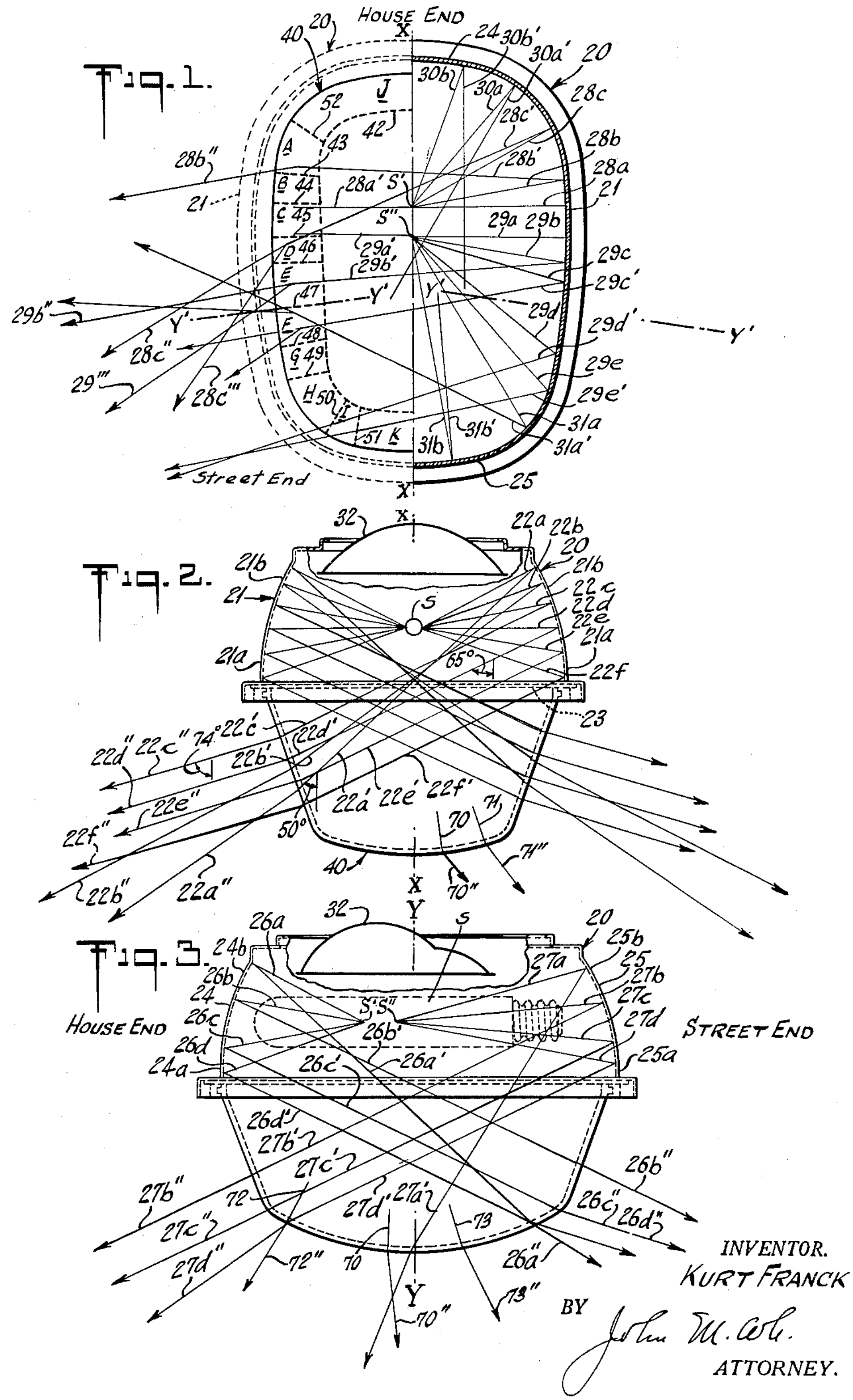
Oct. 25, 1955 K. FRANCK 2,721,931

STREET LIGHTING LUMINAIRES AND REFRACTORS THEREFOR

Filed May 7, 1951 4 Sheets-Sheet 1



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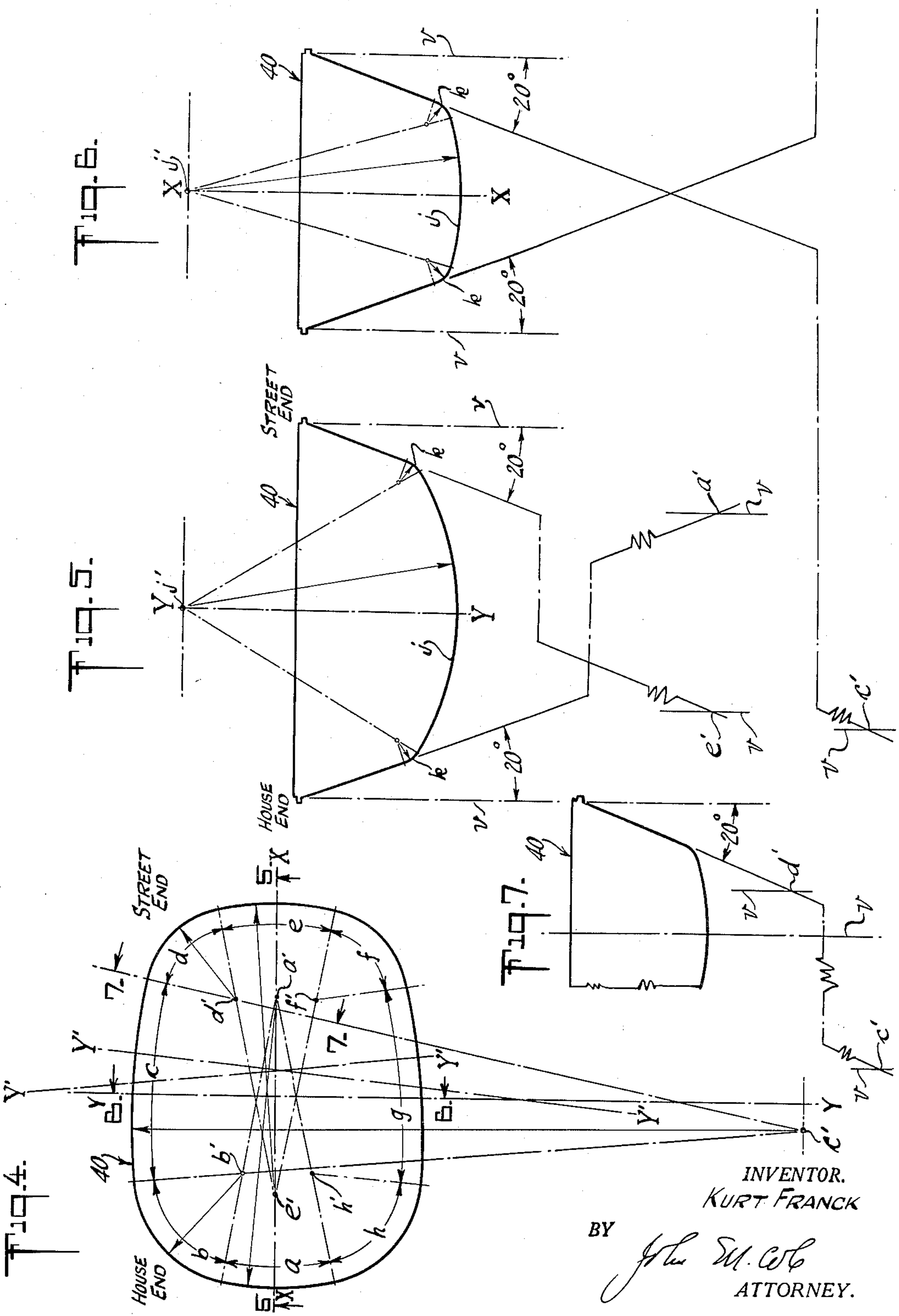
STREET LIGHTING LUMINAIRES AND REFRACTORS THEREFOR

Filed May 7, 1951 4 Sheets-Sheet 2



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STREET LIGHTING LUMINAIRES AND REFRACTORS THEREFOR

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Fig. 10.

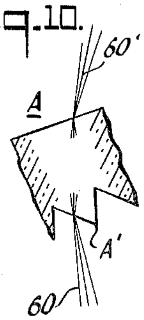


Fig. 11.

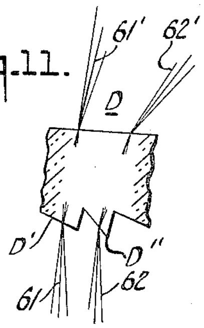


Fig. 12.

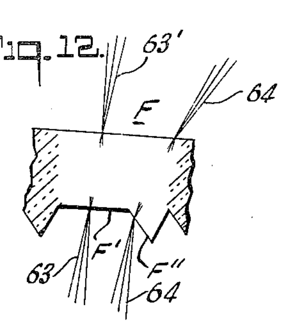


Fig. 8.

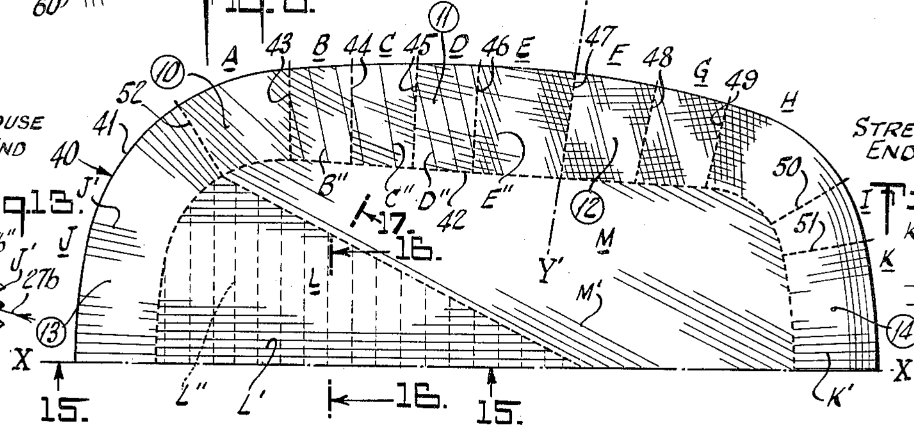


Fig. 13.

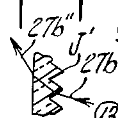


Fig. 14.

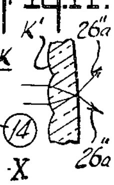


Fig. 9.

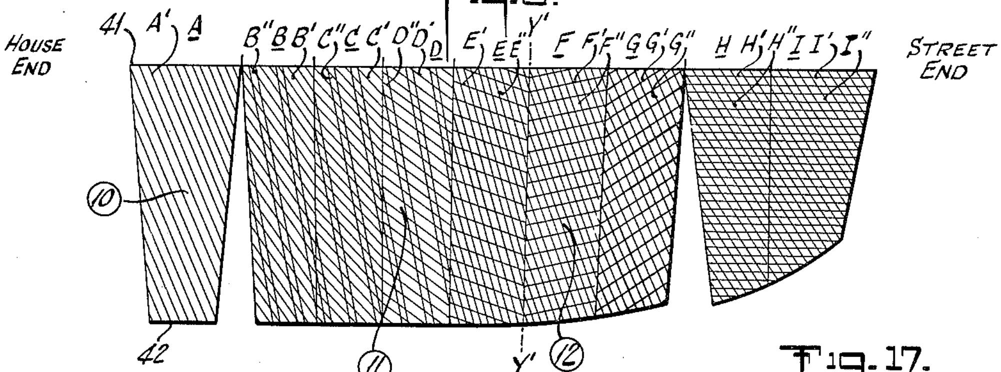


Fig. 15.

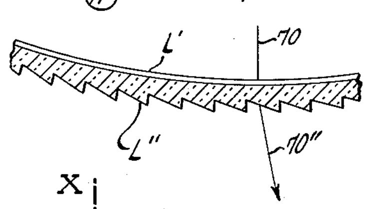


Fig. 17.

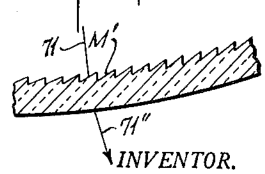
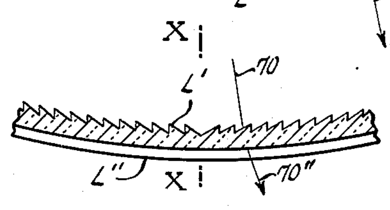


Fig. 16.



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STREET LIGHTING LUMINAIRES AND REFRACTORS THEREFOR

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Fig. 18.

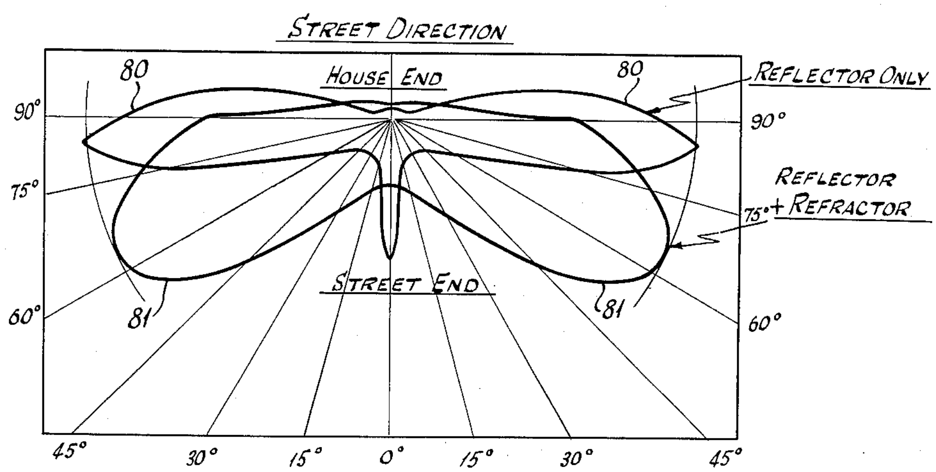
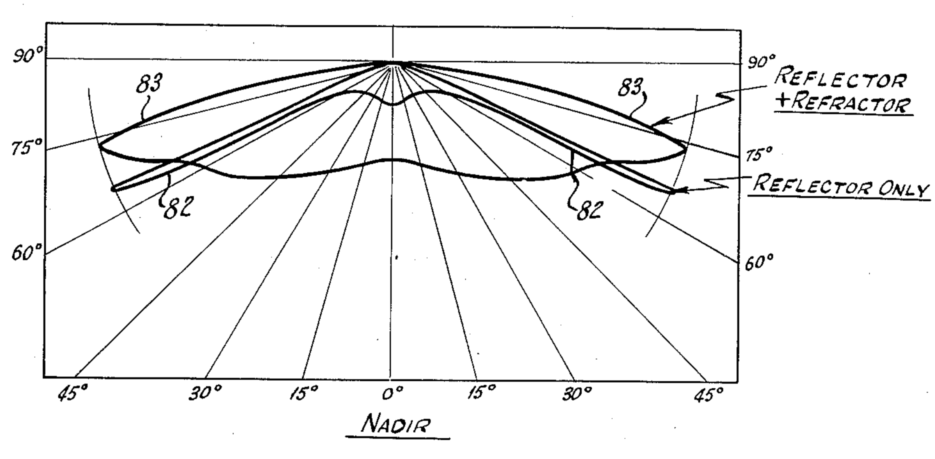


Fig. 19.



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2,721,931
Patented Oct. 25, 1955

2,721,931

STREET LIGHTING LUMINAIRES AND REFRACTORS THEREFOR

Kurt Franck, Newark, Ohio, assignor to Holophane Company, Inc., New York, N. Y., a corporation of Delaware

Application May 7, 1951, Serial No. 224,943

14 Claims. (Cl. 240—106)

The present invention relates to street lighting luminaires and refractors therefor.

Economic street lighting requires the use of widely spaced luminaires at relatively low mounting heights provided with some form of light redirecting means in the form of reflectors or refractors, or both, to place the light on the street surface and have the light from at least one unit reach the entire street surface. In the types of luminaire employing both a reflector and a refractor, the vertical redistribution from point sources is obtained wholly from a non-shielding reflector as in Rolph Patent 2,170,912 or from cooperating shielding type reflector and refractor, as in Rolph Patents 2,260,693, 2,474,326, 2,474,327, and 2,493,087. In these patents the reflectors are annular and do not have any natural asymmetry and the lateral redirection of the light is obtained entirely by the prismatic action of a refractor of generally annular contour. Such redirection to secure lateral asymmetry involves considerable loss of light.

Horizontal elongated light sources disposed across the street have natural asymmetry and tend to send more light lengthwise of the street than across it. Elongated reflectors of various forms as well as elongated reflectors combined with elongated refractors have been used with such sources to produce asymmetric distribution with beam patterns of the street lighting type for lighting the streets in two directions. These are shown in patents such as:

Rolph 2,330,924 (which uses rectilinear specular reflectors of the shielding type and rectilinear plates having diagonal prisms which elevate and laterally shift the reflected and direct rays);

Franck 2,486,558 (which uses a non-shielding, elliptical reflector without lateral redirection and a refracting bowl with transverse vertical prisms which redistribute laterally the direct and reflected light without redistributing it vertically);

Franck, Serial No. 110,109, filed August 13, 1949, (which uses an oval shielding reflector to initiate the desired lateral distribution at too low angles and a refractor with spherical and toroidal prism-carrying profile to elevate the light).

The present invention contemplates street lighting luminaires wherein the reflector and refractor are of oval shape, the reflector is of the shielding type and is shaped to reflect the light downwardly at too steep angles and with a lateral distribution requiring redistribution for efficient use, and the refractor is provided with prisms which effect redistribution both vertcally and laterally in a novel manner whereby the light output is at high angles for lighting remote street areas and has altered lateral distribution to confine it to the street.

The sides of the refractors for this purpose present to the distant observer on the street a relatively long, narrow field of high overall brightness, on which uneven brightnesses are objectionable, and it is an object of the present invention to provide the refractor with auxiliary or supplemental prisms which, without generally affecting

the overall light pattern, direct light toward the observer from regions which might otherwise appear to be dark.

The dominant reflected light coming from the sides of the oval reflector is, according to the present invention, emitted generally lengthwise of the street and is redirected by prismatic action by the side portions of the oval refractor. The source emits direct light below the reflector and the refractor of the present invention is provided with prisms for diverting such light from undesired directions into useful directions. The means employed for this includes prisms in the wall of the refractor at the house end which spread light laterally, and prisms in the bottom of the refracting bowl which spread the light away from nadir and the house end of the luminaire. The source also emits a small amount of light generally crosswise of the street which is redirected by the ends of the oval reflector.

The refractor is a bowl-shaped piece of pressed glass, and, except for certain external prisms in a portion of the bottom, all the light controlling and redirecting prisms are internal. These internal prisms are given the desired configuration by the plunger of the glass molding apparatus, the reverse of the prism configuration being machined into the plunger. The preferred plunger outline or form on which these operations are performed is of smooth oval horizontal section wider at one end than the other and of uniform angle of slope throughout its periphery. This may be obtained by a series of right circular cones of the same apex angle and different vertical axis and radii of curvature. Such surfaces lend themselves to machine operations and the refractor is smooth all the way around. These conical surfaces may be approximated by spherical and toroidal surfaces, or flat surfaces, but with unevenness of contour.

Other and further objects of the invention will appear as the description proceeds.

The accompanying drawings show, for purposes of illustrating the present invention, one embodiment 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:

Figures 1, 2 and 3 are diagrammatic top, transverse, and longitudinal views of the combined reflector and refractor illustrating general ray directions;

Figures 4, 5, 6 and 7 are diagrammatic plan, longitudinal, transverse sectional, and oblique profile views of the refractor form, illustrating the loci of the circular arcs and cone axes in which the refractor surfaces are generated, Figures 5, 6 and 7 being taken on the lines 5—5, 6—6 and 7—7 of Figure 4;

Figure 8 is a top plan view in greater detail illustrating prism distribution over one-half of the refractor;

Figure 9 is a view to show the development of the inside surface of the refractor of Figure 8;

Figures 10, 11, 12, 13 and 14 are fragmentary, substantially horizontal views taken at correspondingly numbered spots in Figures 8 and 9;

Figures 15, 16 and 17 are vertical sections on the corresponding lines of Figure 8;

Figures 18 and 19 are photometric curves plotted to show the maximum candle power at the same distance from the polar coordinate origin of the curves, Figure 18 showing lateral distribution from the reflector alone and from the combined reflector and refractor, and Figure 19 similarly showing the vertical distribution in the beam.

The present luminaire is intended for use with horizontal mercury lamps such as illustrated at S, with the ends of the arc stream at S′ and S″, Figures 2 and 3, so that light may be considered to come from these extreme regions, or, if an incandescent lamp is used, from a more concentrated region intermediate S′ and S″.

The reflector is generally indicated at **20**. It is of oval shape, somewhat wider at the house end than at the street end. It extends above and below the horizontal plane through the source S so as to shield the source and intercept horizontally emitted light in a wide vertical angle. In vertical section or profile the side walls **21**, **21** are inwardly concave the lower parts **21***a*, being shown as parabolic with focus at S and oblique axis about 65° to the nadir, the upper parts **21***b* being shown as elliptical, or circular, so as to reflect light rays such as **22***a*—**22***f* (Fig. 2), inclusive, across the vertical longitudinal axial plane X—X at steep enough angles to pass below the mouth **23** of the reflector, as indicated at **22***a'*—**22***f'*, inclusive. The end walls **24**, **25** are similarly contoured with parabolic and elliptical parts **24***a*, **24***b*, **25***a*, **25***b*, with foci at S' and S'' and reflect light across the transverse vertical median plane Y—Y as indicated in Figure 3 by rays **26***a*—**26***d*, **26***a'*—**26***d'*, **27***a*—**27***d*, and **27***a'*—**27***d'*.

The horizontal contour of the reflector is such as to merge the side and end sections into a smooth oval shape. Light from the source S is redistributed in horizontal directions, as well as in vertical directions. Horizontal ray paths are indicated in Figure 1. Rays such as **28***a*, **28***b*, **28***c*, from the end S' of the source, and rays such as **29***a*, **29***b*, **29***c*, **29***d* and **29***e* and intermediate rays, from the end S'' of the source, fall on the sides of the reflector and are returned across the longitudinal axial plane X—X as indicated at **28***a'*, **28***b'*, **28***c'*, **29***a'*, **29***b'*, **29***c'*, **29***d'*, **29***e'*, respectively. These rays will have vertical angles in the neighborhood of 65° above nadir (see Figure 19)—too steep for proper illumination of street surfaces; and a horizontal divergence of about 30° (see Figure 18)—in directions which would spread it beyond street widths. The rays such as **30***a*, **30***b*, which reach the house end of the reflector, and rays such as **31***a* and **31***b* which reach the street end of the reflector pass out under the other end as indicated at **30***a'*, **30***b'*, **31***a'* and **31***b'*.

The light from the sides and ends of the reflector is emitted through a zone of vertical depth indicated by the paths of the reflected rays. This light, as well as light reflected down from the auxiliary reflector **32** and direct light below the mouth of the reflector is intercepted by a refracting bowl **40** having an oval-shaped flanged rim **41** to fit the mouth of the reflector.

The basic contour of the refractor **40** is illustrated in Figures 4–7, inclusive. The longitudinal axis X—X and transverse axis Y—Y are indicated.

As shown in Figure 4, the oval shape is produced by a succession of circular arcs *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, with centers at *a'*, *b'*, *c'*, *d'*, *e'*, *f'* and *h'* (the center for *g'* being off the sheet). Centers *a'* and *e'* are on the axis X—X, center *c'* (and the center for *g'*) is displaced from the axis Y—Y toward the house end of the refractor, centers *b'*, *d'*, *f'* and *h'* are at the intersections of the extreme radii of arcs *a*, *c*, *e* and *g*, so that all the arcs form a smooth curve free of ridges or valleys. Each of the arcs *a*–*g*, inclusive, may be considered as the base of a segment of an inverted right circular cone with its vertical axis through the corresponding center.

In Figures 5, 6 and 7, verticals are indicated by the letter *v*. The side walls of the refracting bowl are disposed in the surfaces of such a series of cones, all of uniform apex angle. An optimum angle for the purpose and for effective light control is 40° so that the sides of the bowl are at an angle of 20° with the vertical. This angle is indicated on the drawings. This contour provides conic surfaces of suitable vertical depth to intercept the reflected light and on which to place the prisms to be discussed. Below the straight sides, the bowl bottom is spherical as indicated at *j*. The center of the sphere is indicated at *j'*. The spherical bottom and straight sides are connected as indicated by the short radius arcs *k*.

The periphery of the spherical bottom is indicated by the heavy dotted line **42**, Figures 1 and 8, and by the bottom line of Figure 9. The conical side wall region is between this line **42** and the flange of rim **41** of the bowl, as indicated by the oval **41**, Figures 1 and 8, and the upper line **41**, Figure 9. This conical band is alike on opposite sides of the longitudinal axis X—X. It is divided into zones A—K, inclusive. The dividing lines of these zones are indicated by lines **43**–**49**, inclusive, which are in radial planes through center *c'* and lines **50**, **51**, and **52** in radial planes through corresponding centers *b'* and *d'*.

By reference to Figures 1 and 2, it will be apparent that the light rays reflected by the side portions of the reflector, as exemplified by rays **22***a'*–**22***f'*, inclusive **28***a'*–**28***c'*, inclusive, and **29***a'*–**29***e'*, inclusive, fall in the zones A to I and that the rays from the ends of the reflector largely fall on the zones J and K.

As the luminaire is intended for side of street mounting, the light should be directed laterally from the luminaire in beams at an angle considerably less than 180° (usually 130° to 140°) from one another, converging toward the street end. The dividing lines **47** (planes Y'—Y') separating zones E and F are displaced from the light source toward the street end and are preferably placed at about 85° to the center line X—X. At these planes certain of the prisms change sign.

Toward the house end of the refractor from the line **47**, the zones E, D, C, B, and A have diagonal prisms which are marked E', D', C', B', and A' and are inclined at progressively steeper angles, as indicated by the lines (in Figure 8) in those zones sloping downwardly from left to right. In vertical planes, these prisms act to raise the light as indicated in Figure 2 so that the emitted rays **22***a''* to **22***f''*, after refraction, are higher than the reflected rays **22***a'* to **22***f'*, respectively. These diagonal prisms elevate the light and deviate it laterally. Prisms such as A' in zone A receive rays, such as bundle **60** (Figure 10) corresponding with ray **28***b'* (Figure 1) and while elevating them also deviate them as indicated at **60'**, or **28***b''*, toward the street end. Prisms in zone D similarly act on rays **61**, Figure 11, **28***c'*, Figure 1, and while elevating them also deviate them toward the street end.

Should all the light falling on the zones B to H, inclusive, be subjected to the same elevation and lateral deviation throughout these zones, there would be inadequate spreading of the light from the emergent surfaces and undesirable brightness contrasts would be brought about at various points of observation in the beam. While the dominant amount of the light is deviated by these prisms, small portions of it, preferably small portions of each bundle of rays to be handled by each oblique prism, are intercepted by narrow, more nearly vertical, prisms B'', C'', D'' and E'', which cross the prisms B'—E' and have greater lateral refracting power. Typical action of such prisms is indicated in Figure 11 where supplemental D'' prism diverts bundle **62** more to the right as shown at **62'**. Rays such as **28***c'* (Fig. 1) are therefore split, the dominant rays being emitted in direction **28***c''* and the remainder in the direction **28***c'''*.

Toward the street end from plane Y'—Y', zones F and G have diagonal prisms F' and G', which elevate light and bend it toward Y'—Y', as indicated in Figure 12 by the paths of rays **63**—**63'**. Zones H and I have horizontal prisms H' and I', which elevate the light. These diagonal and horizontal prisms in zones F, G, H, I are crossed by prisms F'', G'', H'' and I'' which act similarly to prisms B'', etc. and bend some of the light farther toward the street end as indicated by typical rays **64**—**64'**, Fig. 12. These rays correspond with ray **29***c'*, **29***c''* and **29***c'''*, Fig. 1.

At the house end, zone J is provided with vertical light spreading prisms J' as indicated in Figure 13, rays **27***b''*, **27***c''*, **27***d''* are therefore emitted at wide angles from the axis X—X. At the street end, the zone K is provided with flutes K′, Figure 14, and rays such as **26a″** are scattered. The lateral deviation of the rays of Figures 13 and 14 is accompanied by vertical elevation as indicated in Figure 3.

It will be understood that the steeper reflected light from the upper side walls of the reflector, as well as direct light falling on the zones A–K, inclusive, is transmitted with vertical and horizontal deviation so as to fill in below the dominant reflected and refracted rays, and provide additional lateral spread.

The spherical region inside the line **42**, Figures 1, 8 and 9, which receive direct light and reflected light at too steep angles to fall in the conical zones is provided with prisms which spread the light away from the curb so that it is sent across the street and lengthwise of the street to fill in the regions on the street closer than that reached by the steepest light emitted through the conical zones.

At the house end, a generally triangular area or zone L of the spherical bottom is provided (as shown in Figures 15 and 16) with longitudinally extending light spreading prisms L′ on the upper surface and with transverse refracting prisms L″ on the lower surface. The action of these prisms is illustrated in Figures 2, 3, 15 and 16 by steep direct (or reflected) ray **70** refracted away from X—X by prisms L′ and then refracted away from the house end by prisms L″ as indicated at **70″**.

The remainder of the spherical bottom region, or zone M, is provided with diagonal light spreading prisms M′, Figure 17. The action of these prisms is shown in Figures 2, 3 and 17 by more sloping rays **71** which are diverted as indicated at **71″** in the general direction of the diagonal plane **17—17**.

More sloping direct rays such as **72** and **73** and reflected rays such as **26a′**, **27a′** are likewise deviated away from the house end of the luminaire as indicated at **72″**, **73″**, **26a″** and **27a″**.

In order to improve the external appearance of the bowl and provide overall diffusion of light in controlled amounts and direction, both laterally and vertically, the entire outer surface (except the inactive faces of prisms L″), is provided with a suitable diffusion pattern, such, for example, as shown in my application for patent Serial No. 175,307, filed July 22, 1950.

In Figure 18, the lateral distribution of the beam from the reflector alone shown in curve **80** is about 5° from the street direction. The reflector output has a relatively narrow divergence and even though the maximum beam is about 85° from the street end, much of the light is sent out more than 90° from the street end and would fall on the sidewalk and distant yards and houses. The effect of the laterally deviating prisms of the refractor is such that almost all the light is pulled away from the house end and the beams are toed-in toward the street. The spread as shown by curve **81** is about 40° to 50° wide and the center line of the beam about 25° from the curb direction.

In Figure 19, the vertical distribution curve **82** using the reflector alone is very sharp at about 65° from the nadir. The refractor raises the light to a maximum of about 74° as shown by curve **83** and redistributes the light from nadir out to the maximum angles. It is understood that curves **80—83** are to indicate distribution, the candle power values for the reflector alone being consistent, also those for the reflector and refractor taken together.

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.

What is claimed is:

1. A refracting bowl of elongated shape symmetrical about a longitudinal vertical plane and having smooth walls disposed on a succession of right circular cones of like apex angle and differing parallel vertical axes, the walls forming the side portions of the elongated bowl being each provided with obliquely disposed prisms diverging from a laterally extending median vertical plane making an angle of approximately 90° with the longitudinal plane and acting to elevate light transmitted outwardly therethrough and deviate it horizontally toward the corresponding median plane.

2. A refracting bowl such as claimed in claim 1, wherein the bowl is wider at one end than at the other and the median plane to one side of the longitudinal plane makes an angle of less than 180° with the median plane on the other side of the longitudinal plane when measured toward the smaller end of the bowl.

3. A refracting bowl such as claimed in claim 1, wherein side portions of the bowl have additional relatively small prisms extending transversely with respect to the oblique prisms and intercepting small portions of the light, and of refracting power in amount and direction to bend such intercepted light toward one end.

4. A refracting bowl such as claimed in claim 3, wherein the bowl is wider at one end than at the other and the additional prisms refract light toward the smaller end.

5. A refracting bowl such as claimed in claim 1, wherein the bowl is wider at one end than at the other and the median plane to one side of the longitudinal plane makes an angle of less than 180° with the median plane on the other side of the longitudinal plane when measured toward the smaller end of the bowl, wherein the side portions of the bowl have additional relatively small prisms extending transversely with respect to the oblique prisms and intercepting small portions of the light, and of refracting power in amount and direction to bend such intercepted light toward the smaller end.

6. A refracting bowl such as claimed in claim 1, wherein the bowl has a bottom adapted to receive downwardly proceeding rays, a portion of the bottom near one end having light spreading prisms which bend light away from the longitudinal vertical plane and opposed prisms which bend it away from that end, other portions of the bottom toward the other end having diagonally disposed light spreading prisms which deviate light away from the longitudinal vertical plane and away from the first end.

7. A refracting bowl symmetric about a longitudinal vertical plane, having an upwardly opening, horizontal mouth of elongated, generally oval shape and having downwardly converging walls of substantial depth and at a substantially constant angle to the vertical so that horizontal sections therethrough are smaller ovals of decreasing size and having a closed bottom, the lateral portions of the downwardly converging walls being adapted to intercept light crossing said longitudinal plane and having obliquely disposed light refracting prisms of substantially uniform vertical refracting power to elevate the emitted rays and variant horizontal refracting power to bring such rays into laterally directed beams in which the dominant rays are emitted in directions to form beams converging toward the smaller end of the oval.

8. A refracting bowl such as claimed in claim 7, wherein the side portions of the bowl have additional relatively small prisms extending transversely with respect to the oblique prisms and intercepting small portions of the light and of refracting power in amount and direction to bend such intercepted light toward the smaller end.

9. A refracting bowl such as claimed in claim 7, wherein a portion of the bottom near the wider end has light spreading prisms which bend light away from the longitudinal vertical plane and opposed prisms which bend it away from that end, and the other portions of the bottom have diagonally disposed light spreading prisms which deviate light away from the longitudinal vertical plane and away from the wider end.

10. A street lighting refracting bowl symmetrical about a longitudinal vertical plane, the bowl having an upwardly opening horizontal mouth of oval shape generated by circular arcs, being adapted for side of street mounting with the small end of the bowl toward the street and having downwardly converging walls in right circular cones with vertical axes passing through the arc centers, the laterally disposed walls on the wider end of the bowl having diagonal light refracting prisms which elevate downwardly directed light rays falling thereon into higher angles from the nadir and deviate them toward the narrower or street end, the laterally disposed walls on the narrower end of the bowl having diagonal high refracting prisms which elevate downwardly directed light rays falling thereon into higher angles from the nadir and deviate them away from the street end.

11. A street lighting refracting bowl such as claimed in claim 10, wherein the diagonal light refracting prisms are arranged in zones along said laterally disposed walls, with the prisms in each zone parallel with one another, the slope of the prisms being of opposite sign on the opposite sides of a substantially vertical radial plane displaced toward the street end from the radial plane normal to the longitudinal, and increasing from zone to zone.

12. A street lighting refracting bowl such as claimed in claim 11, wherein a portion of zones in the region toward the larger end of the oval measured from said displaced radial plane are provided with relatively widely spaced, small, prisms crossing the diagonal prisms at steep angles and of greater lateral refracting power and acting to divert portions of the light farther toward the street end.

13. A street lighting refracting bowl such as claimed in

claim 11, wherein a portion of zones in the region toward the larger end of the oval measured from said displaced radial plane are provided with relatively widely spaced, small, prisms crossing the diagonal prisms at steep angles and of greater lateral refracting power and acting to divert portions of the light farther toward the street end, and wherein the zones in the region toward the street end from said displaced radial plane are provided with similar prisms also acting to divert portion of the light farther toward the street end.

14. A street lighting refracting bowl such as claimed in claim 10, having a bottom of spherical contour with its center above the center of the oval mouth, the bottom having on each side of the longitudinal plane and at the street end a system of diagonally disposed light spreading prisms adapted to spread high angled direct light away from the nadir and direct it obliquely downward in diagonal directions onto the street, and also having beyond the diagonal prisms a system of longitudinal light spreading prisms opposed to a system of transverse prisms which direct high angled light falling thereon across the street.

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