June 28, 1949. T. W. ROLPH **2,474,327**

STREET LIGHTING LUMINAIRE

Filed May 7, 1946 3 Sheets-Sheet 1

Fig. 1.

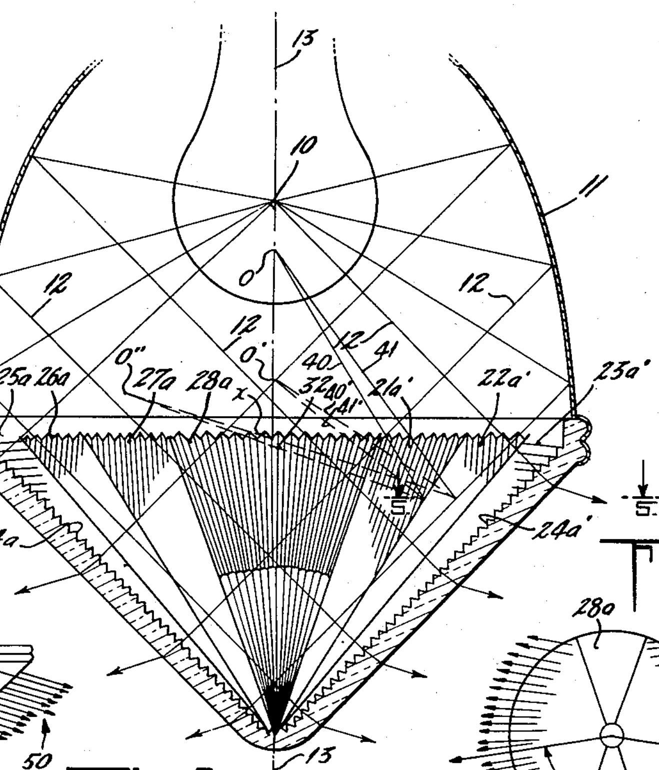


Fig. 3.

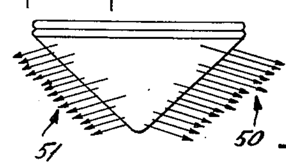


Fig. 4.

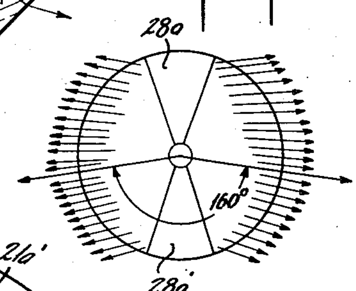
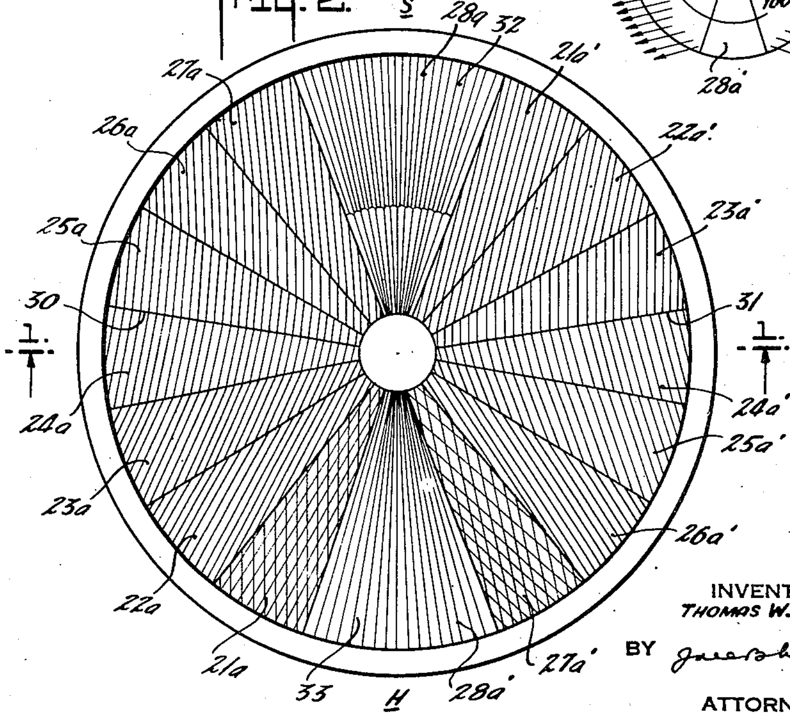


Fig. 2.



INVENTOR
THOMAS W. ROLPH
BY Jacob Lieberman
ATTORNEY

June 28, 1949. T. W. ROLPH 2,474,327

STREET LIGHTING LUMINAIRE

Filed May 7, 1946 3 Sheets-Sheet 2

Fig. 5.

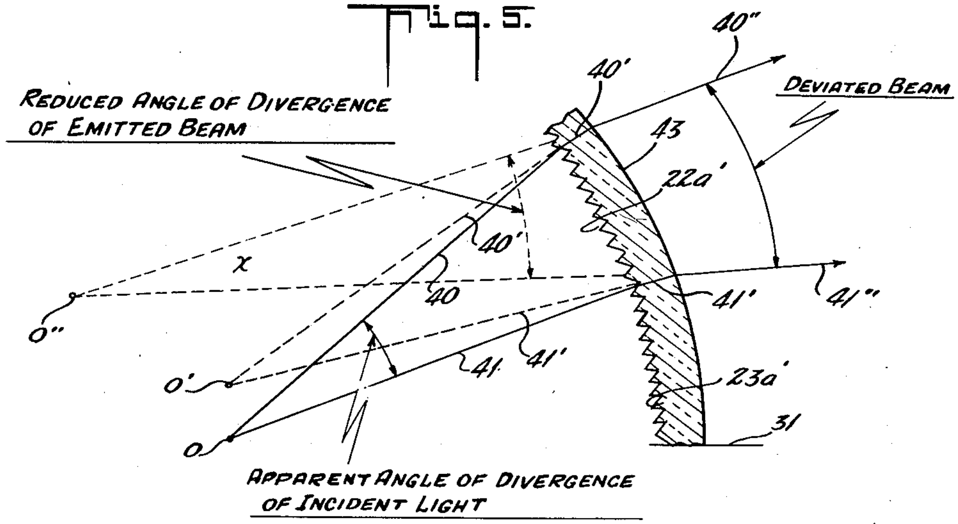


Fig. 6.

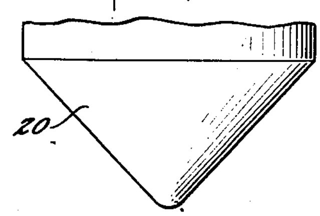


Fig. 7.

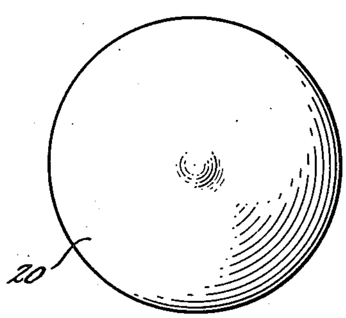
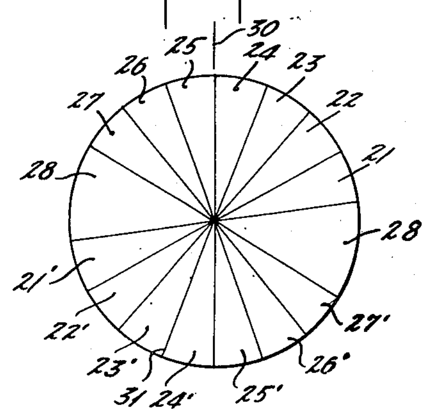


Fig. 8.



INVENTOR
THOMAS W. ROLPH

BY
[signature]
ATTORNEY

June 28, 1949. T. W. ROLPH 2,474,327

STREET LIGHTING LUMINAIRE

Filed May 7, 1946 3 Sheets-Sheet 3

Fig. 9.

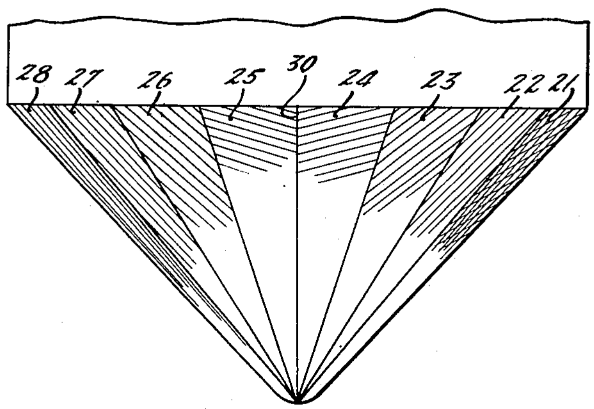
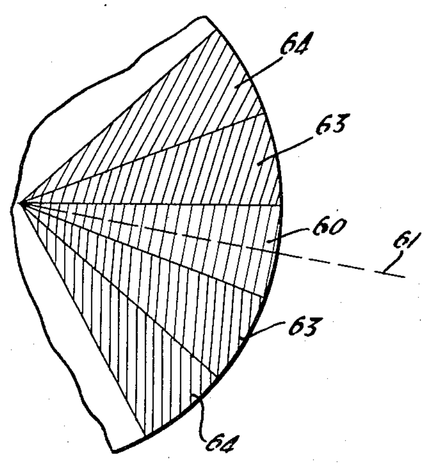


Fig. 10.



INVENTOR
THOMAS W. ROLPH

BY
Jacob Lieberman
ATTORNEY

Patented June 28, 1949 2,474,327

UNITED STATES PATENT OFFICE

2,474,327

STREET LIGHTING LUMINAIRE

Thomas W. Rolph, Newark, Ohio, assignor to Holophane Company, Inc., New York, N. Y., a corporation of Delaware

Application May 7, 1946, Serial No. 667,826

11 Claims. (Cl. 240—106)

1

The present invention relates to street lighting luminaires and is more particularly directed toward asymmetric street lighting luminaires employing shielding reflectors.

In street lighting luminaires it is customary to employ reflectors of parabolic contour to produce parallel downwardly directed light rays at an angle which is too steep for lighting remote street areas. The reflectors extend below the light source so that a substantial portion of the downwardly emitted direct light may be directed into controlled directions, and as a result the reflector shields the light source at substantial angles below the horizontal.

The present invention contemplates providing such street lighting equipment with refractors adapted to close the bottom of the reflectors and redirect the light into higher angles above the nadir and at the same time collect the light into beams adapted for lighting elongated street areas.

According to the present invention, the refractor takes the form of a cone of a depth which permits all the reflected light rays to cross the axis before they are intercepted by the refractor. This shape makes it possible to employ the smallest possible refractor for handling the reflected beam and the straight sides of the conical form have the same angle of incidence with the reflected rays.

In order to obtain the laterally concentrated beams at angles higher than the vertical angle of the reflected light, it is necessary to deviate the light on each side of a medium plane both laterally and vertically. In practicing the present invention this deviation is carried out by systems of prisms on the inside of the refractor, the outside being smooth, except for diffusing flutes. These systems of prisms are tilted at varying angles so as to effect a varying amount of lateral deviation while obtaining a substantially uniform vertical deviation.

Other and further objects will hereinafter appear as the description proceeds.

The accompanying drawings show, for purposes of illustrating the present invention, two 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 taken on the line 1—1 of Figure 2, through a street lighting luminaire, illustrating typical ray paths;

Figure 2 is a top plan view of the refractor of the luminaire;

2

Figures 3 and 4 are side elevational and inverted plan views of the refractor at a small scale illustrating the emission of rays from the refractor;

Figure 5 is a diagrammatic view further illustrating light ray control, a fragment being in section on the line 5—5 of Figure 1;

Figures 6 and 7 are diagrammatic side elevational and inverted plan views of a partly completed plunger for use in making the refractor of Figures 1 to 5;

Figure 8 is an inverted plan view of the plunger after further machining operations;

Figure 9 is a more or less diagrammatic side elevational view of the completed plunger; and

Figure 10 illustrates a modified form of refractor.

In Figure 1, the filament of the street lighting lamp is indicated at 10. The lamp is received in an annular parabolic reflector 11 with a downwardly sloping axis so that all the downwardly reflected rays such as 12 cross the vertical axis 13 through the center of the luminaire are at corresponding angles. Angles such as from about 45° to about 55° are suitable. The 45° angle is illustrated. Owing to the size of the filament the light rays spread slightly above and below these rays.

Any closure across the bottom of the reflector which is to intercept the light only after it has crossed the vertical axis, would have to be deep enough to accommodate the rays reflected from the lower part of the reflector. This determines the vertical depth of the refractor. While various forms of refractor can be made of the desired depth and outside diameter, a very desirable form from the point of view of appearance, ease of molding of the glass, and efficiency, is a straight sided cone.

Manufacturing methods necessary for making pressed glass refractors are not, however, adaptable for making a truly conical refractor with internal prisms for the purposes desired. The metal molds employed in making the pressed glass refractors are made on metal working machinery which is suitable for cutting the metal by turning, planing or milling operations, suitable for annular or spherical surfaces, or on flat surfaces. Annular prisms on the refractor would be effective to change the vertical angle of the light rays but would not be effective in changing the horizontal angle. Furthermore, radial refracting prisms would not be effective for changing the vertical angle.

Reference will now be made to Figures 6 and 9 inclusive, which indicate the method of manufacture employed in making the plunger used in molding the glass. The turned plunger is indicated at **20** in Figure 6. It is an annular conically shaped plunger of the slope and diameter necessary for making the piece of glass of the desired thickness when used with a mold of the desired size. It will be obvious that all surfaces of this cone, in planes other than radial, are curved and that they do not have a constant radius of curvature. The contour is that of an ellipse, hyperbola or parabola, depending upon the direction of the intersecting plane, and hence no tool working from a fixed center is adaptable for cutting along the surface of the cone in any such direction.

As a first step toward providing the plunger with surfaces in which the desired prismatic forms may be cut, the surfaces of the plunger are planed or milled to form flat triangular areas occupying a sector corresponding with that in which lateral deviation is desired. In the illustrated example, as more clearly shown in Figure 8, seven flat areas or sub-sectors **21** to **27** inclusive, each of 20° angular width, are grouped together to form a 140° sector of a pyramid, and seven flat areas **21'** to **27'** inclusive, are similarly grouped together. Between these flattened areas the original straight sided cone remains as indicated at **28—28'**. This machining operation provides a plunger with a number of flat areas, each of which is available for further machine operations to produce a profile suitable for the prism forming elements.

The plunger is then put into the proper machine and cuts made across each face of the plunger in the proper direction and at the proper angle to the face to obtain desired control of light rays when the glass is formed. In the side view in Figure 9 the directions of the cuts are indicated by the parallel lines in the areas **21** to **27**, inclusive.

It will be noted that the formation of the plunger as it appears in the elevation of Figure 9, is symmetrical with respect to a radial median plane **30**. The flat faces **21'** to **27'** on the opposite side of the plunger are similarly machined to form similar grooves which are symmetrical with respect to a radial plane **31** (Figure 8). The conical surfaces **28—28'** are machined radially to provide contours suitable for radial prisms or flutes.

Figures 1 and 2 show the refractor produced when the plunger of Figures 8 and 9 is employed in a conical mold with straight sides of the same slope as the sides of the plunger. The upper surface of the refractor has sectors including areas **21a** to **27a**, and **21a'** to **27a'** respectively, disposed about a pyramid and each of these areas has a system of parallel prisms whose directions are indicated in Figures 1 and 2. The upper conical surface **28a** on the street side S of the refractor is provided with diffusing flutes **32** while the upper conical surface **28a'** on the house side H is provided with radial refracting prisms **33**.

It will be seen that the prisms in areas **24a** and **25a** are alike except as to direction, which is nearly horizontal; that prisms in regions **23a** and **26a** are alike, except as to direction, which is further from the horizontal. Again the prisms in regions **22a** and **27a** are alike and still further from the horizontal. The prisms in region **21a** are still further from the horizontal and are preferably crossed by radial prisms as indicated by the radial lines in Figure 2. There is a similar departure in angle from one area to the other

on the prismatic surfaces on the right hand side of Figure 2.

If one were to take a section through any one of the areas having the parallel prisms on a plane at right angles to the direction of the prisms, there would be obtained a prism outline the same as that appearing in the section of Figure 1, except for the differences in prism angle which arise because of the lateral position of the region relative to the median plane.

The optical action of the refractor will now be discussed. If one were to consider the rays reflected from the right hand side of the reflector **11** across the axis in the position indicated in Figures 1 and 2, it will be seen that all these rays in this plane strike the ribbed surface **21a** at angles which are substantially normal to the general direction of this surface. Inasmuch, however, as this surface has prismatic ribs which refract the light upwardly and the opposite outer surface of the glass is parallel with the general direction of the surface carrying the ribs, the refracted light in this plane is elevated at both the inner and outer surfaces of the refractor. Inasmuch, however, as the prismatic surfaces in **24a** are slightly out of the horizontal, the refracted beam originally in plane **1—1** of Figure 2 is bent toward median plane **30** and out of the plane of the paper, Figure 2. This elevation and lateral deviation takes place with respect to all the rays falling on area **24a**. The same elevation and similar but opposite lateral deviation, is effected on the rays falling on area **25a**, and similarly lateral deviation takes place to a greater extent in areas **23a**, **26a**, **27a** and **21a**.

Owing to the conical configuration of the outside surface of the refractor the lateral deviation of the rays emitted from the refractor is altered from what it would be if the outer surface of the refractor were also pyramidal. This operation is illustrated in Figures 1 and 5. The extreme rays **40** and **41** crossing the axis of the luminaire and falling on an area such as **22a**, have an angle of divergence from the center **0** in the vertical axis **13—13** equal to the angular width of the region **22a** when measured in the oblique plane of about **16**°. The apparent angle of divergence in plan is 20° as in Figure 5. The prisms on the inner surface of the refractor introduce as above described, lateral deviation and elevation of the rays so that in the glass they have directions indicated at **40'** and **41'**, as though coming from **0'**. Owing to the fact that the external surface **43** of the refractor has a radius of curvature about the axis or center **0** and the prism system on **22a** is in a flat plane, the refractor is thicker at the center of region **22a** than at its edges. A condensing action, therefore, takes place along with the elevation and lateral deviation caused by the obliquity of the rays in the glass to the general direction of the outer surface and the light is transmitted with a reduced angle of divergence as indicated by the lines **40''—41''**, as though the rays were coming from a more remote vertical source **0''**. This has the effect of bringing more of the light toward the median plane **31** than would have been the case with an externally polygonal refractor for then the apparent swing of the emitted rays would have been from a point such as X.

Referring now to Figures 3 and 4, it will be seen that the luminaire is adapted to give two beams such as **50—51** directed below the horizontal at an angle of for example 75° to the nadir and converging toward one another at an angle of 160°, and that light is sent in the desired direction from the entire surface of the refractor except that occupied by the zones **28a** and **28a'** on the street and house sides, respectively, of the luminaire. The refracting prisms **28a'** on the house side divert the light from the houses and the diffusing prisms **28a** on the street side place the light in the adjacent street areas.

In the modified arrangement shown in Figure 10 the area **60** adjacent the median plane **61** has horizontal prisms, while the laterally disposed areas **63**, **63** and **64**, **64** have oblique prisms. The horizontal prisms may be annular on a conical area or straight on a flat area, in which case the condensing action A, Figure 5, takes place without additional lateral shift.

What is claimed is:

1. A street lighting refractor having the general shape of an inverted circular cone, the upper surface of the refractor being divided into sectors, on opposite sides of a median vertical plane, each sector including a plurality of pyramidally disposed flat areas, each of these flat areas having a system of parallel light elevating prismatic ridges of uniform refracting power and running in a direction oblique to the horizontal, whereby downwardly directed light rays crossing the axis of the cone at uniform vertical angles and falling on said system of prisms, are deviated uniformly vertically and also deviated laterally toward the median plane, the refracting power of the systems of ridges increasing as the flat areas are more remote from the median plane so that the transmitted rays are directed in the general direction of said plane.

2. A street lighting refractor as claimed in claim 1, wherein said flat areas abut at the median plane so that the light striking the elevating surfaces of the ridges is elevated and deviated laterally.

3. A street lighting refractor as claimed in claim 1, having adjacent the median plane horizontal prisms which effect elevation of rays only.

4. A street lighting refractor as claimed in claim 1, wherein the outer surface is a surface of revolution so that the refractor is thicker opposite the middle of each flat area than at its edges whereby the horizontal divergence of the transmitted rays is reduced below the horizontal divergence of the incident rays.

5. A refractor of inverted conical shape adapted to receive downwardly directed light rays of uniform slope in all azimuths about a coaxial vertical axis after they have crossed said axis, the refractor having a plurality of dihedral sectors, each adapted to receive and transmit the light rays between two radial planes, each sector being subdivided, and certain of the subdivisions on opposite sides of the median plane through the sector, having oblique parallel prisms of uniform refracting power for uniformly deviating the rays incident thereon into higher vertical angles and toward said median plane.

6. A street lighting refractor of inverted conical shape adapted to receive downwardly directed light rays of uniform slope in all azimuths about a coaxial vertical axis after they have crossed said axis and at too steep angles for lighting remote street areas and transmit the light at higher angles above the horizontal and in radially directed beams, the inner surface of said refractor being symmetrical with respect to the median planes of the beams, and having a plurality of pyramidally disposed faces on each side of each median plane, said faces having systems of parallel obliquely disposed prisms of uniform refracting power, the systems being variably disposed to elevate the rays incident thereon and laterally deviate them toward the median plane, the steepness of the prisms and their refracting power increasing with the remoteness of the faces from the median plane.

7. A refractor having a conical outer surface, and an inner surface of pyramidal shape with the same angle of slope as the outer surface whereby plano-convex lens elements are formed between the inner and outer surfaces, the surfaces of the faces of the pyramid having obliquely extending parallel refracting prisms, acting on parallel incident light in radial planes and uniformly deviating the rays in the refractor both angularly about the axis of the cone and with respect to the axis, so that they reach the outer surfaces as an oblique beam with rays parallel in oblique nearly vertical planes and of uniform angles of incidence on the outer surface and with the rays having the original divergence in oblique planes near horizontal, and of varying angles of incidence in such planes on the outer surface whereby substantially constant elevation of the transmitted rays is obtained with horizontal concentration.

8. A refractor having plano-convex lens elements of triangular shape juxtaposed about a vertical axis to form a continuous inverted conical outer surface and a coaxial inner pyramidal surface, the lens elements being of generally uniform thickness, and each having on their inner surfaces systems of parallel obliquely disposed prismatic ribs of uniform refracting power and disposed to deviate incident rays which in radial planes are substantially normal to the corresponding pyramidal surface both laterally about the vertical axis and vertically toward the horizontal, the opposed outer surface acting to laterally deviate the emitted rays in variable amounts and to vertically elevate them uniformly.

9. A refractor adapted to receive downwardly directed light rays of uniform slope in all azimuths about a vertical axis after they have crossed said axis, the refractor having walls at substantially right angles to the direction of the rays, the inner surfaces of the walls being in the form of flat triangular areas, said areas having parallel light elevating prisms of uniform refracting power, the prisms in two adjacent areas sloping upwardly from the median plane between them to swing the emitted rays toward the median plane, the prisms on the areas beyond the said adjacent areas sloping upwardly at greater angles to swing the rays emitted thereby through a greater angle toward the median plane.

10. A refractor as claimed in claim 9, wherein the outer surface of the refractor is continuously convex in horizontal planes and reduces the divergence in horizontal planes of the emitted rays below the divergence of corresponding rays falling on the opposed flat area.

11. A refractor adapted to receive downwardly directed light rays of uniform slope in all azimuths about a vertical axis after they have crossed said axis, the refractor having walls at substantially right angles to the direction of the rays, the inner surfaces of the walls being in the form of flat triangular areas, said areas having parallel light elevating prisms of uniform refracting power, the prisms on areas equally spaced from the median plane sloping upwardly from the median plane between them to swing the emitted rays toward the median plane, the prisms

on the areas beyond the said areas sloping upwardly at greater angles to swing the rays emitted thereby through a greater angle toward the median plane.

THOMAS W. ROLPH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,170,912	Rolph	Aug. 29, 1939
2,260,693	Rolph	Oct. 28, 1941