United States Patent [19]

McNamara, Jr.

[11] 3,902,059

[45] Aug. 26, 1975

[54] LIGHT REFLECTOR SYSTEM

[75] Inventor: Albert C. McNamara, Jr., Houston, Tex.

[73] Assignee: Esquire, Inc., New York, N.Y.

[22] Filed: Feb. 15, 1974

[21] Appl. No.: 443,018

[52] U.S. Cl. .... 240/103 R; 240/41.35 R; 240/41.35 F; 240/41.36

[51] Int. Cl.² F21V 7/09

[58] Field of Search .... 240/1.3, 41.35 F, 41.36, 240/103 R, 103 A, 41.35 R

[56] References Cited

UNITED STATES PATENTS

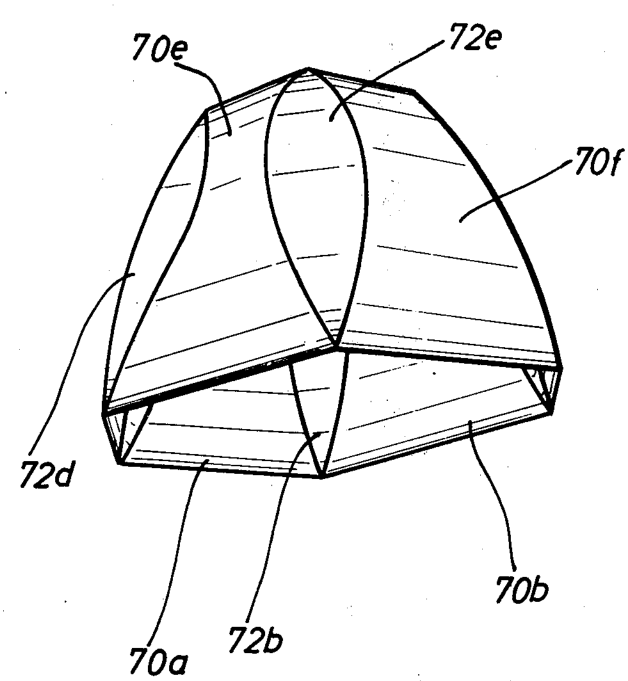
2,205,860 6/1940 Olds .... 240/103 R

Primary Examiner—Samuel S. Matthews
Assistant Examiner—Russell E. Adams, Jr.

[57] ABSTRACT

A multi-sided light reflector for a light source, which reflector incorporates curved reflector surfaces that cooperate with a light source disposed within the reflector to permit only primary reflections from the light source to be emitted from a reflector opening. The reflector includes a plurality of curved side reflecting surfaces disposed in angular relationship with a plurality of curved corner reflector surfaces disposed between the side reflector surfaces and joined to the side reflecting surfaces. The line of juncture between the side reflector surfaces and the corner reflector surfaces is curved and the lower point of each of the corner reflector surfaces is defined by intersection of the curved lines of juncture of the respective corner reflectors and is disposed in the plane of the reflector opening. The reflector opening, from which direct and primary reflections are emitted, is defined by the primary exit pupil ray of the light source from the various side and corner reflectors.

12 Claims, 6 Drawing Figures



PATENTED AUG 26 1975

3,902,059

FIG. 1

PRIOR ART

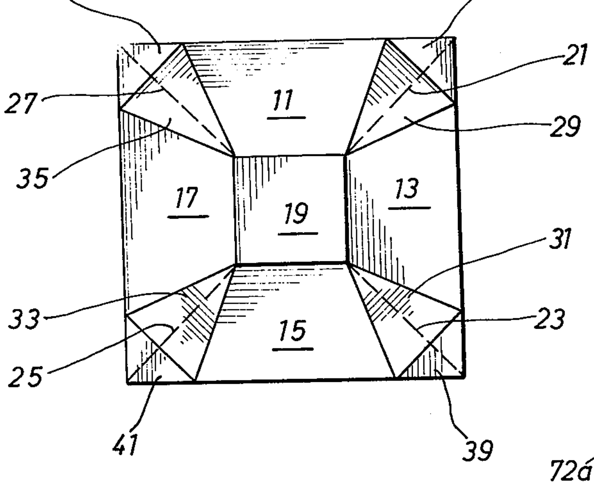
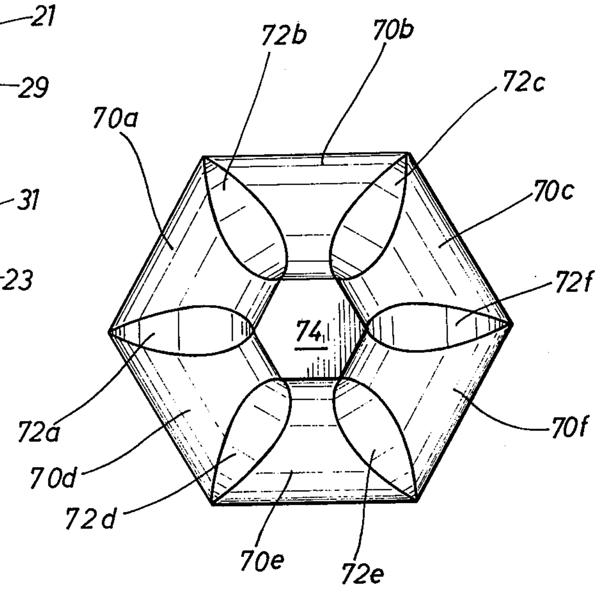


FIG. 2



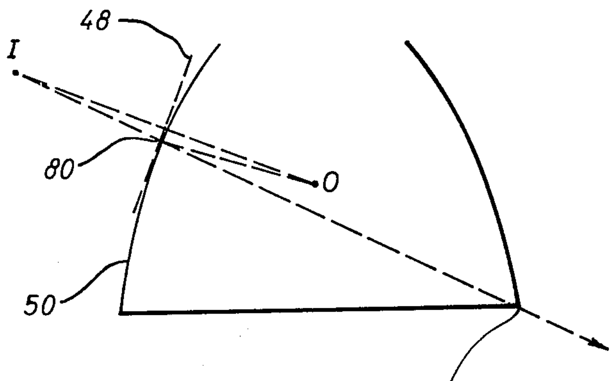
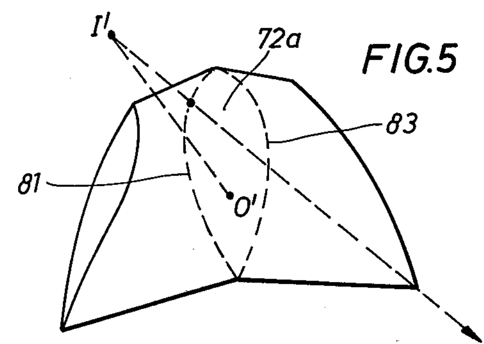


FIG.4

FIG.5



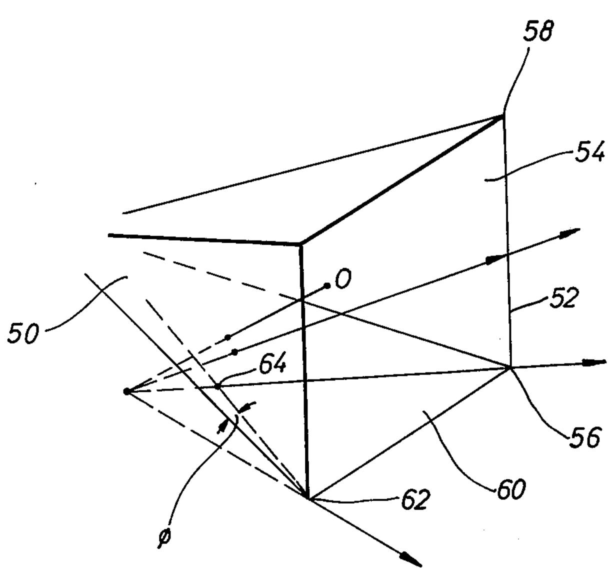


FIG.6

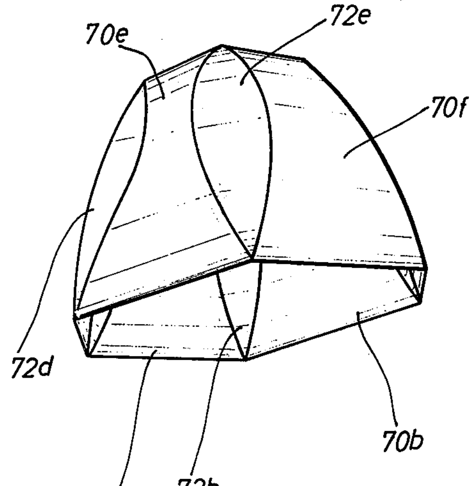


FIG. 3

LIGHT REFLECTOR SYSTEM

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates generally to lighting reflectors and more specifically to such reflectors having multi-sided reflecting surfaces causing at least some primary reflections to be emitted through the opening of the reflector.

2. DESCRIPTION OF THE PRIOR ART

It has long been standard to equip light bulbs, both incandescent and vapor types, with reflectors to concentrate light in a generally desired direction.

The most efficient of these prior art reflectors are those reflectors which are concave in shape so as to permit all light emanating from the light and reflector system to be either the direct light from the source or to be the primary reflective light. Primary reflective light is that light which is reflected only once from the source before the light is emitted from the light and reflector system. Such a light and reflector system that typifies this arrangement is the ordinary flash-light reflector which is typically of hyperbolic internal configuration.

Fabrication of curved surfaces, however, has in the past been considered to make the use of such reflectors extremely expensive in many applications, particularly in systems where the reflectors are somewhat large, as for mounting mercury vapor lamps. Heretofore, flat-sided reflectors slanting backwardly from the opening have been used in such applications, usually presenting a rectangular or square opening through which much of the primary reflections are emitted. Such reflectors are relatively cheap to fabricate and assemble. However, not all of the reflections from such a reflector system are primary reflections and therefore there is great loss in efficiency. For instance, all light which is not reflected initially forward is not emitted before being reflected at least a second time. Further, even forward reflected light which is cut off by the exit pupil of the reflector must be reflected at least a second time before emission. Finally, no light directed at the corners, either direct or from a primary reflection, is emitted from the reflector without undergoing at least secondary reflection.

Lack of light reflection from the corner of square reflectors has resulted in the use of corner inserts. The conventional method of modifying a square-shaped reflector to provide corner reflectors is to use inserts which start at a point at the corner of a square base of the reflector and flares so that at the opening the insert is at its widest dimension. Such a structure effectively changes the square opening into a reduced sized octogan opening and hence creates "dead" corner spaces which are not useful reflection surfaces.

It is therefore a feature of this invention to provide an improved lighting reflector system comprised of multi-sided curved reflector segments that provide optimum direct and primary reflections.

It is another feature of this invention to provide an improved lighting reflector having curved corner reflector surfaces therein that utilize the space of the reflector to an optimum degree and produce more efficient direct and primary reflection emissions than from prior art flat-sided or hyperbolic reflectors.

SUMMARY OF THE INVENTION

A preferred embodiment of the present invention comprises a light reflector in which a light source may be installed and in which the side reflectors are curved, the side reflectors establishing an opening for light emissions. The side reflectors are oriented relative to the light source to cause only primary reflection emissions from the opening. Corner reflectors are disposed between the side reflectors and are also curved in such manner as to permit primary reflection from those portions which would otherwise be cut off by the exit pupil dimension of the side reflectors. The corner reflectors allow the full dimension of the opening to be utilized.

The outlet opening of the light reflector is defined by straight lines lying in each of the curved reflector surfaces, the straight lines of adjacent side reflecting surfaces being disposed in angular intersecting relationship and the lowermost point of each of the corner reflector surfaces being disposed at the intersection of said straight lines.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above-recited features, and various advantages and objects of the invention which will become apparent, are attained and can be understood in detail, more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof which are illustrated in the appended drawings, which drawings form a part of this specification. It is to be noted, however, that the appended drawings illustrate only typical embodiments of the invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

In the drawings:

FIG. 1 is a plan view of a prior art lighting reflector.

FIG. 2 is a plan view of a light reflector constructed in accordance with the present invention.

FIG. 3 is an isometric illustration depicting the light reflector of FIG. 2.

FIG. 4 is a schematic representation illustrating formation of the outlet opening of the reflector structure in accordance with the various reflector orientation thereof.

FIG. 5 is a schematic representation illustrating direct and primary reflection of light from the light reflector system of the present invention.

FIG. 6 is an oblique schematic representation for determining the dimension of corner reflectors.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings and first to FIG. **1**, a light reflector is shown which has previously been preferred for optimizing light reflections from a reflector having a square opening. In such a reflector, side pieces **11**, **13**, **15** and **17** are slanted back from the opening to terminate in a rectangular base **19** at the back of the reflector which is generally parallel with the plane of the opening through which the light is emitted. It may be assumed for purposes of discussion that the reflector is uniformly dimensioned so that each of the side reflectors are of the same dimension and base **19** is square.

Were it not for the corner pieces to be described below, the side pieces would have respectively met each other at corners **21**, **23**, **25** and **27**, respectively (as shown by the dotted lines). Light from a source located in the center of the reflector and emitting light in all directions would not reflect light off of a side reflector through the opening at the corners and therefore a reflector without corner pieces at all is extremely inefficient in its corner emissions.

As is shown, increased efficiency can be developed by the insertion of conventional type corner pieces **29**, 31, 33 and **35**. Corner piece **21** located between side pieces **11** and **13** is in the shape of an isosceles triangle. The corner between the two equal length sides is secured at a corner of base **19** and the other two corners terminate at the plane of the opening, one corner with adjacent side piece **11** and the other corner with adjacent side piece **13**, each being displaced at the opening an equal distance from corner **21**.

Each of corner pieces **31, 33** and **35** are similar in construction to corner piece **29**. It has been demonstrated that such a structure with the corner pieces as described is more efficient in its light emission than a structure without such corner pieces since more primary emission is developed.

It should be noted that for what was originally a square shaped reflector opening, the corner pieces have reduced the effective opening area by the amount of corner spaces **37, 39, 41** and **43**. These spaces are the triangular spaces between the edge of the corner piece and the edge of the side pieces in the plane of the opening.

In accordance with the present invention, side reflector surfaces are developed, as shown in FIG. **4**, which reflect primary light from the source through the reflector opening and which utilize the entire opening of the reflector.

As may be shown in FIG. **4**, a theoretical point source is located at O having an image I with respect to side **50**. That is, a right angle projection from point O to a plane that is tangent to the curved reflector **50** results in point I being established an equal distance from the point of tangency of the plane and the curved reflector surface but on the opposite side thereof from point O. As may be shown in FIG. **4**, a cross-sectional view of the plane **48** that is tangent to the curved surface **50** shows clearly the right angle relationship between the plane **48** and the projection line, O-to-I.

As previously explained, the exit pupil is the edge of the opening on one side of which primary reflections from a light source are allowed to pass and on the other side of which light rays are blocked. The exit pupil ray, therefore, is a ray along the line drawn between point I and the escape edge of the opening. The exit pupil edge is identified with reference numeral **52**.

Now turning to FIG. **6**, it is illustrated that the exit pupil rays from point I which are allowed to escape past opposite side **54** after being reflected from side **50** are allowed to escape at corner **56** and corner **58** of side **54** in the plane of the opening. Of course, rays also escape at all points between corners **56** and **58** along exit pupil edge **52**.

Exit pupil rays are also permitted to escape from side **60** adjacent side **50** at corner **62** between sides **50** and **60** in the plane at the opening and along the edge between corners **62** and **56**.

It will be seen that there are rays within an angle ϕ which are not permitted to be emitted through the opening without being further reflected from side piece **60**. This angle may be determined by drawing a line from image point I to corner **56**, marking the intersection point **64** between that line and plane **50**, and then drawing a straight line from corner **62** through point **64**.

In similar fashion it is possible to determine the point analogous to **64** in FIG. **6** for each tangent plane such as **48** for curve **50**. The locus of these points determining the curve **81** in FIG. **5**.

While FIG. **6** represents straight line calculation of the exit pupil rays for determination of the outlet opening, such is intended for purposes of illustration only. Point or line calculations generated from curved reflector surfaces will function in the same manner.

Now referring to FIG. **2** in more detail, it will be seen that corner reflectros may be inserted, each corner reflectors or piece being defined by two of the 12 curved lines in adjacent side pieces. For example, corner piece **72*a*** lies between curved side pieces **70*a*** and **70*d*** and is defined by the two curved lines, one on each side piece, drawn to the common corner between side pieces **70*a*** and **70*d***. As shown in FIG. **2**, corner pieces **70*a***, 70*b*, 70*c*, 70*d*, 70*e* and **70*f*** and side pieces **72*a***, 72*b*, 72*c*, **72*d***, 72*e* and **72*f*** meet in a six sided shaped base **74**.

Now turning again to FIG. **4**, it should be noted that all rays which are projected at least as forward as the exit pupil ray are allowed to escape at edge **52** (that is, all rays that are at least as forward as the ray from point O intersecting plane **48** at tangent point **80**). These rays are all allowed to be emitted through the opening of the reflector following only a single reflection, a primary reflection. This point **80** is determined by making the angle of incidence from point O to plane **48** equal to the angle of reflection such that the reflected ray passes through point **52**. As is well-known in optical theory, by placing I on the opposite side of plane **48** from **0**, but at the same perpendicular distance therefrom, a line from I to point **52** intersects plane **48** at point **80**. There is no need for the reflecting surface in plane **48** to extend beyond point **80** for this phenomenon to apply. Each of the various points lying in the curved reflector surface may be located graphically by simple determination of the point of tangency between a plane that is tangent to the surface **50**. Moreover, the curved reflector surface **50** effectively eliminates the necessity for providing internal back reflectors that would otherwise promote primary reflection of light rays that are blocked by the escape edge **52**.

It has been demonstrated that the configuration shown in FIG. **2** is approximately 6 to 10 percent more efficient in emitting light than the configuration shown in FIG. **1**.

If the reflector construction employed only side reflectors that are joined along curved lines, light reflected by certain edge portions of the side reflectors will not be capable of primary reflection. It is therefore desirable to to provide corner reflectors that are positioned and configured to provide primary reflection of light that would otherwise become lost or diffused through multiple reflection. In accordance with FIG. **5** the curved corner reflector surfaces, such as depicted at **72*a*** through **72*f*** in FIG. **2** are generated by the various points at which the primary reflections fail to be reflected by the side reflector surfaces. A direct ray of light being emitted from point **0'**, the imaginary center of the reflector system at which the light source is located, and passing through a point of tangency of an imaginary plane intersecting the side reflector surface will pass through the outlet opening of the reflector structure only if the point of imaginary reflection from point I' falls outside of a corner area such as that defined by broken lines. It becomes desirable therefore, to provide the reflector structure with corner reflector surfaces that are generated in such manner that the corner reflectors also provide for primary reflection of light being emitted from the light source. If each point on the side reflector surfaces is generated beyond which primary reflections will not occur, curved lines will be established by the various points, such as illustrated in broken lines at **81** and **83**. Within the areas defined by the curved lines **81** and **83**, corner reflectors may be disposed, the center of which being oriented in substantially normal relation to direct ray of light being emitted from the point **0'**.

Although particular embodiments of the invention have been shown, it will be understood that the invention is not limited thereto, since many modifications may be made and will become apparent to those skilled in the art. For example, the reflector has been depicted as being of six sided configuration. The principles described, however, are also applicable to any other multi-sided reflector system. Also, each of the curved corner reflector surfaces have been described as merging in a corner point. In an actual structure, it may be desired to have that point be a phantom point for ease of construction, operation of the reflector being functionally similar to that described.

What is claimed is:

1. A light reflector for carrying a mounted light source therein and having a light emission opening through which light from the source is emitted, comprising:

first and second curved side reflectors oriented to cause at least some primary reflections of the source to be emitted through the opening,

said curved side reflectors meeting at least at a point defining a first corner at the opening, the primary reflection exit pupil rays of said light source to said curved side reflectors defining curved edges of said curved side reflectors, and

a curved corner reflector being defined within said curved edges of said side reflectors and being oriented relative to said light source to cause at least some primary reflections of said light source to be emitted through the opening without further reflection.

2. A light reflector as described in claim **1**, wherein said opening is defined by a plurality of side reflector surfaces, and

a plurality of substantially identical corner reflectors are disposed one between each of the respective side reflector surfaces.

3. A light reflector as described in claim **1**, wherein one of the extremities of each of said plurality of corner reflectors define a plurality of points, and

a multi-sided generally planar reflector surface is defined by a plurality of straight lines interconnecting said plurality of points.

4. A light reflector for carrying a mounted light source therein and having an opening defined thereby through which light from the source emanates, said light reflector comprising:

a plurality of curved side reflectors slanted inwardly from the plane of said opening to cause at least some primary reflections of the source to emanate through the opening, said side reflectors being disposed in angulated relation to each other in the plane of the opening, and

a plurality of corner reflectors being disposed one between each of said adjacent side reflectors and extending inwardly from the plane of said opening, said corner reflectors being curved and being defined by curved lines that intersect at each extremity thereof.

5. A light reflector as described in claim **4**, wherein one of the points of intersection of said curved lines defining each of said corner reflectors lies at the points of intersection of said side reflectors, and

lines interconnecting said points of intersection of said curved lines coincide with lines defining said opening.

6. A light reflector as recited in claim **5**, wherein lines interconnecting each of the other of the points of intersection of said curved lines define a generally planar surface of multi-sided configuration.

7. A light reflector for carrying a mounted light source therein and having an opening through which light from the source is emitted, comprising:

at least first and second adjacent curved reflectors meeting to form a part of said opening through which light from the source is emitted and being oriented to cause at least some primary reflections of said light source to be emitted through the opening, and

a third curved reflector extending from the plane of said opening, being adjacent at least one of said first and second curved reflectors and having sides merging toward a point at a corner of said opening, the exit pupil of each of said two adjacent curved reflectors permitting the forwardly directed primary light reflections of said light source from said third curved reflector to emanate through said opening without secondary reflection.

8. A light reflector as recited in claim **7**, wherein said first and second reflectors define concave reflector surfaces facing said light source.

9. A light reflector as recited in claim **8**, wherein said third curved reflector is adjacent said first curved reflector and in spaced relation with said second reflector, such that the primary reflections from said third curved reflector directed toward the meeting of said first and second adjacent curved reflectors define a boundary between said first curved reflector and said third curved reflector.

10. A light reflector for carrying a mounted light source and defining an opening through which light from the source is emitted, comprising,

a plurality of curved side reflectors having lower edges meeting to form said opening and defining a plane, and

a plurality of curved corner reflectors disposed between at least some of said curved side reflectors and extending from the plane of said opening, said corner reflectors having curved sides merging toward a point located on the plane of said opening and being oriented to reflect light from said source through said opening, and

the exit pupil of each of said curved reflectors at said opening permitting primary light reflections of said light source from each of said curved corner reflectors to emanate through said opening without secondary reflection.

11. A light reflector as recited in claim 10, wherein said plurality of curved side reflectors includes first and second curved reflectors meeting at said opening, and

said plurality of curved corner reflectors includes a reflector adjacent said first curved reflector but spaced from said second reflector, such that the forwardly directed primary reflections from said curved corner reflector directed toward the meeting of said first and second curved reflectors define a boundary between said first curved reflector and said curved corner reflector.

12. A light reflector as described in claim 11, wherein said plurality of successively adjacent curved reflectors includes a third curved reflector meeting with said first reflector at said opening, and

said plurality of curved corner reflectors includes a second corner reflector adjacent said first curved reflector but spaced from said third curved reflector, such that the forwardly directed primary reflections from said second curved corner reflector directed toward the meeting of said first and third curved reflectors define a boundary between said first curved reflector and said second curved corner reflector.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,902,059 Dated August 26, 1975

Inventor(s) Albert C. McNamara, Jr. Page 1 of 2

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Grant (only) Columns 3 and 4 should appear as shown on the attached sheet.

Signed and Sealed this

tenth Day of *February 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

in the center of the reflector and emitting light in all directions would not reflect light off of a side reflector through the opening at the corners and therefore a reflector without corner pieces at all is extremely inefficient in its corner emissions.

As is shown, increased efficiency can be developed by the insertion of conventional type corner pieces 29, 31, 33 and 35. Corner piece 21 located between side pieces 11 and 13 is in the shape of an isosceles triangle. The corner between the two equal length sides is secured at a corner of base 19 and the other two corners terminate at the plane of the opening, one corner with adjacent side piece 11 and the other corner with adjacent side piece 13, each being displaced at the opening an equal distance from corner 21.

Each of corner pieces 31, 33 and 35 are similar in construction to corner piece 29. It has been demonstrated that such a structure with the corner pieces as described is more efficient in its light emission than a structure without such corner pieces since more primary emission is developed.

It should be noted that for what was originally a square shaped reflector opening, the corner pieces have reduced the effective opening area by the amount of corner spaces 37, 39, 41 and 43. These spaces are the triangular spaces between the edge of the corner piece and the edge of the side pieces in the plane of the opening.

In accordance with the present invention, side reflector surfaces are developed, as shown in FIG. 4, which reflect primary light from the source through the reflector opening and which utilize the entire opening of the reflector.

As may be shown in FIG. 4, a theoretical point source is located at O having an image I with respect to side 50. That is, a right angle projection from point O to a plane that is tangent to the curved reflector 50 results in point I being established an equal distance from the point of tangency of the plane and the curved reflector surface but on the opposite side thereof from point O. As may be shown in FIG. 4, a cross-sectional view of the plane 48 that is tangent to the curved surface 50 shows clearly the right angle relationship between the plane 48 and the projection line, O-to-I.

As previously explained, the exit pupil is the edge of the opening on one side of which primary reflections from a light source are allowed to pass and on the other side of which light rays are blocked. The exit pupil ray, therefore, is a ray along the line drawn between point I and the escape edge of the opening. The exit pupil edge is identified with reference numeral 52.

Now turning to FIG. 6, it is illustrated that the exit pupil rays from point I which are allowed to escape past opposite side 54 after being reflected from side 50 are allowed to escape at corner 56 and corner 58 of side 54 in the plane of the opening. Of course, rays also escape at all points between corners 56 and 58 along exit pupil edge 52.

Exit pupil rays are also permitted to escape from side 60 adjacent side 50 at corner 62 between sides 50 and 60 in the plane at the opening and along the edge between corners 62 and 56.

It will be seen that there are rays within an angle ϕ which are not permitted to be emitted through the opening without being further reflected from side piece 60. This angle may be determined by drawing a line from image point I to corner 56, marking the intersection point 64 between that line and plane 50, and then drawing a straight line from corner 62 through point 64.

In similar fashion it is possible to determine the point analogous to 64 in FIG. 6 for each tangent plane such as 48 for curve 50. The locus of these points determining the curve 81 in FIG. 5.

While FIG. 6 represents straight line calculation of the exit pupil rays for determination of the outlet opening, such is intended for purposes of illustration only. Point or line calculations generated from curved reflector surfaces will function in the same manner.

Now referring to FIG. 2 in more detail, it will be seen that corner reflectros may be inserted, each corner reflectors or piece being defined by two of the 12 curved lines in adjacent side pieces. For example, corner piece 72*a* lies between curved side pieces 70*a* and 70*d* and is defined by the two curved lines, one on each side piece, drawn to the common corner between side pieces 70*a* and 70*d*. As shown in FIG. 2, corner pieces 70*a*, 70*b*, 70*c*, 70*d*, 70*e* and 70*f* and side pieces 72*a*, 72*b*, 72*c*, 72*d*, 72*e* and 72*f* meet in a six sided shaped base 74.

Now turning again to FIG. 4, it should be noted that all rays which are projected at least as forward as the exit pupil ray are allowed to escape at edge 52 (that is, all rays that are at least as forward as the ray from point O intersecting plane 48 at tangent point 80). These rays are all allowed to be emitted through the opening of the reflector following only a single reflection, a primary reflection. This point 80 is determined by making the angle of incidence from point O to plane 48 equal to the angle of reflection such that the reflected ray passes through point 52. As is well-known in optical theory, by placing I on the opposite side of plane 48 from 0, but at the same perpendicular distance therefrom, a line from I to point 52 intersects plane 48 at point 80. There is no need for the reflecting surface in plane 48 to extend beyond point 80 for this phenomenon to apply. Each of the various points lying in the curved reflector surface may be located graphically by simple determination of the point of tangency between a plane that is tangent to the surface 50. Moreover, the curved reflector surface 50 effectively eliminates the necessity for providing internal back reflectors that would otherwise promote primary reflection of light rays that are blocked by the escape edge 52.

It has been demonstrated that the configuration shown in FIG. 2 is approximately 6 to 10 percent more efficient in emitting light than the configuration shown in FIG. 1.

If the reflector construction employed only side reflectors that are joined along curved lines, light reflected by certain edge portions of the side reflectors will not be capable of primary reflection. It is therefore desirable to to provide corner reflectors that are positioned and configured to provide primary reflection of light that would otherwise become lost or diffused through multiple reflection. In accordance with FIG. 5 the curved corner reflector surfaces, such as depicted at 72*a* through 72*f* in FIG. 2 are generated by the various points at which the primary reflections fail to be reflected by the side reflector surfaces. A direct ray of light being emitted from point 0', the imaginary center of the reflector system at which the light source is located, and passing through a point of tangency of an imaginary plane intersecting the side reflector surface will pass through the outlet opening of the reflector

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,902,059 Dated August 26, 1975

Inventor(s) Albert C. McNamara, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The term of this patent subsequent to October 31, 1989, has been disclaimed.

Signed and Sealed this

sixth **Day of** *April 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks