

INDIRECT LIGHTING APPARATUS

TECHNICAL FIELD

[0001]

The present invention relates to an indirect lighting apparatus for irradiating a ceiling face or a wall face of a room with a light beam from a light source so as to light the inside of the room with a reflected light beam by, for example, cove lighting or cornice lighting.

BACKGROUND ART

[0002]

In a lighting method for suppressing glare while creating a soft atmosphere of a room, an indirect lighting apparatus has been conventionally used for irradiating an irradiation face such as a wall face, a floor face, or a ceiling face so as to light the inside of the room with a reflected light beam. As examples of such an indirect lighting apparatus 100 have been proposed various kinds of devices, in which a vapor lamp 104 serving as a light source is contained in a cavity 103 for containing a light source, formed on a boundary between a wall face 101 and a ceiling face 102, and then, a space S to be irradiated is irradiated with a reflected light beam obtained by reflecting a light beam L irradiated from the vapor lamp 104 on an irradiation face 105 such as the wall face 101 or the ceiling face 102, as shown in Fig. 8 (e.g., Patent Document 1).

Prior Art Document

Patent Document

[0003]

Patent Document 1: Japanese Patent Application Laid-open No. 2009-152145

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

In the above-described indirect lighting apparatus 100, a high uniformity ratio of illuminance can be obtained at the irradiation face 105 when a distance between the vapor lamp 104 serving as the light source and the irradiation face 105 is great. However, it is impossible to take a great distance between the vapor lamp 104 and the irradiation face 105 without any leakage of direct radiation from the vapor lamp 104 to the space S to be irradiated. In view of this, the vapor lamp 104 is normally installed in the vicinity of one end of the irradiation face. Therefore, the irradiation face 105 near the end on the side of the vapor lamp 104 is markedly bright; in contrast, the uniformity ratio of illuminance becomes more significantly degraded at the irradiation face 105 more apart from the vapor lamp 104.

[0005]

Hence, an object of the present invention is to provide an indirect lighting apparatus capable of increasing the uniformity ratio of illuminance at an irradiation face even in the case where a light source is installed at an end of the irradiation face.

MEANS FOR SOLVING THE PROBLEMS

[0006]

An indirect lighting apparatus in a first aspect according to the present invention irradiates a planar member with a light beam, and then, lights the planar member with a reflected light beam therefrom. The indirect lighting apparatus includes: an LED line lighting device including a plurality of LEDs aligned at one end of the planar member; and a luminous distributing lens for controlling a luminous distribution of a light beam emitted from the LED line lighting device, the luminous distributing lens being formed in such a manner as to achieve uniformity illuminance at an irradiation face of the planar member based on a previously calculated luminous distribution curve.

[0007]

In the indirect lighting apparatus in a second aspect according to the present invention in addition to the configuration of the indirect lighting apparatus in the first aspect, the luminous distribution curve is expressed by the following mathematic equation:

$$I = \frac{d^2 E}{\sin^n \theta}$$

wherein θ designates an incident angle with respect to the planar member; E denotes a normal illuminance at a position at which the light beam is incident into the planar member; d designates a distance from the planar member to a light source; I denotes an intensity of the light beam transmitting the luminous distributing lens; and n designates a variable ranging from 1 to 3.

[0008]

The indirect lighting apparatus in a third aspect according to the present invention, in addition to the configuration, further includes at least two or more LED line lighting devices for emitting light beams at different color temperatures, wherein a light emitting color temperature can be changed by allowing either one of the LED line lighting devices to emit the light beam.

[0009]

In an indirect lighting apparatus in a fourth aspect according to the present invention in addition to the configuration, the indirect lighting apparatus is either cove lighting for irradiating a ceiling face with a light beam or cornice lighting for irradiating a wall face with a light beam.

[0010]

With the indirect lighting apparatus according to the first aspect, the LED line lighting device including the plurality of LEDs serves as a light source, so that the LEDs having an advantage of a lifetime or power consumption can be used to uniformly irradiate an irradiation face in a widthwise direction. In addition, the luminous distribution of the light beam emitted from the LED line lighting device is controlled by the luminous distributing lens such that the uniform illuminance at the irradiation face of the planar member can be achieved, thus increasing the uniformity ratio of illuminance at the irradiation face.

[0011]

With the indirect lighting apparatus according to the second aspect, the intensity I at each of the incident angles θ obtained based on the above-

described mathematical equation can be expressed as the luminous distribution curve. The light beam emitted from the LED line lighting device is controlled by the luminous distributing lens. The luminous distribution is controlled such that the intensity I at each of the incident angles θ matches with the luminous distribution curve. Thus, the uniformity ratio of illuminance can be increased at the irradiation face. Here, it is much preferable that the variable n is 3 by the cove lighting or the cornice lighting.

[0012]

With the indirect lighting apparatus according to the third aspect, the emitted light color temperature can be changed according to the variations in the case where either one of the two or more LED line lighting devices having different color temperatures is allowed to emit the light beam and the case where the other LED line lighting device is allowed to emit the light beam. Consequently, indirect lighting can be achieved at a more comfortable color temperature according to a use object or a time period of a room at which the indirect lighting apparatus is installed.

[0013]

With the indirect lighting apparatus according to the fourth aspect, the indirect lighting apparatus is either of the cove lighting for irradiating a ceiling face with a light beam and the cornice lighting for irradiating a wall face with a light beam. Thus, the indirect lighting apparatus can be appropriately used as a luminaire in a residential space in, for example, a residence.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a schematic cross-sectional view showing the installation of an indirect lighting apparatus by cornice lighting.

Fig. 2 is a perspective view showing the entire configuration of the indirect lighting apparatus.

Fig. 3 is a schematic cross-sectional view showing the shape of a luminous distributing lens in the indirect lighting apparatus.

Fig. 4 is a cross-sectional view showing distribution of a light beam incident into the luminous distributing lens from an LED line lighting device.

Fig. 5 is a graph illustrating a luminous distribution curve of a light beam transmitting the luminous distributing lens, the graph having an intensity on a vertical axis and an incident angle with respect to a wall face as a lateral axis.

Fig. 6 is a schematic cross-sectional view showing an indirect lighting apparatus having two LED line lighting devices in a modification.

Fig. 7 is a schematic cross-sectional view showing an indirect lighting apparatus by cove lighting in an embodiment.

Fig. 8 is a schematic cross-sectional view showing one example of an indirect lighting apparatus in the related art.

MODES FOR CARRYING OUT THE INVENTION

[0015]

A description will be specifically given below of an indirect lighting

apparatus 1 in a best embodiment with reference to Figs. 1 to 7. An indirect lighting apparatus 1 in the present embodiment is installed in one room 2 in a residential building such as an apartment house or a house. Here, the installation site of the indirect lighting apparatus 1 is not limited to the room 2 in the residential building, but may be a space in a corridor, a stairway, a commercial facility, or an office building. As shown in Fig. 1, the indirect lighting apparatus 1 is a lighting unit that is contained inside of an elongated cavity 4a formed along one side of a ceiling face 3 constituting the room 2. The indirect lighting apparatus 1 includes an elongated frame 11 formed into a C shape in cross section, a board 12 fixed inside of the frame 11, an LED line lighting device 14 including a plurality of LEDs 13 arranged on the board 12, and a luminous distributing lens 15 for controlling luminous distribution of the LED line lighting device 14. The indirect lighting apparatus 1 is secured inside of the cavity 4a via, for example, a support arm 16 that is held in a building body at one end thereof, so that the indirect lighting apparatus 1 receives electric power through an electric wiring. The method for securing the indirect lighting apparatus 1 is not limited to this, and therefore, the frame 11 per se may be fixed to the building body via a bolt, not shown.

[0016]

As shown in Figs. 2 and 3, the frame 11 is a resin or metallic frame whose inner face 11a is whitened or mirrored so as to collimate light beams emitted from the LEDs 13 in an irradiation direction. The board 12 is securely contained inside of the frame 11, and has a plurality of sockets aligned for fixing the LEDs 13 in a longitudinal direction. Each of the LEDs

13 is a light emitting diode configured in combination of one or more light emitting chips so as to emit a light beam at a desired color temperature. The LEDs 13 are secured in the sockets aligned in the board 12, respectively, thereby configuring the LED line lighting device 14.

[0017]

The luminous distributing lens 15 is an elongated transparent or translucent resin member to be fitted to the frame 11 on an opening side. The luminous distributing lens 15 is formed into a curved shape at its surface in such a manner that the light beam emitted from the LED line lighting device 14 can be distributed in a desired luminous distribution curve. That is to say, the luminous distribution curve of the light beam emitted from the LED line lighting device 14 is previously measured, and then, luminous distribution characteristics of a light beam directly incident into the luminous distributing lens 15 from the LED line lighting device 14 and a light beam reflected on the inner face 11a of the frame 11 into the luminous distributing lens 15 are calculated. The surface shape of the luminous distributing lens 15 is machined in such a manner that the luminous distributing lens 15 refracts the incident light beams so as to form a luminous distribution curve expressed by Mathematic Equation 2 below. The luminous distribution of the light beam emitted from the LED line lighting device 14 is controlled when the light beam transmits the luminous distributing lens 15, and then, is incident on the wall face 5, so that the reflected light lights the inside of the room 2, as shown in Fig. 4.

[0018]

As is clearly shown in Fig. 4, Mathematic Equation 2 expresses an

intensity I (cd) of the light beam transmitting the luminous distributing lens 15 at each of incident angles θ° with respect to the wall face 5, wherein E (lx) denotes a normal illuminance at the height of the light beam incident into the wall face 5, and d (mm) designates a horizontal distance from the wall face 5 to the light source. A variable n is 3 in the present embodiment. Incidentally, the luminous distribution curve based on Mathematic Equation 2 is indicated by a curve A in Fig. 5.

[Mathematic Equation 2]

$$I = \frac{d^2 E}{\sin^n \theta}$$

[0019]

The intensity I of the light beam transmitting the luminous distributing lens 15 becomes greater as the incident angle θ with respect to the wall face 5 approaches 0° , as illustrated in Fig. 5. In other words, as the incident height is more equal to a floor face 6, a distance H from the light source is greater, and the incident angle θ is smaller, the intensity I becomes greater. In view of this, the light beam having a greater intensity I is incident in the vicinity of the floor face 6 that is remote from the light source and has a relatively smaller incident angle θ , as indicated by (A) in Fig. 4, whereas the light beam having a smaller intensity I is incident in the vicinity of the ceiling face 3 that is close to the light source and has a relatively greater incident angle θ , as indicated by (B) in Fig. 4. Consequently, the uniformity ratio of illuminance on the wall face 5 can be

increased.

[0020]

Incidentally, in the case where the variable n is 3 in Mathematic Equation 2, the uniformity ratio of illuminance on the wall face 5 becomes excellent. Irrespective of this, the variable n may take any numerical values within a range from 1 or more to 3 or less according to factors such as other lighting environment or the preference of a resident. Here, the luminous distribution curve in the case of the variable n of 2 is indicated by a curve B in Fig. 5: in contrast, the luminous distribution curve in the case of the variable n of 1 is indicated by a curve C in Fig. 5.

[0021]

Although one LED line lighting device 14 is used in the present embodiment, the number of LED line lighting devices 14 may be two or more. As shown in Fig. 6, in the case where the number of LED line lighting devices 14 is, for example, two, LEDs 13 constituting one LED line lighting device 14a may emit light beams of a cold color whereas LEDs 13 constituting the other LED line lighting device 14b may emit light beams of a warm color. With this configuration, the LED line lighting device 14a emits the light beams of a cold color in the morning or daytime whereas the LED line lighting device 14b emits the light beams of a warm color at night, thus achieving the indirect lighting apparatus 1 for emitting the light beams at a comfortable color temperature according to a life cycle of the resident. Here, all of the LEDs 13 per se may emit the light beams of the same color, and further, a film for changing a color temperature may be stuck onto one of the luminous distributing lenses 15. Here, although it is preferable that

the LED line lighting device 14a should emit the light beams of the cold color at a color temperature of, for example, about 5000 kelvin whereas the LED line lighting device 14b should emit the light beams of the warm color at a color temperature of, for example, about 3000 kelvin, an optimum color temperature may be chosen according to the preference of the resident or the color of the wall face 5.

[0022]

Moreover, although the description has been given of the present embodiment in which the indirect lighting apparatus 1 is the lighting unit contained inside of the cavity 4a formed along one side of the ceiling face 3, for irradiating the wall face 5 with the light beam by the cornice lighting, the present invention may be applicable to an indirect lighting apparatus 1 attached at the upper end of the wall face 5, for irradiating the ceiling face 3 by the cove lighting.

[0023]

In, for example, the cove lighting, a cavity 4b is formed along an upper edge of the wall face 5, and then, an indirect lighting apparatus 1 is contained inside of the cavity 4b. As shown in Fig. 7, the indirect lighting apparatus 1 includes an elongated frame 11 formed into a C shape in cross section, a board 12 fixed inside of the frame 11, an LED line lighting device 14 including a plurality of LEDs 13 arranged on the board 12, and a luminous distributing lens 15 for controlling luminous distribution of the LED line lighting device 14, and further, is fixed to a building body via, for example, a support arm 16, like the above-described cornice lighting. The LED line lighting device 14 includes two LED line lighting devices 14a and

14b of, for example, a warm color and a cold color. Both or either one of the two LED line lighting devices 14a and 14b is lighted or extinguished according to factors such as representation of a room 2 or preference of a resident.

[0024]

The luminous distributing lens 15 is formed in such a manner as to convert the light beams emitted from the LED line lighting device 14 into light beams having a luminous distribution curve expressed by Mathematical Equation 2 above. In the cove lighting, Mathematical Equation 2 determines an intensity I (cd) of the light beam transmitting the luminous distributing lens 15 at each of incident angles θ° with respect to the ceiling face 3, wherein E (lx) denotes a normal illuminance at the position of the light incident into the wall face 5, and d (mm) designates a vertical distance from a ceiling to the light source. A variable n is 3, like in the above-described embodiment.

[0025]

With the above-described configuration, the intensity I of the light beam transmitting the luminous distributing lens 15 becomes greater as the incident angle θ with respect to the ceiling face 3 approaches 0° . Therefore, as the light incident position is more located on a side opposite to a side on which the indirect lighting apparatus 1 is installed, a distance from the LED line lighting device 14 serving as the light source is greater, and as the incident angle θ is smaller, the intensity I becomes greater. In view of this, the light beam having a greater intensity I is incident onto the side opposite to the side on which the indirect lighting apparatus 1 is installed at the

ceiling face 3 having a relatively smaller incident angle θ while the light beam having a smaller intensity I is incident on the side where the indirect lighting apparatus 1 is installed at the ceiling face 3 that is near the light source or has a relatively greater incident angle θ . Consequently, the uniformity ratio of illuminance on the wall face 5 can be increased.

[0026]

Like in the above-described embodiment, in the case where the variable n is 3 in Mathematic Equation 2, the uniformity ratio of illuminance on the wall face 5 becomes most excellent. However, the variable n may take any numerical values within a range from 1 or more to 3 or less.

[0027]

Incidentally, it is to be understood that the present invention should not be limited to the above-described embodiments, and therefore, various modifications and alterations should be appropriately embodied within a range without departing from the scope of the idea of the present invention.

Industrial Applicability

[0028]

The present invention is preferably applicable to the indirect lighting apparatus 1 for lighting the room 2 by the cove lighting or the cornice lighting.

Explanation of Reference Numerals

[0029]

- 1 indirect lighting apparatus
- 3 ceiling face (planar member)

- 4 wall face (planar member)
- 13 LED
- 14 LED line lighting device
- 15 luminous distributing lens

CLAIMS

1. An indirect lighting apparatus for irradiating a planar member with a light beam, and then, lighting the planar member with a reflected light beam therefrom, the indirect lighting apparatus comprising:

an LED line lighting device including a plurality of LEDs aligned at one end of the planar member; and

a luminous distributing lens for controlling a luminous distribution of a light beam emitted from the LED line lighting device,

the luminous distributing lens being formed in such a manner as to achieve uniformity illuminance at an irradiation face of the planar member based on a previously calculated luminous distribution curve.

2. The indirect lighting apparatus according to claim 1, wherein the luminous distribution curve is expressed by the following mathematic equation:

$$I = \frac{d^2 E}{\sin^n \theta}$$

wherein θ designates an incident angle with respect to the planar member;

E denotes a normal illuminance at a position at which the light beam is incident into the planar member;

d designates a distance from the planar member to a light source;

I denotes an intensity of the light beam transmitting the luminous

distributing lens; and

n designates a variable ranging from 1 to 3.

3. The indirect lighting apparatus according to claim 1 or claim 2, further comprising at least two or more LED line lighting devices for emitting light beams at different color temperatures, wherein

a light emitting color temperature can be changed by allowing either one of the LED line lighting devices to emit the light beam.

4. The indirect lighting apparatus according to any one of claims 1 to 3, the indirect lighting apparatus being either cove lighting for irradiating a ceiling face with a light beam or cornice lighting for irradiating a wall face with a light beam.

Fig. 5

- 1 INTENSITY
- 2 FLOOR
- 3 ANGLE
- 4 CEILING