Feb. 19, 1946. K. FRANCK 2,394,992

LIGHTING UNIT

Filed June 30, 1943 2 Sheets-Sheet 1

Fig. 1.

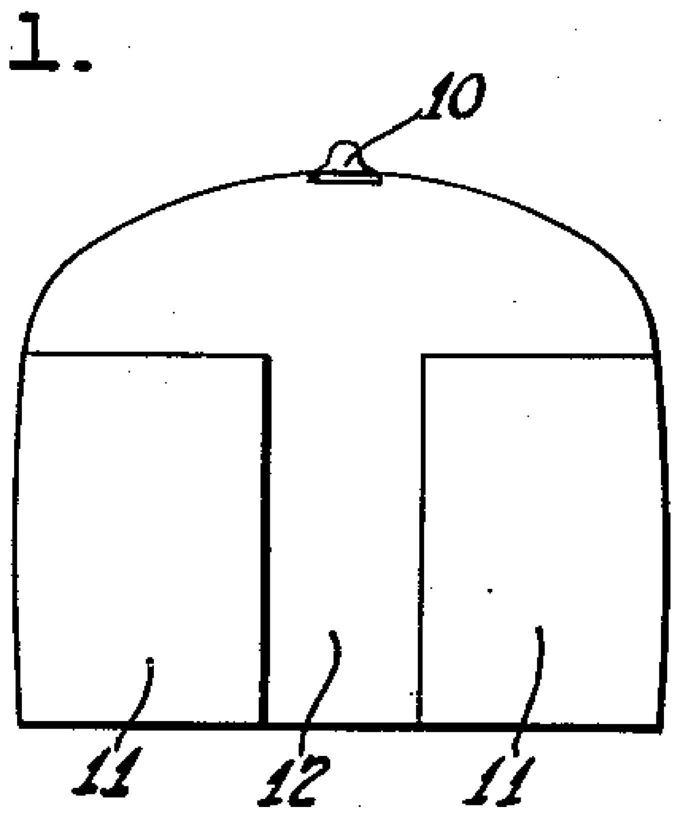


Fig. 3.

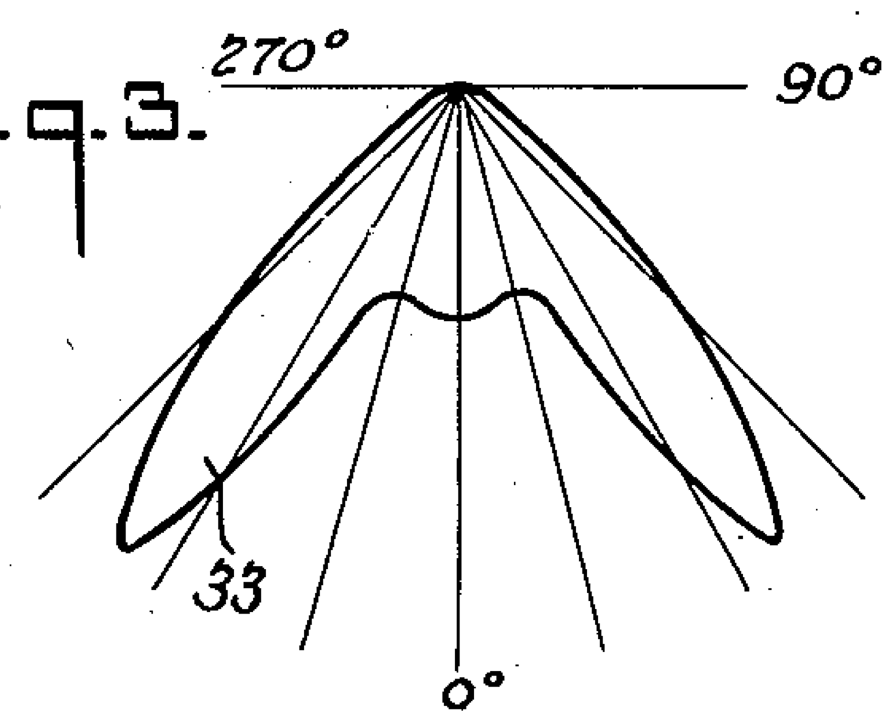


Fig. 2.

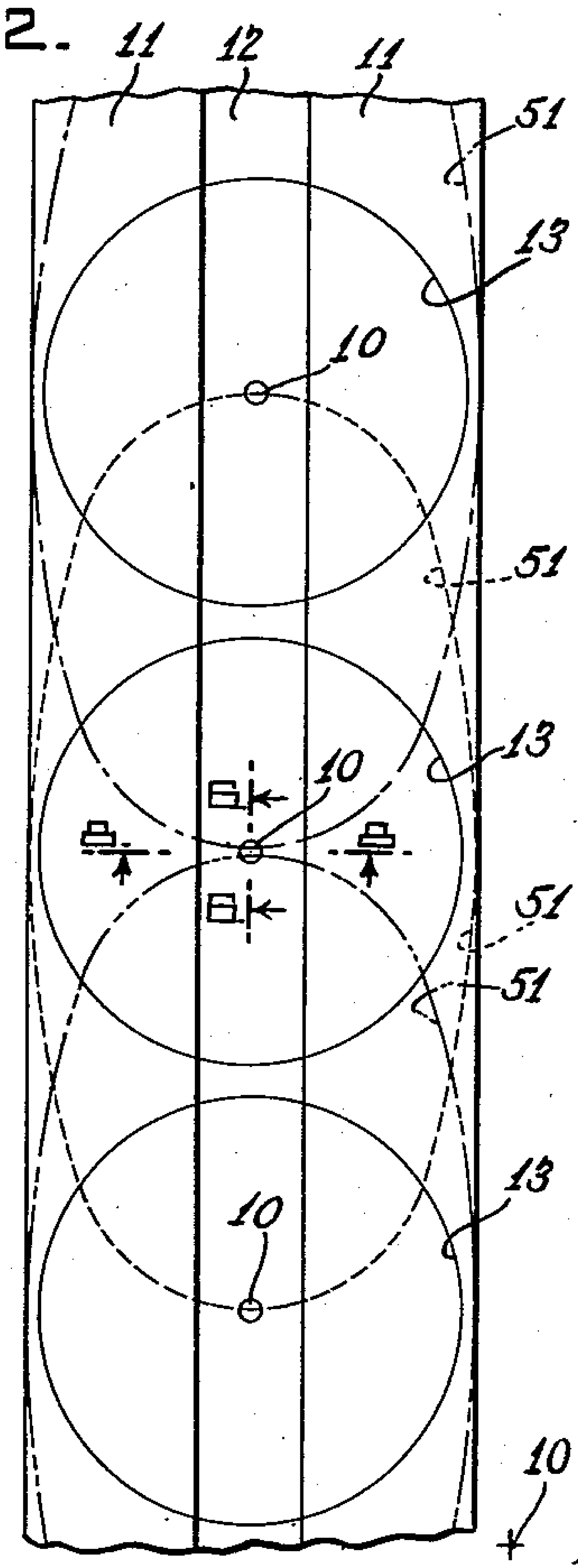


Fig. 4.

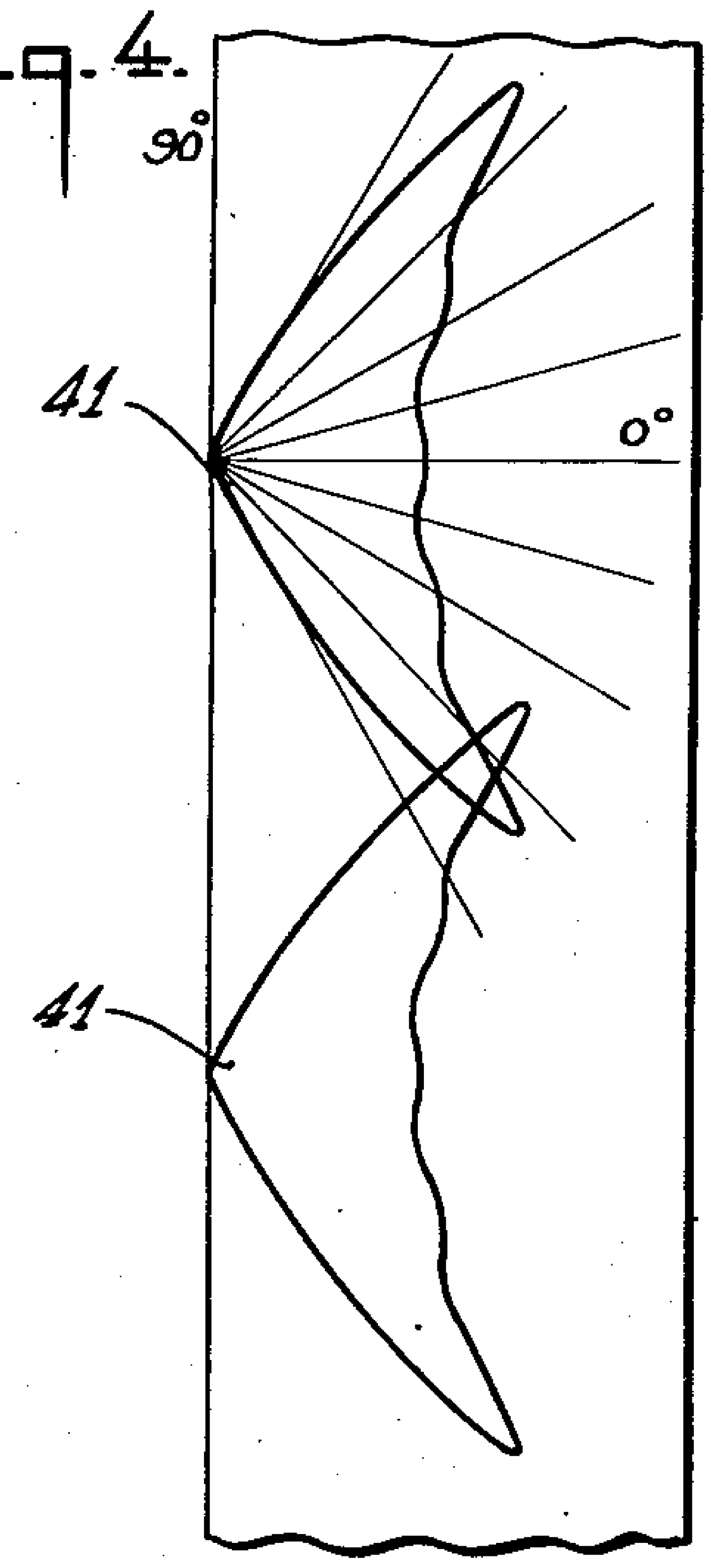
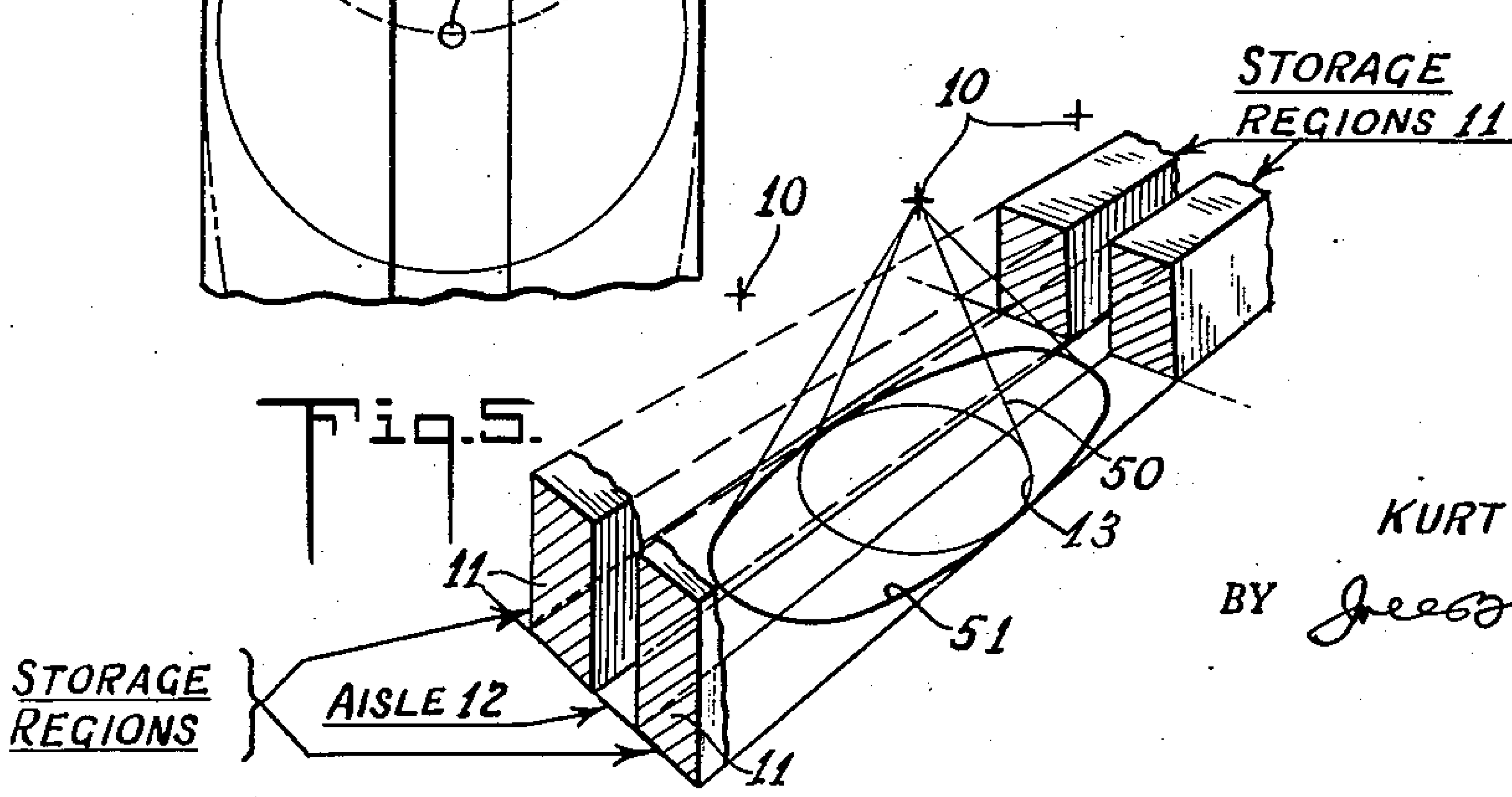


Fig. 5.



INVENTOR.
KURT FRANCK

BY [signature]

ATTORNEY

Feb. 19, 1946. K. FRANCK 2,394,992

LIGHTING UNIT

Filed June 30, 1943 2 Sheets-Sheet 2

Fig. 6.

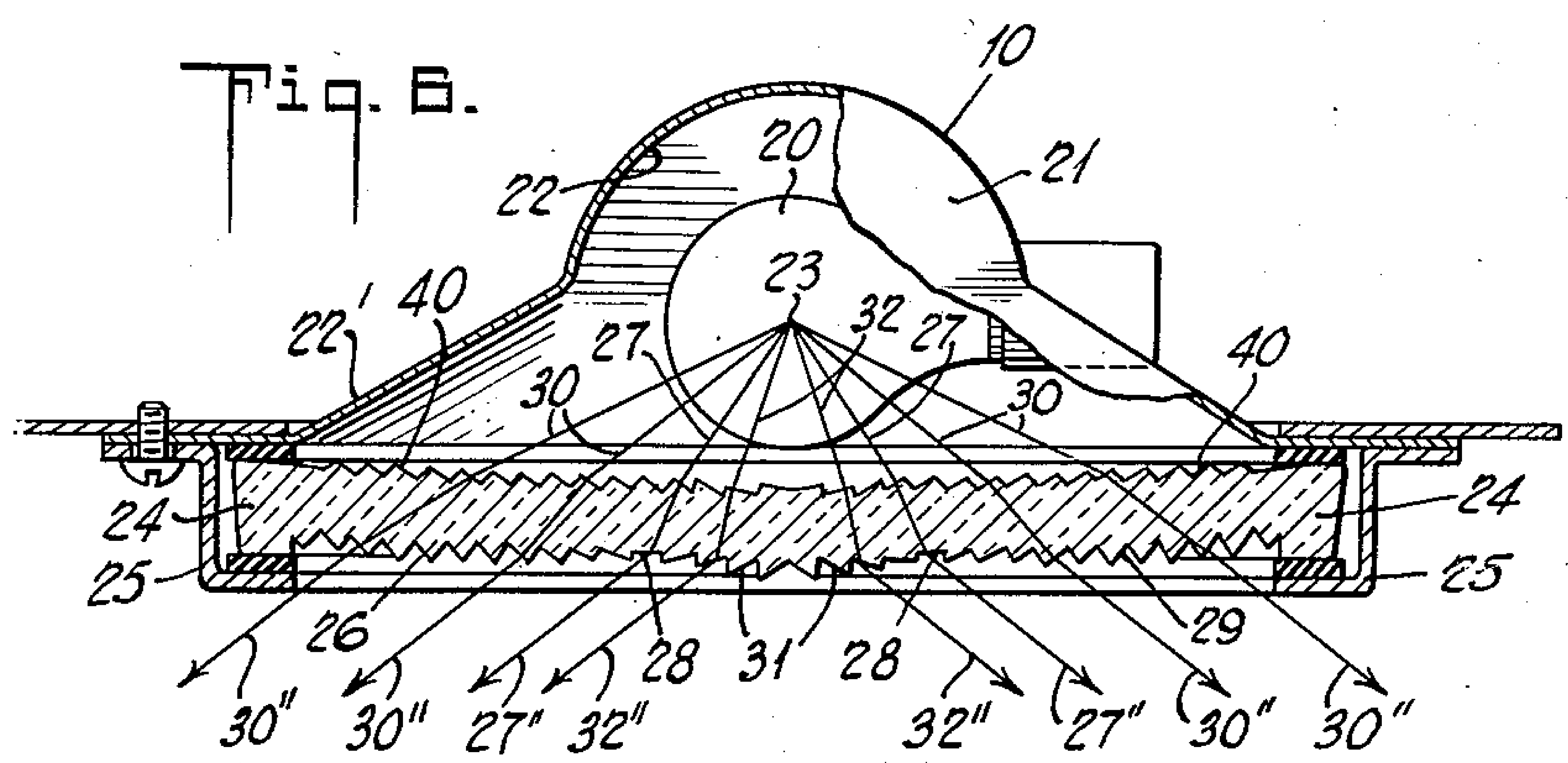


Fig. 7.

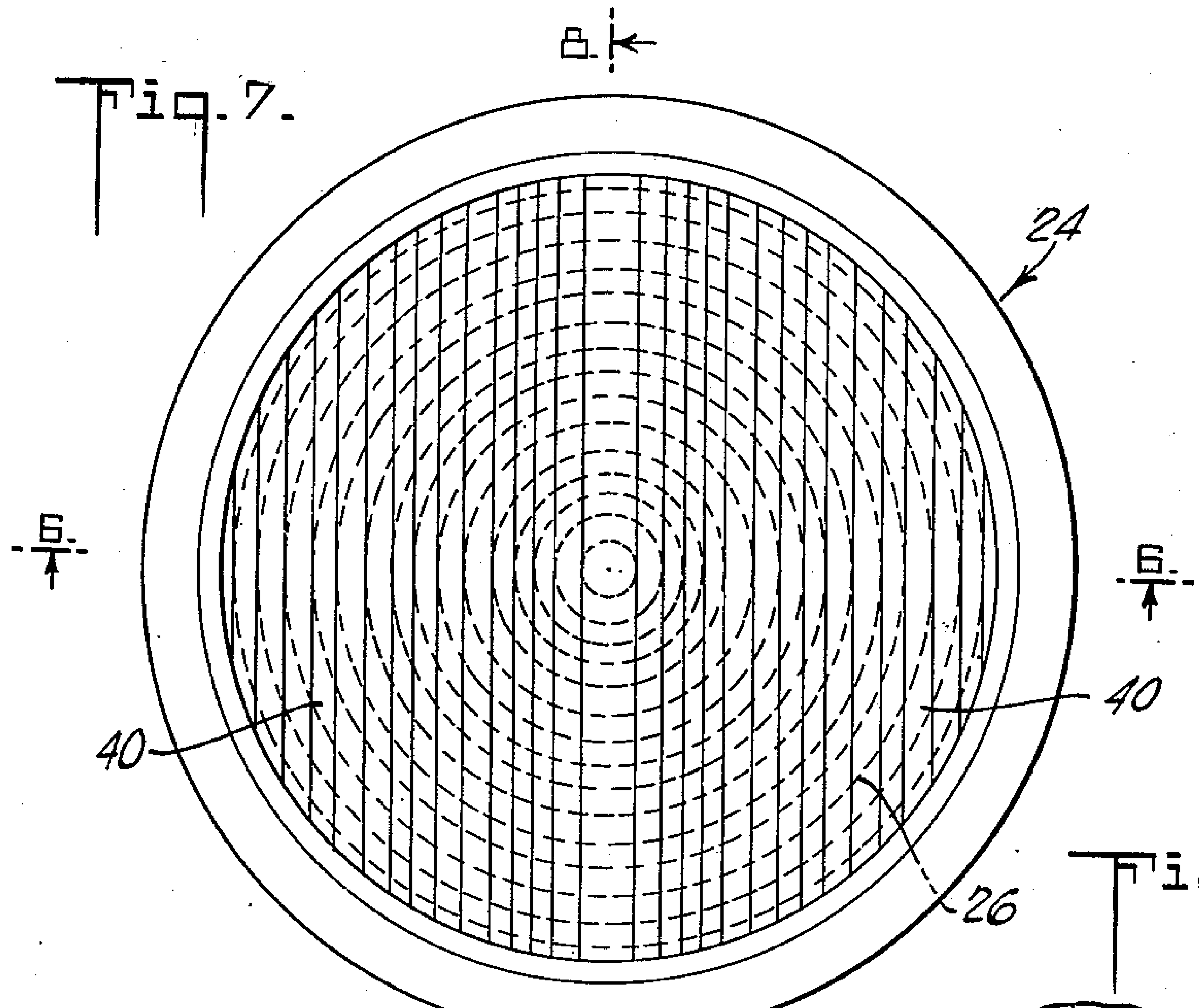


Fig. 8.

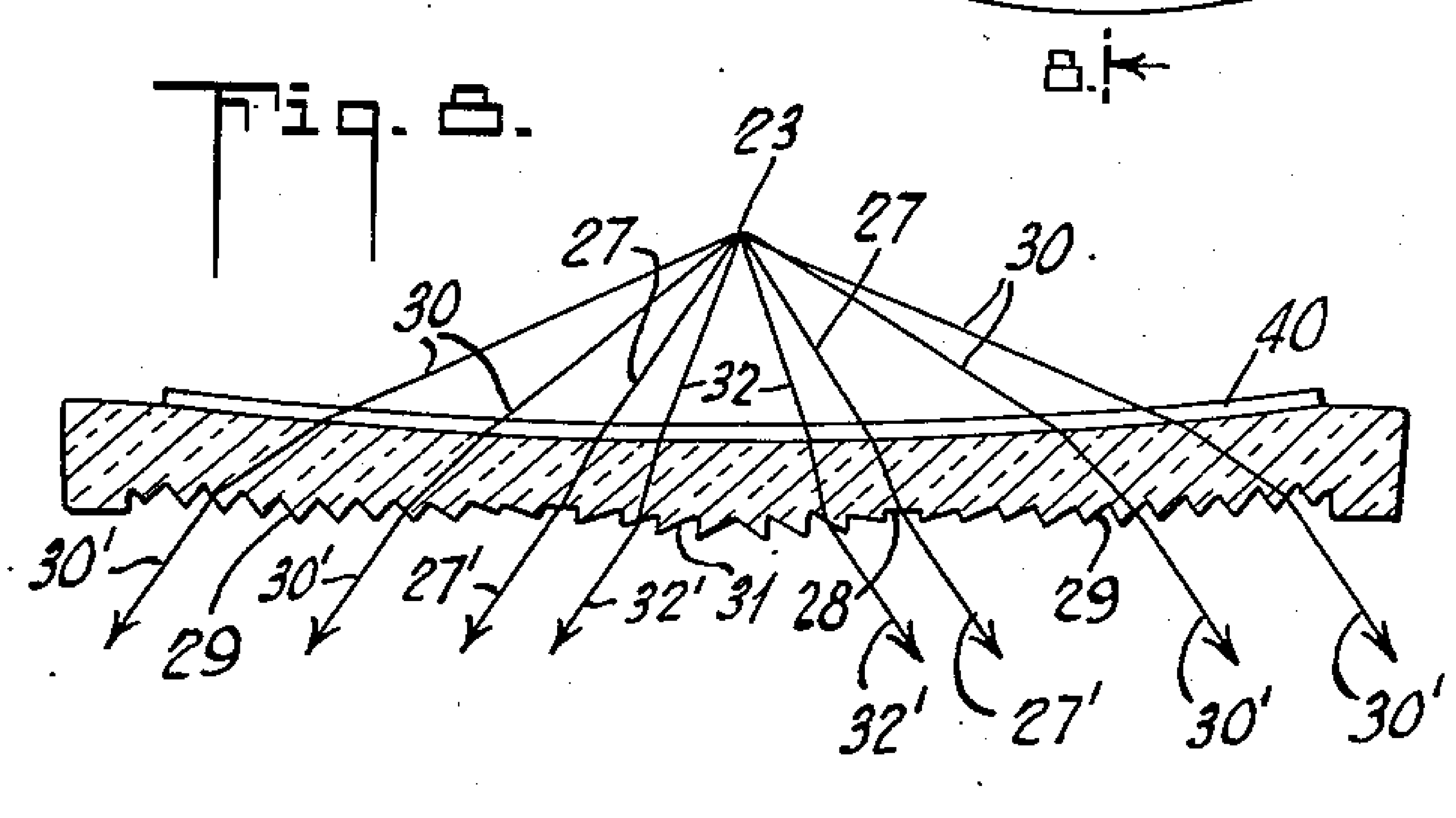
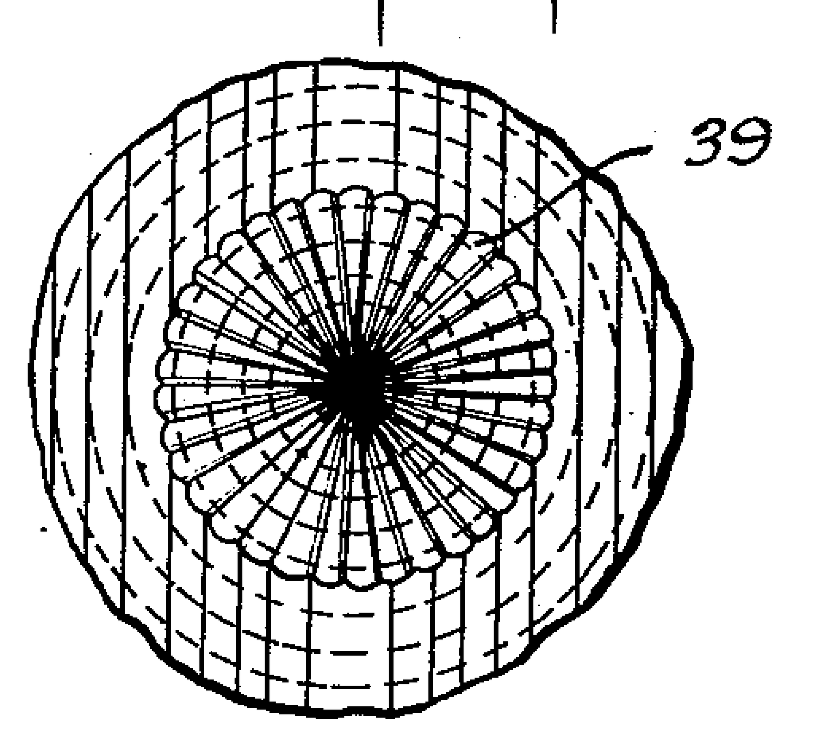


Fig. 9.



INVENTOR.
KURT FRANCK

BY

[signature]

ATTORNEY

Patented Feb. 19, 1946 2,394,992

UNITED STATES PATENT OFFICE

2,394,992

LIGHTING UNIT

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

Application June 30, 1943, Serial No. 492,807

7 Claims. (Cl. 240—93)

The present invention relates to lighting units, and is more particularly directed toward lighting units suitable for providing both vertical and horizontal illumination in long narrow regions such as aisles.

It frequently is desirable to employ a single row of lighting units or luminaires for lighting two regions on the opposite sides of an aisle, as for example, in railway vehicles, buses, the lighting of corridors, book stacks and storage bins, and in the lighting of the cargo carrying space in airplanes. In locations such as these the problem involves the lighting of vertical surfaces of substantial extent. The embodiment of the invention to be described herein is one more particularly developed for lighting the cargo space in a cargo carrying plane.

Where elongated areas are lighted with a single row of luminaires over the center of the space and such luminaires have a symmetric distribution about the vertical axis the illumination tends to be spotty and uneven unless the luminaires are comparatively close together. When such luminaires are spaced more widely the regions intermediate the luminaires are insufficiently lighted.

According to the present invention the system of lighting employed contemplates the use of luminaires provided with light controlling means whereby the light is spread away from the nadir a lesser amount in directions transverse of the regions to be illuminated than it is spread in directions lengthwise of the regions to be lighted. This makes it possible to direct the light emitted generally in the direction of the regions to be lighted at higher angles above the nadir intermediate the luminaires so that it reaches these more distance areas at angles where it can be utilized more effectively.

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

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

Figure 1 is a diagrammatic cross sectional view through a region to be lighted;

Figure 2 is a diagrammatic longitudinal plan view of the same;

Figure 3 shows a photometric curve taken in the plane of Figure 1 through the center of the light source;

Figure 4 illustrates photometric curves taken in the vertical plane through the centers of Figures 1 and 2;

Figure 5 is a diagrammatic perspective view illustrating light distribution;

Figure 6 is a vertical sectional view through a luminaire taken in directions of the line 6—6 of Figures 2 and 7;

Figure 7 is a top plan view of the lens of Figure 6;

Figure 8 is a section through the lens of Figure 6 taken in the direction of the line 8—8 of Figures 2, 6 and 7; and

Figure 9 illustrates a modification.

Figures 1 and 2 illustrate a region to be lighted. Here the luminaires are indicated at 10. The regions to be lighted are indicated at 11, 11 and they are on the opposite sides of an aisle 12. It will be noted that these regions occupy substantial width in horizontal planes, have substantial vertical depth, and that their longitudinal extent may be indefinite.

The spacing of the luminaires 10, 10, as illustrated in Figures 2 and 5, is about one and one-half times the mounting height as illustrated in Figure 1, and the mounting height is shown to be approximately equal to the maximum width of the area to be lighted in a typical arrangement such as illustrated the more remote part of the floor is approximately 30° from the nadir.

If the lighting equipment were designed to have symmetrical distribution about its vertical axis it would produce equal illumination at all points equidistant from the fixture axis, as illustrated by the circles 13 of Figure 2. If the angle of spread were such as not to waste light on the outer side walls of the region directly opposite the luminaires, then the spread in longitudinal directions would be insufficient to have the spots of light meet and overlap. This is illustrated by the failure of the circles 13, 13 to cross one another and overlap. Under such conditions there would be a comparative excess of light close to the fixtures and comparatively no light halfway between the fixtures, and both vertical and horizontal surfaces would be poorly lighted especially these surfaces more distant from the center of the aisle and halfway between the luminaires.

The present invention contemplates providing luminaires with light controlling means whereby the illumination may be satisfactorily built up in those areas which would otherwise be poorly illuminated so that comparatively high illumination is available and yet maintain the desired spacing of the lighting equipment.

Referring now to the structure shown in Figures 6, 7 and 8 it will be seen that the luminaire employs an incandescent lamp 20 which in the present instance is a horizontal, automotive type lamp and may, for example, be a 21 candlepower lamp. The lamp is received in a reflector 21 with an upper specular portion 22, preferably spherical, so that most of the light is directed downwardly as though it came from the source 23. A lens plate 24 is held in place by a ring 25. This lens plate is substantially flat and held very close to the bulb of the lamp 20. It also receives light from the lower, conical diffuse portion 22′ so as to be lighted up thereby.

The lower face of the lens plate is provided with annular prismatic ridges 26. Light rays such as 27, 27 of Figure 8 pass through the annular flat area 28 which does not change the direction of the light ray received directly from the source 23 so that rays 27′, 27′ continue in the original direction. Outside the area 28 the prismatic ridges 29 are of increasing refracting power and bend rays 30, 30 as indicated at 30′, 30′, so that they are generally parallel with the rays 27′. The ridges 29 are the regressed optical equivalent of a negative or divergent spherical lens surface. Inside the areas 28 the prismatic ridges 31, 31 are of increasing refracting power toward the center of the lens so that they bend rays 32, 32 away from the nadir, as indicated at 32′, 32′, so that they are also generally in parallelism with the rays 27′, 27′, those rays therefore forming axes for the downwardly sloping beams. The ridges 31 are the regressed optical equivalent of a positive or convergent spherical lens surface. Owing to the size of the filament and closeness to the refractor there is considerable divergence within the beam. The refracting power of the annular prismatic ridges is such that they are capable of acting on light radiating directly from the source 23 to collect it into an intense beam at a maximum angle of spread and approximately 35° from the nadir, thereby providing a light distribution substantially that shown by the photometric curve 33 in Figure 3. Such a light distribution is well adapted for lighting horizontal and vertical surfaces on opposite sides of and spaced from a vertical axle.

The upper surface of the lens plate 24 has a series of parallel upwardly and outwardly sloping prismatic ridges 40. These ridges have almost zero refracting power along the median plane 8—8 through the center of the lens plate and the lens plate is mounted so that these ridges extend transversely of the aisle. These ridges have uniform cross section lengthwise and their refracting power varies from prism to prism. They are the regressed optical equivalent of a negative or divergent cylindrical lens surface. The angles of incidence on them are less than the angles of incidence on correspondingly distant areas at the median plane (8—8) with consequent lessening of the angle of refraction so that the parallel ridges elevate all the rays such as 27, 30 and 32 (at the same vertical angles as in Figure 8) so that in plane 6—6 they pass through the glass at much higher angles above the nadir than do the correspondingly sloped rays which pass through the glass in the plane of Figure 8. This causes the rays in the glass to fall on the annular prismatic ridges at much higher angles and these rays are transmitted in directions lengthwise of the aisle at much higher angles than the corresponding rays were transmitted in the planes transverse of the aisle. This is indicated by the much higher angle taken by the rays 27″, 30″ and 32″ in Figure 6 than the corresponding rays of Figure 8.

As the radial plane shifts from plane 6—6 through intermediate planes toward 8—8 there is a change in the steepness of the ridge surface in such radial plane and there is less lessening of the angle of incidence and of refraction and hence elevation of emergent rays above the nadir lessens until at plane 8—8 the ray direction is solely controlled by the lower ridges acting as elements of prisms whose upper surfaces are flat.

The upper surface of the lens plate is preferably provided with a rosette of radial diffusing flutes such as indicated at 39 in Figure 9. These flutes act to spread the light away from the nadir and avoid a relatively excessive bright spot immediately below the luminaire. The rosette is omitted from Figures 6, 7 and 8 to facilitate the showing of the light paths. The output of the luminaire is shown by the photometric curves 33 and 41 taken of Figures 3 and 4 along the aisle and across the aisle, respectively. In the example shown the angle of maximum beam in the photometric curve 41 is 50° from the nadir. This is an angle sufficiently high to so spread the light between luminaires mounted at one and one-half times the mounting height as to spread the illumination from one luminaire over into work areas under and opposite the adjacent luminaires.

As a result of the progressively decreasing action of the parallel prismatic ridges as the plane of reference shifts in azimuth directions from along the aisle to across the aisle there is progressively less divergence or spread from the nadir so that at intermediate horizontal angles the spread would vary from that of curve 41 to that of curve 33.

Instead of having light distributions which can readily be illustrated by a cone 50 with a circular base with its apex at 10, such as illustrated in Figure 5, there results a distribution of light which can more properly be as confined to the shell-like surface of a non-circular cone, i. e., one whose base instead of being a circle (as at 13) is a quasi-ellipse, such as illustrated at 51 in Figures 2 and 5. It will thus be apparent that not only is the horizontal illumination improved in regions between the circle 13 and the quasi-elliptical curves 51 of Figure 2, but that each source improves the vertical illumination, particularly on transverse planes opposite or nearly opposite the adjacent sources.

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. In a luminaire, means for acting on a downwardly divergent cone of light to cause the less divergent emitted light to spread away from the nadir throughout the entire circumference at a greater angle above the nadir in two regions diametrically opposite one another than in the two regions at right angles thereto and to reduce the divergence of the more divergent light to substantially the same angle above the nadir as that to which the less divergent light is spread in the same azimuth, whereby the distribution is asymmetric in vertical planes with higher angle of maximum candlepower in the first two regions than in the other two regions, comprising a hori-

zontal lens intercepting the divergent cone of light rays and having parallel, upwardly and outwardly sloping prismatic ridges on the light incident surface disposed in the direction of the lower-angled high-angle light, and annular prismatic ridges on the light emitting side whose refracting power decreases from the center to a minimum and then increases.

2. In a luminaire, a point source, a substantially flat refractor having a system of parallel, upwardly and outwardly sloping prismatic ridges on the light incident surface of minimum refracting power at the center of the refractor and greater refracting power remote from the center for diverging light in two opposed azimuthal directions without affecting it in azimuthal directions at right angles thereto, and annular prismatic ridges on the light emergent surface, the refracting power of the inner annular prismatic ridges being such as to spread incident light away from nadir, the refracting power of the outer annular prismatic ridges being such as to deviate incident light falling thereon toward nadir whereby the angle of maximum candlepower of the emitted light output is higher above nadir in the first two azimuthal directions than in the azimuthal directions at right angles thereto.

3. A luminaire comprising a substantially point light source, a normally horizontal, substantially flat lens plate with its center below the source, the upper surface of the plate having on opposite sides of a median vertical plane through the light source parallel prismatic ridges having variant refracting power from prism to prism, each ridge being uniform throughout its length and having a light incident surface at an angle of incidence to direct light from the source lower than would be the angles of incidence for a similarly placed flat smooth surface, whereby the angle of refraction on entering the plate is less and the angle of the light in the plate is raised higher above the nadir and the lessening effect on the angle of refraction and the raising of the light in the plate decreases with angular distance from the median plane, the lower surface of the plate having annular prismatic ridges which converge the rays transmitted thereby into generally parallel directions in each radial plane and direct the emitted beam away from the nadir a minimum amount in the median plane and a maximum amount in planes at right angles thereto, and continually changing amounts in intermediate planes.

4. An aisle illuminating device symmetrical about a central vertical plane for use in an aisle with a plane of symmetry transverse of the aisle, said device comprising a light source and a refractor underneath and close to the source so as to receive substantially all the downwardly emitted light, the refractor being provided on its upper surface with a system of parallel outwardly and upwardly sloping prismatic ridges extending parallel to said plane of symmetry of minimum refracting power at the center of the refractor and greater refracting power remote from the center for diverging light in the refractor in directions along the aisle without affecting the light in directions across the aisle, and having on its lower surface a system of circumferentially uniform annular prismatic ridges of varying refracting power with varying diameter to concentrate light divergent from the source into an annular region whose diameter is substantially the width of the area intended to be illuminated and with a light beam intensity varying from a minimum at nadir to a maximum at the periphery of said region, the parallel prismatic ridges transmitting the light which falls on them such that it reaches the annular ridges from a lowered virtual source in such an amount that the annular prisms concentrate the emitted light in directions generally lengthwise of the aisle at vertical angles such as to direct said light on to the remote portions of said area.

5. An aisle illuminating device according to claim 4, wherein the maximum beam in said central vertical plane is substantially 35° above the nadir and in the direction at right angles thereto is substantially 50° above the nadir.

6. An aisle illuminating device according to claim 4, wherein the refracting power of the annular prismatic ridges is such as to increase the intensity of the light emitted from a minimum at nadir to a maximum at an angle of the order of 35° from the nadir and lower substantially all the light to more than 30° below the horizontal, and the refracting power of the parallel prismatic ridges is of the order of 15° in directions lengthwise of the aisle.

7. The combination with a concentrated light source of a horizontal refracting plate below the source to accept a cone of divergent light therefrom, said plate on its upper surface carrying a system of parallel regressed prismatic ridges optically equivalent to a negative or divergent cylindrical lens surface each side of a central vertical plane through the source, and on its lower surface at its center carrying a system of annular regressed prismatic ridges optically equivalent to a negative or divergent spherical lens surface, and outside this divergent system carrying a second system of annular regressed prismatic ridges optically equivalent to a positive or convergent spherical lens surface, the two systems being separated by a narrow flat area and the refracting power of each system of annular prismatic ridges being such that the light emitted at each azimuthal direction is substantially parallel to that emitted at that direction through the flat area.

KURT FRANCK.