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LEXICON OF AIRCRAFT TRANSPARENCY TERMS

CLETUS J. MUICK, OD, EDITOR

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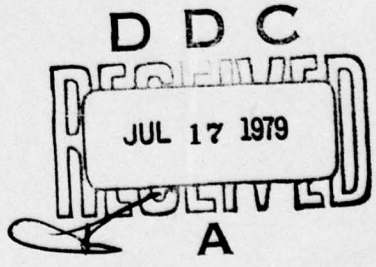

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AMRL-TR-78-122

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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

CHARLES BATES, JR.
Chief
Human Engineering Division
Aerospace Medical Research Laboratory

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This lexicon deals with terms and definitions peculiar to personnel working with aircraft transparent enclosures. All types of material currently used in the fabrication of transparent enclosures (acrylic, glass, polycarbonate) is addressed. Terms are either specific or general when applied to materials; and vision/optics terms, in most instances, are common to windscreens, canopies, and windows.

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PREFACE

The opportunity to develop this lexicon was afforded by Col. Loren Anderson, then Chief of the Directorate of Equipment Engineering, Aeronautical Systems Division (ASD), Wright-Patterson Air Force Base (WPAFB), OH, through the administrative exchange program with Human Engineering Division, Visual Display Systems Branch of the Aerospace Medical Research Laboratory.

The editor is most appreciative of the cooperation received from those who provided lists of terms, namely; Corning Glass Works, Corning, NY; Libbey-Owens-Ford Company, Toledo, OH; Lockheed-California Company, Burbank, CA; PPG Industries, Huntsville, AL and Pittsburg, PA; Air Force Materials Laboratory, WPAFB, OH; University of Indiana, School of Optometry Library, Bloomington, IN.

The editor also wishes to express appreciation to Mr. William L. Welde and members of the Visual Display Systems Branch for their cooperation and excellent critique; Lt. Col. Paul Kemmerling, Chief, Directorate of Equipment Engineering, ASD, for permission to complete this project, and Mr. Harry Holder, Directorate of Equipment Engineering, Crew Station & Escape Branch for the figure drawings.

INTRODUCTION

Consultation with members of the AF Flight Dynamics Laboratory (AFFDL), the AF Materials Laboratory (AFML), and the Aerospace Medical Research Laboratory (AMRL) verified the need for an assemblage of terms applicable to and for use by personnel working with aircraft transparent enclosures. Both government and industry would benefit from the availability of a list of pertinent terms. Eventually, coordination by all those working in the area could lead to some type of standardization.

The term lexicon was chosen because it so aptly describes the special vocabulary of a specific technical area. As in all disciplines, the esoteric language used by those working in the area of aircraft transparencies was developed or borrowed from various sources. To those outside the field the terms used may sound like jargon. The editor hopes this lexicon will provide a bridge for those just entering the field and for those already in the field, that is, a common bond.

Sources used are listed in the reference section. Some sources were used more generously than others; however, no attempt was made to identify the term with the source. Many sources contained identical terms, but slightly different definitions. Editorial prerogative was used in determining the most appropriate definition.

A

Abbe Constant. A mathematical expression used in determining the correction of chromatic aberration of optical systems. It is often called the "Nu Value" or the "Vee Value" and is usually expressed as

$$\nu \text{ or } V = \frac{N_d - 1}{N_f - N_c}, \text{ or } \frac{\text{refractivity}}{\text{DISPERSION}}$$

where n_d, N_f, and N_c are the indices of refraction for light of the wavelengths of the D line of sodium and the F and C lines of hydrogen, respectively.

Aberration. Generally, any systematic deviation from an ideal path of the image-forming rays passing through an optical system, which causes the image to be imperfect. Specific aberrations are spherical aberration, coma, curvature of field, astigmatism, longitudinal chromatic aberration, lateral chromatic aberration, and distortion.

Aberration, chromatic. The dispersion of nonmonochromatic light due to the unequal refraction of the different wavelengths of light in the incident beam.

Aberration, chromatic, lateral. A variation in a lens' image sizes for light of different colors or wavelengths. It is measured as the radial displacement of the image in the first color, from the image of the same point in the second color. A direction away from the axial image point is taken as positive, and a direction towards the image point is negative. In the case of telescopes, lateral chromatic aberration is a difference in magnification for light of different colors, and is measured as the angular separation in apparent field between the images of the same point in two colors.

Aberration, chromatic, longitudinal. The distance between the foci for light of different colors measured along the optical axis.

Aberrations, least circle of. A synonym for confusion, least, circle of.

Aberration, spherical. A symmetrical optical defect of lenses and spherical mirrors in which light rays that come from a common axial point, but strike the lens at different distances from the optical axis, do not come to a common focus. Spherical aberration of an uncorrected or undercorrected lens is of the type illustrated in Figure 1. Overcorrection is possible, and is illustrated in Figure 2. The radius of a zone is ordinarily specified as the height, h. The distance o-y is called the lateral spherical aberration, o-z the longitudinal spherical aberration.

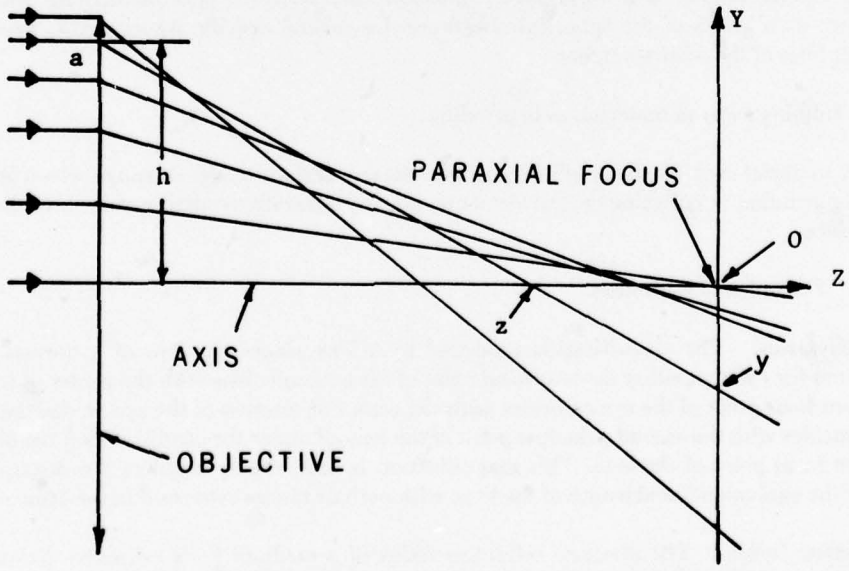


FIGURE 1 UNDERCORRECTED SPHERICAL ABERRATION

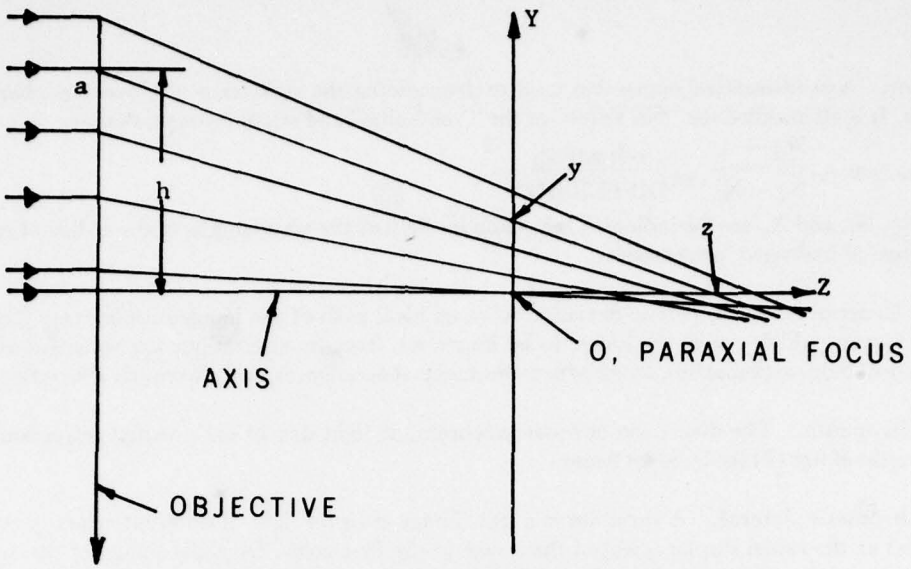


FIGURE 2 OVERCORRECTED SPHERICAL ABERRATION

Aberration, spherical, lateral. The distance o-y from the axis of a ray a-y whose height is h, as shown in Figure 1. The axis Y and Z have the paraxial point o as their origin, and are positive in the directions indicated by the arrows. The lateral aberration y, is negative with undercorrection and positive with overcorrection.

Aberration, spherical, longitudinal. The distance o-z along the axis for a ray a-y of height h, as shown in Figure 2. The longitudinal spherical aberration, z, is negative with undercorrection, and positive with overcorrection.

Aberration, spherical, specification of. A term denoting the magnitude of spherical aberration given by one of the following alternatives: (1) the lateral spherical aberration is plotted or listed as a function of the height, h; (2) the longitudinal spherical aberration is plotted or listed as a function of the height, h, as shown in Figure 1 and Figure 2.

Aberration, spherochromatic. The variation in spherical aberration for light of different wavelengths or colors. Often shown as a graph of the spherical aberration for several specific wavelengths, usually defined by the Fraunhofer lines of the solar spectrum.

Abrasion. The rubbing away of material, as in grinding.

Abrasive. (1) A material such as silica, silicon carbide, emery, cerium oxide, or rouge which is used in the optical industry for grinding or polishing optical elements; (2) Any naturally occurring particles deleterious to a glass or plastic surface.

Absolute Index. See index of refraction.

Absolute Magnification. The magnification produced by a lens placed in front of a normal eye and at such a distance from the eye that either the rear focal point of the lens coincides with the center of rotation of the eye or else the front focal point of the eye coincides with the center of rotation of the eye or else the front focal point of the eye coincides with the second principal point of the lens all under the condition that the object is located close to the front focal point of the lens. This magnification is numerically equal to the distance of distinct vision divided by the equivalent focal length of the lens, with both distances expressed in the same units of length.

Absolute Refractive Index. The absolute refractive index of a medium is its refractive index relative to that of vacuum. Refractive index and absolute refractive index are identical numerically.

Absorptance. The ratio between the flux absorbed by a body and the incident flux. This term, and its specifications, is applied to radiant flux and to luminous flux.

Absorptance Coefficient. The internal absorptance of an infinitesimally thin layer of a medium divided by the thickness dx of the layer. Thus defined, the absorption coefficient is the coefficient $B(\lambda)$ in Bougher's Law,

$$F = F_0 e - B(\lambda)\, x$$

where F_0 is the flux, F, at the point of reference $x = 0$.

Absorptance, internal. The ratio of the flux absorbed between the entrance and emergent surfaces of the medium, to the flux that has penetrated the entrance surface. The effects of interreflections between the two surfaces are not included. Internal absorptance is numerically equal to unity, minus the internal transmittance.

Absorptance, spectral. The absorptance evaluated at one or more wavelengths. Spectral absorptance is numerically the same for radiant and luminous flux.

Absorption, light. The conversion of light into other forms of energy upon traversing the continuous portion of a medium. This conversion weakens the transmitted light beam. Energy reflectance R, transmittance T, and absorption A, obey the law of the conservation of energy, $R + T + A = 1$.

Absorption, selective. The act or process by which a substance "takes up" or "soaks up" all the colors contained in a beam of white light, except those colors which it reflects or transmits. Some substances are transparent to light waves of certain frequencies, allowing them to be transmitted, while absorbing waves of other frequencies. Some reflecting surfaces will absorb light of certain frequencies and reflect others. The color of a transparent object is the color it transmits, and the color of an opaque object is the color it reflects.

Absorptivity. The internal absorptance per unit thickness of the medium. Numerically, absorptivity is unity minus the transmissivity.

Accommodation. A function which the eye performs when it varies its total refracting power in order to see clearly objects located at different distances from the eye. It is measured in diopters. (See Diopters.)

Accommodation, limits of. The distances of the nearest and farthest points which can be focused clearly by the eyes of an observer. Usually varies from 4 to 5 inches to infinity. (See Accommodation.)

Achromat. A contraction of the term lens, achromatic.

Achromatic. Having the quality of being free of chromatic aberration; colorless.

Achromatism. The absence of chromatic aberration.

Acid Polishing. The polishing of a glass surface by acid treatment.

Acrivue.® Trade name for acrylic plastic from Swedlow, Inc.

Acrylic. Plastic based on resins made by the polymerization of acrylic monomers, such as methyl methacrylate.

Acrylic, stretched. Stretching a heated plastic sheet either in two perpendicular directions (biaxial) or in all directions (multiaxial) in the plane of the sheet to improve the physical properties by reorienting the molecules.

Actinic. Any rays of radiant energy having photo chemical effect. Often erroneously applied to the ultra-violet portion of the spectrum only.

Acutance. Edge sharpness and high edge contrast.

Additive. An ingredient included in the making of plastic. (i.e. UV additive).

Adhered Glass. Small transparent glass chips adhering to the glass surface.

Adhesive. A substance capable of holding materials together by surface attachment.

After Image. Transient visual sensation that occurs after the stimulus causing it has been removed.

Air Bells. Bubbles of irregular shape formed generally during the pressing or molding operations in the manufacture of optical glass.

Aluminizing. In optics, the application of a film of aluminum to a surface, usually by evaporation.

Ametropia. The condition of an eye with a refractive error.

Amorphous. Being without crystalline structure.

Analyzer. A polarizing element which can be rotated about its axis to control the amount of transmission of incident plane polarized light, or to determine the plane of polarization of the incident light.

Anamorphic. A condition in an image plane in which magnification is different along mutually perpendicular radii. An optical system which produces this condition.

Angle, critical. The angle of incidence in a denser medium, at an interface between the denser and less dense medium, at which all of the light is refracted along the interface, i.e., the angle of refraction is 90°. When the critical angle is exceeded, the light is totally reflected back into the denser medium. The critical angle varies with the indices of refraction of the two media with the relationship,

$$\sin (I_C) = \frac{n'}{n}$$

where I_C is the critical angle; n' the index of refraction of the less dense medium; n the index of refraction of the denser medium.

Angle Gages. Accurate glass or metal prisms of precisely known angles.

Angle of Azimuth. An angle measured clockwise in a horizontal plane, usually from north. (The north used may be True North, or Magnetic North.) Also used to measure the horizontal angle off of an aircraft's boresight or flight station axis.

Angle of Deviation. The angle through which a ray of light is bent by reflection or refraction. See Figures 3 and 4.

Angle of Incidence. The angle between the normal to a reflecting or refracting surface and the incident ray. See illustration of angle of reflection and angle of refraction. See Figures 3 and 4.

Angle of Reflection. The angle between the normal to a reflecting surface and the reflected ray. See Figure 3.

Angle of Refraction. The angle between the normal to a refracting surface at the point of incidence and the refracted ray. See Figure 4.

Angle of View. The angle subtended by the total field of view at the observer's eye position.

Angle, Parallactic. The angular difference in direction to an object as seen from two points of observation. The angle subtended at the object by the base length of a range-finder.

Angstrom. Abbreviated Å. A unit of measurement of wavelength of light equal to 10^{-8} cm.

Angular. Composed of, or measured by, angles.

Angular Distortion. The failure of a lens to reproduce accurately in the image space the angle subtended by two points in the object space. One of the two points usually selected is a point on the axis of the lens or a point in the object space corresponding to the principal point in the image. See Aberration.

Angular (Optical) Deviation. The change in direction of a ray of light caused by incidence with a reflector or refractor. It is the angle from a vector having the direction of the incident ray to a vector in the direction of the same ray on emergence. See Figure 3 and Figure 4.

Angular subtense. The angle subtended by an object at the nodal point of the eye, about 7mm behind the corneal surface and 17mm in front of the retina.

Aniseikonia. Inequality in size and/or shape of the two ocular images in binocular vision.

Anisometropia. The condition in which the refractive error in the two eyes of a pair differs.

Anisotropic. A term used to denote a substance which exhibits different properties when tested along axes in different directions.

Anneal. To prevent or remove objectionable internal stresses by controlled cooling from a suitable temperature.

Annealing. A controlled heating and cooling process used to reduce internal stresses caused by previous forming or machining processes performed on glass or plastic sheet materials. (See Heat Treating)

Annealing Point (A.P.). The temperature corresponding to a rate of elongation of 0.0136 cm/min when measured by the Method of Test for Annealing Point and Strain Point of Glass (ASTM Designation: C 366). This test prescribes a rate of cooling of approximately 4 cm/min with a fiber of approximately 0.065 cm in diameter, and a suspended load of 1000 g. The annealing point numerically approximates log = 13.0 poises, where internal stress is substantially relieved in a few minutes.

Annealing Range. The range of glass temperature in which stresses in glass articles can be relieved at a commercially desirable rate. For purposes of comparing glasses, the annealing range is assumed to correspond with the temperatures between the annealing point (A.P.) and the strain point (St.P.).

Annealing Schedule. The relationship between time and temperature at which glass is held in order to assure annealing and compacting of an intended quality.

Apex of a Prism. The thin edge of a prism. See Figure 5.

Apparent Field of View. The size of the field of view as it appears to the eye. In a direct sighting instrument (binoculars, etc.) it is equal to the magnification times the angle of the true field of view.

Arris. A narrow, smooth bevel on the edge of a plate of glass.

Aspheric. Aspheric surfaces include all nonspherical surfaces. Aspheric surfaces are frequently but not necessarily surfaces of revolution.

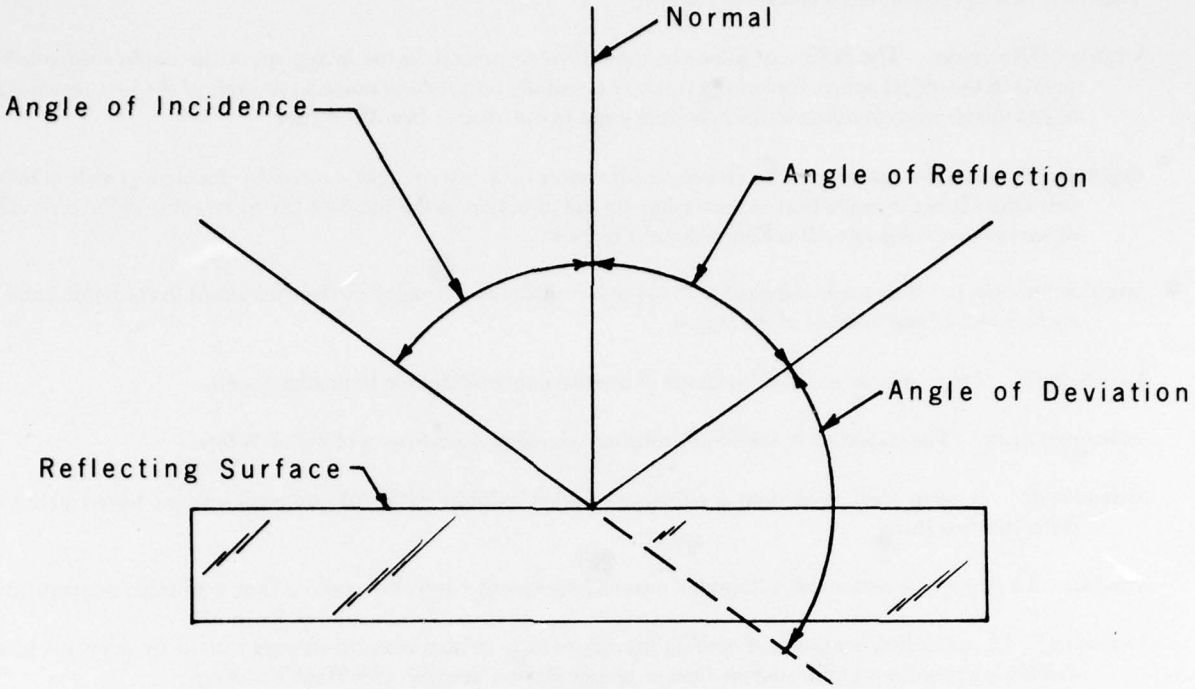


FIGURE 3 ANGLE OF REFLECTION

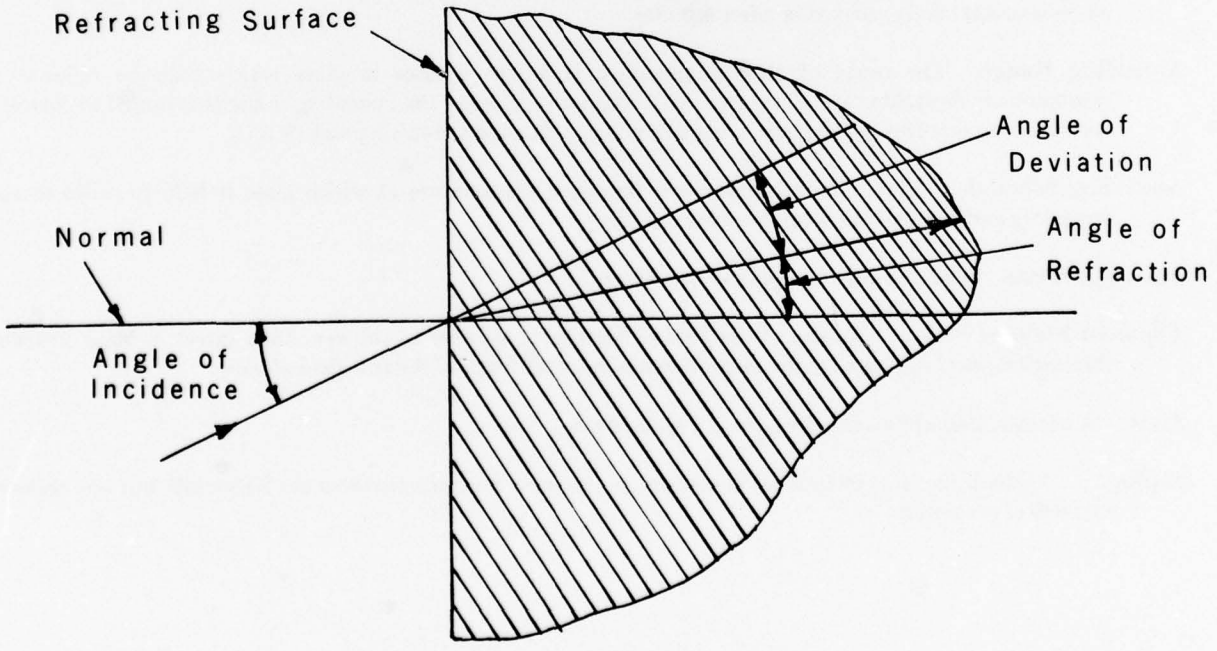


FIGURE 4 ANGLE OF REFRACTION

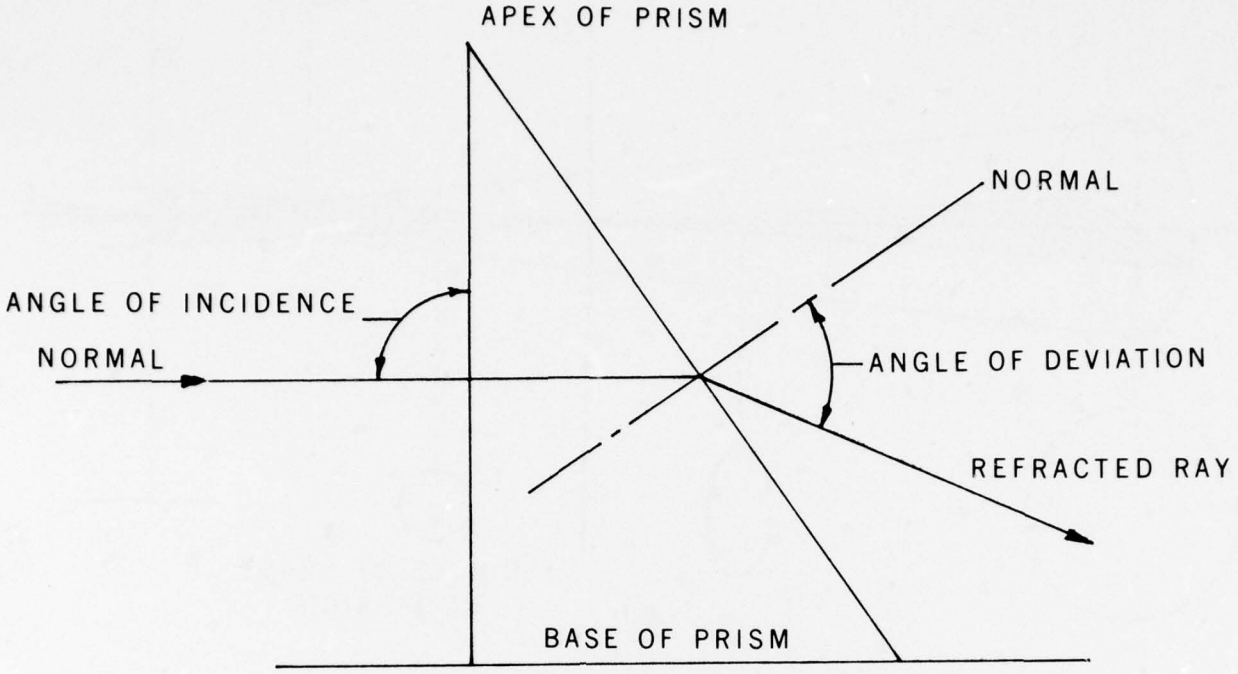


FIGURE 5 PRISM NOMENCLATURE AND REFRACTION

Astigmatism. Abbreviated ASTIG. An aberration which causes an off-axis point to be imaged as a pair of lines at right angles to each other. Each line is at a different distance from the image forming element along the chief ray of the image forming bundle of rays. The image forming element thus has two foci, one radial and the other tangential to the optical axis. A sharp image of a point cannot be obtained. A compromise image position must be selected at a point between the two line images at which the image blur is smallest (circle of least confusion). Lenses, lens systems, mirrors, or mirror systems, or combinations of the two, whose curves are not symmetrical about the axis can produce "axial astigmatism." "Off-axis astigmatism" results naturally with centered spherical surfaces. Axial astigmatism, unless deliberately introduced, is to be considered a defect of workmanship, and not an aberration. It should be noted that in dealing with spherical lenses, astigmatism arises from oblique refraction, whereas in the human eye it arises from a departure of a surface from a truly spherical form. See Figure 6.

Autoclave. A tank or container. The internal pressure and temperature may be controlled at will. Used principally to simultaneously apply heat and pressure.

Axis, principal. A straight line connecting the centers of curvature of the refracting surfaces of a lens. In a mechanical sense, a line joining the centers of a lens as it is placed in a mount. The principle axis is the optical axis of a lens.

Axis, secondary. A line formed by the chief ray of an oblique bundle of rays. See Chief Ray.

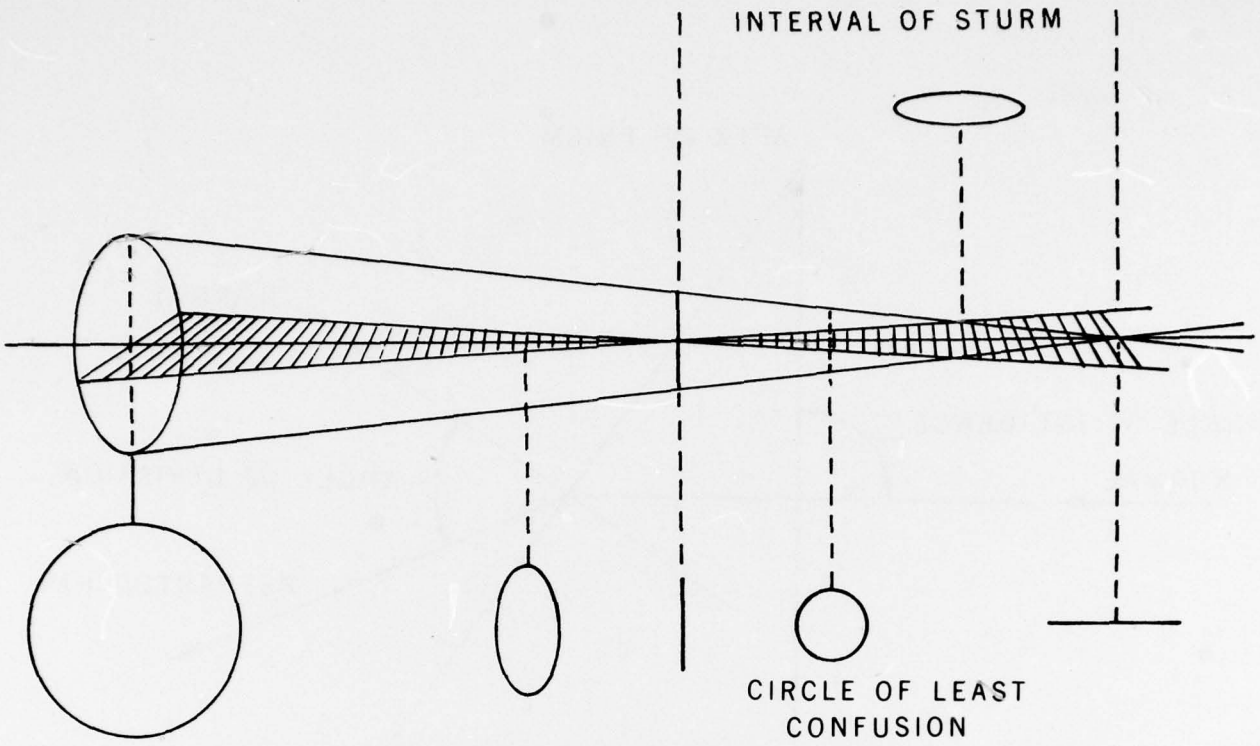


FIGURE 6 CROSS-SECTION OF LIGHT PENCIL SHOWING ASTIGMATISM

B

Bag, Bagging. A manner of preparing a transparent laminate for processing in an autoclave by sealing it in a flexible bag and evacuating the air from the bag.

Banding. A concentrated area of distortion running across a transparent part in the form of a band. This type of distortion is easily demonstrated by viewing a grid pattern through the transparency, and can occur in any area for any length.

Barium Crown Glass. An optical crown glass containing a substantial quantity of barium oxide.

Barium Flint Glass. An optical flint glass containing a substantial quantity of barium oxide.

Barium Glass. Commonly used in reference to a type of glass, one of the ingredients of which is barium oxide added for the purpose of increasing its refractive index, while maintaining a relatively low dispersion.

Base of Prism. The thick edge of a prism. See Figure 5.

Batch. The mixture of raw materials which by fusion is converted into glass.

Beam. With reference to light, a shaft or column of light; a bundle of rays. It may consist of parallel, converging, or diverging rays.

Beam Splitter. An optical device for splitting a light beam into two separated beams. A simple beam splitter is a plane parallel plate with one surface coated with a dielectric or metal coating which reflects part of the incident light and transmits a part of it. If such a plate is placed at 45 degrees to the direction of the axis of the beam a part of the beam is deviated through an angle of 90 degrees and a part is unchanged in direction. The angle of the reflected beam can be changed by changing the angular position of the plane parallel plate with respect to the axis of the beam. A beam splitter is often made by coating the hypotenuse face of one of two 54 to 90 degree prisms and cementing the hypotenuse faces together.

If the beam splitting interface is made of metal, its thickness will determine the proportions of the light reflected and transmitted. Of course, in all metallic beam splitters an appreciable amount of light is completely lost by absorption in the metal.

In the use of beam splitters, sometimes it is necessary that the two beams be matched not only for brightness but for color as well. Hence, it is necessary in these cases to use a material which gives the same color of light both by transmission and by reflections. In cases where color matching of two beams cannot be accomplished by the medium at the surface or interface a correcting color filter is placed in one of the beams.

Bend. A curve of glass or plastic.

Bent Glass. Flat glass that has been shaped while hot into cylindrical or other curved shapes.

Bevel. The slant or inclination of the edge of a piece of glass.

Beveling. The process of edge finishing flat glass to a bevel angle.

Biaxial Stretching. See Stretching; Acrylic, Stretched.

Binocular. Pertaining to vision with both eyes; also, a term applied to instruments consisting of two telescopes, utilizing both eyes of the observer.

Birefringence. The characteristic of having two indices of refraction with different values. Birefringence is the characteristic of certain media, which is dependent on the angle between the ray path within the medium and the optical axis (or axes) of the medium. See refraction double, rainbowing.

Birefringent Crystals. Alternative term for doubly refracting crystals.

Blackbody. A body which absorbs all the radiant energy which strikes it; a perfect radiator and a perfect absorber. It is a contraction of the term "ideal radiator," "full radiator," or "complete radiator".

Blacking, optical. The light absorbing material applied to the ground surfaces of optical elements. Such material should have an index of refraction as high as that of the underlying glass and must be in direct contact with the glass.

Blank. A pressed-glass or plastic mold with the appropriate size and shape of the optical element to be ground and polished.

Blank, flat. A piece of glass or plastic with a rough plane surface on each side.

Blanks (Pressings). Optical glass or optical plastic formed by pressing into the rough shape and size required in the finished article.

Blemish. A defect or flaw.

Blister. An imperfection; a relatively large bubble or gaseous inclusion. See Defects, Minor Optical.

Bloach. An imperfection resulting from incompletely grinding plate glass, caused by a low place in the plate which retains part of the original rough surface.

Block Reek (Rake). A scratch imperfection caused by cullet lodged in the felt in the polishing operation. See Scratches.

Bloom. A surface film resulting from attack by the atmosphere or from the deposition of smoke or other vapors.

Body. The attribute of molten glass, associated with viscosity and homogeneity, which is conducive to workability.

Boil. (1) An imperfection; a gaseous inclusion larger in size than seed; small bubbles. See Blister. (2) The commotion caused by gases escaping from the melting batch.

Bolometer. An electrical instrument for measuring radiant energy by measuring the changes in resistance of a blackened temperature-sensitive device exposed to the radiations.

Bonding, fusion. The process that causes two pieces of material to be permanently united by way of temperature and pressure.

Borate Glass. A glass in which the essential glass former is boron oxide instead of silica.

Boresight. To adjust the line of sight of the sighting instrument of a weapon parallel to the axis of the bore. Also applied to the process of aligning other equipment, such as radar mounts, directors, etc. As a noun, the term defines an optical instrument for checking alignment.

Borosilicate Crown Glass. An optical crown glass containing substantial quantities of silica and boric oxide.

Borosilicate Glass. Any silicate glass having at least 5 percent of boric oxide.

Brewster, law of. When the angle between the refracted and reflected ray is 90 degrees, maximum polarization occurs in both rays. The reflected ray has its maximum polarization in a direction normal to the plane of incidence, and the refracted ray has its maximum polarization in the plane of incidence.

Brightness. The effect upon sensation by means of which an observer is able to distinguish differences in luminance.

Bubble. In glass: a gaseous inclusion.

Bubble, open. A bubble at a polished surface, which has been opened by grinding or polishing.

Bubbles. Gas inclusions in the plastic core ply or the interlayer larger than 1/32 inch in maximum dimensions. These inclusions are usually brilliant in appearance. When larger, they may be flattened or elongated.

Bull, eye. Localized depression or bulge in a transparent surface creating a lens like defect which produces optical distortion.

Bump. An unintentional elevation in a surface.

Bundle, axial. A cone of rays that emanates from an object point which is located on the optical axis of the lens system.

Burn. A surface defect caused by a polisher running dry too long. It occurs with felt or plastic polishers, and may appear as a reddish brown stain.

Burnish. To polish.

Bus-Bar. An electrical conductor used to transmit power to the edge of a thin conductive film.

C

Candela. A unit of luminous intensity of 1/60 of 1 cm^2 of the projected area of a blackbody radiator operating at the temperature of the solidification of platinum (2045K).

Candle. A unit of luminous intensity. Redefined as candela.

Canopy. The transparent portion of an enclosure, normally exclusive of the windshield. Sometimes used interchangeably with windscreen. See Enclosure, Windshield, and Windscreen.

Carbon. An elementary substance occurring native as the diamond, graphite — in glass practice, usually derived from coal.

Cased. Covered with a layer or layers of different glass.

Casehardened. A term sometimes used for tempered glass. See Tempered Glass, Heat Treating.

Casting. Pouring molten material into a mold or form — glass poured onto a table to be rolled into a sheet.

Catadioptric. Optical systems combining refractive and reflective elements.

Catalyst. A small amount of a substance that markedly speeds up the cure of a resin without affecting the chemical properties of the primary reactants.

Cat Eye. An imperfection; an elongated bubble containing a piece of foreign matter.

Cement. See Adhesive. See also Monomeric Cement and Solvent Cement.

Cement, optical. A permanent and transparent adhesive, which is capable of withstanding extremes of temperature. Canada balsam is a classic optical cement although it is being replaced by such modern synthetics as the methacrylates, caprinates, and epoxies.

Cement, thermoplastic. An adhesive whose viscosity decreases as the temperature is raised to a limit. Canada balsam, resin, and pitch are common thermoplastic cements.

Cement, thermosetting. An adhesive which permanently sets or hardens at a certain high temperature. Methacrylate is a common thermosetting cement.

Center, geometrical. The physical center of the lens; it is on the axis of the lens, halfway between the front and rear vertex. It is sometimes referred to as the "mechanical center" of the lens to distinguish it from the optical center.

Center, mechanical. A term sometimes used as a synonym for center, geometrical.

Center, optical. The point, generally within a lens, but sometimes exterior to it, at which the optical axis intersects the optical path of any ray directed at a nodal point.

Characteristics, optical. The qualifications an optical system possesses by reason of its optical nature, such as field of view, magnification, brightness of image, image quality, correction for aberrations. With reference to windscreens; transmission, deviation, distortion, haze, etc.

Check. An imperfection; a surface crack in a glass article.

Chemcor®. A trademark describing a glass or a glass ceramic chemically strengthened by (1) a low temperature ion exchange during which a large ion replaces a smaller one, thereby producing a compressive stress on the surface or (2) a high temperature growth of a low expansion surface phase over a high center body.

Chemical Durability. The lasting quality (both physical and chemical) of a glass surface. It is frequently evaluated, after prolonged weathering or storing, in terms of chemical and physical changes in the glass surface.

Chemical Tempering. An ion exchange process used on glass sheet which hardens the outer surfaces and places the material between into a tensile mode. Also referred to as chemical strengthening.

Chip. An imperfection due to breakage of a small fragment out of an otherwise regular surface.

Chromatic. Perceived as having a hue; not white, gray, or black.

Chromaticity. The combination of the dominant wavelength and purity characteristics, but not the photometric magnitude of light.

Chunks. Random sizes of glass sheets which are smaller than standard sizes of stocksheets.

CIP-(Cast-in-place). A term used to identify a type of interlayer material which is poured between the transparent face sheets of a fabricated part and cured as a component part of the assembly.

Circle of Confusion. The diameter of a lens circular image of a point source resulting from the failure of the lens or optical system to image a point object as a point. The circle diameter depends upon the contrast, color, sensitivity, and other factors of the evaluation or measurement system. It is the permissible size of disc in the lens image of a point source. The commonly accepted maximum size for metric photography is .002 inch and for amateur photography is .01 inch. Where negatives are to be enlarged, this disc should be smaller so that when enlarged the disc will not be greater than .01 inch. This size has been arbitrarily adopted as the maximum diameter to produce a "sharp" picture. See Figure 6.

Circular Polarization. See polarized light.

Clarity. The characteristic of a transparent material whereby distinct images may be observed through it.

Coated Optics. Optical elements of combinations thereof whose refracting or reflecting surfaces are coated with one or more thin layers of dielectric or metallic substances. Such coatings are used more often for reducing the reflectance of refracting surfaces. The optical surfaces of optical elements are coated with dielectric materials such as magnesium fluorde, silicon monoxide, silicon oxide, titanium dioxide, zinc sulfide for the purpose of reducing reflections and/or protecting the surfaces. A single film for reduction of reflection should have an optical thickness of 1/4 wavelength, and in air its index of refraction ideally should be $\sqrt{n_g}$ where n_g is the index of refraction of the coated glass. Such a low refractive index for materials to be used in coating crown glasses is not found; hence, the practical material of lowest refractive index is used. At best, with a single film, only one wavelength of light will have the greatest reduction in reflection. In order to increase the wavelengths to two for which minimum reflection takes place a bi-layer film of two different coating materials is often used.

Coating, Abrasion Resistant. A protective coating for plastic to minimize scratching. See coat, hard, coating, protective.

Coating, antireflection. Thin layers or films, also known as low reflecting films, that are ordinarily used for reducing the reflectance and increasing the transmittance of glass surfaces. The index of refraction, n_c, of a single dielectric film is chosen as close as practical to $\sqrt{n_g}$ where n_g is in the index of refraction of the glass or substrate.

Coating, E-C. Electrically conductive thin film deposited on a transparent material. Used on windscreens as the heating element.

Coating, P-static. Precipitation static coating used to bleed off any static electrical charge buildup on a transparency.

Coating, Antireflective. These coatings, known also as low reflecting films, are ordinarily used for reducing the reflectance and increasing the transmittance of glass surfaces. The refractive index n_1 of a single dielectric film is chosen as closely as practical to $\sqrt{n_g}$ where n_g is the refractive index of the glass or substrate.

Coating, high-reflecting. A broad class of single or multilayer coatings that are applied to a surface for the purpose of increasing its reflectance over a specified range of wavelengths. Single films of aluminum or silver are common; but multilayers of at least two dielectrics are utilized when low absorption is imperative.

Coating, protective. Films that are applied to a coated or uncoated optical surface primarily for protecting this surface from mechanical abrasion, or from chemical corrosion, or both. An important class of protective coatings consists of evaporated thin films of titanium dioxide, silicon monoxide or magnesium fluoride. For example, a thin layer of silicon monoxide may be added to protect an aluminized surface.

Coat, soft. A term designating the soft coating applied to coated optics to differentiate between the harder and more durable coating known as hard coat. Certain evaporating coatings are not capable of forming a hard coat and are easily removed by cleaning. Cryolite is a soft coat material. Also referred to as a ductile coating.

Cold Box. A chamber used to test completed panels for low temperature (-65°F) stability and heat uniformity.

Collimate. To render parallel.

Collimating Telescope. A telescope: the mechanical axis of which, referred to the outer cylindrical surface of the tube, is coincident with its optical axis. In this telescope instead of an eyepiece, a reticle and generally an illuminating system replaces an eyepiece. This telescope provides bundles of parallel light rays; i.e., it images the reticle at infinity. It is generally used for optical adjustments where parallel light is necessary.

Collimation. The process of aligning the optical axis of optical systems to the reference mechanical axes or surfaces of an instrument; or the adjustment of two or more optical axes with respect to each other. The process of making light rays parallel.

Collimator. An optical device which renders diverging or converging rays parallel. It may be used to simulate a distant target, or to align the optical axes of instruments.

Colmascope. A polariscope for demonstrating strain existing in a piece of glass. See Polariscope.

Color. The sensation produced by light of different wavelengths throughout the visible spectrum. The color, shape, and number of Newton's rings present, when two optical surfaces are placed together. This is a very broad term. Color is a synonym for aberration, chromatic.

Colorimeter. An optical instrument used to compare the color of a sample with a synthesized stimulus. For example, in a three-color colorimeter, the synthesized stimulus is produced by mixtures of three colors of fixed chromaticity, but variable luminance.

Color Stimulus. Radiant energy capable of producing color sensation.

Color Temperature. The temperature to which a black body radiator must be raised in order that the light it emits may match a given light source in color. Usually expressed in degrees Kelvin, or currently Kelvin.

Coma. An aberration of a lens which causes oblique pencils of light rays from an object point to be imaged as a comet-shaped blur.

Compacting. The heat-treating process in which the refractive index of glass is stabilized near, or at its maximum value, by holding the glass for different periods at suitable degrees of heat below the range of annealing temperatures. See treating, heat.

Comparator. An inspection instrument, usually a projection device, which presents a composite of a reference contour and the image of the actual contour for comparison. More commonly called on "optical comparator," or "contour projector".

Compensator. An optical element used to correct for mechanical or optical displacement.

Concave. A term denoting a hollow curved surface.

Concentric. The characteristic of having the same center. Circles differing in radius, but inscribed from a single center point.

Conductivity. Quality or power of receiving and transmitting.

Confusion, least, circle of. See Circle of confusion and Figure 6.

Conical. Round and tapering to a point, cone shaped.

Conoidal. Of or shaped like a cone or a cone-shaped thing.

Contamination. Impurities derived from containers or other equipment.

Convection. The process of conveying or transmitting resulting from differences in temperature.

Convergence. In optics, this refers to the bending of light rays toward each other as by convex or plus lens. Physiologically, it is the turning of the eyes inward, converging the visual axes, in order to achieve singleness of binocular vision for near objects.

Convergence, angle of. The angle formed by the lines of sight of both eyes in focussing on any line, corner, surface, or part of an object. It is also referred to as "convergent angle".

Convex. A term denoting a surface like the outside of a sphere or ball.

Copolymer. A compound consisting of two combined polymers.

Cord. An attenuated glassy inclusion possessing optical and other properties differing from those of the surrounding glass.

Core ply. The main ply.

Corona. An electrical field emission surrounding a conducting body; characterized by ionization of the air and often a visable glow.

Correction, color. The reduction of longitudinal, lateral, and secondary chromatic aberrations. The color correction may be specified in terms of the Fraunhofer lines in the solar spectrum, indicative of the wavelength of rays for which the correction has been made; for example, C-F correction.

Cracks, fire. Small clefts or fissures penetrating the surface of the glass, usually in the shape of short-hooked crescents. Fire cracks are caused by the sudden heating or chilling of the surface.

Crack Propagation Resistance. A measure of the work, other than that resulting in permanent deformation, which is absorbed per unit nominal area of crack extension, determined at the time when a creeping natural crack leaps forward. This property is sometimes called "shatter resistance" or "toughness". See K-value, Shatter Resistance, Toughness.

Cradle. A box or crate for the temporary handling of a piece of glass or other material.

Crazing. Fine cracks which may extend in a network in or under the surface or through a plastic. These cracks gradually enlarge with continued application of load. See Crizzle.

Creep. The change in deformation of a material with time under load, following the instantaneous elastic or rapid deformation.

Cribbing. The process of breaking the excess glass from the required shape.

Critical Optical Area. In a windscreen or canopy all of the optical area inside the semicritical optical area as shown on drawings or defined by the applicable specification. High quality area used for critical visual observation purposes.

Crizzle. An imperfection in glass in the form of a multitude of fine surface fractures. For plastic, see crazing.

Crown Flint Glass. An optical crown glass bordering on optical flint glass because of the addition of a substantial content of lead oxide and with somewhat higher dispersion than optical crown glass.

Crown Glass. A type of optical glass, of the alkali-lime-silica type. Usually having an index of refraction in the 1.5 to 1.6 range and an Abbe number (v) in the 64 to 57 range. Since the positive element of an achromatic lens is almost always made of crown glass, it is often referred to simply as the "crown" as differentiated from the negative element, "the flint". See Flint glass.

Crush. A lightly pitted area resulting in a dull gray appearance, usually the result of the abrasive action of a glass chip between two sheets of glass. See scratches.

Crust. A stain in a glass surface.

Cullet. Broken or refuse glass for remelting.

Curvature of Field. An aberration of a lens which causes the image of a plane to be focused as a curved surface instead of into a plane.

Curve, luminosity. A term so called by the Committee on Colorimetry, Optical Society of America to denote the plot of spectral luminous efficiency against wavelength.

Curve, luminosity, absolute. A term so called by the Committee on Colorimetry, Optical Society of America to denote the plot of spectral luminous efficiency against wavelength.

Cyclometer. A device for measuring radius of curvature of a cylindrical surface.

Cylinder Axis. The meridian perpendicular to that in which the cylindrical power functions.

D

Dark Adaptation. Ability of the eye to adjust itself to a low level of illumination.

Daylight Opening. All of the transparent area of the finished part.

Di-Butyl Sebacate (DBS). Abbreviation. Plasticizer for polyvinyl butyral, an interlayer.

Deckle. A ragged, uneven or rough edge.

Defects, beauty. Imperfections on optical surfaces that are not optically critical, and that do not appreciably impair performance.

Defects, minor optical. The imperfections such as scratches, inclusions, bubbles, blemishes, found in transparencies. When not too numerous or do not form an objectionable pattern, are not cause for rejection of the transparency.

Definition. A combination of resolving power and contrast.

Deformation Point. The temperature observed during the measurement of expansivity by the interferometer method at which viscous flow exactly counteracts thermal expansion. The deformation point generally corresponds to a viscosity in the range from 10^{11} to 10^{12} poises.

Delamination, edge. Separation of the layers of a material at the edge of a laminate.

Delamination, internal. Separation of the layers of material in a laminate other than at the edge.

Dense. In optical glass, the subclass of a higher index of refraction.

Density. A term used as a synonym for density, optical.

Density, diffuse. Logarithm to the base 10 of the reciprocal of diffuse transmittance.

Density, luminous. Luminous energy per unit volume.

Density, optical, internal. Logarithm to the base 10 of the reciprocal of the internal transmittance (also called transmission factor).

Desaccommodation. Focus of the eye from the Nearpoint to the Farpoint.

Deviation. The deflection of a ray of light passing through a transparent medium caused by non-parallism of opposite surfaces. Measured in angular milliradians, or in prisms in prism diopters.

Deviation, constant. That property of certain optical devices, e.g., a penta prism, that preserves the angular relationship between the entering and emerging rays passing through the device, regardless of the orientation of the device in the plane of deviation.

Devitrification. Crystallized glass usually opaque in appearance.

Devitrify. To deprive of glass-like luster or transparency — separation of glass components in a crystalline condition.

Diathermanous. Highly transparent to infrared radiation.

Dice. The more or less cubical fracture of tempered glass.

Dichroic. Exhibiting the quality of dichroism.

Dichroic Materials. Materials which exhibit dichroism, in either one or both of the senses listed.

Dichroism. As applied to anisotropic materials, such as certain crystals, this term refers to the selective absorption of light rays vibrating in one particular plane relative to the crystalline axes, but not those vibrating in a plane at right angles thereto. As applied to isotropic materials this term refers to the selective reflection and transmission of light as a function of wavelength regardless of its plane of vibration. The color of such materials, as seen by transmitted light, varies with the thickness of material examined. An alternative term for this phenomenon might be polychromatism.

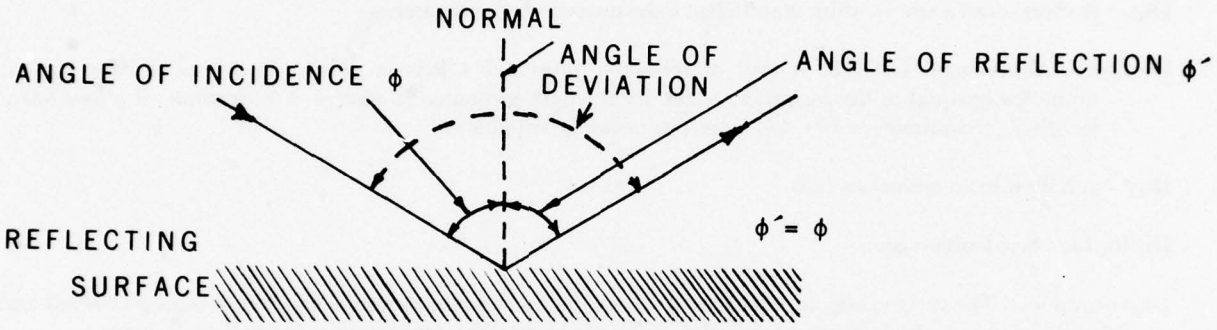


FIGURE 7 ANGLE OF INCIDENCE AND ANGLE OF REFLECTION

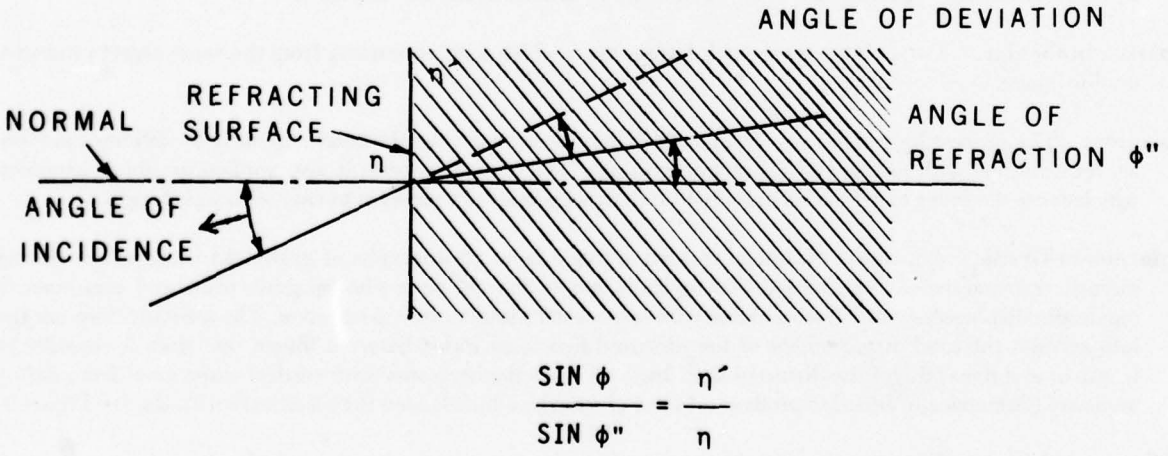


FIGURE 8 ANGLE OF INCIDENCE AND ANGLE OF REFRACTION

Dicing. The violent breakage of an air-tempered or chemically strengthened glass or glass ceramic which produces conchoidal particles with no dimension greater than the thickness of the material.

Diffraction. The process by means of which the propagation of radiant waves or light waves are modified as the wave interacts with an object or obstacle. Some of the rays are deviated from their path by diffraction at the object whereas other rays remain undeviated by diffraction at the object. As the object becomes small in comparison with the wavelength, the concepts of reflection and refraction become useless and diffraction plays the dominant role in determining the redistribution of the rays following incidence upon the object.

Diffusion. The scattering of light by reflection or transmission. Diffuse reflection results when light strikes an irregular surface such as a frosted window or the surface of a frosted or coated light bulb. When light is diffused, no definite image is formed.

Diffusivity. The quantity of heat energy which can pass through a defined surface area of a sheet material, under a temperature gradient condition per unit of time.

Dig. A short scratch whose width is sufficient to be measured. See Scratches.

Diopter. Abbreviated DIOPT. A unit of refractive power of a lens or prism. In a lens or lens system, it is numerically equal to the reciprocal of the focal length measured in meters. For example, if a lens has a focal length of 25 centimeters, i.e., 1/4 meter, its power is 4 diopters.

Dip. A hollow in an optical surface.

Diplopia. See double-vision.

Dipvergence. The vertical angular disparity between the images of a common object seen through the left and right systems in a binocular instrument. It is defined as plus, when the right image is below the left image.

Dirt Hole. A hole in an optical surface filled with dirt such as polishing abrasive. See bubble, dig, pit, scratch.

Disc, airy. When light from a point source passes through a circular or annular aperature, and is brought to a focus by means of a lens, the image so formed is not a point, but owing to diffraction by the aperature, is a bright central disc of light surrounded by a series of progressively fainter rings. The central disc is called the Airy Disc by some authorities; others prefer to apply the term to the entire diffraction pattern.

Disparity, binocular. Two points, one in each retina, upon which light emanating from the same object produces a double image.

Dispersion. The process by which rays of light of different wavelength are deviated angularly by different amounts as, for example, with prisms and diffraction gratings. The term dispersion is also applied to other phenomena which cause the index of refraction and other optical properties of a medium to vary with wavelength.

Displacement Grade. A measure of optical distortion made from photographs of gridboard images seen through aircraft transparencies. The measure is typically made directly on a photographic print and measures the maximum displacement of a distorted line with respect to its undistorted orientation. The measure does not take into account the total displacement of the distorted line from its undistorted image, nor does it consider the length or angular width of the distorted line. In some cases the horizontal and vertical worst cases from defined areas are geometrically added to produce a factor of severity which is used for specification limits. See Figure 9.

Displacement, object. The movement of objects seen through a refracting prism towards the apex of a prism.

Distance, eye. The distance from the vertex of the last optical surface of the visual optical system to the exit pupil. Also termed "eye relief".

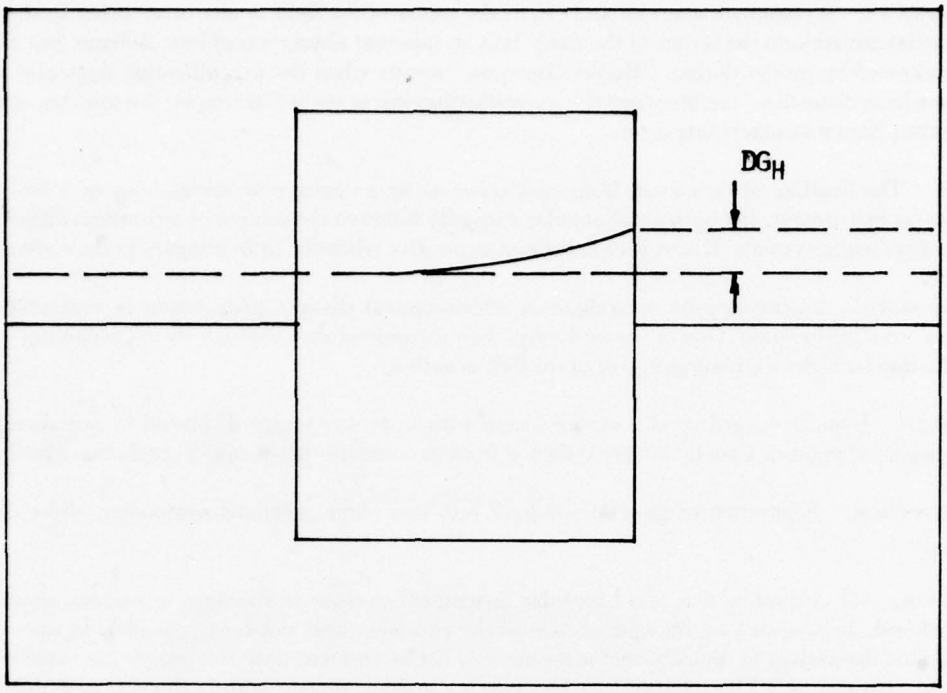


FIGURE 9 DG_H = DISPLACEMENT GRADE, HORIZONTAL

Distance, image. The axial distance between the image and the second principal point of a lens.

Distance, interpupillary. The distance measured in millimeters between the two eye pupils. See PD.

Distance, object. The distance from the object to the observer's cornea, or to the front vertex of the objective in an optical system.

Distance, optical. The length of the path covered by a ray between two points in a medium, multiplied by the value of the index of refraction of that medium.

Distortion. A manifestation of the increase, or decrease, of magnification as the obliquity of the chief ray increases. If the magnification increases with obliquity, we get nominal pin-cushion distortion; if it decreases, we get barrel distortion. See Figure 10. In transparency evaluation using a gridboard, distortion is described as the rate of change of deviation. When distortion is caused by gradual changes of deviation we see banding or waviness in the transparency. With rapid changes of deviation in a given area we see shimmer or orange peel in the transparency. These manifestations of different types of distortion will be exaggerated by increasing the angle of incidence or decreasing the radius of curvature of the transparency. See handling, wave, shimmer and orange peel.

Distortion, barrel. A form of distortion, radial. See Figure 10.

Distortion, pincushion. A form of distortion, radial. See Figure 10.

Distortion, radial. A change in magnification from the center of the field to any other point in the field, measured in a radial direction to the center of the field. It is an inherent aberration of lens systems, but can be eliminated or minimized by proper design. "Barrel distortion" results when the magnification decreases with field angle; "pincushion distortion" results when the magnification increases in field angle. Asymmetry of radial distortion can result from manufacturing errors.

Divergence. The bending of rays away from each other as by a concave or minus lens, or a convex mirror. In a binocular instrument, the horizontal angular disparity between the images of a common object as seen through the left and right systems. Divergence is defined as positive when the right image is to the right of the left image.

Double Exposure. A photographic technique in which optical distortion/deviation is evaluated by taking two "shots" of a grid system. One of the grid only, then the second shot through the transparency being evaluated. Evaluation is made of a photograph or of the film negative.

Double Image. Usually occurring as a strong image with a weaker image displaced in one direction and nearly superimposed upon it. Usually images reflected from two surfaces in the optical path. See Multiple images.

Double Refraction. Separation of unpolarized light into two plane polarized components by a doubly refracting crystal.

Double Vision. (1) A malfunction of a binocular instrument causing two images to be seen separately instead of being fused. It is caused by the optical axes of the two telescopes not being parallel. In minor cases, the eyes will adjust themselves to compensate for the error of the instrument until the images are superimposed and only one object is seen. (2) Physiologically, when viewing a single object, with both eyes, two objects are seen. See dipvergence and divergence and diplopia.

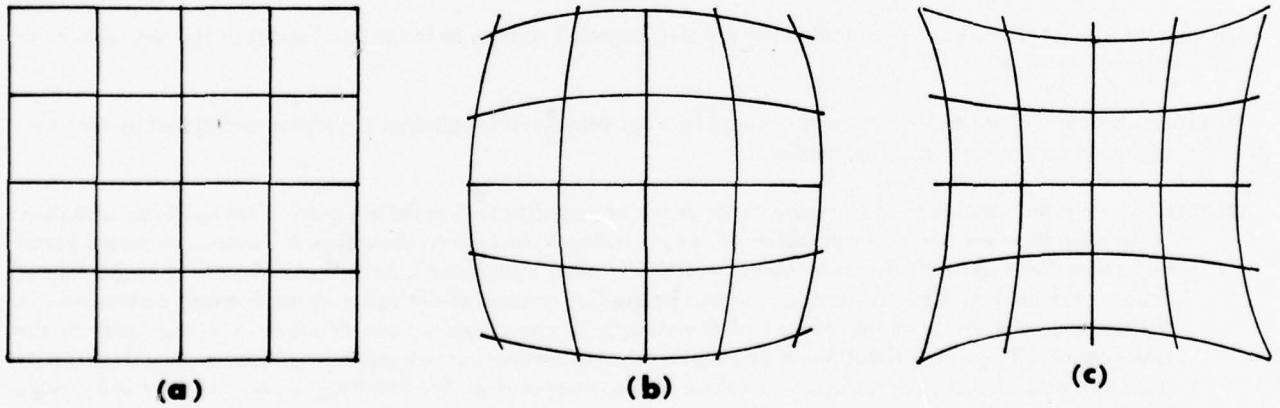


FIGURE 10 Images of a rectangular object screen shown with: a, no distortion; b, barrel distortion; c, pincushion distortion

Dross. Waste matter.

Dummy. A lens formed to the proper curve used to form the polisher. Also, a piece of glass included in a block to fill out the area, called a surround.

DV Light (German Light, Light Box). A device used for measuring the optical deviation of a transparency. It uses the principle of either matching primary and secondary images (reflectance) or displacement of images (projected). See Deviation.

E

Edge Attachment. The means of fastening the side edges of the glazing to the enclosure side beams. Also includes expansion joints and any other connection between the glazing and the enclosure frame. See Enclosure Frame, Expansion Joint.

Edge Chip. A small particle of glass broken out of the edge.

Edge Finish. See pencil edge, seamed edge or swiped edge.

Edging. Grinding the edge of flat glass to a desired shape or size.

Effect, stereoscopic. The sense of relief or solidity resulting when an object is viewed by both eyes. It is due to the fact that each eye views the object from a slightly different point of view or angle.

Efficiency, radiant. The quotient of the radiant flux emitted, divided by the power consumed.

Eikonometer. An instrument for determining size, inequality of binocular, retinal images.

Electrochromic. A crystalline material property which allows changes of color when electrically excited. See Lattice Imperfection.

Electromagnetic Spectrum. The entire range of wavelengths, extending from the shortest to the longest or conversely, that can be generated physically. This range of electromagnetic wavelengths extends almost from zero to infinity and includes the visible portion of the spectrum known as light.

Electromagnetic Theory. The theory of propagation of energy by combined electric and magnetic fields embodied in Maxwell's equations.

Elliptical Polarization. See polarized light.

Emergence. A term referring to the trigonometric relation between the emergent ray and the surface of the medium (See grazing emergence and normal emergence).

Emergence, grazing. A condition in which an emergent ray makes an angle of 90 degrees to the normal of the emergent surface of a medium. See critical angle.

Emergence, normal. A condition in which a ray emerges along the normal to the surface of a medium.

Emery. A dark granular variety of corundum (aluminum oxide) used for polishing.

Emissivity. The ratio of the radiant emittance of a source to the radiant emittance of a blackbody at the same temperature.

Emittance, luminous. A term applied to extended sources; the total luminous flux emitted by a unit area.

Emittance, spectral. A term which usually refers to radiant emittance as a function of wavelength. Where spectral luminous emittance is intended, it should be so specified.

Emmetropia. The theoretical condition of an eye in which no error of refraction is present.

Enclosure. The complete assembly, including canopy, edge attachments, frames, fairings, side beams, seals, etc.

Enclosure Frame. The entire structure immediately surrounding the canopy including side beams, transverse frames, and other reinforcements, but not including such items as aft fairings.

Enclosure, transparent. Any aircraft windscreen, canopy, or window.

Energy, luminous. The radiant energy times the luminous efficiency of radiation.

Erosion. Wearing away.

Error, pyramidal. The geometric error of the lack of parallelism among the edges formed by the faces of a prism. If the sharp edges have been removed by grinding, the above definition refers to the line of intersection of two faces extended, as constituting a prism edge.

Esophoria. Tendency of the eye(s) to turn inward.

ETA. Ethylene terpolymer adhesive (abbreviation).

Etch. To attack the surface of glass with hydrofluoric acid or other agent, generally for marking or decoration.

Etched. (1) Treated by etching. (2) Weathered so that surface is roughened.

ETP. Etheylene terpolymer; used as an interlayer.

EV. Electron volt; a unit of electrostatic energy, not a measure of potential difference.

Exophoria. Tendency of the eye(s) to turn outward.

Expansion Joints. Points of contact between the glazing material and enclosure frame designed to accommodate thermal expansion of the glazing material. Expansion joints are not load bearing as are edge attachments, but may be used to help support the glazing material. See Edge Attachment, Enclosure Frame.

Extinction Coefficient. See absorption coefficient.

F

Fabricate. To frame; construct; build.

Fade. Attack on the surface of glass causing an oily or whitish surface.

Fatigue. Deterioration of a member in a structure due to continued repetition of stress.

Feathers. An imperfection consisting of clusters of fine seed caused by dirt or foreign material entering the glass at the time of casting or shaping.

Fiber Optics. A device for relaying an image by means of a large number of transparent fibers (filaments) by multiple total internal reflection. The fibers are most commonly glass and less often a highly transparent plastic. Each fiber carries only one element of the image, so that the image is a mosaic in which the cell size is the fiber cross section rather than a continuous picture. The image may be transformed in almost any desired manner to a randomly scrambled picture, to produce magnification, or to produce the familiar optical distortions or conversely to correct them.

Field, apparent. The size of the field of view in the image space of an optical instrumet, as differentiated from the size of the field of view in the object space. In the absence of distortion, the following relation holds:

$$\tan \frac{a'}{2} = M \tan \frac{a'}{2}$$

where a' is the apparent field, M the magnification of the instrument, and a is the true field.

Field, linear. The actual width of the field of view at any distance.

Field of Vision. The total three dimensional space within which objects can be seen by moving the eyes and the head. See Visual Field of Regard.

Field, split. The field of view as seen when observing through some types of coincidence rangefinders. It is formed by the juxtaposition of opposite halves of the images produced by two objectives. The half-images are separated by the halving line.

Field, true. The size of the field of view in the object space of an optical instrument as distinguished from the size of the field of view in the image space (see apparent field). More specifically, it is the maximum cone or fan of rays subtended at the entrance pupil that is transmitted by the instrument to form the usable image.

Filter. Often referred to as "ray filter". It is a device with the desired characteristics of selective transmittance and optical homogeneity, used to modify the spectral composition of radiant flux. Usually special glass, gelatin, or plastic optical parts with plane parallel surfaces, which are placed in the path of light through the optical system of an instrument to selectively absorb certain wavelengths of light, reduce glare, or reduce light intensity. Colored, ultraviolet, neutral density, and polarizing filters are in common use. Filters are provided as separate elements or as integral devices mounted so that they can be placed in or out of position, as desired.

Filter, ray. A synonym for filter.

Fine Annealing. Annealing to an extremely low stress and uniform index of refraction.

Fining. (1) The process by which the molten glass approaches freedom from undissolved gases. (2) A grinding process using fine emery.

Fire-polish. To make glass smooth, rounded, or glossy by heating in a fire.

First Side. The surface of plate which is ground and polished first.

Fixation. In physiologic optics, the holding of the accommodation and convergence of one or both eyes for a given point of distance.

Flaking. In glass cutting, small chips leaving the sides of a cut score when the wheel is pressed too strongly or is improperly sharpened.

Flare. (1) The generation of unwanted images by multiple reflections in a transparency. The images so formed are called flare images or ghost images. (2) A knife or razor-edge left near the face of a piece of glass when the cut does not follow vertically through the plate.

Flat. A glass surface whose radius of curvature is infinite.

Flat Glass. A general term covering sheet glass, plate glass, and various forms of rolled glass.

Flat, optical. A test plate having an optically flat surface. Plane parallel surfaces are ground to be flat and parallel to about .00005 inch.

Flaw. In a moulded blank an inclusion of gas or dirt caused by folding of the glass.

Flint Glass. (1) A lead-containing glass. (2) Term used by container industry for colorless glass.

Flint Optical Glass. See optical Flint Glass.

Fluor Crown Glass. An optical crown glass containing a substantial quantity of fluoring and having a very low index of refraction and low dispersion.

Fluorescence. Luminescence that persists for less than about 10^{-8} second after excitation.

Flux. A term used as a contraction for radiant flux or luminous flux.

Focus. The term is used to describe the process of adjusting the eye-piece or objective of a telescope, so that the image is clearly seen by the observer. Often incorrectly used as a synonym for point, focal. The term is also used to denote the adjustment of the lens, plate, or film holder of a camera so that a sharp, distinct image is registered. Also, to move the entire microscope body tube with respect to a specimen, to obtain the sharpest possible image.

Focus, fixed. A term used to denote instruments that are not provided with a means of focussing.

Focal point. The point to which incident parallel rays of light converge, or from which they diverge when they have been acted upon by a lens or mirror. A lens has a single focal point on each side of itself. A mirror has but one focal point.

Fog. A term used to denote the foggy appearance of an incompletely polished surface which scatters light. The individual light scattering centers are too small and close together to appear as discrete. The term is also used to indicate the accumulation of moisture on an optical surface.

Fogginess. As applicable to windscreens, individual light scattering centers too small and/or close together to appear as discrete.

Fold. A flaw caused by folding the plastic surface of a blank during the forming of the blank.

Foot-candle. A unit of illuminance equal to one lumen incident per square foot. The illuminance (formerly called illumination) of a surface placed one foot from a light source having a luminous intensity of one candle.

Forming. The shaping of hot glass or plastic.

Frequency. In light, or other wave motion, the number of crests of waves that pass a fixed point in a given unit of time, usually one second.

Fresnel. A special type of lens designed by Augustin Fresnel, a French physicist, to refract light via a flat stepped surface. Originally used to produce a narrow parallel beam for search lights.

Fringe. Abbreviated FRNG. An interference band, such as Newton's ring.

Frosted. Surface-treated to scatter light or to simulate frost.

Fuse. To be blended — to melt.

Fusing. The permanent uniting of two pieces of glass or plastic by means of a high temperature process.

G

Gage, brass. A measure for determining the accuracy of the curvature of a lap or lens surface.

Generating. A term used to denote a rapid roughing process for quickly removing glass. It is accomplished by means of coarse emery and a regular, or diamond impregnated, lap.

Geometrical Optics. The branch of science which treats light propagation in terms of rays, considered as straight lines in homogenous media.

Ghost, prism. A term used as a synonym for a ghost image formed by a prism.

Glare. The sensation produced by brightness within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility.

Glare, direct. Glare resulting from high brightness or insufficiently shielded light sources in the field of view or from reflecting areas of high brightness.

Glare reflected. Glare resulting from specular reflections of high brightnesses in polished or glossy surfaces in the field of view. It is usually associated with reflections from within a visual task or areas in close proximity to the region being viewed.

Glare, disability. Glare which reduces visual performance and visibility and which is often accompanied by discomfort.

Glass. An amorphous inorganic product of fusion, usually transparent or translucent, consisting ordinarily of a solution of silicates which has cooled to a rigid condition without crystallizing.

Glass, baryta. A type of glass containing lead for increasing the index of refraction, together with barium which further increases the index, while maintaining a relatively low dispersion.

Glass, float. Glass which has virtually plane and parallel surfaces formed by floating in a continuous ribbon of glass on the surface of a bath of molten metal in a controlled atmosphere.

Glass, optical. A glass which during manufacture is carefully controlled with respect to composition, melting, heat treatment, and other processing in order that its optical characteristics such as its index of refraction, dispersion, transmittance, spectral transmittance, freedom from birefringence, permanence, etc., have the values required for the optical application for which it is to be used.

Glass, raw. A term used to denote any solid state of glass prior to its manufacture as an element.

Glass, reading. A low powered magnifier, generally of large diameter.

Glass, test. A master optical surface which is accurately made to a specified figure. It is used to measure the figure tolerance of the surfaces of production elements.

Glazing. Act of furnishing or fitting with glass or plastic.

Grating, power resolving, chromatic. The chromatic resolving power determines the minimum wavelength difference for any spectral order that can be distinguished as separate. The chromatic resolving power for diffraction gratings is usually stated for cases in which parallel rays of light are incident upon the grating and is numerically equal to the number of lines or ruled spacings in the grating (see spectral, order).

Green Block. A porous ceramic material capable of transmitting a partial vacuum, ground to an optical form on which a polished plate of glass is sagged by the application of heat. The glass contacts the green block surface by the applied vacuum and gravitation and the upper polished surface of the glass is used as an optical surface. Generally used for forming aspheric surfaces of medium precision.

Grey. A term used to denote an incompletely polished surface showing a greyness arising from the remains of fine grinding.

Gridboard. An optical evaluation tool used to demonstrate distortion in windscreens; a vertical rectangular backboard with horizontal and vertical intersecting lines using maximum contrast between the lines and background.

Grinding. A term used to denote the process in the fabrication of an optical element which gives it a specific geometrical shape.

Gross Distortion. When viewing a gridboard or outdoor scene from the appropriate eye position through the transparent enclosure, wavy, divergent, convergent, broken lines, or "bulls-eyes" shall be considered gross distortion.

H

Hackle Marks. Fine ridges on the fracture surface of glass, parallel to the direction of propagation of the fracture.

Hair Line. On a polished surface a fine line having no apparent width.

Hard Coat. A term applied to a process or to the result of a process of producing (usually) dielectric coatings that are more durable under adverse conditions than from other processes.

Hard Glass. (1) A glass of exceptionally high viscosity at elevated temperatures; (2) A glass of high softening point; (3) Commonly refers to a glass difficult to melt; (4) A glass hard to scratch.

Haze. (1) The percentage of incident light that is either lost to an optical system or is not image forming, thereby resulting in reduced contrast. Caused by internal scattering of the material. (2) An aggravated form of fog in a polished surface caused by light scattering. The defects causing haze are larger than those causing fog, but not large enough to be seen by the unaided eye as separated. Also known as surface haze.

Heat-absorbing Glass. Glass having the property of absorbing a substantial percentage of radiant energy in the near infrared of the spectrum.

Heat-resisting Glass. Glass able to withstand high thermal shock, generally because of low expansion coefficient.

Heat-treated. Term sometimes used for tempered glass. See Tempered Glass.

Heat Treating. A high temperature process (known also as tempering) which increases the resistance of glass to breakage under impact.

Herculite.® Trade name for fully thermally tempered glass at least 1/4 inch thick.

Herculite II.® Trade name for chemically strengthened glass.

Herculite "K".® Trade name for fully, thermally tempered glass 1/8 inch thick.

Heterogeneous. A mixture of several unlike substances — not uniform.

Heterophoria. Any tendency of the eyes to turn away from the position correct for binocular vision.

Heterotropia. Condition in which the two visual axes are not at the same angle when directed toward the same point. See Strabismus.

Hole, sand. Rough spots on the polished surface produced during coarse grinding, which subsequent fine grinding did not remove owing, to some extent, to coarse grains of grinding sand becoming mixed with finer grades.

Homogeneous. Uniform in structure, composition, etc.

Hoop. The peripheral edge attachment of a canopy.

Hue. The attribute of color perception that determines whether it is red, yellow, green, blue, purple, or the like.

Hydrophylic Compound. A material which has an affinity for moisture.

Hyperphoria. Tendency of the eye to turn upward. See Vertical Phoria.

Hypophoria. Tendency of the eye to turn downward.

Hysteresis. Concerns the inability of a material to return to its original linear dimensions after exposure to a defined temperature cycle.

I

Iceland Spar. A natural crystal form of calcite having a double index of refraction, that is, the incident ray is refracted as two rays, called the ordinary and the extra-ordinary. Calcite, used most often for making polarizing prisms.

Ideal Blackbody. See blackbody.

Ideal Radiator. See blackbody.

Illuminance. Luminous flux incident per unit area of a surface. Widely known as "illumination".

Illuminated. A surface or object is said to be illuminated whenever luminous flux is incident upon it.

Image. A representation of an object produced by means of light rays. An image-forming optical element forms an image by collecting a bundle of light rays diverging from an object point and transforming it into a bundle of rays which converge to a point a real image of the object point is formed; if the rays diverge without intersecting each other they appear to proceed from a virtual image.

Image, aspect of. A term denoting the orientation of the image, such as normal, canted, inverted or reverted.

Image, brightness of. A term used to denote the apparent brightness of the image seen through an optical system. This brightness depends on the brightness of the object, the transmission, magnification, distortion, and diameter of the exit pupil of the instrument.

Image, erect. An image, either real or virtual, that has the same spacial orientation as the object. The image obtained at the retina with the assistance of an optical system is said to be erect when the orientation of the image is the same as with the unaided eye.

Image, geometrical. A term used to refer to the location and shape of the image of a particle, as predicted by geometrical optics alone. The geometrical image is to be distinguished from the diffraction image, which is determined from consideration of both physical and geometrical optics.

Image, ghost. Spurious multiple unwanted images of objects seen in optical instruments, caused by the reflections from optical surfaces. By coating the optical surfaces with low reflection films, the harmful effects of ghosts are greatly reduced. See Imaging multiple, image, reflection.

Image Plane. The plane in which the image lies or is formed. It is perpendicular to the axis of the lens. A real image formed by a converging lens would be visible upon a screen placed in this plane.

Image, real. See image.

Image, reflection. An image formed by a reflecting surface. An unwanted reflection image is more properly termed a ghost image.

Image, reverted. An image, the right side of which appears to be the left side, and vice versa.

Images, ghost. (See imaging, multiple).

Imaging, multiple. Also known as ghost images or flare. The generation by a transparency of unwanted images by internal multiple reflections. See Multiple Images.

Imbalance, vertical. This condition can be created physiologically because of a binocular anomaly or artifically by introduction of vertical prism before the eye.

Impregnate. See Laminate.

Incandescence. The emission of light by thermal radiation in quantities sufficient to render the source of radiation visible.

Incidence. The act of falling upon, or affecting, as light upon a surface.

Incidence, grazing. A term used to denote light incident at 90 degrees to the normal.

Incidence, normal. A term used to denote light incident at 90 degrees to the surface. Often referred to as the normal.

Incident Ray. A ray of light which falls upon or strikes the surface of an object such as a lens, mirror, windscreen, or canopy. It is said to be incident to the surface.

Inclusion. A term used to denote the presence, within the body of the glass or plastic of extraneous or foreign material (see bubble, seed, stria).

Index, absolute. A synonym for refraction, index of.

Index of Refraction. A number applied to transparent substances which denotes the relation between the angle of incidence and the angle of refraction when light passes from one medium to another. The index between two media is called the relative index, while the index when the first medium is a vacuum is called the absolute index of the second medium. The index of refraction expressed in tables is the absolute index, that is, vacuum to substance at a certain temperature, with light of a certain wavelength. Examples: vacuum 1.000; air 1.000292; water 1.333; and ordinary crown glass 1.516. Since the index of air is very close to that of vacuum, the two are often used interchangeably as being practically the same. See Snell's Law.

Index, relative. See refraction, index of.

Infinity Optical. In the optical industry a term used to denote a distance sufficiently great so that light rays emitted from a body at the distance are practically parallel. Infinity is indicated by the symbol ∞.

Infrared. The electromagnetic radiation beyond the red end of the visible spectrum. The wavelengths range from .786 microns to 1 millimeter. Heat is radiated in the infrared region. Referred to as IR radiation (see IR).

Intensity, spherical, mean. The average value of intensity of a source with respect to all directions.

Interference. A term used to denote the additive process, whereby the amplitudes of two or more overlapping waves are systematically attenuated and reinforced. The term is applied also to the converse process in which a given wave is split into two or more waves by, for example, reflection and refraction at beamsplitters.

Interferometer. An instrument employing the interference of light waves for purposes of measurement, such as the accuracy of optical surfaces by means of Newton's rings, the measurement of optical paths, and linear and angular displacements.

Interlayer. A transparent flexible material used as a thermally compensating layer and adhesive between face sheets which expand or contract at different rates. In windscreens, a transparent adhesive material used to separate similar or dissimilar transparent plies. See CIP, DBS, PVB, Vinyl.

Inverted. Turned over; upside-down. Usually refers to the effect of a prism or lens upon the image. Inversion is the effect of turning upside-down.

IR. Infrared spectrum (abbreviation).

Irradiance. Radiant flux incident per unit area.

Irradiation. The product of irradiance and time, i.e., radiant energy received per unit area.

Iseikonic Lenses. Lenses especially designed to correct size inequality of retinal images.

Isoclinic Lines. These are uncolored lines corresponding to points at which the directions of the principal stresses are parallel to the directions of the analyzer and polarizer. They are loci of points at which the principal stresses make the same angle to an external system of coordinates.

Isothermal. Does not change temperature during the imposition of other variables.

Isotropic Materials. Material which exhibits similar properties when tested along axes in any direction.

J

Jump, image. The apparent displacement of an object due to an erroneous prismatic condition in an optical system.

K

Kink. Abrupt deviation from contour or flatness occurring in the tempering process or from defective bending iron.

K-Factor. A measure of the toughness or crack propagation resistance of an acrylic material.

K-Value. For electrically conductive coating, the ratio of power dissipated at either the hot spot or control point the average of the entire heated area.

Knot. An imperfection; an inhomogeneity in the form of a vitreous lump.

L

Laminar. Consisting of layers.

Laminar Shear Strength. The shear strength parallel to the laminar plane of a composite; also, in stretched acrylic, the shear strength parallel to the principal surfaces.

Laminar Tensile Strength. Flatwise tensile strength perpendicular to the laminar planes.

Laminate. The process of bonding together two or more materials. The type of layup differs for different materials or applications.

The transparent laminates used as glazing materials consist of two or more sheets of transparent plastic or glass bonded with or without an adhesive.

The reinforced laminates used for edge attachments consist of one or more layers of reinforcing materials such as glass cloth or synthetic fabric cloth impregnated with a laminating resin. When the resin is cured, the resulting laminate has better properties than either component material. In some instances the laminating resin, if cured in contact with the glazing material, may act as an adhesive between the glazing material and the reinforced laminate. Reinforced laminates are sometimes referred to as impregnates.

Laminated. A term used to denote that the product consists of different layers of material.

Laminated Glass. A composite such as safety glass built up by cementing together two or more single sheets by means of a plastic.

Lap. (1) An imperfection; a fold in the surface of a glass article caused by incorrect flow during forming. (2) A tool used for polishing glass.

Lapping. A term used to refer to the grinding of a rough plano surface.

Lattice Imperfection. A molecular imperfection in a crystalline structure which allows it to change its optical properties upon application of external excitation.

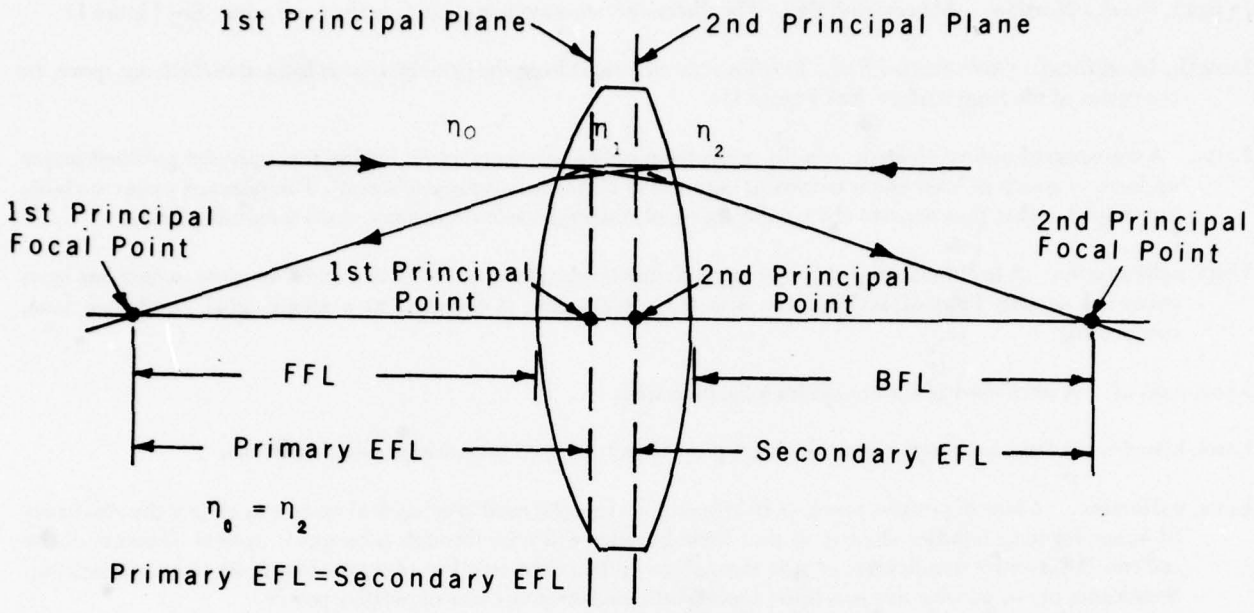


FIGURE 11 FOCAL LENGTHS, PRINCIPAL POINTS, AND PRINCIPAL PLANES

Law of Reflection. The angle of reflection is equal to the angle of incidence; the incident ray, reflected ray, and normal, all lie in the same plane.

Law of Refraction. See Snell's Law.

Layout. (1) In the laboratory, this term refers to the process of positioning and marking a blank or lens preparatory to surfacing or cutting and edging. (2) In manufacturing, this term refers to a quantity of work keyed to a time factor.

Leach. A glass surface from which some of the glass constituents have been removed by chemical action.

Lead Barium Crown Glass. See Barium Flint Glass.

Lead Crown Glass. See Crown Flint Glass.

Lead Glass. Glass containing a substantial proportion of lead oxide (Pb0).

Least Circle of Aberrations. See circle of confusion.

Length, base. The distance perpendicular to the line of sight between the centers of the two entrance pupils in a two-pupil system.

Length, focal. In a lens, focal length is synonymous with equivalent focal length. In a mirror or single refracting surface, it is the distance measured from the focal point to the mirror or surface.

Length, focal, back. Abbreviated BFL. The distance measured from the vertex of the back surface of the lens to the rear focal point. See Figure 11.

Length, focal, effective. Abbreviated EFL. The distance from a principal point to the focal point. See Figure 11.

Length, front focal. Abbreviated FFL. The distance measured from the principal focus located in the front space, to the vertex of the front surface. See Figure 11.

Lens. A transparent optical element, usually made from optical glass or plastic having two opposite polished major surfaces of which at least one is convex or concave in shape and usually spherical. The polished major surfaces are shaped so that they serve to change the degree of convergence or divergence of the transmitted rays.

Lens, achromatic. A lens consisting of two or more elements, usually made of crown and flint glass, which has been corrected so that light of at least two selected wavelengths is focussed at a single axial point. See lens, compound.

Lens, axis of. A term used as a synonym for axis, principal.

Lens, bitoric. A lens, both surfaces of which are ground and polished in a toric or cylindrical form.

Lens, collective. A lens of positive power (a field lens, for example) used in an optical system to refract the chief rays of image-forming bundles of rays, so that these bundles will pass through subsequent optical elements of the system. If the entire bundles do not pass through an optical element a loss of light ensures, known as vignetting. Sometimes the term collective lens is used incorrectly to denote any lens of positive power.

Lens, compound. A lens composed of two or more separate pieces of glass or other optical material. These component pieces or elements may or may not be cemented together. A common form of compound lens is a two element objective, one element being a converging lens of crown glass and the other a diverging lens of flint glass. The combination of suitable glasses or other optical materials (plastics, minerals).

Lens, concave. A term used as a synonym for lens, diverging.

Lens, concavo-convex. A term used as a synonym for meniscus.

Lens, concentric. An optical component, usually a single element, in which the centers of curvature of the surfaces coincide. Concentric lenses thus have a constant radial thickness in all zones.

Lens, condensing. A lens or system of lenses of positive power used for collecting radiant energy from a source and focussing it upon other optical elements.

Lens, converging. Also known as a "convergent lens," "positive lens," "convex lens," "collective lens," and colloquially in some optical shops as a "crown" lens. A lens that adds convergence to an incident bundle of rays. One surface of a converging lens may be convexedly spherical and the other plane (plano-convex), both may be convex (double-convex, biconvex) or one surface may be convex and the other concave (converging meniscus).

Lens, convex. A synonym for lens, converging.

Lens, convexo-concave. A synonym for meniscus.

Lens, corrected. A lens so designed that it is sufficiently free from one or more aberrations. Such a lens, for example, may be a simple lens with an aspheric surface, or it may be a compound lens consisting of several optical elements and different glasses.

Lens, cylindrical. A lens with a cylindrical surface. Cylindrical lenses are used in range-finders to introduce astigmatism in order that a point-like source may be imaged as a line of light. By combining cylindrical and spherical surfaces an optical system can be designed which gives a certain magnification in a given azimuth of the image and a different magnification at right angles in the same image plane. Such a system is designated as being anamorphic.

Lensing. The inherent positive or negative dioptric power found in a curved finished transparency (i.e., windscreen, canopy). In specific windscreens, it also means a magnification of minification of gridboard lines.

Lens Measure. A mechanical device for measuring surface curvature in terms of dioptric power. See diopter.

Lexan.® G.E. trade name for polycarbonate.

Light. A pane of glass. See glazing.

Light Adaptation. Ability of the eye to adjust itself to a change in the intensity of light.

Light, collimated. A light bundle in which the rays emanating from any single point in the object are parallel to one another. Light from an infinitely distant real source, or apparent source, such as collimator reticle, is collimated light.

Light, parallel. A synonym for light, collimated.

Light, pencil of. A narrow bundle of light rays, diverging from a point source or converging toward an image point.

Light, polarized. A light beam whose electric vectors vibrate along the same direction, that is in a single plane containing the line of propagation, is said to be "plane polarized" (often called linearly polarized). If each electric vector can be broken into two perpendicular components that have equal amplitudes and that differ in phase by 1/4 wavelength, the light is said to be "circularly polarized". Circular polarization is obtained whenever the phase difference between the two perpendicular components is any odd, integral number of quarter wavelengths. If the electric vectors are resolvable into two perpendicular components of unlike amplitudes and differing in phase by values other than 1, 1/4, 1/2, 3/4, etc., wavelengths, the light beam is said to be "elliptically polarized".

Light, quantity of. A term applied to the produce of luminous flux and time.

Lime Crown Glass. An optical crown glass containing a substantial quantity of calcium oxide.

Lime Glass. A glass containing a substantial proportion of lime, usually associated with soda and silica.

Line of Sight (LOS). Line of vision; optical axis of a telescope or other observation instrument. Straight line connecting the observer's eye with the aiming point; the line along which the sights are set.

Lines. Fine cords or strings, usually on the surface of sheet glass.

Lint. All laminated sheets will contain small quantities of dirt, dust, hair and fuzz. Collectively these are defined as lint. Lint is lightly and uniformly dispersed. Ordinarily it can be seen only when examined closely.

Long. A comparative term signifying a slow-setting glass.

Lumen. The unit of luminous flux, equal to the flux issuing from one-sixtieth of a square centimeter of opening of a standard source, and included in a solid angle of one steradin.

Lumen-hour. A term used to denote the unit quantity of light equal to one lumen of luminous flux flowing for one hour.

Lumen-second. A term used to denote the unit quantity of light equal to one lumen of luminous flux flowing for one second.

Luminaire. A light or lamp.

Luminance. The ratio of the luminous intensity emitted in a given direction by an infinitesimal area of the source, to the projection of that area of the source upon the plane perpendicular to the given direction. Usually stated as luminous intensity per unit area; i.e., luminous flux per unit solid angle emitted per unit projected area.

Luminescence. The process whereby matter emits radiation which for certain wavelengths, or restricted regions of the spectrum, is in excess of that attributable to the thermal state of the material and the emissivity of its surface. The radiation is characteristic of that particular luminescent material.

Luminescent. Pertaining to any emission of light not ascribable directly to incandescence, occurring at low temperatures.

Luminosity. A term so called by the Committee of Colorimetry, Optical Society of America, to denote the ratio of luminous flux to the radiant flux in a sample of radiant flux, for example, lumens per watt of radiant energy.

Luminous Efficiency of Light Sources. Ratio of the luminous flux emitted to the power consumed by the source, for example, lumens per watt applied at the source.

Luminous Efficiency of Radiation. The ratio of luminous flux to the radiant flux in a sample of radiant flux, for example, lumens per watt of radiant energy. Luminous efficiency of radiation is called luminosity by the Committee on Colorimetry, Optical Society of America.

Luminous Efficiency, Relative. The ratio of the radiant flux at wavelength λm to that required at wavelength λ for producing equally intense luminous sensations under specified photometric conditions where λm is the wavelength for which the ratio assumes its maximum value of unity. Relative luminous efficiency is often designated by the symbol $V\lambda$ or $V(\lambda)$. The plot of $V\lambda$ against λ is called the luminosity curve by the Committee on Colorimetry, Journal of the Optical Society. Refers to the standard Photopic observer unless otherwise stated.

Luminous Efficiency, Spectral. Luminous efficiency of radiation evaluated as a function of wavelength. The plot of spectral luminous efficiency against wavelength is called the absolute luminosity curve by the Committee on Colorimetry, Optical Society of America.

Luminous Flux. The quantity that specifies the capacity of the radiant flux to produce the attribute of visual sensation known as brightness. Luminous flux is radiant flux evaluated with respect to its luminous efficiency. Unless otherwise stated, luminous flux pertains to the standard, photoptic observer.

Luminous Intensity. Ratio of the luminous flux emitted by a source or an element of the source in an infinitesimally small cone about the given direction to the solid angle of that cone. Usually stated as luminous flux emitted per unit solid angle.

Luster. The appearance characteristics of a specimen due to pronounced changes in intensity of light reflected from elemental areas of the specimen when the angle of illumination or view is changed.

Lux. A term used to denote the lumen per square meter; a unit of illuminance.

M

Magnification. Magnification is best defined by the following conditions: (1) Lateral magnification is the ratio of the linear size of the image to that of the object, as used in enlarging lenses. (2) Angular magnification is the ratio of the apparent size of the image seen through an optical element or instrument to that of the object viewed by by unaided eye, when both the object and image are at infinity (telescopes), or when both the object and image are considered to be at the distance of distinct vision (microscopes). Angular magnification is often used as a synonym for power, magnifying.

Magnification, normal, individual. When a magnifier is used by an individual having myopia, or hyperopia, the magnification is different from the absolute magnification and is called "individual normal magnification".

Magnifier. A lens or lens system forming an enlarged virtual image of an object placed near its front focal point. Magnifiers are also referred to as "loupes," "simple microscopes," or "magnifying glasses". The magnifications of magnifiers range from approximately, 3x to 20x.

Major Defects. Gross distortion, excessive surface mark off, chips, cracks, crazing, deep scratches, any defect which causes distortion. Scratches less than .002 in. deep so grouped as to produce a fogged area.

Mark, scuff. A term used to denote damage to polished surfaces due to scraping against an abrasive surface during handling.

Masking. The process of protecting a highly polished plastic surface, usually accomplished by the application of heavy kraft paper to the surface with a pressure-sensitive adhesive that is not harmful to the plastic or by the application of a strippable coating. See Spraylat.

Medium (Plural, Media). Any substance or space through which light can travel.

Melt. A specific quantity of glass made at one time.

Memory. A characteristic of a finished plastic part to return to its original shape once stress has been relieved beyond the forming temperature.

Meniscus. A lens having only spherical surfaces, one of which is convex, the other concave.

Micron (μ). A unit of length in the metric system equal to 0.001 millimeter, also a unit of wavelength measure in the IR range.

Milkiness. A condition of pronounced cloudiness in glass or plastic, usually a quality control problem.

Millidiopters. A unit of metric measure equal to 0.001 diopters. The power of a lens in millidiopters is the reciprocal of its focal length in kilometers.

Millimicron (mμ). A unit of length in the metric system equal to 0.001 micron. It is also equivalent to 10 Angstroms.

Mirror. A smooth, highly polished surface for reflecting light. It may be plane or curved. Usually a thin coating of silver or aluminum on glass constitutes the actual reflecting surface. When this surface is applied to the front face of the glass, the mirror is termed a "front surface mirror".

Mirror, mangin. Essentially, a negative meniscus lens whose second or convex surface is silvered. By carefully choosing the radii, spherical aberration can be corrected for any given position of the image.

Mirror, paraboloidal. A concave mirror which has the form of a paraboloid of revolution. Sometimes the paraboloidal mirror may consist of only a portion of a paraboloidal surface through which the axis does not pass, and is known as an "off-axis" paraboloidal mirror. All axial parallel light rays are focused at the focal point of the paraboloid without spherical aberration, and conversely all light rays emanating from an axial source at the focal point are reflected as abundle of parallel rays without spherical aberration.

Mirror, surface, first. A term used as a synonym for mirror, surface, front.

Mirror, surface, front. An optical mirror on which the reflecting surface is applied to the front surface of the mirror instead of to the back, i.e., to the first surface of incidence.

Modulus. A positive number or quantity expressing the measure of a function, force, or effect, as of elasticity, resistance, etc.

Modulus of Rupture. The fictitious tensile or compressive stress, s, in the extreme fiber of a beam computed by the flexure equation $S + Mc/I$, where M is the bending moment that causes rupture, c is the distance from the neutral axis to the extreme fiber, and I is the moment of inertia of the cross-section area about the neutral axis.

Monochromatic. Having or consisting of one color.

Monocular. Pertaining to one eye.

Monolithic. One-ply of "as-cast" sheet, plastic or glass.

Monomer. A relatively simple compound that can react to form a polymer.

Monomeric Cement. Monomer used as an adhesive; it polymerizes (thickens and hardens) under the influence of heat, light, and/or catalyst in the joint.

MRB (Material Review Board). Used in the disposition of questionably acceptable finished transparencies.

Multiaxial Stretching. See Stretching.

Multiple Images. Usually occurring as a strong image with weaker images not in the same plane or of the same size and due to multiple reflections. If they do fall in the same plane as the strong image they are called ghost images.

N

N, n. A symbol used to indicate index of refraction. It is usually used with a subscript to indicate the wavelength of light, e.g., N_D or n_D indicates the index of refraction for sodium light of 5893 angstrom wavelength. The red and green-blue lines given by the hydrogen tube coincide with the Fraunhofer lines C(N_C) and F(N_F) respectively. Unless specified otherwise, N_o will be the value understood by the term refractive index.

Nanometer (nm) Unit of wavelength equal to 10^{-9} (one one-billionth) meter (formerly called millimicron (mμ).

Neutralization. The process of combining two lenses of equal and opposite powers to produce a resultant with zero power.

Newton's Fringes. Interference fringes of the same nature as Newton's Rings.

Newton's Rings. When two polished surfaces are cleaned and placed in contact with a thin air film between them, reflected beams of light from the two adjacent surfaces interfere to form a series of rings or bands known as Newton's rings or fringes. By counting these bands from the point of actual contact the departure of one surface from the other is determined. The regularity of the fringes maps out the regularity of the distance between the two surfaces. This is the usual method of determining the fit of a surface under test to a standard surface of a test glass.

Nonoptical Area. All of the acrylic or glass screened by the spacer, mounting frame, or machined surface as shown on the engineering drawings or defined by the applicable specification. Area not used for visual purposes.

Normal. Sometimes called the "perpendicular". An imaginary line forming right angles with a surface or other lines. It is used as a basis for determining angles of incidence, reflection, and refraction.

Notch Sensitivity. The ratio of the unnotched and the notched strengths of a material.

Nu-value. Expressed by the Greek letter ν or by the English V. Designates reciprocal dispersive power as follows:

$$\text{Nu-value} = \frac{n_D - 1}{n_F - n_C}$$

O

Object. The figure viewed through or imaged by an optical system. It may consist of natural or artificial structures or targets, or may be the real or virtual image of an object formed by another optical system. In the optical field, an object should be thought of as an aggregation of points.

Object Plane. That plane which contains the object points lying within the field of view.

Object, self-luminous and nonself-luminous. Self-luminous and nonself-luminous objects need to be distinguished since image formation can become quite different depending upon whether or not the object must be regarded as nonself-luminous. A self-luminous object radiates sufficient light flux to render its image visible, whereas nonself-luminous objects do not. Image formation with objects that scatter or diffuse the incident illumination markedly, is very similar to image formation with self-luminous objects.

Oblique Errors. Image errors arising from astigmatism, coma, oblique spherical aberration, lateral color, and distortion.

Ohms per square. A non-dimensional number used to classify the thickness of metallic coatings with relation to their electrical resistance.

Opacifier. Rendering impervious to the rays of visible light.

Opal Glass. A thin layer of opal glass on a supporting sheet of clear glass which transmits a slightly yellowish light. See translucent.

Opaque. Impervious to visible light, i.e., has zero luminous transmittance. A substance which is impervious to light applied to transparent or translucent substances. To make impervious to light.

Open Seed/Blister. A seed or blister leaving a hole in the glass surface. See blister.

Ophthalmic. Pertaining to the human eye.

Ophthalmic Glass. Glass used in spectacles, generally having specified optical and physical properties and quality.

Optical. Pertaining to vision and the phenomena of light.

Optical Axis. The line formed by the coinciding principal axes of a series of optical elements comprising an optical system; in other words, an imaginary line passing through the optical center of the system.

Optical Compenent. In an optical system one or more optical elements which singly or as a group serve a definite, major purpose in arriving at the total performance of the system.

Optical Density. Logarithm to the base 10 of the reciprocal of transmittance.

Optical Element. An optical part constructed of a single piece of optical material; usually single lenses, prisms, or mirrors.

Optical Glass Numerical Designation. The numerical designation in common usage is based on the index of refraction for sodium line (n_D) and the Nu-value (v). The unity factor for the index is dropped (that is, 1.496 becomes 496) and the decimal point for the Nu-value is also dropped (nu = 6.44 becomes 644). Thus, the glass is specified 496/644 without reference to chemical composition. In cases, it is permissible to precede the numerical designation by the abbreviated name indicative of composition. For instance, Borosilicate Crown (BCS) 496/644 may be used. For example, Dense Barium Crown may be Crown 610/574 or DBC 610/574, or just 610/574 meaning $n_D = 1.610$ and Nu-value = 57.4.

Optical Properties. In optical glass or plastic, those properties which pertain to the effect the medium has upon light, such as index of refraction, dispersion, homogeneity, and freedom from defects.

Optical Rotation. The angular displacement of the plane of polarization of light passing through a medium. The azimuthal displacement of the field of view achieved through the use of a rotating prism.

Optical Surface. A reflecting or refracting surface that closely approximates the desired geometrical surface. See lens, optical flat, paraboloidal mirror.

Optical System. A combination of optical components arranged so as to perform one or more optical functions. See optical components.

Optics. That branch of physical science which is concerned with the nature and properties of electromagnetic radiation and with the phenomena of vision. See Geometrical optics and Physical optics.

Orthoscopic. Corrected for distortion.

Overcoat. A term used to denote a layer of material applied to a coated surface to protect it from physical or chemical action. Normally used after finishing of a transparent part to protect it during shipment or storage.

Parallax. An apparent movement of an object against its background due to a change in position of the observer's eye. Optically, parallax in a telescope with a reticle is any apparent movement of the reticle in relation to distant objects seen within the field of view caused by a lateral movement of the observer's eye. This condition exists when the image in the telescope lies in one plane, usually the focal plane, and the reticle lies in another. In a camera, the apparent displacement is due to the fact that the camera lens and the view finder lens are on different axes.

Path, optical. The sum of the optical distances along a specified ray.

Patina. A thin film or coating which forms on various finished surfaces. On optical surfaces it is usually a sign of age.

P.D. An abbreviation for interpupillary distance.

Peel, orange. A term used to describe the unevened or dimpled appearance of a transparency surface which has been improperly or insufficiently polished. A polished surface showing a granular appearance under magnification. See Distortion.

Pencil Edge. Machine ground edge — usually a semi-circular profile.

Peripheral. Near the boundary or edge of the field of an optical system; the outer fringe.

Periscope. An optical instrument designed to displace the line of sight in a vertical direction. It is used to permit observation over the top of a barricade or out of a tank or submarine.

Perspex.® A trade name for polymethyl methacrylate.

Perturbations. Disturbances.

Phoria. Abbreviation for heterophoria.

Phosphate Crown Glass. An optical crown glass containing a substantial quantity of phosphorus pentoxide (P_2O_5).

Phosphate Glass. A glass in which the essential glass former is phosphorus pentoxide instead of silica.

Photochromic. A crystalline material property which changes color when exposed to certain light frequencies. See Lattice Imperfection.

Photoelastic. Showing the phenomenon of birefringence upon the application of stress.

Photometer. An instrument for comparing the luminous intensities of two sources by comparing the illuminance they produce.

Physical Optics. That branch of science which treats light as a wave phenomenom wherein light propagation is studied by means of wave fronts rather than rays.

Physical Tempering. See Thermal Tempering.

Pilkington Process. A process for making flat glass in which the glass continuously pours from a tank onto a spout and thence between forming rolls and is subsequently annealed as one continuous sheet.

Pipe, light. A channel through which light is conducted by means of reflections by the walls. The usual shape is cylindrical or conical, and usually makes use of total internal reflection to propagate the energy.

Pit. A term denoting small holes in a glass surface which can be seen as small red particles by reflected light.

Pitch Polishing. Polishing operation in which pitch rather than felt is the resilient carrier for the polishing agent.

Pits. Small indentations in the glass surface.

Plane. A surface which has no curvature; a perfectly flat surface.

Plane, focal. A plane through the focal point perpendicular to the principal axis of a lens or mirror. The film plane in a camera focused at infinity.

Planes, principal. Planes of unit magnification, i.e., a ray directed at the first principal plane appears to leave the second principal plane at the same height. See Lens.

Plastic (noun). A material that contains as an essential ingredient an organic substance of high molecular weight, is solid in its finished state and, at some stage in its manufacture or in its processing into finished articles, can be shaped by flow.

Plasticizer. A chemical agent added to plastic compositions to make them more flexible and more readily moldable.

Plate, corrector. An optical element computed to correct each zone of a reflector, or refractor, for spherical aberration.

Plate Glass. Flat glass formed by a rolling process, ground and polished on both sides, with surfaces essentially plane and parallel.

Plate, Schmidt. An aspheric plate placed at, or near, the center of curvature of a spherical reflector for correcting spherical aberration.

Plexiglas.® Trade name for acrylic plastic. Plex I, Plex II, and Plex 55 are also included.

Plus Lens. A term used to denote a convex surface or a lens having positive dioptric power or the ability to form a real image.

Point. A unit of lens thickness measurement. Five points are the equivalent of one millimeter.

Point of Fixation. In physiologic optics, the holding of accommodation and convergence of one eye (monocular fixation) or both eyes (binocular fixation) for a given point of distance.

Point, principal, first. The intersection of the optical axis and the first principal plane of an optical system.

Point, principal, second. The intersection of the optical axis and the second principal plane of an optical system.

Points, cardinal. In a thick lens or system of lenses, the two principal points, two nodal points, and two focal points. If the optical medium is the same in the object and image spaces, the principal points and the nodal points are coincident.

Points, conjugate. That pair of points on the principal axis of a mirror or lens so located that light emitted from either point will be focused at the other. Related points in the object and image are located optically so that one is the image of the other.

Points, Gauss. A synonym for points, cardinal.

Points, nodal. Two points within a lens or exterior to it such that any ray aimed at one will emerge from the lens parallel to itself from the second point (see points, cardinal). Figure 12.

Points, principal. The points of intersection of the principal planes and the optical axis (see points, cardinal).

Poise. A Standard International Unit of absolute viscosity.

$$\text{One Poise} = \frac{8}{\text{cm} - \text{s}} \quad \frac{\text{dyne} - \text{s}}{\text{Cm}^2} \quad \frac{\text{N} - \text{s}}{10\text{m}^2}$$

Polarimeter. A polariscope equipped with an half-shade device and an angular scale generally attached to the analyzer. It is used to measure the amount of rotation of the plane of polarization by materials placed within it.

Polariscope. A combination of a polarizer and an analyzer used to detect birefringence in materials placed between them or to detect rotation in the plane of polarization caused by materials placed between them.

Polarization. Briefly, the splitting of a beam of light into two components, each vibrating in its own plane.

Polarization, circular. See light, polarized.

Polarizer. An optical device for converting unpolarized or natural light into polarized light.

Polarizing Filter. A filter that polarizes the light passing through it.

Polished Plate Glass. See Plate Glass.

Polishing. The process of putting a highly finished surface on a glass or plastic surface.

Polishing, plastic. The process of polishing with a plastic pad.

Polyblend. A compound consisting of two or more polymers.

Polycarbonates. A family of polymers of which only the "bisphenol A" type is considered for structural aircraft glazing.

Polychromatism. See dichroism.

Polyesters. See Unsaturated Polyesters.

Polymer. A high molecular weight organic compound whose composition can usually be represented by a chain of repeating structural units.

Polymerization. The process of chemically linking or curing monomeric materials into a polymer.

Position, installed. The angular position of a windscreen as it would be found in an aircraft.

Power, optical. A measure of the ability to bend or refract light in a mirror or lens. It is usually measured in diopters.

Power, optical, inherent. Dioptric power remaining in a finished transparency as an unintentional result of fabrication. See lensing.

Power, magnifying. Synonymous with magnification, magnifying power is the measure of the ability of an optical device to make an object appear larger than it appears to the unaided eye. For example, if an optical element or system has a magnification of 2-power (2X) the object will appear twice as wide and high. The magnification of an optical instrument is equal to the diameter of the entrance pupil divided by the diameter of the exit pupil. For a telescopic system, the magnification is also equal to the focal length of the objective divided by the focal length of the eyepiece. Another expression for the magnification of an instrument is the tangent of an angle in the apparent field divided by the tangent of the corresponding angle in the true field.

Power, prism. The power of a prism, expressed in prism diopters is the apparent deviation, in centimeters, of an object located one (1) meter distant from the prism.

Power, resolving, chromatic. Some optical components, such as prisms and gratings, are used, not to resolve two or more objective points, but rather to separate two wavelengths of nearly equal value. The ability of the instrument to separate two such wavelengths is called chromatic resolving power and is specified as the ratio of the shorter wavelength divided by the difference between the wavelengths.

Power, stereoscopic. The gain in stereoscopic effect afforded by a magnifying binocular instrument, as compared with the ability of the unaided eyes. This power will vary with the separation of the objectives and the power of the instrument.

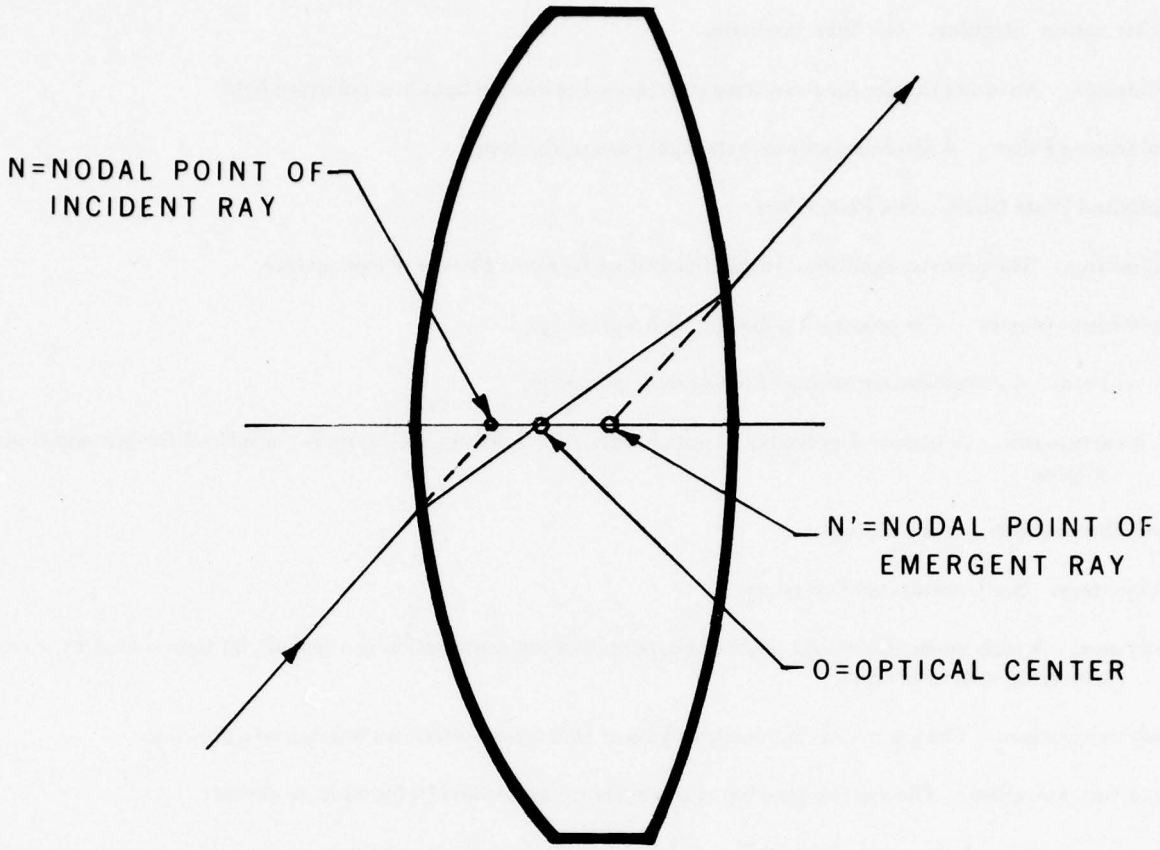


FIGURE 12 ILLUSTRATION OF NODAL POINTS

Power, vertex. The refractive power of a lens based on the measurement of the distance between the vertex of its rear surface and the secondary focal point.

Pressing. A blank with basic surface curves attained as the result of forming heat-softened glass by pressing in a mold.

Prism. A transparent body with at least two polished plane faces inclined with respect to each other, from which light is reflected or through which light is refracted. When light is refracted by a prism whose refractive index exceeds that of the surrounding medium, it is deviated or bent toward the thicker part of the prism. See Prism diopter, Figure 5.

Prismatic. Pertaining to a prism, or the effects produced by prisms.

Prismatic Effect. Pertaining to displacement of the optical center of a lens to produce the effect of a prism; in windscreens non-parallelism of the surfaces.

Prism, base of. The thick edge of a prism, also the non-transmitting side.

Prism Diopter. A unit of measure of the refracting power of a prism. One diopter is the power of a prism that deviates a ray of light by one centimeter at a distance of one meter from the prism.

Prism, objective. Usually a right-angle prism employed in some types of instruments to bend light 90 degrees before it enters the objective.

Prism, ocular. The prisms employed in a rangefinder to bend the lines of sight through the instruments into the eyepieces.

Prismograph. A graphical device for determining prism power.

Prism, power, resolving, chromatic. The chromatic resolving power of a prism is invariably stated for the case in which parallel rays of light are incident on the prism, in which the prism is oriented at the angle of minimum deviation at wavelength λ and in which the entire height of the prism is utilized. The corresponding resolving power R, deduced on the basis of Rayleigh's criterion is $R = \lambda/\Delta\lambda = b\, dn/\lambda$ where n is the index of refraction of the prism for the wavelength λ and b is the maximum thickness of prism traversed by the light rays. The quantities $dn/d\lambda$ and b are often called the dispersion and base-length of the prism, respectively.

Pupil, entrance. The image of the limiting aperature stop formed in the object space by all optical elements preceding the limiting aperature stop; also used as a term to denote the aperature of the objective when there are no other limiting stops following it in the system.

Pupil, exit. The image of the limiting aperature stop in an optical system formed by all lenses following this stop. In photographic objectives this image is virtual and is usually not far from the iris diaphragm. In telescopes the image is real and can be seen as a small bright, circular disc by looking at the eyepiece of the instrument directed toward an illuminated area of light source. In telescopes, its diameter is usually equal to the diameter of the entrance pupil divided by the magnification of the instrument. In Galilean telescopes the exit pupil is a virtual image between the objective and eyepiece and acts as an out-of-focus field stop.

PVB. Polyvinyl butral; used as an interlayer.

Pyrex.® Trade name applied to a wide variety of chemical, cooking, electrical and other glassware items made of low-expansion, heat-resistant, or chemically resistant glasses.

Q

Quality, image. Image quality embraces all the properties of a lens or optical system affecting the optical performance such as resolving power; aberrations, image defects, and contrast rendition. Aberrations contribute to poor image quality. Errors of construction and defects in materials adversely affect image quality. Because of the characteristic effects of aberrations on image quality it is possible to distinguish between their effects and those of accidental errors of workmanship or materials. Among the errors of workmanship are found nonspherical surfaces, poor polish, scratches, pits, decentering, defects in cementing, and scattered light, all of which contribute to deterioration of the image. Defects in glass such as bubbles, stones, striae, crystalline bodies, cloudiness, and strain play a part in poor image quality.

Quality, optical. Surface defects, scratch and dig rating, sphericity and related quantities are usually used to define quality of an optical element or system.

Quality, surface. A means of specifying allowable flaws by comparison to reference standards of quality. Two graded sets of surface quality standards are used. The first indicates defects of a long nature such as scratches, and the second illustrates essentially round defects such as digs. Desired surface quality is specified by reference to these in order, e.g., 80-50 or 80/50.

Quartz. A natural mineral composed of *silicon dioxide* (S_1 O_2) crystallized in the hexagonal crystallographic system. It is uniaxial and optically active. Quartz is used as an optical medium in scientific apparatus because of its transparency over a wide interval of the electromagnetic spectrum, particularly the ultraviolet.

Quartz, fused. A vitreous (glassy) material resulting from the fusion of crystalline quartz. It is optically isotropic, and has a much lower index of refraction than crystalline quartz.

Quartz Glass. A term applied to silica glass made by fusing vein quarta.

R

Radian. Angular measurement equal to $180°/\pi$ or 57.2958°.

Radiance. The radiant flux per unit of projected area and unit solid angle either leaving a surface at a given point in a given direction or arriving at a given point from a given direction.

Radiant Emittance. Radiant flux given off per unit area of a source.

Radiant Energy. The energy of electromagnetic waves.

Radiant Flux. Radiant energy transferred per unit time.

Radiant Intensity. Flux radiated per unit solid angle about a specified direction.

Radiant Power. See radiant flux.

Radiate. Disseminate, especially radiant energy, as light and heat from the sun.

Radiation, (or light), monochromatic. This term refers to the flux at one wavelength or frequency.

Radiator, complete. A synonym for blackbody.

Radiator, full. A synonym for blackbody.

Radiator, ideal. A synonym for blackbody.

Radiator, thermal. The process at emission wherein the radiated energy is extracted from the thermal excitation of atoms or molecules.

Radiometer. An instrument designed to measure radiant intensity.

Radius. A straight line extending from the center of a circle or sphere to the curve or surface.

Rail. The horizontal edge attachment of a canopy. Also see hoop.

Rainbow. Colored patterns in a transparency produced by the birefringent molecular nature of the material and stress gradients in the transparency. Certain angles and light polarizations in relation to some windscreen designs may produce bands of spectral colors localized in the transparency whose effect is to reduce the target image contrast.

Rainbowing. In aircraft transparencies the visible results of phase retardation of the incident light.

Ram Air Loading. The pressures on the forward surfaces of an aircraft which are derived from the compressive forces of the aircraft against the air mass through which it is flying.

Range, environmental. The maximum to minimum range of temperature, pressure, humidity, vibration, and biological conditions under which a transparency can operate and be stored, constitute its environmental range. The range required depends upon the intended use.

Rangefinder. An optical instrument used to determine the distance of an object or target by triangulation.

Ray. A contraction of the term ray, light.

Ray, chief. The central ray of a bundle of rays which passes through the center of the entrance pupil.

Ray, emergent. A ray of light leaving, i.e., emerging from a medium as contrasted to the entering or incident ray.

Ray, extraordinary. A ray which has a nonisotropic velocity in a doubly refracting crystal. It does not necessarily obey Snell's law upon refraction at the crystal surface.

Ray, light. The term applied to the lines perpendicular to the wavefronts of waves of light to indicate their direction of travel.

Ray, ordinary. The ray which has an isotropic velocity in a double refracting crystal. It obeys Snell's law upon refraction at the crystal surface. See Isotropic materials.

Ray, paraxial. A ray of a bundle of rays which is nearly parallel with the optical axis of an optical system. More properly, it is a ray in the sense of Gaussian or first order optics, see Geometrical Optics.

Ray, principal. In the object space, the principal ray is one directed at the first principal point, and hence in the image space this ray, projected backward, would intersect the axis at the second principal point.

Ray, reflected. The ray of light leaving a reflecting surface, representing the path of light after reflection.

Rays, diffuse. See reflection.

Rays, field. Those rays which pass through the center of the entrance pupil and subtend the greatest angle with respect to the optical axis of the optical system.

Ray, skew. In a system having rotational symmetry, it is a ray which does not lie in a plane containing the axis of the system.

Rays, marginal. Rays of light passing through the edge of the entrance pupil of an optical system.

RCS. Radar cross-section (abbreviation); the display of a returned radar signal from reflective surfaces which is considered a cross-section of the target.

Ream. A nonhomogeneity in flat glass in the form of an approximately plane layer.

Rectilinear. In a straight line. When applied to a lens, it indicates that images of straight lines produced by the lens are not distorted.

Rectilinear Propagation. Straight line travel; refers to the fact that light travels in a straight line while traveling through a medium of constant refractive index.

Refining. See Fining.

Reflectance. The ratio of the reflected flux to the incident flux. This term is applied to radiant and to luminous flux. Unless qualified, reflectance applies to specular (regular) reflection.

Reflectance, diffuse. The ratio of flux reflected diffusely in all directions to the total flux at incidence (specular reflection excluded). Also called "Total Diffuse Reflectance". Also, the reflectance of a sample relative to a perfectly diffusing, and perfectly reflecting standard with 45 degrees angle of incidence and observation along the perpendicular to the surface.

Reflectance, spectral. The reflectance evaluated as a function of wavelength. It is numerically the same for radiant and luminous flux.

Reflection. When light rays strike a smooth, polished surface they are bent back into the medium whence they came. Specular or regular reflection from a polished surface, such as a mirror, will return a major portion of the light in a definite direction lying in the plane of the incident ray and the normal (see reflection, angle of). After specular reflection, light can be made to form a sharp image of the original source. Diffuse reflection occurs when the surface is rough and the reflected light is scattered from each point in the surface. These diffuse rays cannot be made to form an image of the original source, but only of the diffusely reflecting surface itself.

Reflection, diffuse. See reflection.

Reflection, direct. See reflection.

Reflection, Image. See ghost image.

Reflection, internal, total. The reflection which takes place within a substance because the angle of incidence of light striking the boundary surface is in excess of the critical angle. See critical angle.

Reflection, mixed. The simultaneous occurrence of specular and diffuse reflection.

Reflection Reducing Coating. Glass reflection reducing coatings on glass-air surfaces consist of a thin film of transparent substances. These substances are so applied and their indices of refraction so chosen that they form a permanent hard coating which limits luminous reflectance at the surface to less than two percent. See coatings, antireflection.

Reflection, regular. See reflection.

Reflection, selective. See absorption, selective.

Reflection, specular. See reflection.

Reflectivity. The reflectance of an opaque material or of a layer of that material of sufficient thickness so that further increases in thickness do not alter the reflectance.

Reflectivity, spectral. The reflectivity evaluated as a function of wavelength.

Reflector. A polished surface or body for reflecting light or heat, as a mirror.

Refraction. The bending of oblique incident rays as they pass from a medium of one index of refraction into a medium of a different index of refraction. See Snell's law.

Relief. The discernment of depth or apparent difference in distance that makes the object stand out from its background due to stereoscopic vision. The impression of relief can be obtained from the arrangement of highlights and shadows when the object is viewed monocularly.

Relief, eye. A synonym for distance, eye.

Repressing. A synonym for blank, molded.

Reradiated. To absorb radiant or sensible energy and again radiate it.

Resilient. Returning to, or resuming, the original position or shape.

Resistant, bird. The requirement imposed on a windscreen to withstand bird impact while the aircraft is flying at a specified speed.

Resolution. In optics, the ability of a lens system to reproduce an image in its finest detail. (See resolving power.)

Resolution, angle of, limiting. The angle subtended by two points or lines which are just far enough apart to permit them to be distinguished as separate. The ability of an optical device to resolve two points or lines is called resolving power and quantitatively is inversely proportional to the limiting angle of resolution as defined.

Resolution of Measurement. The least increment of measure that can be discriminated.

Resolving Power. A measure of the ability of a lens or optical system to form separate images of two objects close together. No lens or optical system can form a perfect image of a point. Because of diffraction at the limiting stop of the system the image of a point will appear as a small bright disk surrounded by alternate concentric dark and bright circles. If two object points have such a small angular separation that the first dark ring of one diffraction image just falls upon the bright central disk of the other, the two points are just resolved, or distinguished as separated. Increasing the diameter of the limiting stop decreases the size of the above mentioned diffraction pattern and allows the resolution of points closer together. See limiting angle of resolution.

Reticle. A scale, indicator, or pattern placed in one of the focal planes of an optical instrument which appear to the observer to be superposed upon the field of view. Reticles, in various patterns, are used to determine the center of the field or to assist in the gauging of distance, determining leads, or measurement. A reticle may consist of fine wires, or fibers, mounted on a support at the ends, or may be etched on a clear, scrupulously polished and cleaned, plane parallel plate of glass. In the latter case the entire piece of glass is referred to as the reticle. An alternate but less common form of spelling is reticule. In England the term "graticule" is generally used.

Reticule. A polished glass plate upon which are placed scales or networks of lines used for measuring or counting.

Reversibility, law of. If the direction of light is reversed, it will travel in the opposite direction over the same path despite the number of times it is refracted or reflected.

Reverted. Turned the opposite way so that right becomes left, and vice versa. It is the effect produced by a mirror in reflecting an image.

Ripples. If a surface is polished without an oscillation of the polishing lap the polished surface contains approximately parallel waves or ripples.

Rolled Glass. (1) Optical glass formed by rolling into plates at time of manufacture, as distinguished from transfer glass. (2) Flat glass formed by rolling.

Roller Rub. The marring of the glass surface leaving a milky white or grayish appearance and having appreciable width as opposed to scratch.

Rouge. Iron oxide; a very fine abrasive used for polishing a lens surface.

Rouge Pits. An imperfection; traces of rouge remaining in an incompletely polished glass surface.

Rough Glass. A glass obtained by cutting the original sheet of rolled glass into workable sizes.

Roughing. A term used to denote a very coarse grinding process.

(RTV) Rubber. A type of flexible silicone rubber which is room temperature vulcanizing.

Rub. A glass surface defect caused by abrasion and has a frosted appearance. See Scratches.

Rubber. Any of a number of elastomeric compounds. Some are used in polyblends to improve impact resistance.

Rule, Prentice's. A means of determining prism power at any point on a lens. Prism power equals dioptric power multiplied by the distance in centimeters from the optical center.

Run. The overall production just as it emerges from the tank or the production line — without selection.

Runner Cut. See scratches.

Rx. Abbreviation for prescription.

S

Saddle. A term used to denote a saddle-shaped polished surface, generally an error, whose contours are indicated by the shape of Newton's rings. It is also a saddle-shaped image of a point light source caused by astigmatism.

Safety Glass. Glass so constructed, treated, or combined with other materials, as to reduce, in comparison with ordinary sheet glass or plate glass, the likelihood of injury to persons by objects from exterior sources or by those wearing safety glasses when they may be cracked or broken. Types of safety glass include: (1) Laminated Safety Glass — Two or more pieces of glass held together by an intervening layer or layers of plastic materials. It will crack and break under sufficient impact, but the pieces of glass tend to adhere to the plastic and not to fly. If a hole is produced, the edges are likely to be less jagged than would be the case with ordinary glass. (2) Tempered Safety Glass — A single piece of specially heat treated glass, with a stress pattern such that the piece when fractured reduces to numerous granular fragments, with no large jagged edges.

Sag. To cause a sheet of glass or plastic to conform to a ceramic or metal form, by heating the medium to its softening point and allowing it to settle. In the geometric sense, it is also used as an abbreviation for "sagitta," the height of a curve measured from the chord.

Sag Forming. A process used for forming glass or plastic by reheating it to a sufficient degree of flexibility for bending over or into a mold shape.

Sagging. See Sag Forming.

Saturating. The attribute of any color perception, possessing a hue, that determines the degree of its difference from the achromatic color perception most resembling it.

Scale, diopter. A scale usually found on the focussing nut of the eyepiece of an optical instrument. It measures the change in the position of the eyepiece necessary to product a correction to compensate the nearsightedness or farsightedness of the individual observer. Thus if the observer knows his diopter correction, he can preset the instrument for focus.

Score. Mark with lines, scratches, notches.

Scratch. Any marking or tearing of the surface appearing as though it had been done by either a sharp or rough instrument. Scratches occur on sheet glass or plastic in all degrees from various accidental causes. Block reek is a chain-like scratch produced in polishing. A runner-cut is a curved scratch caused by grinding. A sleek is a hairline scratch. A crush or rub is a surface scratch or series of small scratches generally caused by mishandling.

Scuff. Abrasion of the glass or plastic surface characterized by a series of shallow digs, usually caused by rubbing one glass or plastic surface against another.

Seamed Edge. Abrasive belt ground edge — usually nominally 45 degree bevels. Also called swiped edge.

Second Side. The final side of a sheet transparency to be ground and polished.

Seed. Minute bubbles less than 1/32 in. in diameter. Seeds are visible only upon close inspection, usually appearing as small specks, are usually present in any laminating interlayer. See minor optical defects.

Seeds, heavy. Refers to a condition when the fine and coarse seeds are very numerous.

Seeds, scattered. A term used to indicate the condition of a few and occasional easily visible coarse seeds. Two or three may be spaced 1 or 2 in. from each other, but one here and there at much greater distances apart is the usual intention of the term.

Selective Reflection. See absorption, selective.

Selective Transmission. See absorption, selective.

Selective Transmittance. The property of variation of transmittance with wavelength.

Semi-critical Optical Area. Outer margin around the daylight opening as shown on the engineering drawings or defined by the applicable specification. The area used for general vision purposes but not for critical visual observation. See semi-critical zone.

Setting Rate. A comparative term referring to the time required for the glass or plastic surface to cool between the limits of the working range. A short time implies a fast setting rate, and a long time implies a slow setting rate.

Shadowgram. Shadow of white light projected through a windscreen panel upon a back-projection screen. Dark shadows, grey, indicate areas of interest.

Shallow. A term used to denote a concave surface when its radius of curvature is too long, i.e., its negative power is too small or low.

Shatter Resistance. See Crack Propagation Resistance; K-Factor, Toughness.

Sheet Glass. Window glass drawn in sheet form from the molten glass and used without grinding or polishing.

Shimmer. The distracting visual effect of a multitude of high frequency interruptions of expected images. It can be produced by moving the eyes/head when viewing objects through a transparency. This phenomena is most striking when viewing a gridboard through a transparency. Probably caused by viewing an object through an area of small (minute) distortions from different angles because of eye/head movement.

Short. A comparative term signifying a fast-setting glass.

Short-finish. An imperfection in plate glass, resulting from incomplete polishing.

Sight, angle of. The vertical angle between the horizontal and the line of sight (line from weapon to target). Also known as angle of elevation.

Silica Glass. Vitreous SiO_2; quartz glass, pure SiO_2 glass.

Silver Spots. Spots in a polished surface of glass which are opaque and have a silvery, metallic reflection.

Skim. A term used to denote streaks of dense seeds with accompanying small bubbles.

Skylight. A very poor quality of plate glass.

Slab Glass. Optical glass obtained by cutting or forming the chunk glass into plates or slabs.

Sleek. An imperfection; a fine scratchlike mark having smooth boundaries, usually produced by a foreign particle in the polishing operation. See scratches.

Slope, grid line. An optics evaluation method of determining the slope of a deviated grid line to that of a non-deviated grid line. A ratio is the index of degree of distortion, e.g., 1:2, 1:8, or 1:16. Also called slope reading. See Figure 13.

Smooth. Finely ground, as applied to a flat glass surface, prior to polishing.

Smudges. These look like smears on the surface of the part but they are in the interior, usually in the vinyl interlayer. Smudges are difficult to define. A light smudge (which would be a slight discoloration) if of a nonobjectionable pattern may be considered an acceptable minor defect. A heavy smudge which would be more opaque and would command attention when viewing a distant object through the part would be considered objectionable.

Snake (Snaking). (1) Progressive longitudinal cracking in continuous flat glass operation. (2) Variation in width of sheet during the sheet glass drawing process.

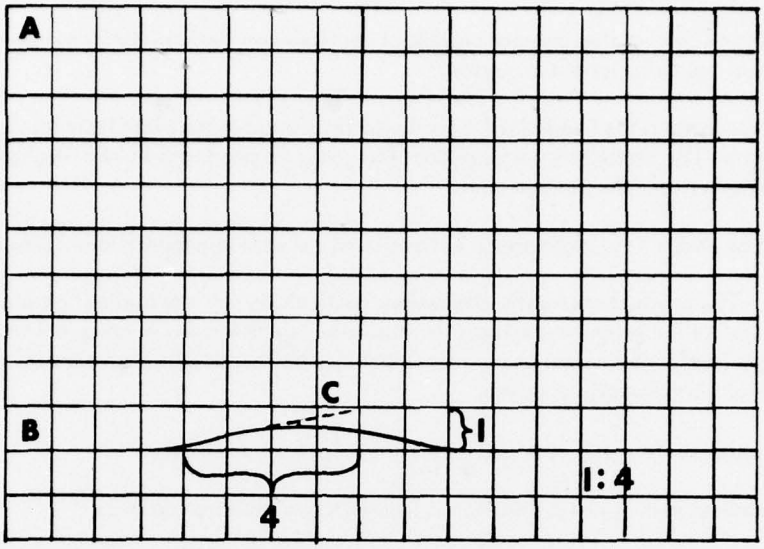
Snell, law of. When light is passing from a given medium to a denser medium, its path is deviated toward the normal; when passing into a less dense medium, its path is deviated away from the normal. Snell's law, often called the law of refraction, defines this penomenon by describing the relation between the angle of incidence and the angle of refraction as follows:

$$\frac{\text{The sine of the angle of incidence.}}{\text{The sine of the angle of refraction.}} \quad \frac{\text{The index of refraction of the medium containing the refracted ray.}}{\text{The index of refraction of the medium containing the incident ray.}}$$

This is written $\frac{\sin i}{\sin i'} \quad \frac{n'}{n}$

Softening Point (S.P.). The temperature at which a uniform fiber, 0.55 to 0.75 mm in diameter and 23.5 cm in length, elongates under its own weight at a rate of 1 mm per min when the upper 10 cm of its length is heated in the manner prescribed in the Method of Test for Softening Point of Glass (ASTM Designation: C 338) at a rate of approximately 5 C per min. For glass of density near 2.5, this temperature corresponds to a viscosity of $10^{7 \cdot 6}$ poises.

Solarization. Change in transmission of glass as a result of exposure to sunlight or other radiation.



A = Transparency
B = Gridline under consideration
C = Gridline slope
1 = One vertical square
4 = Four square run horizontally

FIGURE 13 SLOPE, GRIDLINE

Solvent. Any liquid that attacks and dissolves certain solids with which it comes in contact. Used here to designate solvents which attack acrylic and other transparent plastics, e.g., acetone, benzene, carbon tetrachloride, fire extinguisher and deicing fluids, lacquer thinners, aviation and ethyl gasolines, and certain glass cleaning compounds.

Solvent Cement. A solvent or mixture of solvents, sometimes including monomer, that softens a plastic so that two or more pieces may be bonded.

Spall. A small particle flaking off of a glass or plastic sheet. Spall from the inside surface of a windscreen as a result of high velocity impact could be harmful to the pilot.

Spark. A high-energy thermal emission of short duration of which lightning is the most severe case, and an electrostatic discharge spark between small bodies of opposite charge is the milder case.

Spatter. A term used to denote the condition resulting when small chunks of material may fly from the hot crucible onto the glass surface, and adhere there, in evaporative coatings.

Spectral Order, Diffraction Grating. When, for example, a beam of parallel rays of monochromatic light pass through a diffraction grating, the emergent rays that have remained undeviated belong to the zero spectral order. The light flux in the family of deviated rays that emerge after diffraction at the grating exhibit pronounced maxima along well defined and enumerable directions on each side of the undeviated beam. The integers that distinguish these directions mark the so-called spectral orders.

Spectrometer. A spectroscope provided with an angular scale capable of measuring the angular deviation of radiation or different wavelengths.

Spectroscope. Any one of a class of instruments capable of dispersing radiation into its component wavelengths and observing, or measuring, the resultant spectrum.

Spectrum. The visual spectrum is the band of color produced by decomposing white light into its components by the process of dispersion. The rainbow is an example of a spectrum produced by the dispersion of white light by water droplets (see spectrum, electromagnetic).

Spectrum, primary. The characteristic chromatic aberration of a simple nonachromatized lens or prism.

Spectrum, secondary. The residual chromatic aberration, particularly the longitudinal chromatic aberration of an achromatic lens. Unlike the primary spectrum, it causes the image formed in one particular color to lie nearest the lens, the images in all other colors being formed behine the first at distances that increase sharply towards both ends of the useful wavelength spectrum.

Spew. Layers of nonhomogeneous glass contained within the main body of the glass.

Sphere. A term commonly used in optics to designate a lens with two spherical surfaces.

Sphero-cylinder. A lens or lens surface which is a combination of a sphere and a cylinder.

Spheroid. A figure like a sphere, but not spherical.

Spherometer. An instrument for the precise measurement of the radius of curvature of surfaces. See Sag.

Split. An imperfection; crack or check going from surface to surface of a glass article.

Spraylat.® A trade name for thixotropic water base emulsion that forms a protective strippable coating for glass, or plastic articles.

Stain. Any erosion of the glass surface, cloudy in appearance, sometimes exhibiting apparent color.

Standard Observer. A fictitious subject that always gives the same response to the same stimulus.

Star Fracture. A minute radial craze usually originating from an inclusion, bubble or other microscopic defect. Can be detected by a bright pinpoint reflection in oblique light.

Streamering. An electrical field emission characterized by forklike glows in the presence of a high potential difference.

Steradian. The solid angle subtended at the center of a sphere by an area on its surface numerically equal to the square of the radius. The unit of solid angular measurement.

Stock, bad. Glass having defects which were incurred during original manufacture.

Stone. An opaque inclusion in glass consisting of undissolved or crystalline material.

Stop, aperture. Limits the size of the transmitted bundle of rays.

Strabismus. Same as heterotropia.

Strain. Mechanical tension, compression or shear in optical glass or plastic by internal stress and brought about by improper cooling or annealing during manufacture or the subsequent weakening of molded parts.

Strain Disk. A disk of glass having a calibrated amount of birefringence at a specified location, and used as a comparative measure of the degree of stress.

Strain Point. That temperature at which the internal stress in a glass is substantially relieved in about four hours.

Strength. A term to indicate relative thickness in sheet glass.

Stress. Tension or compression caused by incomplete annealing temperature differences in inhomogeneity or by forces imposed upon the object from without.

Stress, internal. The tension, compression, or shear stresses within an optical element usually caused by cooling or improper annealing.

Stretching. Stretching a heated plastic sheet either in two perpendicular directions or in all directions in the plane of the sheet to improve the physical properties by orientation of the molecules. For purposes of this lexicon no differentiation is made between the methods of obtaining improvements in physical properties by stretching. See acrylic, stretched.

Stria. (1) A defect in optical glass consisting of a sharply defined streak of transparent material having a slightly different index of refraction than the body of the glass. (2) A cord of low intensity generally of interest only in optical glass. See also Cord.

Striae (pl). Internal imperfections of glass appearing as wavy distortion.

Striking. Development of color or opacity during cooling or reheating.

String. An imperfection; a straight or curled line, usually resulting from slow solution of a large grain of sand or foreign material.

Stripe. See sleek.

Strum, interval of. Distance between the two focal points of an astigmatic image.

Surface. One of the exterior faces of an optical element. To grind or generate the face of an optical element.

Surface Errors. Departures of an optical surface from its specified tolerance for figure.

Surface Mark Off. Objectional surface distortion caused by contact with the die in the forming operations. Lines appear fuzzy when viewed through this area.

Surface Resistivity. A nondimensional number in ohms/square which is used to classify the thickness of metallic coatings with relation to their electrical resistances. See ohms per square.

Surface, toric. A surface swept out by revolving a circle about an axis that is in the plane of the circle but does not pass through its center. However, the term applied to other aspheric surfaces means a surface having different curvatures in different sections, the greatest and least powers occurring in meridians perpendicular to each other.

Surround. A term referring to both the color and intensity of the immediate environment of the object or image being viewed.

Sweet. Term applied to easily workable glass.

Swiping. Fogginess appearing as streaks.

Swirl. With normal head and eye movement behind a transparency, it is the elliptical motion of the secondary image around the primary image. Swirl is usually seen in areas of local magnification.

Systems, optical, catadioptric. An optical system containing both lens (dioptric) and curved mirror (catoptric) optical components. Occasionally a single component may be catadioptric, serving simultaneously as a lens or mirror.

T

Tangential Distortion. Tangential distortion is an image defect resulting in the displacement of image points perpendicular to a radius from the center of the field. It is usually caused by errors of centration. Lenses with spherical surfaces are usually designed to be so constructed that the center of curvature of all the surfaces lie on a single straight line termed the axis of the lens. If aspherical surfaces are used, their individual axis should correspond with the axis of the lens. Failure of compliance with these conditions is termed errors of centration. It may also be caused by astigmatism of the various lens elements and surfaces. See Distortion.

Tarnish. A thin film or stain on the surface of glass.

Tear. An imperfection; a small surface section of glass torn out by sticking to hot metal.

Temper. (1) The degree of residual stress in annealed glass measured polarimetrically or by polariscopic comparison with a standard such as one or more strain disks. See Strain Disk. (2) Term sometimes employed in referring to tempered glass. See Tempered Glass.

Temperature, *luminance*. The temperature of an ideal blackbody that would have the same luminance as the source in question for some narrow spectral region.

Temperature, radiation, total. The temperature at which a blackbody radiates a total amount of flux equal to that radiated by the body under consideration.

Tempered Glass. Glass that has been rapidly cooled from near the softening point, under rigorous control, to increase its mechanical and thermal endurance.

Tensile Strength. The resistance of a material to breakage under the stress of pulling or stretching.

Tension. The act of stretching, straining or tensing.

Test, Hartman. A test for spherical aberration, departure from the sine condition, or coma in which incident rays from a point source are isolated by means of small holes in a disk positioned in front of the lens or mirror under test. The focal points of the rays entering the lens or mirror at varying heights are then compared in the image space.

Test, knife edge, Foucault. A method of determining the errors in an image of a point source by partially occulding the light from an image by means of a knife edge. The same test may be used to measure the errors in refracting or reflecting surfaces.

Thermal Tempering. A process of heating glass to near its softening points and rapidly cooling it under rigorous control to achieve its tempered characteristics. Thermally tempered glass can range from "annealed" to "full," with semitempered glass being approximately midway between the two.

Thermoplastic. Capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature. Thermoplastic applies to those materials whose change upon heating is substantially physical.

Thermoset. A plastic that, when cured by application of heat or chemical means, changes into a substantially unfusible and insoluble product.

Thermosetting. Capable of being changed into a substantially unfusible or insoluble product when cured by application of heat or by chemical means.

Threshold, luminance. A contraction of the term threshold, luminance, absolute.

Threshold, luminance, absolute. A term used to indicate the lowest limit of luminance necessary for vision.

"Tin Float" or "Float" Glass. A process in which the glass is floated on molten metal at a sufficient temperature to heat polish while the opposite side is flame polished.

Tit. An imperfection; a small protrusion on a glass article.

Tolerance. Allowed amount of variation from the standard or specified dimensions.

Toughness. See Crack Propagation Resistance, K-Factor, Shatter Resistance.

Traction. The adhesive friction of a body on a surface over which it moves.

Transfer Glass. Optical glass cooled in the pot in which it is melted.

Translucent. Permitting light to pass freely, but so scattered that objects cannot be distinguished. See opal glass.

Transmission. The process by which incident flux leaves a surface or medium on a side other than the incident side.

Transmissivity. The internal transmittance for unit thickness of a nondiffusing medium.

Transmittance. The ratio of the flux transmitted by an object to the incident flux. This term and its specializations are applied to radiant and to luminous flux. Unless qualified, the term is applied to regular (specular) transmission.

Transmittance, diffuse. The transmittance measured with diffusely incident flux. Also, the ratio of the flux diffusely transmitted in all directions to the total incident flux.

Transmittance, internal. The ratio of the flux transmitted to the second surface of a medium to the corresponding flux that has just passed through the first surface, i.e., the transmittance from the first surface to the second surface. Internal transmittance does not include the effects due to interreflection between the two surfaces.

Transmittance, luminous. The ratio of the luminous flux transmitted by an object to the incident luminous flux.

Transmittance, radiant. The ratio of the radiant flux transmitted by an object to the incident radiant flux.

Transmittance, spectral. Transmittance evaluated at one or more wavelengths. Numerically the same for radiant and luminous flux.

Transparency. The property of a material by which a negligible portion of the transmitted flux undergoes scattering. Also any optically clear structure.

Transparent. Permitting light to pass freely, without scattering, so that bodies can be distinctly seen through the material.

U

Ultraviolet. Those rays of radiant energy immediately beyond the violet end of the visible spectrum, between 100 and 390 nanometers. Deleterious to the human eye. Causes varying degrees of deterioration to unprotected plastic aircraft transparencies.

Ultraviolet-Absorbing Plastic. A transparent plastic sheet in which the spectral transmittance at any wavelength in the 290-330 millimicron wavelength band does not exceed five percent when measured on a specimen 0.250 in. thick.

Uniaxial Stretching. A process used in the manufacture of certain films which also makes them birefringent by virtue of the molecular orientation.

Uniform Density. In a transparency, the property of attenuating visible light consistently throughout the part.

Unsaturated Polyesters. Compounds containing linear condensation products made from unsaturated dibasic acids, polyhydric alcohols, and a reactive monomer, usually styrene. Under the influence of heat and catalyst and, in some cases, an accelerator, the linear unsaturated polyester chains are crosslinked by the reactive monomer into thermoset solids.

UV. Ultraviolet spectrum (abbreviation).

V

V-Value. See Nu-value.

Value, nu. A term for constant, Abbe.

Value, vee. A term for constant, Abbe.

Vector, electric. A term referring to the electric field associated with an electromagnetic wave and hence with a light wave. The electric vector specifies the direction and amplitude of this electric field.

Velocity of Light. This term usually refers to the speed of monochromatic light waves, i.e., to the phase velocity. The velocity of light, c_o, in vacuum is 299,792.5 kilometers per second. The phase velocity in a medium is c_o/n where n is the refractive index at the wavelength of the light wave.

Vertex. The point of intersection of the optical axis with any optical surface.

Vertical Phoria. Tendency for one eye to deviate upward or downward with respect to the other eye.

View, field of. In general, the maximum cone or fan of rays passed by an aperature and measured at a given vertex. In an instrument, field of view is synonymous with true field. See visual field.

Viewing conditions. The conditions under which a visual observation is made, including the angular subtense, direction of view, and character of the surroundings.

Vignetting. A term used to denote the loss of light through an optical element due to the entire bundle not passing through.

Vinyl. An interlayer used in many aircraft laminates. The amount of plasticizer used determines "hard" from "soft" vinyl.

Virtual Image. If a bundle of rays having a given divergence has no real or physical point of intersection of the rays, then the point from which the rays appear to proceed is called the virtual image. The distance of the virtual image is inversely proportional to the divergence of the rays. Since there is no physical intersection of rays there is no real image that can be focused on a screen. The image of any real object produced by a negative lens or convex mirror is always virtual. The image produced by a positive lens of an object located within its focal length is also virtual.

Viscosity. Resistance to flow, of a material, particularly a liquid or molten material.

Viscous. Strongly resistant to flow.

Visible Spectrum. The portion of the electromagnetic spectrum to which the retina is sensitive and by which we see. Extends from about 380 to about 760 nanometers in wavelength of the radiation.

Vision, binocular. The simultaneous use of both eyes in the process of vision. Sometimes used as a contraction of binocular single vision.

Vision, distinct, distance of. The near-point distance of the normal eye conventionally given the value of 10 in. or 25 centimeters. This value is used in calculating the designated magnification of a simple magnifier or eyepiece.

Vision, stereoscopic. Vision in depth of three dimensions due to the spacing of the eyes. This spacing permits the eyes to see objects from slightly different points of view.

Visual Acuity. The angular resolving power of vision, or the least angular distance between two contours that can be distinguished from each other visually.

Visual Axis. An imaginary line drawn from the object of regard through the nodal point of the eye to the fovea centralis, or point of keenest retinal acuity.

Visual Field. The totality of perceived objects visible to the unmoving eye and fixed head of the operator at a particular moment. This term should be confined to the unaided eye of the observer. See Visual Field of Regard, and Field of Vision.

Visual Field of Regard. The total space within which objects can be seen by moving the eye, with the head stationary.

Visual Range. That distance where the contrast between object and background of the sky becomes imperceptible owing to aerial light.

W

Warm Forming. A process of forming stretched acrylic by forming at less than its deformation temperature in order to prevent relaxation to its original unstretched dimensions and properties.

Warp. Large surface irregularity.

Wash. In a cemented surface a streak appearing as a striation caused by index of refraction variations in the cement.

Water Glass. Sodium silicate glass that is soluble in water.

Wave. Vibration; a form of movement by which all radiant energy of the electomagnetic spectrum is assumed to travel. It is also used to denote a type of surface defect, usually due to improper polishing, sometimes known as waviness. See banding.

Wavefront. A surface normal to a bundle of rays as they proceed from a source. The wavefront passes through those parts of the waves which are in the same phase. For parallel rays, the wavefront is a plane; for rays diverging from or converging toward a point, the wavefront is spherical.

Wavelength. The length of a wave measured from any point on one wave to the corresponding point on the next wave; usually measured from crest to crest. Wavelength determines the nature of the various forms of radiant energy which comprise the electromagnetic spectrum; it determines the color or light.

Weathering. Attack on a glass or plastic surface by atmospheric elements.

Weather-O-Meter. Equipment used to determine effects of UV (sunlight) exposure on transparent materials, especially plastics.

Wedge, Wedginess. Departure of the opposite surfaces of laminated or monolithic transparencies from parallelism. Usually expressed in minutes or seconds of arc or in interference fringes per inch.

Welding Glass. Colored glass to protect a welder's eyes from injurious radiations. Absorbs UV and IR radiation as well as attenuating visible wavelengths.

White Light. Radiation having a spectral energy distribution that produces the same color sensation to the average human eye as average noon sunlight.

Window Glass. See Sheet Glass.

Windscreen. The areas of an aircraft transparency used for forward vision in taking off, flying, and landing; usually made of laminated glass or plastic. Also known as a windshield. In aircraft where the windscreen and canopy are inseparable, windscreen or windshield is implied when the term canopy is used.

Z

Zinc Crown Glass. An optical crown glass containing a substantial proportion of zinc oxide. See glass.

Zone, critical. Designated area of a windscreen used for gunsight, taxi, takeoff, and landing. See Critical optical area.

Zones. Concentric waves in a polished surface which appear as zones in the Newton's rings when a test glass is applied to the surface.

Zone, semicritical. Designated area of a windscreen used for general visual flight purposes but not usually used during takeoff and landing. See Semi-Critical optical area.

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