United States Patent [19]

Lasker

[11] **3,836,767**

[45] **Sept. 17, 1974**

[54] **LIGHTING FIXTURES**

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[73] Assignee: **Moldcast Manufacturing Company,** Newark, N.J.

[22] Filed: **Feb. 26, 1973**

[21] Appl. No.: **335,538**

[52] **U.S. Cl.** .... **240/25,** 240/11.4, 240/41.1, 240/41.35 C, 240/81 A

[51] **Int. Cl.** **F21s 3/10**

[58] **Field of Search** .... 240/25, 11.4, 41.1, 51.11, 240/84, 64, 41.35 C, 81 A

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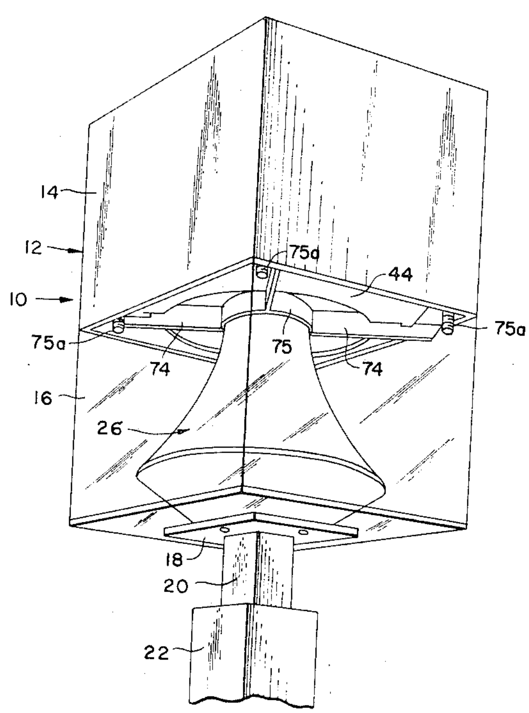
Primary Examiner—Robert P. Greiner
Attorney, Agent, or Firm—Shapiro and Shapiro

[57] **ABSTRACT**

A compact lighting fixture, principally for outdoor use, employs a pair of reflectors in conjunction with a lamp having an elongated light source. One of the reflectors has a downwardly facing concave internal reflecting surface which surrounds the light source. The other reflector is located beneath the first reflector and has a concave external reflecting surface which faces outwardly and upwardly. The light source is aligned with the vertical axis of the fixture, which is the common axis of both reflectors. Light emitted from the source is reflected from the upper reflector to the lower reflector and is then projected outwardly, some light being projected outwardly directly from the source, without reflection. A glare baffle extends inwardly from the bottom of the upper reflector. As a result of this optical system, most of the light is projected from the fixture at a high angle relative to downward vertical, but light cut-off occurs at a selected angle less than 90° relative to downward vertical. The light is evenly distributed on the ground illuminated by the fixture. Glare is minimized. The upper reflector can be modified to produce asymmetrical horizontal light distribution patterns. The reflectors are surrounded by an enclosure having an opaque upper section and a light-transmitting lower section. Reflections from the inner surface of the loser section may provide fill-in illumination near the vertical axis of the fixture. A structural tube extends upwardly through the lower reflector and supports the upper reflector and the upper section of the enclosure upon radially extending arms. The tube may contain a spring-biased, centered receptacle for the lamp, which rests upon a seat at the top of the tube. The upper reflector may be formed in two parts, one part being fixed to a removable top wall of the upper section of the enclosure to provide access to the lamp.

44 Claims, 18 Drawing Figures



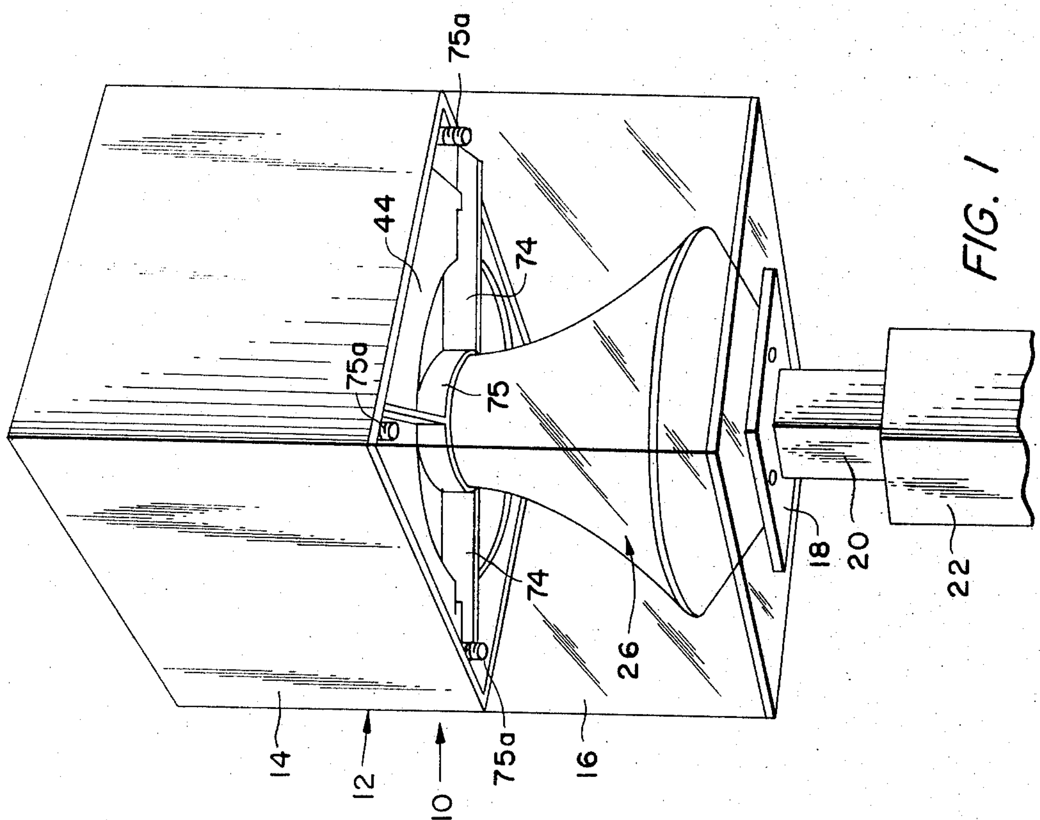

75a
44
74
75a
75
74
26
18
20
22
14
12
10
75a
16

FIG. 1

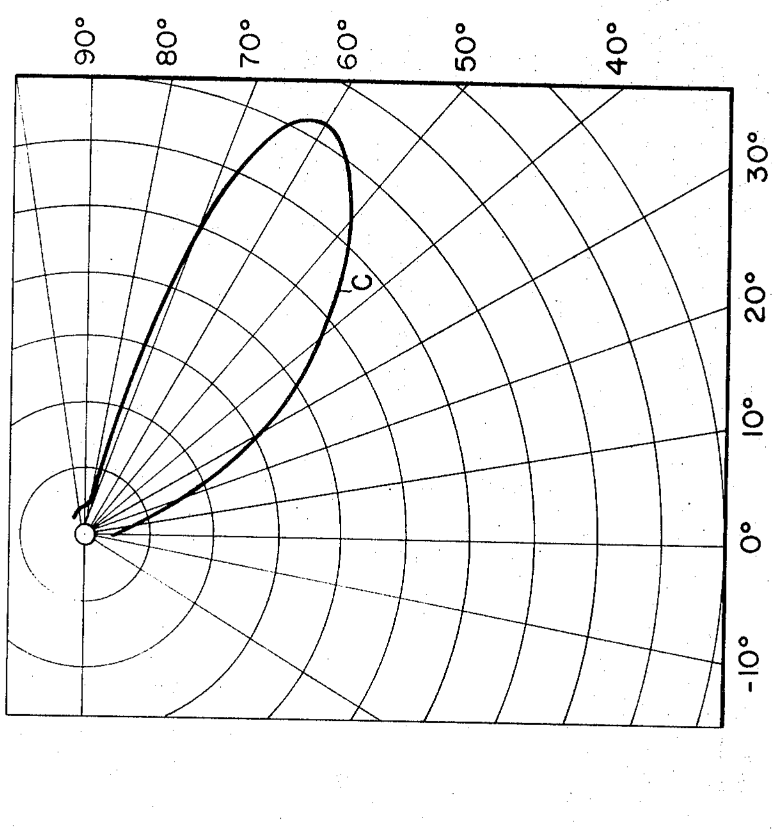

90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
-10°
C

FIG. 2

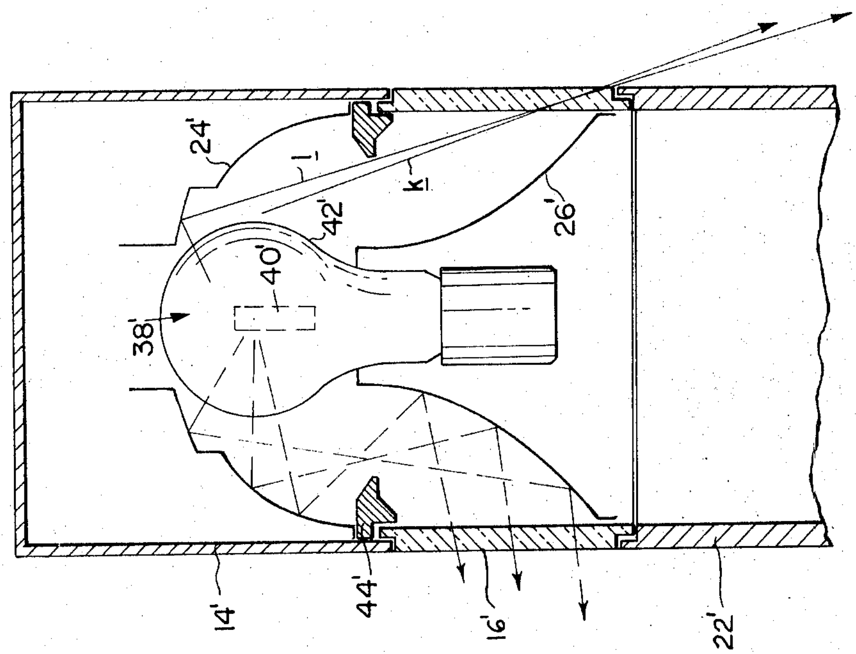


FIG. 4

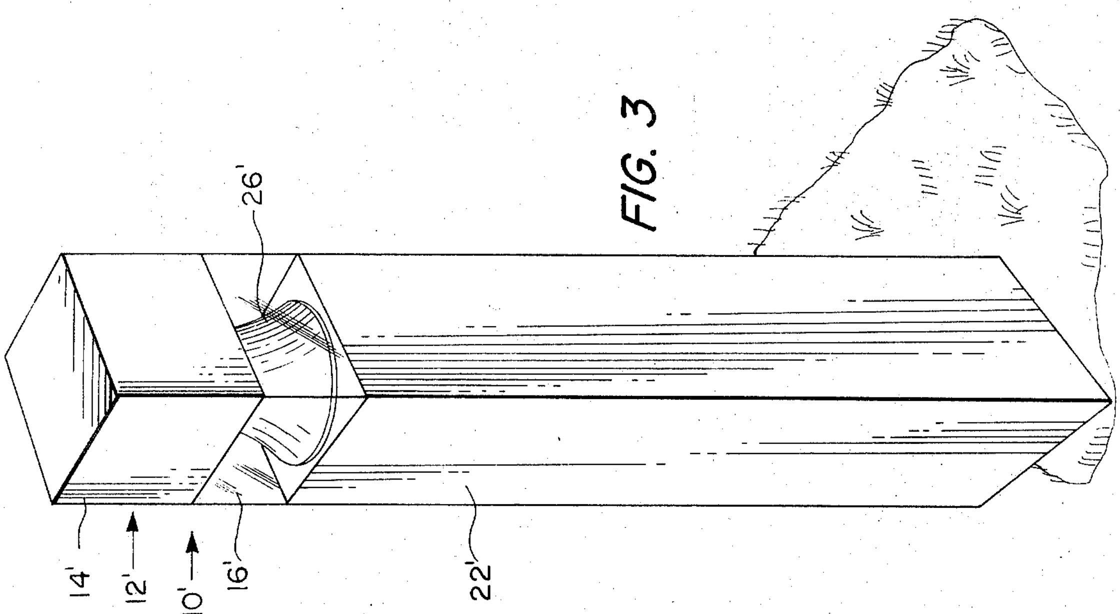


FIG. 3

FIG. 5

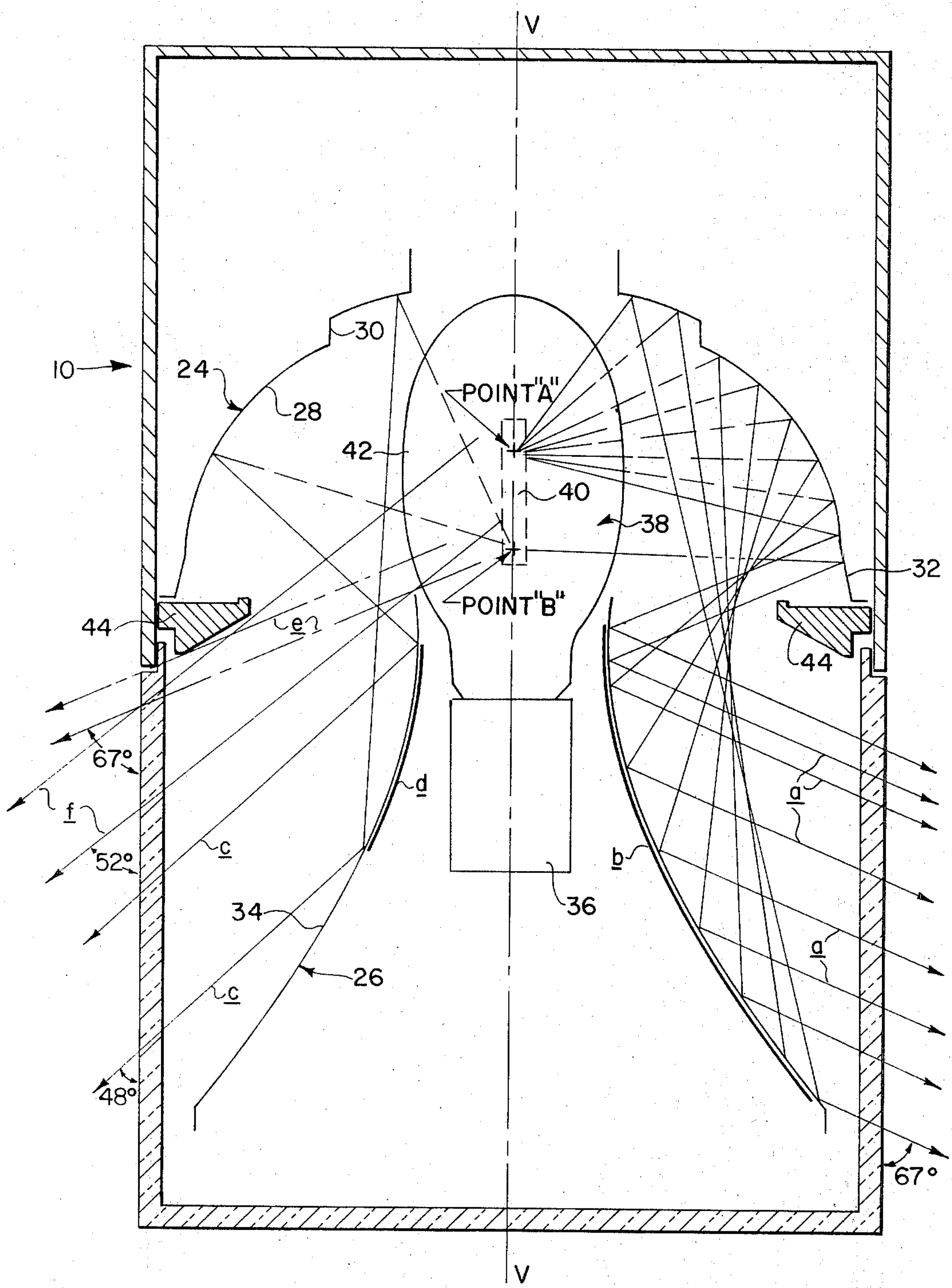

V
10
24
28
30
42
POINT "A"
40
38
32
POINT "B"
44
e
44
67°
f
52°
c
d
a
a
b
36
34
26
c
a
48°
67°
V

FIG. 7

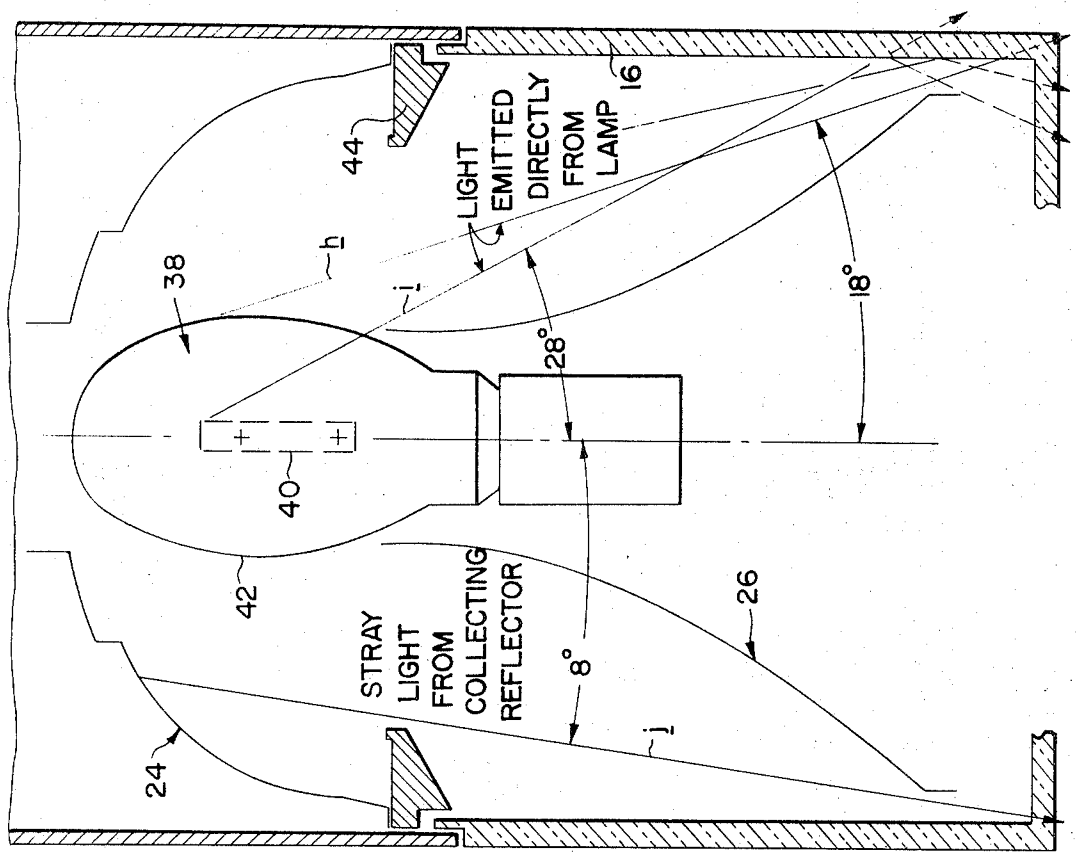
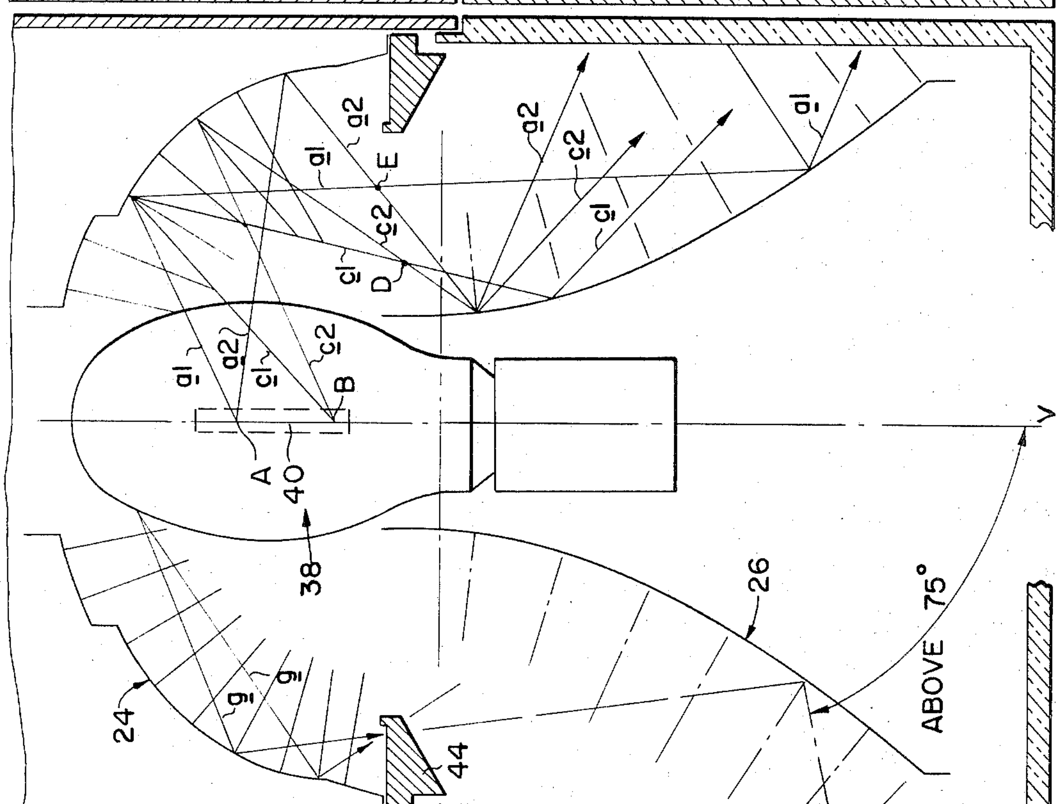
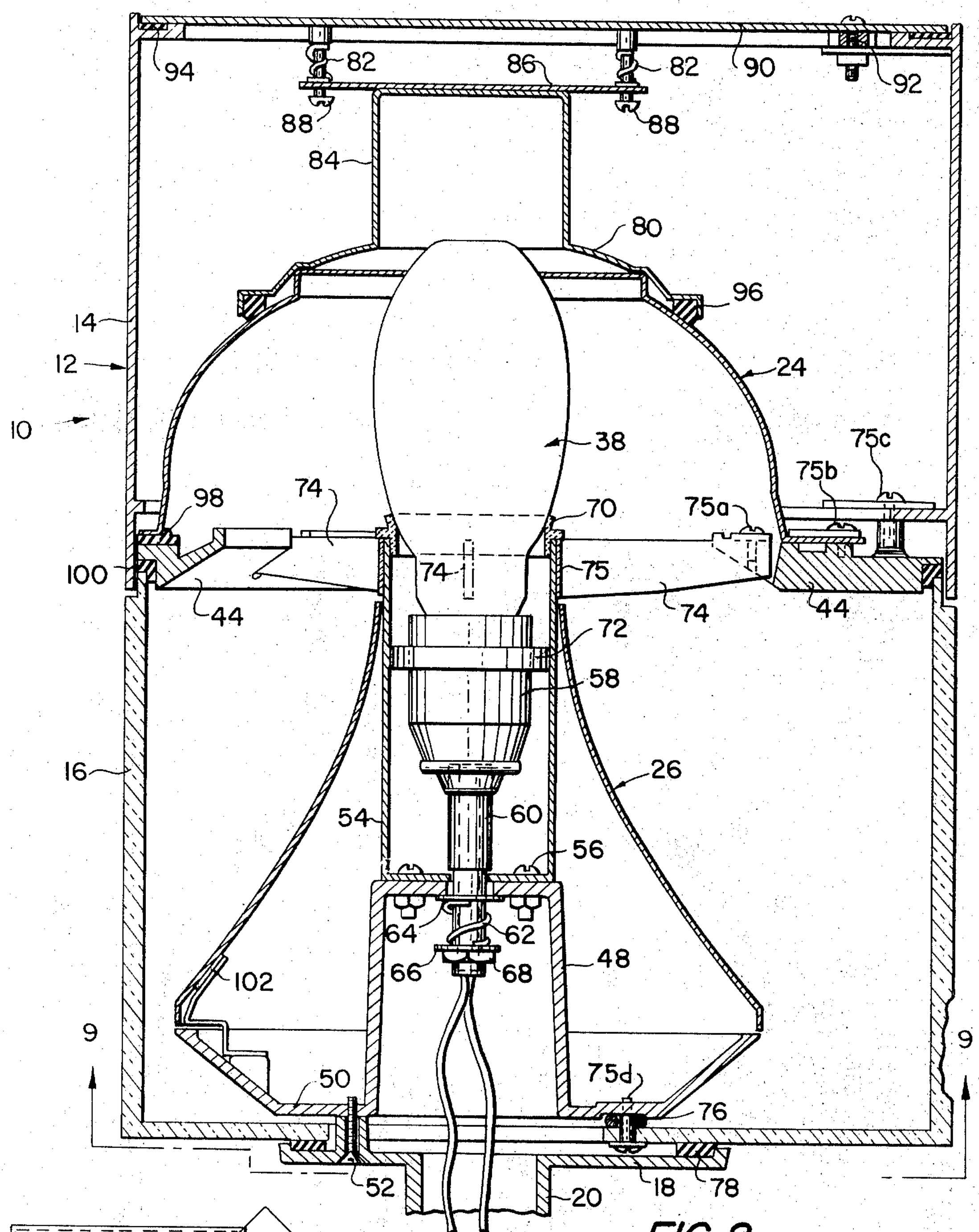

LIGHT EMITTED DIRECTLY FROM LAMP
STRAY LIGHT FROM COLLECTING REFLECTOR
18°
28°
8°
16
44
38
40
42
24
26
h
i
j

FIG. 6


ABOVE 75°
A
B
D
E
38
40
24
26
44
a1
a2
c1
c2
g


94
82
86
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90
92
88
88
84
80
96
14
12
24
10
38
75c
75b
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74
70
75a
100
74
75
44
74
44
72
58
16
26
54
60
56
64
62
66
68
48
102
9
9
50
75d
76
52
18
78
20

FIG. 8

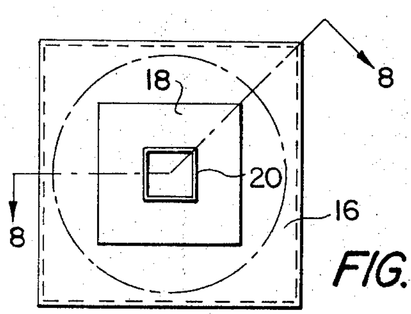
8
18
20
16
8

FIG. 9

FIG. 13

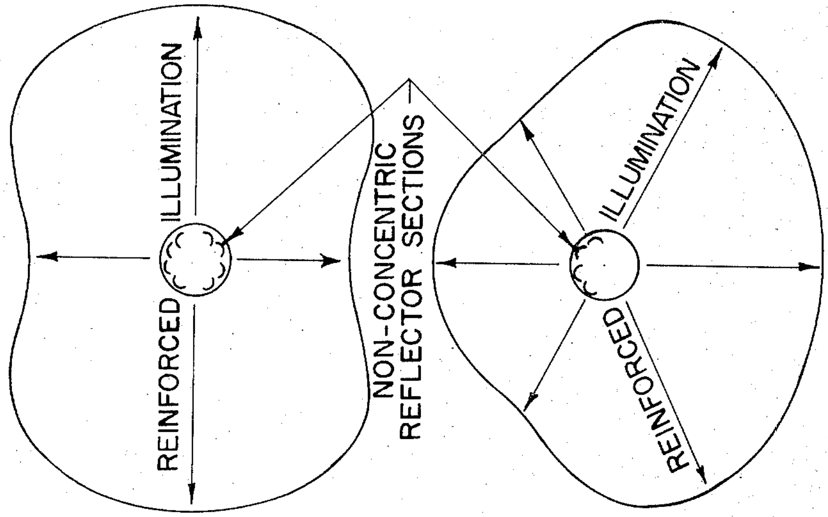

FIG. 14

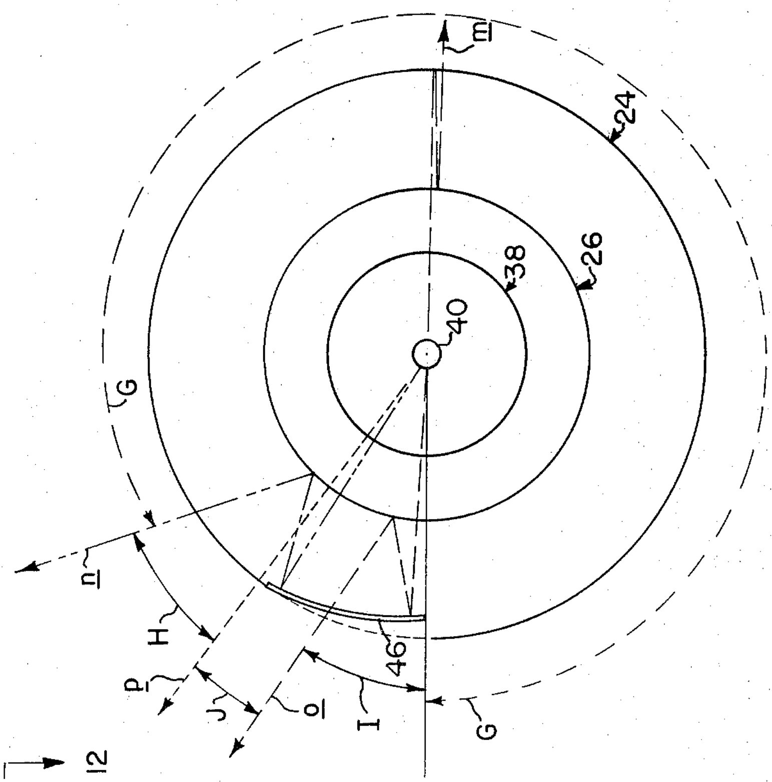

FIG. 12

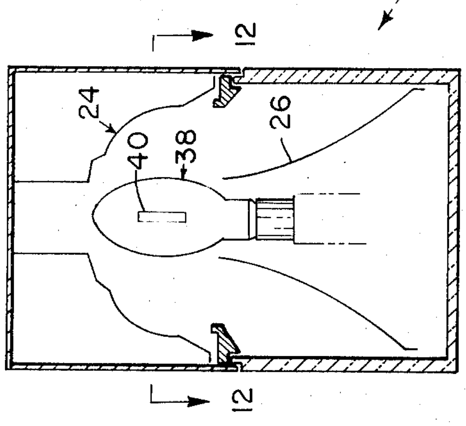

FIG. 11

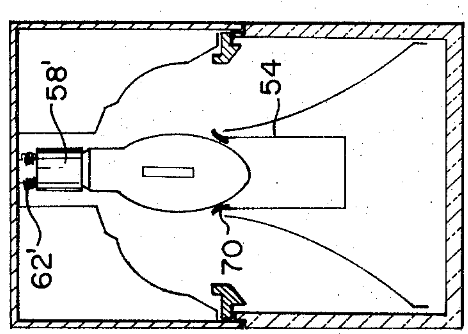

FIG. 10

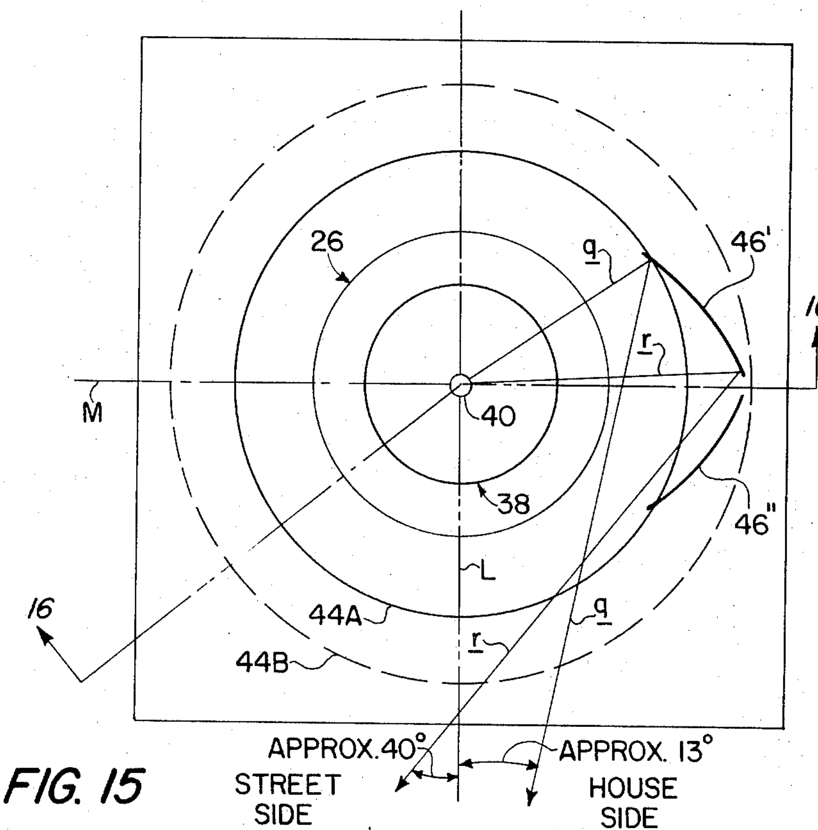
26
q
46'
16
r
M
40
38
46"
L
16
44A
q
r
44B
APPROX. 40°
APPROX. 13°
STREET SIDE
HOUSE SIDE

FIG. 15

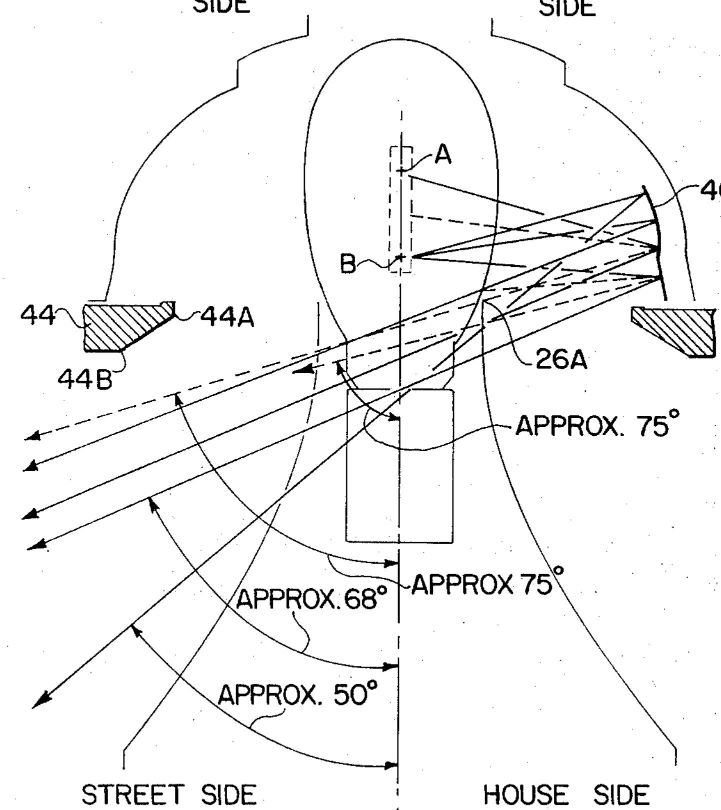
A
46'
B
44
44A
44B
26A
APPROX. 75°
APPROX 75°
APPROX. 68°
APPROX. 50°
STREET SIDE
HOUSE SIDE

FIG. 16

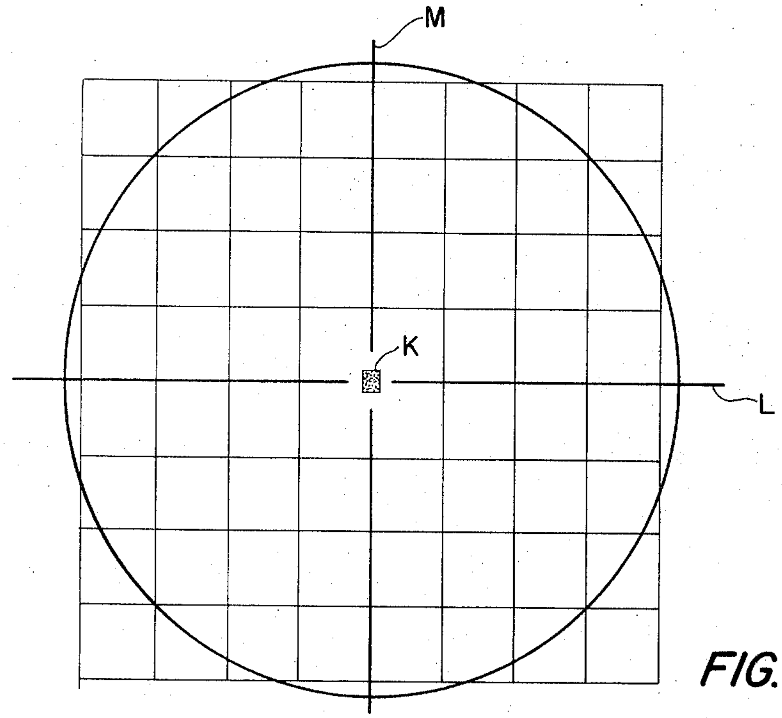

FIG. 17

SYMMETRICAL DISTRIBUTION

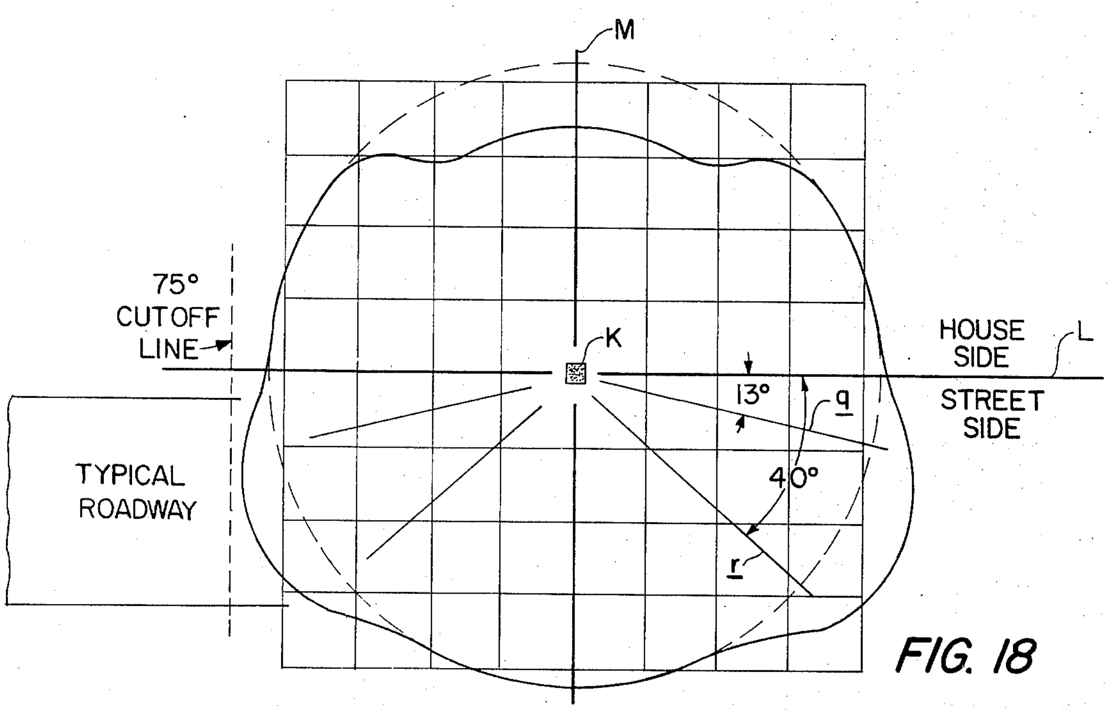

FIG. 18

ASYMMETRICAL DISTRIBUTION

LIGHTING FIXTURES

BACKGROUND OF THE INVENTION

This invention relates to lighting fixtures and is more particularly concerned with outdoor lighting fixtures of the type supported upon posts or poles.

My prior U.S. Pat. No. 3,651,320, granted Mar. 21, 1972, discloses a lighting fixture which provides even illumination over a large area of the ground and which provides complete glare cut-off above a selected angle relative to downward vertical, such as an angle of 72°. The intensity of the light emitted by the fixture is relatively low directly below the fixture, and the intensity increases smoothly as the angle of emitted light relative to downward vertical increases up to a predetermined angle, so that light which travels farther to reach the ground has greater intensity. To achieve this result the lighting fixture of my prior patent employs a pair of reflectors, one of which is substantially tubular and surrounds a portion of the lamp and the other of which is spaced above the first reflector and has a larger diameter. An enclosure of light-transmitting material having a diameter not less than the diameter of the upper reflector extends between and is connected to the reflectors. The enclosure has a central opening on its underside, and an annular support member is secured to the enclosure and extends through the opening. The lower reflector is mounted on the support member and extends therethrough into the enclosure. The lamp, which is hidden from view, emits light to the upper reflector directly, as well as by reflection from the lower reflector. The upper reflector distributes the light in the desired pattern.

While the lighting fixture of my prior patent is quite effective in producing the desired illumination patterns (even asymmetrical patterns in a horizontal plane — by modification of the lower reflector), a need has existed for a different type of lighting fixture capable of producing the same or similar light distribution patterns, with a wide variety of lamps, but without employing an upper reflector having a diameter substantially larger than the diameter of a lower reflector. It is desirable also that the support of the upper portion of the fixture be independent of light-transmitting material of the enclosure, so that if the light-transmitting material is broken, the upper portion of the fixture will not lack support.

The prior art is replete with post-mounted and other lighting fixtures, many of which employ a pair of reflectors in conjunction with a lamp, and many of which attempt to provide different types if illumination patterns, low-glare illumination, and even illumination which cuts off above certain vertical angles. See, for example, U.S. Pat. Nos. 3,679,889; 3,609,340; 3,463,917; 3,089,024; 1,270,261; 2,017,716; 2,191,379; 2,066,631; British Pat. Nos. 1,032,070 (1966); 777,482 (1957); 770,518 (1957); 516,361 (1940); and Danish Pat. No. 50,320 (1935). However, the prior art has failed to teach simple, compact, and aesthetically pleasing lighting fixtures which are capable of producing illumination patterns and glare cut-off characteristics of the type produced by the lighting fixture of my prior patent. The prior art is also replete with different arrangements for supporting reflectors or other portions of lighting fixtures, including arrangements using radiating arms. See, for example, U.S. Pat. Nos. 3,363,093; 3,478,200; 3,339,065; and 3,666,934. Nevertheless, no satisfactory arrangement is disclosed in which a lighting fixture having the aforementioned attributes provides support for the upper portion of the reflector independently of a light-transmitting lower portion and in a manner that is aesthetically pleasing without detracting from structural strength or optical performance. Nor does the prior art teach such lighting fixtures which are capable of using a wide variety of lamps or which provide easy lamp access and ensured lamp alignment.

SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide improved lighting fixtures, particularly lighting fixtures employing an upper reflector which collects light from a lamp and reflects the light to a lower reflector which projects and distributes the light.

A further object of the invention is to provide lighting fixtures of the aforesaid type which are compact, simple in construction, sturdy, and aesthetically pleasing.

Another object of the invention is to provide lighting fixtures of the aforesaid type which may be used with a wide variety of lamps, but particularly lamps having elongated light sources, such as filaments or arc tubes which may be positioned vertically.

A further object of the invention is to provide lighting fixtures of the aforesaid type which produce large amounts of light at high angles relative to downward vertical but in which the light is substantially cut off at a selected angle less than 90° relative to downward vertical.

Still another object of the invention is to provide lighting fixtures of the aforesaid type incorporating a simple but effective glare cut-off baffle.

A still further object of the invention is to provide lighting fixtures of the aforesaid type in which the intensity of the light projected is greatest at a selected high angle relative to downward vertical and decreases progressively at lower angles to provide substantially even illumination over a large area beneath the fixture.

Yet another object of the invention is to provide lighting fixtures of the aforesaid type in which fill-in illumination adjacent to a post is readily achieved.

A still further object of the invention is to provide unique lighting fixtures having an upper reflector and a lower reflector, in which the lower reflector, serving to distribute light, is surrounded by a light-transmitting section of an enclosure, the upper reflector and upper section of the enclosure being supported securely, unobtrusively, and independently of the light-transmitting section of the enclosure.

An additional object of the invention is to provide such lighting fixtures in which the lamp is accurately positioned in a simple manner and in which access to the lamp is easily obtained.

Briefly stated, preferred embodiments of the invention employ a pair of reflectors in conjunction with a lamp having an elongated light source that is oriented vertically. One of the reflectors is disposed above the other reflector, surrounds the light source, and reflects light from the source to the lower reflector, which projects and distributes the light. The upper reflector has a downwardly-facing concave internal reflecting surface which is a surface of revolution about a vertical axis aligned with the light source. The lower reflector has a concave external reflecting surface which faces upwardly and outwardly and which is also a surface of revolution about the vertical axis. Light emitted from the upper end of the light source is reflected from the upper reflector to the lower reflector and is projected by the lower reflector at a high angle relative to downward vertical, such as 67°. Light emitted from the lower end of the light source is reflected from the upper reflector to the lower reflector and is projected by the lower reflector at a somewhat lower angle, such as 48°. Moreover, light emitted from the upper end of the light source covers much more of the height of the lower reflector than light emitted from the lower end of the light source. Light is also emitted directly from the lamp, without reflection. The intensity of this light is greatest at an angle relative to the downward vertical such as 52°, decreasing at higher and lower angles. Above a certain angle, such as 52°, the intensity curves of light projected by the lower reflector and light emitted directly from the lamp are oppositely directed, the former increasing with increase in vertical angle and the latter decreasing. An inwardly directing glare baffle at the bottom of the upper reflector ensures light cutoff at a predetermined maximum angle, such as 75° relative to downward vertical. Fill-in illumination immediately below the fixture may be provided by stray light from the upper reflector, which may be emitted from the lamp envelope, and/or by light reflected from the inner surface of a light-transmitting enclosure section which surrounds the lower reflector. By virtue of the invention an even light distribution is produced over a large area of the ground below the lighting fixture, yet glare is minimized. By modification of the upper reflector, illumination may be increased in certain azimuthal directions and decreased in others. In a particular mechanical embodiment of the invention the upper reflector and the upper section of the enclosure are supported upon arms which radiate from a structural tube extending through the lower reflector, and the support is independent of the light-transmitting section of the enclosure which surrounds the lower reflector. The lamp is received in a centered receptacle within the tube and is seated at the upper end of the tube. Access to the lamp is provided by forming the upper reflector in two parts, one part being movable with a top wall of the enclosure to expose the lamp.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described in conjunction with the accompanying drawings, which illustrate preferred and exemplary embodiments and wherein:

FIG. **1** is a perspective view of a first embodiment of the invention illustrating the mounting of the lighting fixture upon a pole and showing the lower reflector surrounded by the light-transmitting section of the enclosure, the glare baffle, and the support arms for the upper section of the enclosure;

FIG. **2** is a polar coordinate diagram illustrating the intensity of the light projected by the invention at different angles relative to downward vertical;

FIG. **3** is a perspective view of another embodiment of the invention, in which the fixture is supported upon a short post;

FIG. **4** is a diagrammatic vertical sectional view illustrating the operation of the embodiment of FIG. **3**;

FIGS. **5, 6,** and **7** are diagrammatic vertical sectional views illustrating the operation of the embodiment of FIG. **1** and to a large extent the operation of the embodiment of FIG. **3** also;

FIG. **8** is a vertical sectional view illustrating the embodiment of FIG. **1** as seen along line **8—8** of FIG. **9** in the direction of the arrows, most of the structure illustrated being applicable to the embodiment of FIG. **3** also;

FIG. **9** is a bottom plan view of the embodiment of FIG. **1** as seen in the direction of the arrows **9—9** of FIG. **8**;

FIG. **10** is a diagrammatic vertical sectional view illustrating an alternative mode of mounting the lamp;

FIG. **11** is a diagrammatic vertical sectional view employed in conjunction with FIG. **12** to illustrate the manner in which the horizontal light distribution may be modified;

FIG. **12** is a diagrammatic horizontal sectional view taken along line **12—12** of FIG. **11**;

FIGS. **13** and **14** are diagrammatic plan views illustrating asymmetrical light distribution which may be obtained in accordance with the invention;

FIG. **15** is a diagrammatic horizontal sectional view illustrating a different manner in which the horizontal light distribution may be modified;

FIG. **16** is a diagrammatic vertical sectional view illustrating the manner in which light is reflected from an altered reflector section; and

FIGS. **17** and **18** are diagrammatic plan views illustrating symmetrical and asymmetrical light distribution, respectively, in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, FIGS. **1** and **3** illustrate embodiments of the invention which differ somewhat in appearance but which operate similarly (with certain exceptions which will be described later). In the embodiment of FIG. **1** the lighting fixture **10** comprises an enclosure **12** with an upper section **14**, which may be entirely opaque, and a lower section **16**, which may be light-transmitting on all sides and on the outer portions of the bottom which extend beyond a base plate **18** on which the fixture is mounted. The base plate has a tubular depending neck **20** by which the lighting fixture is supported at the top of a post or pole in a conventional manner. Although a single lighting fixture is illustrated in FIG. **1**, it will be apparent that a plurality of such fixtures may be supported upon arms on a single post as disclosed, for example, in my aforesaid patent. Although a rectangular enclosure is shown, other configurations, such as circular, may be employed. Suitable materials for the construction of the lighting fixtures disclosed herein are well known in the prior art and are set forth, for example, in my aforesaid prior patent. In the embodiment of FIG. **3** (wherein primed reference characters designate parts corresponding to those of the embodiment of FIG. **1**) the lighting fixture **10'** has an enclosure **12'** with an opaque upper section **14'** and a light-transmitting lower section **16'**. In this instance, however, the light-transmitting section of the enclosure does not extend into the bottom wall of the enclosure, and the enclosure is supported upon the top of a short post **22'** as an extension of the post, so that the lighting fixture appears to be incorporated into the post. The post of FIG. **3**, including the fixture, may be approximately 42 inches high, for example, while the post **22** of FIG. **1** may range in length from approximately 8 feet to approximately 25 feet, for example.

Turning now to FIG. **5,** a lighting fixture **10** is illustrated which, for purposes of explanation, may be assumed to be the fixture of FIG. **1,** although the basic configuration is applicable to the fixture of FIG. **3** also. The lighting fixture comprises a first or upper reflector **24** and a second or lower reflector **26.** The lower reflector **26** is clearly visible in FIG. **1** and its counterpart **26'** is clearly visible in FIG. **3.** The upper reflector **24** has a downwardly facing concave internal reflecting surface **28** which is a surface of revolution about the vertical axis V—V of the lighting fixture. In the form shown, the upper reflector has a slight step **30** near its uppermost portion and the lower extremity is flared outwardly somewhat as shown at **32.** The upper reflector may be termed a collecting reflector, while the lower reflector may be termed a distributing reflector. The lower reflector has a concave external reflecting surface **34** which faces upwardly somewhat and laterally outward. The reflecting surface **34** is also a surface of revolution about vertical axis V—V. Both reflecting surfaces have a specular (mirror polish) finish. While the upper reflector has the general shape of an inverted dish, the lower reflector is tapered, the upper end of the reflecting surface being closer to the axis V—V than the lower end. In the form shown, the lower reflector is tubular and contains a receptacle or socket **36** which receives a lamp **38.**

The lamp, which has its base engaged within the receptacle **36,** has an elongated light source **40,** such as an arc tube or an elongated filament, and has an envelope **42** which may be a passive envelope or which may itself be light-emitting, as in certain phosphor coated mercury vapor lamps. As shown in FIG. **5,** the elongated light source **40** is aligned with the vertical axis V—V and is surrounded by the collecting reflector **24.** The lighting fixtures of the invention may be used with almost all lamps commonly employed for outdoor lighting, such as the "BT" and "E" shaped mercury vapor lamps, "BT" and "E" shaped metal halide lamps, and "T" shaped high pressure sodium lamps, "T" shaped quartz lamps and "A" and "PS" shaped incandescent lamps. These lamps have differing desirable qualities, such as long life, good lumen maintenance, etc., and it is a distinct advantage of the invention that the lighting fixtures of the invention may be employed with all of them.

In general, the lighting fixtures of the invention are designed to project the greatest amount of light at a high angle relative to downward vertical and to produce a symmetrical or controlled asymmetrical light distribution pattern on the ground, with even illumination over a wide area. The amount of light projected increases progressively (up to a predetermined angle) as the angle increases relative to downward vertical. This increase of light tends to balance the diminution of light reaching the ground caused by the greater distance traveled at high angles.

As shown in FIG. **5,** light from point A at the upper end of the light source **40** is reflected from the collecting reflector **24** to the distributing reflector **26,** which redirects the light outwardly and downwardly toward the ground at a predetermined high angle, such as approximately 67° above downward vertical, as shown by rays a. The amount of "flash," that is, the length of the image of the arc tube on the distributing reflector, has good correlation with the intensity of light projected from the lighting fixture. It is apparent that at 67° the image of the arc tube, indicated by the heavy line b is substantially the full length of the distributing reflector **26,** and hence the light from this reflector at this angle is at its maximum intensity.

Light emitted from point B at the lower end of the light source **40** is also reflected by the collecting reflector **24** to the distributing reflector **36** and is projected outwardly at a lower angle, such as approximately 48° relative to downward vertical, as indicated by rays c. As shown, the image of the arc tube on the distributing reflector at 48°, indicated by the heavy line d, covers much less than the full length of the distributing reflector, and hence the light intensity at this angle is not a maximum. Light emitted from the light source **40** between points A and B is reflected from collecting reflector **24** to the distributing reflector **26** and is redirected outwardly by the distributing reflector at angles which fill in the angles between 67° and 48°. The reduction of image length on the distributing reflector is progressive as the beam moves from 67° to lower angles, and therefore the intensity of light projected is reduced in a like manner.

It will be noted that some light coming from point B and striking the collecting reflector **24** near the open bottom thereof is directed to the distributing reflector **26** by the flared portion **32** at an angle such that it joins light from point A in being projected outwardly at 67°. This is characteristic of the particular construction shown, which may be employed in FIG. **1,** but which need not be employed in all embodiments, as is apparent from the embodiment of FIGS. **3** and **4.** Neglecting the flared portion **32,** it will be noted in FIG. **5** that surface **28** is shaped so that rays originating at a point of source **40** and reflected by progressively lower elements of surface **28** impinge upon progressively higher elements of surface **34,** and by virtue of the shape of surface **34** such rays are reflected therefrom outwardly and downwardly along parallel paths.

Some light is emitted directly from the light source **40** without striking reflectors. This light has been indicated in FIG. **5** by rays e and f at 67° and 52°, respectively, relative to downward vertical. More such light is emitted at low angles, toward 52°, than at higher angles, toward 67°. The amount of light increases as the angle decreases from 67° until at approximately 52° the amount of light begins to decrease progressively. If two intensity curves were plotted in a vertical plane containing the axis V—V, one for reflected light and the other for light emitted directly from the light source **40,** the two curves would be oppositely directed above 52°, the intensity of the light emitted from the reflectors increasing progressively above 52° and the intensity of the directly emitted light decreasing progressively above 52°. Total intensity of the light emitted at each angle is the sum of the two. If the number 1.0 represents the full intensity of light per inch emitted directly from the arc tube and if this number is multiplied by the length of the arc tube visible between the reflectors at its maximum (52°), which may be 1.25 inches, the resulting intensity figure is 1.25. Assuming 80 percent reflector efficiency, the number 0.64 then indicates the intensity of light per inch reflected from the collecting and distributing reflectors in sequence (0.8×0.8). At its maximum (67°) the image of the arc tube covers the full length of the distributing reflector, as noted above, which may be 9 inches long. The resulting intensity is thus 5.76 (0.64 × 9). This confirms that the light projected by the reflector system contributes much more intensity than the light emitted directly from the light source.

The results of the optical system of the invention can be seen in FIG. **2**, which is a candlepower distribution curve, 0° being downward vertical and 90° being horizontal. Although the curve is shown only for the quadrant between 0° and 90°, the same curve would be obtained in the quadrant between 0° and −90° (and in any plane containing the axis of the lighting fixture) due to the symmetrical construction. The intensity of light is low at 0°, toward the bottom of the pole or post on which the lighting fixture is mounted. From 0° to about 45° most of the light is in fact stray light, which will be explained later. The intensity climbs steadily to a maximum at approximately 60° and remains near maximum until 67°, where it rapidly falls off, disappearing completely at angles which exceed the angle of greatest intensity by approximately 10° to 15°. Since these higher angles are the ones at which the fixture will usually be observed, the result is the total elimination of glare, with only a soft glow remaining at the fixture for aesthetic purposes. Moreover, the light distribution on the ground is unusually constant over a wide area.

If light is emitted only from the elongated light source **40**, such as an arc tube or a filament of the lamp, the reflector system will, in itself, eliminate glare. Since light emitted from points low on the arc tube or filament (point B) is distributed at low angles by the invention and since light emitted from high on the arc tube or filament (point A) is distributed at high angles by the invention, the arc tube or filament need only be positioned so that its upper end is located at the exact point where beam cut-off is desired. Lamps which emit light only from the arc tube or filament are the high pressure sodium, metal halide and clear mercury lamps (arc tube types), and the single end quartz and clear incandescent lamps (filament types).

The most popular outdoor lamps, however, are the phosphor coated mercury vapor lamps. While the major position of the light comes from the arc tube of these lamps as well, the phosphor coating which covers the entire lamp envelope radiates enough light to cause considerable glare. It is possible to make the reflector system large enough so that the arc tube would be in position to emit maximum intensity at 60° and still have the top of the lamp envelope occur at the point where beam cut-off is desired. However, since the compactness of the invention is a major advantage, this would be undesirable. To eliminate glare without requiring a larger reflector system the invention employs a glare baffle **44** (FIG. **5**), which may be a horizontal rectangular plate with a large circular opening centered on the vertical axis V—V and with the plate material which surrounds the opening constituting an annulus which protrudes inwardly toward the axis V—V from the bottom of the collecting reflector **24**. The operation of the glare baffle is illustrated in FIG. **6**. The reflector system is so designed that light rays which are ultimately projected outwardly at low angles travel between the collecting and distributing relectors in such a way that they cross at points relatively close to the vertical axis near the open end of the collecting reflector, in comparison to rays which are ultimately projected at higher angles and which cross at points farther from the vertical axis. Thus, as shown in FIG. **6**, rays c**1** and c**2**, emitted from point B and ultimately projected from the lighting fixture at low angles, cross over at point D, which is closer to the axis V—V than the cross-over point E of rays a**1** and a**2** emitted from point A. It is a simple matter, therefore, to provide a glare baffle around the periphery of the collecting reflector **24** which intrudes just the proper amount to cut off the undesirable highest angle rays which produce glare (such as light rays g which would be projected at an angle bove 75° in the embodiment illustrated in FIG. **6**) without in any way diminishing the remaining rays which produce desirable illumination. It will be noted, of course, that the construction of the invention is such that no portion of the lamp is visible at angles above 75°.

The manner in which fill-in illumination at angles close to downward vertical is achieved will now be described with reference to FIGS. **4** and **7**. Referring first to FIG. **7**, which represents the embodiment of FIG. **1**, that is, a lighting fixture mounted high on a pole, it will be recalled that the light-transmitting section **16** of the enclosure extends into the bottom wall beneath the fixture. Light coming directly from the lamp **38**, either from the envelope **42** or the light source **40**, is intercepted by the side wall of the light-transmitting enclosure section **16** at a low angle, approximately 18° with a phosphor coated lamp and approximately 28° with a clear lamp, as indicated by the rays h and i, respectively. Stray light from the upper reflector **24** extends down at an angle of approximately 8° with respect to downward vertical, as indicated by ray j. Light rays such as ray j pass directly through the light-transmitting section at the bottom of the enclosure, while light rays such as rays i and h strike the inner surface of the enclosure at such a low angle of incidence that the inner surface of the enclosure acts as a reflector and redirects some of this light toward and even beyond the vertical axis, as indicated by dashed portions of the rays, thereby providing fill-in illumination for the area beneath the lighting fixture. Since the inner surface of the enclosure receives light rays at many different angles, it is not necessary that the sides of the enclosure be vertical for proper operation, and the side walls may be flared, for example.

In the smaller embodiment of FIGS. **3** and **4**, where, for aesthetic reasons, the light-transmitting section of the enclosure does not extend inwardly beneath the fixture, rays such as rays h and i in FIG. **7** cannot be directed inwardly toward the vertical axis. However, there is still some fill-in illumination as indicated by rays k and l in FIG. **4** emitted directly from the lamp envelope **42** and by reflection from the collecting reflector **24**, for example. Since the lighting fixture of FIGS. **3** and **4** is supported quite close to the ground, the dark circle extends only about seven inches beyond the base of the post and is not objectionable. Also, in the smaller embodiment greatest beam intensity occurs at about 80° relative to downward vertical, and the beam disappears at slightly below 90°.

Since the reflector system is circular in its horizontal cross-section, the pattern of light projected on the ground will ordinarily be symmetrical about the vertical axis. Although asymmetrical patterns could be achieved by blocking out light from various portions of the collecting reflector, either by extending areas of the glare baffle inwardly or by simply painting sections of the collecting reflector black, for example, such methods would create asymmetry by diminishing illumination in certain areas without increasing it in other areas. Light would thus be wasted. Asymmetry could also be achieved by changing the contour angle of selected sections of the distributing reflector, but since this reflector is visible to the observer, an obvious change of this sort has aesthetic disadvantages. Also, such a change would leave the amount of light emitted toward the distributing reflector in radial planes the same in all directions, rather than increasing the amount of light in the direction of the longest throw. FIG. **12** illustrates a better solution to this problem, the figure being a horizontal cross-section taken through the lamp and collecting reflector as indicated in FIG. **11.** Light striking the concentric surface of the collecting reflector is reflected directly back to the distributing reflector in a radial plane and from there is projected outward in the same plane. This is indicated diagrammatically by ray m. If, however, a section of the collecting reflector is altered, so that it is not concentric with the lamp and the distributing reflector, as indicated by section **46,** light rays striking this surface will be reflected in non-radial planes toward the distributing reflector and from the distributing reflector will be projected outwardly in non-radial planes. This is indicated by the rays n and o. As shown in FIG. **12,** this will increase the amount of light thrown in some directions and decrease it in others. Arc G designates the area of unaffected illumination, arc H the area of reinforced illumination, arc I the area of reduced illumination, and arc J the area of relatively unaffected illumination. Ray p designates the distribution from the unaltered reflector, which may be compared with ray n. The proper placement of the altered (non-concentric) reflector sections will create asymmetrical distribution patterns as indicated in FIGS. **13** and **14,** for example. Since the vertical contour of the collecting reflector is not changed in any way, the glare cut-off characteristics and vertical distribution angles will not be affected. Only the amount of light thrown outward will vary from one direction to another.

If light were coming only from the arc tube and if the altered reflector section were a perfectly specular mirror, it is apparent that the outside area which is designated by arc I in FIG. **12** would in fact receive no illumination at all. This could be undesirable. When phosphor coated mercury vapor lamps are used, this problem does not exist, since enough light is radiated from the coating on the lamp to produce the necessary fill light in the affected area. When a non-coated lamp (such as metal halide, high pressure sodium, etc.) is used, the non-concentric reflector sections can be given a semi-diffuse reflector finish, so that the major portion of the light will follow the direction imparted by a specular finish, but enough stray (diffused) light will be created to fill in the affected area.

A further technique for achieving asymmetric light distribution in a horizontal plane will now be explained with reference to FIGS. **15 – 18.** In this embodiment non-concentric sections of the collecting reflector are also employed. However, these sections are so angulated that light rays reflected from them bypass the distributing reflector and are sent directly toward the gound. The technique will be described in its application to a pole-mounted street illumination fixture, but it will be apparent that there are many other applications also.

FIG. **17** illustrates the usual symmetrical light distribution produced on the ground surrounding a pole K when the concentric reflector arrangement of the invention is not modified. FIG. **18** illustrates an asymmetrical light distribution (shown superimposed on a symmetrical distribution for comparison) which may be produced in a manner described hereinafter. It will be noted that FIGS. **17** and **18** are divided by orthogonal lines L and M radiating from the pole K, line L being parallel to a typical roadway (so-labeled) at one side of the line, and line M being perpendicular to the roadway. Lines L and M are also indicated in FIG. **15.**

Referring now to FIG. **15,** it will be noted that there are two non-concentric sections **46′** and **46″** of the collecting reflector. Sections **46′** and **46″** are oppositely angulated in a horizontal plane with respect to line M, and since the sections and their orientation are identical, except for the opposite angulation, a description of the operation of section **46′** will suffice for both. The non-concentric orientation of section **46′** in a horizontal plane causes rays such as q and r emanating from the arc tube **40** and reflected from section **46′** to be reflected past the distributing reflector **26** at one side thereof. Rays will be similarly reflected from section **46″** at the opposite side of the distributing reflector, so that two beams of light are projected toward the street side of line L at opposite sides of line M. Each beam extends from approximately 13° to approximately 40° from line L and diminishes fairly rapidly beyond these angles.

FIG. **16** illustrates light rays of one of the beams in a vertical plane. With the non-concentric reflector section **46′** of the height shown, the beam extends from approximately 50° up to approximately 75° from downward vertical. It is apparent that if the reflector section **46′** were taller, the beam would extend to an angle lower than 50°.

From FIGS. **15** and **16** it is apparent that glare cut-off is still produced by the glare baffle, the leading and following edges of which are indicated at **44A** and **44B.** Also, the top edge **26A** of the distributing reflector assists in producing glare cut-off as indicated in FIG. **16.** For ray q of FIG. **15** cut-off occurs at approximately 75° from downward vertical. For ray r of FIG. **15,** cut-off occurs at slightly over 75°. Rays q and r are also illustrated on the isolux curve of FIG. **18.**

As shown in FIG. **18,** the basic symmetrical distribution is altered to create a relatively long rectangular pattern on the street side. Since light was taken from the house side to create the additional beams referred to above, the distribution is reduced at the house side.

FIG. **18** also illustrates a 75° cut-off line. This line is established by determining the point at which a ray at 75° with respect to downward vertical would strike the ground along line L. From this point the 75° cut-off line is drawn perpendicular to the roadway. Glare cut-off angle is determined by this line (rather than a radial one) for roadway luminaires. Although cut-off occurs at slightly over 75° for ray r, the ray will still strike the ground within the 75° cut-off line.

The mechanical construction of a practical form of the invention, corresponding to FIG. **1** but largely applicable to FIG. **3** also, is illustrated in FIG. **8,** the view being taken along line **8—8** of the bottom view of FIG.

9. The outer configuration is only one of many possible configurations, which may range from contemporary to traditional lantern shapes, for example, all of which may employ the same optical system. The tubular neck **20** of the base plate **18** supports the entire fixture. An inverted cup-shaped base **48** has a skirt **50** which may be secured to the base plate **18** by screws **52**, the periphery of the skirt **50** being flared upwardly and outwardly to engage and support the bottom of the distributing reflector **26**. A structural tube **54** is supported upon the top of base **48**, being secured thereto by screws **56**, and has an open upper end which projects from the top of the distributing reflector **26**. A lamp receptable or socket **58** is mounted on a sleeve **60** which has a reduced diameter portion extending downwardly through openings in the bottom of tube **54** and the top of base **48**. A helical compression spring **62** surrounds the lower portion of sleeve **60** and is held captive between washers **64** and **66**, washer **64** abutting the top of base **48** and washer **66** being supported on a nut **68** threaded onto the bottom of sleeve **60**. The spring biases receptacle **58** downwardly. When the lamp **38** is engaged with the receptacle **58**, as by being threaded therein, the socket **58** is drawn upwardly, spring **62** being compressed, and the shoulder of the lamp envelope is drawn downwardly upon a circular ring seat **70** provided at the top of tube **54**. This centering ring seat and a further centering ring **72**, which surrounds the receptacle **58** and guides the reciprocative movement of the receptacle within the tube **54**, ensure that the lamp **38** is properly positioned relative to the reflector system. Although the lamp is shown base down in FIG. **8**, it may be supported base up as indicated in FIG. **10**. In this embodiment the socket **58'** is again spring-loaded in a downward direction, by springs **62'**, and the top of the lamp is held against the seat **70**, which centers the lamp and holds it vertical. In this case the seat presses the spring-loaded lamp up into position when the hinged or removable top wall of the enclosure is closed. In all other respects the construction is the same as FIG. **8**.

Four horizontal supporting arms **74** (see FIGS. **1** and **8**) have their inner ends attached to a ring **75** fixed about the upper end of tube **54**. The arms radiate from the tube, and their outer ends support the upper portion of the fixture, including the glare baffle **44**, the collecting reflector **24**, and the upper section **14** of the enclosure **12**. The portions of the arms spanning the space between tube **54** and glare baffle **44** have small thickness relative to height, so that the arms have the appearance of vertical fins, which have adequate structural strength without significantly interrupting optical paths. The outer ends of the arms fit into notches in the glare baffle and have portions bent horizontally to receive screws **75**a which fix the glare baffle to the arms. Screws **75**b and **75**c fix the collecting reflector to the glare baffle and the upper enclosure section **14** to the glare baffle, respectively. When the lighting fixture is to be mounted upon a high pole, the arms preferably have a highly specular finish similar to the collecting reflector **24**, so that they are almost invisible when viewed at normal angles (from below). When the fixture is mounted on a short post, below eye level, the arms may simply be painted black. Since the upper portion of the lighting fixture is supported upon and connected to the neck **20** by the structural tube and arm assembly, the light-transmitting enclosure section **16** may simply float, without structural strain, between upper and lower cushions **76** and **78**, the bottom wall being positioned by screws **75**d passing therethrough and threaded into base **48**. This is highly advantageous, because the light-transmitting enclosure section is normally the weakest part of the lighting fixture. If this section is shattered, the upper portion of the lighting fixture will still be supported.

The collecting reflector **24** is preferably constructed in two sections, with an upper section **80** being removable from the remaining lower section of the reflector and spring-biased toward it by means of compression springs **82**, so that the upper section rests firmly against the lower section when in place. The upper section **80** may have a cupped portion **84** depending from a plate **86**, screws **88** passing loosely through plate **86** and being threaded into bosses of the top wall **90** of the enclosure **12**. The top wall **90** is removably attached to the side walls of the upper section **14** of the enclosure by means of conventional fasteners **92**. To gain access to the lamp, the top wall is removed or opened, lifting with it the upper section **80** of the collecting reflector, so that the lamp **38** is exposed through the hole at the top of the collecting reflector resulting from the removal of upper section **80**. Weatherproofing and/or cushioning gaskets may be provided as indicated at **94**, **96**, **98**, **100** and **102**, for example, in addition to those mentioned previously.

While preferred embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that changes can be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims.

The invention claimed is:

1. A lighting fixture comprising upper and lower reflectors, and lower reflector being positioned beneath said upper reflector and having a common vertical axis therewith, an elongated light source positioned vertically along said axis between said reflectors, and means including a downwardly-facing, concave, internal reflecting surface of said upper reflector and a cooperating upwardly-outwardly-facing, concave, external reflecting surface of said lower reflector for causing light rays emitted from the upper end of said elongated source to be reflected from said surface of said upper reflector to said surface of said lower reflector and then to be reflected thereby outwardly and downwardly substantially at a first predetermined angle relative to downward vertical and for causing light rays emitted from the lower end of said source to be reflected from said surface of said upper reflector to said surface of said lower reflector and then to be reflected thereby outwardly and downwardly substantially at a second predetermined angle relative to downward vertical which is less than the first angle.

2. A lighting fixture in accordance with claim **1**, wherein said means causes light rays emitted from the upper end of said source and reflected from said surface of said upper reflector to said surface of said lower reflector to cover substantially more of the length of said surface of said lower reflector than light rays emitted from the lower end of said source and reflected from said surface of said upper reflector to said surface of said lower reflector.

3. A lighting fixture in accordance with claim **2**, wherein the first-mentioned light rays cover substantially the entire length of said surface of said lower reflector.

4. A lighting fixture in accordance with claim 2, wherein the light intensity distribution of said fixture at one side of said axis in a vertical plane containing said axis is substantially in accordance with the distribution illustrated in FIG. 2.

5. A lighting fixture in accordance with claim 2, wherein said source is surrounded by said upper reflector and wherein the top of said lower reflector and the bottom of said upper reflector are positioned relative to each other and said source to provide a space through which light is emitted directly from said source outwardly and downwardly between said reflectors without reflection from said surfaces, the total amount of light emitted fro said fixture being predominantly light reflected from said reflecting surfaces rather than emitted directly from said source without reflection from said surfaces.

6. A lighting fixture in accordance with claim 5, wherein the intensity of light emitted directly from said source without reflection from said surfaces decreases progressively above a third predetermined angle relative to downward vertical up to said first angle and wherein the intensity of light reflected from said surfaces increases progressively above said third angle up to said first angle.

7. A lighting fixture in accordance with claim 6, wherein said first angle is about 67° and wherein said third angle is about 52°.

8. A lighting fixture in accordance with claim 1, wherein said first angle is about 67°.

9. A lighting fixture in accordance with claim 8, wherein said second angle is about 48°.

10. A lighting fixture in accordance with claim 1, wherein said first angle is about 80°.

11. A lighting fixture in accordance with claim 1, wherein light rays emitted from said upper end of said source at different angles in a vertical plane and reflected from said surface of said upper reflector cross over at points which in general are located laterally outward of the cross over points of light rays emitted from the lower end of said source at different angles in the vertical plane and reflected from said surface of said upper reflector.

12. A lighting fixture in accordance with claim 11, further comprising a glare baffle extending laterally inward toward said vertical axis from the vicinity of the lower end of said upper reflector, said light source having an envelope surrounding it, and said glare baffle intercepting rays emitted from said envelope and reflected from said surface of said upper reflector to said surface of said lower reflector along paths which would cause said rays to be reflected from said surface of said lower reflector at a maximum angle relative to downward vertical greater than said first angle.

13. A lighting fixture in accordance with claim 12, wherein said maximum angle is about 75°.

14. A lighting fixture in accordance with claim 12, wherein said maximum angle is about 90°.

15. A lighting fixture in accordance with claim 1, wherein said lower reflector is positioned with respect to said upper reflector to provide paths for the emission of light downwardly at angles less than said second angle without reflection from said reflecting surface of said lower reflector.

16. A lighting fixture in accordance with claim 15, wherein said source has an envelope and rays from said envelope extend along said paths after reflection from said surface of said upper reflector.

17. A lighting fixture in accordance with claim 1, wherein said fixture has a light-transmitting enclosure section laterally outward of said lower reflector and wherein said source is positioned relative to said lower reflector and said enclosure to provide paths from said source to said enclosure section at angles of incidence upon said enclosure section which are low enough to cause the light rays to be reflected downwardly from said enclosure section.

18. A lighting fixture in accordance with claim 1, wherein said upper reflector has a section of its reflecting surface angulated in a horizontal plane with respect to other sections of that reflecting surface for modifying the distribution in a horizontal plane of light projected by said fixture.

19. A lighting fixture in accordance with claim 18, wherein the first-mentioned section is diffusely reflecting and said other sections are specularly reflecting.

20. A lighting fixture in accordance with claim 1, wherein said upper reflector is supported upon the outer ends of arms extending laterally outward from arm supporting means at the top of said lower reflector.

21. A lighting fixture in accordance with claim 20, wherein said fixture has an enclosure with an upper section surrounding said upper reflector and supported upon the outer ends of said arms and with a lower, light-transmitting section surrounding said lower reflector and mounted upon means for supporting said fixture.

22. A lighting fixture in accordance with claim 1, further comprising an additional reflecting surface portion near the open bottom of said upper reflector for causing light rays emitted by said lower end of the light source and striking said additional reflecting surface portion to be reflected therefrom to said surface of said lower reflector for thereby being reflected outwardly and downwardly from the lighting fixture substantially at said first angle.

23. A lighting fixture comprising an upper reflector and a lower reflector, said upper reflector having a downwardly-facing reflecting surface for reflecting light to said lower reflector, said lower reflector being located beneath said upper reflector and having an outwardly facing surface for reflecting outwardly light reflected thereto by said surface of said upper reflector, a plurality of arms extending outwardly from the upper end of said lower reflector, means for supporting the inner ends of said arms, and means for supporting said upper reflector upon the outer ends of said arms.

24. A lighting fixture in accordance with claim 23, wherein said arms are vertical fins.

25. A lighting fixture in accordance with claim 23, wherein said lighting fixture has an enclosure with an upper section surrounding said upper reflector and supported upon the outer ends of said arms and with a lower section of light-transmitting material surrounding said lower reflector and mounted upon base means independently of said upper section.

26. A lighting fixture in accordance with claim 25, wherein said means for supporting the inner ends of said arms and said lower reflector are mounted on said base means, and wherein said lower section of said en-

closure is supported on said base means by cushion means.

27. A lighting fixture in accordance with claim **23,** wherein said fixture has a receptacle for receiving a lamp and for positioning said lamp between said reflectors.

28. A lighting fixture in accordance with claim **27,** wherein said receptacle is spring-biased downwardly, and further comprising an annular seat above said lower reflector against which said lamp is seated by the spring bias of said receptacle.

29. A lighting fixture in accordance with claim **28,** wherein said lower reflector is tubular and wherein said receptacle is supported for vertical movement within said lower reflector and has means for centering the receptacle therein.

30. A lighting fixture in accordance with claim **23,** wherein said fixture has means for mounting a lamp beneath said upper reflector and has an enclosure with an upper section surrounding said upper reflector and having a top wall which opens, said upper reflector comprising two parts, one of which is supported upon said top wall and moves therewith relative to the other part to provide access to said lamp when the top wall is opened.

31. A lighting fixture in accordance with claim **23,** wherein said means for supporting the inner ends of said arms comprises a tube extending vertically within said lower reflector and protruding therefrom at the top of said lower reflector.

32. A lighting fixture having a vertical axis and having spaced upper and lower reflectors, each of the reflectors having a reflecting surface which is a surface of revolution about said axis, and means including a light source cooperating with the reflecting surface of said upper reflector and the reflecting surface of said lower reflector for reflecting light emitted by said source from said upper reflector and then from said lower reflector in sequence and for projecting the light along different paths downwardly and outwardly from said fixture upon a horizontal plane below said fixture with intensities proportional to the lengths of the paths so that an illumination pattern with substantially even illumination is formed in said plane over a generally circular illuminated area surrounding said axis.

33. A lighting fixture in accordance with claim **32,** wherein said surface of said upper reflector is a downwardly concave internal surface surrounding said source and wherein said surface of said lower reflector is an outwardly concave external surface with its lower end farther from said axis than its upper end.

34. A lighting fixture in accordance with claim **33,** wherein light rays from said source are reflected by the reflecting surface of said upper reflector at different angles and are redirected by the reflecting surface of said lower reflector downwardly and outwardly at substantially a predetermined angle.

35. A lighting fixture in accordance with claim **33,** wherein said source is an elongated source aligned with said axis, wherein light rays from the upper end of said source reflected by the surface of said upper reflector to the surface of said lower reflector are redirected at substantially a first predetermined angle relative to downward vertical, and wherein light rays from the lower end of said source reflected by the surface of said upper reflector to the surface of said lower reflector are redirected thereby downwardly and outwardly at substantially a second predetermined angle relative to downward vertical.

36. A lighting fixture in accordance with claim **35,** wherein said first angle is greater than said second angle and wherein the amount of light projected at said first angle is greater than that projected at said second angle.

37. A lighting fixture in accordance with claim **36,** wherein the spacing of said reflectors provides paths therebetween for direct downward and outward emission of light from said fixture by said source without reflection from said surfaces, the amount of such light being less than the amount of light reflected from said surfaces.

38. A lighting fixture in accordance with claim **32,** wherein said fixture comprises means for cutting off the projection of light from said fixture at a predetermined angle relative to downward vertical which is less than 90°.

39. A lighting fixture in accordance with claim **38,** wherein the last-mentioned means comprises a glare baffle protruding inwardly from the reflecting surface of said upper reflector toward said axis.

40. A lighting fixture comprising an upper reflector and a lower reflector having a common vertical axis, each of said reflectors having a reflecting surface which is a surface of revolution about said axis, the upper reflector surface being shaped to reflect light rays from a source to the lower reflector surface in axial planes, the lower reflector surface being shaped to reflect outwardly from said axis in axial planes light rays which are directed thereto by the upper reflector surface in axial planes, and said upper reflector having at least one reflecting surface section which is not concentric with the first-mentioned surface for directing light rays from said source to said lower reflector surface in planes which are not axial, whereby the amount of light directed by said lower reflector surface in some directions is greater than in others.

41. A lighting fixture comprising an upper reflector and a lower reflector having a common vertical axis, each of said reflectors having a reflecting surface which is a surface of revolution about said axis, the upper reflector surface being shaped to reflect light rays from a source to the lower reflector surface in axial planes, the lower reflector surface being shaped to reflect outwardly from said axis in axial planes light rays which are directed thereto by the upper reflector surface in axial planes, and said upper reflector having at least one reflecting surface section which is not concentric with the first-mentioned surface for directing light rays from said source downwardly and outwardly without reflection from said lower reflector.

42. A lighting fixture in accordance with claim **41,** there being a pair of said sections angulated oppositely in a horizontal plane to project light rays outwardly at opposite sides of said fixture without reflection from said lower reflector.

43. A lighting fixture in accordance with claim **41,** wherein said fixture has a glare baffle for limiting the maximum angle with respect to downward vertical of light rays projected from the fixture.

44. A lighting fixture comprising an upper reflector, a lower reflector, and a light source, said upper reflector having a reflecting surface shaped to direct upon progressively higher elements of a reflecting surface of said lower reflector light rays emitted from a point of said source and reflected by progressively lower elements of the first-mentioned surface, said surface of the lower reflector being shaped to reflect such rays downwardly along substantially parallel paths.

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