Jan. 3, 1950 — T. W. ROLPH — 2,493,087

STREET LIGHTING LUMINAIRE

Filed Feb. 2, 1949 — 3 Sheets-Sheet 1

Fig. 1.

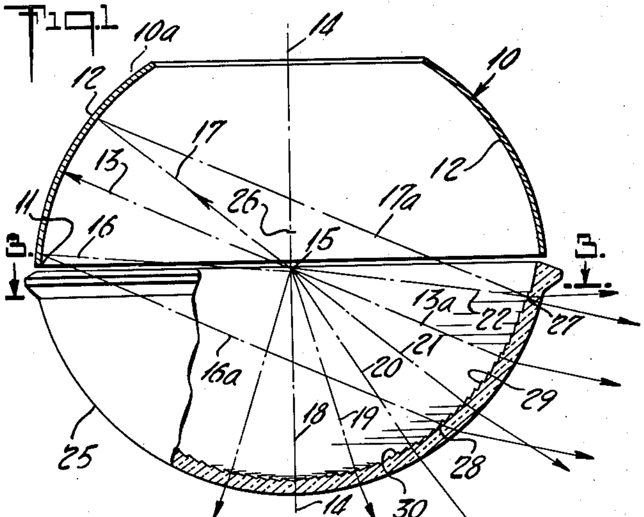


Fig. 2.

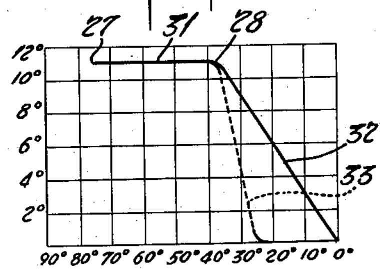


Fig. 5a

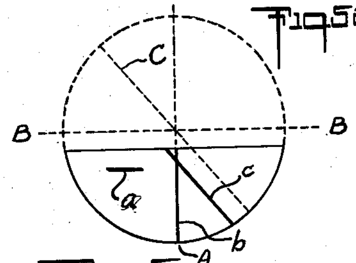


Fig. 3.

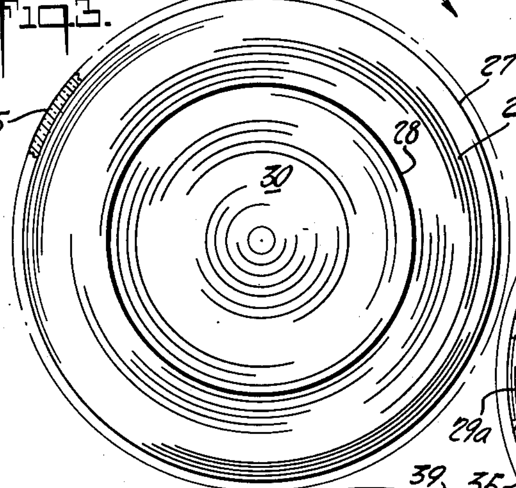


Fig. 5.

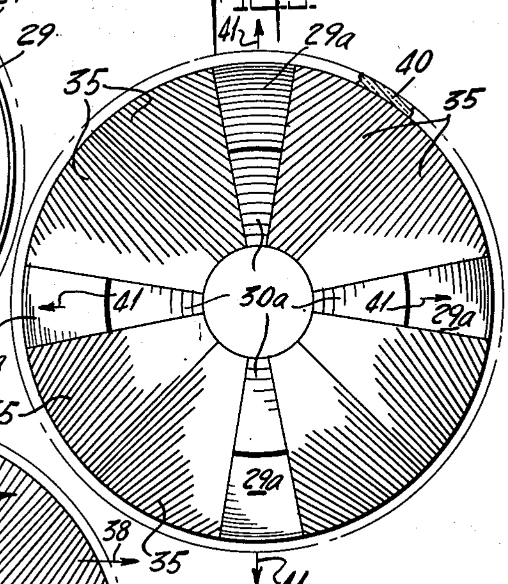
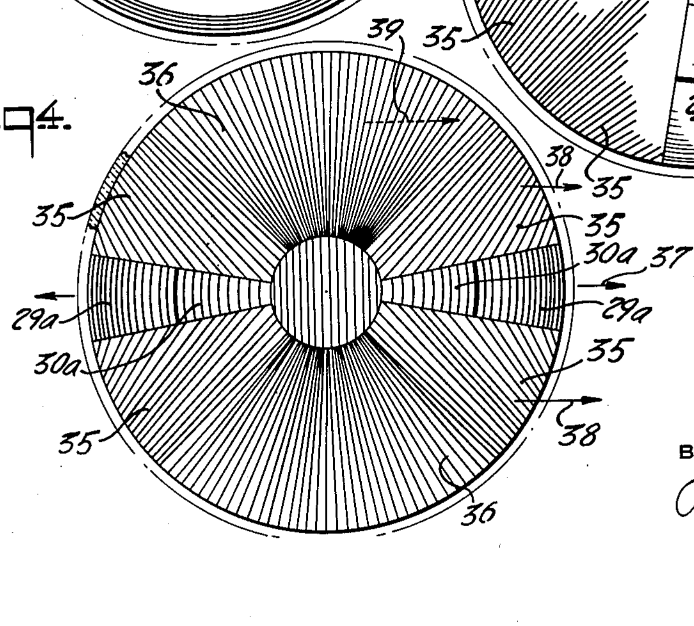


Fig. 4.



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Jan. 3, 1950 T. W. ROLPH 2,493,087

STREET LIGHTING LUMINAIRE

Filed Feb. 2, 1949 3 Sheets-Sheet 2

Fig. 6.

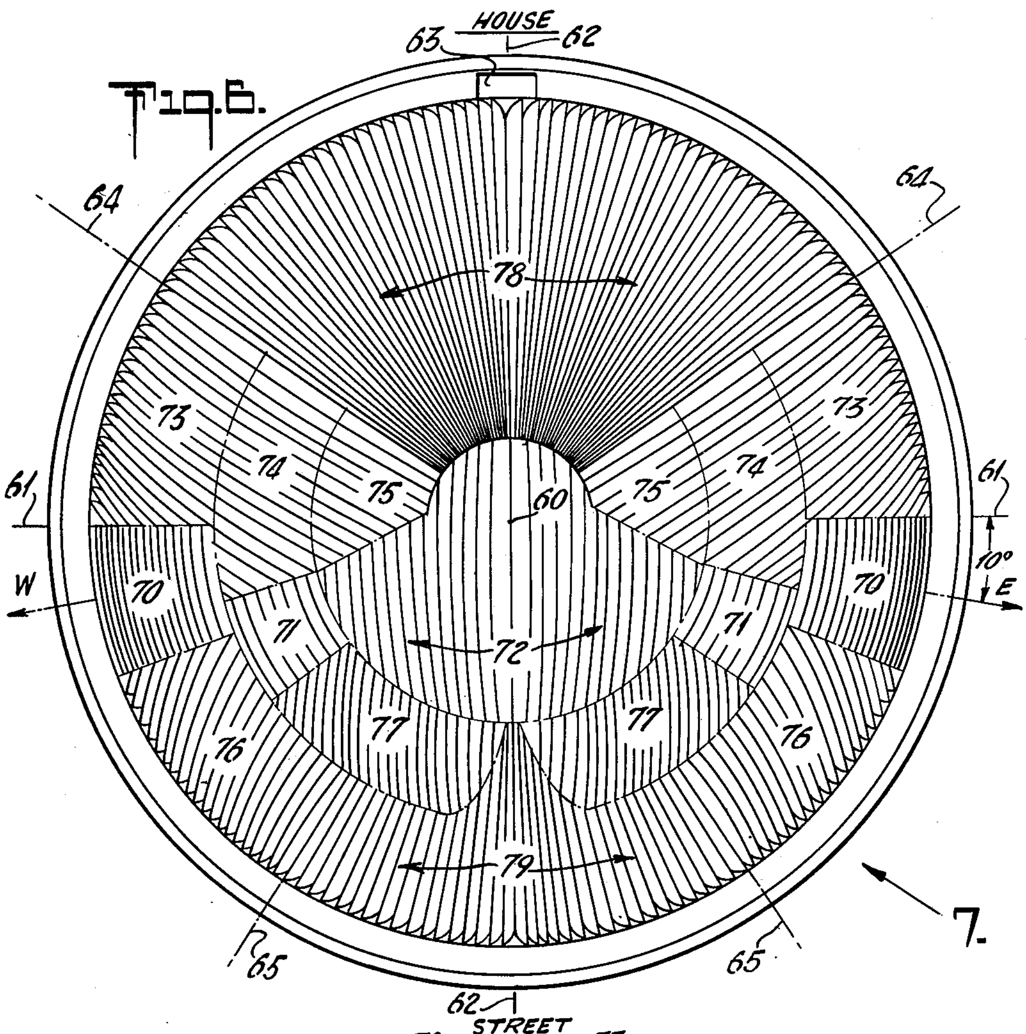


Fig. 7.

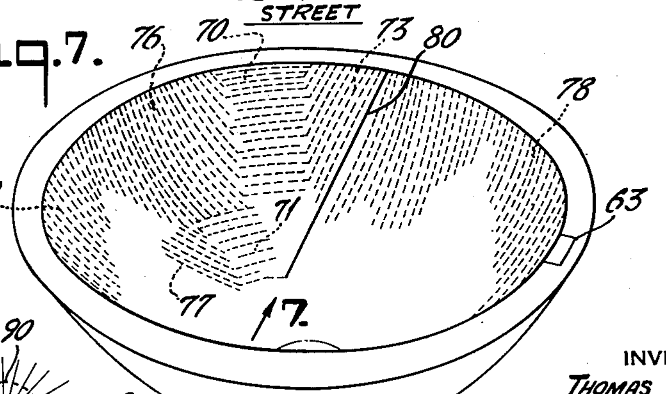
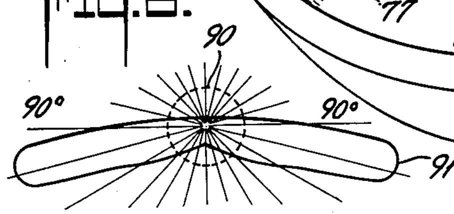


Fig. 8.



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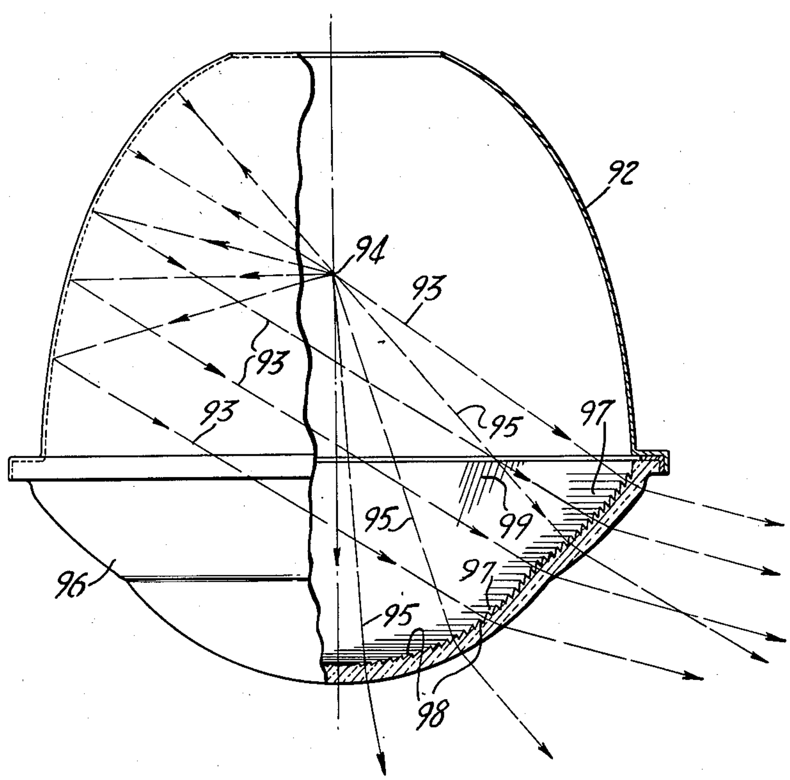
Jan. 3, 1950 T. W. ROLPH 2,493,087

STREET LIGHTING LUMINAIRE

Filed Feb. 2, 1949 3 Sheets-Sheet 3

Fig. 3.



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UNITED STATES PATENT OFFICE

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STREET LIGHTING LUMINAIRE

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Application February 2, 1949, Serial No. 74,139

15 Claims. (Cl. 240—25)

1

The present invention relates to street lighting luminaires.

The invention is more particularly directed toward street lighting luminaires each employing a single concentrated light source, a shielding reflector adapted to accept low angle light above the horizontal and reflect it across the vertical axis at angles too steep for effective street lighting at high ratios of spacing to mounting height, and a refractor to redirect said reflected light falling on it into higher angles whereby the spacing may be increased and to effectively utilize direct and reflected light at steep angles in lighting the nearer parts of the street or highway surface.

As shown in my prior Patent 2,260,693, a shielding reflector alone cannot produce the desired high angled light, but by means of a suitable refractor high angled light may be obtained.

The present invention relates more especially to improvements in street lighting units of the general type shown in said patent.

According to the present invention not only is the high angled reflected light uniformly elevated by horizontal prisms in an upper tier so as to fall on remote street areas but other light, (relatively steep direct and reflected light falling in the lower regions of the refractor) is spread away from the nadir and elevated by horizontal prisms in lower tiers with downwardly decreasing refracting angles so that it merges with the dominant beam of reflected and refracted light. This improves the lighted appearance of the refracting bowl notwithstanding its relatively greater vertical depth. The transition extends over so wide an area as to be less apparent. This feature is suitable for all forms of street lighting units whether for symmetrical lighting or for mounting at the center of a street or crossing, or at the side of the street.

Where the invention is employed in asymmetric units, particularly in residential street lighting, relatively narrow sectors in the direction of the maximum beams may employ the horizontal prisms as, such light need not be deviated laterally. Light diverging more widely from the beam direction falls on sectors of the refractor laterally of the first sectors and in these lateral sectors the invention contemplates the employment of diagonally disposed prisms which effect both vertical and lateral deviation and reinforce the main beam. These diagonal prisms are preferably arranged in tiers of varying vertical and horizontal refracting angles.

2

The accompanying drawings show, for purposes of illustrating the present invention, several embodiments in which the invention may take form, it being understood that the drawings are illustrative of the invention rather than limiting the same.

In these drawings:

Figure 1 is a vertical sectional view through a luminaire of the symmetric type, showing paths of typical direct and reflected rays;

Figure 2 is a graph illustrating the relation of prism refracting power to angular position of the prism with respect to the nadir;

Figure 3 is a section of the symmetric refractor of Figure 1 and taken on line 3—3 thereof;

Figure 4 is a similar view of a refractor arranged for center of street mounting;

Figure 5 is a similar view illustrating a refractor arranged for mounting at a crossing;

Figure 5a is a diagrammatic view illustrating the generation of the different types of prisms employed in structures embodying the present invention;

Figure 6 is a top plan view illustrating in greater detail a refractor designed for side of street mounting;

Figure 7 is a perspective view looking into the refractor of Figure 6 in the direction of the arrow 7, Figures 6 and 7;

Figure 8 illustrates a typical narrow asymmetric distribution obtained by a refractor such as shown in Figures 6 and 7; and

Figure 9 is a vertical section through a modification.

The symmetrical unit illustrated in Figures 1, 2 and 3 has an inverted, dome-shaped reflector 10 with steep walls and is concaved inwardly as shown. The portion of the reflector from its mouth 11 up to substantially the level indicated at 12 is preferably parabolic with downwardly sloping axis 13 intersecting the vertical axis 14—14 at 15 which is substantially on the same level as the mouth 11 of the reflector. The upper part 10a of the reflector is preferably spherical.

With a substantial point light source at 15, direct light rays between rays 16 and 17 are reflected downwardly across the vertical axis 14—14 and below the mouth 11 of the reflector as indicated at 16a, 13a and 17a. These rays are, in the example shown, at an angle of 67° with the nadir. The reflector 10 is symmetrical about the vertical axis so that in all radial planes rays, such as 16a, 13a and 17a, cross the vertical axis and escape below the mouth of the reflector. The light source at 15 also emits direct light rays such as ray 18 directed toward the nadir and rays 19, 20, 21 and 22 with increasing vertical angles.

The dominant light flux from the source emitted above the horizontal is in the reflected beam of parallel rays and the dominant light flux below the horizontal is in the region below the horizontal of corresponding angular width. If the light flux in the parallel reflected beam were allowed to proceed directly toward a street or road surface, it would, as explained in my prior Patent 2,260,693, fall on the street at distances so close to the luminaire as to require close spacing of the units. In order to permit wider spacing of the units, it is desirable to have the maximum light intensity emitted at angles substantially higher than 67°. The construction herein shown is one which elevates the dominant reflected light into angles of substantially 78° above the nadir. To obtain this elevated light it is necessary to elevate such light through an angle of 11°.

In the construction herein shown the mouth of the reflector 10 is closed by a refracting bowl 25. This bowl is of spherical contour with its center at 26 slightly above the light source 15. The general contour of the refractor form is obtained by rotating about the vertical axis 14—14 two concentric arcs centered at 26 and extending up nearly to the level of the mouth of the reflector. The outer surface of the refractor form may be considered for present purposes as smooth. It is usually, however, provided with a suitable diffusion pattern. The inner surface of the refractor form for symmetrical lighting is provided with horizontal annular prisms. External prisms could be used if desired.

These horizontal prisms are arranged in tiers. The uper tier 29 extending from the point 27 down to the point 28 intercepts the parallel reflected beam 16a, 13a, 17a, as well as the higher angle direct light rays. The prisms 30 from the point 28 to the nadir intercept direct light only, or light reflected from the upper spherical part 10a of the reflector 10. The prisms 29 between points 27 and 28 are designed to have uniform light refracting power of 11° for the parallel rays, as indicated by the straight upper portion 31 of the graph shown in Figure 2. The prisms 30 from the point 28 to the nadir have uniformly decreasing refracting power for the direct light as indicated by sloping line 32 of the graph in Figure 2. This results in low brightness contrasts over the entire surface of the light refractor when viewed in the usual directions, and contrasts with previous designs wherein it is customary to provide a very short transition zone, as indicated by the dotted line 33 of the graph of Figure 2, and to omit prisms from the lower portion.

Figure 3 illustrates a plan view of a symmetric refractor containing prisms illustrated in detail in Figures 1 and 2. Such a refractor is suitable for use where symmetric lighting is desired.

The refractor shown in Figure 4 is designed for center of street mounting. It has in plan a triangular sector with portions 29a and 30a occupied by prisms the same as prisms 29 and 30 in Figures 1, 2 and 3. Such a zone, about 20° wide, elevates light received in radial vertical planes without effecting lateral deviation and sends two strong beams of light in the street direction. Laterally of the sectors 29a, 30a the refractor of Figure 4 has areas 35, 35 carrying diagonal prisms and between areas 35, 35 the refractor has sectors 36, 36 occupied by vertical (or radial) light refracting prisms. The prisms 29a, 30a send light in the direction of the arrow 37. Diagonal prisms in regions 35 elevate light falling on them and deviate in directions 38 substantially parallel with 37. The laterally refracting prisms 36 tend to keep the light away from the sides of the street and generally direct it lengthwise of the street as indicated at arrow 39.

The refractor 40 of Figure 5 is arranged for mounting on the center of an intersection. It has tiers of prisms 29a, 30a as before and diagonal prisms 35, 35 as above discussed, and is adapted for producing four beams of light at right angles to one another as indicated by the arrows 41.

A corresponding refractor form is diagrammatically illustrated in light full lines in Figure 5a. It may be compared with the southern hemisphere of the globe, omitting a portion near the equator. It is apparent that such a spherical object, i. e., the spherical surface of the plunger to be used in forming the pressed glass refractor, could be provided with ribbings similar to parallels of latitude suitable to form horizontal prisms by turning the mold about a vertical axis A, A and cutting horizontal lines such as indicated at *a*. These will correspond with the parts of the mold necessary in making the horizontal prisms 29 and 30. If the plunger is turned about a horizontal or equatorial axis B, B, one could obtain radial or vertical prisms meridianally disposed as indicated by the line *b*. These correspond with the prisms 36 of Figure 4.

Any plane passing through the center of a sphere forms a great circle on the surface of the sphere and such an oblique plane is indicated at C. A plane parallel with C would intercept the sphere in a diagonal or oblique line such as indicated at *c*. Suitable contours can therefore be made on a spherical mold to provide diagonal elements as *c* by turning the mold on an axis at right angles to the great circle C. In such manner each of the prism elements in area 35 of Figures 4 and 5 can be provided for by properly cutting the face of the plunger.

The refractor shown in Figures 6 and 7 is designed for side of street mounting to produce narrow asymmetric distributions of I. E. S. type II. Such distributions have a lateral width in the neighborhood of 20°-25°, a maximum candle power in the region of 75° above the nadir and distribute light generally over the entire width of the street alongside which they are mounted. With the 75° angle of maximum beam, the ratio of spacing to the mounting height may be 8 to 1.

The vertical axis of the refractor of Figures 6 and 7 is indicated at the point 60. The house side of the refractor is at the top of the figure and the street side at the bottom of the figure, and the refractor is designed to produce strong beams of light generally in directions E and W which are, in the example shown, 10° below the horizontal line 61—61 parallel with the curb. The right and left sides of the refractor as viewed in Figure 6 are alike, the vertical line 62—62 representing a plane of symmetry, and an orientation notch 63 is placed in the refractor as indicated.

As the refractor is symmetrical on opposite sides of the line 62—62, the structure at one side of this line will be described and the same reference characters used for the other side. An upper tier of prisms 70 is disposed adjacent the vertical radial plane in the beam direction E. This tier of horizontal prisms 70 corresponds with the horizontal prisms 29 of Figure 1. It serves to collect light diverging through an angle of about 20° in horizontal planes and between substantially 38° from the nadir and 75° from the nadir and transmits it at higher angles without lateral deviation. This light falls upon the entire width of the street in the region midway between adjacent street lighting luminaires. Below the tier of prisms 70 and closer to the median plane 62—62, the refractor has a tier of horizontal prisms 71 which have refracting values corresponding with the upper prisms in the region 30 of Figure 1. These prisms serve to transmit the direct light received below the prisms in tier 70 toward intermediate street areas and are placed farther from the axis 61—61 than the tier 70 so as to cover the street width closer to the luminaire.

At still lower levels on the refractor and extending between the vertical axis 62—62 of the figure and region 71, the refractor has a lower tier of prisms 72 of still less refracting power corresponding to the lower portion of the line 32 on the graph of Figure 2. These prisms of comparatively low refracting power are generally parallel but as shown in Figure 6 of the drawings converge toward the street side so as to assist in spreading the nearly vertical light generally in the direction of the street area.

On the house side of the tier of prisms represented at 70, 71 and 72, the refractor has three tiers of diagonal prisms, namely, an upper tier 73, an intermediate tier 74, and a lower tier 75. These tiers extend over to a radial line 64. Each of the prisms in the upper tier 73 is oblique to the incident light and effects both elevation of this light and lateral redirection. The prisms in region 73 have the same vertical light elevating power as those in sector 70, and have increasing lateral deviating power. The prisms in region 74 appear in plan to be continuations of the prisms 73. They are, however, made to have less refracting power in vertical planes and somewhat less maximum refracting power laterally than the corresponding prisms in the upper tier. The prisms 75 in the lower tier receive rather steep direct light and have still less vertical refracting power but substantially the same laterally refracting power as the prisms in region 74. The diagonal prisms in regions 73, 74 and 75 converge upwardly toward one another.

On the street side, the refractor is provided with an upper tier of prisms 76, optically similar to the upper tier of prisms 73 but with reverse sign. These extend over to the line 65 which may be the same angular distance from 61 as is line 64. The street side of the refractor also has a tier of diagonal prisms 77 similar to the prisms 74 but of reverse sign. These extend nearly to the vertical axis 62—62.

The house side of the refractor has a series of laterally deviating prisms 78 occupying the area from the line 64 to the vertical axis 62 and designed to laterally deviate the direct light and generally shift it into the direction of the beam. The prisms 78 become too small near the center of the bowl and terminate as indicated. The street side of the refractor has vertical laterally deviating prisms 79 occupying the area between the line 65 and line 62 and down to the diagonal prisms 77.

While the diagonal prisms in regions such as 73, 74, 75, 76 and 77 appear in the drawing to be curved, each prism lies in a plane and when viewed in that plane appears straight, as shown by the bold line 80 of Figure 7.

The following table indicates refracting powers for prisms in the various areas discussed.

Region	Vertical Action	Lateral Action
	Degrees	*Degrees*
70	11	0
71	7-11	0
72	0-7½	0
73	11	10-40
76	11	10-40
74	9	12-32
77	9	12-32
75	3½	12-32

The output of the refractor of Figures 6 and 7 is illustrated in Figure 8. Here the circle 90 illustrates the symmetric distribution in horizontal planes from a bare lamp and the photometric curve 91 illustrates the asymmetric distribution in vertical planes through the cone of maximum candle power, which in the present instance is about 78° above the nadir.

Figure 9 illustrates a luminaire having a deep shielding reflector 92 adapted to produce downwardly sloping rays 93 from a light source 94. These rays, as well as direct rays 95, are intercepted by a refracting bowl 96 having prism systems similar to those above described. The refracting powers will depend upon the vertical angles of the rays received and the vertical angle of the light to be omitted and the radius of curvature of the elemental area of the bowl in which they are placed. In the figure the upper horizontal prisms of uniform refracting power are indicated at 97, the horizontal prisms of decreasing refracting power to nadir at 98, and diagonal prisms at 99.

The dominant light output from the luminaires comes from the upper portions of the refractors and hence it is possible without affecting the dominant light output to employ in regions below the portion of the refractor acting on the dominantly reflected beam different contours and prismatic constructions from those specifically shown.

Since it is obvious that the invention may be embodied in other forms and constructions within the scope of the claims, I wish it to be understood that the particular form shown is but one of these forms, and various modifications and changes being possible, I do not otherwise limit myself in any way with respect thereto.

I claim:

1. A luminaire comprising a substantially point light source, a reflector form having comparatively steep walls disposed about a vertical axis and concave in all directions toward the light source and intercepting a band of light extending upwardly from the horizontal plane through the light source and reflecting it across the reflector axis and out through the mouth of the reflector at a predetermined vertical angle, and a refracting bowl below the reflector form and of a depth to intercept the reflected light after it has cross the reflector axis, the refracting bowl being of substantially spherical contour below the mouth of the reflector and having, near the top thereof and adjacent to a radial vertical median plane, prism systems for concentrating an intercepted band of reflected light of substantial angular width on both sides of said

radial plane into directions of substantially narrower angular width and for increasing its vertical angle, said prism systems including a series of horizontal light elevating prisms of uniform refracting power and substantially of said narrow angular width, and laterally of said horizontal prisms upwardly and outwardly diverging, diagonally located prisms whose refracting power in vertical planes is substantially the same as that of the horizontal prisms and whose refracting power in horizontal planes increases as they become more remote from the series of horizontal prisms whereby reflected light falling on the diagonal prisms is correspondingly elevated and laterally deflected toward the light emitted through the horizontal prisms.

2. A luminaire such as claimed in claim 1, wherein the diagonally located prisms on each side converge upwardly.

3. A luminaire such as claimed in claim 1, having similar prism systems adjacent to a second radial plane and vertical, laterally refracting prisms adjacent the outermost diagonal prisms for intercepting the more diverging reflected light and refracting it generally toward said radial planes.

4. A luminaire such as claimed in claim 1, wherein the refractor intercepts direct light below the reflected light and has below the horizontal prisms of uniform refracting power additional prisms generally parallel therewith and of refracting power decreasing from said power to zero in the regions of a nadir for divergently spreading direct light from the nadir up to the reflected light refracted by said first mentioned horizontal prisms.

5. A luminaire such as claimed in claim, 1, wherein the refractor intercepts direct light below the reflected light and has below the horizontal prisms of uniform refracting power additional prisms generally parallel therewith and of refracting power decreasing from said power to zero in the region of the nadir for divergently spreading direct light from the nadir up to the reflected light refracted by said first mentioned horizontal prisms, and has similar diagonal prisms laterally of said additional prisms which intercept more horizontally divergent direct light, elevate it and refract it toward said radial plane.

6. A luminaire such as claimed in claim 1, having similar prism systems adjacent a second radial plane and vertical, laterally refracting prisms adjacent the outermost diagonal prisms for intercepting the more diverging reflected light and refracting it generally toward said radial planes, wherein the refractor intercepts direct light below the reflected light and has below the horizontal prisms of uniform refracting power additional prisms generally parallel therewith and of refracting power decreasing from said power to zero in the regions of the nadir for divergently spreading direct light from the nadir up to the reflected light refracted by said first mentioned horizontal prisms.

7. A luminaire comprising a light source, a reflecter of substantially parabolic profile with the focus at the light source with the axis downwardly sloping and intercepting a band of light extending above the horizontal plane through the light source and reflecting it at substantially uniform downwardly sloping angles parallel with the axis across the reflector axis and out through the mouth of the reflector, and a prismatic refracting bowl of the same outside diameter as the mouth of the reflector and occupying a vertical angle of substantially 75° above the nadir, the refractor having a spherical portion provided with a series of horizontal prisms of uniform refracting power to accept the parallel reflected rays and elevate them uniformly into higher angles and between said horizontal prisms of uniform refracting power and nadir an inwardly concave portion which is provided with a series of light spreading prisms extending to the nadir and having refracting powers which decrease from said refracting power to zero in the region of the nadir.

8. A luminaire such as claimed in claim 7, wherein said horizontal prisms and spreading prisms occupy narrow horizontal angles and the refractor has laterally thereof diagonal prisms which effect vertical elevation and lateral deviation of reflected light falling thereon, the vertical refracting power being substantially equal to that of the horizontal prisms and the lateral refracting power increasing as the diagonal prisms become more remote from the horizontal prisms.

9. A prismatic refracting bowl of inwardly concave contour and occupying substantially 75° above the nadir in all azimuths, the bowl having a series of horizontal prisms occupying a vertical angle of substantially 38° and uniform refracting power to elevate parallel downwardly sloping rays in radial vertical planes into higher angles while maintaining parallelism and between the horizontal prisms and the nadir a series of prisms whose refracting power decreases from that of the first mentioned prisms to zero so as to spread light radiating from regions adjacent the center of curvature of the bowl up to the higher angled refracted light.

10. A prismatic refracting bowl of inwardly concave contour and occupying substantially 75° above the nadir in all azimuths, the refracting bowl having in two generally opposite azimuthal directions a series of horizontal prisms near the periphery and of limited angular length and of uniform light elevating refracting power for deviating downwardly sloping parallel rays crossing the axis and falling on the upper inside of the bowl in radial vertical planes into higher vertical angles without change of azimuthal direction, and below said first mentioned horizontal prisms additional horizontal prisms generally parallel therewith and with refracting power which decreases from said uniform refracting power to zero for spreading light radiating from regions adjacent the center of curvature of the bowl from the nadir up to the higher angled refracted light.

11. A refracting bowl such as claimed in claim 10 having laterally of the first mentioned horizontal prisms an area occupied by oblique prisms with their active surfaces sloping away from the horizontal prisms at variant angles such that for similar downwardly sloping parallel light falling on said areas, the latter light is elevated to substantially the same extent as that by the horizontal prisms and is laterally refracted toward the horizontally divergent beam emitted by said horizontal prisms.

12. A refracting bowl as claimed in claim 10 having laterally of the first mentioned horizontal prisms an area occupied by oblique prisms with their active surfaces sloping away from the horizontal prisms at variant angles such that for

similar downwardly sloping parallel light falling on said areas, the latter light is elevated to substantially the same extent as that by the horizontal prisms and is laterally refracted toward the horizontally divergent beam emitted by said horizontal prisms, the bowl also having laterally of the oblique prisms vertical laterally refracting prisms extending midway between the azimuthal planes.

13. A refracting bowl of generally uniform thickness and having opposed surfaces generated by the rotation about a vertical axis of opposed upwardly concave curves extending upwardly from nadir, one surface having sectors of substantial angular extent about said vertical axis occupied by horizontal prismatic ribs thicker at the top than at the bottom for elevating light falling thereon in vertical radial planes without deviating it out of said planes, and adjacent said regions of horizontal prisms sectors occupied by diagonally disposed prismatic ribs diverging upwardly and outwardly and thicker toward the horizontal prisms for elevating light falling thereon in radial vertical planes and laterally deviating it toward the light emitted by the horizontal prismatic ribs.

14. A refracting bowl such as claimed in claim 13, wherein the horizontal and diagonal prismatic ribs are arranged in vertical tiers, all the ribs in

the upper tier having a uniform vertical refracting angle and those in the lower tiers having progressively lessening vertical refracting angles.

15. A refracting bowl of generally uniform thickness and having opposed surfaces generated by the rotation about a vertical axis of opposed upwardly concave curves extending upwardly from the nadir, certain sectors being occupied by horizontal light elevating prisms which effect no lateral deviation of outwardly proceeding light in vertical radial planes, and sectors adjacent thereto and occupied by prisms cut on lesser circles parallel with obliquely disposed greater circles for effecting both vertical and lateral deviation of outwardly proceeding light in radially vertical planes.

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