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FLASH REFLECTOR WITH IMPROVED CORNER ILLUMINATION

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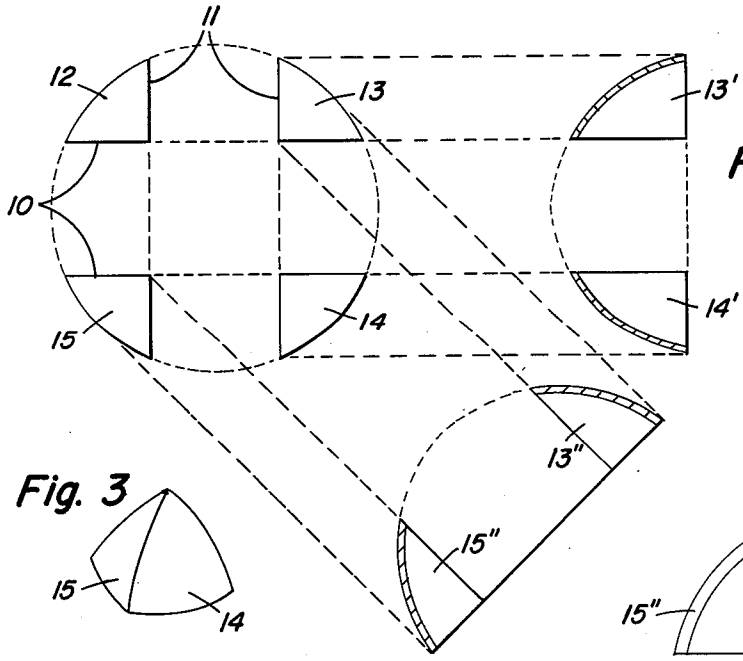


Fig. 1

Fig. 3

Fig. 2

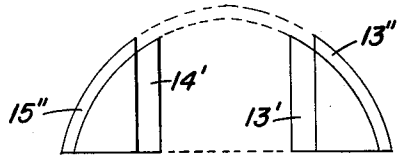


Fig. 5

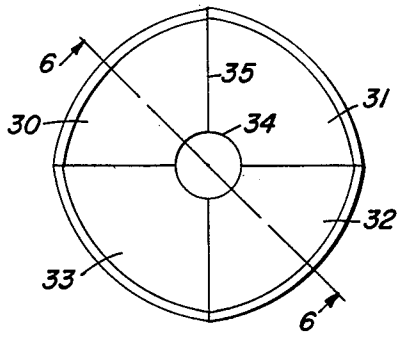


Fig. 4

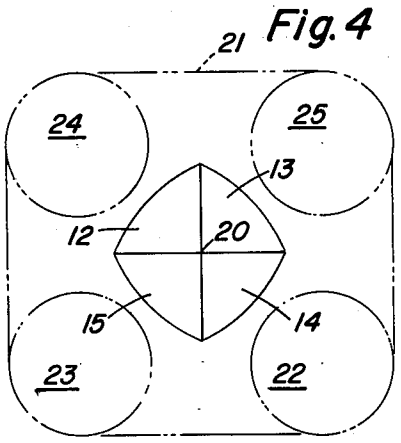
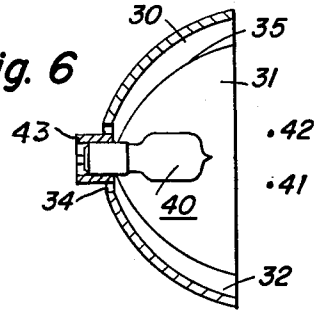


Fig. 6



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This invention relates to reflectors for use with flash or flood lamps.

It is the object of the invention to provide a reflector which gives substantially uniform illumination over a square or rectangular area and which does so efficiently. Prior attempts have been made to illuminate a square or rectangular area for photography. When this has involved the shape of the reflector back of the light source, it has been done by bending the corners of the reflector outward to direct more light to the corners of the rectangle or square. Such an arrangement involves a larger than normal reflector and defeats in part the main purpose of the recent trend toward smaller and smaller flash lamps. Thus the specific object of the present invention is to provide as compact a reflector as is reasonable which is still capable of directing extra light to the corners of the square or rectangle to be illuminated.

In the present invention this is done by making the areas of the reflector which are located coplanar with the diagonals of the field to be illuminated, more convex and effectively closer to the light source than the other areas. That is, the areas on the diagonal are moved inward rather than outward so that these areas reflect the light from an axially located source, back across the axis of the reflector to the opposite corners of the field. Such a system is operative whether the base of the lamp extends through an axial hole in the reflector or extends radially in front of or through a marginal hole in the reflector. However, it is most convenient with the simple axial mounting of the flood or flash lamp and it will therefore be described with reference to such a simple mounting of the lamp.

According to the invention a cup shaped reflector having a square symmetry about its axis, consists of four approximately spherical but preferably toric or ellipsoidal sections as described in detail below. The light from the whole system including the lamp and the reflector, diverges in an approximately square pyramid with rounded dihedral edges. That is, the divergent light has a cross section which is a square with rounded corners and has more or less uniform luminous flux over the area of this approximate square. It should be noted that the square corresponding to the cross section of this divergent light is oriented at 45° to the square of symmetry of the cup shaped reflector; the accompanying drawings illustrate the orientation.

With a simple figure of revolution either a sphere, paraboloid or ellipsoid, the illumination over a square area utilizing a high proportion of the total light, falls off toward the corners of the square to about ⅕ the value at the center. This corresponds to about 2.3 aperture stops of a camera lens. While such variation is often tolerated, it is, of course, quite objectionable.

The use of exact figures in describing the distribution of illumination must either be over-simplified or must become so complicated to gain precision, that the meaning becomes obscured. Actually the intensities or brightnesses which should be compared, are the intensity at one corner and the intensity in the middle of one side of the scene. A diverging cone of light brightest at the center would give circular illumination falling off according to some predetermined function as one proceeds from the center to the periphery of the circle. In order

to concentrate the light on the scene being photographed without wasting any more than is absolutely necessary on other areas, the rate of fall off takes a very sharp dip at some angle (say 30°) from the axis. The square area to be illuminated normally has its corners outside or just at this limiting angle and has the centers of the sides of the square inside the cone thus formed. In such a case the brightness at the corners is about ⅕ to ⅓ the brightness at the center of the sides of the square. The present invention by sending more light to the corners rather than to the center of the field, brings the illumination at the corners up to a value approximately equal to that of the centers of the sides of the square and above half that at the center of the square itself. Thus the difference in intensity between the center of the square and the corners is the equivalent of less than one aperture stop which is rarely if ever objectionable and the illumination around the periphery of the square is more or less constant.

The actual distribution of illumination depends on the precision with which the flash lamp or filament of the flood lamp is located with respect to the reflector. Flash bulbs are commonly located accurately to within ± .01 inch. One of the advantages and objects of the present invention is the fact that the positioning of the lamp is not as critical as it is with a spherical or ellipsoidal reflector. The lamp is approximately at the focal length of each section away from the section so that the light reflected is approximately collimated (slightly diverging) as it travels back across the axis to the opposite corner of the field. That is, each section of the reflector reflects a diverging cone whose axis crosses the axis of the whole reflector.

The invention will be more fully understood from the following description when read in connection with the accompanying drawings in which:

FIG. 1 geometrically indicates the manner in which the reflector according to the invention is generated mathematically.

FIG. 2 similarly illustrates a comparison of two sections of a reflector so generated.

FIG. 3 is a perspective view of the reflector generated as shown in FIG. 1.

FIG. 4 is a diagram to illustrate the operation of the reflector.

FIGS. 5 and 6 are respectively front and sectional views of a reflector according to the invention.

FIGS. 1 to 4 are geometrical illustrations and are described in terms of "cutting," "combining" etc. for clarity. In actual practice the reflectors are made by simply molding and coating. The terms used in describing the geometric generation of the shape required are purely figurative.

In FIG. 1, one end of an ellipsoid is "cut" so that two central sections bounded respectively by planes **10** and **11** are cut away leaving only segments **12**, **13**, **14** and **15**. The center sections which are "removed" are shown quite wide, since this best illustrates the effect of the present invention. It is, however, exaggerated, and in practice only a somewhat narrower horizontal and vertical section are absent (geometrically removed). A side view of sections **13** and **14** appears to the right as **13'** and **14'** and similar views of sections **13** and **15** appear to the lower right as **13''** and **15,''** of FIG. 1.

If superimposed, these sections would appear as shown in FIG. 2. When the four sections are combined (compacted) a complete reflector is formed as shown in FIG. 3. In none of these first three figures is any provision made for the lamp. The lamp may be supported from the front and held at the proper axial location in which case the cup shape reflector remains intact as shown in FIGS. 3 and 4. Alternatively, a hole may be pro-

vided through one or more of the reflector segments so that the lamp may be supported through the hole. The operation of the present invention does not depend on the manner in which the lamp is supported, but it does depend on where it is located.

As shown in FIG. 4 the reflector made up of segments **12, 13, 14** and **15** has a square symmetry about the axis **20**. The diagonals of the square of symmetry are vertical and horizontal coplanar with the dividing lines between the segments of the reflector. Light from a lamp located on the axis **20** radiates in all directions, some of it going directly to the scene to be illuminated. Part of it travels in the opposite direction and is reflected back toward the scene diverging just enough to cover the angular field of view of the camera, but not enough to waste light to the sides. This gives generally uniform illumination at the scene but in order to efficiently illuminate a square area, the reflecting surface **12** reflects more light toward the area **22** which constitutes a corner of the square **21** to be illuminated. Similarly the reflector segment **13** tends to concentrate the light in area (or direction) **23**, the segment **14** tends to concentrate the light in area (or direction) **24** and the segment **15** tends to concentrate light in the area (or direction) **25**. Thus emitting from the lamp and its reflector is a divergent pyramid of light whose cross section or isolumen line (see below) is an approximate square **21** with rounded corners. There is of course some light outside of this pyramid and there is some variation of intensity within the pyramid, but the square **21** more or less identifies the limit of useful illumination.

One can consider light directly from the lamp, i.e. without reflection as forming the core of the divergent pyramid of light and extending outside the pyramid so that some of the direct light is wasted. Because of the edges of the cup shaped reflector, there is a tendency for more of this direct light to be lost beyond the sides of the square **21** than beyond the corners. However, the direct light is not as important as the reflected light. Thus the diverging pyramid of light is primarily made up of the four diverging cones respectively from the four segments and the axes of the cones cross the axis of the reflector itself. The circles of illumination (centered at **22, 23, 24** and **25**) probably overlap considerably and each actually extends across the axis of the reflector. However, these circles **22, 23, 24** and **25** are shown as confined to their own corners, for the sake of clarity. In any case, the light from the lamp and cup shaped reflector does form a diverging pyramid of light with rounded dihedral edges and the light for these dihedral edges comes primarily from the segment of the reflector on the opposite side of the axis.

It is repeated that the light does not fall to zero intensity at the boundary **21**, and the light in each of the four cones from the reflector segments does not fall to zero intensity at the broken circles **22, 23, 24** and **25**. These illustrated lines can be considered as isolux or isolumen lines, although they are only approximately so. Also the rate of change of intensity is quite rapid near these particular isolumen lines. Inside the lines, the light is intense and more or less uniform. Outside the lines, the light falls rapidly to low intensity not useful for photography illumination.

It should be noted that the centers of the segments **12, 13, 14** and **15** lie on the diagonals of the square field **21** to be illuminated. That is, the square of symmetry of the reflector is at 45° to the square of the diverging pyramid of light.

The geometry and operation of the invention have been described with respect to an ellipsoid compacted according to the invention. The invention operates with a sphere similarly compacted or preferably with an approximately spherical toroidal or prolate spheroid section. It should be obvious that the center of curvature of each segment (or the equivalent center of curvature if the segment is not a perfect sphere) falls beyond or on the opposite side of the axis. For a definition of "opposite side" one may refer to FIG. 6 discussed in detail below and note that the axis of the reflector is a horizontal center line (not drawn in) and that the surface **30**, for example is on one side of this axis and its center of curvature **41** is not on the same side of the axis, it is on the "opposite side" of the axis. When a toroid section or zone is used a major curvature is coplanar with the axis of the reflector and the center of this major curvature is on the opposite side of the axis. The lamp on the axis is not located exactly at the focal point of each segment since this would mean that the light reflected would be approximately perfectly collimated and not properly diverging. The lamp is slightly closer to the reflector than the focal point is. It is just "inside" the focal point which is about ½ the distance from the segment to its center of curvature.

An actual reflector according to the present invention which has proven to be particularly efficient is illustrated in FIGS. 5 and 6. The segments **30, 31, 32** and **33** with an axially located hole **34** are shown with the dividing lines such as **35** clearly identified. However, in practice the reflectors are molded of plastic and the dividing lines **35** are rounded off so that they are not apparent. A flash lamp **40** is inserted from the front into a socket **43** in the usual way commonly used in flash lamps. The point **41** represents the approximate center of curvature of the reflector segment **30** and the point **42** similarly represents the approximate center of curvature of the segment **32** of the reflector. If the reflector were a complete surface of revolution (perfectly spherical surface), **41** and **42** would coincide and would lie on the axis of the reflector. The displacement of each of the centers **41** and **42** from the axis is a measure of the amount by which the segment of the reflector is "geometrically compacted" or pushed toward the center by the "removal" of center sections. This displacement of the center of curvature from the axis is therefore a measure of the amount of increase of light to the corners of the picture. The displacement is usually between 7 and 20% of the radius of curvature itself and is preferably about 12%. The distance of the effective location of the lamp **40** from the centers **41** and **42** is slightly greater than half the distance of the centers from the reflectors. If it were exactly half, the reflected light from each segment would be collimated forming a hot spot at each corner. Thus one is easily able to increase the light to the corners to a value greater than required, which means that one may select between the extremes, any distribution desired. As mentioned above it is preferable to select one giving approximately uniform illumination around the square periphery with about double intensity at the center of the square. That is the effective distance of the lamp from the reflector should preferably be between one-third and one-half the effective radius of the reflector.

Having thus described preferred embodiments of my invention I wish to point out that it is not limited thereto but is of the scope of the appended claims.

I claim:

1. A cup shaped reflector in combination with means for holding a light source at a point on the axis thereof to produce a diverging light beam shaped as an approximately square pyramid with rounded dihedral edges, said reflector consisting of four approximately spherical sections concave to the axis and symmetrically located on the diagonals of said pyramid and each section being located with its center of curvature beyond the axis and over twice and less than three times as far from the reflector as said point on the axis to divergingly reflect a portion of the light from the source back across the axis to form the opposite rounded dihedral edge of said pyramid.

2. A reflector according to claim 1 in which said ap-

proximate spherical sections are slightly toric with the greater toric radius being in the plane of said axis.

3. An illuminator comprising a cup shaped reflector formed of four substantially congruent portions of a toric surface, located with square symmetry about the axis of the reflector, the portions having their major radii of curvature in the axial plane and the centers of said curvature of major radii beyond the axis and a lamp on said axis effectively at a distance from said portions more than one-third and less than one-half said greater radius.

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