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Bartenbach

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[54] **LIGHT DISTRIBUTING CEILING STRUCTURE**

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[52] **U.S. Cl.** .... **240/103 R,** 240/9 A, 240/78 LK

[51] **Int. Cl.** **F21v 7/00**

[58] **Field of Search** ..... 240/9 A, 9 R, 78 R, 78 LD, 240/78 LK, 106 R, 103 R

[56] **References Cited**

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1,469,067	1/1967	France	240/78 LK
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[57] **ABSTRACT**

A ceiling structure consists of intersecting vertical reflecting strips or battens with reflecting surfaces with a mirror finish and having two surfaces which converge in a downward direction. Above some of the intermediate spaces, or above all intermediate spaces, between the battens or strips, reflector lights are arranged.

8 Claims, 6 Drawing Figures

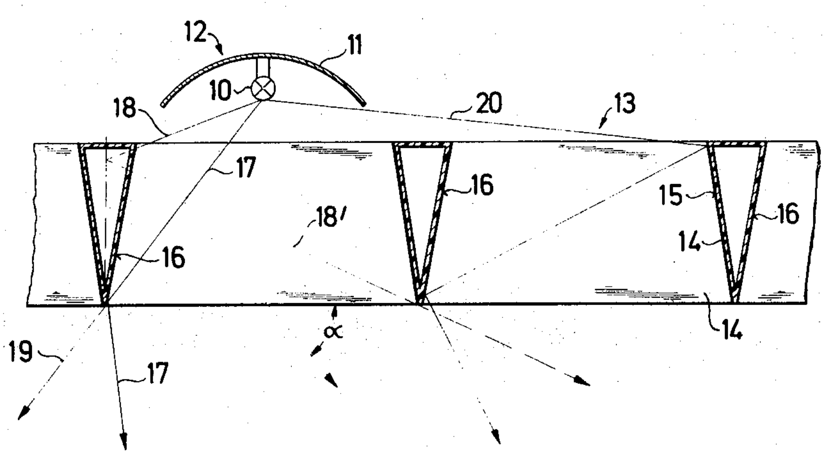


Fig. 1

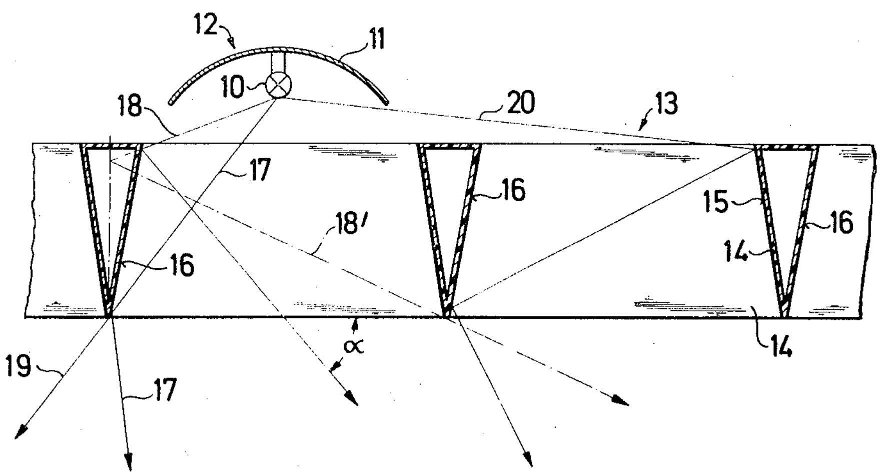


Fig. 2

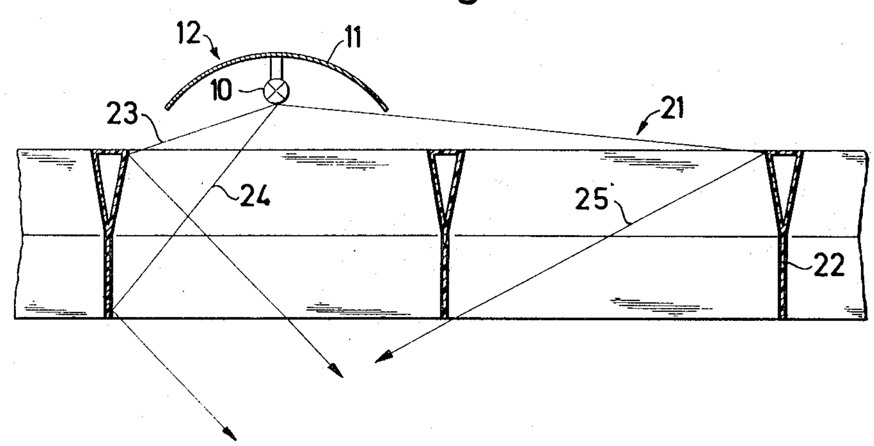


Fig. 3

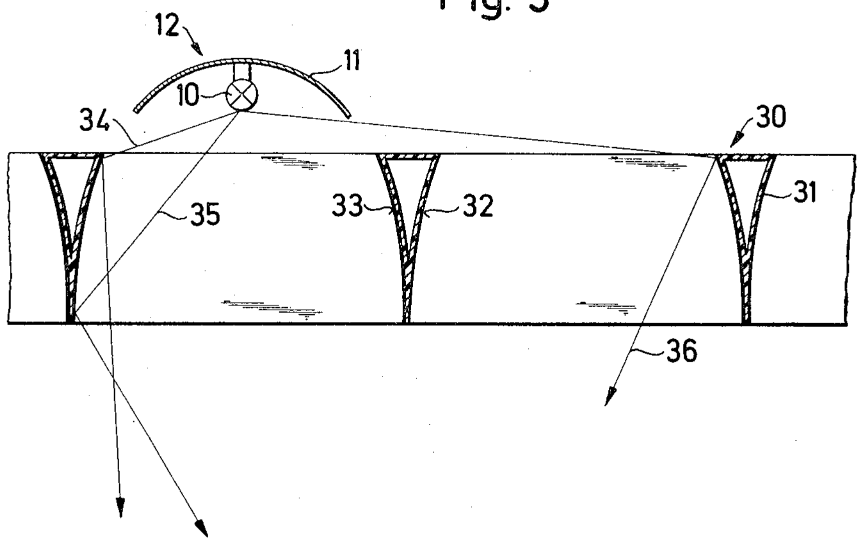


Fig. 4

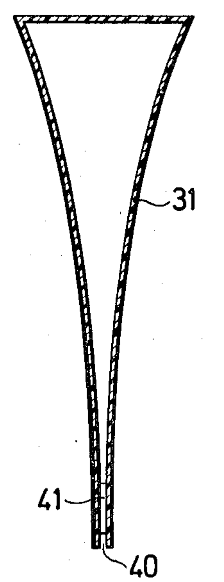


Fig. 5

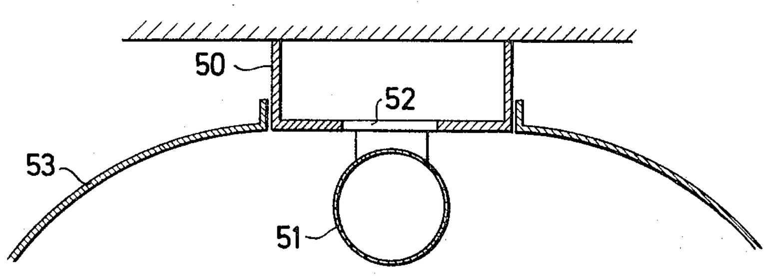
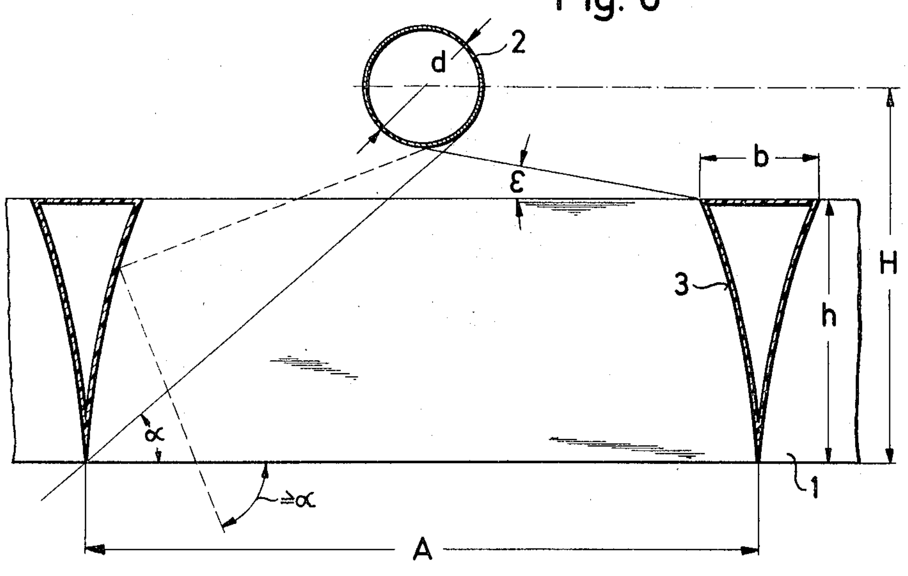


Fig. 6



LIGHT DISTRIBUTING CEILING STRUCTURE

BACKGROUND OF THE INVENTION

The present invention relates to a light distributing ceiling structure with a number of reflector lights and an anti-dazzle grid beneath the reflector lights. More specifically, the present invention relates to a light distributing ceiling structure with a number of reflector lights and an anti-dazzle grid beneath the reflector lights having a plurality of substantially vertically disposed, opaque members with reflecting surfaces.

Heretofore, such light distributing ceiling structures have been proposed in German Pat. specification No. 1,251,703. This patent specification also describes the mathematical relationships obtaining for their construction. In the case of these previously proposed ceiling structures, the vertically extending opaque reflection surfaces possess a matt, white surface so that they reflect the light diffusely. These ceiling structures make it possible to illuminate, in a very even fashion, the whole of the room or space underneath the ceiling structure with light which shines downwards at a large angle of view (α), where it is intensive and only has an angle value which is less than the minimum value for the angle of view (α), where it has a low intensity. The latter value is due, inter alia, to the fact that, because of the diffuse reflection at the anti-dazzle grid, the latter reflects light in all directions and there is naturally a principal direction of reflection at which the condition is fulfilled that one may not use a value less than the angle of view (α).

Although these previously proposed light distributing ceiling structures have been widely accepted, they can be improved still further as regards the light yield and draw closer to the ideal case, in which the whole light coming from the lights is evenly distributed over the whole surface of the grid and shines downwards in a distributed manner with an angle of view (α) of approximately 60° to 90°.

SUMMARY OF THE INVENTION

The invention relates to a light distributing ceiling structure with a number of reflector lights, preferably, arranged at the same level and which are equipped, preferably, with fluorescent tubes or lamps, and an anti-dazzle grid, which is arranged underneath the lights and is made up of intersecting substantially vertically extending opaque members with reflecting surfaces, through whose intermediate spaces the lights can only be seen at an angle of view which is not less than a certain pre-established minimum value, and, preferably, both the height of the grid and also the breadth and length of the grid gaps lying between the reflecting surfaces is substantially greater than the diameter of the lamp or tube, which is, preferably, arranged horizontally. The term "angle of view" is taken in the present context to mean the angle between the horizontal and the direction of incidence of the light at the eye.

BRIEF DESCRIPTION OF THE DRAWINGS

In what follows, the invention is explained in more detail with reference to embodiments shown diagrammatically in the drawings, wherein:

FIG. 1 shows, diagrammatically, a light distributing ceiling structure, in accordance with the invention, in a vertical section through a row of antidazzle grid apertures and through a number of fluorescent lights above the anti-dazzle grid, running perpendicular to the plane of the drawing;

FIG. 2 shows, in a similar view to that of FIG. 1, a different embodiment of a light distributing ceiling in accordance with the invention;

FIG. 3 shows, in a similar view to that of FIGS. 1 and 2, the preferred form of a light distributing ceiling structure in accordance with the invention;

FIG. 4 shows, on a scale larger than that of FIG. 3, a section through two reflection surfaces of the anti-dazzle grid in accordance with the invention, having their backside facing each other, and in which the grid is constructed as an air supply duct for an air conditioning system;

FIG. 5 shows, on a larger scale, the construction of the light where it is used as an air removal device for air conditioning; and

FIG. 6 shows the geometrical relationships which are to be observed in the design of light distributing ceiling structures in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

The aim of improving the light yield and providing a closer approximation to the lower limiting angle of view (α) to a value of approximately 60° is achieved in accordance with the present invention by providing reflection surfaces having mirror finishes and having their upper parts inclined towards the oppositely placed reflection surface. Because of the mirror finish, the light loss, which was caused by the fact that part of the light incident on the prior art diffuse reflection surfaces was reflected upwards into the space above the grid, is prevented. Also, because of the inclination of the reflection surfaces, the lower limiting angle of view (α) is substantially increased. In the case of the new principle provided by the invention, there is admittedly a certain loss of light due to the fact that the light incident in the zone between two reflection surfaces with their back sides turned towards each other is lost for illumination of the room, this slight loss in light is, however, a small sacrifice indeed when one considers the gain as regards the quantity of light shining downwards and the favorable angle at which this light shines downwards, since in the case of a proper arrangement and dimensioning of the reflector, only a very small part, that is to say the beams or rays leaving the lower part of the lamp or tube at a very small angle, shines on those loss zones which in themselves are extremely small in extent. If it is desired, it is even possible for these surfaces, which in practice, for the sake of simplicity, are covered by horizontally extending strips, to be replaced by reflecting strips set at a suitable angle, and which reflect a large part of the light incident here into the reflectors of the next adjacent lights. Having regard to the small degree of the loss occurring in this respect, such a construction is, however, usually too expensive.

References in the present specification and claims to a mirror finish or a silvered finish should not be taken to mean that a high luster mirror finish is implied as would be the case with mirrors in the narrow or household meaning. In fact, it is sufficient if the mirror finish is more or less matt, as is often used in reflectors and the like in practice. Furthermore, by the use of the word "finish," it is not intended to imply that the reflecting surface is always uncovered. References to "mirror finish" and "silvered" are not intended to restrict the invention to the use of the element silver.

As regards references to the use of reflector lights, in accordance with the invention, it is not to be understood that this limits the invention to reflector lights in the narrow sense. The term "reflector light" is instead used in a sense to mean that the light sources are to be provided with means which ensure that the light radiated by them shines substantially downwards onto the grid field and that the greater part of the light is not radiated upwards towards the upper roof or ceiling of the room. This is generally carried out by the use of reflectors above the lamp tubes or fluorescent tubes. If, as is preferred, the lamp or tube is arranged centrally above a field or opening in the grid, it is advantageous for the breadth of the reflector to be made substantially less than the breadth of the grid opening underneath it. In this respect, the reflector is advantageously so dimensioned that the light reflected by it and coming from the lamp or tube is caused to shine downwards through the underlying grid opening without a substantial part being directed on the grid.

In the case of the present invention, the grid when measured with respect to the apparent or actual luminous or shining surface of the light should be comparatively large. This means that the grid opening located under each light is to be substantially larger than this apparent luminous surface. Although it is possible to arrange one light above each grid aperture, it is preferred to arrange the lights in a striplike manner over each second row of apertures of the grid. Naturally, other lights and fluorescent tube arrangements are possible. Thus, lights in the form of intersecting light strips or strip lighting units can be arranged. There is also the possibility of arranging the fluorescent lamps or tubes in the form of light strips, each of which runs at a distance from two, three or more rows of grid openings from the adjacent light strip. There is also the possibility of arranging one lamp or tube above a grid strip separating two grid openings from each other. In this case, the two side edges of the reflector are advantageously arranged to end at a certain distance from the two grid strips, thus providing a lateral limitation of the double grid opening located under the light.

In the simplest case, the reflection surfaces are plane and inclined at a suitable small angle towards each other. In the case where two reflection surfaces are spaced from each other, with their backsides turned towards each other, the result is more satisfactory if the reflecting surfaces are made up of several, preferably two, plane part surfaces, of which the respective upper part surface is more inclined towards the vertical than the ones underneath it.

However, the most favorable result is obtained when the reflection surfaces are curved concavely with respect to the oppositely placed reflection surface. The curvature can in this case be determined, for example, graphically by drawing the corresponding limiting light rays, which shine on the other edge of the grid and drawing from their end points rays which run downwards at the angle α. As a result, one obtains the inclination of the reflection surfaces at the upper edge. It is now possible, by constructing intermediate values, to represent a corresponding curvature in points and then produce an approximation by a suitable curve.

The degree of inclination of the reflection surfaces, with respect to the vertical, should not be excessively large in order to ensure that the upper surfaces of the grid do not absorb an excessive amount of light. Very satisfactory results are obtained if the reflection surfaces are inclined at their lower edge at 0° to 10° and at their upper edge at 10° to 20°, with respect to the vertical. The range is still more satisfactory when the reflection surfaces are inclined, with respect to the vertical, at their lower edge between 0° and 5° and at their upper edge between 12° and 17°.

An important or essential feature of the invention is naturally that the reflectors, on the one hand, are not arranged at an excessive height above the grid arrangement, as this would lead to a loss in space. On the other hand, the reflectors need not be arranged at an excessively low level above the anti-dazzle grid, since the lower limiting angle of view (α) would otherwise be too small.

Satisfactory values can be obtained if the reflector of the light overlaps the respective underlying grid aperture by one to two thirds, and preferably by approximately one half. In this case, the distribution of the light radiation coming from the light over the underlying aperture and the two adjacent apertures is satisfactory, that is to say, a large part of the light is shone directly downwards through the underlying grid opening. However, in the case of the preferred embodiment, so much light leaves the lamp or tube and the space and passes into the adjacent grid apertures that the latter do not appear dark.

The reflectors, preferably, have a breadth which is approximately equal to five to seven times the lamp or tube diameter, while their height is advantageously equal to 1.5 to 2 times their diameter. This small height is sufficient, because the anti-dazzle grid with a mirror finish supplements the reflector of the light in a downward direction. The broader the reflector, the less height is required. Advantageously, the height of the light above the upper edge of the reflector is equal to 1 to 3 times the light diameter.

The grid width can be varied to a relatively considerable extent. Useful results are obtained with grid widths of 3 to 20 times the lamp or tube diameter. A particularly favorable arrangement uses a grid width of approximately 10 times the diameter of the lamp or tube.

The above particulars apply in the case where straight, horizontally extending arrangements of the fluorescent tubes or lamps are used for the design of the light distributing ceiling in vertical normal planes to the fluorescent tubes or lamps. The quantity of light which is radiated in the axial planes of the tubes or lamps in the direction opposite to the radial direction, from the axis of the tube or lamp, is relatively small. In this direction, the grid pitch can therefore be relatively large. The simplest arrangement is, therefore, when the grid pitch is somewhat greater than the length or half the length of the fluorescent tube or lamp.

In the case of approximately spherical or point light sources, the above data apply for the design of the grid which, in this case, is made square or possibly hexagonal. In this case, the reflectors are round, square or hexagonal.

It is advantageous, if two respective reflection surfaces with their backs facing each other are combined together, to form an upwardly widening hollow body which is open at its lower narrow edge and which can serve as an air duct for an air conditioning plant. Suitable parts can easily be made of plastics material by injection, molding or pressing. Advantageously, the reflection surfaces are connected adjacent their lower edges by means of bridge pieces which serve as air guides and divert the air downwards.

A particularly favorable construction is one in which the supports of the lights are constructed as air removal ducts of an air conditioning system. In this case, the waste air drawn off can simultaneously cool the fluorescent tubes or lamps.

Reference is first made to FIG. **6,** which, in a manner similar to FIG. **1,** shows an anti-dazzle grid opening **1** in a vertical section through one of its lights **2** and the vertically arranged reflection surfaces **3,** which are curved in accordance with FIG. **3.**

In this case, the following equations I to VI apply:

$$A - x' \; b \; 1.15\,(A - x') \qquad \text{I}$$

$$2h = (d + A \sin \alpha/\cos\alpha) + y' \qquad \text{II}$$

$$x' = x \sin \alpha + y \cos\alpha \qquad \text{III}$$

$$y' = y \sin \alpha - x \cos\alpha \qquad \text{IV}$$

$$x = d\left[1 - 2tg\,\frac{\alpha+\epsilon}{2}\left(\frac{\alpha+\epsilon}{2} + \frac{\frac{A}{d}\cos\alpha - \alpha}{1+(\alpha-1)\cos 2\alpha}\right)\right] \qquad \text{V}$$

$$y = d\left[\left(1 - tg\,\frac{2\alpha+\epsilon}{2}\right)\left(\frac{\alpha+\epsilon}{2} + \frac{\frac{A}{d}\cos\alpha - \alpha}{1+(\alpha-1)\cos 2\alpha}\right) - tg\,\frac{\alpha+\epsilon}{2}\right] \qquad \text{VI}$$

In these equations:

α denotes the shut off and minimum angle of view,
A denotes the grid width,
h denotes the grid height.
b denotes the upper grid breadth,
H denotes the height of the source of light above the lower surface of the grid,
d denotes the light source diameter,
ϵ denotes the minimum angle at which the light from the light source shines on the reflection surfaces of the underlying grid opening, and
α and ϵ are measured in radians.

ϵ is, in this respect, selected as a preestablished fixed angle. Furthermore, it is assumed that the light source is located symmetrically in the center above the underlying aperture of the grid opening.

In the case of the height distributing ceiling shown in FIG. **1,** a row or series of reflector lights **12** is provided, which are in the form of fluorescent tubes **10** and reflectors **11.** The reflectors throw the light shone onto them by the fluorescent tubes **10** downwards at an angle to the horizontal, which is greater than the preestablished minimum angle of view (α) and is preferably so large that this light shines downwards through the underlying grid opening without being incident upon the grid structure itself.

Beneath the lights **12,** the anti-dazzle grid **13** is arranged, which consists of intersecting reflector strips **14,** which together form a grid sheet with, in the present instance, a square aperture. It can be seen that the individual strips **14** consist of reflection surfaces **15** and **16,** respectively, with a mirror finish and their backsides turned towards each other. The reflection surfaces are inclined, in this embodiment, at a small angle for example 10° with respect to the vertical.

In FIG. **1,** some of the relevant limiting rays have been drawn. In this case, the limiting ray **18,** which is just incident on the other edge of the reflecting strip **16,** emerges from the anti-dazzle grid below the minimum limiting angle α with respect to the horizontal. All other rays of the lamp **10,** incident on the reflection surface **16,** emerge at a steeper angle. The light ray emerging with the steepest angle is the light ray **17,** which just manages to be reflected at the lower edge. It will be seen that the light ray **19,** slightly adjacent to the light ray **17** and which just passes the lower edge, emerges at a substantially steeper angle than the light ray or beam **18.**

For comparison with the light beam **18,** the course of a light ray **18'** is shown in broken lines. This ray is incident on an assumed vertically arranged reflection surface. It can be seen that the invention makes possible a light exit angle which is substantially more satisfactory than that of previously proposed arrangements.

Furthermore, in FIG. **1,** a light ray **20** is drawn in, which comes from the light source **10** and shines on the upper edge of the reflection surface **15** of an adjacent grid strip **14.** In the embodiment concerned, this light ray **20** finally emerges very steeply in a downward direction as well. Where other dimensioning factors are chosen, it may readily be possible for such a light ray from a reflection surface **15** to no longer be incident on the opposite reflection surface **16** but instead to shine downwards directly from the grid. This, however, does not constitute any substantial impairment of the systems, since the intensity of light emerging at such angles from the fluorescent light **10** is very small and these portions of the light can, for practical purposes, be neglected. Furthermore, these rays can readily be controlled by a suitable placement of the reflector **11** of the light **12** so that the reflector is lower down.

FIG. **2** shows a different construction of the light distributing ceiling structure, in accordance with the invention, which differs from that of FIG. **1** mainly in that the strips **22,** forming the anti-dazzle grid, consist in the lower half of vertically extending mirror finish surfaces, while in the upper half they are inclined at the same angle as the reflection surfaces **14** and **15** of the construction in accordance with FIG. **1.**

It can be seen here, from the few light rays **23, 24** and **25** shown, that relatively favorable emerging angles for the light fractions emerging with a high intensity are present and that a small emergence angle is only present in the case of such rays (**25**) which have a small light intensity.

However, if, in the case of the grid **21** shown in FIG. **2,** the upper breadth of the individual grid strips or battens, which in FIG. **2** are only half as large as in FIG. **1,** were to be made as large as in FIG. **1,** the exit angle relationships would be still further improved and most of the light would shine at a very steep angle α downwards.

An optimum construction of the light distributing ceiling structure in accordance with the invention is shown in FIG. **3.** In this case, the same light arrangement is provided as in FIGS. **1** and **2.** The battens or strips **31** consist of V-shaped hollow girders whose flanks **32** and **33** are so curved that their mirror finish, reflecting outer surfaces have their upper parts concavely curved with respect to each other. Such a construction has the great advantage that in the upper part of the battens **31,** the reflection surfaces **32** and **33** can be inclined at a relatively large angle with respect to the vertical. For this purpose, there is no need to have a great angle of inclination of these surfaces with respect to the vertical in the lower part. In the lower part, this is also less important. The greater inclination, which in this manner is achieved in the upper zone of the reflection strips **32** and **33,** ensures that it is just those rays, which would otherwise shine downwards at a relatively small angle of view with respect to the horizontal, which also shine downwards relatively steeply. As a result, the angle of view for the various rays coming from each light differs less than in the case of prior art constructions. Also, in this case, for purposes of explanation, three rays **34, 35** and **36** have been drawn in. In this case, it can be seen that it is just those rays, which otherwise shine downwards at a relatively small angle and are reflected downwards by the upper edges of the anti-dazzle grid, which are reflected downwards at a very steep angle.

A construction, as shown in FIG. **1** or FIG. **3,** can with a substantial advantage also be used as an air supply and air removal device for air conditioning. For this purpose, the battens **31,** preferably made of pressed plastics material, have a narrow exit gap **40** at their bottom side, and, in the gap **40,** narrow air guidance bridging pieces **41** are arranged. These bridging pieces divert air downwards which flows perpendicularly to the plane of the drawing of FIG. **4** through the batten **31.**

For the same purpose the light construction shown in FIG. **5** can be used for removing stale air. In this case, an air supply channel **50** is provided at the ceiling or roof of the room, which at its lower end is provided with air draw-in openings **52** above the fluorescent tubes **51.** The holding means for the fluorescent tubes **51** are also provided in the air shaft **50.** Furthermore, the reflectors **53** of the light are provided in the air shaft **50.** In this manner, the stale air, which is drawn off through the air shaft **50,** also serves to cool the fluorescent tube **51.**

It is to be noted generally that, in the above indicated equations I to VI, the limiting value 1.15 is an empirically determined value, which can be departed from in accordance with particular constructions. Generally, however, departures should not be excessive in this respect.

In the above, the light factors have not been considered in the longitudinal direction of the fluorescent tubes. Light, which emerges, in the figures shown, at a substantial angle to the plane of the drawing, can, however, be neglected in the case of the use of normal fluorescent tubes, since the light intensity in this direction is small. Therefore, it is also possible to use a grid whose apertures are square, the longitudinal sides of the rectangles being parallel to the fluorescent tubes. The corresponding emergence angles of such rays, running obliquely in relation to the plane of the drawing, can readily be determined, after determining the corresponding numbers in the abovementioned drawing planes, with the help of Pythagoras' Theorem.

If one naturally has light sources, which radiate light in all directions evenly, as for example incandescent lamps, the use of a square or even hexagonal grid arrangement is recommended. In the case of a hexagonal grid arrangement, the rays falling in the corners of the grid apertures can usually be neglected. In the case of a square grid arrangement, the limiting angle of view C α) will have to be selected to be so low that the rays incident in the corners of the grid will also shine downwards sufficiently steeply.

In accordance with what has been stated above, the invention provides an optimum illumination of a room with a very steep angular view of downwardly shining light and with a minimum of dazzle, despite the use of an anti-dazzle grid with a mirror finish. In this respect, the light loss is as small as can be imagined. For the first time, the invention has made it possible to achieve an intensive illumination of large rooms without dazzle and without the light coming from the light distributing ceiling structure being considered disturbing.

A further substantial advantage of the invention resides in the fact that, because of the low light losses, it is possible to work with a comparatively low energy requirement per unit surface area (W per sq. meter), something which again is of substantial significance as regards technical requirements for air conditioning of the room illuminated with an illuminated ceiling structure in accordance with the invention. The air conditioning plant can be made substantially smaller than with a light distributing ceiling of the initially-described, previously-proposed type.

For normal fluorescent lamps with a diameter of approximately 37 to 38 mm, an anti-dazzle arrangement in accordance with FIG. **3** is particularly suitable, in which case the pitch of the square grid amounts to 500 mm. In this case, the height of the grid amounts to 240 mm or slightly more. The center of the fluorescent lamp should have a height of 320 mm above the lower limiting plane of the anti-dazzle grid. The anti-dazzle screen can have a breadth of approximately 250 mm and have its lower outer edges extending approximately 15 mm below the lower edge of the fluorescent tube. While the breadth of the battens, forming the grid at the lower edge, can be approximately 10 to 12 mm, in the case of construction as an air supply duct for air conditioning, the battens can have a breadth of approximately 75 mm at the upper edge.

It will be obvious to those skilled in the art that many modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

What is claimed is:

1. In a light distributing ceiling structure having a plurality of reflector lights and an anti-dazzle grid disposed beneath said lights, the improvement comprising an anti-dazzle grid, including, a plurality of spaced, substantially vertically disposed opaque grid members, each of said grid members having a pair of curved and concave reflecting surfaces with a mirror finish facing outwardly toward the opposing grid members of said grid and diverging outwardly from the vertical from bottom to top at an angle of about 0° to 5° at their bottom portion and about 12° to 17° at their top portion, said grid members being spaced from one another a distance of at least twice their height, and a plurality of reflector lights spaced above the top of said grid members a distance less than the height of said grid members.

2. A light distributing ceiling structure in accordance with claim 1, in which each of the reflector lights are positioned above openings in the grid.

3. A light distributing ceiling structure in accordance with claim 1, in which the reflector lights are fluorescent lamps.

4. A light distributing ceiling structure in accordance with claim 1, in which the reflector of the reflector lights only partly covers the underlying grid aperture.

5. A light distributing ceiling structure in accordance with claim 1, in which pairs of the reflecting surfaces have their backsides turned to each other and combined to form an upwardly broadening hollow body which is adapted to serve as an air supply duct for air conditioning and is open at its lower narrow side.

6. A light distributing ceiling structure in accordance with claim 5, in which the reflecting surfaces are connected by bridging pieces at their lower edges which serve as air guide surfaces and are adapted to divert air downwards.

7. A light distributing ceiling structure in accordance with claim 5, in which support means of the lights are constructed as air removal ducts of an air conditioning system.

8. A light distributing ceiling structure in accordance with claim 1, in which the reflecting surfaces are in the form of plastic parts with a mirror finish.

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