

# REPORT DOCUMENTATION PAGE

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DOCUMENT 458-96

OPTICAL SYSTEMS GROUP

**GLOSSARY OF OPTICAL  
AND  
PHOTOINSTRUMENTATION TERMS AND DEFINITIONS**

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**GLOSSARY OF OPTICAL  
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## PREFACE

This glossary is a collection of terms with definitions pertaining to the fields of physical and geometrical optics, photoinstrumentation, optical-data gathering, and metric photography. It is intended to serve as a quick reference guide for those requiring brief practical technical information about optics, photoinstrumentation, and associated systems. Also included are commonly used acronyms and initialisms. Scientific photographers, test planners, technical editors and writers, and procurement personnel requiring simple text that helps clarify and define specific topics will benefit from using this document.

**A-wind** - a way to denote the relative position of sprocket holes and emulsion on a roll of film having sprocket holes only on one edge. If film is wound on a spool or core with the emulsion in (toward the center) and the film spool is held in front of an observer so that it unwinds toward the observer and from the top of the spool, the film is A-wind if the sprocket holes are on the observers left.

**Abbe condenser** - a compound lens used for directing light through the object of a compound microscope. All the light enters the object at an angle with the axis of the microscope.

**Abbe prism** - a type of roof prism used to invert an image.

**aberration** - the failure of an optical system to form an image of a point as a point, of a straight line as a straight line, and of an angle as an equal angle. Major optical aberrations are astigmatism, chromatic aberration, coma, curvature of field, distortion, and spherical aberration.

**ablation** - the removal of material by vaporization or erosion, usually caused by extremely high temperatures and friction.

**abrasions** - scratches, digs, or any physical marks on an optical surface.

**absolute magnification** - the enlargement that results when an object is at the focal point of a magnifying lens. Generally, the magnification is equal to the distance of distinct vision, nominally 250 mm, divided by the effective focal length of the magnifying lens, in millimeters (mm).

**absorbing wedge** - a piece of glass of optically dense material whose density increases from one end to the other.

**absorptance** - the ratio of the absorbed radiation to the incident radiation on an object.

**absorption** - the physical process by which incident radiation is assimilated into an object.

**acetate film** - a photographic film whose base is composed of cellulose acetate or triacetate.

**achromat** - a compound lens corrected to have the same focal length for two or more different wavelengths. Commonly, the F and C lines of the Fraunhofer spectrum are chosen.

**actinometer** - a general name for any instrument used to measure the intensity of photochemically active radiation.

**active optics** - optical elements whose shape can be controlled to constrain aberrations or to affect the performance of an optical system.

**acuity** - a measure of the eye's ability to detect detail.

**acutance** - the measure of the sharpness of an edge in a photographic image; the optical density gradient as measured across the edge.

**additive color process** - a system of color photography in which the color synthesis is obtained by the addition of colors, one to another in the form of light instead of colorants or dyes. The color addition may take place (1) by simultaneous projection of two or more color images onto a screen, (2) by projection of color images in rapid succession onto a screen, or (3) by viewing minutely divided juxtaposed color images.

**aeolight** - a discharge lamp in which the intensity of illumination is proportional to the applied signal voltage. The aeolight lamp is used to produce a modulated light source for motion picture sound recording.

**aerial camera** - a camera used in aircraft or satellites to photograph the Earth's surface.

**aerial image** - a real image formed in space by an optical system.

**afocal** - an optical system with no finite focal length whose object and image points are at infinity.

**air bearing** - a mechanical support that allows a bearing or a load bearing device to be supported by a volume of air to reduce friction.

**airy pattern** - the image of a point source produced by an optical system. The image consists of a bright central circle surrounded by alternating light and dark concentric circles.

**albedo** - the ratio of the reflected radiation of an object to the incident radiation.

**altazimuth mount** - an optical mount that provides for both azimuth and elevation adjustments.

**ambient light** - naturally occurring, diffuse illumination.

**amici prism** - a prism used to erect images in elbow telescopes and camera viewfinders.

**anamorphic system** - an optical system that produces different magnifications in the horizontal and vertical plane.

**anastigmat** - a compound lens combination corrected so that both astigmatism and curvature of field are largely eliminated over a considerable area in the image plane.

**angle of incidence** - the angle between an incident light ray and a line perpendicular to the surface to which it is incident.

**angle of reflection** - the angle between a reflected ray and a line perpendicular to the surface from which it is reflected.

**angle of refraction** - the angle between a refracted ray that has traveled from a medium of one refractive index into a medium of a differing refractive index and the normal angle to the surface of the medium into which the ray was refracted.

**angle tracking** - a method of target tracking in which a continuous sequence of known target positions is fed to electronic tracking filters to produce a refined estimate of past, present, and future target positions.

**angstrom** -  $1.0 \times 10^{-10}$  meter.

**angular magnification** - the ratio of the apparent angular size of an image as seen through an optical system to the size of an object as seen with no optical magnification.

**angular resolution** - the smallest angular distance, as measured from the entrance pupil of an optical system, between two point sources that permits an optical system to resolve the sources as two separate images instead of a single image.

**anomalous dispersion** - light separation as a function of the refractive index of a medium.

**ANSI** - American National Standards Institute

**antifog coating** - a coating on optical surfaces to help stop moisture condensation on the elements.

**antihalation backing** - a light absorbing material applied to the base of a photographic film to prevent light scattering and resulting secondary image formation.

**antireflection coating** - a chemical compound evaporated onto an optical surface to reduce reflection and to increase transmission of light through the element.

**aperture** - any opening through which radiation may pass.

**aperture priority** - an exposure system that sets a camera shutter speed as a function of the pre-set aperture.

**aperture stop** - a diaphragm in an optical system that determines the amount of light entering the system.

**aplanatic lens system** - a lens system designed and manufactured to minimize spherical aberration and coma.

**aplanatic points** - two points on the axis of an optical system having the property that rays proceeding from one of those points shall all converge to or appear to diverge from the other. The two foci of an ellipsoid are aplanatic points.

**apochromat** - a lens designed to optimize focusing of the three primary colors.

**arc lamp** - a lamp that produces illumination by having an electrical arc between the two lamp electrodes.

**ASA** - American Standards Association

**ASCII** - American Standard Code for Information Exchange

**aspheric lens** - a lens that has at least one surface not spherically symmetric.

**astigmatism** - an aberration of a lens with spherical surfaces such that the image of a point not lying on the optical axis is a pair of short lines normal to each other and at slightly different distances from the lens. Radial and tangential lines are in focus in different image planes.

**astronomical camera** - a camera designed to interface with telescopes to photograph celestial objects.

**astrophotography** - the science of photographing celestial objects.

**atmospheric turbulence** - irregularities and disturbances in the atmosphere that deteriorate the quality of optical images.

**attenuator** - a light absorbing filter or material placed in an optical system to reduce the amount of light passing through the system.

**autocollimator** - 1. a device by which a lens makes a divergent beam from an aperture parallel and then after the parallel light has passed through a prism to a mirror and has been reflected back through the prism. The same lens brings the light to a focus at an exit slit. 2. a telescope with a graduated reticle so that angles subtended by distant objects may be read directly.

**autoexposure** - a method to automatically control the amount of light passing through an optical system by coupling aperture control and shutter speed.

**autofocus** - a method to constantly maintain integrity focus within an optical system.

**auxiliary lens** - a simple lens placed in front of a camera lens to change the focal length.

**axis** - a straight line passing through an object to denote its center.

**azimuth angle** - 1. the rotation of an object in a horizontal plane pivoted about a vertical axis passing through the object. 2. the rotation angle measured eastward from true north.

- B-wind** - a way to denote the relative position of sprocket holes and emulsion on a roll of film having sprocket holes only on one edge. The film is wound on a spool or core with the emulsion in (toward the center), and the film spool is held in front of an observer so that it unwinds toward the observer and from the top of the spool. The sprocket holes are on the observers right.
- back focal length** - the distance from the center of the rear surface of a lens to the second or rear focal point.
- backlash** - dead spots or lost motion between driving gears and driven gears in a mechanical system. The nonmovement of the driven system is a result of errors in the coupling between the two systems.
- backlighting** - the placement of an illuminating source behind an object, so the object is between the camera and source thus producing a shadow or silhouette of the object in the camera.
- baffle** - an opaque shield placed in an optical system to reduce stray light.
- ballistic camera** - a camera that takes multiple exposures on a single piece of film to record projectile trajectory data.
- ballistic photography** - the science of photographing high speed projectiles.
- bandpass filter** - a filter that has a high transmission rate for a specified range of wavelengths but a decreasing rate above and below the specified range.
- Barlow lens** - a negative lens used to increase the focal length of an optical system.
- barrel** - a cylindrical mechanical lens housing.
- barrel distortion** - an optical aberration that causes a square grid pattern to be imaged as barrel shaped.
- bayonet mount** - a mechanical system consisting of a spring loaded locking pin on the lens which fits into a flange mounting on the camera body; used to expedite lens changes.

**beam** - a column of light, considered as a bundle of rays that may consist either of parallel, diverging, or converging rays.

**beam candlepower second** - a unit of light output from an electronic strobe.

**beam divergence** - the increase in diameter of a collimated beam of light caused by the light not coming from a true point source.

**beam expander** - an optical device used to change the diameter of a collimated beam.

**beamsplitter** - a device used to divide a beam into two or more separate beams.

**beamwidth** - the angular divergence or convergence of an optical beam.

**bellows** - a flexible, light-tight tube placed between a camera lens and film plane to allow for variable focusing.

**bevel** - a chamfer or radius ground on the rim of a lens to help prevent chipping and for mechanical mounting.

**biconcave lens** - a lens whose surfaces curve inward; a negative lens.

**biconvex lens** - a lens whose surfaces curve outward; a positive lens.

**bifocal lens** - a lens composed of two parts having two different focal lengths.

**billet split lens** - a lens with two parts separated along the optical axis.

**binocular** - an instrument composed of two similar telescopes, one for each eye, independently focused.

**binocular vision** - the ability of the human eyes to determine depth by viewing objects from a slightly different angle.

**biprism** - an optical prism having an apex angle only slightly less than 180°. Used to produce a double virtual image of a point source.

**bitoric lens** - a lens whose surfaces are cylindrical.

**blackbody** - an infrared source that when heated has an emissivity of 1; an object that absorbs all wavelengths striking it.

**black light** - ultraviolet light.

**blank** - a piece of rough cut or roughly molded glass that is to be polished into a finished lens.

**bleach** - a photographic chemical that dissolves silver to vary the color and intensity of color film.

**blind spot** - the place on the retina where the optic nerve is attached.

**blisters** - elliptically shaped bubbles in glass.

**blur circle** - the image of a point source formed by a lens.

**borescope** - an optical inspection device having a flexible fiber optic with an illuminator and an eyepiece; used to inspect or photograph normally inaccessible places.

**boresighting** - the alignment of the optical axis of a camera system to the mechanical axis of a system under test.

**boresight error** - the linear displacement between the axis of an optical system and the mechanical axis of a system under test or between two parallel lines of sight.

**boresight tool** - an optical device used to align and focus camera systems that do not have a reflex viewing capability.

**Brewster angle (or polarizing angle of a dielectric)** - the angle of incidence for which a wave polarized parallel to the plane of incidence is wholly transmitted (no reflection). An unpolarized wave incident of this angle is resolved into a transmitted partly polarized component and a reflected perpendicularly polarized component.

**brightness** - the attribute of visual perception with which an area appears to emit more or less light. The quantitative value of luminance should be used when referring to photometric quantities. Luminance (brightness) is measured in lamberts. One lambert is equal to 1 lumen per square centimeter leaving a surface within all directions within a hemisphere.

**bright field image** - the image contained within a brightly lit background.

**bubble level** - a device containing liquid sealed in a leak-proof, flat-bottom housing that contains a naturally occurring air bubble; used to find a horizontal line or plane.

**buckle switch** - a small mechanical arm attached to an electrical microswitch that pushes against film as it runs through a camera. When the film supply is exhausted, the arm releases the microswitch and turns off the camera.

- C-mount** - a standard thread mounting for 16-mm film cameras. The threaded barrel has a 1-inch diameter with 32 threads per inch. The flange focal distance is 0.690 inch.
- cable release** - a wire connected to a camera shutter release mechanism to trip the camera shutter without having to physically touch the camera.
- calibrated source** - a lamp that can be traced to a standard light source.
- calibration** - the process of determining certain specific parameters in an optical system to extract engineering data from photographed images.
- camera movement** - the mechanical transport that moves film through a camera.
- camera station** - the physical point in space that defines the exact location of a camera lens nodal plane at the time of exposure.
- candela** - a unit of luminous intensity. A point source of 1 candela radiates 1 lumen into a solid angle of 1 steradian.
- candlepower** - the luminous intensity of a source measured in candelas.
- carbon arc** - the high voltage discharge arc between two carbon rods in a high intensity searchlight.
- cardinal points** - the focal points and nodal points of an optical system.
- Cassegrain optical system** - An optical system that uses a concave mirror as the primary reflector and a convex mirror as a secondary mirror to shorten the actual length of the system. Light is reflected off the primary onto the convex secondary back through a hole in the primary to the focal plane.
- cassette** - a container that holds film or tape.
- catadioptric optical system** - an optical system that uses both reflective and refractive elements in the optical train.
- catoptric optical system** - an optical system that uses only reflective surfaces to form an image.

- centering** - the mounting of components of an optical system so that the optical axes of the elements lies on the mechanical axis of the system.
- changing bag** - a light tight cloth enclosure with armlets in which light sensitive materials may be handled without the need of a darkened room.
- characteristic curve** - a graph that relates the increase in film density versus its time of exposure.
- charge coupled device (CCD)** - a solid state imaging mechanism that uses metal-oxide semiconductor (MOS) technology, surface charge storage, and information transfer.
- charge insertion device (CID)** - a solid-state imaging detector composed of a two-dimensional array of coupled metal-oxide semiconductor (MOS) charged storage capacitors. It is designed to convert near-infrared radiation to electrical signals.
- chief ray** - a ray passing through the center of the aperture stop of an optical system; the primary or principal ray.
- chopper** - a rotating opaque shutter or an opaque vibrating membrane that is used to interrupt a light beam in an optical system.
- chromatic aberration** - image distortion of an optical system caused by nonlinear dispersion of light as a function of wavelength.
- CIE (Commission Internationale de l'Eclairage)** - the International Commission on Illumination.
- cine camera** - a motion picture camera that takes successive photographs on one continuous piece of film with accurately spaced sprocket holes.
- cinematography** - the science of photographically recording motion.
- cineradiography** - the photographic recording of sequential x-ray images onto film.
- cinesextant** - a mobile, trailer-mounted, mechanical-tracking mount having optical or electro-optical instrumentation attached to its support system. Used to track airborne targets to record event data and trajectory information.

- cinetheodolite** - a mechanical tracking mount with a long focal length tracking telescope and an optical data recording system integrated directly into the mount. Either electromagnetic or optical-encoding devices are affixed to the azimuth and elevation bearings of the mount so that angular data can be recorded directly onto the data recording system. The data recording system may either be 35-mm film, or a visible or infrared video recording system.
- circle of confusion** - the image of a point source that appears as a circle of finite diameter because of defocusing or aberrations inherent in an optical system.
- click stop** - a lens having an f stop ring that produces an audible click to locate certain f stop settings.
- coated optics** - optical surfaces having dielectric films deposited onto the surfaces. The coatings increase or decrease the transmittance or reflectance of the uncoated surface.
- coelostat** - a two-mirror system that optically tracks celestial objects. One mirror is mounted on an electrically driven polar axis mount so that the polar axis is parallel to the plane of the mirror. The second mirror is stationary and reflects the beam from the first mirror. The plane mirror is moved at an angular rate of one revolution per 48 hours, so the tracked object will remain stationary in the field of view of the second mirror.
- cold mirror** - a mirror that reflects visible light and transmits infrared radiation.
- collimation error** - the angular misalignment between the axes of an optical system and a mechanical system under test or between two lines of sight that are near parallel.
- collimator** - an optical instrument that produces parallel rays of light; a collimated beam.
- color** - the observed differences in a visual scene that are due only to the variances in spectral composition of the light illuminating the scene.
- color correction** - the reduction of chromatic aberrations in an optical system.
- color filter** - an optically transparent material that alters the color or color temperature of light emitted by a source or reflected from an object.

- color negative film** - a type of film that produces the complimentary colors of the original colors of an object or scene.
- color positive film** - a type of film that reproduces the original colors of an object or scene.
- color temperature** - a blackbody radiator temperature that emits the same color radiation as the apparent visual color as the subject or scene in question.
- coma** - an aberration of an optical system that causes off-axis rays from a source not to focus on the same point in the image plane but rather to focus as a pear-shaped spot.
- complementary colors** - two colors that produce white light when added together.
- complex lens** - a lens composed of multiple elements arranged in two or more groups.
- compound lens** - a lens composed of two or more separate elements that may or may not be cemented together.
- compound shutter** - a shutter made of several identical shutter leaves, mounted symmetrically around the lens axis; opens from the center.
- concave lens** - a lens having one or both surfaces negative or curved inward.
- concave-convex lens** - a lens having one surface negative or curved inward and one surface positive or curved outward.
- condenser lens** - a lens that collects light from a source and evenly illuminates an object or area.
- conical lens** - a lens having a surface ground as a cone instead of with a spherical radius.
- conjugate distance** - the object and image distances from the front and second nodal points.
- contrast** - the difference in brightness between light and dark areas of an image.

**contrast tracker** - an electronic automatic tracking device that uses differences in scene contrast within a video field to automatically track a specified target within the field.

**converging lens** - brings an incident bundle of light rays to a focus.

**convex lens** - a lens having at least one surface ground positive or curved outward.

**copy camera** - a large format camera used to copy large art work or drawings positioned on a vertical easel and usually mounted on an optical rail. The desired magnification is obtained by sliding the camera and easel along the rail.

**core** - a small plastic or metal cylinder that film stock is spooled onto for loading into cameras.

**corrected lens** - a lens designed and manufactured to have reduced aberrations.

**critical aperture** - the f number at which a lens produces the best image.

**cross hairs** - the etched reticle lines on an optical substrate placed inside an optical system that denote the optical axis of the system.

**crown glass** - a collective term for a group of optical glasses exhibiting low optical dispersion.

**curvature of field** - a lens aberration causing a flat object to be imaged as a curved surface rather than a plane.

**cylindrical lens** - a lens having at least one surface ground in the shape of a cylinder.

**Dall-Kirkham telescope** - a telescope similar to a Cassegrain telescope but has an ellipsoidal primary reflector and spherical secondary mirror.

**damping** - the resistance to oscillatory motion.

**dark adaptation** - the ability of the human eye to adjust to low light levels.

**dark slide** - an opaque, removable panel that prevents accidental film exposure.

**data matrix** - a block of light emitting diodes (LEDs) placed in the image plane of a camera that record encoder elevation, azimuth, timing, or other information in a binary format.

**data reduction** - the process of extracting, analyzing, and organizing metric information from photographic images.

**daylight bulb** - a photo illumination source whose output replicates daylight.

**daylight load** - a spool of film that can be loaded into a camera under normal ambient light without damaging exposure to the entire film roll.

**dedicated flash** - electronic strobe units that are used only with specific cameras so that the strobe light sensor can communicate with the camera exposure controls.

**definition** - the combination of acutance and resolution that results in the clarity of an image.

**defocus** - to intentionally blur an image.

**densitometer** - a device used to measure the optical density of photographic emulsions.

**density** - a measure of the amount of light that passes through a photographic image or light absorbing material.

**depth of field** - the distance in object space over which satisfactory image definition is obtained when a lens is focused at a certain distance.

**depth of field index** - a symmetrical pair of distance marks scribed in a lens focusing ring that indicates the approximate depth of field.

**depth of focus** - the distance in image space over which a satisfactory image definition is obtained when a lens is focused at a certain distance in object space.

**detector** - the element of a measurement system that is exposed to and affected by the variable being measured.

**developer** - a chemical that changes a latent image of silver halides on photographic film into a visual image of black metallic silver.

**diaphragm** - an aperture placed inside an optical system. The aperture may be variable as in a shutter or fixed as in a light baffle to reduce stray light.

**diathermic mirror** - a mirror that is designed to reflect visible light and pass infrared radiation.

**diazo film** - a photographic film that is processed thermally needing no liquid processing.

**dichroic filter** - an optical filter that selectively passes light according to its wavelength.

**dichroic mirror** - a coated mirror that selectively reflects light according to its wavelength.

**diffraction** - the interference effect caused by light rays passing through different parts of an aperture or around different parts of an opaque object when the rays recombine.

**diffraction grating** - an optical element composed of very fine, closely spaced slits or very narrow parallel reflecting surfaces which, when white light is incident upon it at a definite angle, produces a component spectrum of the light.

**diffraction limited** - a description of an optical system whose image degradation is due only to the effects of diffraction.

**diffuser** - a device used to scatter incident or transmitted light; also known as a diffusing filter or a diffusing screen.

**diffuse reflectance** - the ratio of diffusely reflected radiation to incident radiation.

**diffuse reflection** - nonspecular reflection from a diffuse or rough surface.

**diffuse reflector** - a reflective surface that scatters incident radiation.

**dig** - a defect in an optical surface.

**digital camera** - an electronic imaging detector whose signal is sampled and digitized inside the camera housing.

**DIN** - Deutsche Industrie Norm. A system of film emulsion speeds developed by the German Standards Organization. It is a logarithmic system in which the film speed is doubled when the DIN value is increased by three.

**diopter** - the refractive power of a lens expressed as the reciprocal of its focal length in meters.

**dioptrics** - the science of the refraction of light.

**dioptric system** - an optical system that forms an image only by refractive elements.

**direct illumination** - light that strikes an object from a light source that is not reflected or refracted.

**directional reflectance** - a specific direction for a specific incidence angle.

**direct ray** - a light ray traveling between two points without being reflected or refracted.

**direct screen focusing** - the method of forming an image on a ground glass screen in a camera where the film will be inserted.

**dispersing prism** - a prism that separates light into its various wavelengths.

**dispersion** - the process of separating light into components in accordance with some characteristic such as frequency, wavelength, or energy.

**dispersive power** - the ability of a prism to separate white light into component wavelengths.

**divergence** - the bending of light rays away from each other.

**diverging lens** - a negative lens that causes a beam of light to expand.

**DOAMS** - Distant Object Attitude Measurement System

- double concave lens** - a lens whose surfaces curve inward (see biconcave).
- double convex lens** - a lens whose surfaces curve outward (see biconvex).
- double exposure** - two images recorded on a single piece of film on the same frame.
- double image** - a dim secondary image usually caused by stray internal reflections.
- double image prism** - a lens capable of forming two images of a single object.
- double slit** - two closely spaced narrow parallel apertures.
- doublet** - a compound lens of two separate lenses either cemented together or with an air space between them.
- dove prism** - a prism used in a parallel beam that rotates imaging-forming rays through twice the angle that the prism is rotated.
- drum camera** - a high speed film camera that uses a long strip of film wrapped around a cylindrical drum that rotates to record the event on the film.
- dump** - a term used to describe the inverting of an optical system on a mechanical mount to check the optical alignment of the system. The optical axis of the system should assume the same spatial orientation it had before dumping.
- duplet lens system** - An optical system having two sets of lenses separated by an air space.
- DX code** - a pattern printed on the outside of film cassettes that can be read by the automatic sensor in a camera to determine film speed.

**effective aperture** - the limiting aperture of a photographic system that lets light to the film plane or detector.

**effective exposure time** - that time between when a shutter is half open and half closed.

**effective f number** - the image distance measured from the rear nodal point divided by the effective aperture.

**elbow telescope** - a refractive telescope that bends the image 90° with a prism.

**electrolytic shutter** - an effect produced in liquids by using a birefringence caused by passing electric current through the liquid.

**electromagnetic radiation** - radiant energy, in the form of waves, produced from vibrating charged particles. This radiant energy includes radio waves, microwaves, infrared, visible light, ultraviolet light, and gamma rays.

**electromechanical shutter** - a shutter whose exposure duration is controlled electronically rather than by pure mechanical means.

**electronic flash** - a small gas-filled tube that emits light when a capacitor is discharged through the gas.

**electronic photography** - the science of recording images in an analog or digital electrical format such as with charge coupled devices, charge insertion devices, image intensifiers, or other solid state media.

**electronic shutter** - a shutter speed control that employs electromagnetic devices and electronic timing circuits not controlled with mechanical springs and gears.

**electro-optics** - the science that deals with the use of electric fields to generate and control electromagnetic radiation.

**emissivity** - the ratio of the radiation emitted by a surface to the radiation emitted by a blackbody at the same temperature, under similar conditions, and at the same wavelength.

**emulsion number** - the number on a film package denoting a particular production lot.

**emulsion speed** - the number that denotes the sensitivity of photographic emulsions to light; the higher the number, the more sensitive.

**engineering sequential** - a time-continuous series of images on a single piece of film with recorded on-frame timing from which metric data can be obtained for scientific evaluation.

**entrance pupil** - the image of the aperture stop of a photographic system as seen in object space.

**equatorial mount** - a telescope mount having a polar axis that can be aligned parallel with the Earth's axis and a declination axis that is orthogonal to the polar axis.

**erect image** - an image whose orientation is the same as the object when seen with the unaided eye.

**Estar** - A Kodak trademark for polyester-based films.

**etching** - the engraving of an optical surface by using acid or mechanical tools.

**exciter lamp** - a small lamp focused on the optical soundtrack of motion picture films. The sound track modulates the lamp output to produce audible sound.

**exit pupil** - the image of the aperture stop of a photographic system as seen from image space.

**exposure** - the total amount of energy that is incident on a piece of film or a detector over the spectral interval in which the film or detector is sensitive.

**exposure index** - a number corresponding to film speed.

**exposure meter** - an instrument which measures the amount of light incident on or reflected from a scene to be photographed. The meter is used to determine the correct shutter speed and exposure time as a function of the film speed.

**exposure settings** - the f number and exposure time.

**exposure time** - the amount of time light is incident on film or a detector during exposure.

**extended range film** - photographic film having a very large exposure range.

**extended source** - a light source that has finite angular dimensions as compared to a point source that is infinitesimally small.

**extension tubes** - an attachment that fits between a camera lens and the camera body to increase the lens to film distance, thus allowing the camera lens to image objects extremely close to the lens.

**eye guard** - a flexible cup placed over a viewfinder to block out stray light.

**eyepiece** - a compact lens system used to magnify and observe a final image produced by an optical system.

**eye relief** - the distance between the last optical surface of an optical system and the exit pupil.

- facet** - any one of the plane surfaces on a multisurface polygon or prism.
- FDRS** - (Film Data Recording System) - an electronic system that transfers azimuth, elevation, and timing information in a binary format onto a film frame.
- f flash synchronization** - a shutter synchronization time that corresponds to a type of flash bulb that reaches its peak light output about 5 milliseconds after the bulb is triggered; fast synchronization.
- fiber optics** - the science dealing with the transmission of light through flexible transparent material by means of total internal reflection.
- fiducial mark** - permanent reference marks inside a camera or optical system that are superimposed on the film with the image to assist in finding the center of the film frame and in image evaluation.
- field flattener** - a lens placed in an optical system to reduce curvature of field.
- field glasses** - small hand-held binoculars.
- field lens** - a lens placed near or at the focal plane of another lens to transfer an image through an optical system.
- field of a plane mirror** - the exit pupil of a plane mirror system is the pupil of the observer's eye, and the entrance pupil is the behind-the-mirror virtual image of the observer's eye pupil. The field stop is the edge of the mirror. The region in front of the mirror is the object field, and the region behind the mirror is the image field.
- field of view** - the area or solid angle visible through an optical instrument.
- field stop** - the aperture in an optical system that determines the field of view of the system.
- figure** - the geometrical shape of an optical surface.
- film** - a light sensitive material deposited onto a rigid supportive base.

**film cutoff sensor** - a photo-optical device that senses when a camera is out of film and automatically stops the film transport.

**film cutoff switch** - a mechanical spring-loaded device that senses when a camera is out of film and automatically stops the film transport.

**film data recording system** - an electronic system that transfers azimuth, elevation, and timing information in a binary format onto a film frame.

**film float** - the inconsistent positioning of film in a film gate.

**film format** - a property generally identified by the physical width of the film or the aspect ratio of the image size of the camera such as 16, 35 or 70 mm.

**film frame** - a single photograph or image in a continuous series of motion picture images.

**film gate** - a rigid support structure housing the aperture plate and pressure plate that secures film in place while a photograph is being taken.

**film holder** - a light-tight housing that protects film from accidental exposure while being transported or loaded into a camera.

**film loop** - a section of film under no tension that is above and below the pull down forks that allows the film to move in and out of the film gate without tearing.

**film notch** - an identifying mark cut into the corners of sheet films that denotes film type and the emulsion surface.

**film plane** - the position in a photographic system where the film is placed so that an image may be recorded.

**film reader** - an optical-mechanical device used to measure image parameters from film to derive metric data.

**film specifications** - the physical properties of a film such as format, thickness, base support material, emulsion type, speed, sprocket hole pitch, and perforation type denoted numerically.

**film transport** - a geared mechanical movement that moves film through a camera or projection system.

- filter** - an optical material used to modify incident electromagnetic radiation.
- filter factor** - an increase in exposure to compensate for the absorption of light in the photographic filter.
- first principal point** - the front point of a lens relative to object space.
- first surface mirror** - a mirror made so the reflecting surface is deposited on the front and not on the back surface.
- fish eye lens** - a photographic lens having an extremely wide field of view, generally 140 to 180°.
- fixed camera** - a camera whose optical axis and mechanical mount remain stationary throughout its operation.
- fixed focus system** - a photographic system whose focus cannot be varied.
- flange focal distance** - the distance from the lens mounting flange to the film plane in a photographic system.
- flare** - stray light in a photographic system not used to form the primary image; usually caused by stray reflections inside the camera system.
- flash lamp** - a sealed glass bulb containing a fast burning combustible material that is ignited by an electrical current.
- flicker** - the rapid variation in brightness that occurs when viewing a series of images that are separated by opaque bands such as motion picture film.
- flint glass** - a collective group of soft glasses used to make optical elements.
- FLIR (Forward Looking Infrared)** - a generic term used to denote any infrared sensitive optical system.
- floating reticle** - a reticle that can be moved about in an optical system's field of view.
- floodlamp** - a high wattage light bulb with a built in diffuser used for auxiliary light for photographic purposes. The bulbs usually are manufactured to correspond to a specific color temperature.

**fluid head** - a tripod head filled with viscous oil to dampen tripod movement and to provide smooth elevation and azimuth movement.

**fluoride lens** - a lens made from synthetic crystals of calcium fluoride.

**f number** - the focal length of an optical system divided by its diameter.

**focal collimator** - an optical instrument consisting of an objective lens at one end of a tube and a pair of cross hairs placed accurately at its focal point at the other end.

**focal length** - the distance from the rear nodal point of a lens to the point where parallel light comes to a point focus when the lens is focused at infinity.

**focal plane** - the plane perpendicular to the optical axis where an imaged is formed.

**focal plane shutter** - a shutter located directly in front of the film plane; usually consisting of a long slit in an opaque material that slides across the film plane to expose the image.

**focal point** - the place on the optical axis where light from a specified object point comes to focus.

**focometer** - a device used to measure the focal length of a lens or optical system.

**focus** - a lens or optical system adjustment that defines the sharpest possible image.

**focus control** - a mechanism used to focus an optical system.

**focus gate** - a removable ground glass that fits into the film gate of a camera.

**focusing scale** - a series of scribed marks on a lens barrel denoting where the lens should be set to obtain a proper focus for a specified object distance.

**fog** - the unintentional exposure of a piece of film.

**footage counter** - a device to indicate the amount of unexposed film remaining in a camera.

**footcandle** - a unit of illuminance equal to 1 lumen per square foot.

- footlambert** - a unit of luminance equal to  $1/\pi$  candela per square foot.
- foot switch** - a device activated by foot pressure; sometimes used on optical tracking mounts to allow the operator to activate camera systems while leaving the hands free to do other tasks.
- foreshortening** - a distorted perspective rendering the distances between images in a photograph unrealistically small.
- format** - an identifier that describes the size of film required for a camera system or the size of images recorded by a camera system.
- Foucault knife edge test** - an optical test to detect spherical aberration in a lens. A knife edge is moved laterally across the image of a pinhole source. An observer behind the image plane can see nonuniform dark areas denoting aberration.
- frame** - 1. to place an image in any desired part of the field of view to be photographed. 2. a single image on a continuous roll of images that constitutes a sequence on motion picture film.
- frame line** - a defining border between consecutive frames on a continuous piece of film.
- framing camera** - a high speed cine camera that records discrete frames of a continuous time event.
- framing mask** - a physical aperture placed inside a camera to ensure well defined edges around the perimeter of a frame.
- frames per second** - the number of discrete images per second recorded by a high-speed cine camera.
- Fresnel lens** - a lens that functions as a planoconvex or planoconcave lens but whose surface is cut into narrow concentric rings; generally made of plastic.
- friction head** - a tripod head that provides a smooth friction resistance to camera azimuth and elevation movements.
- front focal length** - the distance in object space from the front focus to the first principal plane.
- front surface mirror** - first surface mirror.

**front vertex focal distance** - the distance from the front focus of an optical system to the vertex of the front surface.

**full aperture** - the maximum opening of a lens diameter.

**Galilean telescope** - a refracting telescope that produces an erect image by using a positive lens for the main objective and a negative lens for the eyepiece.

**gamma** - the slope of the density versus log exposure curve for a photographic emulsion; a measure of film and development contrast.

**Gaussian optics** - first order or paraxial optics.

**geometrical optics** - the branch of physics that treats light as if it is composed of and behaves like rays emanating in straight lines from a source and bent abruptly by refraction and reflection.

**germanate glass** - a type of glass used in the manufacture of infrared optics.

**germanium** - a semiconductor material that is transparent to infrared radiation.

**ghost image** - a secondary image that is usually caused by stray light and reflections.

**giga** - prefix denoting  $1 \times 10^9$ , a billion.

**gimbal mount** - a camera mounting platform that can be rotated and tilted in any direction.

**glare** - specular reflection from a highly reflective or polished surface.

**glass plates** - pieces of flat glass coated with photographic emulsion and used as film in large format cameras.

**gloss** - a surface property that determines the degree to which reflections may be seen in the surface.

**goniometer** - an autocollimator used to measure prism angles.

**goniometer eyepiece** - an eyepiece that rotates about its optical axis and employs cross hairs and an angular scale to acquire angle measurements in an optical system.

**grain** - the silver particles resulting from the development of a silver halide crystal in a photographic emulsion.

**graphic arts camera** - a camera used to copy large sheets of art work; usually mounted on a lathe bed rail. Features a copy lens that is movable along a focusing rail to change the magnification of the image.

**gray scale** - a succession of neutral gray paper strips, ranging from white to black, used to produce a sample set of exposures. The optical density between successive strips is usually 0.10.

**ground glass** - optical glass used to focus images in the film plane of camera systems; a piece of glass that has been frosted or roughened by blasting or etching.

**guide number** - the number that denotes the relative light output from an electronic flash unit used to determine proper exposure. The guide number is divided by the flash-to-subject distance to find the f number.

**gun camera** - a small, 16mm or video, camera boresighted to a weapons system that photographs the performance of the weapon.

**gyroscopic camera mount** - a stabilized platform with a suspension system and gimbals that dampen vibration and movement allowing the camera mounted on the platform to remain at a fixed angle.

- H -

**halation** - a halo of exposed emulsion appearing around the image of a bright object on film; produced by back reflection of the image forming light from the base of the film.

**half frame camera** - a camera that produces images half the size of its normal format.

**half silvered mirror** - a mirror that has been coated to be approximately 50 percent reflective.

**halftones** - gray tones in the range between dark shadows and bright highlights in an image; halftone prints or negatives.

**halftone screens** - screens used in printing continuous tone photographs that have uniform transparent holes on an opaque background.

**halide** - a chemical compound that contains fluorine, chlorine, iodine, or bromine as a major component.

**halo** - a faint but sometimes broad ring that seems to surround a light source when viewed through a dispersing material such as mist or fog.

**h and d curve** - the characteristic curve or density versus log exposure curve for a particular photographic emulsion.

**hand viewer** - a small device with an illuminator, lens, and a frosted screen that is used to view photographic transparencies.

**Hartman test** - a photographic test for spherical aberration, coma, or astigmatism.

**haze** - smoke, dust, and particulate matter suspended in the atmosphere that can cause reduced light transmission and a reduction in contrast in a photographic image.

**haze filter** - a photographic filter that absorbs blue and ultraviolet light scattered by the atmosphere.

**heat absorbing filter** - a filter that absorbs infrared radiation but passes visible light.

**heat resistant glass** - glass designed to withstand extremely high temperatures and to not shatter upon rapid cooling.

**heat transmitting filter** - a filter that reflects visible light but passes infrared radiation.

**heliostat** - a mirror mounted on a mechanical clock drive that rotates at a rate to constantly reflect sunlight.

**hertz** - a frequency unit equal to 1 cycle per second.

**high contrast** - an attribute of a scene or image that has areas of black and white near saturation limits.

**highlight** - a light area in a scene or image.

**high speed film** - a generic term used to classify film emulsion speeds that are nominally rated at ASA 400 or higher.

**high speed film camera** - a camera that can record more than 50 pictures per second (nominally).

**high speed photography** - the science of sequentially recording movement or events too rapid to be recorded with normal photographic techniques. Nominally, framing rates of greater than 50 frames per second are considered to be high speed.

**high speed shutter** - a rapidly rotating shutter used in high speed cameras to obtain extremely short exposure times.

**high speed videography** - the science of recording video images at faster than the normal 60 field, 30 frames per second rate.

**holo camera** - a camera that records the hologram of an object on a photographic plate.

**holographic lenses** - photographic recordings of the interference patterns between plane waves and spherical waves.

**horizon** - the apparent junction of the Earth and sky.

**hue** - a variation in color depending upon the spectral composition of the incident light.

**Hurter-Driffield curve** - a plot of density versus log exposure for a particular photographic emulsion; a characteristic curve.

**hyperfocal distance** - the distance at which a lens must be focused so the far depth of field just extends to infinity.

**IFLOT** - intermediate focal length optical tracker.

**illuminance** - the amount of light or radiant energy striking a surface per unit area. The three most common units are the footcandle (1 lumen per square foot), the lux (1 lumen per square meter), and the phot (1 lumen per square centimeter).

**illuminated magnifier** - a magnifying lens with an attached light source.

**illumination** - the light incident upon an object.

**image** - the visualization or reproduction of an object using light.

**image blur** - the effect the movement of an image has on film while a photograph is being taken; same as image motion.

**image brightness** - the luminance of an image produced by an optical system. The image brightness is a function of the brightness of the object, the transmittance, and the magnification of the optical system.

**image contrast** - the difference between light and dark areas in an image.

**image distance** - the distance from the rear nodal plane of an optical system to the image plane.

**image enhancement** - any photographic or electronic method to improve image quality.

**image jump** - the movement of an image in a motion picture camera caused by film or prism movement during exposure.

**image motion camera** - a camera that uses continuously moving film to record a single image of a moving object. Film speed is proportional to the magnification of the objective lens and the velocity of the target. To reduce image blur, the field of view in the direction of motion is limited by a slit placed between the objective lens and film plane.

**image motion compensation** - any mechanical or optical means by which the movement of an image at the film plane or across an optical detector is minimized.

- image orthicon** - a type of camera tube used in television recording.
- image plane** - the plane perpendicular to the optical axis of an optical system where an image is formed.
- image quality** - a subjective description of how well an optical system reproduces the likeness of an object.
- IMC** - image motion camera or image motion compensation.
- incandescence** - the emission of electromagnetic radiation from an object caused by the object being heated.
- incandescent lamp** - a lamp that emits light when a current flows through a wire enclosed in the lamp envelope.
- incident light** - the light falling on an object.
- incident light meter** - an instrument that measures the amount of light falling upon a subject.
- index of refraction** - the ratio of the velocity of light in a vacuum to the velocity of light in a specific medium, usually given at a specified wavelength.
- indirect illumination** - light falling on an object that has been rerouted or reflected from the original source.
- infinity** - an object distance that corresponds to where the object's best image is formed at the rear focal length of a lens. In object space, the point at where parallel lines seem to converge.
- infrared black and white film** - a negative film with an emulsion layer that is sensitive to infrared radiation from 700-1200 nanometers, nominally.
- infrared camera** - a camera that specifically records images produced by the thermal radiation emitted from an object.
- infrared color film** - a pseudo color positive film that has green, red, and near infrared sensitive emulsion layers.
- infrared mark** - a scribed line on a lens barrel that denotes the difference in focus points between visible light and infrared radiation.

- infrared radiation** - the part of the electromagnetic spectrum beyond 0.75 microns nominally.
- instrumentation camera** - a camera system whose images are used to reduce metric information about the subject being photographed.
- intensity** - the amount of radiant energy flowing through a unit area or unit solid angle per unit time.
- interface** - an optical surface between two media of differing indices of refraction.
- interference** - the variation of wave amplitude with distance or time caused by the superposition of two or more waves.
- interference filter** - an optical filter that controls spectral transmittance or reflectance by using constructive and destructive interference.
- interferometer** - an optical measuring instrument using a beam of light that separates into two or more parts by partial reflections, then reunites after traversing different optical path lengths.
- interframe time** - the time between consecutive frames on a continuously moving piece of film; the reciprocal of the framing rate.
- interlaced** - a standard method of raster scanning where a video frame is composed of two separate fields.
- intermittent movement** - the alternating stop and go movement of film through an instrumentation camera. The film is held stationary when the film is exposed and then advances to the next frame when the shutter is closed.
- interocular distance** - the distance between the two eye pieces on a binocular instrument.
- intervalometer** - a mechanical or electronic device that is used to control the time a camera starts and stops.
- invar** - a metal composed of iron and nickel exhibiting a low coefficient of thermal expansion; often used in the manufacture of optical instruments.
- inverse square law** - the principle that the luminance from a point source is inversely proportional to that square of the distance from the source.

**inverted image** - an image that is rotated 180° about the optical axis of a lens.

**iridescence** - a spectrum of color caused by interference phenomena on the surface of a material.

**IRIG** - Interrange Instrumentation Group

**IRIG time** - a classification of rate-scaled serial time formats containing standard coded expressions. Time formats are identified as A, B, D, E, G, and H. Each format contains binary coded decimal formats for days, hours, minutes, and seconds.

**iris diaphragm** - a device in an optical system that controls the amount of light through the system.

**irradiance** - the radiant power per unit area incident on a surface.

**ISO** - International Standards Organization

**isodensities** - points on a photographic negative having the same optical density.

**- J -**

**jam** - the failure of film to be properly transported through a camera causing the film to accumulate in the transport mechanism.

**jena glass** - a group of optical glasses having low dispersion relative to their refractive indices.

**jig transit** - an optical instrument that has a gimballed mounted telescope used to measure elevation and azimuth angles.

**jitter** - rapid irregular movement of film in a camera film gate causing the image to move about on the film plane.

**joule** - a unit of energy equal to 10,000,000 ergs and 1 watt-second.

**joy stick** - a manually operated electromechanical controller used to guide a process or a mechanical system.

**JPEG** - Joint Photo Experts Group

- K -

**Kellner eyepiece** - an eyepiece consisting of a planoconvex field lens and a cemented doublet as the eye lens.

**kelvin** - a unit of temperature equal to 10 Celsius.

**Kerr cell** - a cell filled with a transparent material that, when electric current is applied, can act as a very fast shutter for light beams

**key light** - the main light source used to illuminate a subject.

**keystone distortion** - a type of image distortion that is produced when an image is projected nonparallel to a surface.

**kilo** - a prefix denoting  $10^3$ .

**kinematic mount** - an optical assembly designed so all six degrees of freedom of movement can be obtained; each independently of the others.

**ladar** - laser detection and ranging.

**lambert** - the unit of luminance equal to  $1/\pi$  candela per square centimeter.

**Lambertian surface** - (theoretically) a perfect diffusing surface exhibiting the characteristic that the brightness of the surface is constant regardless of the viewing angle.

**landolt ring** - the opaque image of a broken circle used as a target to determine visual acuity.

**lapping** - the process of grinding an optical surface.

**laser** - an acronym for light amplification by stimulated emission of radiation; an optical device that produces a coherent monochromatic beam of light.

**laser footprint** - the area, dimension, and power distribution of a laser beam radiation pattern at a specified distance.

**laser line filter** - a filter that passes a specified laser wavelength and blocks unwanted background radiation.

**laser rangefinder** - an electro-optical instrument used to measure the distance to a specified target with a laser as a source.

**laser speckle** - the granular appearing random interference pattern produced when a laser beam is reflected from a diffuse surface.

**latent image** - a recorded but unprocessed image on a piece of film.

**lateral shift** - the movement of a camera lens or a camera film pack sideways that results in a horizontal image shift.

**latitude** - the range of exposure over which a photographic emulsion will produce a satisfactory image.

**law of reflection** - an optical principle stating that the angle of incidence is equal to the angle of reflection and that the incident ray, reflected ray, and the normal to the reflecting surface are in the same plane.

**law of refraction** - an optical principle describing the behavior of a light ray as it passes from one medium to another as a function of the refractive indices of the media. Also states that the incident ray, the refracted ray, and the normal to the refracting surface are all in the same plane.

**law of reversibility** - an optical principle stating that if the direction of a light ray is reversed, it will follow the same path.

**leader** - the blank film at the beginning and end of a roll of processed film.

**lens** - a transparent optical element used to converge or diverge light passing through it.

**lens axis** - an imaginary line passing through the optical centers of all the elements in a lens system.

**lens barrel** - the housing that holds all the elements of a lens together.

**lens board** - a plate holding a lens; made so that the plate and lens assembly can be removed from the camera as a unit.

**lens cap** - a protective cover that fits over the front or rear of a lens assembly.

**lens flare** - stray light in a photographic system that is not used to form the primary image.

**lens power** - the reciprocal of the effective focal length of an optical element.

**lens resolution** - the ability of a lens to resolve detail.

**lens sag** - the image displacement caused by the gravitational or downward settling movement of a structural element of an optical system.

**lens shade** - an opaque shroud around the front of a lens to prevent stray light from entering the lens.

**lens speed** - the light transmitting capability of a lens usually given as an f number; the lower the f number, the higher the speed.

**lens turret** - a rotating lens support containing multiple lenses affixed to the front of a camera, so lenses can be interchanged quickly.

**level board** - a board or target placed in the field of view of an instrumentation camera with one edge level in the horizontal plane; used as a reference.

**lidar** - light detection and ranging.

**light** - the electromagnetic radiation detectable by the eye throughout the wavelength range from about 400 to 750 nm.

**light box** - a generic term for a device to view transparencies or negatives that consists of a light source and a diffuser.

**light emitting diode** - a solid state device that emits light when current is passed through it.

**light meter** - any device that is used to measure the amount or intensity of light falling on or emitted by a surface.

**light ray** - the optical path of a specific point on an electromagnetic wavefront.

**light source** - any source of visible electromagnetic radiation.

**light tight** - the ability to keep out unwanted stray light.

**light valve** - a device that controls the transmission of light by using a sensitive medium that changes its optical properties when exposed to an electrical charge.

**line of sight** - a straight line in space connecting an object to the optical axis of a system.

**liquid crystal display** - a type of segmented digital display that uses voltage to control the transmission and reflection of light through a liquid sealed in a membrane.

**lithium fluoride** - a material used for optical elements requiring high transmittance in the ultraviolet, visible, and infrared spectrums.

**loupe** - a low power optical magnifier.

**low light level camera** - a video camera employing an extremely responsive photosensitive detector that enables it to record images under low levels of illumination.

**lumen** - the luminous flux emitted per unit solid angle by a point source having a luminous intensity of one candela.

**lumen second** - the luminous flux emitted by a source multiplied by the time the source is radiating in seconds.

**luminance** - the luminous flux emitted from a surface per unit solid angle per unit area.

**luminance meter** - an instrument used to measure the light emitted from or reflected by an object; a reflectance meter.

**luminosity** - the subjective perception of the amount of light being emitted by a surface.

**luminous emittance** - the luminous flux emitted per unit area of a source.

**luminous flux** - the amount of visible electromagnetic energy that passes a given point in a given time.

**luminous intensity** - the luminous flux emitted by a source per unit solid angle; 1 lumen per steradian equals a source intensity of 1 candela.

**lux** - the unit of illuminance; 1 lumen per square meter.

**lux second** - 1 lumen-second per square meter or 1 meter candle second.

**mach number** - the speed of a moving object compared to the speed of sound in the same medium.

**macro lens** - a lens used for close up photography that is optimized for magnifications of approximately 1:1.

**macrophotography** - the science of photographing objects which produces images with magnifications of approximately 1:1.

**magazine** - the part of a film camera containing the film supply which is removable from the camera.

**magnesium fluoride** - a transparent compound used as an antireflection coating on optical elements.

**magnification** - the ratio of the size of an image to the size of an object.

**magnifier** - a simple lens that produces an enlarged virtual image of an object.

**magnifying power** - the ratio of the apparent size of an object as seen through an optical instrument as compared to the actual size of the object seen without the instrument.

**Maksutov (Bouwers) lens** - a negative meniscus lens used to introduce spherical aberration causing a small chromatic effect with very little focusing effect. The primary mirror is then made spheroidal which cancels the spherical aberration introduced by the lens.

**Mangin mirror** - a second surface mirror whose spherical first surface corrects the spherical aberrations of the second.

**marginal rays** - light rays that pass through an optical system near the edges of the apertures away from the optical axis.

**mask** - an opaque or semitransparent device used to block, limit, or modify the amount of light transmitted from one area to another.

**massive optics** - a generic term used to describe optical elements that are larger than 24 inches in diameter.

**matte surface** - a diffusing surface that appears uniformly bright in all directions when illuminated.

**MDI** - miss distance instrumentation or miss distance indicator.

**mechanical shutter** - a device used to control the exposure time in a camera.

**medium format** - a generic term for cameras that use a 120- or 220-size roll of film.

**meniscus lens** - a thin lens that has one convex surface and one concave surface.

**mercury vapor lamp** - a lamp that produces light by passing an electric arc through mercury vapor.

**meridional plane** - the plane in an optical system that contains the optical axis and a principal ray.

**metallic coating** - a thin metallic layer that is deposited on a substrate to control the reflectance or transmittance of the material.

**meter** - a metric unit of length equal to 39.37 inches.

**meter candle** - 1 lumen per square meter or 1 lux of illuminance.

**meter candle second** - the amount of exposure or illumination received by a unit area in 1 second.

**metric photography** - the science of photographing subjects so that accurate measurable information about them can be obtained from their images. A missile trajectory measured from a cinetheodolite is an example.

**metrology** - the science dealing with measurement.

**m flash synchronization** - a shutter opening synchronized with the maximum light output from an m-type flashlamp which is about 20 milliseconds from initiation.

**micro** - a numerical prefix denoting  $1 \times 10^{-6}$ .

**microfilm camera** - a 16- or 35-mm camera that is used with high resolution film to copy large documents for archiving.

**microflash** - an electronic flash unit that emits flash pulses in the millionths of a second range.

**micron** - a unit of length equal to 1 millionth of a meter.

**microprism** - a type of camera focusing screen that uses a large number of very small prisms embedded in a ground glass.

**microscope** - an optical instrument using high power objectives and eyepieces to magnify small objects.

**mid-shutter pulse** - an electrical signal generated when the center of a shutter opening is symmetrically positioned in the film gate aperture.

**mil** - an angle measure equal to 1/6400 of the circumference of a circle.

**milli** - a numerical prefix denoting  $1 \times 10^{-3}$ .

**minimum angle of deviation** - the smallest angle through which light is bent through an optical prism.

**mirage** - a distorted reflection of a distant object cause by atmospheric heating near the Earth's surface.

**mirror** - a highly reflective surface used to alter the path of incident light.

**mirror camera** - a high speed instrumentation camera that holds the film stationary while the images are projected onto the film using a high speed rotating mirror.

**mirror lens** - an optical system that forms images by using a series of mirrored surfaces instead of refractive lens elements.

**mirror lock** - a device to secure the focusing mirror out of the optical path while an exposure is being made.

**mirrored shutter** - a type of rotating camera shutter with a reflective front surface that transfers the image to a viewing port during part of the exposure cycle.

**miss distance** - the closest distance between two moving objects or one stationary and one moving that are intended to impact.

**modular camera** - a camera system comprised of a single piece of equipment such as the camera body but whose accessories are detachable.

**modulation transfer function** - a mathematical representation of an optical system's ability to accurately reproduce original object detail in the final image.

**monitor** - a computer or video display terminal.

**monochromatic** - having one color, one wavelength, or one frequency of optical radiation. No optical beam can be purely monochromatic. It will, at best, contain a narrow band of frequency.

**monochromator** - an optical instrument that produces a beam of nearly monochromatic light containing a select region of frequencies.

**monochrome** - composed of one color.

**monocular** - an optical instrument that is viewed through a single eyepiece.

**monopod** - a camera support with a single vertical leg.

**motion analysis projector** - a device designed to project images at varying rates, both forward and backward, or frame by frame.

**motion picture camera** - a camera that uses long rolls of film to take a series of individual sequential photographs of objects in motion. The film is held stationary while a rotating shutter exposes it. The shutter blocks exposure while the film is moved mechanically to position it for the next frame.

**motion picture film** - a generic class of long rolls of film with precisely spaced sprocket holes to match film movements in motion picture and instrumentation cameras.

**motion picture photography** - the science of recording sequential single images of continuous motion.

**motion sensor** - a photoelectric device that produces an electrical signal when an image of sufficient contrast moves across its light sensitive detector.

**motor drive** - an attachment that automatically advances film after an exposure and prepares the camera for the next exposure.

**moviola** - a type of film editing device.

**MPE (maximum permissible exposure)** - the maximum amount of laser radiation that a person can be exposed to without damaging effects. The MPE is generally related to threshold levels affecting the human eye.

**multifocal lens** - a lens featuring movable elements that allow it to have several different focal lengths.

**multi-image camera** - a camera having multiple lenses that takes several identical images of the same subject at the same time.

**multispectral camera** - a camera having multiple lenses with different spectral filters and films or sensors that record the identical images of the same object or scene in different spectral bands.

**multiple exposure** - the recording of two or more images on the same frame of film.

**mural** - a very large wide-angle photograph.

**mylar** - a type of polyester film base.

**nano** - a numerical prefix denoting  $1 \times 10^{-9}$ .

**near infrared** - the shorter wavelengths of the infrared region, nominally 0.7 to 3.0 microns.

**near ultraviolet** - the longest portion of the ultraviolet spectrum, nominally 0.3 to 0.4 microns.

**negative** - a film on which an image is recorded with light and dark areas reversed from the original object.

**negative lens** - a lens with both surfaces curved inward; a biconcave lens.

**neutral density filter** - an optical filter that absorbs all visible wavelengths uniformly.

**Newtonian telescope** - a reflecting telescope that has a 450 mirror located inside the focus, so the primary image is observed through a hole in the side of the tube.

**Newton rings** - an interference phenomenon produced when a convex lens or a thin film of material is placed on a flat glass plate. The light and dark rings are produced by the interference of light at the film of air between the glass surfaces.

**night vision camera** - a video camera that produces a visible image or a dark scene by employing an infrared sensitive imaging device or an extremely sensitive visible light sensor with an image intensifier.

**nit** - a brightness measurement equal to 1 candela per square meter.

**nodal point** - two points on an optical axis located such that if a light ray goes through the first nodal point at some angle it will seem to emerge from the second nodal point at that same angle. The vertical planes that contain these points are the nodal planes.

**nodal separation** - the distance between the two nodal planes of a lens.

**nodal slide** - an optical test apparatus used to find the nodal points and focal points of a lens.

**nondestructive testing** - a testing method that is not physically intrusive or physically damages the sample under test.

**normal** - the line perpendicular to an optical axis or surface.

**normal lens** - a camera lens with a focal length approximately equal to the camera image plane diagonal.

**NTSC** - National Television Systems Committee

**object** - the primary subject or item to be photographed or imaged by an optical system.

**object distance** - the distance from the front nodal point of a lens to the object to be photographed.

**objective** - the first and closest lens to the object to be imaged by an optical system.

**objective prism** - a prism that bends light before it enters the main objective of a system.

**ocular** - a compact lens system used to magnify and to observe a final image produced by an optical system (see eyepiece).

**off-axis parabolic mirror** - a front surface reflecting mirror whose surface is figured in the shape of a paraboloid but is not manufactured symmetrically about the axis of the paraboloid.

**opacity** - the ratio of the amount of light falling on material to that transmitted by the material; the reciprocal of transmittance.

**opal glass** - a type of translucent diffusing screen.

**opaque** - a descriptor of a medium that does not transmit any light.

**optical axis** - an imaginary line that allows a light ray to pass undeviated through an optical system.

**optical bench** - a rigid, linear, rail type support for mounting lenses, filters, light sources, and other optical components, so their optical centers can be aligned.

**optical comparator** - an optical measurement device that uses backlighting to cast a shadow of the object to be measured onto a screen. Linear measurements are made by moving the object on a mechanical micrometer slide referenced to a scale also projected on the screen.

**optical density** - a measure of transmittance through a medium.

**optical disk** - a circular rigid disk with a reflective layer; used to store information in a digital format.

**optical element** - a single optical component.

- optical encoder** - a device used to accurately measure linear or rotary motion by recording the progressive movement of opaque markings on a clear substrate.
- optical flat** - an extremely flat piece of optical glass with both sides highly polished to be parallel to a known tolerance; used as a reference to measure the flatness of other optical components.
- optical lever** - an optical device for amplifying small rotations and movements. The rotating object carries a small mirror and reflects a beam of light through twice the angle of object rotation.
- optical path length** - a geometric path length that is multiplied by the refractive index of the material in the path.
- optical pyrometer** - an optical device used to measure the surface temperature of an object from its incandescent brightness.
- optical quality glass** - glass that is manufactured to specific tolerances, so its physical characteristics will be known when it is formed into optical elements.
- optical transfer function** - a mathematical description of an optical system's ability to accurately image information about its subject.
- optical wedge** - a glass block of varying thickness used to vary the optical path length.
- optics** - the branch of physical science dealing with the phenomena of light and vision.
- orientation** - a set of parameters that locates the position of a camera station. The position is usually given by three rectangular coordinates and two angular coordinates.
- original** - an initial or first recorded image from which reprints can be made.
- orthochromatic** - denoting sensitivity to all colors but orange and red.
- oscillograph camera** - a camera used to record the traces produced on an oscilloscope.
- overexpose** - to illuminate a photosensitive material with more than the optimum amount of light either by too much time or too much intensity.

- pan** - a smooth continuous movement of a camera and tripod in azimuth.
- panchromatic film** - a photographic film that is sensitive to all colors of the visible spectrum.
- panoramic camera** - a camera that has a long horizontal format compared to its vertical format and is designed to have a very wide azimuth angle coverage.
- parabolic mirror** - a first surface concave reflecting mirror that has a surface figure of a paraboloid.
- parallax** - the relative change in position between two objects when viewed from different positions.
- paraxial** - relating to rays traveling through an optical axis at very small angles.
- parfocal lenses** - have the same rear flange focal distances, so they can be moved in and out of an optical system without refocusing each lens.
- pechan prism** - a prism that is used to evert an image left to right; made of two air spaced elements.
- pellicle mirror** - a thin elastic membrane used as a beam splitter.
- penta prism** - a five-sided prism used in camera viewfinders that has two reflecting surfaces and whose entrance and emergent beams are orthogonal.
- penumbra** - the partially darkened area of a shadow produced by an opaque object.
- perceived color** - the apparent or subjective color as perceived by a human eye.
- perforation** - very accurately spaced and shaped apertures in long rolls of film. The film can be held in place by camera sprockets that move the film through the camera or can be held stationary by register pins while the exposure is being made.
- peripheral photography** - the technique of taking a full 360 view of an object so that it can be printed in a flat format.
- periscope** - an optical instrument, housed in a long tube; used to translate the observer's line of sight in a vertical direction.

**persistence of vision** - a time lag between visual stimulation of the retina and a response to the stimulation or between cessation of stimulation and the perception of the cessation.

**perspective** - the perceived three dimensionality of a scene or object when viewed in the two-dimensional plane of a photograph.

**Petzval lens** - a high speed, narrow field-of-view lens composed of two achromatic lenses positioned about an aperture stop.

**Petzval surface** - the curved surface over which an image is formed.

**phot** - a unit of luminance equal to 1 lumen per square centimeter.

**photocell** - a solid state detector that converts light into an electrical signal.

**photochromic glass** - a type of glass that darkens and exhibits reduced transmittance as a function of the incident light level on it.

**photoconductivity** - the electrical conductivity increase that results when photon energy is absorbed by a material.

**photodetector** - a device that is sensitive to incident electromagnetic radiation.

**photodiode** - a solid state junction device whose current increases with the amount of light incident on the detector.

**photoelectric effect** - the emission of an electron from material as a result of energy absorbed from an incident photon.

**photogrammetry** - the science of extracting metric data from photographic images.

**photoinstrumentation** - a collective term to describe any mechanical, optical, or electro-optical hardware or equipment used to record optical images for the purpose of scientific evaluation.

**photometry** - the science of light measurement over the visible portion of the electromagnetic spectrum.

**photomicrography** - the science of photographing specimens through a microscope.

- photon** - the fundamental unit of energy of electromagnetic radiation. The amount of energy is frequency dependent.
- photonics** - the science of generating, detecting, and manipulating electromagnetic energy whose fundamental unit of energy is the photon.
- photosphere** - the visible surface of the sun.
- phototheodolite** - a mechanical tracking mount with a long focal length telescope and an optical data recording system integrated directly into the mount. Either electromagnetic or optical encoding devices are affixed to the azimuth and elevation bearings of the mount, so angular data can be recorded directly onto the data recording system. The data recording system may either be 35-mm film or a visible or infrared video recording system (see cinetheodolite).
- phototube** - an electron tube having a photosensitive cathode that generates an electric current.
- physical optics** - the branch of optics that describes electromagnetic radiation as a wave phenomenon rather than treating it as rays.
- pico** - a numerical prefix denoting  $1 \times 10^{-12}$ .
- piezoelectric effect** - the production of an electrostatic voltage as a result of the mechanical compression or stress on certain crystals.
- PIN** - positive-intrinsic-negative
- pinch roller** - a small metal or plastic cylindrical wheel that functions as a film guide or pushes film against sprockets in camera movements.
- pincushion distortion** - a type of lens aberration that results when a lens focal length changes with an increase in field angle.
- pinhole camera** - a simple box camera with no lens, shutter, or moving parts and only a small pinhole as its light emitting aperture.
- pin registered camera** - a framing camera that uses a mechanical movement to hold the film stationary in the film gate when the exposure is taken, then releases the film to advance to the next frame while the shutter is closed. Small metal pins protrude through film sprocket holes to secure the film while the exposure is being made.

- pitch** - 1. the vertical angle of elevation of an object from the horizontal plane.  
2. the distance between two corresponding points on two adjacent perforations on a roll of film.
- pixel** - the smallest resolvable element in a solid state imaging device; a picture element.
- plane** - a flat surface.
- planoconcave lens** - a lens having one flat surface and one concave surface.
- planoconvex lens** - a lens having one flat surface and one convex surface.
- platinum silicide** - an infrared detector material that has a sensitivity out to about 5 microns.
- plumbicon** - a type of low light level imaging tube.
- point source** - an infinitesimally small light source.
- point spread function** - a mathematical expression describing the energy distribution about the image of a point source.
- polarized light** - light waves that have their electric and magnetic fields vibrating in a restricted plane.
- polarizing filter** - an optical material that passes light waves that have been polarized in a specific direction.
- polycarbonate** - a type of optical quality plastic used to manufacture molded optical elements.
- polyester** - a tough plastic material used as a film base.
- polygon** - a transparent, solid, cylindrical optical element with a series of flat surfaces around the circumference. The element is mounted on a rotating shaft in a rotary prism camera to record an image on a roll of continuously moving film.
- polystyrene** - a type of plastic used to manufacture molded optical elements.
- Porro prism** - an optical prism that uses total internal reflection to displace a light beam and reflect the beam through a 180° angle.

- positive image** - an image whose dark and light areas correspond to the dark and light areas on the subject.
- positive lens** - a lens having either both surfaces curved outward (biconvex) or one surface flat and the other surface curved outward (plano-convex).
- precision** - the quality of execution or degree of refinement in the performance of an operation. Precision is relative to the quality of execution and is distinguished from accuracy which relates to the quality of the result.
- pressure plate** - a rigid flat plate that secures a piece of film in the film gate during exposure.
- prime time** - a generic term used to describe an optimum time of day when atmospheric turbulence and scintillation are at a minimum.
- principal planes** - two planes located in a lens system such that an object ray passing through the first principal plane at a certain angle appears to exit the optical system at the second principal plane at the same angle.
- prism** - a piece of solid optical glass cut at precise angles for beam displacement or dispersion.
- process camera** - a camera used to copy art work for reproduction or for photomechanical enlarging or projection.
- pulldown claw** - a metal tooth in a camera movement that engages the film sprocket hole to advance the film.
- pulse camera** - a type of motion picture camera that automatically exposes and then advances the film one frame after receiving a remotely generated electrical signal.
- pupil** - the image of the aperture stop of an optical system seen either from object or image space.

**rack and pinion** - a type of focusing mechanism that uses a toothed wheel engaged in a notched bar to move the lens.

**rack over viewfinder** - a type of sliding focus and alignment aid positioned in a camera film plane to precisely align and focus a camera.

**radial velocity** - the velocity of an object along a line directly toward or away from an observer.

**radian** - an angular measurement equal to  $3600/2\pi$ .

**radiance** - a measure of the radiant power emitted by a source in a unit solid angle in units of watts/square meter/steradian.

**radiant emittance** - a measure of the radiant power emitted by a unit area of source into a sphere in units of watts/square meter.

**radiant energy** - the energy in electromagnetic radiation emitted by a source.

**radiant exitance** - a measure of the radiant flux or power per unit area emitted by a source in units of watts/square meter.

**radiant intensity** - a measure of the radiant energy per unit solid angle from a source in units of watts/steradian.

**radiant power** - a measure of the time rate of flow of radiant energy in units of watts.

**radiation** - radiant energy, in the form of waves, that is produced from vibrating charged particles. The main form of radiant energy which includes radio waves, microwaves, infrared, visible light, ultraviolet light, and gamma rays (see electromagnetic radiation).

**radiography** - the science of photographing objects using x-rays as the illuminating source.

**radiometer** - an electro-optical instrument used to measure the intensity of radiant energy.

**radiometry** - the science of measuring electromagnetic energy.

**RADOTT** - Recording Angular Digitized Optical Tracking Theodolite

**rangefinder** - an optical device to determine the distance to an object.

**raw stock** - unexposed and unprocessed film.

**ray** - a graphic representation of the optical path of a specific point on an electromagnetic wavefront.

**ray tracing** - a trigonometric calculation and a geometric representation of the path of a ray of light through an optical system.

**real image** - an image formed by convergent rays in an optical system; can be viewed directly on a diffusing surface.

**rectilinear** - in a straight line; nondistorted line images produced by a lens.

**reciprocity law** - the principle that the optical density of a photosensitive material is a function of only the irradiance and exposure time. When the duration of an exposure is decreased, a proportionate increase in illumination will produce a negative of the same density.

**reduction ratio** - the reciprocal of optical magnification.

**reel** - a metal or plastic holder for long rolls of film.

**reel ejector** - mechanical spring loaded device to release long rolls of film reels from a camera spindle.

**reflectance** - the ratio of the reflected radiant flux from a surface to the total radiant flux incident on a surface.

**reflected light meter** - an instrument that measures the amount of reflected light from a surface.

**reflected ray** - a light ray that has been redirected from a surface.

**reflecting telescope** - a telescope that uses mirrors as the image forming elements instead of lenses.

**reflection** - the redirection of radiation by a surface.

**reflective coating** - a thin layer of material deposited on a surface to increase the reflectance of the surface.

**reflector** - a surface that redirects radiation.

**reflex viewer** - a device attached to a camera that allows the operator to view a scene through the primary lens as it will be photographed.

**refracted ray** - a ray that has been redirected by traveling from one medium to another.

**refraction** - the bending of rays or wavefronts as they travel from one medium to another with differing refractive indices.

**refractive index** - the ratio of the velocity of light in a vacuum to the velocity of light in a specific medium; usually given at a specified wavelength.

**register pin** - a small retractable metal pin inserted into the sprocket holes of a roll of film that stabilizes the film in a camera film gate during exposure. The pin is retracted while the film advances to the next frame.

**registration** - the accurate alignment of film within a film gate by the use of register pins.

**relative aperture** - the ratio of the diameter of the entrance pupil of an optical system to the equivalent focal length of the system.

**relay lens** - a lens used to transfer an image from one point to another in an optical system without magnifying it.

**resolution** - an optical system's ability to separate distinct object points and accurately reproduce them as distinct image points.

**resolution target** - a printed chart of opaque lines on a light background containing a sequence of sets of lines at progressively closer spacing; used to determine the resolution of an optical system.

**resolving power** - a measure of the ability of an optical system to separate the images of two closely spaced objects.

**reticle** - an optical substrate, on which a pattern has been etched, that is placed within an optical system to aid in the alignment of the system.

**reticulation** - random wrinkling of a film emulsion usually caused by sudden changes in the temperature of the processing chemicals.

- retrofocus lens** - a lens that has a negative element near its front focal plane resulting in a wide field of view with a long back focus.
- retroreflector** - a reflecting element that returns an incident beam upon itself.
- reverted image** - an image that is reversed left to right from the object orientation.
- reversal film** - a film that produces a positive image after development.
- rewind** - the act of transferring film from one spool or reel to another to change the orientation of the film.
- ribbon frame camera** - a camera that uses wide long rolls of film and produces frames that are full film width but vary in height. Frame height is determined by the camera framing rate which is controlled by a drum with removable apertures spinning in the opposite direction the film is moving when the images are recorded.
- right angle prism** - redirects an incident beam 90°.
- Ritchey-Chretien telescope** - a type of Cassegrain telescope that has a concave hyperbolic primary mirror and a convex hyperbolic secondary mirror.
- roll** - rotation about an axis along the line of sight or direction of travel.
- roller** - a free spinning wheel used to guide film along its proper direction of travel.
- roof prism** - see amici prism.
- rotating disk shutter** - a circular device with a finite angular opening that rotates synchronously with a camera's mechanical film movement. The image is recorded when the aperture in the shutter passes in front of the film gate. The film is advanced when the opaque portion of the shutter is in front of the film gate.
- rotating mirror camera** - a framing camera that uses a rapidly rotating mirror to scan the image forming beam along a stationary piece of film.
- rotating prism camera** - a camera that transports film in a continuous motion and uses a multifaceted, parallel-sided prism between the lens and film to scan the image forming beam synchronously with the moving film to compensate for image motion.

**ROTI - Recording Optical Tracking Instrument**

**rulings - the finely etched or scribed lines on a reticle or glass scale.**

**run time - the amount of time a camera will function with a specific amount of film.**

**schlieren effect** - refraction anomalies produced in a beam of light by differences in density in the air or substance in which it is transmitted.

**schlieren photography** - an optical technique that detects density gradients occurring in a fluid flow; in its simplest form, light from a slit is collimated by a lens and focused onto a knife-edge by a second lens, the flow pattern is placed between these two lenses, and the diffraction pattern that results on a screen or photographic film placed behind the knife-edge is observed.

**Schmidt objective** - reflecting telescopes designed to correct for the aberration of the spherical mirror without introducing coma or blurring into the system.

**Schumann plate** - a plate used for ultraviolet photography that has a very thin emulsion.

**Schwarzschild telescope** - a reflecting telescope that uses two mirrors designed to be free of spherical aberration and coma.

**scintillation** - a generic term for rapid variations in apparent position, brightness, or color of a distant luminous object viewed through the atmosphere.

**scratch** - a surface defect on an optical element.

**screen** - a translucent or white matte surface used to view an image.

**Seidel aberrations** - the six major lens aberrations: astigmatism, chromatic aberration, coma, curvature of field, distortion, and spherical aberration.

**sensitivity** - the relative response of a photographic emulsion or a detector to light.

**sensitometer** - a calibration instrument used to determine the sensitivity of photographic emulsions.

**sensor** - a generic term for a detecting device.

**sequence camera** - a type of motion picture camera (see pulse camera) that photographs single frame images at a slow predetermined rate.

**servo brake** - an electromechanical system that automatically adjusts film tension in an instrumentation camera.

**servo speed control** - an electronic system that automatically maintains film speed and framing rates in an instrumentation camera.

**shadowgraph photography** - a technique used to photograph and study shock waves and other fluid phenomena (see schlieren photography).

**shock wave** - an abrupt discontinuity in the physical properties of a medium in which a body or particle is traveling.

**shutter** - a device that controls the film exposure time in a camera.

**shutter angle** - the open portion of a rotating shutter blade, given in degrees.

**shutter correlation pulse** - an electrical signal generated to indicate the midpoint of the shutter opening.

**shutter phase lock** - an electronic system connected between two or more cameras to ensure the camera shutters are all synchronized to expose film at the same time or to maintain a constant phase difference between the shutters.

**shutter position sensor** - an optical sensor that detects when a camera shutter is open or closed; an optical sensor.

**shutter priority** - an automatic exposure mode where the shutter speed is set first and the camera then automatically adjusts the lens aperture.

**shutter speed** - the amount of time a shutter is open allowing light to expose film.

**shuttle** - a type of sliding mechanical device that moves film through a camera.

**single lens reflex camera** - a camera system that allows an object to be viewed directly through the primary lens by means of a mirror and prism assembly in the viewfinder.

**skylight** - diffused and reflected sunlight.

**sky screen** - a type of motion sensor that detects shadows of objects moving between the detector and a uniformly lit sky background.

**slant range** - the line of sight range between two points not at the same elevation.

**slit** - a long, thin rectangular aperture.

- slow motion** - the visual effect created when motion is photographed at a much higher framing rate than when it is projected and viewed.
- smear** - a lack of image sharpness caused by image movement across the film while an exposure is being made.
- sodium vapor light** - an electric discharge lamp that has metallic sodium mixed with the gas inside the lamp.
- soft** - a slightly defocused image.
- solid angle** - the angular spread at the vertex of a cone or similar figure measured by the area intercepted on a unit sphere about the vertex as centered by the cone surface.
- spectral ballistic camera** - a camera that records objects and their self-luminous plasmas for spectral evaluation.
- spectrophotometer** - an instrument used for measuring spectral transmittance or reflectance.
- specular reflection** - occurs when all the incident rays from a mirror or a highly polished or smooth surface are reflected in approximately the same direction.
- spherical aberration** - the blurring effect caused by rays refracted by the outer portion of a spherical lens coming to focus in a different place than rays passing through the lens close to the center.
- spherometer** - device used to measure the radius of curvature of a spherical lens or mirror.
- splice** - the taped joint where two pieces of film are joined together.
- split field** - the dual images produced by a rangefinder focusing device.
- split frame camera** - a camera with an internal prism and masking device that photographs several images in the same area of a normal sized frame.
- spot meter** - a type of reflectance light meter that measures over a narrow angle only.
- sprocket** - a toothed wheel in a camera movement that interfaces with the perforations in the film to aid in moving the film through the camera.

**sprocket holes** - the perforations along the edges of long rolls of film.

**standard lens** - a camera lens whose focal length is equal to the diagonal of the image plane.

**star calibration** - a method used to determine the image area of a fixed camera when the look angle is such that no calibration targets can be placed in the field of view. The shutter of the camera is held open for a time exposure to photograph bright stars with known positions. The stellar images are then used to calibrate the image plane with respect to angular position.

**steradian** - the solid angle subtended at the center of a sphere by an area on its surface equal to the square of the sphere radius.

**stereo camera** - a camera that employs two primary lenses and two shutters to photograph two simultaneous images. When the images are viewed, they produce a three-dimensional effect.

**stilb** - a unit of luminance equal to 1 candela per square centimeter.

**stop** - the change in aperture area associated with adjacent numerical f numbers. A one-stop difference changes the aperture area by 50 percent.

**stop down** - the act of decreasing the diameter of the iris diaphragm in a lens.

**streak camera** - a type of instrumentation camera that produces a single image of a moving object. The film moves continuously in the opposite direction of the moving object, past a slit located at the focal plane of the lens; also known as a smear or synchroballistic camera.

**striae** - imperfections in optical glass caused by areas of differing refractive index.

**stroboscope** - an electro-optical device that produces a series of bright flashes of short duration. The frequency of the flashes is controllable.

**subsonic** - a velocity less than the speed of sound.

**superimpose** - to photograph two objects or scenes on the same frame of film.

**supersonic** - a velocity higher than the speed of sound.

**supply spindle** - a metal post that protrudes into a camera body to hold the film spool in place.

**synchroballistic camera** - see streak camera.

**synchronous motor** - an ac electric motor whose speed is dependent on the frequency of its power source.

**synchronous shutters** - shutters on different cameras that are electronically controlled to open at the same time so that all cameras take a photograph at the same time.

- T -

**tachometer** - a device that measures the rotational speed of symmetrical objects.

**talbot** - 1 lumen-second

**Talbot's law** - the principle that the brightness of an image as measured through a slotted rotating shutter is proportional to the angular aperture divided by the opaque sections.

**target board** - a surveyed camera target photographed to assist in camera orientation and object location during the process of data reduction.

**technicolor** - a color process used to make positive color films by dye transfer or imbibition based on the superposition of yellow, magenta, and cyan images on the final film base.

**telecentric lens** - a lens system having the aperture stop located at the front focus and the exit pupil at infinity.

**telecine system** - a film-to-video conversion system.

**telemetry** - the engineering discipline of measuring data at one location and transmitting the information to another location for recording.

**telephoto lens** - a lens whose physical length is less than the effective focal length.

**telephoto power** - the ratio of the focal length of a telephoto lens used on a camera to that of the standard lens used on a camera; the image diagonal.

**telephoto ratio** - the ratio of the physical length of a telephoto lens to the effective focal length.

**telescope** - an optical device used to magnify and to view distant objects.

**tempered glass** - a type of glass that is heated then cooled quickly to produce internal stress in it so the surfaces are under compression.

**temporal coherence** - the speed of light divided by the line width of a laser output beam.

**terrestrial telescope** - a telescope that produces an erect image for direct viewing.

**Tesaar lens** - a lens system used in medium speed cameras and enlargers that has an achromotized rear element for improved coverage and definition.

**test chart** - a resolution target.

**theodolite** - a telescope mounted on precision bearings that can measure vertical and horizontal angles.

**theoretical resolving power** - the limiting resolution of an optical system having no aberrations because the limit is dependent only on the aperture of the system, and it is said to be diffraction limited.

**thermal detector** - any detecting device sensitive to heat.

**thermal imaging** - the science of producing images by using infrared electromagnetic radiation and infrared sensitive devices.

**thermal photography** - the science of recording images by using infrared sensitive film emulsions and optics.

**thermal radiation** - infrared radiation.

**thermography** - the science of recording infrared images to determine temperature differences among selected areas of the image's source.

**thick lens** - any lens with a thickness sufficient that it must be accounted for while calculating lens parameters for image formation.

**thin lens** - any lens whose thickness is such that it is negligible while calculating lens parameters for image formation.

**through the lens system** - a camera with a viewing and metering system that uses light entering the primary lens for focusing and exposure calculations.

**tilt** - the elevation angle rotated about a horizontal axis.

**time code** - a binary format used when recording days, hours, minutes, and seconds onto photographic film.

**time code receiver** - an electronic device designed to receive and decode IRIG timing signals.

**time delay generator** - an instrument that provides for preselection of time intervals for the generation of electric pulses.

**time exposure** - a method for recording images on photographic film that involves bypassing the preprogrammed shutter speeds and keeping the shutter open for a long duration.

**time lapse camera** - a camera that records slowly changing events over an extended period of time. Such a camera is usually programmable, so a single frame can be recorded from time intervals of nominally one frame per second up to one frame per several hours.

**time magnification** - the apparent speeding up or slowing down of time while viewing a sequence of recorded images.

**time resolution** - the shortest time duration that can be extracted from sequential images of recorded motion.

**timing block** - a mechanical holder for light emitting diodes (LEDs) or small timing lights that expose film to encode timing information.

**timing light** - an LED or small lamp inside an instrumentation camera that turns on to expose film and to encode timing information when a time code signal goes positive.

**timing layoff** - the distance between the image plane in an instrumentation camera and the point on the film where the timing mark is displayed when the image is taken.

**t number** - the speed of a lens based upon the actual geometric f number and the transmittance of the optics. The t number is the f number divided by the square root of the transmittance.

**tonality** - the distribution of gray scales within an image.

**topogon** - a wide angle lens corrected for spherical aberration and chromatic aberration. Angular coverage can be up to 90°.

**total flux** - the entire amount of luminous flux emitted by a light source in all directions.

- total image runout** - image displacement caused by lens decentering. Such displacement is measured when the lens is rotated on a line passing through the geometrical center of the lens rim.
- total internal reflection** - reflection that occurs within a material, adjacent to a boundary of less dense material, because the angle of incidence of the light ray striking the boundary surface is greater than the critical angle.
- tracking rate** - the angular rotation rate of a tracking mount required to keep up with a moving target.
- tracking scope** - a small telescope attached to a tracking mount to magnify the target for the operator.
- tracking system** - an instrument with azimuth and elevation movement (controlled either manually or with electronic feedback signals) that follows and records trajectory and event data from vehicles such as missiles, rockets and satellites.
- translucent** - a descriptor of a material having a diffusing effect when light is transmitted, reflected, and scattered by it.
- transmission** - the physical passing without scattering or absorption of electromagnetic radiation through a substance.
- transmission efficiency** - the percentage of light transmitted through an optical system.
- transmission grating** - a transparent diffraction grating.
- transmission limit** - an upper or lower wavelength boundary defining the spectral transmission characteristics of an optical system.
- transmissivity** - the internal transmittance of a nondiffusing material per unit thickness.
- transmittance** - the percentage of total incident power transmitted by an optical system.
- transparency** - a photographic film that can be projected onto a screen for viewing; usually referring to positive color or reversal black and white.

**transparent** - a descriptor of a material that transmits most of the incident light without diffusion or absorption.

**transposition** - the reversal of tonal qualities of an image.

**triangulation** - a trigonometric method to determine an unknown position in space by means of three or more known surveyed points.

**triple aplanat** - a biconvex lens of crown glass cemented between two negative lenses made of flint glass.

**triple mirror** - a corner cube reflector.

**triplet** - a lens system composed of three individual elements.

**tripod** - an adjustable camera stand with three legs.

**TSPI** - time-space-position information.

**twin lens reflex camera** - a camera that has two lenses mounted on its main body; one is used for framing and focusing, and the other is used as the main lens for taking the photograph.

**tungsten lamp** - a bulb with an elongated tungsten filament that emits light when heated with an electric current.

- U -

**ultra high speed photography** - the photographic recording of images on the order of 1 million frames per second.

**ultra violet radiation** - an emission of energy from the 0.01 to 0.4 micron portion of the electromagnetic spectrum.

**umbra** - the central completely darkened portion of the shadow of an object.

**uncorrected** - the description of a lens system that has not been corrected for any aberrations.

**underexpose** - to receive less than the adequate illumination needed to produce an optimum image.

**underwater camera** - a camera that has been environmentally sealed to photograph objects underwater.

**universal time** - same as Greenwich Mean Time.

**vacuum back** - a film platen connected to an air suction device that holds film securely in place during exposure.

**vanishing point** - a theoretical place where two parallel lines appear to intersect.

**variable focus lens** - a lens having elements that can be moved to change its effective focal length.

**variable shutter** - a rotating disk device with movable blades that allows the aperture angle to be changed.

**variac** - a type of transformer used to manually control output voltage.

**vernier** - an adjacent set of linear scales, one sliding against the other, that increases measurement precision.

**vertex** - the highest or lowest point on a lens where it intersects with the optical axis.

**video tracker** - an electronic device that automatically detects changes in object contrast within a video field, processes the information from the scene, and derives azimuth and elevation coordinates for a target of interest within the scene.

**vidicon** - a small black and white television tube developed for closed circuit television.

**view camera** - a large format camera that allows both lens and film plane adjustments to change image perspective.

**viewfinder** - an optical device attached to a camera that allows framing and focusing of the subject.

**vignetting** - the gradual darkening of an image towards the outer edges.

**virtual image** - an image that cannot be brought to focus on a viewing screen.

**visibility** - the distance at which the eye can recognize specific objects.

**visible spectrum** - the region of the electromagnetic spectrum between 0.4 and 0.75 microns.

**visual field** - the angular view field of the eyes, nominally 1300.

- W -

**watt** - a unit of power equal to 1 joule per second.

**wave** - the traveling vibrational motion of electromagnetic energy.

**wavefront** - the surface points on a wave that are all equidistant from the energy source.

**wavelength** - the distance between two corresponding points on a wave in consecutive periods.

**wave number** - the frequency of a wave divided by its velocity; the reciprocal of the wavelength.

**white light** - light having no distinguishable color.

**wide angle distortion** - the distortion produced at the edges of an image by large field of view lenses.

**wide angle lens** - a lens having a focal length much shorter than the diagonal of the image plane.

**window** - a piece of optical glass used to protect the entrance of an optical system.

**Wratten filter** - a type of optical filter manufactured by Eastman Kodak.

- X -

**xenon arc lamp** - a high intensity light that excites xenon gas between two electrodes.

**x-radiography** - a type of photography that uses x-rays as a source to record an image of an object penetrated by the radiation.

**x synchronization** - the timing of an electronic flash to fire when the connected shutter is fully open.

- Y -

**yaw** - the rotation of an object in a plane around a vertical axis.

**y-tilt** - in aerial photography, the deviation of a camera from the vertical caused by the pitch of the aircraft.

- Z -

**zone plate** - a flat glass plate with concentric opaque rings that forms an image caused by diffraction rather than reflection.

**zoom** - to change the magnification and focal length of a zoom lens.

**zoom lens** - a lens having internal movable elements that allow the focal length to be changed without changing the image plane.