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LUMINAIRE

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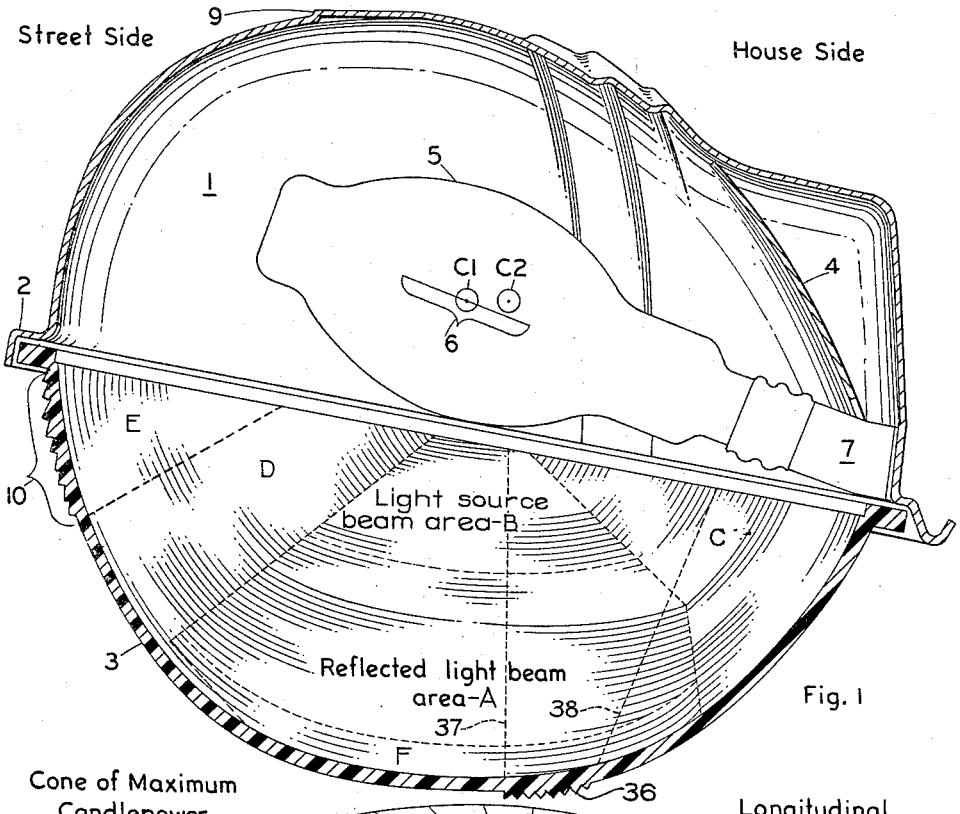

Fig. 1

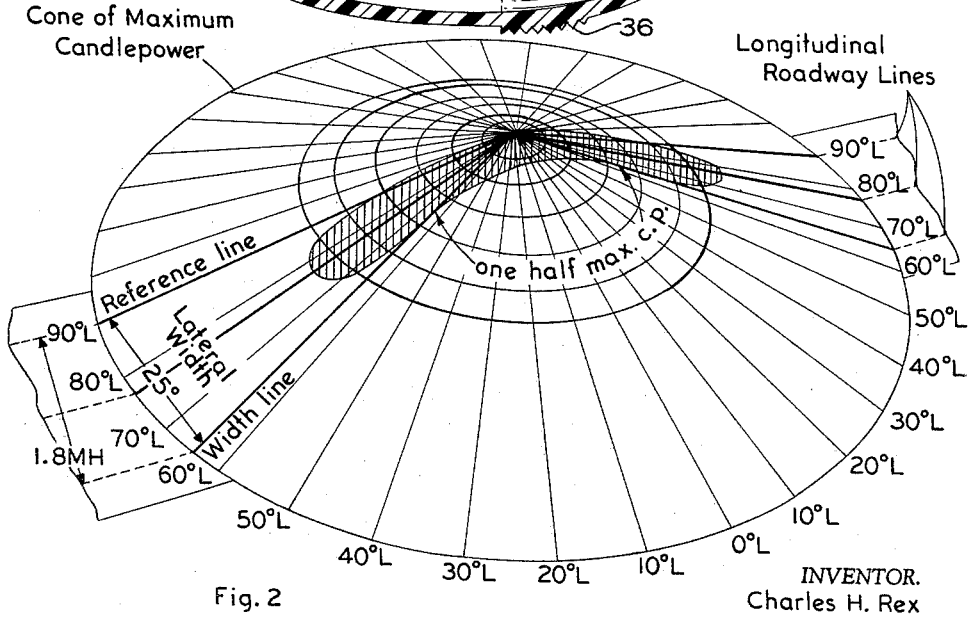

Fig. 2

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LUMINAIRE

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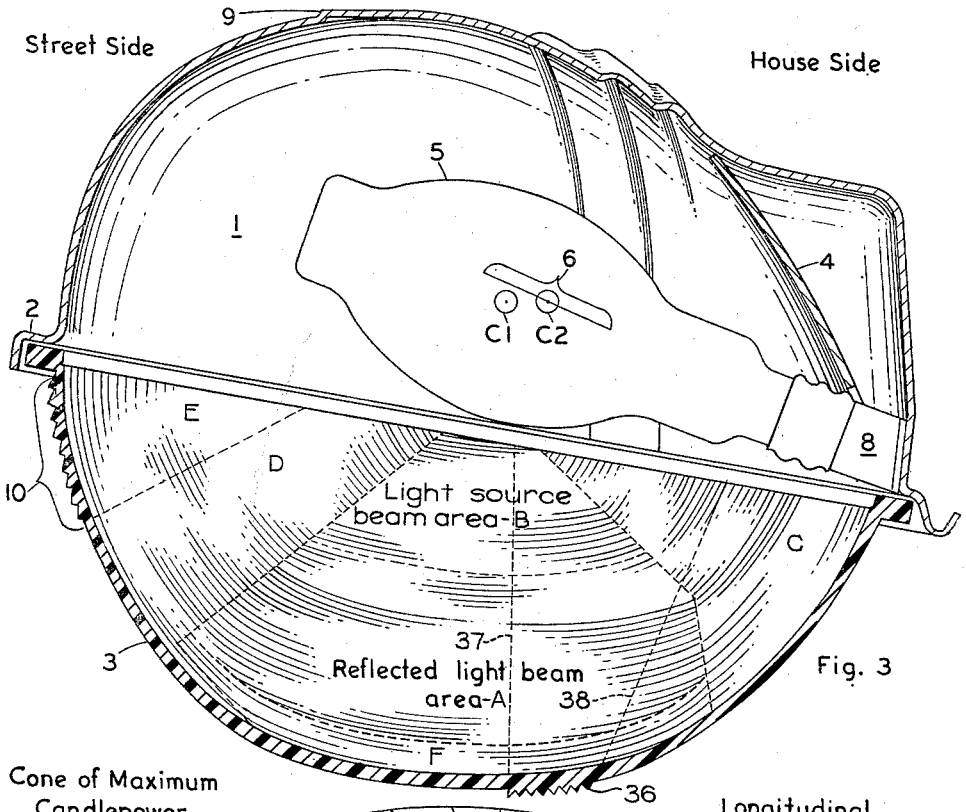

Fig. 3

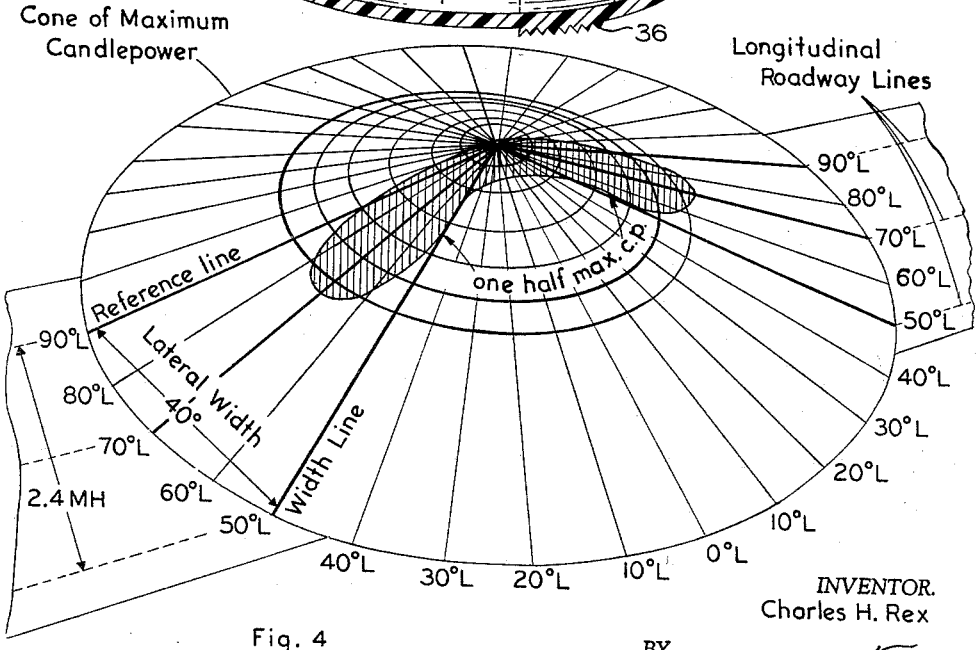

Fig. 4

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LUMINAIRE

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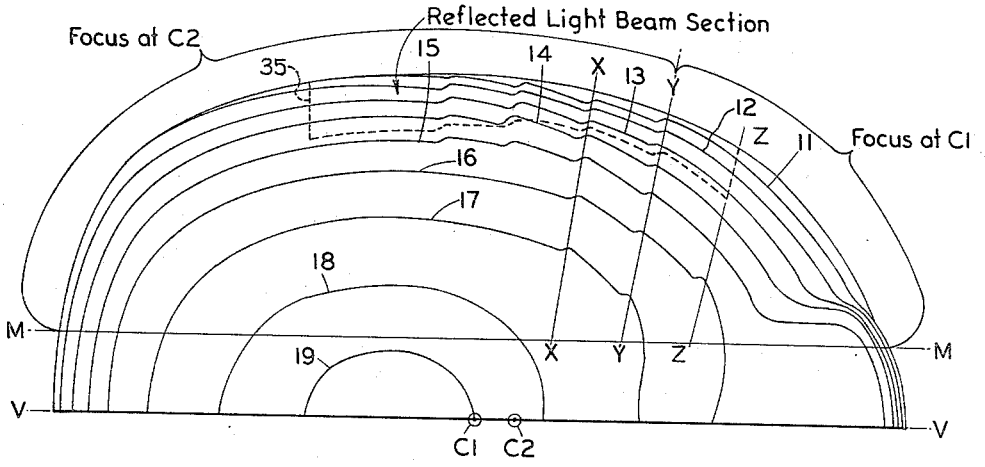

Fig. 5

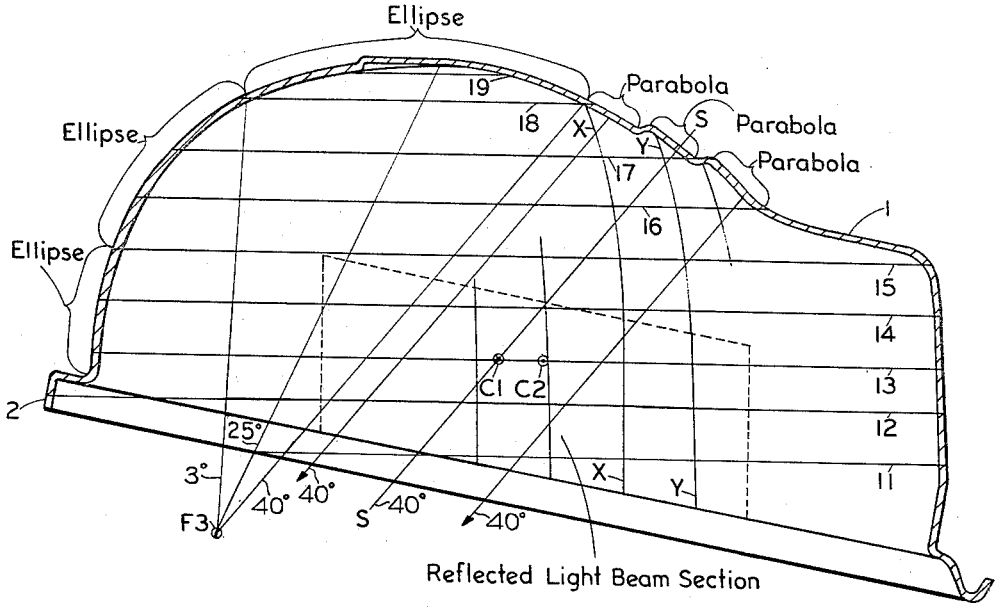

Fig. 6

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LUMINAIRE

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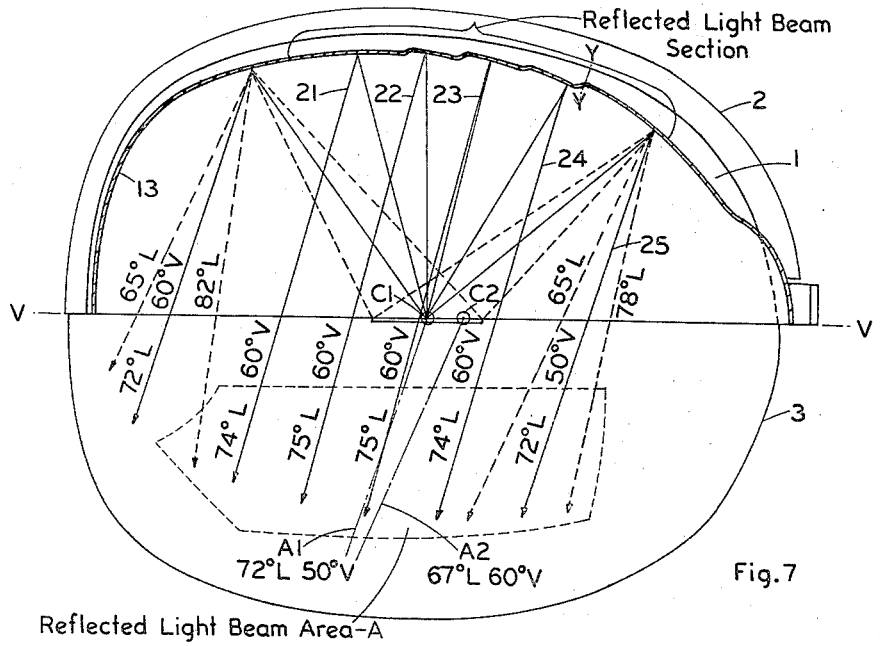

Fig. 7

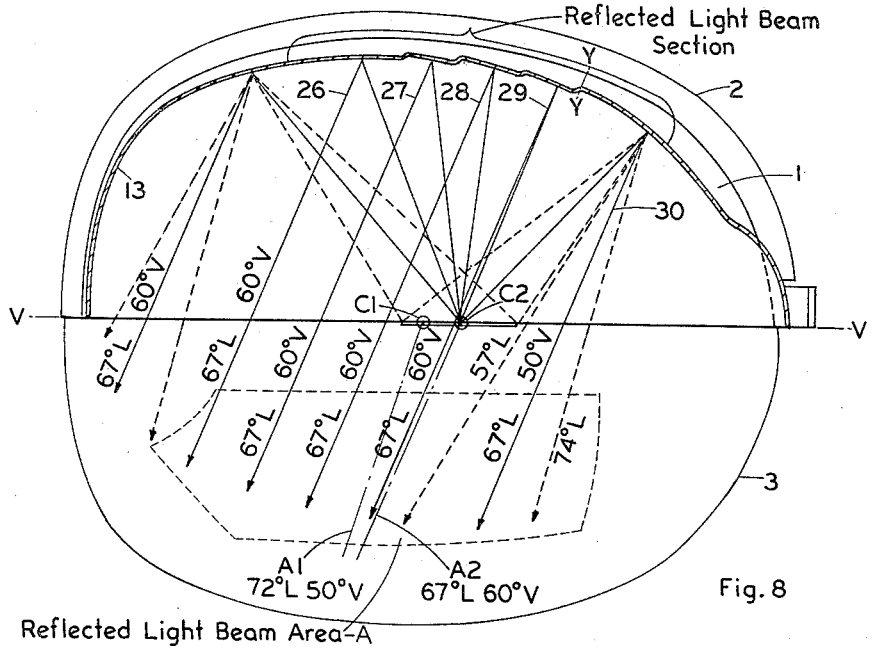

Fig. 8

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LUMINAIRE

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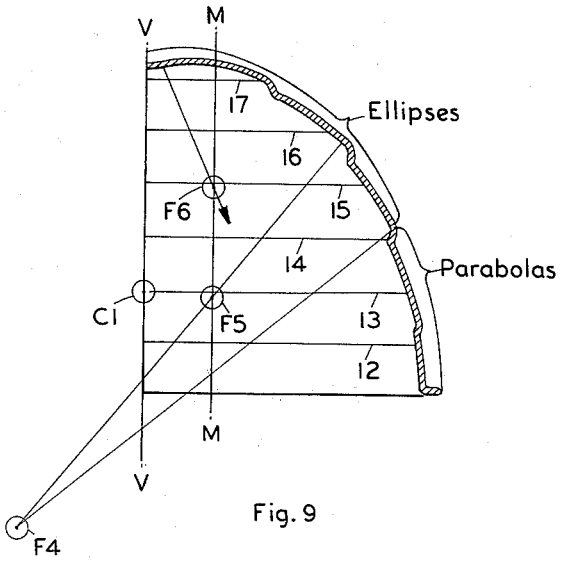

Fig. 9

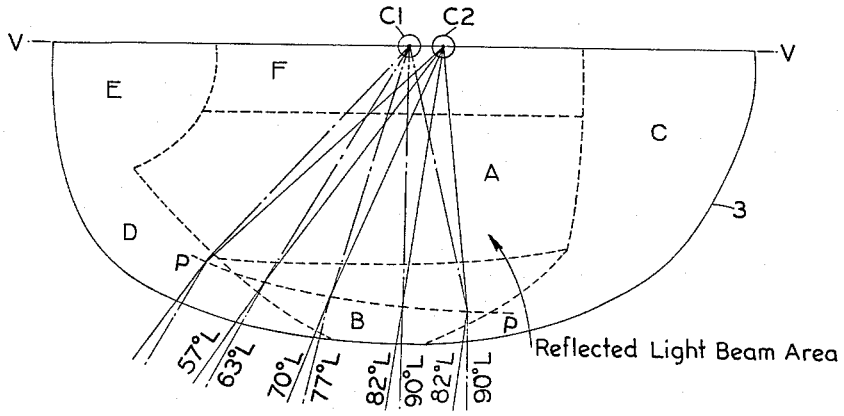

Fig. 10

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United States Patent Office 3,102,693 Patented Sept. 3, 1963

3,102,693

LUMINAIRE

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Filed May 25, 1959, Ser. No. 815,710
7 Claims. (Cl. 240—25)

This invention relates to luminaires and, more particularly, to luminaires intended for side-of-the-roadway mounting and which are capable of producing at least two standard types of roadway illumination with the same basic reflector and refractor.

Proper distribution of the light from luminaires is one of the essential factors in efficient roadway lighting. It has become standard practice in the lighting industry to design luminaires for certain type installations such that the light emanating from the luminaires is directionally controlled and proportioned to approximate certain standardized patterns of light distribution in accordance with the requirements for good seeing and visibility. Generally speaking, a given luminaire offers but one type of light distribution useful under a typical range of conditions, which conditions include luminaire mounting height, transverse location of the luminaire, longitudinal spacing of luminaires, widths of roadway to be effectively lighted, and percentage of lamp light directed toward the pavement and adjacent areas.

In order to have an adequate inventory of luminaires on hand to provide different accepted patterns of light distribution, it has usually been necessary to stock several types of luminaires, one type for each desired distribution. More recently, a successful step in simplifying the problem of providing a different type luminaire for each type light distribution desired has been to provide a single luminaire which, with interchangeable reflectors in combination with the same refractor, is capable of supplying two distinct types of light distribution.

It is an object of the present invention to further simplify the above-mentioned problem by providing a single luminaire which by reason of its unique optical properties is capable of efficiently providing two different standard light distributions with a single reflector-refractor combination.

In carrying out the present invention, I have provided a luminaire having a downwardly concave reflector, which preferably serves also as a housing, and a refractor closing the mouth of the reflector. The reflector is uniquely contoured to possess not one but two distinct focal centers, spaced apart from each other a horizontal distance longitudinally of the luminaire depending upon the desired degree of difference in spread of the two light distributions. Depending upon the type of light distribution desired, the elongated light source, preferably a mercury arc, is mounted within the luminaire with its geometric center at one or the other of the two focal centers. When the light center is located at the focal center closer to the street side of the luminaire, a preferred embodiment of this invention produces an oblique pair of comparatively narrow beams directed in opposite directions along the roadway to provide an ASA Type II light distribution. Shifting the center of the light source rearward to the focal center located closer to the house side of the luminaire results in an ASA Type III light distribution, in which the oblique light beams are broader and are directed further out into the roadway pattern.

These two patterns of light distribution are provided with high utilization efficiency as a result of the unique optical properties of the luminaire which will further be described below in connection with the accompanying drawings, wherein:

FIG. 1 is a vertical cross-sectional view of a luminaire constructed in accordance with these teachings and having the center of the light source positioned at the street side focal center to provide an ASA Type II distribution;

FIG. 2 is a three-dimensional graph of the ASA Type II distribution, showing the lateral width of the oblique light beams in the cone of maximum candle power;

FIG. 3 is a vertical cross-sectional view of the luminaire shown in FIG. 1 but having the center of the light source positioned at the house side focal center to provide an ASA Type III light distribution;

FIG. 4 is a three-dimensional graph of the ASA Type III light distribution showing the lateral width of the oblique light beams in the cone of maximum candle power;

FIG. 5 represents the horizontal reflector contours at equal vertical spacings, it being understood that the contours are symmetrical on opposite sides of the vertical median plane V—V;

FIG. 6 is a vertical cross-sectional view of the reflector taken along line M—M of FIG. 5;

FIG. 7 is a top view of the luminaire shown in FIG. 1 showing one-half the reflector in a horizontal cross section through the focal centers and one-half the refractor in plan view and illustrating the paths of certain representative reflected light rays for Type II distribution;

FIG. 8 is a view similar to FIG. 7 illustrating the paths of certain representative reflected light rays for Type III distribution;

FIG. 9 is an inclined plane light ray diagram taken on line S—S of FIG. 6; and

FIG. 10 is a top plan view of one-half of the refractor illustrating its action on the direct light beam for Type II and Type III distributions.

Referring now to the drawings, there is shown in FIG. 1 the essential optical parts of a luminaire embodying this invention, including a downwardly concave reflector 1 having a down turned open mouth defined by rim 2, which is of a generally ovate configuration. Disposed below and closing the mouth of the reflector is a bowl-shaped prismatic globe or refractor 3. To fill in the rear part of the reflector where an enlarged end portion is provided for the attachment of a slip fitter, an inserted reflector section 4 is placed with an optically correct configuration. Because the present invention is concerned with the optical properties of luminaires including the cooperative relationships between the light source, the reflector contours, and the refractor configurations, certain mechanical details such as mounting features of the various elements in the luminaire have been omitted from these drawings to simplify the presentation and to avoid burdening the description with nonessential details. Mounted within the reflector-refractor combination is, in the illustrated embodiment, a mercury vapor lamp 5 of a common type shown only in outline and having an elongated arc type light source, the limits of which are defined by bracket 6. The socket 7 which supports the lamp positions the light source so that its center coincides with one of two focal centers, C1 and C2, of the luminaire. In the forward or street side position occupied by the light source shown in FIG. 1, the luminaire illustrated is intended to produce an ASA Type II light distribution, one of the two most widely used patterns of light distribution in luminaires intended for side-of-roadway mounting.

The lateral light distribution curves from a luminaire are customarily plotted on the surface of cones such as that shown in FIG. 2. The apex and vertical axis of the cone correspond respectively to the light center and vertical axis of the luminaire. When the conical surface includes the line of maximum candle power, as it does in FIGS. 2 and 4, this is the cone of maximum candle power.

The angular lateral width of a light beam is measured in the cone of maximum candle power between the reference line and the width line. The reference line is either

of the two radial lines formed on the surface of the cone of maximum candle power where it is intersected by a vertical plane parallel to the curb and passing approximately through the focal center of the luminaire. The width line is the radial line which passes through the point of one-half maximum candle power on the lateral light distribution curve plotted on the surface of the cone of maximum candle power. Within the angular width between these two lines falls the line of maximum candle power of light distribution. Type II light distribution as it is defined by the American Standards Association comprises a pair of light beams directed obliquely out into the roadway pattern, each beam having a preferred lateral width of 25° with an acceptable range of 20° to less than 30°. This distribution is generally applicable to luminaires located at or near the side of relatively narrow roadways, and in the FIG. 2 example it can be seen that the main light beams are directed to cover a transverse roadway distance which is about 1.8 times the mounting height (MH) of the luminaire. This applies when the cone is at the vertical angle of 75°.

Another widely used pattern of distribution, Type III, is provided according to the present invention with the same basic reflector-refractor combination merely by positioning the light source with its center at the rearward or house side optical center, **C2**, as shown in FIG. 3. Mounting of the light source in this position in the embodiment shown is accomplished by the provision of a differently dimensioned socket bracket assembly **8** having a shorter front-to-back dimension, although it is obvious that other mechanical expedients could be employed to accomplish the same purpose. The Type III lateral light distribution which is represented in FIG. 4 can be seen to possess oblique light beams having a wider spread than those of Type II. These beams have a preferred lateral width of 40°, with an acceptable range of 30° to less than 50°. This distribution is intended for luminaire mountings at or near the side of wider roadways than those for which Type II is most suitable. In FIG. 4, the transverse roadway distance to which each of the oblique beams is directed is shown as extending approximately 2.4 times the mounting height (MH) of the luminaire.

In the examples shown in FIGS. 1 and 3, the luminaire is positioned with its elongated light source tilted up toward the roadway at an acute angle to make better use of the candle power and lumen output of mercury arc lamps, which is highest at angles perpendicular to the lamp axis. With the tilted light source and the reflector opening inclined, more of the direct and reflected light can be directed into the roadway pattern, and a desirable low angle of cut-off is obtained on the house side of the luminaire. A leveling pad **9** is provided on top of the luminaire to aid in fixing the proper angle of inclination of the lamp and reflector cut off upon installation of the luminaire. To prevent too much light from being wasted beyond the far side of the roadway, a visor-shaped area E of light-depressing external prisms **10** is provided on the street side of the refractor; the shape of this area and especially the lower boundary thereof which is constituted by the intersection of the front or street side of the refractor by an inclined plane (about 58° from the vertical) passing upward through the general region occupied by the light source is partially responsible for a generally rectangular pattern of light distribution on the far side of the roadway within the pavement line. The features of the inclined light source (preferably 10–20°), the slanted angle of reflector cut off (preferably about 10°), and the visor-shaped area of light-depressing prisms are not, in and of themselves, the subject of the present application but are described and claimed in my co-pending application entitled "Luminaire," Serial No. 542,267, filed October 24, 1955, and assigned to the same assignee as that of the present invention.

The refractor, of course, acts over its entire area on direct light from the source. It is sectionalized, however, in such a way that certain areas are designed primarily to accommodate direct light from the source while others are intended principally for the redirection of reflected light. Each of the main light beams identified on the cones of maximum candle power in FIGS. 2 and 4 is made up principally of a reflected light beam and a direct light beam. The portions of the refractor through which are transmitted these two principal component beams are shown in FIGS. 1 and 3. The portion of the refractor enclosed in dotted lines and labeled "reflected light beam area—A" comprises a series of prisms on the internal surface of the refractor running generally longitudinally thereof and designed principally to raise the vertical angle of the reflected light beam incident thereon with only nominal lateral redirection. Above the reflected light beam area A is a light source beam area B of prisms on the internal portion of the refractor which primarily function for the vertical redirection of direct light incident thereon. The prisms in light source beam area B run generally longitudinally of the refractor to lift source light at varying angles into the light source beam. To do this the vertical redirection of the prisms is increased as the vertical angle of light from the source decreases. At the house side of areas A and B, the prisms curve upward to give a steadily increasing forward bending action while decreasing the lift.

The prism area C adjacent to and at the house side of the reflected light beam area includes prisms which curve up to give a greater amount of lateral redirection to the incident direct light passing therethrough to keep this light in or adjacent to the roadway light beams.

The prisms in area D at the street side of the reflected light beam area and extending upward are inclined so that light from the source (as well as reflected light) is laterally as well as vertically redirected in or adjacent to the roadway light beams. The primary purpose of these prisms is to prevent source light from extending beyond the pavement line as designated in FIGS. 2 and 4. The internal prisms in area E redirect the source light laterally so that a minimum of depressing action by the external visor prisms **10** is required to direct the light to the pavement. Area F at the bottom or keel has longitudinally extending prisms to spread the light along the roadway.

Good results may also be obtained by substituting for the refractor **3** illustrated herein, a refractor having a configuration like that shown and described in my aforesaid co-pending application Serial No. 542,267 and which is incorporated herein by reference.

On the reflector, as it is shown in FIGS. 5 and 6, the dotted lines enclose the approximate portion of the lateral reflector surface which reflects light toward the reflected light beam area A of the refractor; this portion of the reflector, known as the reflected light beam section, contributes more than any other section of the reflector to the establishment of the lateral width of the main beams to provide either Type II or Type III lateral distributions. The importance of this reflected light beam section of the reflector in this connection cannot be too strongly emphasized. To avoid confusion, portions of the reflector referred to in this description will be referred to throughout as "sections" while refractor regions will be designated "areas."

In FIG. 5 are shown the lateral contours at each of several horizontal planes numbered respectively **11** through **19** which intersect the inside reflecting surface at vertical spacings, most of which are equal. These horizontal planes are identified by the same numbers in FIG. 6. Each of the horizontal and vertical reflector contours is a conic section, either parabolic or elliptical, and certain discontinuities or indents can be observed between adjacent portions occurring along major indentation lines X—X, and Y—Y and along lesser indentations on either side of them including Z—Z.

The said indentation lines X—X, Y—Y, Z—Z, etc. in FIG. 5 preferably converge at, or are radial about, a

point on line which is normal to V—V and which includes the line 35 which defines the forward boundary of the reflected light beam section which extends from said line 35 back to the indentation line Z—Z. The function of these discontinuities or indentations is primarily to enlarge the house side end of the luminaire by adjusting the reflector contours outwardly, thereby permitting more effective cooperation between the reflector and the refractor in this region. Within the reflected light beam sections of the reflector each of the countours is parabolic both in horizontal and in vertical section. A major feature of this luminaire resides in the fact that forward of the line Y—Y on either side of the reflector, and particularly within the reflected light beam section, each of the reflector curvatures has its focus at the house side or Type III light center C2, while the reflector curvatures to the rear of this line have their foci at the street side or Type II center C1. This division of the reflector surface into discrete sections having separate focal centers contributes importantly to maintaining a high degree of light utilization efficiency, whether the luminaire is providing Type II or Type III light distribution.

Most of the reflector contours above and in front of the reflected light beam section are elliptical, as the reflected light rays in FIGS. 6 and 9 demonstrate. The top portion of the reflector throws reflected light downward and forward and is generally of elliptical contour in vertical and horizontal sections, with a principal focus at C1 and conjugate foci such as F3, F4, F5 and F6 spaced from and about the light source. The end portions of the reflector are elliptical in horizontal and vertical sectional contour. The house-side end portion of the reflector reflects light downward and forward through the mouth of the reflector, and the street-side end portion throws light downward and to the rear through the mouth of the reflector. At the top of the reflector on the house side, the reflector curvatures in longitudinal vertical planes are generally parabolic to reflect light generally downward and forward at vertical angles of about 40°.

FIGS. 7 and 8, with their reflected light ray diagrams, illustrate the effect of locating the center of the light source at the Type II and Type III focal centers C1 and C2, respectively. A1 represents the common parabolic axis of the rearmost or house-side portion of the reflected light beam section, while A2 designates the common parabolic axis for the reflected light beam section on the street side of Y—Y. It should be noted that A2 is directed farther out into the roadway at a lateral angle of about 67° as compared with 72° for A1 and at a higher vertical angle of 60° as compared with 50° for A1. In FIG. 7, which shows the light source positioned for Type II distribution, it will be remembered that all but the rearmost portion of the reflected light beam section is actually designed with its focus at the Type III light center position C2. Because all the reflector curvatures in this section, however, are parabolic, the off-center positioning of the light source with respect to the forward and lateral sections does not occasion a significant spread in the light beam reflected therefrom. For example, the representative light rays 21, 22, 23 and 24 reflected from these portions of the specular surface are directed at nearly parallel lateral angles of 74° and 75°. If the rearmost portion of the reflected light beam section from which is reflected the representative light ray 25 were also designed with its focal center at the Type III light center position C2, the reflected light beam would be considerably broadened and less suitable for Type II distribution. By placing the focus of the rearmost portion of the reflected light beam section at the Type II light center position C1, the light reflected from this portion is not directed too far out into the roadway and the reflected light beam is successfully kept narrow.

The dotted line light ray diagrams drawn from the effective ends of the elongated light source illustrate that the beam spread from the reflected light beam section due to the elongated source approximates 13° to 17° in lateral angles. While most of the light reflected from the reflected light beam section is directed downward at vertical angles of approximately 60° to be lifted by the prismatic areas on the refractor into higher, more usable angles, the portion of the reflected light beam reflected from the rearmost part of the reflected light beam section is directed at somewhat smaller vertical angles of approximately 50°. This depression of the light reflected from the rearmost portion of the reflected light beam section helps further to avoid high angle light directed out of the main beams of the Type II lateral distribution.

As a natural consequence of moving the light source rearward to the Type III light center position C2 as shown in FIG. 8, each of the rays reflected from the reflected light beam section is shifted forward farther out into the roadway pattern at lateral angles of about 67° before redirection by the refractor, as representative reflected light rays 26 through 30 demonstrate. Because the light center remains generally in the same horizontal plane, the vertical angles before redirection of the light by the refractor are substantially identical to those resulting in the FIG. 7 example. The light beam spread due to the length of the light source is, as shown by the dotted line reflected light rays, also approximately equivalent except that light reflected from the rearmost portion of the reflected light beam section has a greater spread because of the fact that the light center is not located at its focus. Shifting of the reflected light beam forward to lateral angles of about 67° places it close to the center of the desired main beam for Type III distribution.

FIG. 10 represents the effect on the light source beam of the location of the lamp at the Type II and Type III positions. Representative direct light rays from each of the focal centers C1 and C2 are shown incident on the light source beam area B along a horizontal intersecting plane P—P. It is to be observed that each point on the surface of the refractor transmits the direct light passing therethrough at different lateral angles depending upon the position of the light source. The rearmost light rays designated 82° lateral and 90° lateral include the additional redirection accomplished by a band of external prisms 36 (FIG. 1) running around the refractor in vertical planes between the boundaries 37 and 38. When the light source center is at C2, the Type III focal center, light from the source is directed farther out into the roadway pattern that it is when the light source center is at the Type II focal center, C1. This effect, of course, is precisely what is desired and constitutes another reason why the rear portion of the reflector should have a focal center spaced horizontally from and on the street side of the focal center for the forward portion of the reflector. With this arrangement, the reflected light beam cooperates efficiently with the light source beam to produce a combined main beam directed at appropriate lateral angles whether for Type II or for Type III distributions.

The salient features of this invention have been described in connection with a single embodiment shown in some detail. Persons skilled in the optics of luminaires will appreciate, however, that other embodiments of these teachings may take different forms with numerous variations. The scope of the invention, therefore, in its broader aspects should not be limited except by a fair interpretation of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A luminaire adapted to be positioned at one side of a roadway comprising: a generally ovate concave reflector symmetrical on opposite sides of a vertical median plane transverse to the roadway; an ovate bowl-shaped refractor having its opening facing the opening in said reflector; said refractor having prismatic areas defining reflected light beam areas on lower opposite sides thereof

and light source beam areas above and adjacent said reflected light beam areas; said reflector having reflected light beam sections on opposite lateral surfaces thereof for directing light downward into the reflected light beam areas of said refractor, the reflected light beam section of said reflector being composed of forward and rearmost curved specular surfaces which are parabolic in horizontal and vertical cross section, said rearmost curved surfaces of said reflected light beam section having a common focus within the opening in said reflector in said vertical median plane, said forward surfaces having another common focus located in said vertical median plane on the rearward side of said first-mentioned focus and spaced horizontally therefrom.

2. A luminaire adapted to be positioned at one side of a roadway comprising: a generally ovate concave reflector symmetrical on opposite sides of a vertical median plane transverse to the roadway; an ovate bowl-shaped refractor having its opening facing the opening in said reflector; said refractor having prismatic areas defining reflected light beam areas on lower opposite sides thereof and light source beam areas above and adjacent said reflected light beam areas; said reflector having reflected light beam sections on opposite lateral surfaces thereof for directing light downward into the reflected light beam areas of said refractor, the reflected light beam section of said reflector being composed of forward and rearmost curved specular surfaces which are parabolic in horizontal and vertical cross section, said rearmost curved surfaces of said reflected light beam section having a common focus within the opening in said reflector in said vertical median plane; said forward surfaces having another common focus located in said vertical median plane on the rearward side of said first-mentioned focus and spaced horizontally therefrom; and means for mounting a light source with its geometric center at one of said foci.

3. A luminaire adapted to be positioned at one side of a roadway comprising: a generally ovate concave reflector symmetrical on opposite sides of a vertical median plane transverse to the roadway; an ovate bowl-shaped refractor having its opening facing the opening in said reflector; said refractor having prismatic areas defining reflected light beam areas on lower opposite sides thereof and light source beam areas above and adjacent said reflected light beam areas; said reflector having reflected light beam sections on opposite lateral surfaces thereof for directing light downward through the vertical median plane into the reflected light beam areas of said refractor, the reflected light beam section of said reflector being composed of curved specular surfaces which are parabolic in horizontal and vertical cross section, the rearmost or house-side parabolic surfaces of said reflected light beam section having a common focus within the opening in said reflector in said vertical median plane, the parabolic surfaces of said reflected light beam section forward of said rearmost surfaces having a different common focus located in said vertical median plane on the rearward side of said first-mentioned focus and spaced horizontally therefrom.

4. A luminaire adapted to be positioned at one side of a roadway comprising: a generally ovate concave reflector symmetrical on opposite sides of a vertical median plane transverse to the roadway; an ovate bowl-shaped refractor having its opening facing the opening in said reflector; said refractor having prismatic areas defining reflected light beam areas on lower opposite sides thereof and light source beam areas above and adjacent said reflected light beam areas; said reflector having reflected light beam sections on opposite lateral surfaces thereof for directing light downward through the vertical median plane into the reflected light beam areas of said refractor, the reflected light beam section of said reflector being composed of curved specular surfaces which are parabolic in horizontal and vertical cross section, the rearmost or house-side parabolic surfaces of said reflected light beam section having a common focus within the opening in said reflector in said vertical median plane and a parabolic axis directed along and across the roadway, the parabolic surfaces of said reflected light beam section forward of said rearmost surfaces having a different common focus located in said vertical median plane spaced horizontally on the rearward side of said first-mentioned focus and having a parabolic axis directed further across the roadway and at higher vertical angles than said first-mentioned parabolic axis.

5. A luminaire adapted to be positioned at one side of a roadway comprising: a generally ovate concave reflector symmetrical on opposite sides of a vertical median plane transverse to the roadway; an ovate bowl-shaped refractor having its opening facing the opening in said reflector; said refractor having prismatic areas defining reflected light beam areas on lower opposite sides thereof and light source beam areas above and adjacent said reflected light beam areas; said reflector having reflected light beam sections on opposite lateral surfaces thereof for directing light downward through the vertical median plane into the reflected light beam areas of said refractor, the reflected light beam section of said reflector being composed of curved specular surfaces which are parabolic in horizontal and vertical cross section, the rearmost or house-side parabolic surfaces of said reflected light beam section having a common focus within the opening in said reflector in said vertical median plane and a parabolic axis directed along and across the roadway, the parabolic surfaces of said reflected light beam section forward of said rearmost surfaces having a different common focus located in said vertical median plane spaced horizontally on the rearward side of said first-mentioned focus and having a parabolic axis directed further across the roadway than said first-mentioned parabolic axis.

6. In a luminaire adapted to be positioned at one side of a roadway, a generally ovate, downwardly opening, concave reflector having specular surfaces which in horizontal and vertical profile are conic sections symmetrical on opposite sides of a vertical median plane transverse to the roadway, said reflector having two distinct focal centers located within the opening in said reflector in said vertical median plane and spaced apart from each other a horizontal distance, the rearmost or house-side portions of said reflector having a common focus at the forward one of said two focal centers, and the portions of said reflector on the forward side of said rearmost portions having a common focus at the rearward one of said two focal centers.

7. In a luminaire adapted to be positioned at one side of a roadway, a generally ovate, downwardly opening, concave reflector symmetrical on opposite sides of a vertical median plane transverse to the roadway and having reflected light beam sections on opposite lateral surfaces thereof for directing light downward through the vertical median plane, the reflected light beam sections each being composed of forward and rearmost curved specular surfaces which are parabolic in horizontal and vertical cross section, the said forward surfaces together constituting the major part of the total area of said reflected light beam section, said rearmost surfaces constituting a minor part of the total area of said reflected light beam section and having a common focus within the opening in said reflector in said median plane and having a parabolic axis directed downwardly at a vertical angle of approximately 50° and laterally at a lateral angle of approximately 72°, said forward surfaces having another common focus located in said vertical median plane on the rearward side of said first-mentioned focus and spaced horizontally therefrom and having a parabolic axis directed downward at a vertical angle of approximately 60° and laterally at a lateral angle of approximately 67°.

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2,786,130	Elmer	Mar. 19, 1957
2,886,698	Dorman	May 12, 1959
2,945,945	Rex	July 19, 1960