This cloud remains around the filament till the high voltage circuit is activated.

- 4. **When the exposure button is pushed** the high voltage circuit is activated. The electron cloud produced at the cathode is accelerated across the X-ray tube to the anode. The molybdenum cup of the cathode directs the electrons to the tungsten target in the anode.
- 5. The electrons travel from the cathode to the anode. When the electrons strike the tungsten target, their energy motion (kinetic energy) is converted to Xray energy and heat.
- **Less than 1 percent** of the energy is converted to X-rays, the remaining 99 percent is lost as heat.

- 6. The heat produced is carried away by the copper stem and absorbed by the insulating oil in the tube head. The X-rays produced are emitted from the target in all directions. However, the **leaded glass housing prevents the X-rays from escaping from the X-ray tube** in any direction. Only a small number of X-rays are able to exit from the X-ray tube **via the unleaded glass window** portion of the tube.
- 7. The X-rays travel through the unleaded glass window, the tube head seal, the aluminum disks, which **filter** the long wave X-rays from the beam.
- 8. The size and shape of the X-ray beam is controlled by the **lead collimator**. The X-ray beam then travels down the lead lined **PID** and exits the tube head at the opening of the PID.

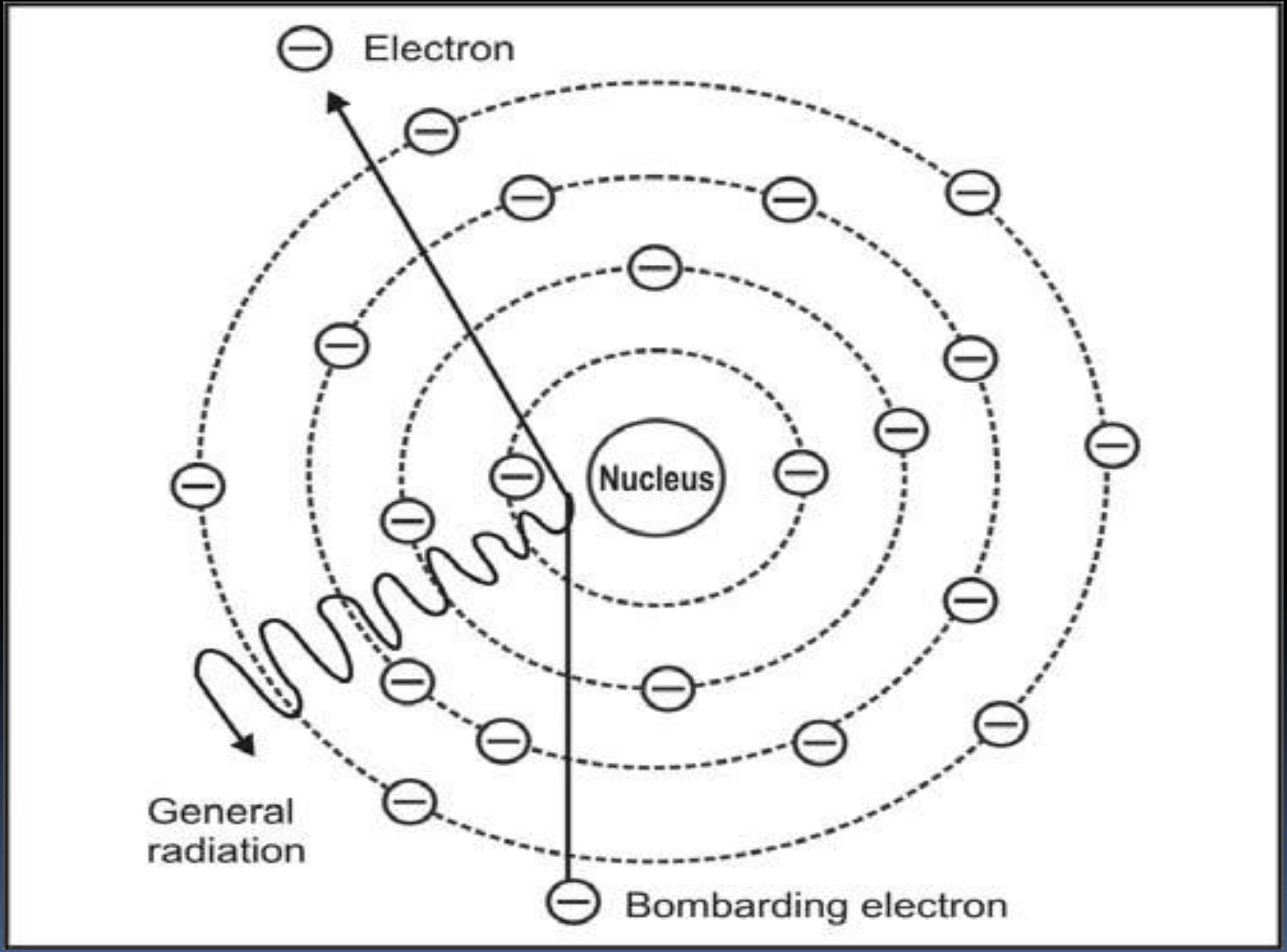
Types of X-rays produced:

- The **kinetic energy of the electrons is converted to X-ray photons via** one of the following **mechanism**:
- a. *General (Bremstrahlung Radiation or Breaking Radiation) Radiation*
- b. *Characteristic Radiation*

General Radiation

- 70% of the X-rays are produced in this manner.
- If the **electron hits the nucleus** of the tungsten atom all its kinetic energy is converted into "High Energy X-ray Photon". But most of the time, instead of hitting the nucleus, most electrons **just miss the nucleus** of the tungsten atom.
- When the electron comes close to the nucleus, it is attracted to the nucleus and slows down, consequently an **X-ray photon is released** (due to the decrease in the kinetic energy of the photon).

General Radiation

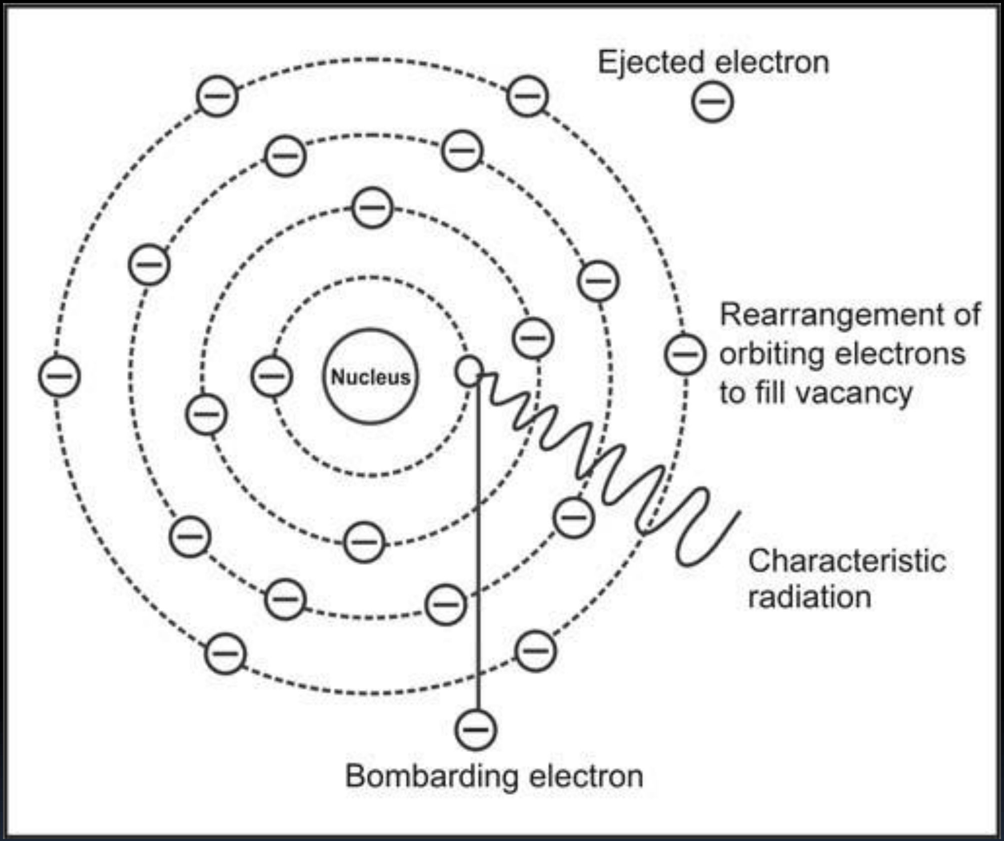


- The electron that misses the nucleus **continues to penetrate many such tungsten atoms** producing **many lower energy X-ray photons** before it imparts all its kinetic energy.
- As a result General Radiation consists of **X-rays of many different energies and wavelengths.**
- It is also called Continuous Spectrum.

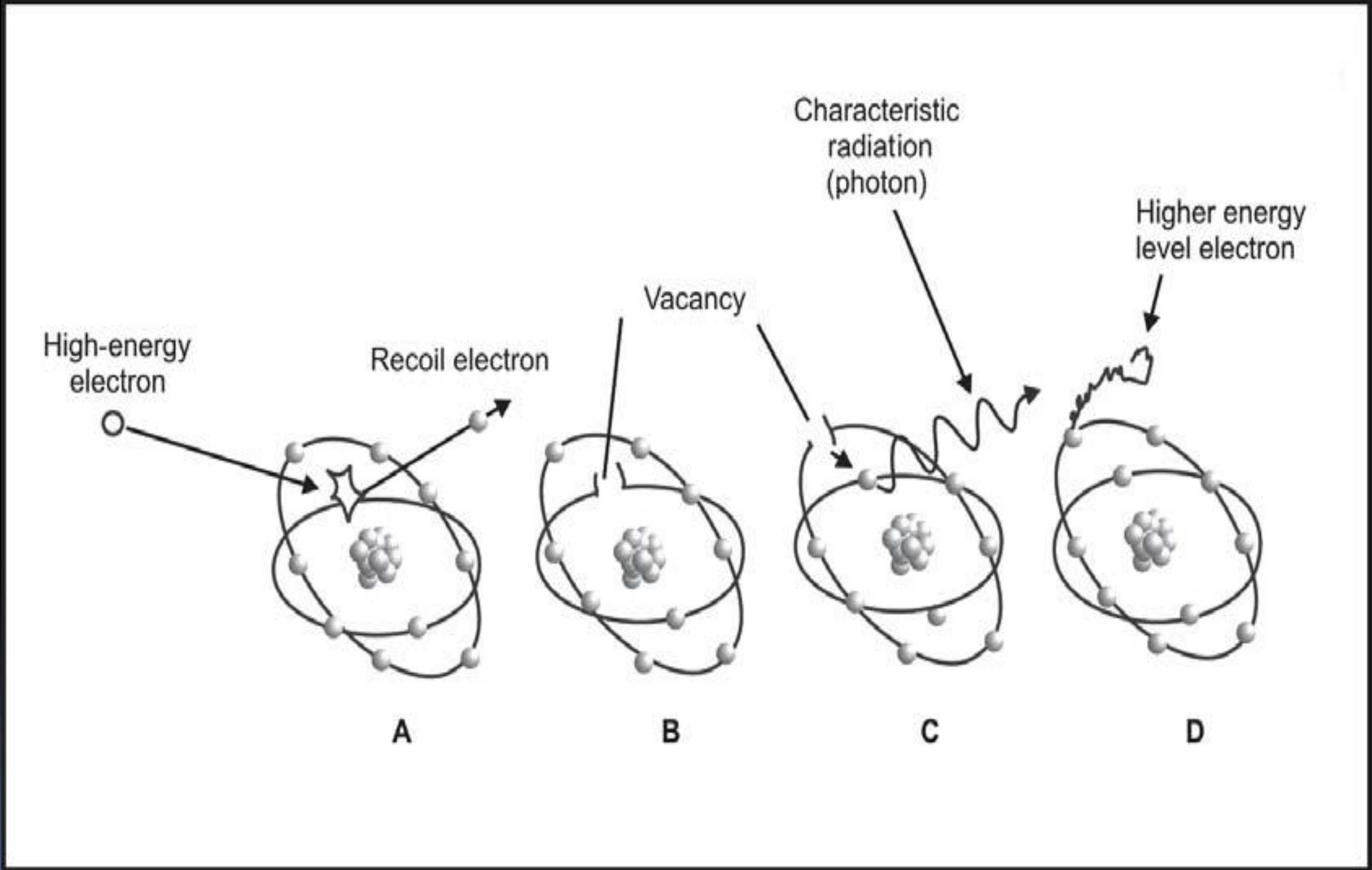
Characteristic Radiation

- It is produced when a high speed electron **dislodges an inner shell electron from the tungsten atom** and causes ionization of the atom.
- Once the electron is dislodged the remaining orbiting electrons are **rearranged to fill the vacancy.**
- This **rearrangement produces a loss of energy that results in the X-ray photon**, with the energy equal to the **difference in the two orbital energy states.**
- The X-ray thus produced is called Characteristic Radiation.

Characteristic Radiation



An electron that dislodges an inner shell electron from the tungsten atom results in the rearrangement of the remaining orbiting electrons and the production of an X-ray photon known as characteristic radiation


High-energy electron
Recoil electron
Vacancy
Characteristic radiation (photon)
Higher energy level electron
A
B
C
D

Uses of X-rays

- 1. Radiology:

  I . Diagnostic use in dentistry and medicine, helps to diagnose various pathological lesions.

  ii. Medicolegal cases.

- 2. Radiotherapy:
- X-rays are used to destroy malignant tumors and to cure skin diseases. The treatment may be curative or palliative.

Uses of X-rays

- 3. Industry:
  - i. Used to detect
    - defect in radio valves, tennis balls, tyres.
    - presence of pearls in oysters.
  - iii. Used to test the uniformity of insulating material.
  - iv. Used to test the quality of oil paintings
- 4. Engineering:
  - i. For examination of gross structures.
  - ii. Used to detect cracks in structures and blow holes in metals.
  - iii. To test quality of welding, moulds and metal castings.
  - iv. To detect cracks in the body of airplanes, motor cars and vans.

Uses of X-rays

- 5. Spectroscopy: Identification of **elements** and their **atomic numbers and structures**.
- 6. Photochemistry: Ionization of **chemicals** producing **oxidation reduction**, etc.
- 7. Radiobiology: Alteration of **cells and tissues** for experimental purposes.
- 8. Crystallography: Analysis of **molecular structures.**

THANKYOU

FACTORS AFFECTING THE PRODUCTION OF AN IDEAL RADIOGRAPH

Ideal Radiographs

- In HM Worth's words; "An Ideal Radiograph is one which has desired density and overall blackness and which shows the part completely without distortion with maximum details and has the right amount of contrast to make the details fully apparent".

Characteristics:

The characteristics of an Ideal Radiograph are:

- A. Visual characteristics:
  - I . Density.
  - ii. Contrast.
- B. Geometric characteristics:
  - I . Sharpness or detail, resolution or definition.
  - ii. Magnification.
  - iii. Distortion.
- C. Anatomical accuracy of radiographic images.
- D. Adequate coverage of the anatomic region of interest.

Factors affecting the production of an ideal radiograph

Classification of factors:

1. Factors related to the radiation beam
   a. Exposure time
   b. Milli amperage
   c. Kilo voltage peak
   d. Tube film distance
   e. Focal spot size
   f. Collimation
   g. Filtration
   h. Equipment efficiency.

Classification of factors:

2. Factors related to the absorbing media or object
   a. Object thickness
   b. Object density.
3. Factors related to the technique
   a. Position of patient's head
   b. Placement and position of the film
   c. Angulation of the X-ray beam.
4. Factors related to image recording
   a. Reduction in secondary radiation
   b. Films and film storage
   c. Intensifying screens
   d. Film processing.

VISUAL CHARACTERISTICS

1.Density:

- It is the overall blackness or darkness of a dental radiograph.
- Density is this degree of silver blackening.
- Darker areas represent heavier deposits of black silver particles.
- A radiograph with correct density enables the radiographer to view black areas (air spaces), white areas (enamel, dentin and bone) and gray areas (soft tissue).

Factors Effecting the Density of a Radiograph

- ***First Degree Factors***

  a. *Milliamperage (mA)*

  b. *Exposure time*

  c. *Operating kilo voltage peak (kVp)*

  d. *Source film distance*

- ***Second Degree Factors***

  a. *Subject thickness*

  b. *Developing process*

  c. *Type of film*

  d. *Screens*

  e. *Grids*

  f. *Amount of filtration used*

  g. *Fog*

First Degree Factors

Milliamperage (mAs):

- The number of photons produced by an x-ray tube in a second
- An increase in milliamperage produces more X-rays that expose the film and as a result increase film density.

- density varies directly and proportionately as the milliamperage or the tube current.

Exposure time

increase in the exposure time

↓

increase the total number of X-rays

↓

film density is increased.

↑ Exposure time → ↑ density

Operating kilo voltage peak (kVp)

- potential difference between the cathode and the anode
- An increase in the kVp increases the energy of the X-rays, hence increases their power of penetration there by increasing the film density.

$D\ \alpha\ (kVp)2$ (Thumb Rule)

Source film distance:

- The intensity of an X-ray beam varies inversely as the square of the (S-F) distance, density also varies inversely as the square of the (S-F) distance.

$$\text{Density} = \frac{(\text{kVp})^2 \times \text{mA} \times \text{S}}{[(\text{S-F})\ \text{distance}]^2}$$

↑ distance → ↓ density

Second Degree Factors

Subject thickness

- Fewer X-rays will reach the film in a patient with an increased amount of soft tissue or thick dense bones. As a result the radiograph will appear light and have less density.

↑ subject thickness → ↓ density

- In case of a suspected pathology—
  - If destruction is suspected then

    E.g.= periapical abscess, cyst

exposure time is decreased.

  - If deposition is suspected then

exposure time is increased.

E.g.= osteomylitis, condensing osteitis

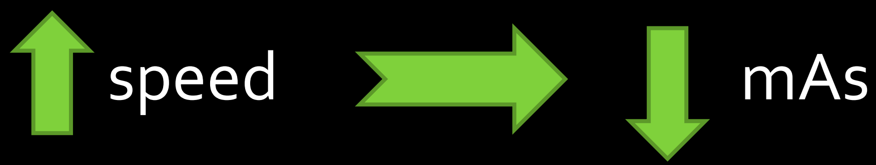
Developing process

Overdeveloped → dark film

Underdeveloped → light film

Type of film:

- *Film speed: High speed films require less mAs* in order to obtain a density change.



- *Film latitude: It is measured as a range of* exposures that can be recorded as distinguishable densities on a film.
- *Radiographic noise: It is the appearance of* uneven density of a uniformly exposed radiographic film. It is seen on a small area of film as localized variations in density. The primary cause is radiographic mottle.

Type of film:

- ***Slow films:*** *very small grain of* silver bromide
  - emulsion is on one side only.
  - Their speeds are denoted by A, B, C.
- ***Fast films:*** *larger grain size*
  - emulsion is on both sides.
  - D-ultra speed, E- ekta speed and F- ultra ekta speed.
- ***Hyper speed G:*** *This is a 800-speed film that can* half the patient exposure without blurring image quality.

Screens

- Use of screens require less mAs in order to obtain a density change.

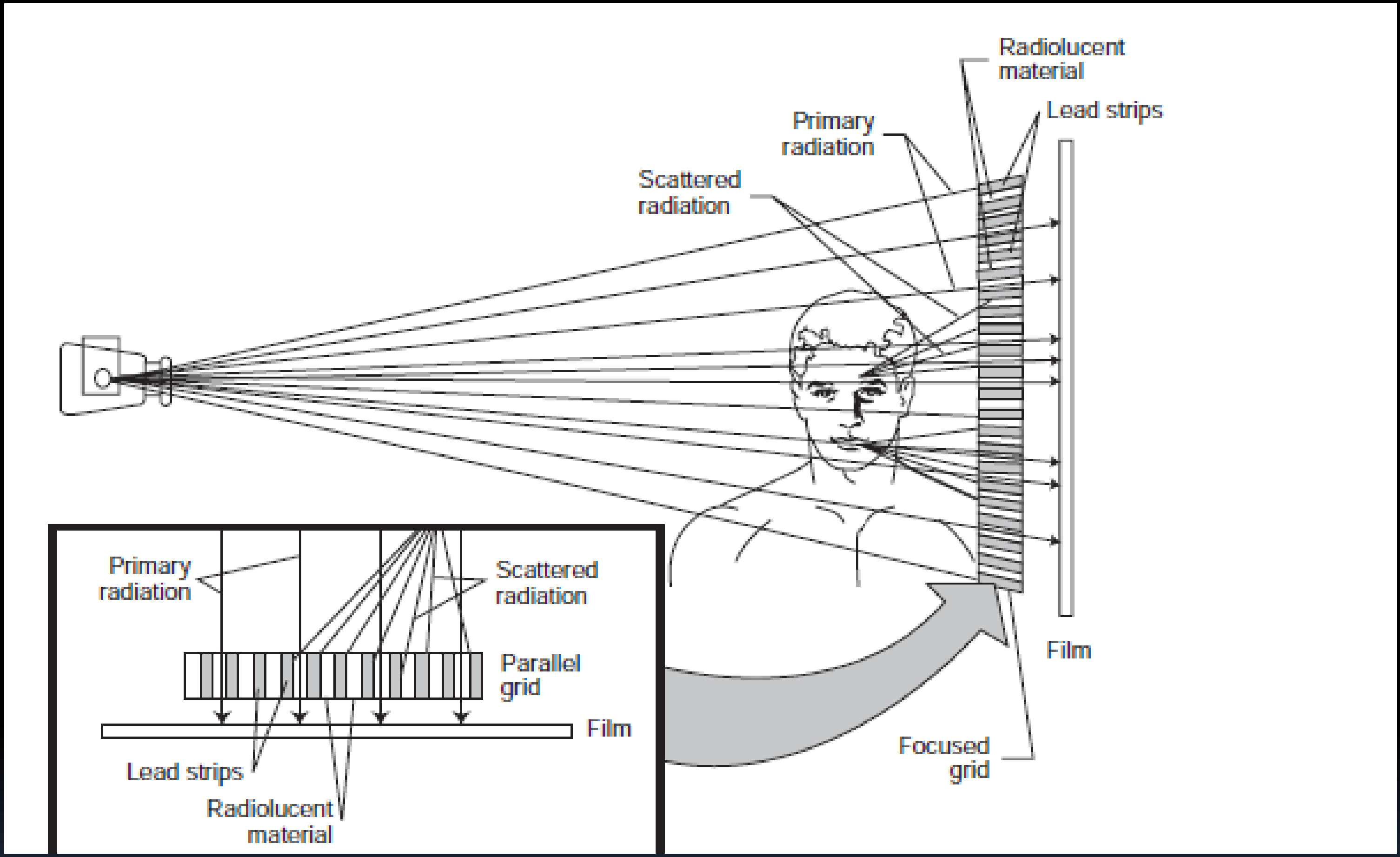
↑ screen → ↓ mAs

Grids

- The use of grids require more mAs in order to obtain a density change.

↑ grids → ↑ mAs

Grids



An x-ray grid absorbs scattered x-ray photons from the primary beam and prevents them from fogging the fi lm. In a focused grid the absorber plates are angled toward the anode; in a parallel grid the absorber plates are parallel.

Amount of filtration used

- Reduction in the amount of added filtration used will increase the number of photons reaching the film and hence increase the density.

↓ added filtration → ↑ density

Fog

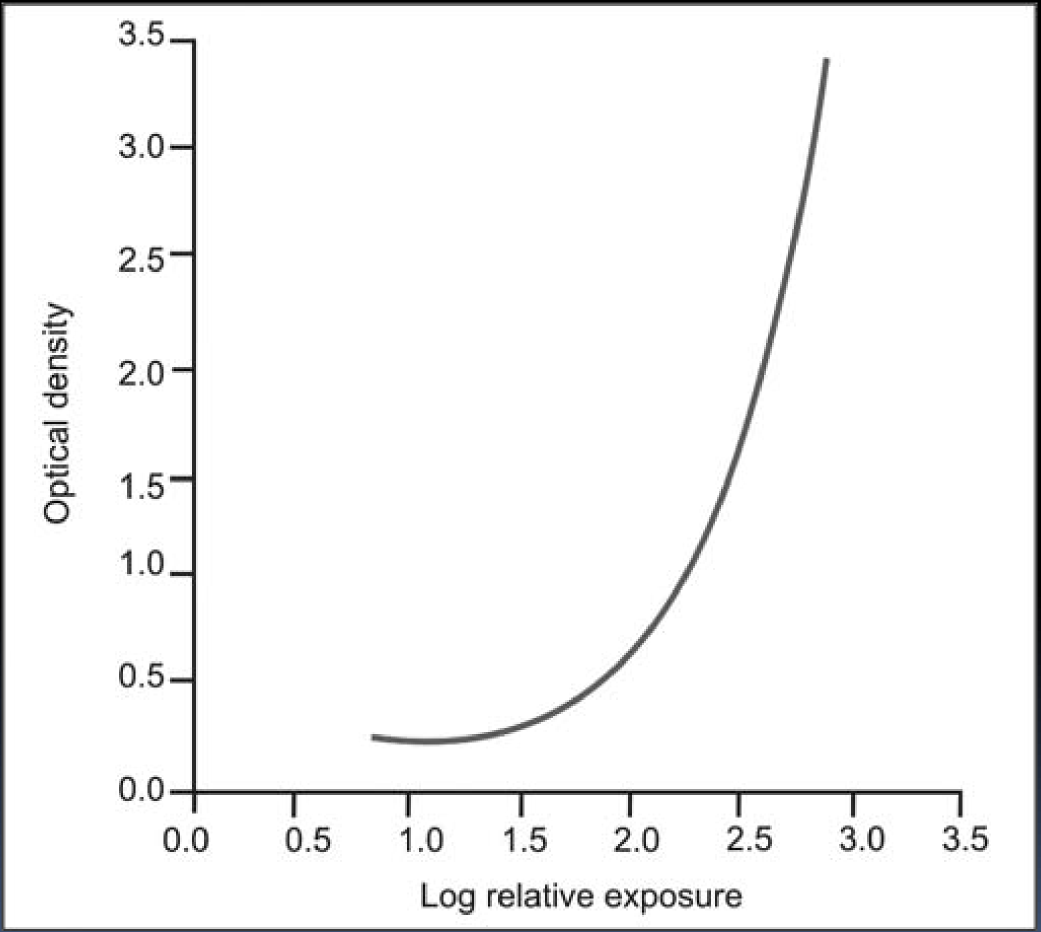
- Film fog may result in an undesirable form of darkening of the film.

Degree of Desired Density

- Optical density = $\log_{10} \frac{I_o}{I_t}$
- Io is the Intensity of Incident Light (e.g. from the view box)
- It is the Intensity of light transmitted by the film.
- When , D = 0, 100% light is transmitted.
  D = 1, 10% light is transmitted.
  D = 2, 1% light is transmitted.
- In routine radiographs, the useful range of film density is approximately 0.3 (very light) to 2 (very dark).
- Beyond these limits, the image is not of any diagnostic value.

Characteristic Curve

- A graphic plot of relationship between film density and exposure is called a Characteristic Curve or H and D Curve after Hurter and Driffield who first described this relationship in 1890
  - As exposure is increased, density also increases.
  - The film has greatest diagnostic value, at the relatively straight portion of the graph, that is between 0.6 and 3, optical density units.



3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Optical density
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Log relative exposure

Contrast

- It is the difference in the degree of blackness (densities) between adjacent areas on a dental radiograph.

very dark areas and very light areas,

↓

'high contrast',

many shades of gray

↓

'low contrast'.

low contrast

high contrast

Factors determine contrast:

- a. *Film contrast*
- b. *Subject contrast*
- c. *Operating kilo voltage peak (kVp)*
- d. *Exposure time*

Film contrast:

- refers to the characteristics of the film that influence the radiographic contrast.
- These characteristics include:
  - *Inherent qualities of a film*
  - *Film processing*

Inherent qualities of a film

- These are under the control of the film manufacturer
  - Fast film → less exposure → decreased contrast and sharpness.
  - Double coated film → less exposure → decreased contrast.
  - thicker layer of emulsion → more developing time → increased contrast.

Film processing

↑ developing time → ↑ contrast.

↑ developer temperature → ↑ contrast.

- Only Elon in the developing solution will give indistinct contrast.
- Only Hydroquinone in the developing solution will produce a harsh black and white image.
- Therefore a combination of Elon and Hydroquinone is used to produce better results and adequate contrast.
- Film fog, smothers the whole film with a dull gray shadow, giving a very poor contrast.

b. *Subject contrast*

- Subject contrast is determined by:
  - Thickness of the subject.
  - Density of the subject.
  - Composition (atomic number) of the subject.
- Subject contrast can be controlled by regulating the kilo voltage peak.

↑ kVp → ↓ subject contrast

c. Operating kilo voltage peak (kVp)

- Only exposure factor which has a direct influence on the contrast of a dental radiograph.

Increase in kVp

↓

increase in the energy of the X-rays produced.

↓

increase in the penetrating power of the X-rays,

↓

more variation in the tissue densities recorded.

↓

production of various shades of gray.

↓

decrease in the contrast

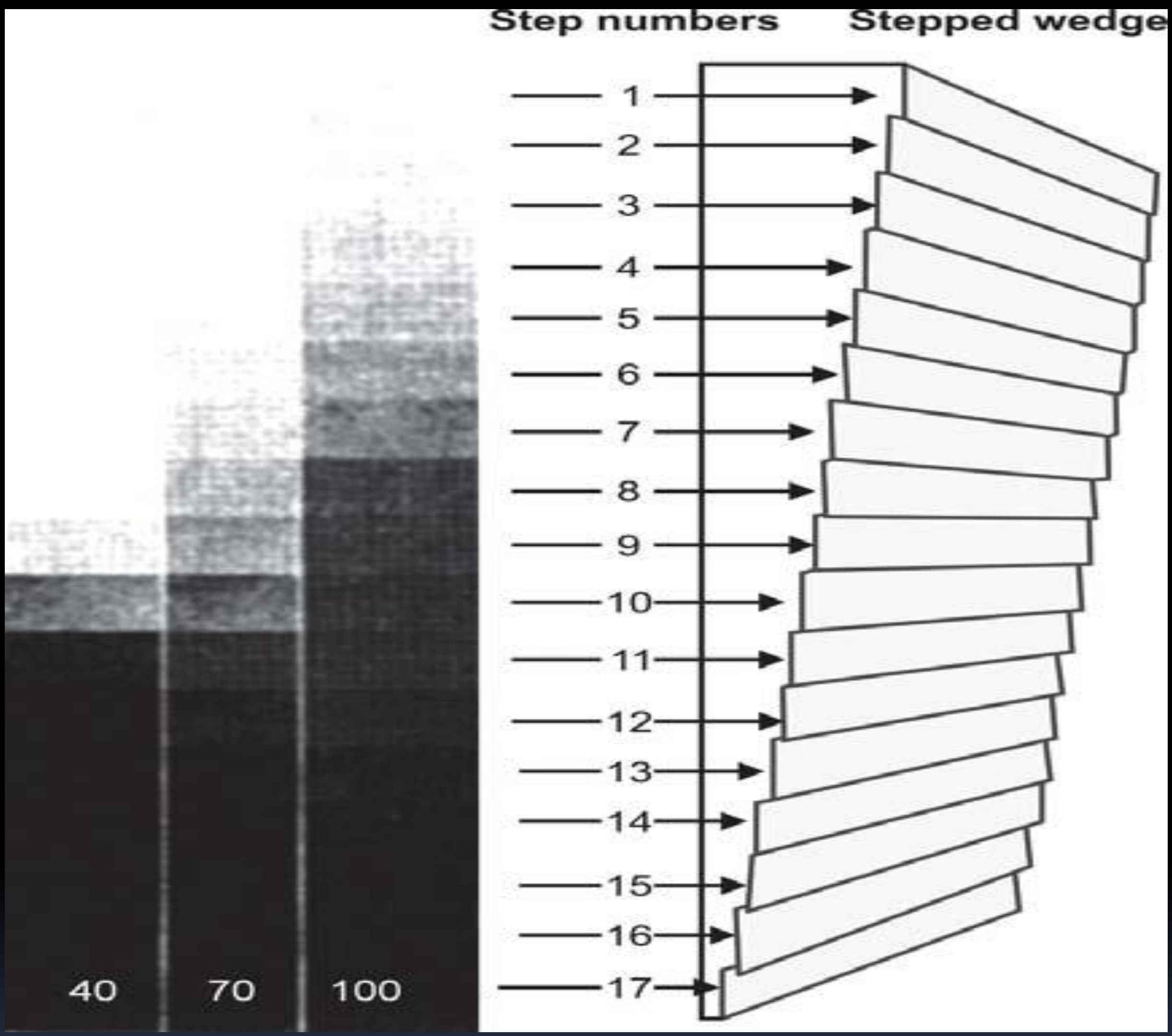
d. *Exposure time*

↑ Exposure time → ↑ contrast

- The dental radiograph needs to have a compromise between the high and low contrast in order to produce a range of useful densities on a dental radiograph. This is called 'Scale of Contrast'

Scale of Contrast

- Short Scale Contrast is produced by decreasing the kVp which produces black and white areas giving high contrast.
- Long Scale Contrast is produced by increasing the kVp which produces many shades of gray areas giving low contrast



Radiographs taken at 40 kVp are predominantly black and white—that is they have high contrast (a short contras scale). Those taken at 100 kVp show many shades of gray (along contrast scale)

Relationship between Contrast and Density

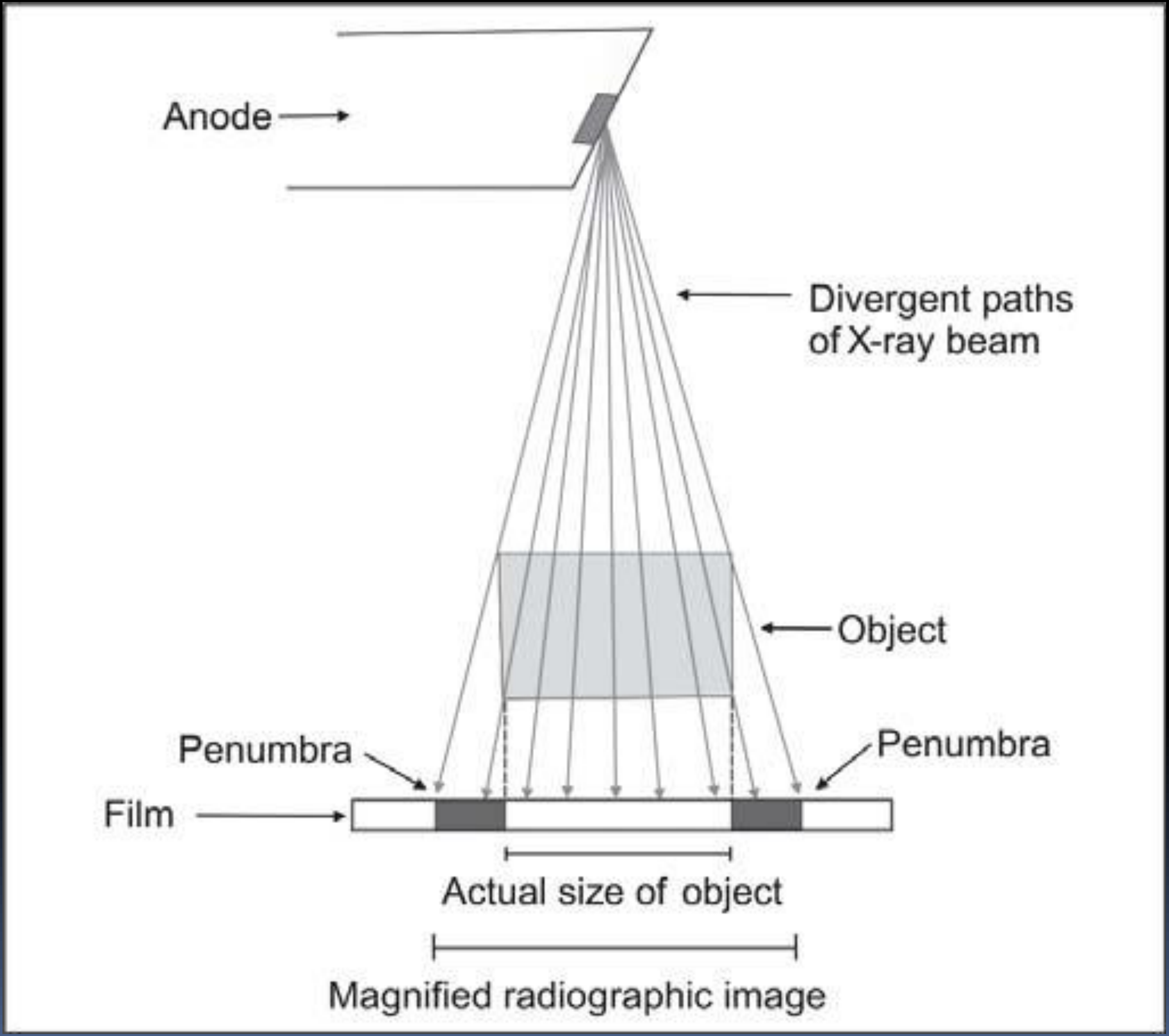
- *When Contrast is altered, the Density is also changed.*
- This is because
  - Change in kVp produces a change in Contrast and Density.
  - Change in mA alone does not change the Contrast.

GEOMETRIC CHARACTERISTICS

I. Sharpness

- also referred to as Detail, Resolution or Definition.
- Refers to the capability of X-rays to reproduce distinct outlines of an object or to reproduce the smallest details of an object on a dental radiograph.

- *Umbra is defined as that part of the shadow where* all light is absorbed, or area of total darkness.
- *Penumbra is defined as that part of the shadow of* an object which is larger than a point and yet represents a single point of the object. It is thus the unsharpness of the image seen at the edge of the image.


Anode
Divergent paths of X-ray beam
Object
Penumbra
Penumbra
Film
Actual size of object
Magnified radiographic image

factors that control sharpness:

a. Geometric unsharpness

- – Size of the Focal Spot.
- – Object Film Distance.
- – Target Film Distance.

b. Motion unsharpness

- – Patient.
- – Tube.
- – Film.

c. Film unsharpness

- – Grain Size
- – Single and Double Emulsion.
- – Film Thickness.

.

d. ‘Fog’ unsharpness

- – Scattered Radiation.
- – Unsafe, Safety Light in the Darkroom.
- – Chemical Fog.

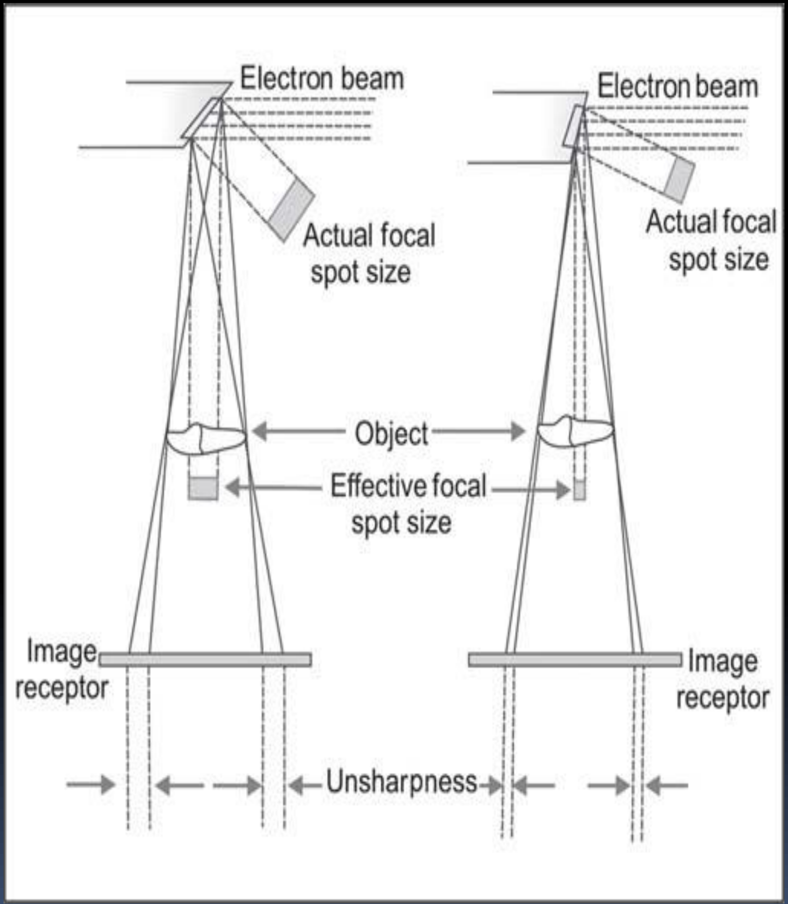
e. Intensifying screen unsharpness

- – Crystal Size.
- – Back Screen Scatter.
- – Mottle

a. *Geometric unsharpness*

- This type of unsharpness is due to criss-crossing of rays at the edges of the object, resulting in a fuzzy image border.
  - Size of the focal spot :

    Smaller the focal spot → sharper the image
  - Object film distance : as small as possible, to get a sharper image.



Electron beam
Electron beam
Actual focal spot size
Actual focal spot size
Object
Effective focal spot size
Image receptor
Image receptor
Unsharpness

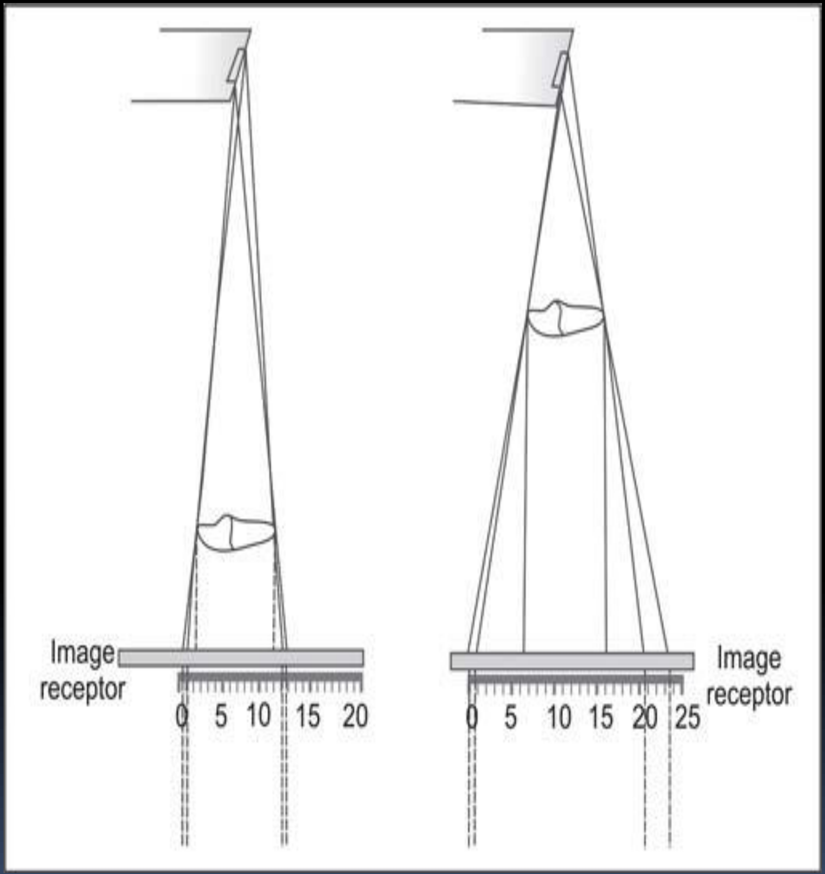


Image receptor
0 5 10 15 20
0 5 10 15 20 25
Image receptor

- Target object distance :as large as possible, to get a sharper image
- The width of the zone of Geometric Unsharpness or Penumbra can be illustrated by the following equation:
- $$Ug = F \times \frac{d}{D}$$

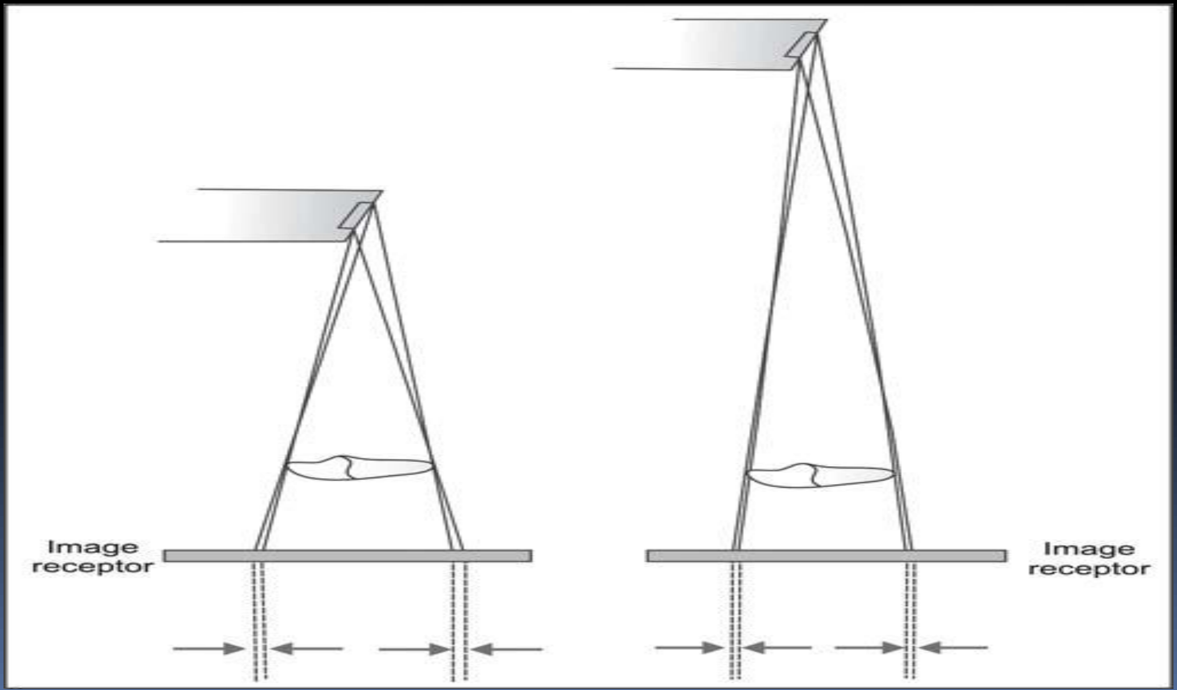
Where, Ug = Penumbra size

F = focal spot size

D = Source to object distance in inches.

d = Object to film distance in inches.

- In the Dental Radiographs, *the portion of the structures closest to the film will have greater sharpness*, therefore lingual cusps of teeth have a more sharper image than the buccal cusps, on the dental radiograph.



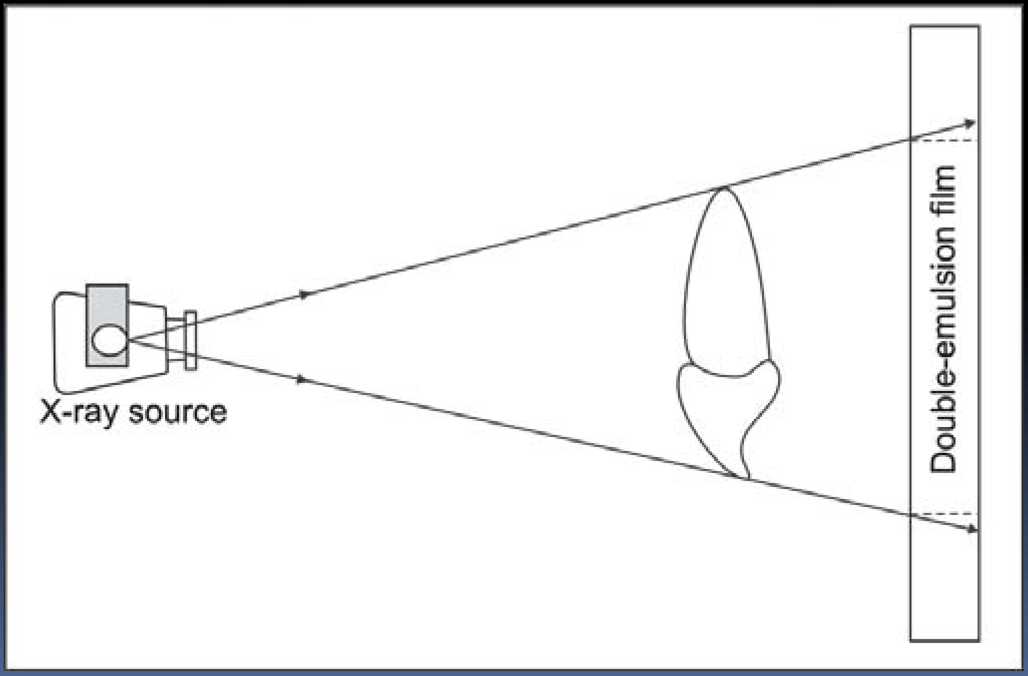
b. *Motion unsharpness*

- Any movement of either the Patient, Tube, or Film, results in unsharpness of the image produced.
- A decrease in the exposure time will give less time for movement thus helping to obtain more sharpness on the radiograph.

c. *Film Unsharpness*

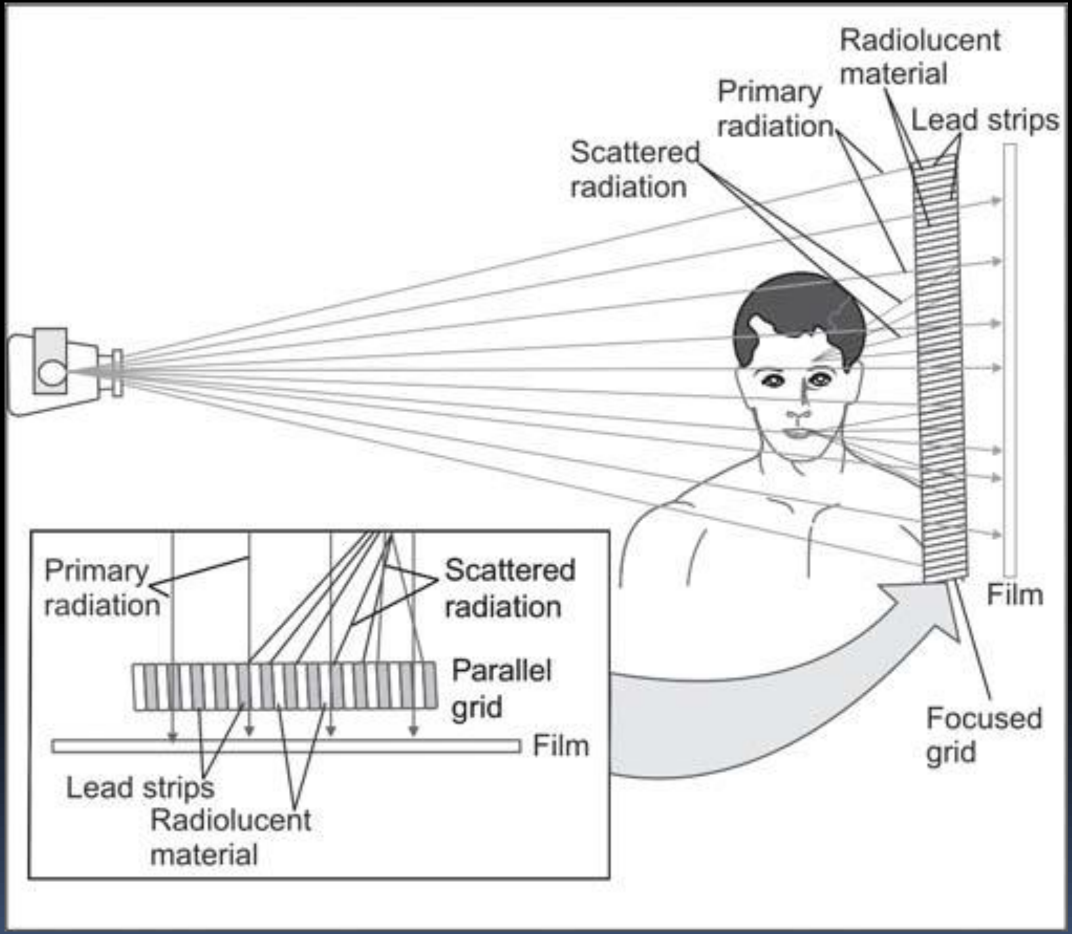
- Grain Size: The composition of the film emulsion influences the sharpness of the image produced, which is related to the grain size of the crystal.
- Faster the film speed → bigger the grain size → decreased image sharpness.

- Single and double emulsion and film thickness :Use of double coated films → increased thickness → unsharpness due to parallax.



d. *Fog Unsharpness*

- Scattered radiation: Scattered, stray, leakage or any other radiation not belonging to the primary beam is undesirable as it produces film fog.
  - For intra oral films, filtration, collimation and film packets with lead backed sheets should be used to reduce scattered and secondary radiation.
  - For extra oral films grids are used .
- A grid is a sheet of radiolucent material in which strips of lead are embedded. It is placed between the object and the film and allows only the X-rays which originate from the anode to pass through the object, without any change in direction to reach the film.


Radiolucent material
Primary radiation
Lead strips
Scattered radiation
Film
Focused grid
Primary radiation
Scattered radiation
Parallel grid
Film
Lead strips
Radiolucent material

- Disadvantage:

  1. lead strips produce white lines on the radiograph which decreases the contrast and produces distraction.

  2. the exposure time has to be increased when a grid is used

- Potter Bucky Diaphram:

  To prevent the grid lines from appearing on the radiograph, a moving grid called Potter Bucky Diaphram is used, but, here too due to the movement of the grid itself there is decreased contrast and density of the image produced, along with unsharpness

- Unsafe, safety light in the darkroom:

Use of unsafe safe light produces fogging which can be verified by performing the "Coin Test", in the dark room.

- Chemical fog: It's produced by prolonged development or development at high temperatures.
  - Potassium Bromide or the restrainer prevents chemical fogging of the X-ray film by restraining the action of the developing agents on the unexposed silver halide crystals.
  - If the radiograph is not adequately rinsed before putting it in the fixing solution, the alkaline developer will neutralize the acidic fixer and then the fixing and hardening action of the fixer solution is impaired, resulting in stains on the resultant radiograph.

– After fixing the radiograph should be thoroughly washed to remove all residual processing chemicals and silver salts from the film surface, as these may attack the silver image and/or certain products of fixation may decompose and produce a yellowish stain.

– If the temperature difference between the processing solutions and the rinsing water is more than 15°F, an orange peel appearance (reticulations) will appear on the film.

– The film must be adequately dried. If a wet film is touched or splashed with water during the drying process, it will produce spots that cannot be removed.

- *Potassium alum shrinks and hardens the gelatin so that the radiograph can withstand abuse of normal handling.*

e. *Intensifying screen unsharpness:*

- Intensifying screens are used in extraoral radiography in order to reduce the exposure to the patient.
- They may used singly or in pairs, placed in a metal cassette with the film sandwiched between them.
- They work on the principle of "Fluorescence".

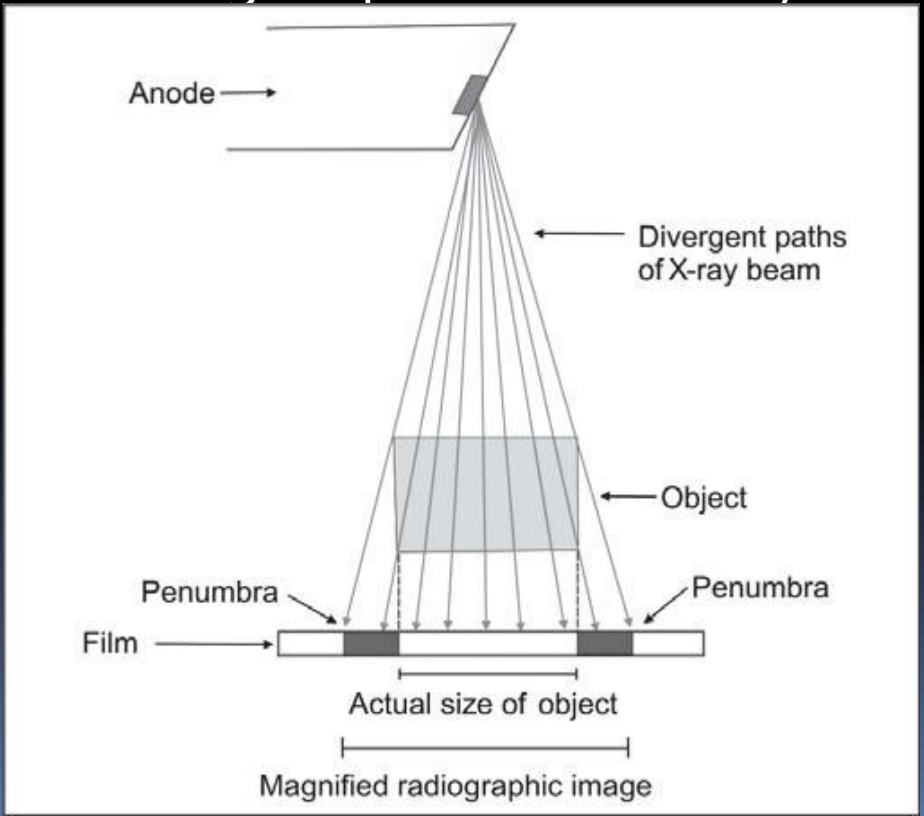
Unsharpness may be caused due to

- Improper film contact with the screens, thus when the X-rays strike the intensifying screen the fluorescent crystals emit light in all directions, producing stray radiations and thus causing unsharpness.
- Screen Mottle.
- Quantum Mottle.

- Use of the intensifying screens helps to reduce the exposure time, therefore there are less chances of any movement of patient, tube or film, hence reducing Motion Unsharpness.

II. Magnification

- This refers to a radiographic image that appears larger than the actual size of the object it represents.
- This results because of the divergent path of the X-rays from the focal spot.



Factors which influence magnification of the image are:

a. *Target film distance*

b. *Object film distance*

c. *Use of intensifying screens*

a. *Target film distance*

- Determined by the length of the position indicating device (PID).
  - Longer the PID → more parallel → less magnification.
  - Shorter the PID → less parallel X-rays more of the diverging rays → more magnification.

b. *Object film distance*

↑ Object film distance → ↑ magnification

↓ Object film distance → ↓ magnification

c. *Use of intensifying screens*

intensifying screens

↓

increases the film to object distance

↓

Produces magnification.

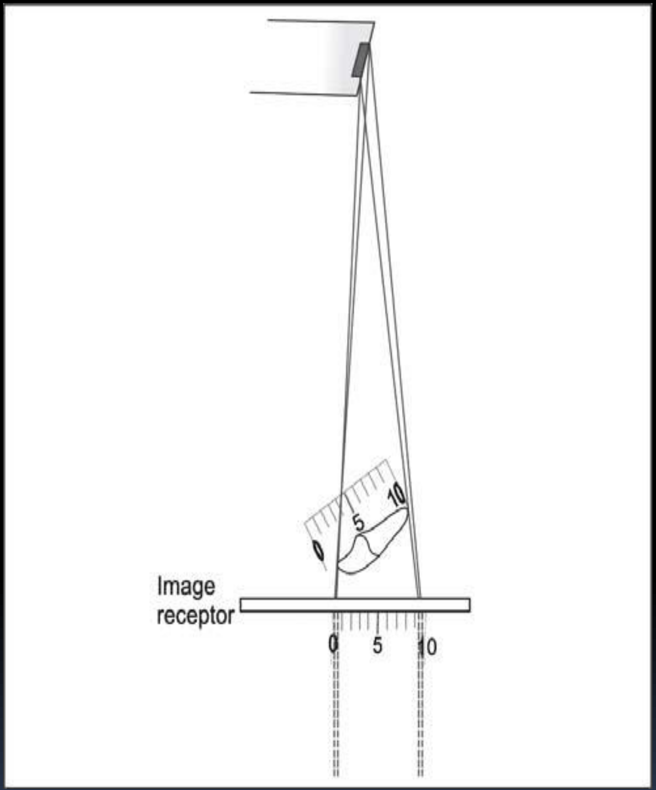
III. Distortion

- Dimensional distortion of a radiographic image is a variation in the true size and shape of the object being recorded.
- A distorted image results from the unequal magnification of different parts of the same object.
- This may occur due to
  - a. *Object-film alignment*
  - b. *X-ray beam angulation*
  - c. The film should never be bent

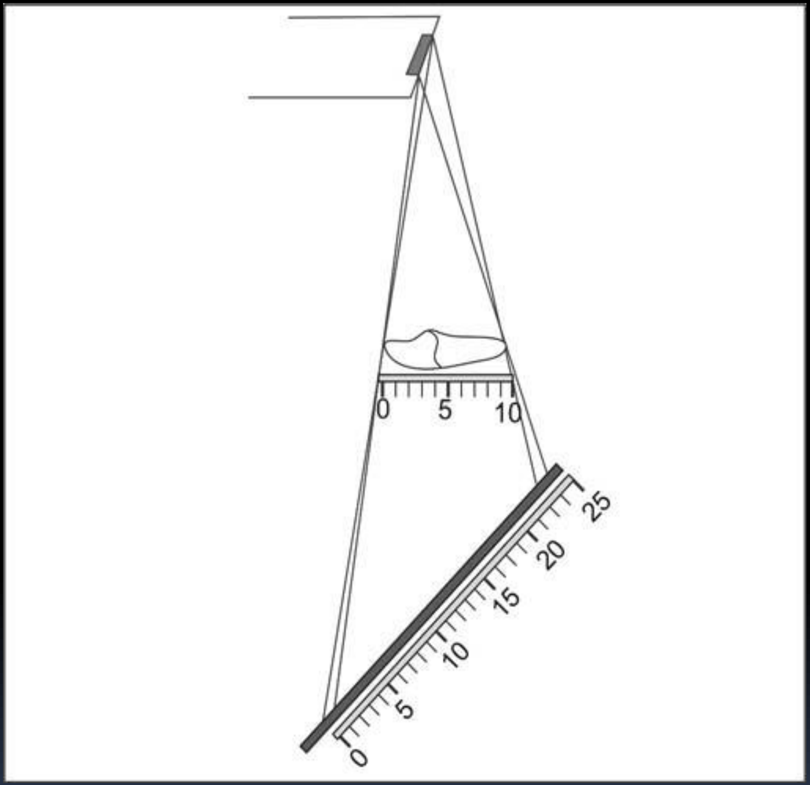
- a. *Object-film alignment: The object and the film* should be placed parallel to each other, because if they are not parallel and if an angular relationship results, it will produce variation of the distances between the tooth and the film resulting in distortion.
- A distorted image may appear too long or too short.

b. *X-ray beam angulation: To minimize dimensional* distortion the X-ray beam must be directed perpendicular to the tooth and the film

- ↑ vertical angulation → shortening of the image.
- ↓ vertical angulation → elongation of the image.
- ↑ horizontal angulation → overlapping of structures.



Foreshortening of a radiographic image result when the central ray is perpendicular to the film but the object is not parallel with the film



Elongation of a radiographic image results when the central ray is perpendicular to the object but not to the film

c. The film should never be bent in the direction of the long axis of the tooth, and the film holder should be used to prevent movement during exposure.

ANATOMICAL ACCURACY

- A radiograph is said to have anatomical accuracy when:

  1. Labial and lingual cemento enamel junctions of the anterior teeth are superimposed.

  2. Buccal and lingual cusps of the posterior teeth are superimposed.

  3. Contacts of the teeth are opened in at least one of the projections of a given area.

  4. Buccal portion of the alveolar crest is superimposed over the lingual portion of the alveolar crest.

  5. There is no superimposition of the zygoma over the roots of the maxillary molars.

- *For intraoral periapical radiography, more accuracy is achieved by using the paralleling technique.*

RADIOGRAPHIC COVERAGE

- It is important that the area of interest is well covered in the radiograph. In case of the intraoral periapical radiograph, an adequate amount of bone surrounding the apices of the teeth should be revealed.
- Adequate coverage of the area of interest depends upon several factors:

  1. Proper alignment of the film and the radiation beam to the area of interest.

  2. Proper selection of the film types.

  3. Proper selection of the film projection techniques

Image Quality

- This describes the subjective judgement by the clinician of the over all appearance of the radiograph.
- It combines the features of density, contrast, latitude, sharpness, resolution etc.
- The *detective quantum efficiency (DQE) is a basic measure of the efficiency* of an imaging system.
- It encompases image contrast, blur, speed and noise.

Image factors	*Clarity*	*Image size*	Shape *distortion*	*Film density*	Radiographic *contrast*
kVp				X	X
mAs	X			X	X
Collimation		X		X	X
Filtration				X	X
Focal spot size	X	X			
Object-to-film distance	X	X			
Focal spot-to-film distance	X	X		X	
Motion	X	X			
Alignment			X		
Subject density	X			X	X
Subject shape	X			X	X
Film speed	X			X	X
Developing time				X	X
Technique	X	X	X		
Screen speed	X	X		X	X

THANKYOU