Title: OPTICAL SYSTEM FOR UNIFORM DISTRIBUTION OF LIGHT EMITTED BY LIGHT SOURCES

Abstract: An optical system (1) for uniform distribution of light emitted by light sources, comprising at least one optical device (9), or primary module, having one or more rows (11) of light sources (4), said system being characterized in that said optical device or primary module (9) has a profile suitable for reflecting the rays (8) arriving from said one or more rows (11) of light sources (4), and by the fact that said one or more rows (11) of light sources (4) is placed within said profile, said profile presenting inside at least partly diffusing and high reflectivity reflecting surfaces (5), suitable for reflecting said rays (8) along a direction not intersecting said reflecting surfaces (5), without any direct light output from said light sources (4) thereby getting a low luminance of the sources together with a high efficiency of the system.
OPTICAL SYSTEM FOR UNIFORM DISTRIBUTION OF LIGHT EMITTED BY LIGHT SOURCES

The present invention fits in the field of the illuminating engineering, and in particular relates to an optical system for uniform distribution of light emitted by punctiform light sources, particularly Light-Emitting Diodes (LEDs).

More specifically, the invention concerns an apparatus for indoor lighting, which takes advantage of the use of punctiform light sources, such as LEDs, and ensures a homogeneous light distribution, while keeping a high efficiency of the apparatus.

In the recent years, LEDs have demonstrated a high application potential in the field of architecture, having numberless advantages.

For example, beyond to be very convenient and durable over time, their sizes allow to integrate a lighting system directly in the architecture, thereby being possible to eliminate the traditional light source and place the light source only where it is necessary.

The presence of light with the use of LEDs, a visible lighting body lacking because built-in in an architectural particular, offers to the architect countless possibilities of expressing their own creative inspiration, creating each time different and suggestive lighting backgrounds.

The ability of creating, with the LEDs, a light of any colour, or a white light of any colour temperature, has allowed the application of these light sources to the lighting bodies, causing as such a certain revolution in architecture and design.

Even these light sources, like all the others, are subject to specific regulations regarding the lighting in interiors, in order to keep the luminance level necessary for the various activities.

For example, in the specific field of lighting of work tops in presence of display terminals, EN 12464-1 standard analyzes the usual visual tasks, highlighting the needs of visual comfort and giving indications about the lighting levels, uniformity and maximum dazzling degree.
necessary for the various visual performances that involve the use of display terminals.

In order to get a proper lighting, it is necessary to meet three basic needs, such as visual comfort (wellbeing sensation), visual performance (task execution even in difficult and extended situations) and safety.

In order to meet these standards it is necessary to avoid too high or too low luminance contrasts, because a modest dazzling prevents a correct vision of the visual task.

In order to meet the requirements defined in such a standard, some devices currently on the market use appropriate shape lenses (figure 1a) so as to obtain the desired lighting distribution on a reference surface. These devices have the drawback of presenting a too high luminance, since the observer sees the radiation coming from a small area corresponding to the virtual image of the LED.

In other known devices, shown in figure 1b, mirror-like reflectors are used, which partly deflect the radiation of the LED. These devices have the drawback of however presenting an excessive luminance, since the radiation seems to come from the LED itself for the direct light, or from the virtual LED source (mirror-like reflector) for the reflected light.

Another solution, used in some devices shown in figure 1c, is to take sets of LED, shielded from diffusing filters. In this case, it is possible to use a sufficiently diffusing material so as to allow to effectively reduce the luminance, given the large surface of the screens, but the transmission efficiency is generally low.

Finally, a solution as shown in figure 1d, involves the use of light guides, usually made of plexiglass, which work by exploiting the inner reflection through their properly polished walls. A drawback of this latter solution is the light refraction through the walls, which causes a low efficiency of the lighting body.

Of course, as far as it is possible to provide a lighting device according to the above mentioned standards, taking the last two solutions, the low efficiency which would result would prevent the advantages
ascribable to the choice of the LEDs as light sources. Indeed, by reducing the efficiency, it would be necessary to increase the number of diodes used and consequently the energy consumption, as well as the size volume of the lighting body.

It remains thus, at the state of the art, the lack of a LED optical system, able to comply with the standards and which, at the same time, allows to also use the features of the LEDs that make them advantageous compared to other light sources.

Purpose of the present invention is therefore to overcome the drawbacks of the prior art, creating an optical system for uniform distribution of light emitted by punctiform light sources.

In particular, primary purpose of the present invention is to design an optical system for limiting dazzling caused by direct or indirect light of LEDs, without for this reason losing the efficiency of the lighting body obtained.

Further purpose of the invention is to provide an optical system for uniform distribution of light emitted by punctiform light sources, in which the radiations coming from these sources undergo only one reflection, in order to avoid the efficiency losses that usually occur with the multiple reflections.

Purpose of the invention, moreover, is to provide an optical system for uniform distribution of light emitted by punctiform light sources, in which these sources are not visible either directly or indirectly, reflected on a reflector.

Yet another purpose of the present invention is to indicate an optical system for uniform distribution of light emitted by punctiform light sources, which ensures sufficiently high and rationally distributed luminance, in connection with the lighting deriving from ambient or external light, in order to allow the perception of the important areas, as well as of the details, and minimize any form of dazzling.

Finally, purpose of the present invention is to carry out an efficient optical system of simple and economic construction, so as it can be put into the market at a competitive price, offering an advantageous
energy saving.

In this general contest of search of getting the best aesthetic and technical features for a lighting apparatus, the present invention fits in, aimed at achieving elegance, efficiency and reliability features in an optical system for uniform distribution of light emitted by punctiform light sources, whose structure, in this way, presents aesthetic and functional advantages.

These and other purposes, according to the present invention, are achieved through an optical system for uniform distribution of light emitted by punctiform light sources, according to the attached claim 1.

Additional technical features are contained in the subsequent dependent claims.

The present invention will now be described, by illustrative, but not limiting, way, according to an embodiment thereof, with particular reference to the attached figures, in which the operation of the system according to the invention is schematically shown. In particular,

- figure 1a shows schematically a first optical system for the diffusion of the light emitted by a punctiform light source according to a first known solution;

- figure 1b shows schematically a second optical system for the diffusion of the light emitted by a punctiform light source according to a second known solution;

- figure 1c shows schematically a third optical system for the diffusion of the light emitted by a punctiform light source according to a third known solution;

- figure 1d shows schematically a fourth optical system for the diffusion of the light emitted by a punctiform light source according to a fourth known solution;

- figure 2 is a perspective view from the bottom of an optical system according to the invention;

- figure 3 is an assonometric cross-section of the optical system of figure 2, in which the screening element is not present;

- figure 4 is a sectional view of half of the primary optical system of
figure 3, in which the schematic rays tracing is shown, in the ideal
case of punctiform light source and totally mirror-like reflector;
and
- figure 5 shows the rays tracing in the optical system of figure 2 with
diffusing primary optics and screening element.

With particular reference to the mentioned figures 2, 3, 4 and 5,
the optical system, object of the invention, which can be partly or fully
used, in one or more units, in the design of a reflector for lighting
apparatuses, is defined as follows.

The optical system, indicate with the reference number 1 in the
figures, consists of a primary optics 2 and a screening element 3.

The primary optics 2 is formed by one or more sets of LEDs 4
and one or more diffusing reflective surfaces 5.

From now on, it has to be intended for "diffusing surface" any
surface with non-null component of diffuse reflectance, even in presence
of mirror-like component.

The screening element 3 consists of an anti-dazzling grid with
one or more reeds 6.

The particularity of the primary optics 2 consists in that the
radiation 7, coming out of it, is not the direct radiation 8 of the LEDs 4. The
LEDs 4 are not directly visible and their radiation 8 is conveyed outside the
apparatus is conveyed by the diffusing reflective surfaces 5. The direct
radiations 8 of the LEDs 4 are thus distributed on an area larger than
those ones of emission, namely those one of the LED 4 themselves. The
luminance resulting from such a primary optics 2, then, is lower than that
one which would arise in case of direct light emission by the same group
of LEDs 4.

A further reduction, due to the application of the screening
element 3, which consists of anti-dazzling grid, adds to the consequent
dazzling reduction, necessary for satisfying the aforesaid standard.

Another specificity consists in the shape of the diffusing
reflective surfaces 5 and in the position of the LEDs 4 with respect to
them: the primary optics 2 is designed so that the radiations 8 coming from
the LEDs undergo a single reflection, thus avoiding efficiency loss which would arise with multiple reflections. In order to increase efficiency, highly reflective materials are used to produce the diffusing reflective surfaces 5.

In particular, in the embodiment described, the material used is satiny aluminium with high reflectance; alternatively, plastic or metallic materials, painted with a diffusing white paint with high reflectance, can be used, obtaining in this second case a better comfort, although at the expense of efficiency.

With reference to figures 3 and 4, the primary optics 2 consists of two parts 9 symmetrical with respect to a central plane 10. The reflector is obtained by extruding an elliptical profile in each part 9.

The LEDs 4 are arranged along a row 11 coincident with the axis perpendicular to the plane of the ellipse, passing through one of the focus F1 of the ellipse itself. In figure 4 the tracing of rays 7, 8 is shown in section, in the simplified case of only one punctiform light source with bidimensional emission on the drawing plane and in case of a mirror-like reflector. In the ideal case of mirror-like reflector the radiation 7 is directed from the reflective surface 5 towards the outside of the primary optics 2, after giving undergone a single reflection on it.

With this geometry, indeed, a virtual source 12 is obtained, at the axis passing through the other focus F2 of the ellipse. The cut of the part 9, at the axis passing through the two foci F1, F2, prevents the radiation 7, coming from the virtual source 12, to meet again the reflective surface 5.

So far a particular embodiment of the primary optics included in optical system according to the invention has been described, inherent the extrusion of an elliptical profile, but it has to be understood that the same result can be achieved by providing any profile, able to convey towards the outside the radiations coming from a mono or bidimensional LED light source, minimizing the number of interactions with the reflector. Of course, the profile can also be obtained by bending, moulding, or any other technique available at the time of the provision of the optical system, suitable for the material used.
The second focus $F_2$ of the ellipse, where most of the rays 7 concentrate, coming from the ideal punctiform source 12, after having been reflected by the reflecting surface 5, can be placed in a different position compared to that one illustrated, provided that the abovementioned requirements are met, of minimizing the number of interactions with the reflective surfaces 5.

In order to avoid seeing the image of the reflected LEDs over the reflecting surface 5, the inner surface of primary optics 2 is obtained by using a diffusing instead of mirror-like material. This also allows to increase the emitting surface thereby reducing the dazzling coming from the apparatus.

Once defined the profile of the primary optics 2, the LEDs 4 are oriented so as to maximize the flow coming out from the apparatus.

Referring now to figures 2 and 5, as already mentioned, the screening element 3 is a CPC (Compound Parabolic Concentrator) anti-dazzling grid, which reduces the angle of emission of the radiation by the primary optics 2.

In order to meet the abovementioned standard, the reeds 6 of the grid are designed with an angle having a cut-off value of 60 degrees. With angles greater than 65° with respect to the vertical direction, a luminance lower than 200 cd/m² is reached.

The use of a CPC grid for the screening element must not be intended as restrictive. The screening element could also consist for instance of reeds obtained from extruded circumference arcs or planes.

The primary optics 2 and the screening element 3 form together a single complete optical system 1 (or cell) that can be repeated depending on the overall output flow required for the lighting apparatus to which it is desired to applied it.

In the embodiment described herein, represented in Figure 2, two cells 1, symmetric with respect to a plan, constitute a basic form.

In an alternative embodiment of the invention, an elementary module may consist of a single cell 1 or any number of cells 1 arranged according to various symmetry criteria, or even one of the two parts 9 of
the primary optics 2, with an appropriate screening element, if necessary.

Advantageously, by applying the optical unit according to the invention to a lighting body, it is possible to light very wide areas, still ensuring a substantially uniform lighting on the work top.

Further advantage of the present invention is to obtain an emission of indirect light, being the light source used invisible.

Another advantage of the current invention is to provide a smaller number of light sources in order to get the lighting level required by the regulations, thanks to the high efficiency of LED light sources and thanks to the high efficiency of the optical system described.

The present invention has been described by illustrative, but not limiting, way according to a preferred embodiment thereof, but is has to be understood that changes and/or modifications may be made by the men skilled in the art without for this reason departing from the relative scope of protection, as defined by the appended claims.
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CLAIMS

1. Optical system (1) for uniform distribution of light emitted by light sources, comprising at least one optical device (9), or primary module, having one or more rows (11) of light sources (4), said system being characterized in that:
   - said optical device or primary module (9) has a profile suitable for reflecting the rays (8) arriving from said one or more rows (11) of light sources (4),
   and in that
   - said one or more rows (11) of light sources (4) is placed within said profile, said profile having inside reflecting surfaces (5) suitable for reflecting said rays (8) along a direction not intersecting said reflecting surfaces (5), without any direct light output from said light sources (4).

2. Optical system (1) according to claim 1, characterized in that said light sources (4) comprise punctiform light sources, particularly, e.g., LEDs.

3. Optical system (1) according to claim 1 or 2, characterized in that said primary module (9) has at least one elliptical portion, with a first (F1) focus and a second (F2) focus, said one or more rows (11) of light sources (4) coinciding with the axis passing through said first focus (F1), or being close to the same.

4. Optical system (1) according to one of claims 1-3, characterized in that said reflecting surfaces (5) are realised using a diffusing or a partially diffusing material.

5. Optical system (1) according to claim 4, characterized in that said diffusing material is high reflectance satinated aluminium.

6. Optical system (1) according to claim 4, characterized in that said diffusing material is a plastic or metallic material, painted with a diffusing high reflectance white paint.

7. Optical system (1) according to one of claims 1-6, characterized in that it comprises at least two primary modules (9), arranged in pairs symmetrically with respect to a vertical plane (10), parallel to said one or more rows (11) of light sources (4), or combined
according to different symmetries.

8. Optical system (1) according to one of claims 1-7, characterized in that it further includes a screening element (3), consisting of a CPC anti glare grid, or extruded arcs of a circle or plans.
Fig. 1a
PRIOR ART

Fig. 1b
PRIOR ART

Fig. 1c
PRIOR ART

Fig. 1d
PRIOR ART
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. G02B17/06 F21V7/08

**A. CLASSIFICATION OF SUBJECT MATTER**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. MINIMUM CLASSIFICATION**

Minimum documentation searched (classification system followed by classification symbols)

G02B F21V

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of Box C.

See patent family annex.

**Date of the actual completion of the international search**

18 August 2011

**Date of mailing of the international search report**

24/08/2011

Name and mailing address of the ISA:

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Authorized officer

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