

[54] **FLUORESCENT FIXTURE WITH OPTICAL DEVICE**

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[51] Int. Cl. .... **F21v 5/02, F21v 11/02, F21s 3/00**

[58] Field of Search ..... **240/106 R, 51.11 R, 9 R**

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Primary Examiner—Joseph F. Peters, Jr.

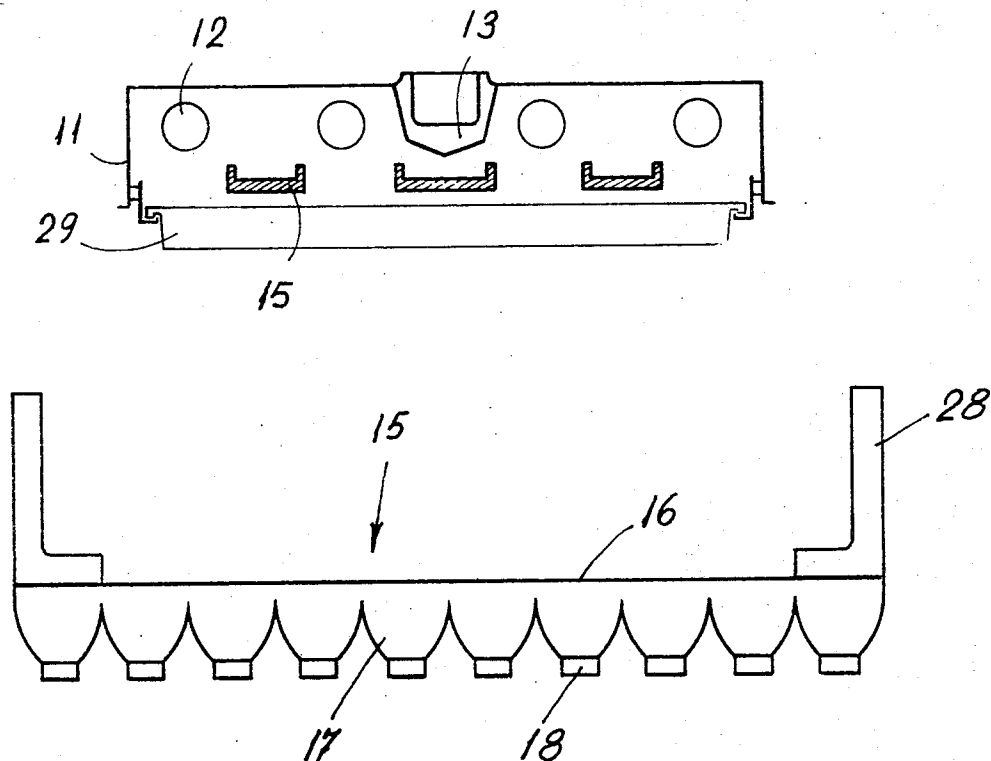
Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57]

**ABSTRACT**

Strips of transparent material, of a length and width approximately equal to those of a fluorescent tube, with an even and smooth face and the other face being provided with triangular longitudinal prisms the top edges of which are cut off and replaced by a rectangular prismatic portion with its free surface being opaque or opal, these strips being disposed parallel and spaced beneath the fluorescent tubes of a lighting apparatus. When the strips are arranged so that each one comes to be placed beneath each fluorescent tube with their prismatic face directed towards the tube they intercept the light rays whose direction is near to the vertical and are being diverted laterally giving a "batwing" illumination. When the strips are disposed beneath each space between each two fluorescent tubes of the apparatus with their prismatic face directed towards the outside they intercept the light rays whose inclination is great and divert them so that the light rays are approached to the vertical thus giving a low luminance illumination.

**21 Claims, 13 Drawing Figures**



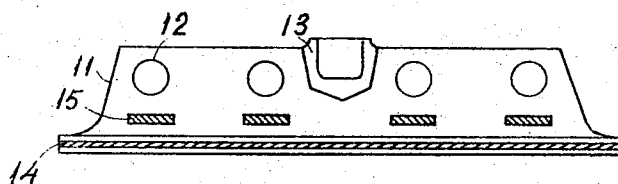


Fig. 1

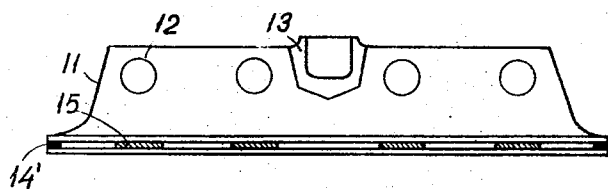


Fig. 2

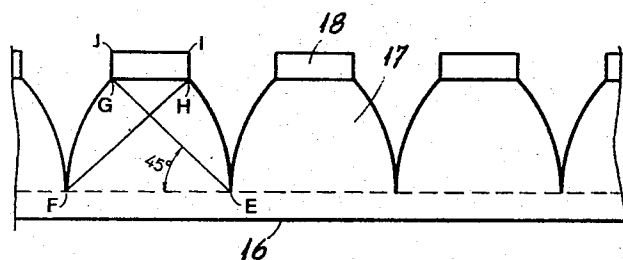


Fig. 3

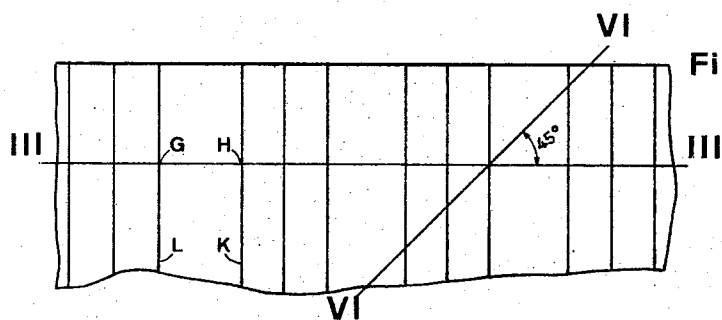


Fig. 4

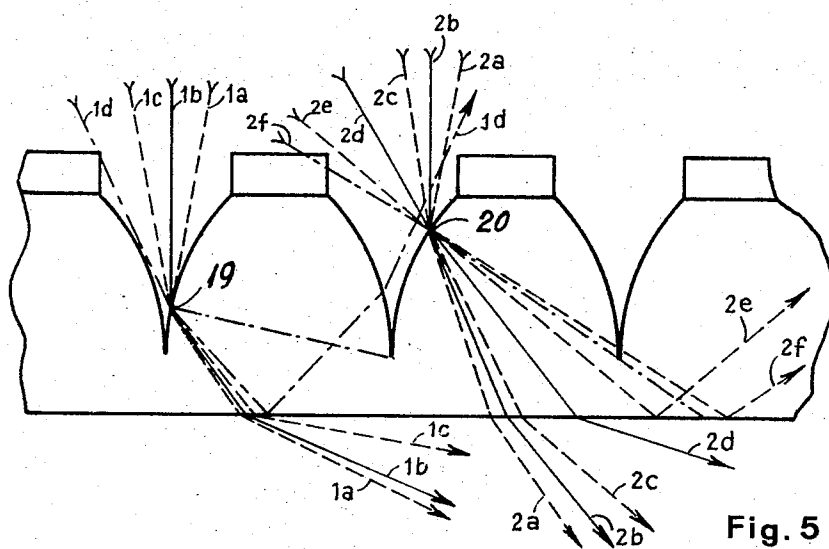


Fig. 5

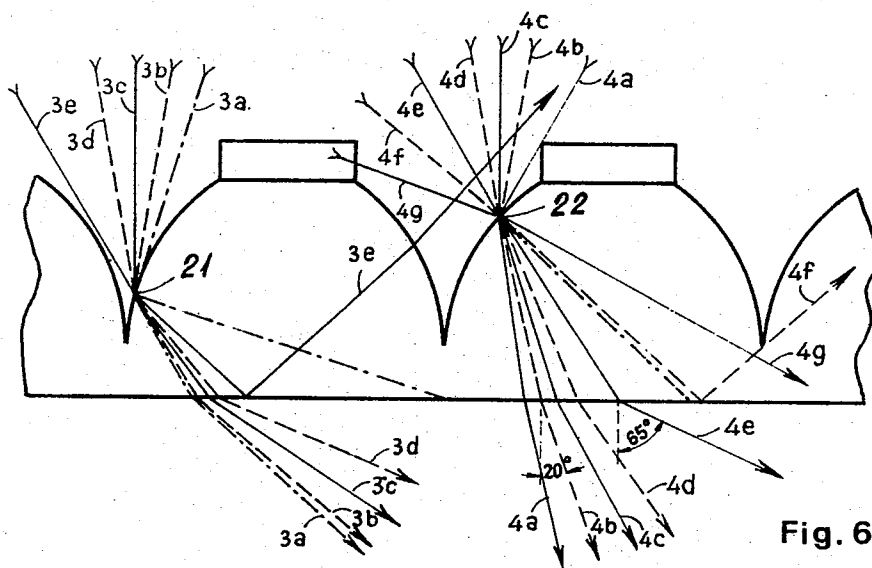


Fig. 6

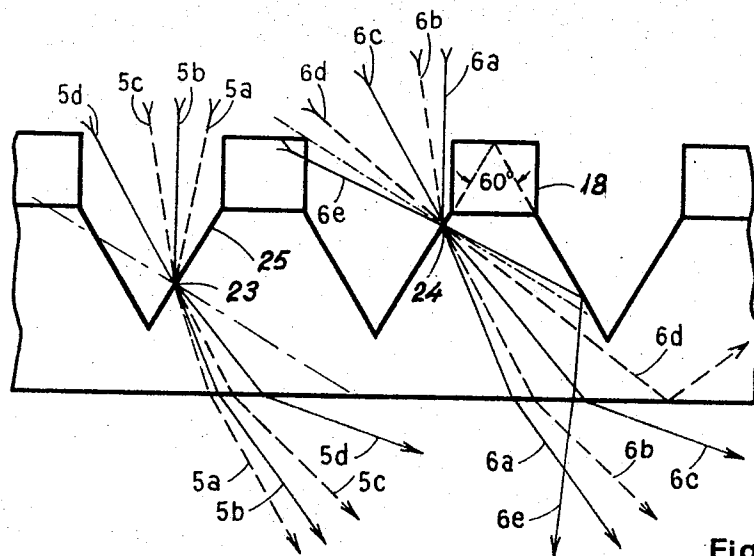


Fig. 7

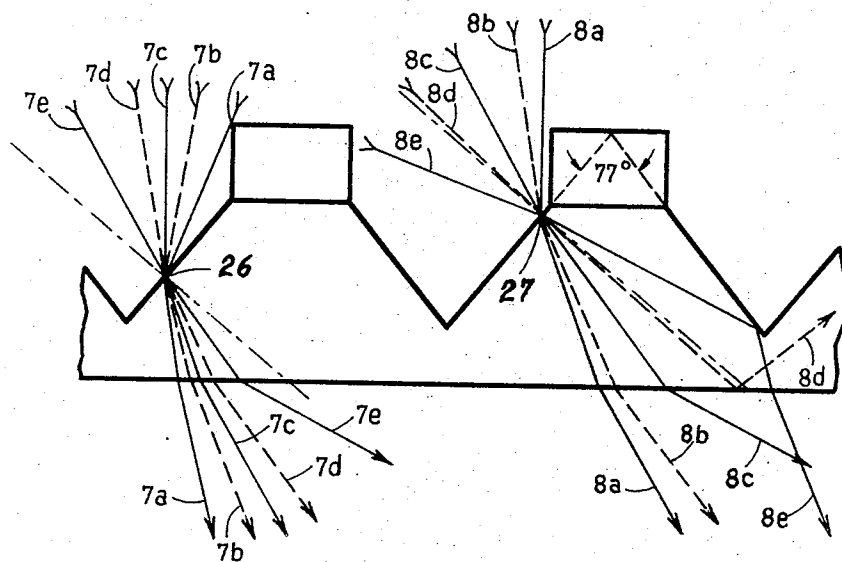


Fig. 8

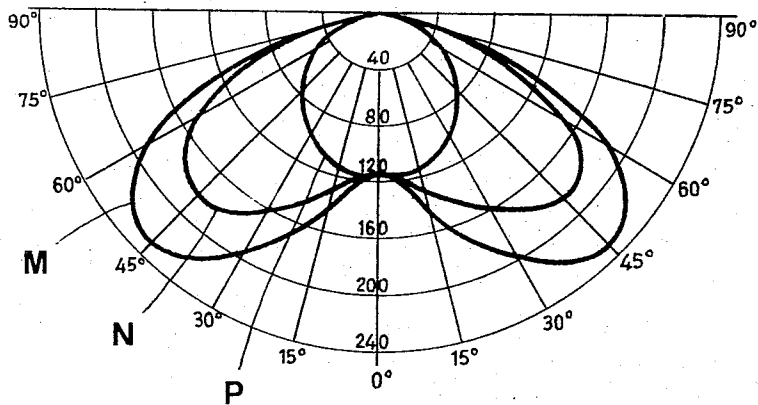


Fig. 9

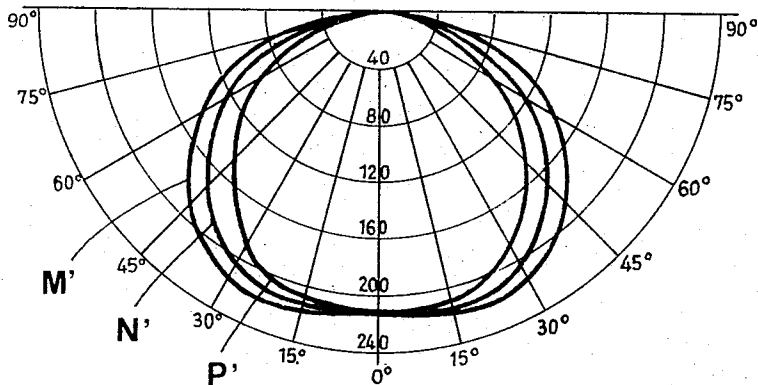


Fig. 10

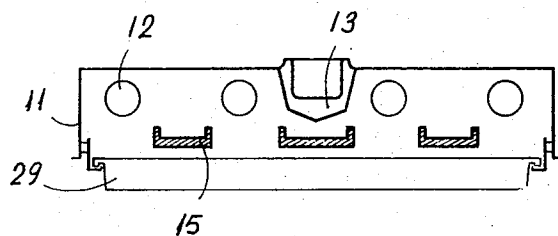


Fig. 11

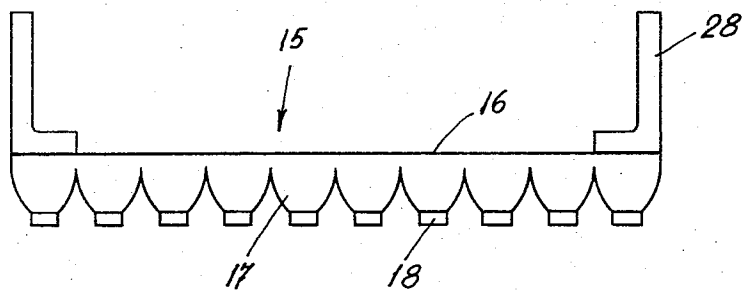


Fig. 12

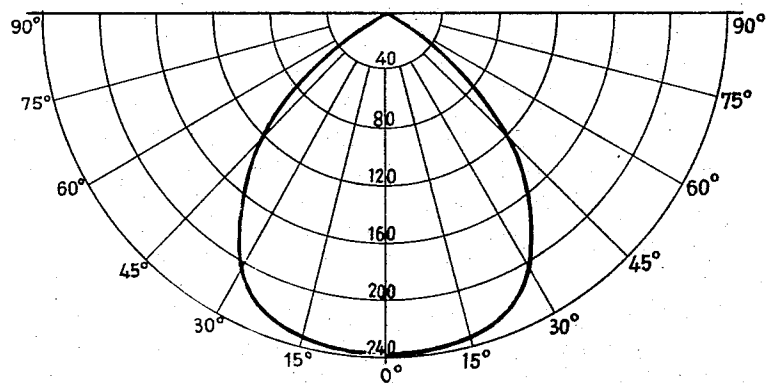


Fig. 13

## FLUORESCENT FIXTURE WITH OPTICAL DEVICE

The present invention deals with an optical device to improve the distribution of luminous flux in lighting apparatus fitted with fluorescent tubes.

At the present time great importance is given to the way in which light emitted by a luminous source is distributed.

Great importance is given to trying to achieve a distribution of light which fulfils two conditions which are practically opposed to each other.

One of these is the suppression of dazzle produced by reflexion from the surface illuminated. Because of this every effort is made to eliminate as far as possible those rays which strike the surface illuminated, in a direction either vertical or close to the vertical, in such a way as to obtain a distribution of the luminous flux defined by a curve which presents a minimum in its intersection with the vertical and a maximum in its intersection with a line forming an angle of about  $45^\circ$  with the vertical, this form of distribution of the luminous flux being called "batwing."

The other desired condition consists in achieving a minimum luminance, that is the disappearance of practically all of the luminous rays proceeding from the luminous source which form with the vertical, angles greater than  $60^\circ$  capable of producing dazzle at a certain distance from the light source.

In both cases it is important to obtain a good lumen output, that is, that the number of luminous rays striking the surface to be illuminated should be as high as possible.

While the batwing type of distribution of the luminous flux may be obtained without great difficulty using light source of the theoretically a point emission, that is, using bulbs, it is nevertheless a much more difficult achievement when the light source is an apparatus fitted with fluorescent tubes in which the emitted surface is somewhat long.

Several solutions have been proposed as giving batwing illumination with fluorescent tube apparatus, consisting in incorporating prismatic refracting panels of a special type in the apparatus, but these are difficult and costly to make and produce a considerable absorption of the useful luminous rays, therefore giving a low lumen output.

On the other hand to obtain low luminance illumination refracting prismatic screens or panels have been proposed, as well as grids formed by vertical lamellas which are fitted to the lower part of the reflecting frame or box holding the fluorescent tubes, but in general, while such prismatic screens give a good lumen output, their luminance is still excessive and the grids while having practically no luminance give a very low lumen output.

The present invention has as its object an optical device which can be applied to any type of lighting apparatus using fluorescent tubes, either of type comprising a box or frame which contains the fluorescent tubes or the type having one or two bare tubes, which has a high output, is simple and cheap to make and has the special advantage of lending itself to being used in two ways, one to obtain a batwing type of illumination, and to the other to obtain low luminance illumination, with excellent results in both cases.

The basis of the invention consists of a strip of transparent plastic material, of a length substantially equal to the length of the fluorescent tube, of a width equal to or greater than that of the tube, and of a relatively low thickness, which has one flat plain face and the other having a series of triangular longitudinal prisms, having contiguous bases situated on that side of the strip and which their free salient angles truncated thus presenting a trapezoidal section, such upper truncated salient angle being substituted by a portion in form of a low sized rectangular prism the larger face of which is of such a nature as to intercept all or at least part of the luminous rays which strike it.

While such prisms may have flat lateral faces such faces should preferably be made up of cylindrical surfaces, the prisms thus presenting a transversal section of truncated ogival form.

According to the invention, in a lighting apparatus of any type fitted with fluorescent tubes, a number of said strips are fitted beneath the fluorescent tubes and parallel to them at a variable distance, this distance being regulated according to the width of the strip in such a way as to produce the distribution of luminous flux desired.

These strips may be fitted, one beneath each tube and with the prismatic face towards the tube; in which case, a batwing distribution of the luminous flux is obtained, or, placed between the tubes and with the prismatic face towards the exterior of the apparatus, a low luminance distribution light being then obtained.

In the first case, the strips may be fitted to the lighting apparatus as the only light modifying element, or else, may be used in combination with any type of screen, or panel, that is, diffusing, refracting or grid type, the strips being fixed by the ends in any convenient way, even though the preferred form of application would be that the strips should be fixed by the ends in opposite elements of a frame of appropriate dimensions, to be fitted in the apparatus instead of the usual diffusing or refracting panel.

Such prismatic strips fitted beneath each one of the fluorescent tubes deflect the luminous flux which proceeding from the particular tube strike them, turning them away from the vertical or near vertical; but they do not produce any modification in the rays which pass through the space between each pair of strips, and such rays, as there are no tubes above these spaces, do not have directions close to the vertical. Thus a batwing type of distribution is obtained, as also high lumen output, as the proportion of luminous rays intercepted is very small.

If beneath the strips, subject of this invention, any of the usual types of panel is fitted, the effect of such panel will be added to that of the batwing effect, but in this case the output will be much reduced due to the loss suffered by the luminous flux on its passage through the panel.

When it is desired to obtain a low luminance illumination using this invention, the strips are fixed to the box of the apparatus by their ends, using any convenient method and in the inverted position previously indicated, it being then useful to fit walls of opal diffusing plastic facing upwards along the longitudinal edges of each strip, so as to intercept the luminous rays which might pass directly between the two strips with an excessive inclination, and to also fit some vertical trans-

versal lamellas along beneath the tubes to get rid of luminance longitudinal to the tubes.

The manufacture of the object of this invention is simple and cheap as it does not require expensive moulds but can be easily made by extrusion or else cut from plastic material.

With reference to the attached drawings,

FIG. 1 is a schematic view in transversal section of the whole of the lighting apparatus fitted with fluorescent tubes and a normal diffusing or refracting panel, to which the device of the invention has been fitted, so as to give a batwing type of illumination.

FIG. 2 is a view similar to FIG. 1 in which the device of the invention has been fitted instead of the usual panel.

FIG. 3 is a partial detail of one of the strips of the invention, in section according to the line III—III of FIG. 4.

FIG. 4 is a partial detail of said strip looking at its upper face.

FIG. 5 shows schematically, the path of the luminous rays which strike two points of the profile of the prisms of cylindrical lateral faces of a strip of the device, this profile being that corresponding to a transversal section of the strip according to the line III—III of FIG. 4.

FIG. 6 is a view similar to FIG. 5 in which the profile of the prisms corresponds to a section according to a line VI—VI of FIG. 4 which forms an angle of 45° with the line III—III.

FIGS. 7 and 8 are schematic views equivalent respectively to those of FIGS. 5 and 6 but corresponding to a variant in the invention in which the lateral faces of the prisms are flat.

FIG. 9 is a diagram showing the batwing type luminous flux distribution curves of a fluorescent tube lighting apparatus, fitted only with the device of the invention.

FIG. 10 is a diagram of the curves of distribution of light emitted by a conventional lighting apparatus using fluorescent tubes, that is, devoid of the strips of the invention and without any other type of screen or panel.

FIG. 11 is a similar view of that of FIGS. 1 and 2, of a lighting apparatus to which has been fitted the device of the invention so as to obtain a low luminance illumination.

FIG. 12 is a detail of one of the strips of FIG. 11 in transversal section.

FIG. 13 is a diagram of the curves of low luminance type distribution of light obtained by employing the device of the invention according to FIG. 11.

The device of the invention is designed to be fitted to a lighting apparatus with fluorescent tubes of whatever normal type, such as those represented schematically in FIGS. 1 and 2 which comprise a box or frame 11, in which a certain number of fluorescent tubes are fitted 12, as well as the ballast and other auxiliary elements represented by 13, said device consisting of transparent plastic elements in the form of strips, indicated by 15 in FIGS. 1 and 2, which have a longitude substantially equal to that of the tubes 12, and a width equal to or greater than that of the tubes 12, one of these strips 15, being fitted beneath and parallel to each one of the fluorescent tubes 12 of the apparatus, so as to obtain a batwing type of illumination.

The box 11 of the apparatus may have the mouth completely open, or, as in the example of FIG. 1, closed by a panel 14, of any normal type, such as plastic diffus-

ing, fitted with refracting prisms, or a grid made up of vertical lamellas, in this case, the strips of the invention being placed between the fluorescent tubes and the mouth of the box, the strips being fixed by the ends to the walls of this box by any convenient method.

Preferably, as in the example in FIG. 2, the strips 15 are fixed by their ends to opposite elements of a frame 14', (whether closed or not) which is fitted in the mouth of the box 11, of the lighting apparatus in substitution of panel 14 of FIG. 1, which permits the fitting of strips of the invention to lighting apparatus already in use, without the need to carry out any modifications or adaptations of such apparatus.

In any case, the distance of the strips from the fluorescent tubes is regulated taking into consideration the width of the strips, in such a way as to obtain the desired curve of distribution of the light.

According to a preferred embodiment, as represented in FIGS. 3 and 4, these strips have a face 16, flat and plain, and the opposite face has a series of triangular longitudinal prisms 17, having their bases contiguous, the lateral faces of which are cylindrical and which their free salient angle truncated and substituted by a rectangular prismatic portion 18, of the same or other material, in such a way that the said prisms have a transversal section truncated ogival form finished in a rectangle in which the sides FG and HE are arcs of circumferences of equal radii EG and FH, the centers of which F and E are situated on the base at a distance between each other FE equal to or greater than the radius EG, FH, of the sides, which cover angles of 45°, these strips 15 being fitted in the apparatus with the prisms 17 directed towards the respective tubes 12, that is in the upper position.

The cited upper prismatic portion 18, the transversal section of which is defined by the rectangle GHIJ, can be, as has been said of the same material as the rest of the prism 17, thus forming one whole piece, the upper face JI having a coating of for example paint, or being rough finished, thus intercepting all or at least part of the luminous rays striking said face.

However, the said prismatic rectangular portion is preferably made up of a layer of translucent opal plastic material, or opaque, of a thickness HI of about 1 mm. fixed to the face GHLK of the truncated prism.

The width GH of said rectangular prismatic portion 18, in relation to the base FE of the prism, will be

$$GH = FE(2 \cos 45^\circ - 1) = 0.414 FE$$

that is, that the total intercepting surface for the luminous rays, formed by the sum of the prismatic rectangular portions, will be less than 50 percent of the total surface of the strip 15.

FIG. 5 shows the path of the luminous rays proceeding from the fluorescent tubes 12 and the reflecting walls of the box 11, which in the form of a radiation strike at any two points 19 and 20 of the lateral face FG of the prisms. As can be seen the rays 1a, 1b, 1c, which strike at point 19 are refracted, emerging through the lower flat face 16, of the strip, deflecting from the vertical, while ray 1d due to its inclination, suffers total internal reflection in the lower face of the strip deflecting towards the interior of box 11.

At point 20, the rays 2a, 2b, 2c, 2d, are refracted also emerging through the lower face of the strip, deflecting from the vertical while the rays 2e, 2f, undergo total internal reflection at the lower face of the strip, deflect-

ing towards the interior of the box 11, and they will only turn towards the lower part when the prism in which they act constitutes that situated at an extreme of the strip of prisms, that is, when, there is no other contiguous prism which intercepts the path of these rays, as happens in FIG. 5.

It is obvious therefore, that the rays which pass through the prisms are deflected from the vertical while those rays, which strike the upper rectangular portion, which could emerge in directions close to the vertical or even vertical are intercepted or diffused by that portion, which makes it evident that by means of the device of the invention a batwing type distribution of light is obtained.

FIG. 6 similarly shows the path of luminous rays situated in a plane which forms an angle of  $45^\circ$  with the plane of the FIG. 5, indicated by the lines VI—VI of FIG. 4, in this case, the sides of the section of the prisms being arcs of ellipse in which minor axis is FE and the major axis is  $FE: \cos 45^\circ = 1,42 FE$ .

As we can see the luminous rays 3a, 3b, 3c, 3d, which strike at point 21 are refracted emerging through the lower face of the strip 15, while ray 3e is totally reflected and deflects towards the interior of the box. At point 22 the rays 4a, 4b, 4c, 4d, 4e, are also refracted emerging through lower face of the strip and the ray 4f undergoes total internal reflection, while the ray 4g can only emerge through the lower part when the prism which corresponds to point 22 is situated at one extreme of the strip 15, that is, when there is no other contiguous prism which might produce total internal reflection of the ray. It should be observed also, that the ray 4a, because it is almost tangential to the surface of the prism at point 22 is in part refracted and in part reflected, which means that the ray 4a, which emerges almost at a vertical angle, losses part of its intensity, that is, to say, that a batwing distribution will also be obtained in this case.

If the prisms are made with their lateral faces flat, so that they form with each other an angle of  $60^\circ$ , a batwing distribution will also be obtained but less perfect than that obtained with prisms of cylindrical lateral faces, since as can be seen in FIGS. 7 and 8, which are equivalents of FIGS. 5 and 6 there will be produced a certain proportion of rays which emerge in directions close to the vertical. Thus, the rays 5a, 5b, 5c, and 5d, which strike at point 23 will emerge with a divergence from the vertical, the same as at point 24 the rays 6a, 6b, and 6c but the ray 6e will be refracted emerging in a direction close to the vertical. Thus it is necessary for the layer of opal or opaque plastic 18, to have a height approximately double that of FIG. 4, so that portion 25 of the straight profile of the prism which receives the useful luminous rays which are refracted would be shorter thus reducing the proportion of rays, which like 6e, would emerge in a direction close to the vertical.

The same occurs in FIG. 8 with the rays situated in a plane which forms an angle of  $45^\circ$  with the plane of FIG. 7, in which the rays 7a, of the point 26 and 8e of the point 27 also emerge in directions close to the vertical. On the other hand if the angle at the vertex or formed by the flat faces of the prism, were greater than  $60^\circ$  this would also increase the proportion of rays emerging in directions close to the vertical.

The diagram of FIG. 9 shows the curves of distribution of light, measured in candelas and referred to 1,000 lumens, experimentally obtained using a fluo-

cent tube lighting apparatus, without screen nor panel, and to which the device of the invention has been fitted, and in which the rectangular prismatic portions 18 of the prisms of cylindrical lateral face 17, were of opal plastic material and for purposes of comparison in the diagram of FIG. 10 are similarly shown the curves of distribution of light obtained using the same lighting apparatus, but without the device of the invention or other panel of any type.

In the mentioned diagrams the curves M and M' have been obtained on a plane normal to the axes of the fluorescent tubes 12, the curves N and N' are those obtained in a plane which forms an angle of  $45^\circ$  with the direction of the axes of the tubes 12, and the curves P and P' have been obtained in a plane parallel to the axes of the tubes 12, it being evident that the curves M and N of FIG. 9 are of the batwing type and that in those, the maximum is situated in a direction which forms an angle of about  $45^\circ$  with the vertical, which is essentially the form of the curves of distribution of light corresponding to the batwing type.

As has been said before the invention can also be used to obtain low luminance illumination with excellent output. To achieve this, all that is necessary is to invert the position of the strips 15, that is, place them with their prismatic faces 17, directed towards the outside of the apparatus and with the flat plain face 16 directed towards the fluorescent tubes and fitted to the box 11 of the lighting apparatus parallel to the tubes 12 and beneath these, but, the reverse of the previous case, coinciding with the free spaces between each of the tubes 12 as represented schematically in FIG. 11.

With this layout, the luminous rays emitted by the tubes 12 in vertical or near vertical directions, will pass directly without deflection through the spaces between the strips 15, while the rays which emerge from the tubes at more inclined angles will strike the contiguous strips 15 and will be refracted through these to emerge in directions close to the vertical, therefore, following a path which can be represented by the FIG. 5 in an inverted position.

As can be seen, in this way maximum illumination is obtained in a vertical direction while those rays which emerge with angles greater than  $60^\circ$  with respect to the vertical, are eliminated.

As a proof I obtained the curve of distribution of the light of an apparatus as in FIG. 11 in a plane transversal to the direction of the fluorescent tubes 12 thus producing the curve represented in the diagram in FIG. 13, which has also been measured in candelas and based on 1,000 lumens, and from which we can see that there is no luminance over  $60^\circ$  and in which at  $0^\circ$  output is practically 100 percent.

However, it is useful to fit strips or walls 28 along the longitudinal edges of these strips 15 and directed upwards so as to intercept those luminous rays of high inclination which proceeding from one of the lateral tubes 12 might pass through the space between the strip contiguous to this tube and the following strip.

It is also preferable to fit a series of vertical opaque lamellas 29 beneath the tubes 15 for example at the mouth of the box 11 of the apparatus, and in a direction transverse to that of the tubes, the object being to impede the passage of those rays having an inclination greater than  $60^\circ$  and which have directions parallel and close to parallel to the fluorescent tubes.

What is claimed is:

1. An optical device to improve the distribution of luminous flux in lighting apparatus fitted with at least one fluorescent tube which consists of an elongated element in the form of a strip made of transparent material, the length of such elongated element being substantially equal to the length of a fluorescent tube and its width equal to or greater than the width of a fluorescent tube, one of the larger faces of such elongated element having a flat plain surface and the other face a plurality of longitudinally placed triangular prisms, the bases of such triangular prisms situated close together on said face of the strip and the free salient angles of such triangular prisms being truncated in a plane parallel to the base, each angle being substituted by a prismatic portion of rectangular transversal section of small height, the larger free face of the rectangular prismatic portions having a surface capable of intercepting the luminous rays which strike it, such strip element being placed beneath and parallel to the tube or tubes of the lighting apparatus.

2. An optical device to obtain a batwing type of illumination using a lighting apparatus consisting of a box containing a plurality of equal and parallel fluorescent tubes, such device consisting of a number of elongated elements of transparent material, each elongated element being substantially equal to the length of the fluorescent tubes of the lighting apparatus and a width equal to or greater than the width of said fluorescent tubes said elongated elements being situated in the same plane, parallel and evenly spaced from each other, and each one beneath one tube and parallel to it, the larger face of each of these elements facing towards the fluorescent tubes having a plurality of longitudinal triangular prisms with their bases contiguous and having the free salient angles truncated and substituted by a prismatic portion of rectangular cross section and low height, the larger free face of such rectangular prismatic portions having a surface capable of intercepting the luminous rays which strike them, while the other face of such elongated elements which faces towards the exterior of the lighting apparatus has a flat plain face.

3. An optical device according to claim 2 in which the elongated elements in the form of strips are supported at the ends in opposite walls of the box of the lighting apparatus.

4. An optical device according to claim 3 in which the elongated elements in the form of strips are fitted between the fluorescent tubes and a conventional panel which closes the mouth of the apparatus.

5. An optical device according to claim 2 in which the elongated elements in the form of strips are fixed by the ends to opposite elements of a frame mounted in the mouth of a lighting apparatus instead of a conventional panel.

6. An optical device according to claim 2 in which the lateral faces of the prisms of the elements are flat.

7. An optical device according to claim 6 in which the flat lateral faces of the prisms of the elongated elements form with one another angles of about  $60^\circ$ .

8. An optical device according to claim 2 in which the lateral faces of the prisms of the elongated elements consist of two cylindrical surfaces of equal radius, the separation between the axes of the cylindrical surfaces of both faces are equal to the radius of said cylindrical surfaces.

9. An optical device according to claim 8 in which the cylindrical surfaces of the lateral faces of the prisms of the elongated elements cover an angle of about  $45^\circ$ .

10. An optical device according to claim 2 in which the rectangular prismatic portions which substitute the truncated salient angle of said elongated elements consist of loose pieces superimposed and fixed to said truncated prisms.

11. An optical device according to claim 10 in which rectangular prismatic portions superimposed on the truncated prism of the elongated elements are made of opaque plastic material of reflecting surface.

12. An optical device according to claim 10 in which the rectangular prismatic portions superimposed on the truncated prisms of the elongated elements are made of opal plastic material of light diffusing characteristics.

13. An optical device to obtain a low luminance type of illumination in a lighting apparatus comprising a box containing a plurality of equal and parallel fluorescent tubes, such device consisting of a plurality of elongated elements in the form of strip of transparent material each one of such elements being of a length substantially equal to that of the fluorescent tubes and of a width equal to or greater than the width of such tubes, these elongated elements being situated in the same plane, parallel and equally spaced from one another, and each one beneath the free space between each two adjacent fluorescent tubes, and parallel to them, the larger face of these elements which faces towards the interior of the box of the lighting apparatus being flat and plain, while the other face of the elongated elements which faces towards the exterior of the box of the lighting apparatus is fitted with a plurality of longitudinal triangular prisms having their bases contiguous and having their free salient angles truncated and substituted by a superimposed prismatic portions of rectangular section and low height, made of a material which intercepts the passage through them of luminous rays.

14. An optical device according to claim 13 in which said elements in the form of strips have along the length of their longitudinal edges walls of a luminous rays intercepting material which project perpendicularly from the flat plain face.

15. A device according to claim 13 in which said elements in the form of strips are fitted between the fluorescent tubes and a series of vertical lamellas parallel to each other and perpendicular to the longitudinal direction of the fluorescent tubes.

16. An optical device according to claim 13 in which the lateral faces of the prisms of the elongated elements are flat.

17. An optical device according to claim 16 in which the flat lateral faces of the prisms of the elongated elements form with each other an angle of about  $60^\circ$ .

18. An optical device according to claim 13 in which the lateral faces of the prisms of the elongated elements consist of two cylindrical surfaces of equal radius, the separation between the axes of the cylindrical surfaces of both faces being equal to the radius of said cylindrical surfaces.

19. An optical device according to claim 18 in which the cylindrical surfaces of the lateral faces of prisms of the elongated elements cover an angle of about  $45^\circ$ .

20. An optical device according to claim 13 in which the rectangular prismatic portions superimposed on the

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truncated prisms of the elongated elements are made of an opaque plastic material of reflecting surface.  
21. An optical device according to claim 13 in which the rectangular prismatic portions superimposed on the

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truncated prisms of the elongated elements are made of an opal plastic material of light diffusing characteristics.

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