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## (54) REFLECTING GRID FOR FLUORESCENT LAMPS

(71) I, POUL WILLUMSEN, a Danish Citizen, of Mortonsvej 11, 2800 Longby, Denmark, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The prior art discloses a fluorescent lamp unit for use in a frame, comprising one or more light sources and a plurality of self-supporting reflector elements or grids. Such grids may have a directional effect as is known from the so-called low luminance grids which direct a controlled luminous flux down towards a region of limited illumination, or they may be formed as shielding grids producing a diffuse room illumination. In the so-called low luminance grids all the vertical faces of the grid are formed as parabolic arches whereby the grid prevents the light source from being viewed directly, and from the side the grid has a dull greyish appearance. These low luminance grids transmit a controlled luminous flux, i.e. they illuminate only a limited space. The known shielding grids, which consist of a plurality of plane parallel vertical faces at right angles to one another, emit a diffuse luminous flux illuminating a room, but in this grid it is possible to see the light source itself from certain angles.

It is the object of the present invention to provide a grid having properties deriving both from a low luminance grid and a shielding grid. By means of the grid according to the invention there is achieved a controlled luminous flux directed against a primarily illuminated object as well as room illumination. A lamp provided with such a grid is capable of providing a bright illumination of objects below the lamp and at the same time has an accurately adjusted luminous power extending in all directions from which the lamp unit is normally viewed, so that on the one hand there is no possibility of people being dazzled by the lamp and on the other hand the lamp produces such a lighting

effect that it appears to be an architecturally integrated part of the room in which it is located because one has a clear impression of from where the light originates. A grid of this type is suitable as both ceiling and wall illumination unlike the heretofore known fluorescent lamp units.

According to the present invention there is provided a grid for fluorescent lamp units for ceiling or wall illumination wherein the grid comprises a system of open-ended tubular elements arranged in a regular pattern each of which has both an external convex reflecting face or faces and an internal concave reflecting face or faces each of the tubular elements having a smaller cross-sectional area at that end which in use would face said light source than at the end which in use would face away from said light source and being so constructed that its cross-sectional area never decreases in a direction which in use would extend away from the light source.

According to an aspect of the present invention there is provided a grid for fluorescent lamp units for ceiling or wall illumination, wherein the grid comprises a system of open-ended tubular elements arranged in a regular pattern each of which has both an external convex reflecting face or faces and an internal concave reflecting face or faces, each of said faces being of single or double curvature and each having a generant curve whose radius of curvature is constant or increases in a direction which in use would extend away from a light source, and in that the end of said tubular element which in use would face said light source has a smaller inner cross-sectional area than the end which in use would face away from said light source, and wherein said grid is constructed so that in use the incident luminous flux will be transmitted both through and in between said tubular elements. It is achieved by such a grid that the luminous flux from the light source will partly pass through the tubular elements, being directed down towards the object it is desired primarily to

illuminate as a controlled luminous flux, and secondly that a certain percentage of the luminous flux will pass the grid outside the tubular elements through the spaces there-between, where the luminous flux will be reflected against the external convex faces and leave by the space openings farthest away from the light source as a diffuse luminous flux. Viewed from the side, the grid will give the impression of a number of dark regions deriving from the tubular elements which do not reflect any light to the sides, and a number of luminous faces deriving from the luminous flux diffused reflected from the external faces.

The grid may be further distinguished by the individual tubular elements being bodies of revolution whose generant curves are substantially parabolic segments, and in that the generant curve of the external convex face conforms to the generant curve of the internal concave face, and particularly by the element being a body of revolution whose rotary axis forms a given angle to the main axis of a curve of the shape  $y = p \cdot x^n$ , of which the generant curve forms part. Preferably the curve, of which the generant curve of the body of revolution is part, is a second degree parabola. This has the advantage that the luminous flux through the elements may be directed in a safe controlled manner, as it is possible to calculate mathematically or by trial and error the luminous flux through the elements.

It is yet another preferred feature of the grid that the focal point of the generant curve is disposed at or adjacent the edge of the body of revolution closest to the light source. This ensures a safe guidance of the luminous flux through the body. Furthermore, given that the edge of the body farthest away from the light source is determined relative to the geometric height of the body by light rays originating from the edge closest to the light source and having a given angle to the axis of the body, these rays will precisely cut off the parabolic arches at their points farthest away from the light source in the case of a parabola of the second degree. This has the advantage that the entire luminous flux which enters through the opening closest to the light source will flow out as controlled light through the opening farthest away from the light source within a desired solid angle.

A second embodiment of the grid according to the invention is distinguished by the cross section of each of the individual tubular elements being formed as a planar polygon with straight sides or being a planar polygon having two or more curved sides, and in that the convex and concave faces of the elements have generant curves which are elliptical, hyperbolic or parabolic segments. Preferably the generant curves of the faces of the elements are second degree parabolas. By varying

in this manner the form of the individual elements it is possible to vary the volume of controlled luminous flux in relation to the volume of diffuse luminous flux emitted from the face of the grid farthest away from the light source.

Said second embodiment is further characterized in that a focal line or focal point of a face is substantially at the edge of the element closest to the light source and opposite the respective face. This ensures positive guidance of the luminous flux from the light source into the element.

The grid according to said second embodiment is further distinguished by the edge of each element farthest away from the light source being determined relative to the geometric height of the element by light rays originating from the edge closest to the light source and having an inclination of a given angle such as  $45^\circ$  to the axis, which rays intersect the element at the farthest edge. This means that the entire luminous flux entering the element will flow out as controlled luminous flux from the face of the grid farthest away from the light source.

The aforesaid grids may be further distinguished by the individual elements being moulded, bonded or otherwise mounted with respect to each other so as to form a connected whole of a given design, as determined by the desired light effect. The amount of controlled light relative to the size of the elements might be adjusted in relation to the amount of passing diffuse light as the area of the spaces between the individual elements may be adapted to desired conditions or results.

The grid may be further characterized in that the individual elements are interconnected in a regular pattern such that their geometric centres viewed from the light source and also from the opposite side of the grid towards the light source will form a plane polygonal pattern or a pattern in the form of a plane polygon having two or more curved sides. This ensures that the grid will have a design giving it an attractive appearance both when the illumination is on or when it is off which is essential for marketing purposes.

The grid may be further distinguished by the individual elements being moulded together or otherwise mounted, in and interconnected by, a shielding grid known *per se* having the walls in plane parallel relationship and disposed at right angles to one another. This feature makes it possible to control the ratio of the passing controlled luminous flux to the passing diffuse luminous flux.

The latter configuration is furthermore distinguished by each individual element being inserted so as to have its rotary axis coincide with an X-portion removed from the shielding grid, or by the individual elements being

so inserted as to have their rotary axes coincide with the intersecting lines of the horizontal diagonals of the individual openings of the shielding grid. One achieves thereby a simple geometric pattern which is easy to make. It is also an essential feature of the grid that the shielding grid is of lower height than the individual elements. This ensures that the shielding grid will not prevent any portion of the luminous flux from reaching the openings of the elements closest to the light source, and it also ensures that the highest possible percentage of the luminous flux from the light source will reach the shielding grid, and it has further been possible to reduce the number of reflections prior to the diffuse luminous flux leaving the face of the grid farthest away from the light source.

The grid may also be distinguished by being made from a material capable of being formed into sheets, for example plastics. The material also may be glass or metal although this is not expedient as it will add too much weight to the grid. The use of plastics permits the grid to be made by a simple operation such as moulding.

Furthermore, the grid may be distinguished by having the reflecting faces being made by metallizing the surface of the material or consisting of a layer which is inherently reflective on both faces. The layer may be coated with a transparent material on one or both of its faces. It is recommended in the preferred embodiment to metallize the surface of the material as this involves the least luminous loss.

It is another preferred feature of the grid that colouring matter may be added to the reflective material of certain reflecting faces, such as all faces except the internal sides of the elements. This ensures that the controlled luminous flux transmitted from the light source through the elements towards the primarily illuminated object will be as high as possible, whereas the toning obtained by adding a colouring matter will dim the diffuse luminous flux a little such that the diffuse luminous flux will not be felt as a cold reflected light but rather as a warm and pleasant room illumination.

The grid may also be distinguished by a configuration which permits the transmitted light to spread as a controlled luminous flux, like that obtained from low luminance grids known per se, i.e. grids where the lateral faces are substantially parabolic faces, and also to spread as a diffuse luminous flux like the distribution of luminous flux obtained from shielding grids known per se, i.e. grids where the lateral faces are substantially plane parallel faces, and by having a light distribution curve basically as shown in Figure 11 and further described below.

Finally, the grid is preferably distinguished by a light distribution curve in a polar co-

ordinate system in symmetry about the 0° axis, extending as a closed curve below the 90° axis and with the latter as a horizontal tangent, and being otherwise a substantially pear-shaped curve having a marked indentation in the upper portion of the pear-shaped curve, which means that the pear-shaped curve has two inflection on either side of the axis of symmetry in the upper portion of the pear-shaped curve. This light distribution curve has not been disclosed in any heretofore known fluorescent lamp unit and must therefore be described as a novel surprising effect of the grid according to the invention. This will also be evident if one studies "British Zonal Classification" described by the "Illuminating Engineering Society" in I.E.S. Technical Report No. 2: The Calculation of Utilisation Factor—the B. Z. Method", London, revised edition, February 1971, whose light distribution curves for comparative measuring with other lamps are all of essentially pointed oval shape.

The invention will now be explained below with reference to the drawings in which

Fig. 1 illustrates a grid for fluorescent lamp units for ceiling illumination or as wall units according to the invention, viewed in section along the line I—I in Fig. 2,

Fig. 2 is a grid section at right angles to the section as shown in Fig. 1, as viewed from the light source,

Fig. 3 is a second grid according to the invention, viewed in section along the line III—III in Fig. 4,

Fig. 4 is a grid section at right angles to the section as shown in Fig. 3, as viewed from the light source,

Fig. 5 shows the construction of a body of revolution for the lamp unit in Fig. 1, designated V, and the construction of the faces of Fig. 3.

Fig. 6 shows the light transmission through a parabola of revolution as used in the grid,

Figure 7 shows the light distribution of an unshielded fluorescent lamp,

Figure 8 represents two examples of light distribution curves of fluorescent lamp units where the grid consists of plane parallel faces orientated substantially away from the light source toward the object illuminated,

Figure 9 shows a light distribution curve for a unit with two fluorescent lamps shielding at angles greater than 45°,

Figure 10 shows a light distribution curve derived from comparative experiments at the Lighting Engineering Laboratory of the Technical University of Denmark.

Figure 11 shows a Light Distribution curve derived from experiments at the Lighting Engineering Laboratory having the characteristic configuration of the light distribution curve for the grid according to the invention.

Figures 1 and 2 show a grid 1 according to

the invention where the numeral 2 designates bodies of revolution or elements having both external, convex reflecting faces 3 and internal concave reflecting faces 4. The individual elements 2 are secured to or moulded in one with a shielding grid which consists of a plurality of locally interrupted walls 6, 7 at right angles to one another. As will be evident from Figure 2, every second wall 6, 7 is continuous and every second wall 6, 7 is interrupted by elements 2. All faces of wall 6, 7 are reflecting. The walls 6, 7 are shorter in length than the elements 2, extending from the edge B farthest away from the light source 5. The elements 2 may alternatively be mounted within the alternate square openings of the shielding body with the rotary axis of the elements coinciding with the intersections of the diagonals of the openings to form in a chessboard pattern as shown in Figures 3 and 4. If necessary, the shielding grid may be left out altogether, and the individual elements may be joined and secured at the edge B farthest away from the light source 5.

The elements 2 are bodies of revolution having a generant curve whose radius of curvature increases in a direction away from the light source 5 and whose centre of curvature lies in a direction toward the interior of the tube. The generant curve of the configuration specifically shown here is a parabolic segment of a second degree parabola. The generant curve and the construction of the elements will be further detailed below.

Figures 3 and 4 show a second embodiment of the grid according to the invention. In this case the grid 1 is composed of a plurality of elements 2' having a square cross section and being interconnected at the edge farthest away from the light source. However, it is possible instead to use other plane polygons with straight sides or a plane polygon having two or more curved sides for creating the cross-sectional pattern. The faces 3', 4' of the elements 2 are reflecting and of single curvature in the example shown, having a generant curve whose radius of curvature is increasing in a direction away from the light source 5' and with the centre of curvature of the generant curve in a direction toward the interior of the tube. The generant curves of the embodiment shown here are parabolic segments of a second degree parabola. It is noted that adjoining corners of the individual faces 3', 4' resemble in shape hip-roofs of arched configuration.

In the construction shown in Figures 3 and 4 the afore said shielding grid is left out as in each individual square the external convex faces of the individual elements form a shielding grid section of substantially the same technical light effect, as a corresponding square in a shielding grid of conventional construction.

The structures illustrated here are moulded from plastics in large or small sections and thereafter assembled and bonded together. The finished grid is then metallized on all faces with a highly reflecting material, such as aluminium, whereupon, if desired, the grid is immersed in a suitable pickle to render the reflecting face resistant to corrosion, etc. Another method consists in constructing the grid from material having reflecting faces and coating these with a transparent material such as a clear plastic material. The latter method will, however, result in a somewhat more costly and heavier unit and therefore is not expedient.

To dim or tone the luminous flux in between the elements 2, 2', the spaces 8, 8' between the elements may be covered with a transparent sheet of a material such as plastic or glass to which a colouring matter may be added. An alternative for dimming the luminous flux between the elements is adding to the metallizing coat for the external faces 3, 3' of the elements a coloring matter and also to the plane parallel walls 6, 7 at right angles to one another. The spaces between the elements may also be partly filled with transparent material such as glass or clear plastics.

Figure 5 shows the construction of the generant curve of the faces 3, 4 and 3' and 4'. A parabola P of the configuration  $y = p \cdot x^2$  is drawn in conventional manner. Through the focal point B<sub>1</sub> of the parabola there is drawn a line at the angle V to the main axis, which line intersects the parabola P at B<sub>2</sub>. The centre normal C of B<sub>1</sub> and B<sub>2</sub> is drawn, and the parabolic segment B<sub>1</sub>D<sub>1</sub> is reflected with the centre normal C as axis of symmetry on to B<sub>2</sub>D<sub>2</sub>. The edge closest to the light source 5, 5' is determined by the line B<sub>1</sub>B<sub>2</sub>, while the edge farthest away from the light source 5, 5' may be determined by drawing lines from B<sub>1</sub> and B<sub>2</sub> of the angle V to the centre normal. The point where these intersect the original parabola and the reflected parabola respectively will determine the edge farthest away from the light source 5, 5'. If bodies of revolution are desired, the centre normal C is used as axis of rotation. In case of other cross sections of the element 5 the curve is displaced in space along the desired curve.

The passage of light through an optical system having internal parabolic faces will be further explained below.

Fig. 6 illustrates an optical system having the characteristic that light entering the upper opening of the system at any angle of incidence will only be able to leave the lower opening B of the system at an angle to a vertical line which is always less than or equal to V.

The system consists of opposing reflecting faces whose vertical sectional lines form

parabolas  $P_1$  and  $P_2$ .—These parabolas are symmetrical about the vertical axis of the system as explained above. In a rotary symmetrical system it is possible to have the parabolas coincide with each other.

The parabola  $P_1$  has the focal point  $B_1$  and the axis  $A_1$  forming the angle  $V$  to the vertical axis.

The parabola  $P_2$  being symmetrical to  $P_1$  is so positioned as to pass through the focal point  $B_1$  of the parabola  $P_1$ . For reasons of symmetry the focal point  $B_2$  of the parabola  $P_2$  must therefore be on the parabola  $P_1$ .

Only that part of the parabola  $P_2$  shown to be fully drawn in the figure and which is between the focal point  $B_1$  and the intersection of line  $L_2$  which is designed to pass through the focal point  $B_2$  of  $P_2$  and forms the angle  $V$  to the vertical axis, is used.

The corresponding section of  $P_1$  is used. The system functions as follows:

An imaginary light source is placed in the focal point  $B_1$ . The rays from this light source hitting the opening  $B$  of the system will readily be seen to leave the system in directions forming an angle to the vertical axis which is less than  $V$ . All rays from  $B_1$  hitting the parabola  $P_1$  will be reflected in a direction forming the angle  $V$  to the vertical axis. Rays from  $B_1$  hitting the parabola  $P_2$  will likewise by necessity be reflected in directions forming small angles to the vertical axis.

If the light source is located on the line between  $B_1$  and  $B_2$ , it will be seen that only the ray hitting the parabola  $P_1$  at  $B_2$  will be reflected at the angle  $V$ . All other rays will be transmitted at other angles.

The same applies to light sources located above the line  $B_1$ — $B_2$ , and it follows that no ray could leave the system in directions forming an angle to the vertical axis greater than  $V$ .

The opening  $B$  of the system can be of any size but the ratio of the height  $H$  to the opening  $B$  has geometrical dependency as the lines  $L_1$  and  $L_2$  forming the angle  $V$  to the vertical axis must specifically intersect the parabolas  $P_1$  and  $P_2$  at the upper and lower points  $B_1$  and  $B_2$ , respectively as explained above.

The "Lighting Engineering Laboratory, the Technical University of Denmark, the Technical High School of Denmark" has measured the photometric characteristics of the optical grid according to the invention. The principle of measuring is further described in the publication "Lampetten" No. 4/1967 issued by the "Lighting Engineering Society", Denmark on pages 79 to 88. The principle of the method of measuring depends on using a special photocell of at least the same size as the lamp and which is designed so as to be sensitive only to light hitting the surface thereof at right angles,

which will, among other things, make it possible to reduce the distance from the lamp to the measuring photocell.

A photocell being only sensitive to incident light at right angles will measure the true luminous power of the lamp, provided the photocell is of at least the same size as the lamp and that the sensitivity of the cell is the same throughout the surface since each surface element of the cell will measure the luminous power of the corresponding surface element of the lamp. The summation then takes place within the photocell. Apparently this measuring of luminous power is quite independent of the distance between lamp and cell, and it is therefore possible to place the cell as close to the lamp as is mechanically feasible.

For this purpose is used a specially designed photocell comprising an inner white cavity, one plane side of which is a grid permitting light hitting the grid within a very small angle to the normal to pass. The light penetrating the grid into the cavity is reflected by the white faces thereof, summated and measured by a photomultiplier. To ensure that the light will hit the photocell substantially at right angles thereto, a special guiding raster is made, comprising eight about 1 cm deep layers each provided with a hole on the surface facing the light source. The openings are centered with respect to each other so as to guide a light ray from the lamp toward the photocell. The measuring itself is effected by the photocell being rotated  $360^\circ$  about the centrally positioned lamp. It should be mentioned that the "Commission International de l'Eclairage comité E-2.2. Photometric Requirements for Luminaries" have accepted the measuring principle.

In testing the grid according to the invention, the grid was positioned such that its plane formed an angle of  $45^\circ$  to the photocell, and the transmission factor and light distribution curve of the grid were measured.

Prior to measuring the light distribution of the grid, comparative tests were made to show the light distribution of the incident flux on the grid, see Fig. 10.

For evaluating the invention Figs. 7, 8 and 9 show light distribution curves for a fluorescent lamp without mounting unit and also for ordinary heretofore used fluorescent lamp units. Figs. 7 to 9 have been reproduced from "Lys og Belysning" (Lighting and Illumination) Nos. 3, 4 and 5 published by "Aschehoug Dansk Forlag", Copenhagen 1967/1968, respectively pages 3—29, 5—25 and 4—10. It will be evident from Figs. 8 and 9 that the light distribution curves of the heretofore customary fluorescent lamp units are substantially convex.

In comparing these curves with the light distribution curve of Fig. 11, the grid accord-

ing to the invention will be seen to have a light distribution curve which is substantially pear-shaped or shaped as a babushka doll, i.e. a marked deformation of the upper portion of the pear-shaped curve, and in fact such that the pear-shaped curve has two inflections on either side of the axis of symmetry in the upper portion of the pear-shaped curve. The report on the test received from the "Lighting Engineering Laboratory" reads in English Translation as follows:

"Object: Integral silvered grid, manufacturer Poul Willumsen. Scope of test: Measuring of photometric characteristics of optical grid.

A grid used below a lamp unit will, in addition to the transmission of light, also reflect the unit. The light reflected will travel back to the lamp unit and therefore to a certain extent hit the grid again and be transmitted. The total transmission of light will therefore to some degree depend on the construction of the lamp to which it is affixed.

To obtain unequivocal measuring results, the grids were therefore illuminated from above with diffuse light in such a manner that the light reflected from the grid surfaces could not markedly be reflected back to the grids again.

The transmission factor of a grid is equal to the ratio of the luminous flux. This transmission factor may be used for comparing different grids, but may not as a matter of course be used for evaluating the useful effect of a real lamp unit.

The light distribution curve of the incident flux on the grid has been drawn such that the maximum luminous power is equal to 10 divisions. Based on this definition of the scale, the light distribution curves of the grids have been drawn.

#### Result of measurement

"The transmission factor of the grid is 55%. The distributions of light measured are attached in graphic form".

Naturally, a grid having the light distribution curve indicated, as stated in the body of the specification, could be designed in many ways within the scope of the following claims. These embodiments are likewise comprised by the object of the invention as based on the disclosures of the present specification as they would be obvious to one skilled in the art.

#### 55 WHAT I CLAIM IS:—

1. A grid for fluorescent lamp units for ceiling or wall illumination wherein the grid comprises a system of open-ended tubular elements arranged in a regular pattern each of which has both an external convex reflecting face or faces and an internal concave reflecting face or faces each of the tubular ele-

ments having a smaller cross-sectional area at that end which in use would face said light source than at the end which in use would face away from said light source and being so constructed that its cross-sectional area never decreases in a direction which in use would extend away from the light source.

2. A grid for fluorescent lamp units for ceiling or wall illumination, wherein the grid comprises a system of open-ended tubular elements arranged in a regular pattern each of which has both an external convex reflecting face or faces and an internal concave reflecting face or faces, each of said faces being of single or double curvature and each having a generant curve whose radius of curvature is constant or increases in a direction which in use would extend away from a light source, and in that the end of said tubular element which in use would face said light source has a smaller inner cross-sectional area than the end which in use would face away from said light source, and wherein said grid is constructed so that in use the incident luminous flux will be transmitted both through and in between said tubular elements.

3. A grid as claimed in claim 1 or claim 2 wherein said individual elements are bodies of revolution.

4. A grid as claimed in claim 2, or claim 3 when dependent on claim 2 wherein said generant curves are segments of substantially parabolic shape and that said generant curve of said external convex face or faces conforms to said generant curve of said internal concave face or faces.

5. A grid as claimed in claim 4, wherein said element is a body of revolution whose rotary axis forms a given angle to the main axis of a parabola of which said generant curve forms part.

6. A grid as claimed in claim 5, wherein said curve of which said generant curve of said body of revolution forms part is a second degree parabola, and that said rotary axis forms a given angle to the main axis.

7. A grid as claimed in claims 5 and 6, wherein the focal point of said generant curve is at or adjacent the edge of said body of revolution which in use would be situated closest to said light source.

8. A grid as claimed in any one of claims 5 to 7, wherein the edge of the element which in use would be situated farthest away from said light source is determined relative to the geometric height of the element by the light rays originating from said edge which in use would be situated closest to said light source and having said given angle to the axis of said element which rays will intersect the edge of the element.

9. A grid as claimed in claim 1 or claim 2, wherein said individual elements have a cross section formed as a planar polygon with



ing to the invention will be seen to have a light distribution curve which is substantially pear-shaped or shaped as a babushka doll, i.e. a marked deformation of the upper portion of the pear-shaped curve, and in fact such that the pear-shaped curve has two inflections on either side of the axis of symmetry in the upper portion of the pear-shaped curve. The report on the test received from the "Lighting Engineering Laboratory" reads in English Translation as follows:

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A grid used below a lamp unit will, in addition to the transmission of light, also reflect the unit. The light reflected will travel back to the lamp unit and therefore to a certain extent hit the grid again and be transmitted. The total transmission of light will therefore to some degree depend on the construction of the lamp to which it is affixed.

To obtain unequivocal measuring results, the grids were therefore illuminated from above with diffuse light in such a manner that the light reflected from the grid surfaces could not markedly be reflected back to the grids again.

The transmission factor of a grid is equal to the ratio of the luminous flux. This transmission factor may be used for comparing different grids, but may not as a matter of course be used for evaluating the useful effect of a real lamp unit.

The light distribution curve of the incident flux on the grid has been drawn such that the maximum luminous power is equal to 10 divisions. Based on this definition of the scale, the light distribution curves of the grids have been drawn.

#### Result of measurement

"The transmission factor of the grid is 55%. The distributions of light measured are attached in graphic form".

Naturally, a grid having the light distribution curve indicated, as stated in the body of the specification, could be designed in many ways within the scope of the following claims. These embodiments are likewise comprised by the object of the invention as based on the disclosures of the present specification as they would be obvious to one skilled in the art.

#### WHAT I CLAIM IS:—

1. A grid for fluorescent lamp units for ceiling or wall illumination wherein the grid comprises a system of open-ended tubular elements arranged in a regular pattern each of which has both an external convex reflecting face or faces and an internal concave reflecting face or faces each of the tubular elements

having a smaller cross-sectional area at that end which in use would face said light source than at the end which in use would face away from said light source and being so constructed that its cross-sectional area never decreases in a direction which in use would extend away from the light source.

2. A grid for fluorescent lamp units for ceiling or wall illumination, wherein the grid comprises a system of open-ended tubular elements arranged in a regular pattern each of which has both an external convex reflecting face or faces and an internal concave reflecting face or faces, each of said faces being of single or double curvature and each having a generant curve whose radius of curvature is constant or increases in a direction which in use would extend away from a light source, and in that the end of said tubular element which in use would face said light source has a smaller inner cross-sectional area than the end which in use would face away from said light source, and wherein said grid is constructed so that in use the incident luminous flux will be transmitted both through and in between said tubular elements.

3. A grid as claimed in claim 1 or claim 2 wherein said individual elements are bodies of revolution.

4. A grid as claimed in claim 2, or claim 3 when dependent on claim 2 wherein said generant curves are segments of substantially parabolic shape and that said generant curve of said external convex face or faces conforms to said generant curve of said internal concave face or faces.

5. A grid as claimed in claim 4, wherein said element is a body of revolution whose rotary axis forms a given angle to the main axis of a parabola of which said generant curve forms part.

6. A grid as claimed in claim 5, wherein said curve of which said generant curve of said body of revolution forms part is a second degree parabola, and that said rotary axis forms a given angle to the main axis.

7. A grid as claimed in claims 5 and 6, wherein the focal point of said generant curve is at or adjacent the edge of said body of revolution which in use would be situated closest to said light source.

8. A grid as claimed in any one of claims 5 to 7, wherein the edge of the element which in use would be situated farthest away from said light source is determined relative to the geometric height of the element by the light rays originating from said edge which in use would be situated closest to said light source and having said given angle to the axis of said element which rays will intersect the edge of the element.

9. A grid as claimed in claim 1 or claim 2, wherein said individual elements have a cross section formed as a planar polygon with



straight sides or a planar polygon with at least two curved sides.

10. A grid as claimed in claim 9, wherein said convex and concave faces of the elements have generant curves which are substantially parabolic segments.

11. A grid as claimed in claim 10, wherein said generant curves of the faces are second degree parabolas.

12. A grid as claimed in claims 10 and 11, wherein a focal line or focal point of a face is located near to or at said edge of said element which in use would be situated closest to said light source and opposite said respective face.

13. A grid as claimed in any one of claims 9 to 12, wherein said edge of said element which in use would be situated farthest away from said light source is determined relative to the geometric height of the element, by the light rays originating from said edge situated closest to said light source in use and having an inclination of, for example,  $45^\circ$  relative to said grid which rays intersects the edge of the element.

14. A grid as claimed in any one of the preceding claims, wherein said individual elements are moulded, bonded or otherwise mounted with respect to each other so as to form a connected whole of a given design as determined by the desired technical luminous effect.

15. A grid as claimed in claim 14, wherein said individual elements are interconnected such that their geometric centres viewed from said light source and also from the opposite side of the grid towards said light source will form a plane polygonal pattern or a pattern in the form of a plane polygon having at least two curved sides.

16. A grid as claimed in claim 15, wherein said individual elements are moulded together with or otherwise mounted in, or interconnected by a shielding grid known *per se* having plane parallel walls at right angles to one another.

17. A grid as claimed in claim 16, wherein each individual element is inserted so as to have its rotary axis coincide with an X-portion removed from said shielding grid.

18. A grid as claimed in claim 16, wherein said individual elements are inserted so as to have their rotary axes coincide with the intersecting lines of the horizontal diagonals of the individual openings of said shielding grid.

19. A grid as claimed in claim 15, wherein said shielding grid is of lower height than said individual elements.

20. A grid as claimed in any one of the

preceding claims, wherein it is made from a material capable of being formed into sheets, such as plastic.

21. A grid as claimed in any one of the preceding claims, wherein said reflecting faces are made by metallizing the surface of the material or consist of a layer which is inherently reflective on both faces, one or both of the faces being coated with transparent material.

22. A grid as claimed in claim 21, wherein a colouring matter is added to the reflective material of certain reflecting faces, for example all faces except said internal faces of the element.

23. A grid as claimed in any one of claims 14 to 22, wherein said spaces between said elements are partly filled with or covered by transparent material such as glass or clear plastic with a colouring matter added, if desired.

24. A grid as claimed in any one of the preceding claims, wherein the grid has a configuration which permits the transmitted light to spread as a controlled luminous flux, like conventional low luminance grids, i.e. grids where the lateral faces are substantially parabolic faces, and also to spread as a diffuse luminous flux, like the distribution of luminous flux obtained from conventional shielding grids, i.e. grids where the lateral faces are substantially plane parallel faces.

25. A grid as claimed in claims 1 to 24, having a light distribution curve substantially as shown in Figure 11 of the accompanying drawings.

26. A grid as claimed in claims 1 to 24, having a light distribution curve in a polar coordinate system which is symmetrical about the  $90^\circ$  axis, extends as a closed curve below the  $90^\circ$  axis with the latter as horizontal tangent and is otherwise a substantially pear-shaped curve with a marked indentation in the upper portion of the pear-shaped curve, i.e. such that the pear-shaped curve has two inflections on either side of the axis of symmetry in the upper portion of the pear-shaped curve.

27. A grid according to any one of the preceding claims, substantially as described above and shown in the accompanying drawings and having the characteristics appearing from the curve shown in Figure 11.

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