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(54) Lighting device with an optical system for the control of UGR Index and luminance

(57) A controlled-emission lighting device (1) comprises at least one light source (2) and an optical system (4) for the control of UGR index and luminance; the optical system (4) comprises a multi-lens optical element (8) formed by a plurality of lenses (9) arranged side-by-side along two directions, and a grid (10), located on an inner face (11), facing towards the light source (2), of the optical element (8); the grid (10) is dimensioned so as to limit the angle of incidence of the light rays that impinge on respective entry surfaces (13), facing towards the inside of the lighting device (1) and towards the light source (2), of the lenses (9); and the lenses (9) have respective exit surfaces (14) shaped so as to project the light rays passing through the grid (10) with emission angles lower than a threshold value.

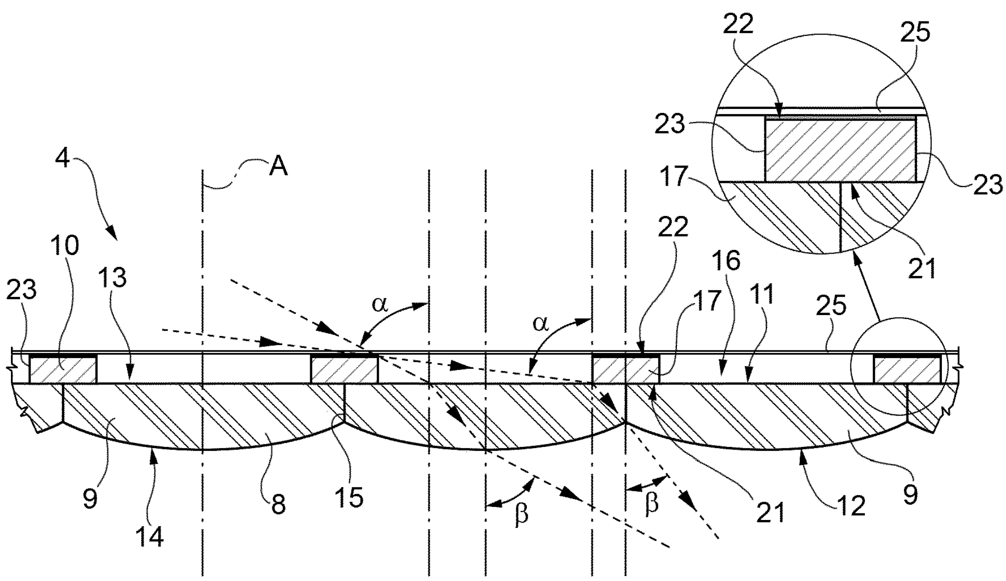

FIG. 4

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Description

[0001] The present invention relates to a lighting device provided with an optical system for the control of UGR index and luminance.

[0002] The invention is intended, in particular, to provide "dark" effect lamps (i.e. having emission above 65° lower than a predetermined threshold) for interior lighting.

[0003] In the field of interior lighting and in particular of workplace lighting, there is the problem of ensuring a controlled emission. Specific regulations also exist in this regard which limit the emission cones of the devices to predetermined values.

[0004] In order to meet the regulatory requirements, it is for example known to use, in technical lighting devices (i.e. intended for lighting workplaces, and in particular offices) where a uniform emitting surface is required, prismatic plates which narrow the emission of the light sources, in particular producing a polar curve complying with the regulatory requirements, namely:

- UGR (Unified Glare Rating): lower than 19;
- luminance at 65° and higher: lower than 3000 cd/m2.

[0005] A prismatic plate of this type is schematically shown in figures 1 and 2.

[0006] Plate 30, commonly made of transparent methacrylate, has a smooth entry face 31 which is mounted towards the inside of the lighting device (towards the light sources), and a prismatic exit face 32, consisting of cones 33 with angle at the apex of 120°. The bases of cones 33 are cut in a hexagonal shape so as to optimize the composition of the structure, which thus proves to be a honeycomb.

[0007] As may be seen in figures 1 and 2, plate 30 works effectively, allowing an excellent control of UGR and luminance at 65° and higher, when the light rays, and in particular the light rays, the most critical to control, grazing on the entry face 31 of plate 30 (i.e. having a high angle of incidence α, the angle of incidence being the angle between the direction of the light ray impinging on a surface and an axis perpendicular to the surface at the point of incidence of the light ray), pass through "rising" surfaces 34 of the cones (figure 1). In this case, the light ray emerges from the exit face 32 with a satisfactory (for example lower than the threshold required by the regulations) emission angle β (angle between the direction of the light ray exiting from a surface and an axis perpendicular to the surface at the exit point of the light ray).

[0008] If, however, a light ray crosses a "descending" surface 35 of cones 33 (figure 2), then the angle of incidence α is greater than the limit angle and a total internal reflection effect is achieved. The light ray therefore does not pass through plate 30 but begins to "bounce" inside plate 30. The resulting multiple internal reflections change the orientation of the light ray and when finally there is an incidence on a "rising" surface, the light ray may emerge above 65°.

[0009] This condition causes the light intensity higher than 65° not to be zero but have a certain value, which may be critical or not depending on the emitting surface of the device. This is because luminance is defined as the ratio between the light intensity and the apparent emitting surface.

[0010] In conclusion, known systems of the type described above are not able to implement sufficiently clear "cut offs" to make the prismatic plates effectively usable on all devices. In particular, UGR and luminance may exceed the law limits when the emitting surface is very small.

[0011] An object of this invention is to provide a lighting device provided with an optical system for the control of UGR index and luminance, in particular adapted to make "dark" effect lamps, which overcomes the drawbacks of the prior art mentioned herein.

[0012] In particular, an object of the invention is to provide a lighting device which enables an efficient control of UGR and luminance even with small emitting surfaces.

[0013] The present invention therefore relates to a lighting device provided with an optical system for the control of UGR index and luminance, in particular to make "dark" effect lamps, as defined in essential terms in the appended claim 1 and, in its additional features, in the dependent claims.

[0014] The invention is further described in the following non-limiting embodiment examples, with reference to the accompanying figures in which:

- figures 1 and 2 show a lighting device with emission control obtained, according to the prior art, with a prismatic plate;
- figure 3 is a schematic perspective view of a lighting device with optical system for the control of UGR index and luminance according to the invention;
- figure 4 is a schematic cross-sectional view, with a portion on an enlarged scale, of a detail of the device in figure 3.

[0015] Figure 3 schematically shows a controlled-emission lighting device 1, in particular adapted to make "dark" effect lamps.

[0016] The lighting device 1 is precisely a device for interior lighting and in particular for workplace lighting.

[0017] The lighting device 1 comprises at least one light source 2, housed in a casing 3, and an optical system 4 for the control of UGR index and luminance.

[0018] The light source 2 may be of various types, for example a row of LEDs.

[0019] The casing 3 may be variously shaped, also according to the use of the lighting device 1 (such as a ceiling lamp). In general, the casing 3 is provided with an internal chamber 5, which houses the light source 2 and has an emission aperture 6 delimited by a peripheral edge 7, from which the light emitted by the light source 2 exits.

[0020] The optical system 4 closes the emission aperture 6 and intercepts the emission of the light source 2.

[0021] With reference to figure 4, the optical system 4 comprises a multi-lens optical element 8, formed by a plurality of lenses 9 arranged side-by-side along two directions, and by a grid 10, located on an inner face 11 (facing towards the inside of the lighting device 1 and towards the light source 2) of the optical element 8.

[0022] The optical element 8 is substantially flat and extends between the inner face 11 and an outer face 12, opposite the inner face 11 and facing, in use, towards the outside of the lighting device 1 and thus towards the room to be lighted.

[0023] The optical element 8 is spaced apart from the light source 2, in particular being located at a distance from the light source 2 larger than the thickness (distance between the inner face 11 and the outer face 12) of the optical element 8.

[0024] Advantageously, the optical element 8 is a monolithic element of a transparent polymer material, such as PMMA.

[0025] The lenses 9 are in contact with one another along respective sides.

[0026] Each lens 9 extends along a central axis (optical axis) between an entry surface 13, facing towards the inside of the lighting device 1, and thus towards the light source 2, and an exit surface 14, opposite the entry surface 13 and thus directed towards the outside of the lighting device 1 and towards the room to be lighted.

[0027] The lenses 9 are plano-convex lenses, i.e. having respective opposite surfaces which are a plane surface and a convex surface, respectively, having a predetermined bending radius.

[0028] In particular, each lens 9 has the entry surface 13 which is a plane surface, and the exit surface 14 which is a convex surface.

[0029] The entry surfaces 13 form the inner face 11, substantially plane, of the optical element 8; the outer face 12 is formed by a plurality of convex surfaces, consisting of respective exit surfaces 14 of lenses 9.

[0030] The lenses 9 are joined to one another along respective common lateral faces 15.

[0031] In the preferred embodiment shown, the lenses 9 are square lenses, i.e. lenses having a square shape in plan view.

[0032] The grid 10 has a plurality of meshes 16 aligned to respective lenses 9 and delimited by lateral walls 17.

[0033] The grid 10 is arranged on the inner face 11 of the optical element 8 and in contact with the inner face 11; the lateral walls 17 contact the inner face 11 of the optical element 8 and are arranged along the faces 15 which join the lenses 9.

[0034] In particular, the lateral walls 17 have respective bottom contact surfaces 21, resting on the inner face 11 of the optical element 8, and respective top free surfaces 22 opposite the contact surfaces 21.

[0035] Then, each lateral wall 17 has a pair of opposite lateral sides 23 which join the contact surfaces 21 and the free surfaces 22.

[0036] Preferably, the lateral sides 23 have light-absorbing black surfaces, while the free surfaces 22 are diffusive white surfaces having a high reflection coefficient, so as to recover inside the casing 3 the light impinging on the grid 10. For example, the free surfaces 22 are made of/coated with a white polymer material having high reflectance, for example an overall reflectance of visible light of 95% or higher.

[0037] The grid 10 is dimensioned so as to limit the angle of incidence α of the light rays that impinge on the entry surfaces 13 of the lenses 9 (the angle of incidence α being the angle formed by the direction of a light ray impinging on an entry surface 13 with an axis perpendicular to the entry surface 13 at the point of incidence); precisely, the grid 10 and in particular the lateral walls 17 are dimensioned so that only light rays with angles of incidence α (with respect to the entry surfaces 13) higher than a minimum threshold α_{min} impinge on the lenses 9 (on the entry surfaces 13), so as to limit or avoid internal reflections that generally grazing rays (with high angle of incidence) undergo, which are difficult to control.

[0038] The lenses 9 and in particular the exit surfaces 14 thereof are then shaped so as to project the light rays that pass through the grid 10 with emission angles β (the emission angle β being the angle between the direction of the light ray exiting from the exit surface 14 and an axis perpendicular to the exit surface 14 at the exit point of the light ray) lower than a threshold value β_{Max} for example 65° as indicated by the current regulations.

[0039] In this way, all the light rays that pass through the lenses 9 are refracted at angles of refraction that meet the requirements, in particular being lower than 65°.

[0040] By way of example, the lateral walls 17 have a thickness (distance between the opposite lateral sides 23) greater than the height (distance between the contact surface 21 and the free surface 22). For example, the lateral walls 17 have a thickness of about 1.5-2.5 mm and a height of about 0.5-1.5 mm.

[0041] The dimensions of meshes 16 depend on the dimensions of the lenses 9, in particular on the length of the sides (in plan view) of the lenses 9, which for example may be about 8-10 mm.

[0042] The bending radius of the lenses 9 (precisely of the exit surfaces 14 thereof) is in general comparable with the length of the sides of the lenses 9, in particular being equal to or slightly greater than the length of the sides of the lenses 9, for example about 8-12 mm.

[0043] In one example, the lenses 9 have sides of 9.2 mm and a bending radius of 11 mm.

[0044] Optionally, the optical element 8 is coupled to or facing towards a diffusive sheet 25, the diffusive sheet, made of suitable light-permeable and diffusive material (such as a polycarbonate film), has the function of making the emission of the lighting device 1 more homogeneous without altering the angles of emission.

[0045] With the optical system 4 of the invention it is possible to get a clear "cut off" at the desired angle, preventing the total internal reflection.

[0046] The optical system 4 allows obtaining the desired emission (also of the "dark" type) without requiring further optical elements on the light source 2; in particular, if the light source 2 is formed by a plurality of LEDs, the LEDs do not require their own lenses or optics associated with the single LEDs.

[0047] The optical system 4 of the invention in fact operates independently of the light source 2 and can be used with different light sources; therefore, implementing a specific optical system for different light sources or providing the light sources with dedicated optics is not necessary.

[0048] Finally, it is understood that further changes and variations may be done to the lighting device described and shown herein without departing from the scope of the appended claims.

Claims

1. A controlled-emission lighting device (1), comprising at least one light source (2) and an optical system (4) for the control of UGR index and luminance; **characterized in that** the optical system (4) comprises a multi-lens optical element (8), formed by a plurality of lenses (9) arranged side-by-side along two directions, and by a grid (10), located on an inner face (11), facing towards the light source (2), of the optical element (8).

2. A lighting device according to claim 1, wherein the grid (10) is shaped and dimensioned so as to limit the angle of incidence of the light rays that impinge on respective entry surfaces (13), facing towards the inside of the lighting device (1) and towards the light source (2), of the lenses (9).

3. A lighting device according to claim 2, wherein the grid (10) is shaped and dimensioned so that only light rays with angles of incidence greater than a minimum threshold impinge on the entry surfaces (13) of the lenses (9), so as to limit or avoid multiple internal reflections in the optical element (8).

4. A lighting device according to one of the preceding claims, wherein the lenses (9) have respective exit surfaces (14) shaped so as to project the light rays with emission angles lower than a threshold value.

5. A lighting device according to one of the preceding claims, wherein the lenses (9) are plano-convex lenses, having respective plane entry surfaces (13) facing towards the inside of the lighting device (1) and towards the light source (2); and respective convex exit surfaces (14), opposite to the entry surface (13).

6. A lighting device according to claim 5, wherein the optical element (8) has a substantially plane inner face (11), facing towards the light source (2) and formed by the entry surfaces (13) of the lenses (9); and an outer face (12), opposite to the inner face (11) and formed by a plurality of convex surfaces, defined by respective exit surfaces (14) of the lenses (9).

7. A lighting device according to one of the preceding claims, wherein the lenses (9) are square lenses, i.e. lenses having a square shape in plan view.

8. A lighting device according to one of the preceding claims, wherein the grid (10) has a plurality of meshes (16) aligned to respective lenses (9) and delimited by lateral walls (17).

9. A lighting device according to claim 8, wherein each lateral wall (17) has a pair of opposite lateral sides (23) that have respective light-absorbing black surfaces.

10. A lighting device according to one of claims 8 or 9, wherein the lenses (9) are joined to one another along respective common lateral faces (15) and the lateral walls (17) of the grid are located along said lateral faces (15).

11. A lighting device according to one of the claims 8 to 10, wherein the lateral walls (17) of the grid (10) have respective top free surfaces (22), facing towards the inside of the lighting device (1) and towards the light source (2); said free surfaces (22) being diffusive white surfaces having a high reflection coefficient.

12. A lighting device according to claim 11, wherein said free surfaces (22) are made of and/or coated with a white polymer material having high reflectance, for example an overall reflectance of visible light of 95% or higher.

13. A lighting device according to one of the preceding claims, wherein the grid (10) is arranged on an inner face (11), facing towards the light source (2), of the optical element (8) and in contact with the inner face (11) of the optical element (8).

14. A lighting device according to one of the preceding claims, comprising a diffusive sheet (25), made of a light-permeable and diffusive polymer material, for example a polycarbonate film, which is coupled to or faces the optical element (8).

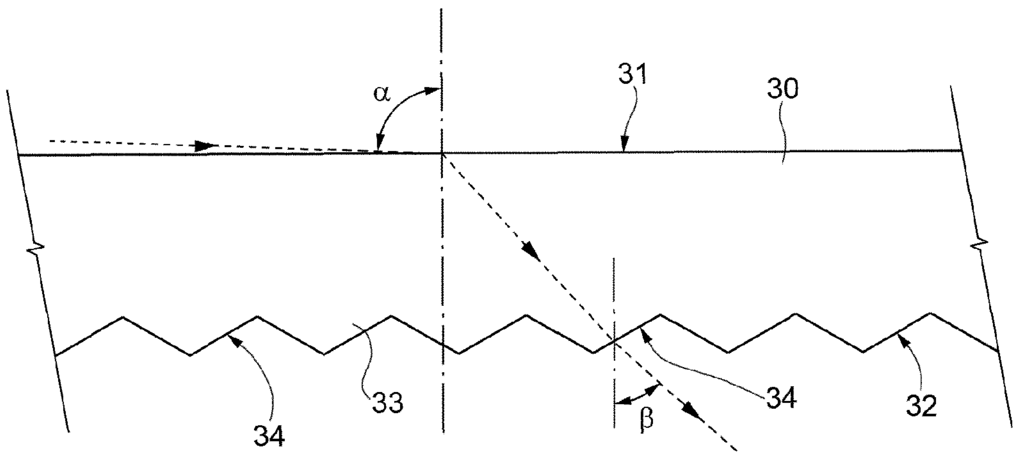

FIG. 1 (prior art)

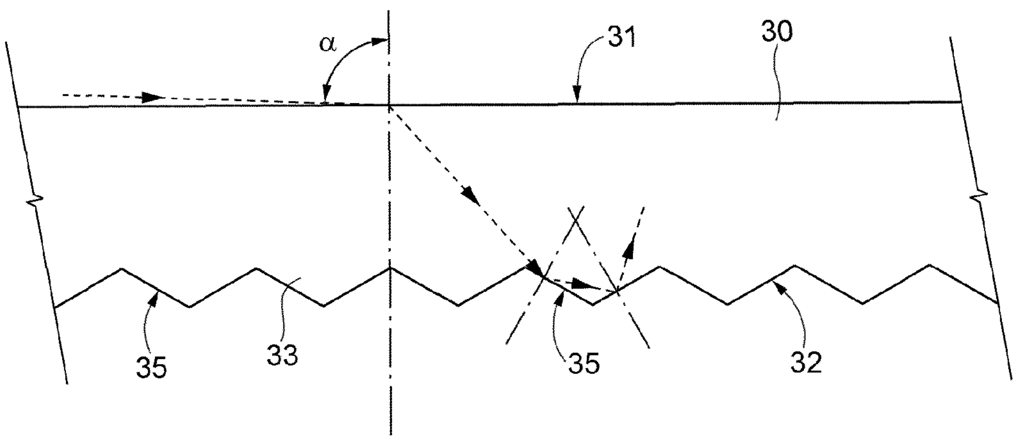

FIG. 2 (prior art)

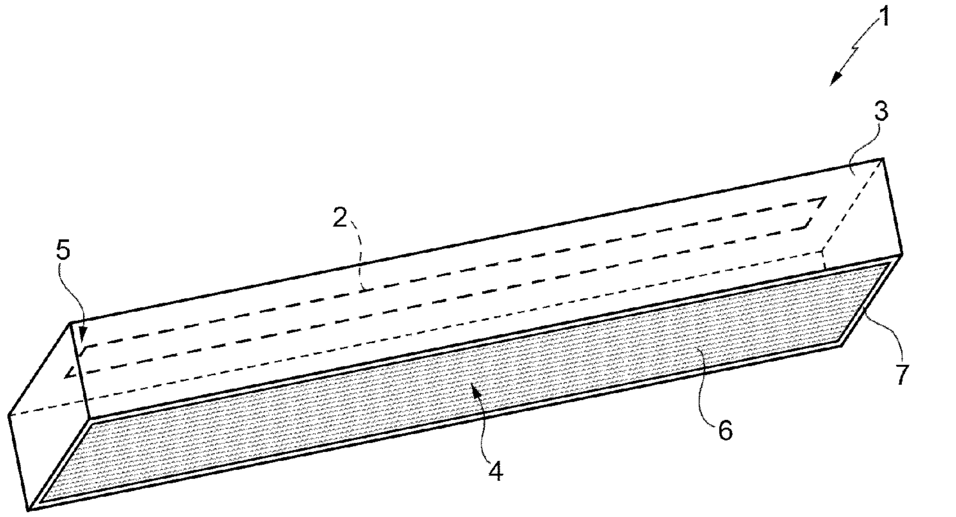
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FIG. 3

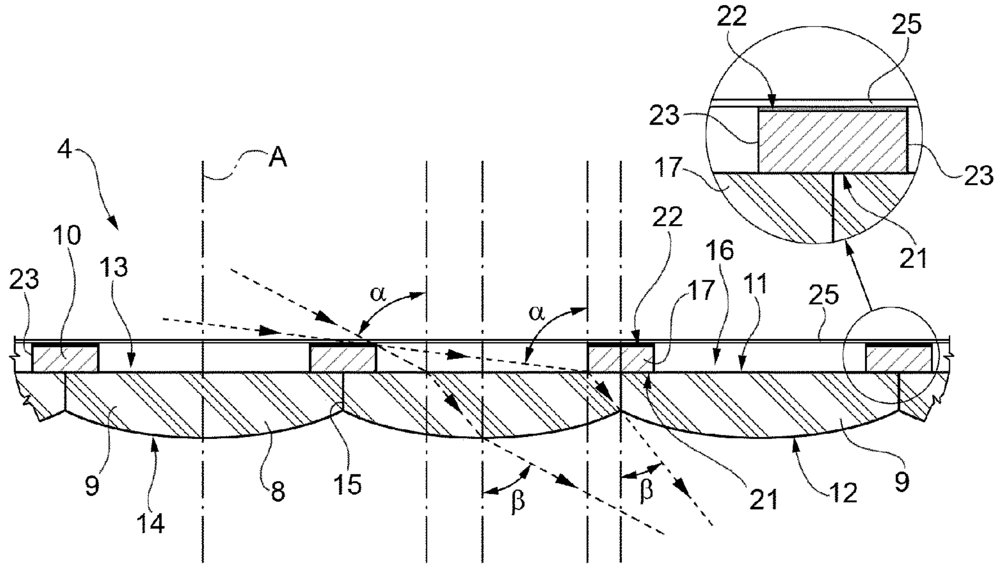
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FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 9107

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	19 February 2015	Schulz, Andreas

CATEGORY OF CITED DOCUMENTS

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