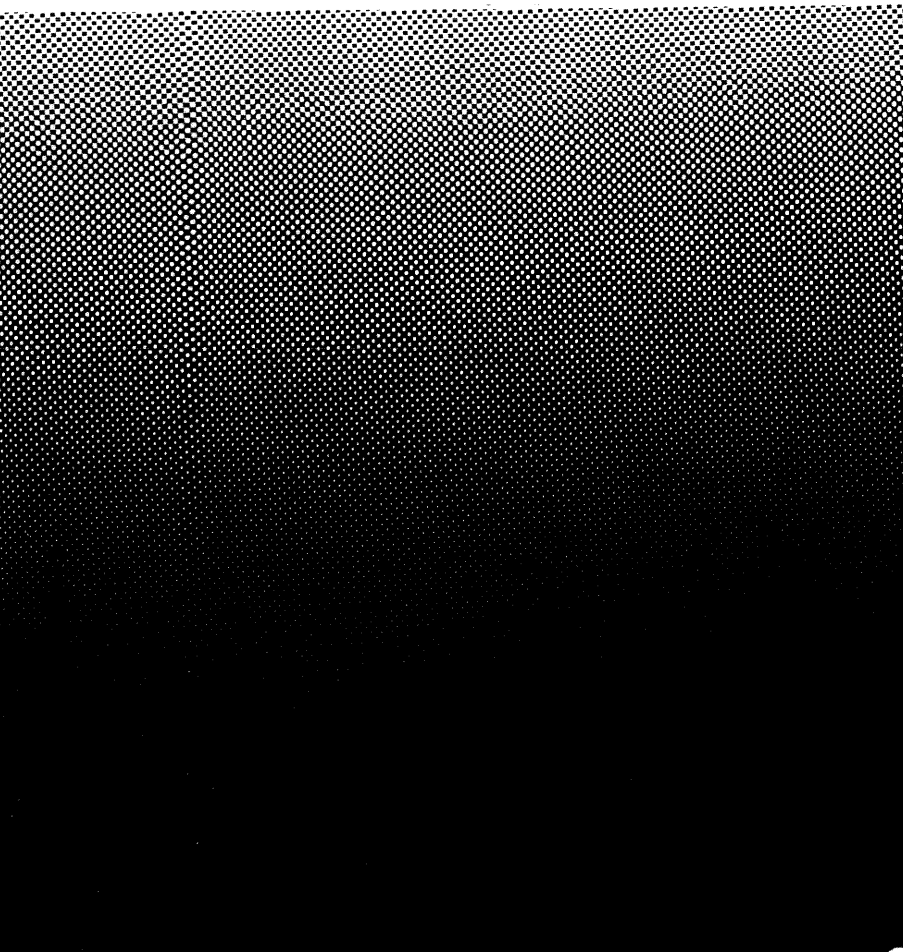
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Radiographic Terminology For Biological Research

Southern Forest Experiment Station

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Radiographic Terminology For Biological Research

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Foreword

This glossary is designed for scientists and technicians using radiography whose formal education is in other fields. The entries include terms from related areas such as physics, chemistry, medicine, and photography, as they apply to radiography. Other entries of purely historical interest are included, since they might be encountered by the researcher in reading.

To use the glossary effectively, one must have some knowledge of elementary radiographic principles and techniques. It can supplement an instruction program. References listed will provide additional descriptions for the interested reader.

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Absorbed dose. The amount of energy imparted to matter by ionizing radiation per unit mass at a given location; expressed in units of *rad.*

Absorber. Any material absorbing ionizing radiation.

Absorption. The process whereby particles or *quanta* in a beam of radiation are reduced in number or energy by interaction with either the *nucleus* or *electrons* of the matter they penetrate.

Accelerator. 1. A device that increases the velocity of electrically charged atomic particles. 2. A sodium carbonate solution that allows the developing agent to break down the protective coating on film.

Acetic acid. In processing film, an organic acid used during the developing process to remove developer remaining in the emulsion after latent image formation. See *Stop bath.*

Activation. The process of making stable atoms radioactive by neutron bombardment; inducing radioactivity by *irradiation.*

Active. Radioactive. See *Radioactivity.*

Active layer. Fluorescent material (commonly calcium tungstate) in a binding medium used in *intensifying screens.* There is a direct relationship between active layer thickness and the speed of the screen, and an inverse relation between active layer thickness and *resolution* of the radiographic image.

Activity. Number of nuclear transformations occurring in a quantity of material per unit time; measured in *curies.*

Actual focal area. That focal area formed at the *filament,* where *electron* streams originate. This electron flow strikes the *target* on the *anode.*

Acutance. A measure of sharpness of image determined by the distinction of the boundary between the *subject* and *background.* See *Penumbra, Umbra.*

Adaptation. The adjustment of the eye to dim light or red light necessary when viewing a fluoroscopic image without intensification. Pupil size changes automatically to control the amount of light reaching the retina.

Added filtration. Any filtering material placed in the path of an emitted x-radiation beam after it leaves the *tube.*

Adhesive. Bonding agent fixing emulsified silver halide gelatin to the polyester base in radiographic film.

Advanced asymmetry. In *tomography,* an asymmetrical exposure at the beginning of the tube-film trajectory.

Afterglow. See *Phosphorescence, Lag.*

Agitation. Moving film in solutions during processing. Failure to agitate film can result in streaking and loss of uniformity.

Air-contrast. Technique of using air to outline soft-tissue structures for *radiographic contrast* on film. Air-contrast studies require low to moderate kilovoltage.

Air-dose. Quotient of the mean energy imparted to air by ionizing radiation divided by the mass of air.

Air-gap. Separating *object* and film to reduce *scattered radiation* between them.

Alpha particle (α). A positively charged particle of radiation emitted from certain *radionuclides.* It is identical to a helium nucleus (2 protons and 2 neutrons) and carries a double positive charge that strongly ionizes atoms of matter it passes through. Because of its strong ionizing potential, it is not deeply penetrative although it leaves the nucleus at 9,000 to 18,000 miles per second. It is absorbed by an ordinary piece of paper.

Alternating current (AC). An electric current which periodically reverses its direction in both the coil and the external circuit as the armature rotates.

Aluminum equivalent. The thickness of aluminum equal to the object to be radiographed; that will offer similar *attenuation* under similar exposure conditions.

Ammeter. An instrument used to measure current.

Ammonium thiosulfate. Liquid fixing agent.

Ampere (amp). Unit of electric current; one coulomb per second.

Amplification. Magnifying ionization impulses for measurement in radiation detection instruments.

Amplitude. 1. Maximum height of a wavelength crest.
2. Travel distance of an x-ray tube during a tomographic exposure.

Angiography. Radiography of blood vessels exposed to *contrast media*

Angstrom (Å). Unit of linear measure often used to express wavelength; 10^{-8} cm.

Anion. A negatively charged *ion,* attracted to the *anode.*

Annihilation reaction. The combining of a *positron* with a nega-

tive *electron* giving rise to two *photons* moving in opposite directions.

Anode. The positive *electrode* of an *x-ray tube.* Negatively charged electrons are attracted to the *anode,* which then releases the x-rays. Anodes may be either stationary or rotating. The quality of an anode may be expressed by its effective *focal spot* size.

Anode-grounded tube. See *End-grounded tube.*

ANSI. American National Standards Institute.

Antero-posterior (AP). A *subject* position where x-rays enter the anterior portion of the subject and exit posteriorly for image production.

Aperture diaphragm. A device to restrict the *x-ray beam* area and reduce *scattered radiation.* A restriction in x-ray beam area requires an increase in *exposure.*

Arteriography. Radiography of arteries exposed to *contrast media.*

Artifact. Any anomalous structure on a radiographic image that can contribute to misinterpretation.

Artificial radionuclide. *Nuclides* made radioactive by bombardment of stable nuclides with subatomic particles in an *accelerator.*

ASME. American Society of Mechanical Engineers.

ASTM. American Society for Testing and Materials.

Asymmetrical tomography. A tomographic technique using either *advanced asymmetry* or *retarded asymmetry* to avoid streaking *artifacts.*

Atom. The smallest part of an element capable of entering chemical reactions; it consists of a *nucleus* with *protons, neutrons,* and extranuclear *electrons.* The number of protons equals the number of electrons.

Atomic Mass Unit (AMU). One-twelfth the mass of one neutral atom of ^{12}C.

Atomic number (Z). Number of protons in the nucleus of an atom.

Atomic weight. Mass of an atom expressed in *AMU.*

Attenuation. Gradual decrease of intensity of radiation as it passes through some material. It is influenced by absorption through interaction with the material's atoms, *scattered* and *secondary radiation* emissions, and the *inverse square law.*

Atto (a). Pretix meaning 10^{-18}

Automatic brightness stabilizer. A phototiming system that automatically increases either kilovoltage or milliamperage to compensate for *object* thickness, resulting in good *contrast* and optimal brightness in the image intensifier.

Automatic film processing. A system incorporating processor, transporters, water, recirculation, replenishment, and dryer subsystems which automatically processes film from developer through dried product. Timing varies from 90 seconds to 15 minutes.

Automatic shutter. A sensing device which limits beam size by adjusting *focus-film distance* to film format by opening or closing *collimator* shutters.

Autoradiograph. An image produced on a sensitized surface by radiation emanating from radioactive materials within the specimen examined.

Autotomography. A limited, difficult tomographic procedure in which the object is rotated beneath a stationary x-ray tube during exposure which allows only images of points within the axis of rotation to be in sharp focus.

Autotransformer. A transformer in an x-ray generator that allows the x-ray tube easily variable output voltage (within a limited range).

Average gradient. A numerical expression of the relative average contrast properties of a film and processing combination for a specified exposure; represented by the slope of a straight line connecting specific density points on a *characteristic curve.*

Background. Presence of ionizing radiation in the environment from both external emissions (*cosmic rays,* natural *radionuclides*) and internal emissions (from *object* of radiograph, material of instrument).

Back-reflection method. An x-ray diffraction method using *monoenergetic* x-rays and material foils that are thick enough to diffract the radiation back to the film for image forming.

Backscatter. Radiation deflection by scattering rays in the *object* at angles greater than 90° from the entering *primary ray.* This increases the object's radiation exposure and fogs the film. It can sometimes be arrested by placing a lead sheet beneath the film.

Backup timer. A *phototimer* that controls the maximum exposure in a radiographic tube.

Ballistic mAs meter. A mechanism registering *milliampere-sec-*

onds (mAs) for x-ray units operating in excess of 200 *mA*. In exposures of less than 0.1 sec, an ordinary ammeter can not register exposure accurately, so the mAs is determined by connecting the meter with an impulse timer.

Barium clay. A molding clay used to reduce the amount of *scattered radiation* intercepting the film. The clay is formed around an irregularly shaped object. The clay itself can be a source for additional scattering.

Barium lead sulfate. A fluorescent chemical that emits a visible blue-violet light when activated by x-radiation. It is used in *intensifying screens.*

Barium platinocyanide. Historically important as the fluorescent layer on cardboard used by *Roentgen* in his original fluoroscopic process.

Barium sulfate. *Radiopaque* contrast medium. Using barium sulfate may require higher kilovoltage than usual.

Barrier. Protective shields of radiation-absorbing material. Thickness of material depends upon its absorbing qualities, the source of radiation, and distance from source to protection area. Commonly used materials are lead and concrete. Air is adequate when sufficient distance is practical.

Base. A transparent plastic (usually polyester) about 0.008 inch thick used to hold the emulsion layer of radiography film.

Base density. The minimum *density* of a film. It is a function of light absorption by the plastic base and the base dye and does not include the emulsion layer.

Base film. In *subtraction*, the original *radiograph* used to produce the mask.

Base fog. See *Base density.*

Beam. A directed flow of electromagnetic radiation.

Becquerel, Henri. Reported in 1896 that uranium emitted rays which could pass through paper and darken a photographic plate in a dark room.

Beta emitter. Source of beta radiation; a radioactive atom.

Beta particle (β). Strongly ionizing electron ejected at high speeds from certain radioactive materials.

Betatron. An accelerator used to produce electron beams and high energy x-rays by accelerating moving electrons in an alternating magnetic field.

BeV. Billion electron volts.

Binding energy. Energy holding together *protons* and *neutrons* in the atomic *nucleus.*

Biological burden. In radiography, the amount of any acquired radiation in a biological system per unit of time.

Biological half-life. In radiography, the time required for any biological system to naturally eliminate one half of an acquired *dose.*

Biplane studies. A technically difficult simultaneous exposure of two films, each in a separate plane, which allow clarification when interpreting problems created by overlap.

Blocking. See *Masking.*

Body-section radiography. See *Tomography.*

Bragg's law. A mathematical expression used to determine the positions of crystalline structure as imaged in x-ray diffraction: $n\lambda = 2\ d \sin \theta$, where n = order of the spectrum, λ = wavelength of the x-rays, d = distance between atomic planes, and θ = the angle between the diffracted x-ray and the atomic plane.

Bragg method. An x-ray diffraction method using monoenergetic x-rays and a rotating crystal.

Braking radiation. See *Bremsstrahlung.*

Bremsstrahlung. "Braking radiation" (German). A process in which electrons are deviated from their original path by strongly positive nuclear fields and decelerated, transforming some of their original energy to an x-ray of equivalent energy. Bremmsstrahlung is composed of *heterogeneous* beams.

Bright fluoroscopy. See *Image intensification.*

Brightness gain. An increase in illumination of 4,000 to 7,000 times for viewing *fluoroscopy.* The electron energy of the formed image is converted through an optical system to an image on a closed circuit television or cine recording.

British thermal unit (BTU). The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit at atmospheric pressure.

Bucky. Commonly used to refer to the entire *Potter-Bucky grid* and moving mechanism.

Bucky grid. A stationary grid of 60 to 110 alternating parallel strips of lead and plastic placed between the object and film to reduce *scattered radiation.* Gustave Bucky designed it in 1913.

Bunsen-Roscoe reciprocity law. The end result of a photochemical reaction is dependent only on the product of the radiation intensity (I) and the duration of the exposure (t), and is independent of absolute values of either quantity.

Cabinet x-ray system. An x-ray system completely enclosed in one housing.

Calcium tungstate. A naturally occuring mineral or synthesized crystal that fluoresces with x-radiation to emit visible blue-violet light. It is used in *intensifying screens.*

Calibration. Instrument standardization in relation to a known standard.

Canting. The manufacturing process allowing grids to be produced flat while their lead lines are inclined to provide the correct fixed *focus-film distance.*

Capacitor-discharge unit. A mobile x-ray generating unit that operates by storing electricity in a capacitor. The electricity may then be discharged through an x-ray tube.

Cardboard film holder. A film holder made of any lightproof paper; requires darkroom loading.

Cassette. A sturdy, lightproof container with a *radiolucent* front used for holding radiographic film during exposure. It may also have *intensifying screens* and/or *filters.*

Cathode. The negative electrode of an x-ray tube. The cathode terminal consists of a filament, supporting wires, and focusing cup.

Cation. A positively charged ion attracted to the cathode.

Centi (c). Prefix meaning 10^{-2}.

Central beam. X-rays in the center of a generated beam. The beam usually does not have a homogenous intensity throughout because of the *heel effect* from the *anode.*

Cephalopelvimetry. A technique developed to calculate the relative sizes of a fetal skull and the maternal pelvis using image geometry. It can be used to determine actual subject size from any enlarged image when values are known for the enlarged image, *FFD,* and *OFD.*

Chalky radiographic contrast. Low *contrast* on radiographic film that impairs image interpretation.

Chamberlain-Towne projection. A technique using an angle of beam projection with less than 90° between the tube and the

object-film plane. This results in greater *parallax effect* than perpendicular beam projection.

Characteristic curve. A curve that expresses the relation between the image density and the amount of exposure of a radiographic film. Exposure is usually expressed by logarithm. The nearly straight portion of the slope of the curve represents maximum contrast; values from the shoulder and toe of the slope produce low contrast.

Characteristic radiation. Discrete energies emitted from a target element that characterize the target. The energy is produced by an inner-orbit electron collision. The amount of energy released equals the amount of energy required to remove the inner-orbit electron, which in turn is characteristic of the target element. See *Monoenergetic beam.*

Cholangiography. Radiography of bile ducts exposed to *contrast media.*

Chrome alum. An additive in the emulsion gelatin of radiographic film which hardens the film to protect against scratching.

Cinefluorography. See *Cineradiography.*

Cineradiography. A method of permanently saving a fluoroscopic image on photographic film. Although the technique requires film processing, it affords better resolution and better quality slow motion replay than video tape.

Clearing time. The time it takes for *fixer* to dissolve undeveloped silver halide; characterized by disappearance of milky diffusion on film after it is placed in fixer solution.

Coherent scattering. *Scattering* produced by interaction of a very low-energy *photon* with a bound orbital *electron.* The scattered photon has the identical wavelength of the entering photon, but a different direction.

Cold tube. See *Field emission x-ray tube.*

Collimation. A process changing a diverging beam of radiation into a useful parallel beam by means of lead *collimators.*

Collimator. A device that accurately delimits beams to a sharp image, reducing the *penumbra.* Collimators have variable apertures, can automatically adjust to any cassette size, and usually have a beam-centering device.

Comets. Artifacts produced on film that resemble comets. They are usually caused by rust particles adhering to film during development.

Compensating filter. Any material that can produce an image of more even density on a radiographic film by compensating for varying object opacities.

Compton effect. A phenomenon of attenuation. *Scattered radiation* is produced when loosely bound outer-shell electrons are bombarded by photons. The electron changes velocity after collision with a photon and is then called a Compton electron. The photon is reduced in energy and has a longer wavelength. The photon's velocity is also changed and it is now known as a scattered photon. As scattered radiation, such photons cause film fogging.

Cone. A conical metal tube used to restrict the area of an x-ray beam.

Contrast. Interpretation of density differences which are the result of relative silver distribution on developed film. See *Radiographic contrast, Subject contrast,* and *Film contrast.*

Contrast improvement factor. The ratio of radiographic contrast with a grid to contrast without a grid.

Contrast medium. A *radiopaque* or *radiolucent* material used in an object which allows differentiation of density by selective absorption of the material.

Controlled area. An area where radiation sources are used. Protection of all personnel is afforded through procedures of construction, access, and exposure.

Convergence line. The intersection of imaginary lines that extend upward from the planes of tilted lead strips in *focused grids.*

Conversion factor. The ratio of the brightness of the output screen to the rate of exposure of radiation at the input screen. A standard, as proposed by ICRU, which specifies the intensifying ability of any given x-ray image intensifier.

Converter foil. A metal foil (gadolinium, rhodium, indium, or cadmium) exposed during *neutron radiography* of an object. The foil then emits beta or gamma radiation, producing an image on film.

Coolidge tube. A hot cathode diode tube commonly used to produce x-rays; invented by W. D. Coolidge in 1913.

Cooling curve. The graphic relation between heat accumulated in an x-ray tube and the time it takes for the tube to cool.

Corona. A blue electrical discharge surrounding a high voltage conductor caused by air ionized by current leakage.

Corpuscular theory of radiation. A theory explaining the move-

ment of x-rays as that of photons travelling at the speed of light and bearing no electrical charge.

Cosmic rays. High energy electromagnetic radiation of extremely short wavelength, originating outside the earth's atmosphere.

Coulomb (C). A unit of electrical charge consisting of one *ampere* second.

Cradle. A mechanical device for rotating or positioning a subject for radiographing.

Crimp marks. Curved lines, one or two cm in length, resulting from bending film sharply. Marks will be white if occuring before exposure, and black if occuring after exposure.

Cross-hatch grid. Any two stationary grids placed one on top of the other so that the lead strips in each are at right angles to each other. See *Moire pattern.*

Cumulative dose. The total dose of repeated radiation exposure received by an *object.*

Curie (Ci). A unit of measure for the disintegration rate of a sample of radioactive material. Specifically, any radioactive source with a decay rate of 3×10^{10} disintegrations per second.

Curie, Marie and Pierre. Discoverers of polonium and radium (1898) for which Marie invented the term radioactivity.

Cutie pie. Popular name for a battery-operated portable monitoring device. It is an ionization-chamber ratemeter used to detect beta and gamma rays in the range of 1 to 5000 mR/hr.

Cyclotron. A particle accelerator which uses a magnetic field to accelerate a positive ion beam by alternating electric fields to maintain the high speed particles in a spiral path. Used for nuclear research and to produce x-rays.

D-log E curve. See *Characteristic curve.*

D-max. The maximum *density* that can be produced on a film.

Dark adaptation. A 20- to 30-minute period spent in nearly complete darkness which enables the retina of the eye to adjust for viewing low-light sensitivities such as those encountered in conventional fluoroscopy. Red-adaptation goggles may also be used.

Daylight system. A technique combining film holders and automatic processing that eliminates dark room requirements.

Dead-man switch. A safety switch that closes a circuit only by continuous pressure from the instrument operator.

Debye-Scherrer method. A method using diffraction of *mono-*

energetic x-rays to identify a powdered specimen packed in a glass capillary or adhering to a ribbon of x-ray transparent material.

Deci (d). Prefix meaning 10^{-1}.

Definition. Sharpness of detail or clarity of lines in a radiograph: a major factor in radiographic quality. It is determined primarily by factors of geometry, film, and radiation. See *Acutance.*

Degassing. A technique used in assuring the high vacuum necessary in the envelope of x-ray tubes. The tube is heated to expel gases entrapped in the component parts.

Deka (da). Prefix meaning 10.

Densitometer. An instrument used to measure *density.* For transmitted density, a photocell gives direct readings; for reflected density values, a series of printed, standard density values is compared to the unknown for an approximate match.

Density. The amount a radiographic film darkens as a result of radiation interacting with silver halide crystals in the emulsion.

$$\text{density} = \log \frac{\text{incident light}}{\text{transmitted light.}}$$

Density gradient. A numerical value that refers to *contrast* values on film; the higher the number, the higher the contrast. It is determined from a film's *characteristic curve* by dividing the value of the vertical rise by the value of the horizontal rise.

Depth dose. Radiation *dose* at a specific depth within an object. It is usually measured in percentage of surface dose.

Depth localization. A means of determing the location (depth) of an object within a *subject* using either *stereoradiography, tomography,* or the *parallax method.*

Detail. Sharp, clear delineation of objects in a radiograph. See *definition.*

Detection. Any of several methods used to indicate the presence of x-rays; the methods can be photographic, fluorescent, ionizing, or physiological.

Detergent rinse. A technique used to shorten film drying time. After final washing and before drying, films are rinsed in a weak detergent solution (5 ml/41 ml of water).

Developer. The chemical solution that converts the latent image on

film to a visible image. It consists of a developing agent (hydroquinone), an accelerator (sodium carbonate), a preservative (sodium sulfite), and a restrainer (potassium bromide) to prevent unexposed silver bromide crystals in film from blackening.

Diaphragm. A simple device for restricting the primary x-ray beam and reducing *scattered radiation.* It is usually used as a component of another device such as a *Potter-Bucky diaphragm.*

Diffraction mottling. A mottled, diffuse diffraction pattern on a radiograph.

DIN. Deutsche Industrie Norm. (German Standards Organization).

Diode. 1. An electron tube with two electrodes (anode and cathode). 2. An electrical rectifier with a semiconducting crystal and two electrodes.

Direct current (DC). An electric current which flows through a conducter continually in one direction.

Direct-exposure film. See *Nonscreen film.*

Direct-positive film. A contact film used to duplicate radiographs which maintains the same positive-negative densities.

Disc. See *Rotating anode.*

Discography. Radiography of intervertebral discs exposed to *contrast media.*

Disengagement. A technique used in *tomography* that erases images in the *object* along the beam path to allow better *subject* resolution.

Distance. See *Inverse Square Law.*

Distortion. A false representation of an *object's* true size and shape.

Dose. The amount of radiation or energy absorbed by an object per unit mass; measured in *rads.*

Dose equivalent (DE). An expression used in radiological *health* to express the effective absorbed dose, measured in units of *rem.* By definition of *ICRU:* H = QND. H = dose equivalent, Q = quality of beam, N = product of other modifiers, D = *absorbed dose.*

Dose rate. Amount of radiation per unit time received by an object; measured in *rems* per hour.

Dosimeter. An instrument that detects and measures radiation dose, such as *film badge* or *ionization chamber.*

Dosimetry. Measurement of the amount of radiation delivered to or absorbed at a particular point or area.

Double-coated film. Radiographic film with an *emulsion* layer on both sides.

Double exposure method. See *Parallax method.*

Double focus tube. An x-ray tube with two *filaments* mounted side by side. The filaments are of different sizes and produce correspondingly different *focal spot* sizes. The focal spot size can be selected by a control switch.

Dryer system. A rapid-drying mechanism in the *automatic film processor.* It uses a series of squeeze rollers to remove surface moisture from the film and a forced hot air system to complete drying.

Drying. Film must be dried after washing. This is accomplished with controlled heat or time. A detergent rinse after washing will shorten drying time.

Duplication. A technique for photographically reproducing a radiographic image.

Duplication film. A direct positive photographic film used to duplicate radiographs.

Duplicating printer. A light-controlled, exposure regulating device for duplicating radiographs by exposing copying film.

Edison, Thomas A. Invented *fluoroscopy* and the *fluoroscopic screen* in 1896.

Effective focal area. The actual focal area of electrons at the *object.* Electrons originating at the *filament* strike an area on the *target* and are reflected at right angles. The focal area at the object is only a fraction of the focal area at the target. The effective spot area is critical to good radiographic *definition.* The smaller the effective focal spot, the greater the definition. The angle of the target (*anode*) to the filament determines the effective focal area by simple geometry. A 10° to 22° angle is common.

Effectual voltage. In a self-rectified circuit, the current passes through the x-ray tube for only a half-cycle of effective voltage and no current flows during the second half-cycle.

Electrolytic silver recovery. The process of recovering plated silver deposited on the cathode. An electric current is passed between two electrodes placed in used fixer solution.

Electromagnetic radiation (EMR). An energy form radiated at right angles to the direction of electron travel when the velocity of the electron is changed. All forms of EMR originate from

an electric particle, travel at the speed of light, and exhibit wave motion.

Electromagnetic spectrum. The inclusive range of all forms of electromagnetic radiations, radio, infra-red, visible light, ultra-violet, x-ray, gamma, and cosmic energies.

Electromotive force (emf). The potential difference between electrodes which allows current flow; measured in volts.

Electron. An elementary, negatively charged particle.

Electron emission. Liberation of electrons by heat, light, field emission, or bombardment by other radiation.

Electron emission radiography. Technique of exposing a specimen to *hard x-rays* through the film. The object is distinguished by emissions, depending on its atomic number. This is called reflection microradiography in Europe.

Electron impulse timer. Timer that uses thyratron tubes to measure one impulse accurately (1/120 sec). All exposures are made in multiples of one impulse.

Electron radiography. A technique in which *hard x-rays* strike a lead screen which then emits electrons to the *object.* The *subject* should be thin and have a low atomic number.

Electron volt (ev). The amount of energy gained by one electron passing through a potential of one volt; 1 ev $= 1.6 \times 10^{10}$ erg.

Electronic timer. A timer accurate to 1/10 second.

Electroscope. An instrument used to detect electric charges by displacement of an electrically charged component of the instrument.

Electrostatic latent image. The latent image produced in *xerography* by photon excitation of selenium crystals on an aluminum plate.

Emulsion. A suspension of silver bromide crystals in thin gelatin coating on the film base. It is characterized by its *speed* and *latitude.*

Emulsion fog. The minimum *density* of film possible because of spontaneous unexposed crystal development during long development and processing of fast films.

End-grounded tube. A long, narrow x-ray tube useful for probe type instrumentation. It emits a 360° beam. The anode side of the high voltage pole is grounded and therefore requires

no electrical insulation. It is also called an anode-grounded tube or a rod-anode tube.

Enlargement. Radiographic enlargement necessitates the use of one of two special processes. A simple photographic enlargement is unacceptable because grains in the radiographic film are magnified, as are *grid lines,* when present. Radiographic enlargement (direct roentgen enlargement) requires changing the geometry of *FOD* and *OFD* with an x-ray tube with a *focal spot* 0.3 mm or less, from which enlargements up to 3x linear or 9x area are possible. The other technique uses medical *fluoroscopy* with an *FFD* of at least one meter.

Envelope. A glass tube surrounding the electrodes of an x-ray tube inside which a vacuum is maintained.

Equivalence factor. A guide used to approximate the relative *penetration* by x-rays of materials with different *atomic numbers.* Aluminum is the standard at low Kv while steel is the standard for high Kv and gamma rays.

Erythema. Blood distension in skin capillaries resulting in redness. It is caused by x-rays, heat, drugs, or ionizing radiation.

Exit radiation. See *Remnant radiation.*

Expiration date. The date after which the manufacturer of a film will no longer maintain the warranty for quality control.

Exposure. Amount of radiation generated in standard atmosphere that is measurable in units of *Roentgen.*

Exposure angle. The arc through which the x-ray beam moves during a *tomography* exposure; the larger the angle, the thinner the section shown on the film. Zero degree angle is normal radiography.

Exposure chart. A graphic relation that gives exposure values for materials of uniform thickness, taking into account *peak kilovoltage (kVp)* and exposure (in *mAs*). It is impractical for biological specimens.

Exposure factor. Represented by the formula: $\frac{\text{milliamperes x time}}{\text{distance}^2}$

Exposure rate. Radiation exposure per unit of time, measured in R/min. It may be controlled by varying tube current, tube potential, distance from tube to *object,* or amount or kind of filtration.

Extended traverse radiography. A form of in-motion radiography where the source moves along a linear path to cover a long, narrow subject.

Femto (f). Prefix meaning 10^{-15} .

Field emission x-ray tube. A specially designed tube that emits x-rays by using very high voltage to expel electrons from a cold metal (field emission).

Filament. A small coil of wire (usually tungsten) mounted in a metal shield that releases free electrons when heated in a vacuum *envelope*.

Filament evaporation. Gradual erosion of the *filament* caused by prolonged use.

Filament current. A low voltage current used to heat the *filament*. Increasing filament current increases filament temperature which increases the rate of electron emission. One of the wires leading to the filament carries the high voltage necessary to propel electrons to the target.

Filament stabilizer. A capacitor and transformer arranged to provide nearly constant filament current by compensating for any line voltage changes that may occur during exposure.

Film. A transparent, flexible polyester base coated with a silver halide emulsion suspended in gelatin. The emulsion is sensitive to portions of the electromagnetic radiation spectrum (including visible light and x-rays) which can form a latent image which becomes visible when processed.

Film badge. A light-tight package of filters and films of various sensitivities worn to monitor exposure to radiation. The degree of film darkening allows the *absorbed dose* to be calculated.

Film contrast. *Radiographic contrast* attributed solely to inherent properties of the film and the manner of processing.

Film hanger. A device to attach radiographic film to a rigid frame used to transport film during manual processing.

Film intensification. The process of enhancing the *density* of underexposed film. It can be accomplished even after the film has been fixed and dried.

Film latitude. The exposure range that is most effective for a given film. Film latitude and *film contrast* are reciprocal. High contrast film usually has less latitude than low contrast film.

Film marker. Lead numbers and letters which can be placed on a film before exposure to identify subject, date, and conditions of exposure.

Film plane. Position of the film in relation to the x-ray beam and

the subject. An important factor in the geometry of good radiographic images.

Film side. That side of a *subject*, film holder, *cassette*, or *grid* that is placed adjacent to the *film plane*. Proper orientation of film is especially critical when using multi-pack film or *focused grids*.

Film speed. A measurement of the quantity of radiation necessary to produce a designated image *density*. A fast film takes less radiation to produce the same density than a slow film. Relative film speed may be determined from a *characteristic curve* by plotting several films on the same graph.

Film streaking. *Artifacts* caused by failure to stir processing solution, or by inadequate agitation of film in developer or fixer, or by insufficient rinsing.

Filter. 1. Any substance that attenuates x-radiation after it leaves the *target*, such as the glass *envelope* of the tube or metal filters placed outside the tube. The purpose of a filter is to absorb longer wavelengths emitted from the target and allow the harder x-rays to reach the subject.
2. A device used to reduce the intensity of illumination in a darkroom by selective absorption of light.

Filtration. A technique of hardening the quality of an x-radiation beam reaching the subject by using a filter to selectively absorb softer radiation from the beam.

Fixer. A solution of ammonium thiosulfate for removing unexposed silver halide crystals from film. It also includes aluminum chloride for hardening the gelatin, acetic acid as a buffer, and sodium sulfite to lessen colloidal sulfur formation. Fixers used in automatic processors unlike those used in manual processing are usually highly acidified, and buffered automatic processors do not usually employ stop bath.

Flash radiography. An instrument with very high voltage capability that produces short but intense x-ray flashes (see *Field emission*); useful for high speed, rapid motion subjects.

Fluorescence. In radiography, a phenomenon whereby certain substances such as calcium tungstate receive x-radiation and emit radiant energy of a visible wavelength.

Fluorography. See *Photofluorography*.

Fluoroscopic screen. A screen coated with zinc cadmium sulfide crystals which emit a yellow-green visible light when struck by x-rays.

Fluroscopy. A technique whereby a radiographic image is intensified and viewed directly rather than as a latent image on film. Two procedures are available, dark and intensified fluoroscopy. In dark fluoroscopy, the image is viewed as green light emitted from a zinc cadmium sulfide screen. This is an inefficient viewing system which requires viewing in a darkened room. Intensified fluoroscopy uses electronic image intensifiers to increase the brightness of the image about 6,000 times which allows viewing in ordinary light through television or cineradiography.

Focal spot. The area where the electron stream discharged from the filament strikes the anode *target.*

Focal track. On a rotating *anode,* the circumferential area that actually receives the electron impact, producing a *focal spot.*

Focus-film distance (FFD). Distance between the *focal spot* and the *film plane.*

Focus-grid distance. The distance between the tube focus and grid surface that can be used without excessive *grid cutoff.*

Focus-object distance (FOD). Distance between the *focal spot* and object to be radiographed.

Focus-plane distance (FPD). In *tomography,* the distance between the *focal spot* and the *objective plane.*

Focused grid. A grid with its lead strips slanted to conform to the angle of the primary ray, which diminishes *grid cutoff.* See *Convergence line.*

Focusing cup. A negatively charged *cathode* component (usually made of molybdenum) placed behind the *filament* to focus the electron beam and keep it on a narrow path towards the *target.*

Focusing distance. The vertical distance from the *convergence line* to the center of a *moving grid.*

Fog. The minimum overall *density* of radiographic film; *base density* plus *emulsion fog.* Fog reduces image quality.

Forward scatter. Radiation scattered in the same direction as the primary beam.

Fractional-focus tube. A special x-ray tube with a *focal spot* of 0.3 mm or less. Used in direct image enlargement.

Freeze. Image retrieval from image storage systems (such as a video disc scanner).

Frequency. Number of cycles per unit of time; measured in *Hertz.*

Frilling. Separation of emulsion from film base. Usually caused by wash water or processing solutions being too hot.

Fulcrum. In *tomography,* the convergent point of the beam common to the shifting tube and the film shift. The fulcrum level determines the *objective plane.*

Gadolinium oxysulfide. Rare earth phosphor (manganese activated) used in radiographic *intensifying screens;* emits primarily green light.

Gamma. The slope of the straight-line portion of a *characteristic curve.* It measures contrast.

Gamma rays (γ). Electromagnetic waves distinguished from x-rays by having a nuclear origin.

Gaseous burst agitation. A technique of automatically aerating film that is being processed manually. An inert gas, usually nitrogen, is released into the tank. Bubbles then agitate the film.

Geiger counter (GM). Geiger-Muller (GM) counter. An electronic radiation detector that counts individual photons and is particularly efficient for beta particles.

Gel swell. The action of an accelerator (sodium carbonate) in the developer that swells up the gelatin, speeding development.

Gelatin. A colloidal, amphoteric matrix that fixes silver halide crystals to the film emulsion layer.

General radiation. See *Bremsstrahlung.*

Generator. In radiography, a device that provides electrical potential to the x-ray tube for electron acceleration.

Geometric unsharpness. See *Penumbra.*

Geometry. In radiography, the spatial relation of the image producing factors *(FFD, FOD, FPD)* to the latent image.

Giga (G). Prefix meaning 10^9.

Gradient. An objective measure of *film contrast* calculated from a *characteristic curve* for that film. The higher the gradient value, the higher the film contrast at that same kV.

Graininess. Uneven *density* observed in film image caused by distribution of silver halide crystals in emulsion, particularly in fast film where large crystals have uneven distribution. See *film speed.*

Grenz Rays. X-rays produced in the 5 to 20 kV range.

Grid. 1. An apparatus placed between the subject and film, composed of alternating lead and radiolucent strips fixed vertically, in line with the tube's *focal spot.* The lead strips absorb photons of *scattered radiation* from the subject, while the *radiolucent*

material allows the primary radiation to pass and expose the film. Grids are generally classified as stationary or moving.
2. An electrode (See *Grid-controlled x-ray tube*).

Grid bias. The negative potential in kV between the *grid* and the *anode* in a *grid-controlled x-ray tube* (triode). The negative charge applied to the grid can interrupt electron flow to the anode and offer more exact control of tube current.

Grid cassette. A cassette with a built-in *grid.*

Grid-controlled x-ray tube. An x-ray tube with three electrodes, *anode, cathode,* and *grid.* The grid is placed between the *filament* and *target* and regulates the flow of *space charged* electrons by grid bias.

Grid cutoff. Underexposure on one side of the radiograph caused by poor alignment of the x-ray beam with the *grid.*

Grid efficiency. A grid's ability to minimize *scattered radiation.*

Grid lines. 1. Images on the film caused by shadows of the lead strips.
2. The number of lead strips per inch on a *grid.*

Grid radius. See *Convergence line.*

Grid ratio. An expression of the ratio of height of lead strips in the grid to the distance between the strips, r =h/d where r = grid ratio, h = height of lead strips, and d = distance between lead strips. A higher grid ratio means greater grid efficiency, thus greater image detail.

Grid specifications. *ICRU* recommends that five specifications be furnished with each focused grid: *grid ratio,* number of lead strips per inch, *focusing distance, focus-grid distance* limits, and *contrast improvement factor.*

Guide marks. An *artifact.* Uniform scratches on film caused by improperly adjusted guides and rollers in an automatic processor.

Gurney-Mott theory. A theory proposed in 1938 by Gurney and Mott to explain the formation of a latent image by silver halide after photon capture. The silver halide crystal is struck by a photon which liberates an electron from a halide ion. Additional electrons gather at the site of photon capture, which becomes negatively charged. This attracts positively charged silver ions to the site which then becomes neutralized, forming metallic silver. Processing converts the latent image into a visible one.

H and D curve. Hurter and Driffield curve. See *Characteristic curve.*

Half-life. The time in which one half the atoms of a radioactive material disintegrate into another nuclear form.

Half value layer (HVL). The thickness of any material that reduces the *dose rate* of an x-ray beam to one-half its initial value. See *Filter.*

Halides. A chemical term for the salt-forming compounds of fluorine, chlorine, bromine, iodine, and astatine.

Hard x-rays. A common term meaning a beam of relatively high energy and short wavelength. A hard x-ray beam may be produced by filtering out *soft x-rays* with aluminum or copper.

Hardening agent. An additive (usually glutaraldehyde) in *developer* for automatic processing; it reduces *gelatin swelling.* See *Fixer.*

Health physics. The application of radiological safety techniques to recognizing, evaluating, and controlling the effects of ionizing radiation and the use of its generating equipment. Both subject and operator must be protected from radiation and high voltage electrical apparatus. Each user is also responsible for the effects on nearby organisms.

Heat dissipation rate. The rate at which heat energy is transferred away from an *anode;* measured in heat units. Cooling curves are supplied by the tube manufacturer to help avoid prolonged tube heating from excessive exposures.

Heat storage capacity. The ability of the *anode* to store heat energy during exposure without damage. Exceeding the manufacturer's heat storage capacity with short, numerous exposures will significantly shorten the life of an x-ray tube.

Heat Unit (HU). The unit of measure for heat energy generated at the anode during exposure. 1 HU = kV $\times$ mA $\times$ sec.

Hecto (h). Prefix meaning 10^2.

Heel effect. A decrease in the exposure rate of an x-ray beam toward the edges of the beam. The variation is greatest (less exposure) on the *anode* side of the beam. Heel effect is also greater with an increase in *FFD* or film size.

Helium (He). See *Alpha particle.*

Hertz (Hz). Unit of measure of radiation; cycles per second.

Heterogeneous x-rays. A usual x-ray beam consisting of photons of wavelengths that vary from 0.05 Å to 1000 Å. See *Bremsstrahlung.*

Hot tube. See *Coolidge tube.*

Housing cooling. A mechanism that dissipates heat generated at the *anode;* usually an oil bath between the tube *envelope* and the housing. See *Heat dissipation rate.*

Hydroquinone. In film processing, an organic reducing agent used in *developer.*

Hypo. See *Fixer.*

Hypo eliminator. In film processing, a chemical added between fixing and washing to reduce the amount of time and volume of water required to complete manual processing.

ICRP. International Commission on Radiological Protection.

ICRU. International Commission of Radiation Units and Measurements.

Illuminator. A device that allows a *radiograph* to be viewed without glare by evenly diffusing enough light through it, over its entire area.

Image distributor. An optical device used to split the beam from an output *phosphor* enabling several channels to carry the image. Channels might be for mirror viewing, *cineradiography,* or strip filming.

Image intensification. An electronic system that intensifies an ordinary fluoroscopic image about 5000 times. An image intensifier converts the *x-ray* image patterns into visible light patterns which are then shown on a video screen.

Image quality indicator. See *Penetrameter.*

Image receptor. Any device that can transform x-ray photons into a visible form.

In-air exposure. Exposure rate measured at any given point in a beam with no scattering material in the beam path. Measured in units of R/min. In-air exposure = R/min × time.

Incoherent scattering. Scattering of photons resulting in loss of energy by the photon.

Industrial radiography. Application of radiography to industrial needs. It requires energies capable of penetrating subjects ranging from oil paintings to steel structures.

Inherent filtration. Any material filtering x-radiation emitted from the *target* through the tube, such as a glass *envelope,* oil coolant, or other housing materials.

In-motion radiography. A special technique in which a moving source traverses a stationary subject or vice-versa; used in ex-

tended linear traverse radiography, *rotary rotation* radiography, *orthogonal* scanning, and *tomography.*

Insulating oil. An oil used to prevent high voltage sparking between terminals of a radiographic tube. Terminals are immersed in insulating oil between the envelope and a metal housing.

Intensifying factor. A value used to achieve particular film *density* when exposing film with *intensifying screens.* Intensifying factor $= \frac{\text{exposure without screens}}{\text{exposure with screens}}$.

Intensifying screen. A composite of fluorescing material (usually calcium tungstate) and binder which is used with film to convert photon x-ray energy into visible light. The amount of light emitted is in direct proportion to the intensity of x-rays striking the *phosphor.* The image developed on the film is intensified by the fluorescing calcium tungstate.

Intensity. Amount of energy per unit of time passing through a unit of area perpendicular to the beam direction.

Interaction. Effects resulting from photons physically associating with atoms of material in their path. Some interactions are: *photoelectric process, coherent scattering, Compton effect,* and *pair production.*

Interlock. A safety device that prevents generation of x-rays at the source until radiation shielding is properly aligned.

Intermediate voltage. The energy range from 130 to 150 kV.

Internal scatter. Scatter produced by photons striking and interacting with materials inside a *subject,* that may cause a blurred image.

Intravenous pyelography (IVP). Radiography of kidneys, ureter, and bladder exposed to *contrast media.*

Inverse square law. The intensity of the *source* at the *subject* is inversely proportional to the square of the distance from the source to the subject.

Ion. An electrically charged atom or molecule.

Ionization. The addition or removal of electrons from atoms or molecules. X-ray energies may produce ionization.

Ionization chamber. An instrument that detects and measures ionizing radiation by measuring electrical current produced when the incoming radiation ionizes the gas in the chamber, making it act as a conductor.

Ion pair. Two *particles,* an *electron* and a positively charged residue, that are the product of ionizing radiation interacting with orbiting atomic electrons.

Irradiation. *Radiation exposure.*

Isotopes. Atoms (of the same element) with the same atomic number but with different atomic weights.

Jerman, Ed C. A contemporary of Roentgen, Jerman began an instruction program in radiography for physicians and technicians in 1897.

Jig. A device used to fix an object in a position to be radiographed.

K shell. An energy level associated with an inner electron shell of an atom. It is the usual site of photon excitation during photoelectric interaction, which produces characteristic x-rays. *See L shell.*

Kenotron. *See Valve tube rectifier.*

Kilo (k). Prefix meaning 10^3

Kilovolt (kV). An electrical potential difference of 1000 volts.

Kilovoltmeter. A voltmeter wired with an *autotransformer* that allows the primary voltage to be pre-set for an exposure.

Kinescopic image. Direct image photography from a television screen; photos from television fluoroscopy.

Kymography. A specialized technique for viewing a moving subject by a sequential series of exposures and using a special grid.

L shell. An electron shell level of an atom that has less energy than the K shell, and that usually fills the K shell when an electron is removed. When this occurs, an x-ray is emitted with *characteristic energy* equal to the potential between the two shell energy levels. *See K shell.*

Labyrinth. *See Light lock, Maze.*

Lag. *See Screen lag.*

Laminography. *See Tomography.*

Lanthanium oxysulfide. *See Gadolinium oxysulfide.*

Latent image. The image formed by the interaction of x-ray energies with silver halide crystals in film *emulsion.* The latent image is invisible and must be developed to a permanent or *manifest image.*

Lateral projection. Transverse passage of x-rays through a *subject.*

Latitude. See *Film latitude.*

Laue method. A method of *x-ray diffraction* using heterogeneous x-rays and a stationary crystal.

Lead equivalent. A lead thickness that *attenuates* the beam the same amount as the material to be radiographed.

Lead foil screen. Different thicknesses of lead foil placed around radiographic film in a cassette to intensify radiation reaching the film and reduce *scattered radiation.*

Lead rubber. A masking material composed of lead oxide evenly distributed in a plastic or rubber envelope; used to restrict the primary beam to subject contour or to mask radiographic film.

Leakage radiation. Radiation penetrating protective barriers.

Leakage test. Carefully monitored surveys of rate of exposure from *leakage radiation* in a *controlled area;* scheduled regularly in *health physics* program.

Level determination. In *tomography,* fixing the exact location of the *fulcrum.*

Light beam. The visible light emitted from a *collimator* that shows the size of the entrance beam at the *subject.* The exit beam will have significantly larger area than the entrance area shown by the light beam.

Light lock. A passage in or out of a processing room that does not allow light into the room; consisting of a revolving door, a maze, or double doors at right angles.

Line-focus. A principle of *anode* construction causing a beam of smaller area, but greater intensity to reach the film than hit the target originally. See *Effective focal area.*

Linear accelerator. A device used to increase energy levels of charged particles by varying potentials along a straight line as the particles pass by. See *Accelerator, Cyclotron.*

Linear energy transfer. The energy lost per unit length of the path of ionizing radiation through a biological material.

Line voltage. The voltage entering an x-ray generator.

Line voltage compensator. A device designed to assure constant power adjusting the line voltage while the x-ray generator is producing the primary beam.

Localization. A method of determining depth of a subject within a radiographed object by *stereoradiography,* or *parallax effect.*

Low voltage. The energy range from 50 to 120 kV.

Luminescence. A general term for light emission from biological, chemical, or *radiation* sources.

Lymphangiography. Radiography of lymph glands, lymphatics, and lymph vessels. Usually incorporates fluoroscopic *spot film* enlargement or *fractional-focus tube* techniques.

Magnification factor. Magnification factor $= \frac{\text{image size.}}{\text{object size.}}$

Magnification radiography. See *Enlargement.*

Mammography. 1. Radiography of the breast.
2. A generic term for radiographic techniques used with soft tissue of poor subject contrast.

Manifest image. The permanent, visible image produced after developing the *latent image.*

Manipulator. A mechanical device used to turn, hold, or position a subject. It is usually used inside a cabinet x-ray system and allows external control during fluoroscopic examination.

Manual processing. Developing, fixing, and washing film by hand in a dark room, in a series of tanks with separate solutions, or under ordinary room light by changing solutions in a single light-tight tank.

Mask. 1. A *radiopaque* material, usually lead, placed around the subject to reduce *scattered radiation.*
2. In *subtraction,* the reverse density copy of the *base film.*

Maximum permissible dose (MPD). The maximum *dose* of radiation allowed by regulation to be given to any subject per unit time.

Maze. See *Light lock.*

Mega (M). Prefix meaning 10^6.

Megavoltage. The energy range above 1 MV.

Metallic shot. Small shot pellets, usually lead, poured around irregularly shaped subjects for *masking.*

Micro (μ). Prefix meaning 10^{-6}.

Microradiography. Radiography of thin specimens with low x-ray absorption, using low kV; usually accompanied with photographic image enlargement.

Milli (m). Prefix meaning 10^{-3}.

Milliampere (mA). An electrical current of 0.001 *ampere.*

Milliampere-second (mAs). An exposure value obtained by multiplying the tube current (*mA*) by the exposure time (seconds). Any combination of the two factors giving the same product will reproduce the same exposure value (assuming no other changes). See *Reciprocity law.*

Mirror viewer. A series of lead mirrors used to transmit the image in *fluoroscopy* that permits direct viewing of the radiographic image without exposing the viewer to radiation. See *image distributor.*

Moire pattern. An undesirable pattern on the film resulting from superimposing two stationary grids with the grid lines all running in the same direction. See *Cross-hatch grid.*

Molybdenum (Mo). A naturally occurring element used in *focusing cups, rotating anodes,* and spiral supporting *filaments.*

Monitor. A device that determines the amount of ionizing radiation present.

Monoenergetic beam. Radiation beam of one energy. See *Characteristic radiation.*

Mottle. A spotted appearance on film exposed with *intensifying screens* because of random exposure by photon groups hitting the screen.

Moving grid. ICRU terminology for a *Potter-Bucky diaphragm.*

Multiple film exposure. A technique of exposing several different film types simultaneously on the same subject. It is particularly useful when radiographing a subject with variable densities or thickness.

Multitomography. See *Plesiotomography.*

Myelography. Radiography of the spinal canal exposed to *contrast media.*

N-unit. The amount of measurable *neutron* radiation that will produce the same amount of *ionization* as one *roentgen* of *x-radiation.*

Nano (n). A prefix meaning 10^{-9}.

Natural radionuclide. A member of any parent family (thorium, uranium, or actinium) that decays naturally at a spontaneous, fixed rate.

NCRP. National Council on Radiation Protection and Measurements.

Net density. *See Emulsion fog.*

Net fog. *See Emulsion fog.*

Neutron. An uncharged elementary nuclear particle.

Neutron radiography. *Radiography* by differential *neutron* absorption. To produce an image, a neutron source must be used with radiographic film to form a latent image.

Noise. Any *radiation* other than direct primary radiation causing exposure of film. See *Scattered radiation, Fog,* and *Quantum mottle.*

Nomogram. In radiographic exposure charts, a graphic representation enabling a dependent variable to be found by connecting the known values of two or more independent variables with a straight line.

Nondestructive testing (NDT). Any method of detecting concealed structures in a subject without damaging the subject.

Nonscreen film. Radiographic film relying on direct radiation for image production; designed for use without *intensifying screens.*

Notch coding. A means of identifying film types in the dark by the design and number of notches cut into the film.

Nuclide. An atom of any element with a specific number of of nuclear *protons* and *neutrons;* not synonymous with *isotopes,* which are different nuclides of one particular element.

Object. An entity being radiographed. *See Subject.*

Object-film distance (OFD). Distance between an *object* and the *film plane.*

Objective plane. In *tomography,* the plane produced at the *fulcrum level,* stationary relative to the *film plane.*

Object shift. In *stereoradiography,* the *tube* is usually shifted laterally while the *object* remains fixed and the resulting pair of images is viewed stereoscopically. However, it is also possible to fix the tube and shift the object to produce the stereoradiograph. *See Tube shift.*

Off-focus radiation. Radiation produced by electrons hitting a metal surface on the *anode* other than the *target.* The resulting radiation exits the tube at varying angles and is of no use without *collimation.*

Ohm. Unit of electrical resistance. Resistance against one *ampere* of current at a potential of one *volt.*

Orthicon camera tube. A type of television camera tube used for closed circuit image viewing in radiography. It requires only low-light levels and produces fine *resolution.*

Orthogonal projection radiography. A form of *in-motion radiography* where an irregularly shaped subject is slowly moved under a fixed source which exposes the film through a slit.

Orthovoltage. The electrical energy range from 160 to 500 kV.

Overcollimation. Excessive restriction of an x-ray beam by lead shutters with a *collimator.*

Overlay. A transparent aid placed on top of a *characteristic curve* which allows direct reading of interpolated values from the characteristic curve.

Packaging. Types of film available commercially, such as sheet film, roll film, or enveloped film.

Pair production. The conversion of energy to mass as a result of an accelerated *photon* (at least 1.02 *MeV* energy) striking a *nucleus,* producing an *electron* and a *positron.* The positron subsequently undergoes an *annihilation reaction.*

Pantomography. *Tomography* in which a panoramic image is obtained by using *slit scanning* with a narrow beam.

Paper radiography. A technique using rapid processing, image-forming, and photosensitive paper for convenience and mobility. The image must be fixed for permanent storage.

Parallax effect. Displacement or enlargement of an image on film as a result of the geometry of the radiation.

Parallel grid. A grid with all its lead strips parallel to each other which results in high *grid cutoff.*

Particle. A minute unit of matter with a measurable mass. See *Alpha particle, Beta particle.*

Pass box. A double-doored light-tight cabinet connecting two rooms through a common wall for the purpose of passing film or cassettes.

Peak kilovoltage (kVp). The greatest value of a potential difference in *kV.* In wave-form propagation, the crest value.

Penetrameter. A standard test piece which is radiographed simultaneously with the subject to insure conditions of exposure, film processing, and overall quality. Referred to in Europe as an *image quality indicator.*

Penetration. The ability of x-radiation to penetrate an object

without absorption. Penetration is directly proportional to kilovoltage (*kV*).

Penumbra. Area of hazy, unclear *definition* surrounding the edge of an image in a radiograph. See *Umbra.*

Phantom. A piece of material (water, pressed wood, or beeswax) that approximates a biological subject in *density* and is used to determine radiation *penetration* and *scatter* before exposing the subject.

Phosphorescence. The ability of certain substances to continue emitting visible light after exposure to x-radiation is discontinued.

Phosphor. A fluorescent material used in crystal form to make *intensifying screens.*

Photoelectric cell. See *Phototube.*

Photoelectric process. Ejection of an *electron* from an *atom* by a *photon.*

Photofluorography. Photography of fluoroscent screen images.

Photometry. A portion of *radiometry* that measures wavelengths within the human visual spectrum.

Photomultiplier tube. See *Phototube.*

Photon. A particle with electromagnetic energy that has momentum but no mass or electrical charge. See *Quantum.*

Photoradiograph. A photograph of the image on a radiograph. On the resulting print, the dark areas of the radiograph will be light on the print from the photoradiograph. To produce a print with normal *density* and *contrast* patterns, an intermediate negative should be made and the photoradiograph printed from it.

Phototimer. A light-sensitive *phototube* activating an electric timer and stopping exposure.

Phototube. A light sensitive diode that when excited by light emits electrons from its cathode which are attached to the anode. See *Fluorescence, Phosphor, Phototimers.*

Pi line. A straight line *artifact,* so called because it occurs 3.14 times the diameter from the film edge. It is produced during automatic processing by a deposit on a roller.

Pico (p). Prefix meaning 10^{-12}

Pinhole projection. A practical method of determining the size of a tube's *focal spot* by making a pinhole in a thin lead

sheet placed halfway between the focal spot and film. The image projected on the film will be approximately the focal spot size.

Pitting. Erosion of the *target* surface from electron bombardment. Of the common targets, rhenium-molybdenum surfaces are more resistant than tungsten.

Planck's constant (h). A constant factor used to determine energy (E) or frequency (v) of a *photon:* $h = E/v$ ($h = 6.6256 \times 10^{-27}$ erg-sec).

Plane-film distance. In *tomography,* distance between *object plane* and film. See *Object-film distance.*

Planigraphy. See *Tomography.*

Plesiotomography. Specialized *tomography* using several film or screen combinations separated in a cassette so that several tomographic sections can be exposed simultaneously.

Plumbicon camera tube. A type of television camera tube used for viewing of radiographic images. A type of *vidicon tube* with better resolution and lower light requirement.

Pneumoencephalography. Radiography of the ventricle system exposed to *air-contrast.*

Pocket dosimeter. A portable, direct reading *ionization chamber* for personnel protection that gives an immediate reading of exposure to ionizing radiation. See *Dosimeter.*

Polyenergetic beam. Radiation beam of mixed energies.

Port. The point of entry of an x-ray beam.

Positive recall video tape system. An electronic keying device which stores video tape in a central location and can locate and project a specific image on demand from a remote location.

Positron. A positive *electron.* A product of *pair production.*

Potential difference. See *Electromotive force.*

Potter-Bucky. *ICRU* terminology for the mechanism that activates the *grid* in a *Potter-Bucky diaphragm.*

Potter-Bucky diaphragm. A *grid* that is moved during exposure. The movement blurs out the images of the grid's lead strips on the film, eliminating *artifacts.*

Preservative. An inorganic chemical, sodium sulfite, used in *developer* to protect organic agents from natural oxidation.

Primary radiation. X-rays emitted from the anode *target* consisting of *Bremsstrahlung* and *characteristic radiation.*

Print. The manifest image produced on photographic paper after exposing the negative and photographic paper to light and *processing.*

Print-out image. Darkening of film from exposure to light. See *Base density.*

Processing. The chemical process of converting a *latent image* on film into a permanently visible image.

Projection. The relative attitude of the *subject* to the film.

Protection. See *Health physics.*

Protective barrier. See *Barrier.*

Proton. An elementary, positively charged particle found in all nuclei.

Pulse. An electrical signal generated by a single event of ionizing radiation.

Pulse amplifier. An instrument designed to amplify relatively weak or intermittent signals of radiation detection equipment.

Purple discoloration. Change of coloration of glass in x-ray tubes; an effect of x-radiation or Beta rays on glass.

Quantum. A unit of energy equal to the product of the frequency of radiation (u) and *Planck's constant* (h). Quantum = hu. A *photon* carries a quantum of electromagnetic energy.

Quantum mottle. A mottled film appearance caused by the action of x-ray *quanta* striking *fast film* and *screen* combinations. See *Mottle.*

Quantum theory. A theory proposed by Planck that energy is not emitted or absorbed continuously, but is intermittently radiated in units of definite magnitude called *quanta.*

R-meter. An instrument designed to measure radiation *dose.*

Rad. Unit of *absorbed dose* of ionizing radiation (acronym for **r**adiation **a**bsorbed **d**ose). 1 rad = 100 ergs/gram.

Radiation. Emission of energy through matter or space in either waveform or particle form.

Radioactivity. Emission of ionizing radiation from unstable *nuclides* undergoing spontaneous decay.

Radioautography. See *Autoradiography.*

Radiobiology. The study of the effects of *radiation* on biological systems.

Radiograph. The image produced on film as a result of exposure to x-radiation. See *Processing, Latent image.*

Radiographic contrast. The overall *contrast* on the radiographic image resulting from difference in density of the subject and the film.

Radiography. The study and application of x-radiation and its application to image production.

Radiology. The study and application of radiation (including x-rays and radionuclides).

Radiolucent. Allowing transmission in whole or part of x-radiation through a subject. See *Contrast agent, Radiopaque.*

Radiometry. The study of measuring radiant energy of ultraviolet, visible, and infrared radiation.

Radiomimetic. Chemical reactions causing biological effects similar to those caused by ionizing radiation. See *Erythema.*

Radionuclide. A radioactive *nuclide.*

Radiopaque. Not allowing transmission of x-radiation through a subject. See *Contrast agent, Radiolucent.*

Ray. A beam of energy.

Reciprocity law. In *radiography,* the product of tube current (mA) and exposure (seconds) equals a constant (mAs).

Rectification. The process of changing *alternating current* to *direct current.*

Reflection microradiography. See *Electron emission radiography.*

Relative Biological effectiveness (RBE). A factor used to compare the effectiveness of *absorbed doses* of different types of ionizing radiation on a biological system. See *Rad, Rem.*

Relaxation. In *xerography,* the process of cleaning and heating the aluminum plate for reuse after exposure. Improper relaxation results in incomplete image removal and possible double exposure.

Rem. Unit of dose equivalent (acronym for **r**oentgen **e**quivalent **m**an). For x-radiation, 1 rem = 1 rad = 1 roentgen.

Remnant radiation. Radiation that passes through the subject and strikes the film.

Replenishment. Adding volume or adjusting concentration of processing chemicals to compensate for use and evaporation.

Resolution. The minimum distance between two image *subjects*, that may be distinguished on the film, monitor, or fluoroscope.

Restrainer. A chemical, usually potassium bromide, which reduces *fogging* by allowing the developer to act on exposed (but not unexposed) silver grains in film emulsion.

Retarded asymmetry. In *tomography*, an asymmetrical exposure near the end of the *tube-film trajectory*.

Reticulation. Netlike pattern in film emulsion caused by extreme temperature changes during *processing*.

Reverse-density. Transposing *densities* in a contact print made from a radiograph. See *Mask*.

Rinsing. Process of exposing film to a running water rinse that minimizes contamination in processing solutions and reduces risk of streaking dried film with fixer residue.

Rod-anode tube. See *End-grounded tube*.

Roentgen (R). Unit of exposure. 1 R $= 2.58 \times 10^{-4}$ coulomb of ions/kilogram of air under standard conditions. Named for Wilhelm Konrad Roentgen, German physicist credited with discovering x-rays in 1895.

Roentgenography. See *Radiography*.

Roentgenology. See *Radiology*.

Roentgenoscopy. See *Fluoroscopy*.

Roentgen rays. See *X-rays*.

Roll processing. A form of manual processing whereby film is rolled onto a reel and placed inside a light-tight container. Processing solutions are poured into and out of the container through the cover.

Rotary radiography. A form of *in-motion radiography* where a strip film is placed around the circumference of a cylindrical subject, covered with a lead mask and exposed through a slit as the subject and film rotate.

Rotating anode. A rotating *target* in x-ray tubes composed of a disc of rhenium-tungsten alloy on a molybdenum body which rotates at 3300 rpm (or triple speed at 10,000 rpm).

Safelight. A light providing visibility during the dark phases of processing. The light wavelength is selected according to the sensitivity of the film being exposed, or processed.

Scanner. A video recording system which allows image storage of a single x-ray image from *fluoroscopy*.

Scanning disc. A piece of lead with apertures of various sizes placed in front of the *Bucky* or *grid*, used with early *phototimers*.

Scattered radiation. Radiation which has interacted with atoms, changing the direction of the photons. See *Backscatter*.

Scholz tunnel. An early fluoroscopic spot film device named for its innovator, Frank Scholz.

Scintillation. Light produced when a photon strikes *phosphor* crystal. See *Fluorescence*.

Scout. In *tomography*, a test exposure to determine the correct *objective plane*.

Screen. See *Intensifying screen*.

Screen contact. The space between *screen* and film must be as small as is practical to keep photon excitation from the screen from producing blurred film images.

Screen film. Radiographic film used with *intensifying screens*.

Screen lag. Continuing phosphorescence of *fluoroscopic* and *intensifying screens* after removing the source. Fluoroscopic lag is considerably stronger than that of intensifying screens.

Second-order subtraction. Preparing two *masks* from the *base film* during subtraction. The second mask is usually prepared to overlay a poorly exposed first mask.

Secondary radiation. Radiation emitted after interaction of x-radiation with atoms. See *Primary radiation*.

Section. In *tomography*, the plane of exposure. A section's thickness is determined by the amplitude of the tube travel.

Self absorption. Absorption of radiation within the subject radiographed.

Sensitivity. See *Film speed*.

Sensitometric curve. See *Characteristic curve*.

Sensitometry. A method of quality control for image standardization. See *Characteristic curve*.

Shape distortion. A misrepresentation of the object shape caused by improper alignment of *tube*, *object*, and *film*.

Sharpness. See *Definition*.

Shield. See *Barrier*.

Short stop. See *Stop bath*.

Shoulder. That portion of the slope on a *characteristic curve* representing film images of high *densities* and low *contrasts*.

Shutter. A lead projection inside a collimator used to adjust or restrict the size of an x-ray field or to stop the radiation completely. Many collimators have automatic shutter adjustments to compensate for beam restriction as *focus-film distance* varies.

Side scatter. Scattered radiation produced by photons striking and interacting with walls adjacent to the subject.

Silver bromide. The light sensitive chemical in film emulsion which when excited by photons produces a *latent image* that is made visible by immersing the film in a solution of silver nitrate and potassium in total darkness.

Single-coated film. Radiographic film with an emulsion layer on one side only.

Size distortion. A misrepresentation of the object size caused by divergence of the x-ray beam when the *object-film distance* is short.

Slit scanning. A radiographic technique to shield the entire *object* from excessive x-radiation. The primary beam passes through a lead slit exposing only the *subject.* A disadvantage is that the lead shielding must be heavy enough to absorb all radiation except that passing through the slit.

Soft tissue radiography. See *Mammography.*

Soft x-rays. A beam of relatively low energy and long wavelength, produced by low generating kV.

Solid state rectifier. A consolidation of individual *diodes* connected in series and insulated; usually made of silicon. They have a very low voltage drop as compared with *valve tube rectifiers* and do not need a heated *filament.*

Source. The *focal spot* on the *anode* where the primary beam originates.

Source-film distance (SFD). See *Focus-film distance.*

Space charge. The result of *thermionic emission* from an incandescent filament. See *Thermion.*

Spectral distribution curve. A plot of an x-ray beam's wavelength and photon energy. See *Spectrum.*

Spectral window. A combination of *target* and *filter* made of the same metal, usually molybdenum, in which the filter transmits the *characteristic radiation* emitted by the target.

Spectrum. A representation of the distribution of radiation intensities, usually expressed in terms of wavelength, energy, or frequency.

Speed. See *Film speed.*

Speed factor. See *Intensifying factor.*

Spinning top. A device used to check the accuracy of radiographic timers. A lead top with a single hole drilled through its periphery is spun on film during an exposure and the number of holes shown on the film is related to the accuracy of the timing device.

Spot film. A technique used to obtain a still radiograph during *fluoroscopy.* See *Scanner.*

Stable. Not *radioactive.*

Stanford stereoscope. A large *stereoscope* using prisms and mirrors for viewing *stereoradiographs.*

Static marks. Circular or tree-like black artifacts on radiographic film caused by static electrical discharge when handling film in dry atmosphere. These may be avoided by removing film from cassette or envelope gently.

Stationary grid. A non-moving *grid* whose disadvantage is that its lead strips may appear as images or shadows on the processed film. See *Bucky grid.*

Stem radiation. See *Off-focus radiation.*

Stereoradiography. Technique of producing radiographs that are viewed in three dimensions.

Stereoscope. An optical instrument allowing three dimensional viewing of stereo images.

Stereoscopy. Viewing objects in three dimensions.

Stop bath. An acetic acid solution that stops the developing process of film chemically. A two minute rinse in running water may be substituted for it.

Stratigraphy. See *Tomography.*

Stray radiation. The sum of off-focus and *scattered radiation* reaching the subject.

Streaming. Increased transmission of x-rays through a less dense area of the subject.

Strip film camera. A serial camera capable of taking *spot films* rapidly (1-5 frames/sec) and directly from the *phosphor* output of an *image intensifier.*

Subject. That part of an *object* being radiographed that is the point of interest.

Subject contrast. The portion of radiographic *contrast* attributed to differential absorption and transmission of x-rays through the subject. See *Streaming.*

Subtraction. A photographic technique used to clarify radiographic interpretation. After radiographing the subject, a *contrast medium* is introduced into the subject and a second radiograph is prepared. The first radiograph (the *base film*) is exposed with subtraction film to produce a reverse-density image (the mask). The mask is superimposed over the second film with the contrast agent in the subject. All images except the ones with the contrast agent are eliminated from the two superimposed films, leaving the subject for easy interpretation.

Supervoltage. See *Megavoltage.*

Survey meter. A portable radiation detection instrument.

Tank processing. A method of processing film manually in a series of tanks containing the different processing solutions.

Target. The surface area on the *anode* which is struck by free electrons emitted from the *filament.*

Target angle. The degree of bevel on the *anode* face; usually about 18°.

Teleradiography. A radiographic procedure that minimizes distortion by using parallel rays and a *focus-film distance* of at least six feet.

Tera (T). Prefix meaning 10^{12}.

Thermion. An electron liberated by heating an *electrode.* See *Space charge.*

Thermionic emission. The liberation of *thermions* from a conductor by an electric current.

Thermionic tube. Tube that produces electrons by heating an *electrode.*

Thoraeus filter. A filter of tin, copper, and aluminum (in that order from tube to object) allowing the *half value layer* of copper and aluminum but with less beam *attenuation.*

Thoriated. A cathode filament impregnated with thorium oxide (ThO_2) to increase *thermionic emission.*

Timer. See *Electron impulse timer, Electronic timer, Phototimer.*

Time-temperature. The manufacturer's recommended developing time and temperature combination for processing film. Standard time-temperature for manual developing is five minutes at 20° C (68° F).

Tomogram. A radiograph produced by a *tomograph.*

Tomograph. The instrument used in *tomography.*

Tomographic angle. The angle produced by amplitude of the *fulcrum.* The larger the tomographic angle, the thinner the section. See *Tomography.*

Tomographic section. In *tomography,* the radiograph of the *objective plane.*

Tomography. A radiographic procedure that makes an image of a single plane in the subject. The plane is chosen by making it the *fulcrum level* between the x-ray tube travelling in one direction and the *film plane* travelling in the opposite direction. All planes above and below the fulcrum are blurred out of focus on the film. The synchronous tube-film motion may be linear, circular, or hypocycloidal.

Tomoscopy. A technique coupling *tomography* with an *image intensifer* for specifically locating a *subject.*

Toner. In *xerography,* a negatively charged powder (calcium carbonate) that is sprayed on the positively charged aluminum plate, producing the manifest image.

Total filtration. The sum of *inherent filtration* plus added filtration.

Triode. See *Grid-controlled x-ray tube.*

Tube. The device which generates x-rays. A *filament* heated by an electric current (*cathode*) produces electrons which are propelled by a high voltage source toward the *target* on the *anode.* All components are surrounded by an evacuated glass *envelope.*

Tube current. Current passing between the *cathode* and *anode* during x-ray generation; measured in milliamperes.

Tube-film trajectory. In *tomography,* the synchronously opposing paths of the tube and film.

Tube rating. The manufacturer's specified heat-loading capacity of an x-ray tube.

Tube shift. The actual lateral distance necessary to shift the x-ray tube when producing a *stereoradiograph.* Generally, tube shift/focus-film distance = 1/10.

Tube side. That side of a subject, film holder, *cassette,* or *grid* which must face the tube *focal spot.*

Tungsten. The metal usually used in the *filament* coil of *cathodes*

and the *target* surface of *anodes* in x-ray tubes because of its high atomic number, high melting point, high thermal conductivity, and low vapor pressure at high temperatures.

Ultrasonic testing. Transmitting high frequency sound waves through a *subject* as a method of *nondestructive testing.*

Umbra. The image proper on a *radiograph.* See *Penumbra.*

Undercut. Shadow formation in a subject of variable thickness, caused by scattered radiation from a thinner portion creating a darker border near the thicker portion. See *Scattered radiation.*

Unmodified scattering. See *Coherent scattering.*

Unsharpness. Lack of *definition,* low *acutance* in an image caused by improperly aligned geometry. See *Penumbra.*

Unstable. *Radioactive.*

Urography. Radiography of the kidney and urinary system.

Use factor (U). That part of the energy used to introduce *primary radiation* to the *subject.*

Useful beam. See *Primary radiation.*

Vacuum cassette. A special film cassette which can be evacuated to assure better screen-film contact.

Vacuum diode rectifier. See *Valve tube rectifier.*

Valve tube rectifier. A *diode,* vacuum tube which permits electric flow in only one direction, used in circuits to rectify currents. They do not produce x-rays unless a sufficient voltage drop occurs.

Venography. Radiography of veins using *contrast media.*

Ventriculography. Radiography of the skull ventricles exposed to air as a *contrast medium.*

Video disc scanner. See *Scanner.*

Video system. Electronically coupling the fluoroscope with a television camera and monitor, *video tape system,* or *video disc scanner.*

Video tape system. In *fluoroscopy,* a video tape recording with the advantage of showing images immediately, without processing. It also requires less radiation exposure than *cineradiography.*

Vidicon camera tube. A type of television camera tube used for image viewing in radiography. It is relatively inexpensive but requires bright light levels for operation.

Viewing room. A room with variable light intensity and equipped with illuminators for inspecting radiographs.

Volt. Potential difference allowing a current of one *ampere* to pass a resistance of one ohm.

Voltage compensator. An instrument used to adjust and control voltage to an x-ray source.

Wafer grid. Any laminated materials alternating *radiopaque* and *radiolucent* layers to reduce *secondary radiation.*

Washing. An intermediate processing step using running water to remove excessive chemicals from the film. The minimum washing time is 20 minutes at 20° C.

Water marks. Spots left on a dried film caused by water drops adhering to the film after washing. As the film dries, the areas under the drops dry slower than the remainder of the film resulting in gelatin distortion. Water marks may be avoided by using *wetting agents.*

Watt. An electrical unit of work per unit of time. Wattage = amperage × voltage; 746 watts = 1 horsepower.

Wavelength. The distance between two successive crests in a wave propagation; ordinarily, the practical range of x-ray wavelengths are between 0.1 and 0.5 Å.

Wave theory of radiation. A theory that explains the movement of x-rays as electromagnetic waves traveling at the speed of sound and bearing no electrical charge.

Wet reading. Viewing the exposed radiograph before completed processing, such as during fixing or washing.

Wetting agent. A surface tension reducing solution applied after washing film to reduce *drying* time and prevent *water marks.*

Wheatstone stereoscope. A large *stereoscope* using prisms and mirrors for viewing *stereoradiographs.*

Wiremesh test. A simple test of screen-film contact. A 1/4" wire mesh is placed in direct contact with screen-film (cassette) and radiographed. The image is then checked for sharpness. Poor screen-film contact results in a blurring of the wiremesh image.

White radiation. See *Bremsstrahlung.*

Workload. The amount an x-ray generator is used, expressed in mA minutes/week or in R/week.

Xerography. An image-forming process in which photons excite selenium crystals on a positively charged aluminum plate. A latent image is formed on the plate (the charge and selenium excitation are proportional to the subject's absorption of photons), which is made visible by spraying a negatively charged powder (*toner*) on the plate. The plate is then *relaxed* by heating and cleaned for reuse.

Xeroradiography. Xerography in which x-radiation is used to excite the selenium crystals. See *Xerography.*

X-ray. A penetrating form of electromagnetic radiation with short, but variable wavelengths, traveling at the speed of light. X-rays are generated within an x-ray tube by fast moving electrons suddenly changing velocity.

X-ray crystallography. See *X-ray diffraction.*

X-ray diffraction. Measuring and identifying crystalline structure by the image diffraction of *monoenergetic photons* colliding with characteristic atomic planes in the crystal.

X-ray machine. See *X-ray system.*

X-ray protection. See *Health physics.*

X-ray quality. Penetrating power of an x-ray beam. A high quality photon beam has high energy, high frequency, and short wavelength.

X-ray quantity. The amount of exposure to ionizing x-radiation, measured in air in units of *roentgen.*

X-ray spectroscopy. Technique of representing energy or wavelength emission spectra of elements bombarded with x-rays. The x-ray emitted from the element (*characteristic radiation*) is measured with a spectrometer.

X-ray system. The total assembly used to produce x-radiation, including generator, controls, shielding and power.

X-ray tube. See *Tube.*

Yttrium oxysulfide. See *Gadolinium oxysulfide.*

Zinc cadmium sulfide. A *phosphor* used in fluoroscopic screens that emits a green light and has little or no phosphorescence.

Zonogram. Radiograph produced using *zonography.*

Zonography. A type of *tomography* using a *tomographic angle* of 5° to 10° that produces a relatively thick *section* (about 10 mm), but with good contrast.

References

The following references will provide supplemental definitions, techniques and terminology.

Culinan, John E.
1972. Illustrated Guide to X-ray Technics. J. B. Lippincott, Philadelphia. 204 pages.

DuPont, Radiographic Products Div.
No date. NDT Terminology. DuPont, Wilimington, Del. 31 pages.

Eastman Kodak, Radiography Markets Div.
1969. Radiography in Modern Industry. Eastman Kodak, Rochester. 160 pages.

GAF, X-Ray Products Div.
1976. Radiographic Education Programs. GAF, New York. 79 pages.

General Dynamics, Convair Div.
1967. Radiographic Testing, CT-6-6. General Dynamics, San Diego. 228 pages.

International Commission on Radiation Units and Measurements.
1975. Radiation Quantities and Units. ICRU Report 19. ICRU, Washington, DC. 20 pages.

International Organization for Standardization.
1969. Nuclear Energy Glossary. ISO, Switzerland. 35 pages.

National Council on Radiation Protection and Measurements.
1968. Medical X-Ray and Gamma Ray Protection for Energies up to 10 Mev. NCRP Report #33. NCRP, Washington, DC. 42 pages.

Selman, Joseph.
1974. The Fundamentals of X-Ray and Radium Physics. 5th Ed. Charles C. Thomas, Springfield. 524 pages.

U.S. Atomic Energy Commission.
1974. Nuclear Terms, A Glossary. AEC, IB-006. 80 pages.

U.S. Department of Health, Education, and Welfare, PHS.
1970. Radiological Health Handbook, PHS Pub. #2016. 458 pages.

Vozzo, J. A.
1978. Radiographic terminology for biological research. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. SO-18, 45 p.

A glossary of terms used in radiography.

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