

Jan. 23, 1945.

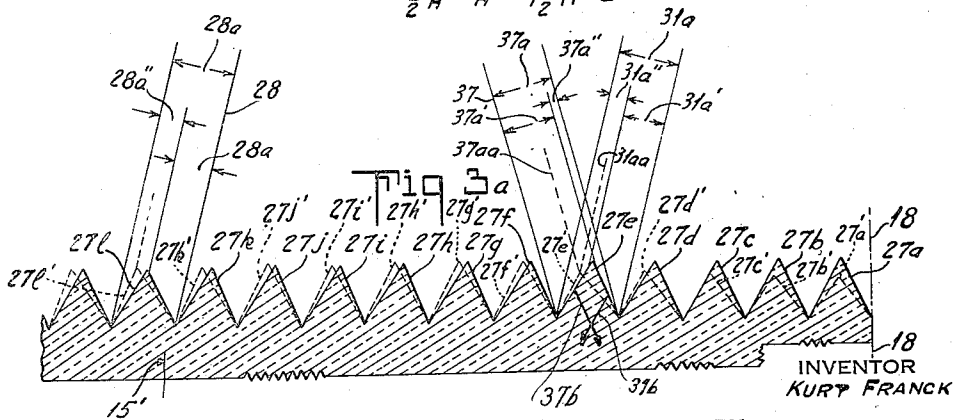
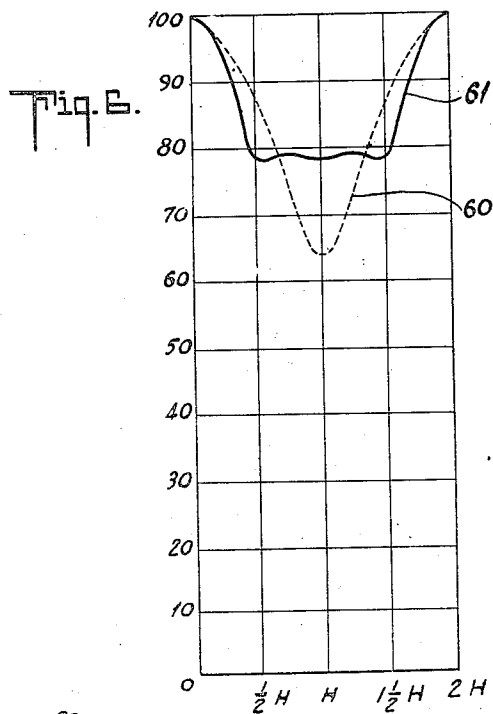
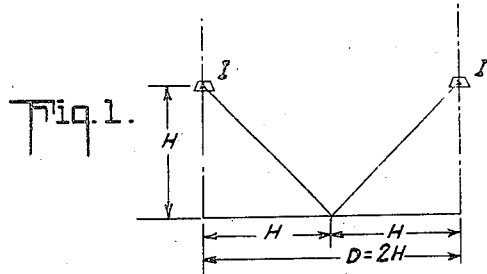
K. FRANCK

2,368,014

LUMINAIRE

Filed Feb. 10, 1943

3 Sheets-Sheet 1



INVENTOR
KURT FRANCK

BY
Joseph L. Schirmer
ATTORNEY

Jan. 23, 1945.

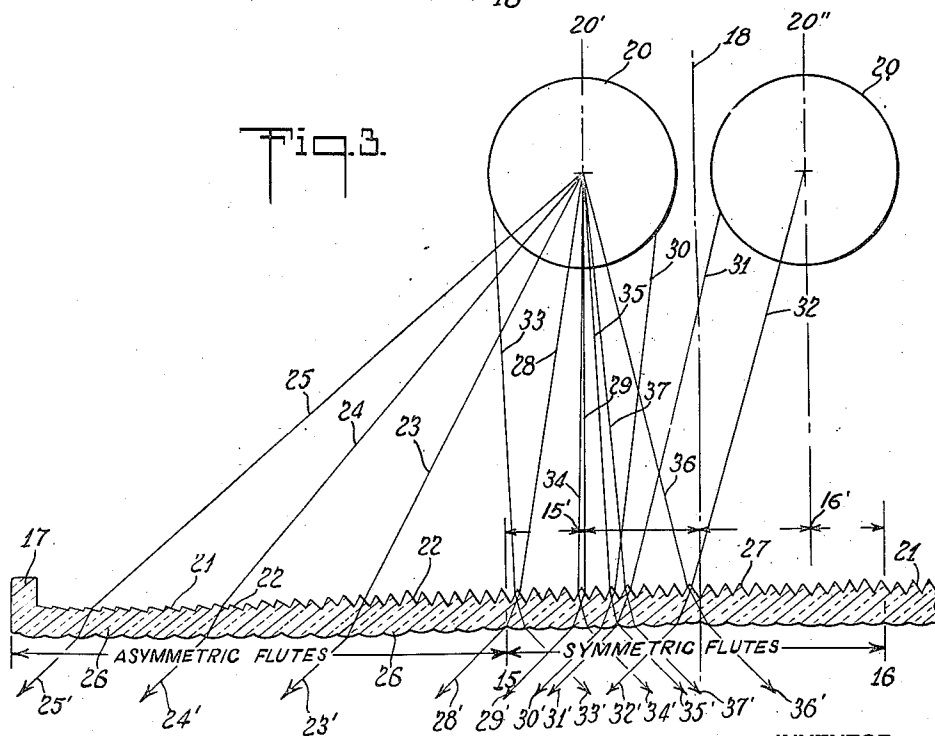
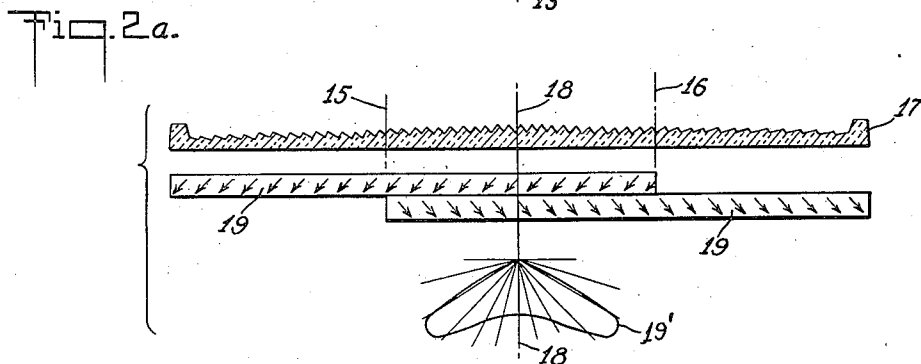
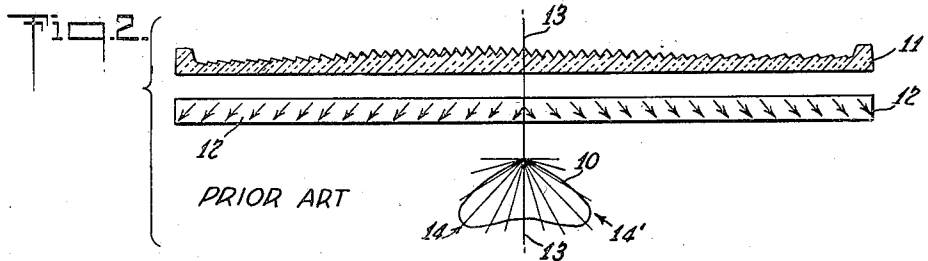
K. FRANCK

2,368,014

LUMINAIRE

Filed Feb. 10, 1943

3 Sheets-Sheet 2



INVENTOR

KURT FRANCK

BY

Isaac B. Liberman

ATTORNEY

Jan. 23, 1945.

K. FRANCK

2,368,014

LUMINAIRE

Filed Feb. 10, 1943

3 Sheets-Sheet 3

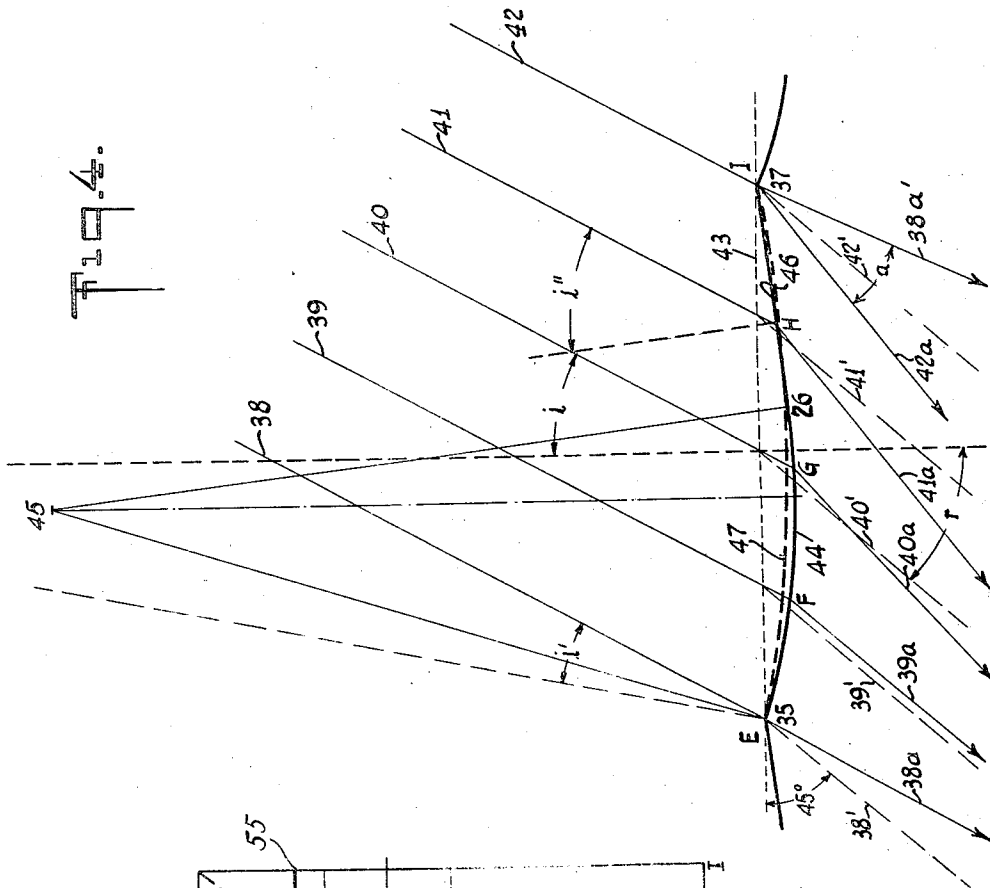
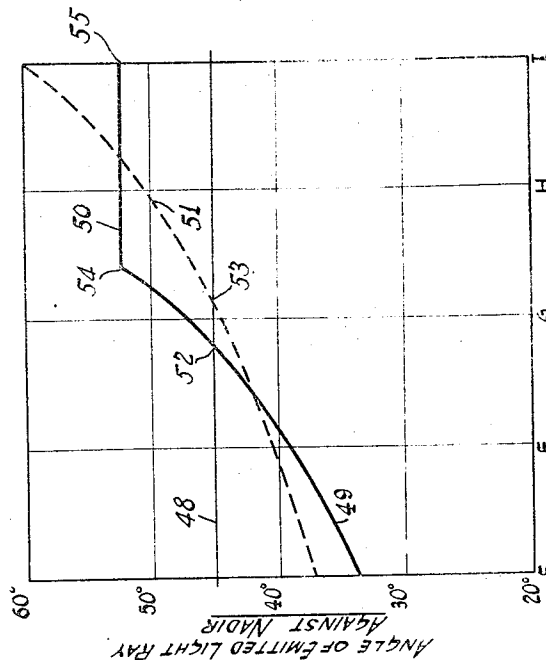


Fig. 5.



INVENTOR
KURT FRANCK
BY
Joel S. Liberman
ATTORNEY

UNITED STATES PATENT OFFICE

2,368,014

LUMINAIRE

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

Application February 10, 1943, Serial No. 475,362

3 Claims. (Cl. 240—106.1)

The present invention relates to luminaires and more particularly to luminaires of the type employing fluorescent light sources and designed to produce extensive light distribution.

The candlepower distribution designated usually as "extensive" allows spacing of the units at twice the mounting height to produce uniformity of horizontal illumination on the working plane. With the extended length of the fluorescent lamp it is, of course, only possible to produce a distribution of extensive character in the vertical plane at right angles to the axis of the lamp.

To obtain extensive distribution of light from fluorescent lamps by lens action direct light is caused to fall on a light spreading plate symmetrical about a median plane, and wherein the prism surfaces to one side of this plane spread all the light possible away from the nadir to build up intensities at higher angles, generally in the neighborhood of 45° . This divides the light so that except for the diffusion in the plate and for the scattered reflected light falling on the plate, there is nothing to contribute brightness on the portions of the surface of the plate remote from an observer stationed in a region toward which the dominant rays are directed. As a consequence the plate does not light up with complete uniformity over its entire surface. The half of the plate nearer the observer lights up very uniformly, but the remote half is not so well lighted and consequently comparatively dull.

To improve the appearance of the plate it has been provided with shallow symmetrical flutes which spread the rays each side of the direction into which the general prismatic action sends them. As this general direction is in the neighborhood of 45° of the nadir there is a tendency for these symmetric flutes to elevate some of the light too high, i. e., into regions 60° above the nadir causing it to get into the glare zone.

The present invention contemplates extensive lighting luminaires and light transmitting plates for use in the same, wherein the light is controlled in such a way as to obtain a material increase in the luminous area of the plates and a diminution of the high angle diffused light so that the light is kept out of the glare zone.

The present invention also contemplates obtaining either of these results singly.

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:

5 Figure 1 diagrammatically illustrates a typical extensive lighting installation with spacing of the luminaires twice the mounting height;

10 Figure 2 is a diagrammatic view illustrating a typical extensive lighting distribution and the brightness aspects of the plate of usual construction;

Figure 2a is a view similar to Figure 2 illustrating the approach to the ideal as provided for herein;

15 Figure 3 is a cross sectional view through the sources and lens plate showing light control;

20 Figure 3a shows at a greatly enlarged scale the light control of certain of the prismatic ribs and contrasts their contour with the prior art contour;

Figure 4 is a view at an enlarged scale illustrating diffusion obtained by flutes;

25 Figure 5 is a diagram illustrating the directional control at various points across the width of a flute; and

Figure 6 shows comparative curves of relative illumination results in a horizontal plane.

A typical installation of extensive lighting equipment is illustrated in Figure 1 where the mounting height H of the luminaires I is twice the spacing D , i. e., $D=2H$ and the angle between nadir and the rays falling midway between the luminaires is 45° . As this is the region hardest to light by reason of the greater distance ($1.41 \times H$) and the angle of incidence 45° , it is important to get as much light as possible in the region approximately 45° above nadir. Higher angled light tends to be wasted under remote fixtures and contributes to glare.

30 Where the light output is divided in the typical manner illustrated by the extensive distribution photometric curve 10 of Figure 2, by a simple prior art prismatic plate 11 whose prism outline is shown dotted in Figure 3a, each half of the plate is lighted up as illustrated by the short arrows in the rectangles 12, 12. All light going to the left of the center line 13 comes from the left half of the plate so that this half appears bright when observed in the direction of the arrow 14 at the usual viewing distance. For similar reasons the right half only appears bright when the plate is similarly observed from the right in the direction of the arrow 14'.

35 The present invention makes it possible to have, as illustrated in Figure 2a, a fairly wide middle

portion 15—16 of the plate 17 appear bright, whether viewed from the right or left of the centerline 18, 18, this being diagrammatically illustrated by the arrowed lines in small rectangles 19, 19, which overlap in the region 15—16. The distribution curve is shown at 19'. To facilitate comparison of values the curves 14' and 19' are at the same scale. In 19' there is an increase in candlepower in both beams. The reason for this increase in efficiency will be pointed out below.

In Figure 3 the plate 17 is assumed to be receiving the direct light from two fluorescent lamps 20, 20 whose centers are in planes 20'—20'' as indicated. The overall width of the combined sources is approximately equal to the width of the middle portion 15—16. Outside of points 15 and 16 the upper surface of the lens plate has regressed prisms 21 with active surfaces 22 which concentrate rays such as 23, 24, 25, and render them substantially parallel in the refracting medium at such angles that the emergent rays would be transmitted at an angle of approximately 45° from the nadir, provided the lower surface of the plate were smooth. Such dominant ray directions are indicated by the lines 23', 24' and 25'. The lower surface of the plate 17, opposed to prisms 21, is, however, provided with small flutes 26 which are preferably asymmetric as explained below.

The middle portion 15—16 of the plate is again divided into a central portion 15'—16' of a width substantially equal to the spacings 20'—20'' of the light source centers and portions 15'—15 and 16'—16 under the outer halves of the lamps and intermediate the central portion and the outer or marginal portions which are beyond 15 and 16, respectively. As shown in Figures 3 and 3a the plate has eight ridges or ribs 27a—27h, inclusive, in the left half of the central portion (18—15') and four ridges or ribs 27i—27l, inclusive, in the left intermediate portion 15—15'.

The surfaces of the ridges 27a—27h, inclusive, on the sides toward the plane 18—18 are active and have such slopes as to receive light, e. g., rays 29, 30, 31 and 32, originating in portions of lamps 20—20 between the planes 20'—20'', and refract these rays away from the axis 18—18 in such directions that the dominant transmitted rays 29', 30', 31' and 32' are in directions generally parallel with the rays 23', 24', 25'. The left faces of ridges 27a—27h, inclusive, are also active in diverting light rays such as 35, 36 and 37 toward the right for transmission into the right hand beam. Similar action takes place in the corresponding ridges to the right of center line 18—18.

The ridges 27i—27l, inclusive (between 15' and 15) have active surfaces on the side toward center line 18—18 which act on rays such as 28 from the nearer source and bend them away from the nadir for transmission as shown at 28', and also active surfaces acting on rays such as 34 and bending them to the right as shown at 34'.

Each ridge surface receives a bundle of sub-incidence i of ray 40 to the normal to such a substantially parallel rays from the source of a width equal to the apparent width of the ridge. For example, ridge 27e may be assumed to receive (as indicated in Figure 3a) a bundle of rays 31 of a width 31a and another bundle of rays 37 of a width 37a. Each bundle will be divided into definite proportions depending upon the location of the apex of the ridge. Portions such as 31a' and 37a' strike the respective left and right active surfaces and are refracted with the directions indicated by the arrows 31b and 37b, while portions

31a'' and 37a'' strike the left and right surfaces, respectively, which for such rays are substantially inactive. The ridge 27l receiving ray 28 divides the bundle of rays 28 of a width 28a as indicated at 28a' and 28a''.

The ridge outline (27a'—27l') of prior art plate 11 is shown in Figure 3a by dotted lines superposed on the outline of the new plate. In the prior art plate a considerably greater portion of the bundle 31a to the right of line 31aa impinges on the surface near the center line and is sent to the left, while a much smaller portion of the bundle 37a to the left of line 37aa is intercepted by the left surface of the ridge and transmitted through the plate. This left surface is in fact merely a riser to provide a connection from one active ridge surface to the next with proper mechanical strength. In the ridge outline in full lines the left surface instead of being a mere riser handles a considerable portion of the light and transmits it in a direction to build up the brightness of the plate. The action of the dotted prior art ridge (corresponding in position to 27l) in dividing a ray bundle such as 28a is also indicated. There the contribution of the riser surface was negligible.

It will thus be seen that at each side of the axis 18, 18 there is a substantial area of the plate wherein the ribs have supplemental action which contributes light in a direction so as to cross the axis, therefore this area of the plate will appear bright when viewed from a position on either side of the fixture. The lens plate therefore has a much larger projected area of uniform brightness. As more of the lens surface is lighted up to increase the projected area of high brightness, more luminous output is emitted in the directions under discussion. The resultant increase in efficiency is obtained because in the region 15—16 the two beams (in both directions) can be generated as efficiently as one beam in one direction.

In practice the distance between the center lines of the lamps may be varied within a considerable range, from that of the requirements of mechanical clearance to the width separations within the limitations imposed by considerations of efficiency of the entire light control system which decreases when the lamps are spaced too far apart. For practical ranges of distance, the principle discussed in Figure 3 is applicable.

Figure 4 illustrates asymmetric flutes 26 for altering the general contour which gives shape to a light transmitter. To analyze the operation of the flute, its width is divided into four equal parts and lines 38, 39, 40, 41 and 42 (to represent parallel rays originating on the right hand side of the flute) are drawn at angles to the general (horizontal) contour such that if the bottom of the plate were smooth, as indicated by the dotted line 43, the light would be refracted so as to be emitted at an angle of 45° with the nadir. The angle of incidence i of ray 40 to the normal to such a horizontal plane is such that the angle of refraction r of ray 40' would be 45° as indicated. Such refracted rays are indicated at 38', 39', 40', 41' and 42', respectively, and it is obvious that throughout the width of the plate surface being considered there would be no diffusion and all the light (except losses) would be emitted at 45° to the nadir.

Each flute 26 in Figure 4 is composed of a cylindrical portion at the left, or remote side, as indicated by the arc 44 struck about a center at 45 to the left of the middle of the flute, and a plane portion at the right, or near side, as indicated by the tangent line 46. In the drawings the rays

38—42, inclusive, are continued to the flute surface where it will be seen that the angle of incidence for the rays striking the convex surface diminishes from the value i near the point G to a smaller angle i' at point E, and the angle of incidence for the rays striking the plane surface is uniformly increased to i'' over the entire plane surface. The refracted rays are indicated by the lines 38a, 39a, 40a, 41a and 42a, respectively. The flutes 26 therefore introduce a diffusion as represented by the angle a between rays 42a and 38a', the light from the plane portion being at higher angles and the light from the convex portion being at lower angles than it would have come from the plane surface 43.

Figure 4 also shows by a dotted arc 47 the contour of the symmetric flute used in the central part of the plate of Figure 3, thereby indicating the departure in contour of the asymmetric flute from a symmetric flute.

Figure 5 shows graphically at the various reference points E, F, G, H, I, on the flat surface 43, the asymmetric flute 26 and the symmetric flute 47 the angle in degrees from the nadir at which the light is, or would be, emitted. The horizontal line 48 at 45° from the nadir indicates the absence of diffusion for the rays from the smooth plate. The curved line 49 shows that at point E the ray 38a is at an angle of about 33° to the nadir, and that the angle continuously changes along the convex portion of the flute 26 up to the point of tangency with the line 46, where the maximum departure from the nadir of about 52° is achieved. This angle is retained over the plane area of the asymmetric flute as indicated by the horizontal line 50. This provides a definite upper limit to the angle into which the light can be diffused. The dotted line 51 shows the diffusion from the comparison symmetric flute in which spread of light is between about 38° and 60° from the nadir. The more highly elevated light of the near edge of the symmetric flute is avoided by the asymmetric flute, and hence adequate diffusion may be had without building up plate brightness in the region adjacent 60° from nadir.

Further analysis of Figure 5 shows that the solid curve representing the emission of light from the asymmetric flute intersects the horizontal 45° line 48 at point 52. Reference point G divides the width of the flute in half. Thus the horizontal distance from E to 52 is less than half and the horizontal distance from 52 to I more than half. Accordingly, less light is diffused downward below 45° than upward above 45°. By scaling off Figure 5 the actual location of point 52, it can be shown that about 45% of the incident light is diffused downward and 55% upward; expressed differently this means that 20% more light is diffused upward than downward.

The ordinary symmetric flute does exactly the opposite. This is shown by point 53 at which the dashed curve, representing the emission from the symmetric flute, intersects the 45° line a little to the right of reference point G. This means that more light is diffused downward than upward.

The asymmetric flute as shown on Figure 4 might well be considered as a combination of a flute and a prism.

The curved part generated by a radius around center 45, constitutes the flute part and produces diffusion of the incident light. The straight line portion extending on Figures 4 from 26 to 37 acts as a prism, elevating the beam without diffusing it.

The result of this elevation is graphically shown on Figure 5 by the horizontal straight line portion of the emission curve of the asymmetric figuration as shown between points 54 and 55.

The fact that line 54—55 is horizontal indicates that no diffusion is produced; the fact that it lies at about 53° against nadir shows that the beam is elevated by about 8° above the 45° emission which would be obtained if no prismatic formation were provided on the outside surface of the lens.

Figure 6 illustrates the comparative output of the luminaires of Figures 2 and 2a when spaced twice the mounting height. The relative horizontal illuminations are given in percentage. With the earlier construction the illumination midway between the luminaires was about 64% of that immediately under them, as shown in the dotted line curve 60, while with the changed construction above described the corresponding curve 61 indicates approximately 80% of the maximum illumination over a wide area between the fixtures. A difference such as 35% in illumination appears spotty to the eye, while a 20% difference is not noticed.

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 direct lighting luminaire for producing an extensive light distribution with high output in regions approximately 45° above the nadir each side of a central median plane and having two adjacent horizontal fluorescent light sources of substantial width side by side, one on each side of said median plane, and a flat horizontal light transmitting plate substantially wider than the overall width of the two sources and disposed below the sources, the upper surface of the plate having a central portion of a width substantially equal to the spacing of the light source centers, and composed of longitudinally extending V-shaped ridges wherein both surfaces of each ridge are active and receive light from both light sources and are of such slopes as to refract it away from the nadir for transmission from the lower surface of the plate at substantially 45° angles above the nadir, the upper surface of the plate also having intermediate portions extending laterally of the central portion and composed of longitudinally extending V-shaped ridges wherein both surfaces of each ridge are active and receive light from the nearer source and are of such slopes as to refract it for transmission at substantially 45° angles above the nadir, the upper surface of the plate also having marginal portions provided with longitudinally extending regressed prisms of variant refracting power with active surfaces sloped in variant amounts for spreading away from the nadir light incident thereon from the adjacent source for transmission from the lower surface of the plate at a substantially 45° angle above the nadir and inactive riser surfaces receiving substantially no direct light from either source, whereby the area of brightness of the plate when viewed in either direction of the dominant light output extends over the corresponding marginal portion, the central portion, and both intermediate portions.

2. A luminaire such as claimed in claim 1, wherein the lower surface of the plate has sym-

metric light spreading flutes opposite the central and intermediate portions for symmetrically diffusing light and has asymmetric light spreading flutes opposite the marginal portions for strengthening the upward diffusion and limiting its angle from the nadir.

3. A direct lighting luminaire for producing an extensive light distribution with high output in regions approximately 45° above the nadir each side of a central median plane with controlled diffusion above and below said 45° angle and having two adjacent horizontal fluorescent light sources of substantial width side by side, one on each side of said median plane, and a flat horizontal light transmitting plate substantially wider than the overall width of the two sources and disposed below the sources, the upper surface of the plate having marginal portions provided with longitudinally extending regressed prisms of variant refracting power with active surfaces sloped in variant amounts for spreading away from nadir

light incident thereon from the adjacent source and rendering it parallel in the plate and at an angle to the normal to the horizontal plane corresponding with an angle of refraction of substantially 45° from said normal, the lower surface of the plate opposite said regressed prisms being composed of longitudinally extending flutes, each flute having a downwardly convex portion disposed in the more remote portion of the flute and intercepting the more remote rays of the bundle of rays received by the flute at diminished and varying angles of incidence whereby said remote rays are transmitted with corresponding lowering of the rays toward nadir, each flute also having a plane portion intercepting the nearer rays of the bundle of rays received by the flute at uniformly increased angles of incidence whereby said rays are transmitted with corresponding but limited raising of the rays above the 45° line above nadir.

KURT FRANCK.