

[DESCRIPTION]

[Title of Invention] LIGHTING SYSTEM

[Technical Field]

[0001]

5 The present invention relates to a lighting system.

[Background Art]

[0002]

 Depending on a color of light emitted from a lighting fixture or
the like, the temperature a person feels is known to change, or more
10 specifically, a person feels warm or cool. For example, a person
feels cool (has a cool feeling) when seeing cool color light and feels
warm (has a warm feeling) when seeing warm color light.

[0003]

 Using this, for example, Patent Literature (PTL) 1 discloses a
15 lighting device that maintains or increases comfort of a person by
controlling a light color of a light source according to the humidity
and temperature.

[Citation List]

[Patent Literature]

20 [0004]

[PTL 1] Japanese Unexamined Patent Application Publication No.
2009-230907

[Summary of Invention]

[Technical Problem]

25 [0005]

 However, the effect of causing a warm or cool feeling may
decrease for a person who stays for a long time in a space illuminated
by a conventional lighting fixture.

[0006]

30 In view of this, the present invention has an object to provide
a lighting system that is capable of effectively causing a person to
feel a warm or cool feeling.

[Solution to Problem]

[0007]

35 A lighting system according to an aspect of the present

invention includes: a first lighting fixture that is adjustable for an amount and a color of light emitted from the first lighting fixture; and a signal generator that generates a light modulation signal for adjusting the amount and the color of the light emitted from the first lighting fixture, wherein the first lighting fixture includes: a first light source that emits first light of a first light color; a second light source that emits second light of a second light color higher in hue than the first light color; and a light source controller that obtains the light modulation signal from the signal generator, and adjusts an amount of light for each of the first light source and the second light source, based on the light modulation signal, the signal generator generates the light modulation signal that causes the color of the light emitted from the first lighting fixture to repeatedly change between the first light color and the second light color, and the color of the light emitted from the first lighting fixture increases in hue as the color changes from the first light color to the second light color.

[Advantageous Effects of Invention]

[0008]

A lighting system according to the present invention is capable of effectively causing a person to feel a warm or cool feeling.

[Brief Description of Drawings]

[0009]

FIG. 1 is a diagram schematically illustrating a configuration of a lighting system according to an embodiment.

FIG. 2 is a block diagram illustrating a configuration of the lighting system according to the embodiment.

FIG. 3 is a CIE 1931 color space xy chromaticity diagram for describing colors of light emitted from a first light source, a second light source, a third light source, and a fourth light source included in a first lighting fixture according to the embodiment.

FIG. 4 is a schematic diagram illustrating cross-sectional views of the first light source, the second light source, the third light source, and the fourth light source included in the first lighting fixture according to the embodiment.

FIG. 5 is the CIE 1931 color space xy chromaticity diagram

illustrating an example of a toning range of the first lighting fixture according to the embodiment.

FIG. 6 is a diagram illustrating an example of a warm or cool feeling that changes with time.

5 FIG. 7 is a diagram illustrating an example of temporal change in hue of light emitted from the first lighting fixture according to the embodiment.

FIG. 8 is a diagram illustrating an influence on color discrimination caused by a delay in start of presentation.

10 FIG. 9 is a flowchart of example operation 1 performed by a signal generator according to the embodiment.

FIG. 10 is a flowchart of example operation 2 performed by the signal generator according to the embodiment.

15 FIG. 11 is a flowchart of example operation 3 performed by the signal generator according to the embodiment.

FIG. 12A is a diagram for describing an example of a relationship between room temperature and comfort.

FIG. 12B is a diagram for describing an example of a relationship between room temperature and comfort.

20 FIG. 13 is a flowchart of example operation 4 performed by the signal generator according to the embodiment.

[Description of Embodiment]

[0010]

Hereinafter, embodiments will be described in detail with
25 reference to the Drawings. Note that each of the following embodiments shows a generic or specific example. The numerical values, shapes, materials, components, the arrangement and connection of the components, steps, the processing order of the steps, etc., shown in the following embodiments are mere examples,
30 and thus are not intended to limit the present invention. Furthermore, the respective figures are schematic diagrams in which emphasis, omission, or proportion adjustment has been carried out in order to show the present invention. The respective figures are not necessarily accurate illustrations, and thus actual shapes,
35 positional relations, and proportions may differ.

[0011]

[Embodiment]

The following describes a lighting system according to the present embodiment.

5 [0012]

[Configuration of Lighting System]

A configuration of the lighting system according to the present embodiment is first described with reference to FIG. 1 and FIG. 2.

[0013]

10 FIG. 1 is a diagram schematically illustrating a configuration of lighting system 1 according to the present embodiment. FIG. 2 is a block diagram illustrating the configuration of lighting system 1 according to the present embodiment.

[0014]

15 Lighting system 1 includes first lighting fixture 10, second lighting fixture 20, lighting control device 30, and operator 40. Lighting control device 30 includes signal generator 31 that generates a first light modulation signal that is an example of a light modulation signal used for adjusting an amount and a color of light
20 emitted from first lighting fixture 10. Although not illustrated, each of first lighting fixture 10, second lighting fixture 20, lighting control device 30, and operator 40 is supplied with operating electric power from an internal electric power source, such as a battery, or from an external electric power source. Lighting system 1 is installed in an
25 indoor space, such as an office, a factory, a commercial facility, a hotel, or a restaurant.

[0015]

First lighting fixture 10 is adjustable for an amount and a color of light emitted from first lighting fixture 10. First lighting fixture
30 10 emits light of a color that causes a person to feel a warm-cold feeling. First lighting fixture 10 emits light to walls and/or a ceiling of the indoor space mainly. For example, first lighting fixture 10 is a space-creation lighting fixture, and thus used for space creation in an indoor space. To be more specific, first lighting fixture 10 is a
35 lighting fixture for coffer lighting, cornice lighting, cove lighting, or

floor-stand lighting. First lighting fixture 10 illustrated in the example is mounted on a ceiling. However, first lighting fixture 10 may be mounted to a wall or set to stand on a floor surface. In FIG. 1, the number of first lighting fixtures 10 included in lighting system 1 is two. However, the number of first lighting fixtures 10 included in lighting system 1 is not limited to two, and may be one or three or more.

[0016]

Second lighting fixture 20 emits white light. Second lighting fixture 20 emits light to a floor surface of the indoor space mainly. For example, second lighting fixture 20 is a work lighting fixture, and thus emits light necessary for work (such as reading, writing, visual work, hand work, operation using an electronic device, and eating) of a worker in the indoor space. To be more specific, second lighting fixture 20 is used for downlighting, ceiling lighting, or base lighting. In FIG. 1, the number of second lighting fixture 20 included in lighting system 1 is three. However, the number of second lighting fixture 20 included in lighting system 1 is not limited to three, and may be one, two, or four or more.

[0017]

Second lighting fixture 20 may include a plurality of light sources, and may be capable of dimming and toning by adjusting the amount of light for each of the plurality of light sources. The tone of white light emitted from second lighting fixture 20 is adjusted in a range of correlated color temperature between 2700 K to 7200 K. The tone of white light emitted from second lighting fixture 20 may be adjusted in a range of correlated color temperature between 2700 K to 6500 K.

[0018]

Here, light emission ranges of first lighting fixture 10 and second lighting fixture 20 are described.

[0019]

Second lighting fixture 20 emits light to work area A in which a worker performs work. The center of the light emission range of second lighting fixture 20 (a direction of the optical axis) is located in

a floor surface of the indoor space or in a horizontal surface of a work desk, for example.

[0020]

First lighting fixture 10 emits light outside the light emission
5 range of second lighting fixture 20. The light emission range of first
lighting fixture 10 may partly (for example, half or less than half the
light emission range of first lighting fixture 10) overlap or may not
overlap with the light emission range of second lighting fixture 20.
The center of the light emission range of first lighting fixture 10 is
10 located outside the light emission range of second lighting fixture 20,
for example. The center of the light emission range of first lighting
fixture 10 is located in a vertical plane, such as a wall, a shelf, or a
partition in the indoor space. For example, first lighting fixture 10
does not emit light to work area A. If the plurality of first lighting
15 fixtures 10 are used as illustrated in the diagram, the light emission
ranges of second lighting fixtures 20 may be located between the
light emission ranges of the plurality of first lighting fixtures 10.

[0021]

In this way, second lighting fixture 20 emits the white light to
20 work area A. Moreover, first lighting fixture 10 emits, outside the
light emission range of second lighting fixture 20, the light of a color
that causes the person to feel a warm or cool feeling as described
below. If working in light of a chromatic color like the light of the
color that causes the person to feel the warm or cool feeling, the
25 worker may feel uncomfortable and thus working efficiency of the
worker may decrease. If working in the indoor space including
lighting system 1, the worker does not have to work in the light of a
chromatic color like the light of the color that causes the person to
feel the warm or cool feeling. More specifically, the worker can work
30 in work area A illuminated by the white light for working. Thus,
lighting system 1 controls an impression of the indoor space and
thereby effectively causes the person to feel the warm or cool feeling,
without reducing the working efficiency of the worker.

[0022]

35 Lighting control device 30 is a control device that generates

the first light modulation signal used for adjusting an amount and a color of light emitted from first lighting fixture 10. To be more specific, signal generator 31 of lighting control device 30 generates the first light modulation signal. Lighting control device 30
5 generates the first light modulation signal on the basis of information from various sensors or operation information from operator 40. Lighting control device 30 transmits the generated first light modulation signal to first lighting fixture 10. For example, lighting control device 30 integrated with first lighting fixture 10 is installed
10 in the indoor space. Lighting control device 30 may be separate from first lighting fixture 10 and placed in a location different from the location of first lighting fixture 10. For lighting system 1 including the plurality of first lighting fixtures 10, lighting control device 30 may be integrated with each of the plurality of first lighting
15 fixtures 10. At least one lighting control device 30 may be integrated with at least one first lighting fixture 10. Then, the at least one lighting control device 30 may transmit the first light modulation signal to the plurality of first lighting fixtures 10.

[0023]

20 Operator 40 is a remote controller that receives an operation from a user and that causes first lighting fixture 10 and second lighting fixture 20 to operate in response to the received operation. Operator 40 transmits the operation information that is used for causing first lighting fixture 10 and second lighting fixture 20 to
25 operate and that is thus related to lighting-up, lighting-out, dimming, or toning of first lighting fixture 10 and second lighting fixture 20. Operator 40 receives the operation from the user and generates the operation information based on the received operation. Operator 40 transmits the operation information to signal generator 31. For
30 example, operator 40 is a wall-mounted controller. Operator 40 may be an operating remote controller or a wall switch, for instance. Operator 40 may be implemented by installing an application program onto a general-purpose mobile terminal, such as a smartphone or a tablet terminal.

35 [0024]

Next, first lighting fixture 10 and lighting control device 30 of lighting system 1 are described in detail.

[0025]

[First Lighting Fixture]

5 As illustrated in FIG. 2, first lighting fixture 10 includes first light source 11, second light source 12, third light source 13, fourth light source 14, and light source controller 15.

[0026]

10 Colors of light emitted from first light source 11, second light source 12, third light source 13, and fourth light source 14 are first described. FIG. 3 is a CIE 1931 color space xy chromaticity diagram illustrating the colors of light emitted from first light source 11, second light source 12, third light source 13, and fourth light source 14 included in first lighting fixture 10 according to the present
15 embodiment.

[0027]

Each of first light source 11, second light source 12, third light source 13, and fourth light source 14 emits light of a different color. Note that first lighting fixture 10 need not include third light source
20 13 and fourth light source 14.

[0028]

First light source 11 emits first light of a first light color. For example, the first light color is a fixed light color. As illustrated in FIG. 3, the first light color is within basic color name area circle C1 of
25 white color defined by JIS Z 8110-1995, for example. Basic color name area circle C1 of white color defined by JIS Z 8110-1995 is an area specified in the CIE 1931 color space xy chromaticity diagram, by elliptic equations expressed as: center coordinates (0.333, 0.333); semi-major axis $a = 0.070$; semi-minor axis $b = 0.025$; and
30 slope θ (deg) with respect to major axis $x = 59$.

[0029]

Second light source 12 emits second light of a second light color that is higher in hue than the first light color. For example, the second light color is a fixed light color. As illustrated in FIG. 3, the
35 second light color has chromaticity coordinates in quadrilateral area

C2 with four vertices at $(x, y) = (0.200, 0.175)$, $(x, y) = (0.275, 0.270)$, $(x, y) = (0.220, 0.360)$, and $(x, y) = (0.155, 0.275)$ in the CIE 1931 color space xy chromaticity diagram, for example. The second light color having the chromaticity coordinates in area C2 is a cool light color. As known from the comfortable region of the Kruithof curve, a person feels gloomy and uncomfortable with a small amount of cool color light like a high color temperature light. In contrast, the person feels more comfortable with a small amount of warm color light like a low color temperature light. Thus, an illumination level at which the person feels comfortable is higher when cool color light is emitted than when warm color light is emitted. For example, when the cool color light is emitted, the illumination level at which the person feels comfortable is ten times as high as when the warm color light is emitted. Here, the light from second light source 12, which emits the second light color having the chromaticity coordinates in area C2, contains a wavelength of a region where human visibility is high. On this account, second light source 12 has high luminous efficiency. Thus, the second light of the second light color having the chromaticity coordinates in area C2 increases the luminous efficiency of second light source 12 and also increases the effect of causing the person to feel a cool feeling.

[0030]

In the present specification, one of two light colors that is higher in hue than the other has chromaticity coordinates relatively farther from the chromaticity coordinates of the equal-energy white color. The chromaticity coordinates of the equal-energy white color (the equal-energy white point) in the CIE 1931 color space xy chromaticity diagram are at $(x, y) = (0.333, 0.333)$.

[0031]

For example, a straight line passing through coordinates $(x, y) = (0.302, 0.692)$ and the equal energy white point at $(x, y) = (0.333, 0.333)$ is a boundary in the CIE 1931 color space xy chromaticity diagram. With respect to this boundary, a light color at chromaticity coordinates on the positive side in the x-axis direction is a warm color. Moreover, with respect to this boundary, a light color at chromaticity

coordinates on the negative side in the x-axis direction is a cool color, for example.

[0032]

Third light source 13 emits third light of a third light color. For example, the third light color is a fixed light color. As with the first light color, the third light color is within basic color name area circle C1 of white color defined by JIS Z 8110-1995, for example.

[0033]

Fourth light source 14 emits fourth light of a fourth light color that is higher in hue than the third light color. For example, the fourth light color is a fixed light color. As illustrated in FIG. 3, the fourth light color has chromaticity coordinates in quadrilateral area C3 with four vertices at $(x, y) = (0.380, 0.330)$, $(x, y) = (0.510, 0.360)$, $(x, y) = (0.470, 0.440)$, and $(x, y) = (0.350, 0.420)$ in the CIE 1931 color space xy chromaticity diagram, for example. The fourth light color having the chromaticity coordinates in area C3 is a warm light color. The fourth light of the fourth light color having the chromaticity coordinates in area C3 increases the luminous efficiency of fourth light source 14 and also increases the effect of causing the person to feel a warm feeling.

[0034]

Note that the second light color and the fourth light color may replace each other. For example, the second light color may have the chromaticity coordinates in area C3, and the fourth light color may have the chromaticity coordinates in area C2. More specifically, one of the second light color and the fourth light color may be a cool light color, and the other may be a warm light color.

[0035]

Furthermore, if the second light color is a warm light color, a maximum allowable amount of the second light emitted from second light source 12 may be greater than a maximum allowable amount of the fourth light emitted from fourth light source 14. For example, an increase in the suppliable amount of current or in the number of second light-emitting devices 121 described later increases the maximum allowable amount of the second light emitted from second

light source 12. This enables first lighting fixture 10 to emit a large amount of the second light of a cool light color that is required more than warm color light to make the person feel comfortable.

[0036]

5 If at least two of first light source 11, second light source 12, third light source 13, and fourth light source 14 emit light, first lighting fixture 10 emits light generated by mixing the light emitted from the at least two light sources.

[0037]

10 Note that the ranges of the chromaticity coordinates of the first light color, the second light color, the third light color, and the fourth light color described above are merely examples. The chromaticity coordinates of the first light color, the second light color, the third light color, and the fourth light color are not limited to the
15 examples described above.

[0038]

 Next, configurations of first light source 11, second light source 12, third light source 13, and fourth light source 14 are described in detail. FIG. 4 is a schematic diagram illustrating
20 cross-sectional views of first light source 11, second light source 12, third light source 13, and fourth light source 14 included in first lighting fixture 10 according to the present embodiment.

[0039]

 As illustrated in FIG. 4, first light source 11 includes first
25 light-emitting device 111, first fluorescent element 112, and sealant 200. First light source 11 is a chip-on-board (COB) light-emitting module. First light source 11 has first light-emitting device 111 mounted on board 300 and is sealed by sealant 200 in which first fluorescent elements 112 are dispersed. The first light emitted from
30 first light source 11 is a mix of light from first light-emitting device 111 and light from first fluorescent element 112. Although not illustrated, first light-emitting device 111 includes a metallic line for electric power supply, for example.

[0040]

35 Second light source 12 includes second light-emitting device

121, second fluorescent element 122, and sealant 200. The second light emitted from second light source 12 is a mix of light from second light-emitting device 121 and light from second fluorescent element 122. Third light source 13 includes third light-emitting device 131, third fluorescent element 132, and sealant 200. The third light emitted from third light source 13 is a mix of light from third light-emitting device 131 and light from third fluorescent element 132. Fourth light source 14 includes fourth light-emitting device 141, fourth fluorescent element 142, and sealant 200. The fourth light emitted from fourth light source 14 is a mix of light from fourth light-emitting device 141 and light from fourth fluorescent element 142. Each of second light source 12, third light source 13, and fourth light source 14 has the same configuration as first light source 11, and thus description of these light sources is omitted. Each of second light source 12, third light source 13, and fourth light source 14 is supplied with electric power from a circuit different from the circuit for first light source 11.

[0041]

First light source 11, second light source 12, third light source 13, and fourth light source 14 may be surface-mount device (SMD) light-emitting modules. Alternatively, first light source 11, second light source 12, third light source 13, and fourth light source 14 may be remote phosphor light-emitting modules. The number of first light source 11, second light source 12, third light source 13, and fourth light source 14 may be adjusted as appropriate according to the intended use.

[0042]

For example, each of first light-emitting device 111, second light-emitting device 121, third light-emitting device 131, and fourth light-emitting device 141 is either a blue light-emitting diode (blue LED) or a violet LED. A blue LED emits blue light with a main emission peak in a wavelength region from 430 nm to 460 nm. A violet LED emits violet light with a main emission peak in a wavelength region from 380 nm to 430 nm. Examples of the blue LED and the violet LED include a gallium nitride LED. First

light-emitting device 111, second light-emitting device 121, third light-emitting device 131, and fourth light-emitting device 141 may be LEDs that have the emission peaks at the same wavelength or at different wavelengths. To simplify power circuit design by equalizing their current-voltage characteristics, first light-emitting device 111, second light-emitting device 121, third light-emitting device 131, and fourth light-emitting device 141 are to be LEDs of the kind having the same emission peak wavelength. Note that first light-emitting device 111, second light-emitting device 121, third light-emitting device 131, and fourth light-emitting device 141 may be collectively referred to simply as the "light-emitting device".

[0043]

First fluorescent element 112 is excited by at least a part of light from first light-emitting device 111, and emits light of a wavelength longer than that of the light from first light-emitting device 111. For example, first fluorescent element 112 includes at least one of a red phosphor, a yellow phosphor, a green phosphor, or a blue phosphor. The number of kinds of phosphors included in first fluorescent element 112 may be one or two or more.

[0044]

Second fluorescent element 122 is excited by at least a part of light from second light-emitting device 121, and emits light of a wavelength longer than that of the light from second light-emitting device 121. For example, second fluorescent element 122 includes at least one of a blue phosphor or a green phosphor. The number of kinds of phosphors included in second fluorescent element 122 may be one or two or more.

[0045]

Third fluorescent element is excited by at least a part of light from third light-emitting device 131, and emits light of a wavelength longer than that of the light from third light-emitting device 131. For example, third fluorescent element 132 includes at least one of a red phosphor, a yellow phosphor, a green phosphor, or a blue phosphor.

[0046]

Fourth fluorescent element 142 is excited by at least a part of light from fourth light-emitting device 141, and emits light of a wavelength longer than that of the light from fourth light-emitting device 141. For example, fourth fluorescent element 142 includes at least one of a red phosphor or a yellow phosphor. The number of kinds of phosphors included in fourth fluorescent element 142 may be one or two or more. Note that first fluorescent element 112, second fluorescent element 122, third fluorescent element 132, and fourth fluorescent element 142 may be collectively referred to simply as the "fluorescent element".

[0047]

A red phosphor is excited by light from the blue LED or the violet LED and thereby emits red light having a main emission peak in a wavelength region from 600 nm to 650 nm. Examples of the red phosphor include $\text{Ca-}\alpha\text{-SiAlON:Eu}^{2+}$, $\text{CaAlSiN}_3\text{:Eu}^{2+}$, $(\text{Sr, Ca})\text{AlSiN}_3\text{:Eu}^{2+}$, $\text{Sr}_2\text{Si}_5\text{N}_8\text{:Eu}^{2+}$, $\text{Sr}_2(\text{Si, Al})_5(\text{N, O})_8\text{:Eu}^{2+}$, CaS:Eu^{2+} , and $\text{La}_2\text{O}_2\text{S:Eu}^{2+}$.

[0048]

A yellow phosphor is excited by light from the blue LED or the violet LED and thereby emits yellow light having a main emission peak in a wavelength region from 540 nm to 600 nm. Examples of the yellow phosphor include $(\text{Y, Gd})_3\text{Al}_5\text{O}_{12}\text{:Ce}^{3+}$, $\text{Y}_3\text{Al}_5\text{O}_{12}\text{:Ce}^{3+}$, Pr^{3+} , $(\text{Tb, Gd})_3\text{Al}_5\text{O}_{12}\text{:Ce}^{3+}$, $(\text{Sr, Ba})_2\text{SiO}_4\text{:Eu}^{2+}$, $(\text{Sr, Ca})_2\text{SiO}_4\text{:Eu}^{2+}$, $\text{CaSi}_2\text{O}_2\text{N}_2\text{:Eu}^{2+}$, $\text{Ca-}\alpha\text{-SiAlON:Eu}^{2+}$, $\text{Y}_2\text{Si}_4\text{N}_6\text{C:Ce}^{3+}$, and $\text{CaGa}_2\text{S}_4\text{:Eu}^{2+}$.

[0049]

A blue phosphor is excited by light from the blue LED or the violet LED and thereby emits blue light having a main emission peak in a wavelength region from 440 nm to 480 nm. Examples of the blue phosphor include $(\text{Ca, Sr, Ba})\text{MgAl}_{10}\text{O}_{17}\text{Eu}^{2+}$, $(\text{Ba, Sr, Ca, Mg})_2\text{SiO}_4\text{Eu}^{2+}$, $(\text{Mg, Ca, Sr, Ba})\text{Si}_2\text{O}_2\text{N}_2\text{:Eu}^{2+}$, $(\text{Ba, Sr, Ca})_3\text{Si}_6\text{O}_{12}\text{N}_2\text{:Eu}^{2+}$, and $(\text{Ba, Sr, Ca})_3\text{Si}_6\text{O}_9\text{N}_4\text{:Eu}^{2+}$.

[0050]

A green phosphor is excited by light from the blue LED or the violet LED and thereby emits green light having a main emission peak

in a wavelength region from 480 nm to 540 nm. Examples of the green phosphor include $\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Ce}^{3+}$, $\text{Tb}_3\text{Al}_5\text{O}_{12}:\text{Ce}^{3+}$, $\text{BaY}_2\text{SiAl}_4\text{O}_{12}:\text{Ce}^{3+}$, $\text{Ca}_3\text{Sc}_2\text{Si}_3\text{O}_{12}:\text{Ce}^{3+}$, $(\text{Ba}, \text{Sr})_2\text{SiO}_4:\text{Eu}^{2+}$, $\text{CaSc}_2\text{O}_4:\text{Ce}^{3+}$, $\text{Ba}_3\text{Si}_6\text{O}_{12}:\text{Eu}^{2+}$, $\beta\text{-SiAlON}:\text{Eu}^{2+}$, and $\text{SrGa}_2\text{S}_4:\text{Eu}^{2+}$.

5 [0051]

Note that the above examples of the phosphor for each color are merely examples. Phosphors commonly vary significantly in characteristics. On this account, a phosphor having one of the aforementioned composition formulas classified according to color
10 may emit light of a color different from its corresponding classified color.

[0052]

The kind of phosphor to be included, a combination ratio for at least two kinds of phosphors to be included, and the amount of
15 phosphor to be mixed with sealant 200 are adjusted for each of first fluorescent element 112, second fluorescent element 122, third fluorescent element 132, and fourth fluorescent element 142. This adjustment enables the first light, the second light, the third light, and the fourth light to achieve their intended colors.

20 [0053]

Sealant 200 is a translucent resin material that individually seals first light-emitting device 111, second light-emitting device 121, third light-emitting device 131, and fourth light-emitting device 141. Light from first light-emitting device 111, second
25 light-emitting device 121, third light-emitting device 131, fourth light-emitting device 141, first fluorescent element 112, second fluorescent element 122, third fluorescent element 132, and fourth fluorescent element 142 is to pass through the translucent resin material. However, the translucent resin material is not limited to a particular material. Examples of the translucent resin material
30 include a silicone resin, an epoxy resin, and a urea resin. For first light source 11, second light source 12, third light source 13, and fourth light source 14 illustrated in FIG. 2, the same kind of sealant 200 is used. However, a different kind of sealant may be used for
35 each of first light source 11, second light source 12, third light source

13, and fourth light source 14.

[0054]

First light source 11, second light source 12, third light source 13, and fourth light source 14 are mounted on board 300. For example, board 300 is a metal-base board, a resin board, or a ceramic board.

[0055]

Referring back to FIG. 2, light source controller 15 obtains the first light modulation signal by receiving the first light modulation signal from an external source, or more specifically, from signal generator 31. Then, on the basis of the first light modulation signal, light source controller 15 adjusts the amount of light for each of first light source 11, second light source 12, third light source 13, and fourth light source 14. In this way, dimming and toning are performed on the light emitted from first lighting fixture 10.

[0056]

Light source controller 15 provides electric power individually to first light source 11, second light source 12, third light source 13, and fourth light source 14 from a power circuit, for example. Light source controller 15 individually varies the amount of current for each of the light sources and thereby adjusts the amount of light for each of the first light, the second light, the third light, and the fourth light. Furthermore, control performed by light source controller 15 includes lighting-up and lighting-out. More specifically, light source controller 15 includes a dimmer switch, the power circuit, a current control circuit, and a dimming circuit. Light source controller 15 may further include a memory and a processor. Furthermore, light source controller 15 may also include a communication circuit for teleoperated control.

[0057]

[Lighting Control Device]

Next, lighting control device 30 is described. As illustrated in FIG. 2, lighting control device 30 includes signal generator 31, communicator 32, clock circuit 33, temperature sensor 34, light sensor 35, and microphone 36. Note that at least one of

communicator 32, clock circuit 33, temperature sensor 34, light sensor 35, and microphone 36 need not be included in lighting control device 30.

[0058]

5 Signal generator 31 generates the first light modulation signal used for adjusting an amount and a color of light emitted from first lighting fixture 10. More specifically, signal generator 31 generates the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to repeatedly change between the first
10 light color and the second light color or between the third light color and the fourth light color. For example, signal generator 31 is directly connected to light source controller 15 of first lighting fixture 10, and transmits the generated first light modulation signal to light source controller 15. Here, if first lighting fixture 10 and lighting
15 control device 30 are separately located, signal generator 31 may transmit the first light modulation signal to light source controller 15 via communicator 32 through wired or wireless communication.

[0059]

 Moreover, signal generator 31 may generate a second light modulation signal used for adjusting an amount and a color of light emitted from second lighting fixture 20. In this case, signal generator 31 transmits the second light modulation signal to second lighting fixture 20 via communicator 32 via wired or wireless communication, for example.

25 [0060]

 For example, signal generator 31 obtains operation information from operator 40 via communicator 32. Then, on the basis of the obtained operation information, signal generator 31 generates the first light modulation signal that causes first lighting
30 fixture 10 to operate according to an operation received by operator 40 from the user. Moreover, signal generator 31 may generate the second light modulation signal that causes second lighting fixture 20 to operate according to the operation received by operator 40 from the user.

35 [0061]

Furthermore, signal generator 31 obtains environmental information indicating at least one of a set temperature of air conditioner 50, an air temperature, a season, or a time of day, for example. Then, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit light of a color (a cool color or a warm color, for example) determined on the basis of the obtained environmental information.
[0062]

Moreover, signal generator 31 obtains light color information indicating a correlated color temperature of light emitted from second lighting fixture 20, for example. Then, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit light of a color (a cool color or a warm color, for example) determined on the basis of the obtained light color information.
[0063]

Furthermore, signal generator 31 obtains light amount information indicating the amount of light emitted from second lighting fixture 20, for example. Then, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit light of the amount determined on the basis of the obtained light amount information.
[0064]

Moreover, signal generator 31 obtains music information related to music played in a space equipped with the lighting system, for example. Then, signal generator 31 generates the first light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color in a cycle based on characteristics of the music included in the obtained music information.
[0065]

Furthermore, signal generator 31 stores an information table that associates each of the environmental information, the light color information, and the light amount information with a color and/or an amount of light to be emitted from first lighting fixture 10, for

example. Signal generator 31 determines the color and/or the amount of light to be emitted from first lighting fixture 10 by reference to the information table, for example.

[0066]

5 Signal generator 31 includes a central processing unit (CPU) and memories, such as a random access memory (RAM) and a read only memory (ROM). Signal generator 31 may be a microcomputer that includes a microprocessor and a memory for storing a program. Alternatively, signal generator 31 may be hardware that includes an
10 analog circuit and a digital circuit.

[0067]

Communicator 32 is a communication circuit via which signal generator 31 receives the operation information, the music information, the environmental information, the light color
15 information, and the light amount information. For example, communicator 32 receives the operation information, the light color information, and the light amount information from operator 40. For example, communicator 32 receives information indicating a set temperature of air conditioner 50 as the environmental information
20 from air conditioner 50. For example, communicator 32 receives information related to music played by audio device 60 as the music information from audio device 60. Communicator 32 transmits the received information to signal generator 31. Moreover, communicator 32 may transmit the first light modulation signal and
25 the second light modulation signal to first lighting fixture 10 and second lighting fixture 20, respectively. Communicator 32 may perform wired or wireless communication. A communication standard of the communication performed by communicator 32 is not limited to a particular standard. Communicator 32 includes a
30 communication interface for wired or wireless communication.

[0068]

Clock circuit 33 counts time and date, and outputs the environmental information indicating a season or a time of day based on the counted time and date.

35 [0069]

Temperature sensor 34 is a thermometer that detects an air temperature of the indoor space equipped with lighting system 1, for example. Temperature sensor 34 may be implemented by a temperature measuring element or circuit, for example.

5 Temperature sensor 34 outputs the environmental information indicating the detected air temperature.

[0070]

Light sensor 35 is a color photometer that measures an amount and a color of light emitted from sensor lighting fixture 20, for example. Light sensor 35 may be implemented by a photoelectric conversion element or circuit. Light sensor 35 outputs: the light amount information indicating the detected amount of the light emitted from second lighting fixture 20; and the light color information indicating the detected correlated color temperature of the light emitted from second lighting fixture 20.

15

[0071]

Microphone 36 collects the music played in the indoor space equipped with lighting system 1, for example. For example, microphone 36 includes a voice coil, a diaphragm that vibrates the voice coil, and a magnetic circuit that produces a magnetic field that passes through the voice coil. Microphone 36 outputs the music information related to the collected music.

20

[0072]

Note that clock circuit 33, temperature sensor 34, light sensor 35, and microphone 36 need not be included in lighting control device 30. Clock circuit 33, temperature sensor 34, light sensor 35, and microphone 36 may be individually installed separately from lighting control device 30, for example. In this case, the respective pieces of information from clock circuit 33, temperature sensor 34, light sensor 35, and microphone 36 may be transmitted to signal generator 31 via communicator 32.

30

[0073]

[Operation]

Next, an operation of lighting system 1 according to the present embodiment is described.

35

[0074]

First, the following describes an operation performed by lighting system 1 to cause the color of light emitted from first lighting fixture 10 to change between the first light color and the second light color or between the third light color and the fourth light color.

[0075]

Upon supply of electric power to first lighting fixture 10 and lighting control device 30, signal generator 31 generates the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to change between the first light color and the second light color or between the third light color and the fourth light color. Signal generator 31 may generate the first light modulation signal according to a predetermined condition. Alternatively, signal generator 31 may generate the first light modulation signal on the basis of the various pieces of information described later.

[0076]

Light source controller 15 of first lighting fixture 10 receives the first light modulation signal. Then, on the basis of the obtained first light modulation signal, light source controller 15 adjusts the amount of light for each of first light source 11, second light source 12, third light source 13, and fourth light source 14. Light source controller 15 individually adjusts the amount of current for each of first light source 11, second light source 12, third light source 13, and fourth light source 14 and thereby temporally varies the amount of light for each of first light source 11, second light source 12, third light source 13, and fourth light source 14. In this way, dimming and toning are performed on the light emitted from first lighting fixture 10.

[0077]

When receiving the first light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color, light source controller 15 passes current through first light source 11 and second light source 12 but does not pass current through third light source 13 and fourth light source 14. By varying

the amount of current for each of first light source 11 and second light source 12, light source controller 15 causes the color of the light emitted from first lighting fixture 10 to change between the first light color and the second light color. For example, light source controller 15 varies the amount of current supplied to first light source 11 so that the amount of light from first light source 11 changes from a predetermined amount of light to zero and then from zero to the predetermined amount of light. At the same time, light source controller 15 varies the amount of current supplied to second light source 12 so that the amount of light from second light source 12 changes from zero to a predetermined amount of light and then from the predetermined amount of light to zero. As a result, the color of the light from first lighting fixture 10 changes from the first light color to the second light color and then from the second light color to the first light color. Here, light source controller 15 may vary the amounts of current to first light source 11 and second light source 12 not to reduce the amounts of light from first light source 11 and second light source 12 to zero.

[0078]

Furthermore, when receiving the first light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the third light color and the fourth light color, light source controller 15 passes current through third light source 13 and fourth light source 14 but does not pass current through first light source 11 and second light source 12. By varying the amount of current for each of third light source 13 and fourth light source 14, light source controller 15 causes the color of the light emitted from first lighting fixture 10 to change between the third light color and the fourth light color. For example, light source controller 15 varies the amount of current supplied to third light source 13 so that the amount of light from third light source 13 changes from a predetermined amount of light to zero and then from zero to the predetermined amount of light. At the same time, light source controller 15 varies the amount of current supplied to fourth light source 14 so that the amount of light from fourth light source 14

changes from zero to a predetermined amount of light and then from the predetermined amount of light to zero. As a result, the color of the light from first lighting fixture 10 changes from the third light color to the fourth light color and then from the fourth light color to the third light color. Here, light source controller 15 may vary the amounts of current to third light source 13 and fourth light source 14 not to reduce the amounts of light from third light source 13 and fourth light source 14 to zero.

[0079]

FIG. 5 is the CIE 1931 color space xy chromaticity diagram illustrating an example of a toning range of first lighting fixture 10 according to the present embodiment. In FIG. 5, the first light color has chromaticity coordinates L11, the second light color has chromaticity coordinates L12, the third light color has chromaticity coordinates L13, and the fourth light color has chromaticity coordinates L14.

[0080]

As illustrated in FIG. 5, first lighting fixture 10 emits the light of a cool color like the second light color having chromaticity coordinates L12 and thereby makes the person feel a cool feeling. Chromaticity coordinates L12 of the second light color in particular are located outside a specified color temperature range on the high color temperature side, and thus make the person feel the cool feeling highly effectively. Moreover, first lighting fixture 10 emits the light of a warm color like the fourth light color having chromaticity coordinates L14 and thereby makes the person feel a warm feeling.

[0081]

FIG. 6 is a diagram illustrating an example of a warm or cool feeling that changes with time. FIG. 6 shows an example of a result of an experiment performed on a test subject in a darkroom. The experiment was performed to find out how a comfortable temperature for the test subject changes with time by warm color light emission and by cool color light emission. The vertical axis in FIG. 6 represents difference ΔT between a comfortable temperature

for the test subject by the warm color light emission and a comfortable temperature for the test subject by the cool color light emission. The horizontal axis in FIG. 6 represents time elapsed since the lighting-up. In FIG. 6, plotted squares show an evaluation result obtained in summer and plotted triangles show an evaluation result obtained in winter.

[0082]

As illustrated in FIG. 6, a difference is observed between the comfortable temperatures for the test subject by the emissions of light of different colors after a short time since the lighting-up. However, the difference between the comfortable temperatures reduces with time, and substantially no difference is observed after about 30 minutes. This is because of chromatic adaptation causing the person to feel less of a hue of the light color with time.

[0083]

Thus, as described above, first lighting fixture 10 of lighting system 1 varies the color of the emitted light to reduce the chromatic adaptation and effectively cause the person to feel the warm or cool feeling. More specifically, first lighting fixture 10 emits light of a color higher in hue and then temporarily changes this color of the light to a color lower in hue. For example, first lighting fixture 10 repeatedly changes the color of light between the first light color and the second light color, as illustrated in FIG. 5. To be more specific, the color of the light emitted from first lighting fixture 10 changes between chromaticity coordinates L11 and chromaticity coordinates L12. Here, when the light color changes from chromaticity coordinates L11 to chromaticity coordinates L12, the color changes to be farther away from equal-energy white point LW. In other words, as the color of the light emitted from first lighting fixture 10 changes from the first light color to the second light color, the color stays higher in hue. In contrast, when the light color changes from chromaticity coordinates L12 to chromaticity coordinates L11, the color changes to be closer to equal-energy white point LW. In other words, as the color of the light emitted from first lighting fixture 10 changes from the second light color to the first light color, the color

stays lower in hue.

[0084]

Furthermore, first lighting fixture 10 repeatedly changes the color of the emitted light between the third light color and the fourth light color, for example. To be more specific, the color of the light emitted from first lighting fixture 10 changes between chromaticity coordinates L13 and chromaticity coordinates L14. Here, when the light color changes from chromaticity coordinates L13 to chromaticity coordinates L14, the color changes to be farther away from equal-energy white point LW. In other words, as the color of the light emitted from first lighting fixture 10 changes from the third light color to the fourth light color, the color stays higher in hue. In contrast, when the light color changes from chromaticity coordinates L14 to chromaticity coordinates L13, the color changes to be closer to equal-energy white point LW. In other words, as the color of the light emitted from first lighting fixture 10 changes from the fourth light color to the third light color, the color stays lower in hue.

[0085]

In this way, first lighting fixture 10 emits the light of a color high in hue to cause the person to feel a warm or cool feeling and temporarily changes this color of the light to a color lower in hue. This reduces the chromatic adaptation. Hence, lighting system 1 can effectively cause the person to feel the warm or cool feeling.

[0086]

For example, chromaticity coordinates L11 of the first light color and chromaticity coordinates L13 of the third light color are closer to a perimeter of basic color name area circle C1 of white color than equal-energy white point LW is, as illustrated in FIG. 5. For the light changing in color from a high hue to a low hue, a hue that is too low (or more specifically, a light color that is closer to the equal-energy white) may cause the person to feel a complementary color of the high hue. For this reason, chromaticity coordinates L11 of the first light color and chromaticity coordinates L13 of the third light color located closer to the perimeter of basic color name area circle C1 of white color make the person feel less of discomfort that

may be caused by the complementary color. For the same reason, chromaticity coordinates L11 of the first light color and chromaticity coordinates L13 of the third light color may be located outside basic color name area circle C1 of white color.

5 [0087]

FIG. 6 shows substantially no effect of causing the person to feel the warm or cool feeling after about 30 minutes. On this account, the change of light color made within 30 minutes after the light emission can reduce the chromatic adaptation and also increase
10 the effect of causing the person to feel the warm or cool feeling as compared to the case where the light color is not changed.

[0088]

Thus, to easily cause the person to feel the warm or cool feeling, signal generator 31 generates the first light modulation
15 signal that causes the color of light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color in a cycle (hereafter, may be simply referred to as the toning cycle) of 30 minutes or less. Signal generator 31 may generate the first light modulation signal having a cycle of 20
20 minutes or less, or the first light modulation signal having a cycle of 10 minutes or less. To reduce a complicated feeling for the person, signal generator 31 may generate the first light modulation signal having a cycle of 5 seconds or more, the first light modulation signal having a cycle of 10 seconds or more, or the first light modulation
25 signal having a cycle of 20 seconds or more.

[0089]

Furthermore, signal generator 31 repeatedly changes the color of light emitted from first lighting fixture 10 between the third light color and the fourth light color in a cycle similar to the cycle in
30 which the light color is repeatedly changed between the first light color and the second light color.

[0090]

Next, the following describes a speed of hue change of light emitted from first lighting fixture 10.

35 [0091]

FIG. 7 is a diagram illustrating an example of temporal change in hue of light emitted from first lighting fixture 10. The vertical axis in FIG. 7 represents color difference ΔE of a color of light emitted from first lighting fixture 10 with respect to the first light color.

5 More specifically, color difference ΔE increases as the color of light emitted from first lighting fixture 10 approaches the second light color, and decreases as the color of the light emitted from first lighting fixture 10 approaches the first light color. Assume that chromaticity coordinates of the color of the light emitted from first
10 lighting fixture 10 are represented by (x_e, y_e) , and that chromaticity coordinates of the first light color are represented by (x_s, y_s) . In this case, color difference ΔE is calculated by an equation below.

$$\Delta E = ((x_e - x_s)^2 + (y_e - y_s)^2)^{1/2}$$

Here, the horizontal axis in FIG. 7 represents time.

15 [0092]

As illustrated in FIG. 7, the light emitted from first lighting fixture changes in hue faster as color difference ΔE increases and more slowly as color difference ΔE decreases, for example. More specifically, the speed of hue change is faster when the first light
20 color changes to the second light color than when the second light color changes to the first light color. Thus, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit light having the speed of hue change faster when the first light color changes to the second light color than when the
25 second light color changes to the first light color. In this way, the speed of hue change to the second light color that causes the person to feel the warm or cool feeling is faster. This makes the person easily notice the change in hue.

[0093]

30 FIG. 8 is a diagram illustrating an influence on color discrimination caused by a delay in start of presentation. FIG. 8 shows a result of an experiment in which light of a given wavelength was emitted and, after a predetermined period of time, light of a wavelength different from the given wavelength was emitted to find
35 out whether a test subject could recognize the light of the different

color. The horizontal axis in FIG. 8 represents the aforementioned predetermined period of time (a so-called delay in start of presentation). The vertical axis in FIG. 8 represents minimum wavelength difference $\Delta\lambda$ (a so-called wavelength discrimination value) between the light of the given wavelength and the light of the different wavelength that is recognizable as the light of the different color to the test subject. A graph illustrated in FIG. 8 is a semilogarithmic graph having the horizontal axis as a logarithmic axis.

10 [0094]

As illustrated in FIG. 8, although increasing with increase in the delay in start of presentation, wavelength difference $\Delta\lambda$ is substantially constant from 200 ms. Thus, varying the wavelength by wavelength difference $\Delta\lambda$ or more within 200 ms allows the person to easily recognize the change of light color.

15 [0095]

If wavelength difference $\Delta\lambda$ is replaced with color difference ΔE described above, color difference ΔE that allows the person to recognize the change of light color within 200 ms is about 0.002. On this account, a change in color difference ΔE per 200 ms may be 0.002 or more with the speed of increase in color difference ΔE , or more specifically, the speed of hue change from the first light color to the second light color in FIG. 7, for example. Thus, signal generator 31 generates the first light modulation signal that causes the hue of the light emitted from first lighting fixture 10 to change at such a speed. As a result, lighting system 1 can more effectively cause the person to feel the warm or cool feeling. Furthermore, a change in color difference ΔE per 200 ms may be less than 0.002 with the speed of decrease in color difference ΔE , or more specifically, the speed of hue change from the second light color to the first light color. Thus, signal generator 31 generates the first light modulation signal that causes the hue of the light emitted from first lighting fixture 10 to change at such a speed. As a result, even when light that is temporarily lower in hue is emitted, lighting system 1 can make this color change less noticeable to the person.

[0096]

In FIG. 7, the hue of the light emitted from first lighting fixture 10 changes constantly. However, this is not intended to be limiting. For example, signal generator 31 may generate the first light modulation signal that causes first lighting fixture 10 to emit light that keeps the second light color for a certain period of time.

[0097]

To increase the effect of reducing the chromatic adaptation, color difference ΔE between the first light color and the second light color may be 0.05 or more, or 0.1 or more.

[0098]

With reference to FIG. 7 and FIG. 8, the case where first lighting fixture 10 repeatedly changes the color of the emitted light between the first light color and the second light color has been described. The same advantageous effect can be achieved when the color of the emitted light is changed between the third light color and the fourth light color.

[0099]

Next, an operation of lighting control device 30, or more specifically, an operation of signal generator 31 of lighting control device 30 is described.

[0100]

Lighting-up, lighting-out, dimming, and toning are performed for each of first lighting fixture 10 and second lighting fixture 20 of lighting system 1 in response to an operation performed by the user using operator 40. At this time, electric power is being supplied to first lighting fixture 10, second lighting fixture 20, lighting control device 30, and operator 40. Lighting control device 30 (signal generator 31) may perform dimming and toning for each of first lighting fixture 10 and second lighting fixture 20 on the basis of the information from the various sensors. For example, the user is to choose between: manual dimming and manual toning for each of first lighting fixture 10 and second lighting fixture 20 using operator 40; and automatic dimming and automatic toning performed by lighting control device 30 (signal generator 31) for each of first lighting

fixture 10 and second lighting fixture 20.

[0101]

Signal generator 31 generates the first light modulation signal on the basis of the operation information based on the operation performed by the user or the environmental information, the light color information, and the light amount information from the corresponding sensors. Then, signal generator 31 transmits the generated first light modulation signal to first lighting fixture 10. This enables the light emission from first lighting fixture 10 to be controlled. For example, lighting-up, lighting-out, dimming, and toning are performed on first lighting fixture 10. Moreover, signal generator 31 may generate the second light modulation signal on the basis of the operation information based on the operation performed by the user or the environmental information, the light color information, and the light amount information from the corresponding sensors. This enables the light emission from second lighting fixture 20 to be controlled. For example, lighting-up, lighting-out, dimming, and toning are performed on second lighting fixture 20.

[0102]

Example operation 1 performed by signal generator 31 is first described. FIG. 9 is a flowchart of example operation 1 performed by signal generator 31.

[0103]

First, signal generator 31 obtains, from light sensor 35, the light amount information indicating the amount of light emitted from sensor lighting fixture 20 (Step S11). Note that signal generator 31 may obtain the light amount information from operator 40 or second lighting fixture 20 via communicator 32. For example, if the light amount of second lighting fixture 20 is adjusted by the user using operator 40, signal generator 31 obtains information about the light amount of second lighting fixture 20 set by the user, as the light amount information.

[0104]

Next, on the basis of the obtained light amount information,

signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit the amount of light positively correlated with the amount of light emitted from second lighting fixture 20 (Step S12). More specifically, on the basis of the obtained
5 light amount information, signal generator 31 determines the amount of light to be emitted from first lighting fixture 10 by calculating, using a preset correlation coefficient, the amount of light positively correlated with the amount of light emitted from second lighting fixture 20. Signal generator 31 generates the first light
10 modulation signal that causes first lighting fixture 10 to emit the determined amount of light. The correlation coefficient is set according to an installation environment of light system 1 or a desired level of causing the person to feel the warm or cool feeling, for example.

15 [0105]

Next, signal generator 31 transmits the generated first light modulation signal to light source controller 15 of first lighting fixture 10 (Step S13). Light source controller 15 obtains the first light modulation signal, and then adjusts the amount of light for each of
20 first light source 11, second light source 12, third light source 13, and fourth light source 14 on the basis of the obtained first light modulation signal. As a result, dimming is performed on the light emitted from first lighting fixture 10 on the basis of the light amount information.

25 [0106]

In this way, the amount of light emitted from first lighting fixture 10 is positively correlated with the amount of light emitted from second lighting fixture 20. Thus, the amount of light emitted from first lighting fixture 10 changes following a change in the
30 amount of light emitted from second lighting fixture 20. This keeps the amount of the light emitted from first lighting fixture 10 from being too larger or too smaller than the amount of light emitted from second lighting fixture 20. As a result, the person can feel the warm or cool feeling by an appropriate amount of light.

35 [0107]

Next, example operation 2 performed by signal generator 31 is described. FIG. 10 is a flowchart of example operation 2 performed by signal generator 31.

[0108]

5 First, signal generator 31 obtains, from light sensor 35, the light color information indicating a correlated color temperature of light emitted from second lighting fixture 20 (Step S21). Note that signal generator 31 may obtain the light amount information from operator 40 or second lighting fixture 20 via communicator 32. For
10 example, if the correlated color temperature of second lighting fixture 20 is adjusted by the user using operator 40, signal generator 31 obtains information about the correlated color temperature of second lighting fixture 20 set by the user, as the light color information.

15 [0109]

Next, on the basis of the obtained light color information, signal generator 31 determines whether the color of light emitted from first lighting fixture 10 is to be a warm color or a cool color. If the correlated color temperature of the light emitted from second
20 lighting fixture 20 is 5000 K or higher (YES in Step S22), signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit cool color light (Step S23). For example, as the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to vary within a cool light
25 color range, signal generator 31 generates the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to change between the first light color and the second light color.
[0110]

If the correlated color temperature of the light emitted from second lighting fixture 20 is lower than 5000 K (NO in Step S22), signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit warm color light (Step S24). For example, as the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to vary within a warm
30 light color range, signal generator 31 generates the first light
35

modulation signal that causes the color of light emitted from first lighting fixture 10 to change between the third light color and the fourth light color.

[0111]

5 Next, signal generator 31 transmits the generated first light modulation signal to light source controller 15 of first lighting fixture 10 (Step S25). Light source controller 15 obtains the first light modulation signal, and then adjusts the amount of light for each of first light source 11, second light source 12, third light source 13,
10 and fourth light source 14 on the basis of the obtained first light modulation signal. As a result, toning is performed to cause the color of light emitted from first lighting fixture 10 to be a warm color or a cool color, on the basis of the light color information.

[0112]

15 Thus, if the light emitted from second lighting fixture 20 has a color that is relatively high in the correlated color temperature among the colors in white light and that thus easily causes the person to feel the cool feeling, first lighting fixture 10 also emits cool color light that causes the person to feel the cool feeling. Furthermore, if
20 the light emitted from second lighting fixture 20 has a color that is relatively low in the correlated color temperature among the colors in white light and that thus easily causes the person to feel the warm feeling, first lighting fixture 10 also emits warm color light that causes the person to feel the warm feeling. Thus, the light from first
25 lighting fixture 10 and the light from second lighting fixture 20 are consistent on whether to cause the cool feeling or the warm feeling to the person. Hence, lighting system 1 can more effectively cause the person to feel the warm or cool feeling.

[0113]

30 Here, for the determination of whether the color of light emitted from first lighting fixture 10 is to be a warm color, the predetermined reference value of the correlated color temperature of the light emitted from second lighting fixture 20 is not limited to 5000 K. A predetermined value different from 5000 K may be set
35 according to the environment, for example.

[0114]

Next, example operation 3 performed by signal generator 31 is described. FIG. 11 is a flowchart of example operation 3 performed by signal generator 31.

5 [0115]

First, signal generator 31 obtains the environmental information indicating at least one of a set temperature of air conditioner 50, an air temperature (a room temperature of the space equipped with lighting system 1, for example), a season, or a time of day, from at least one of time clock 33, temperature sensor 34, or air conditioner 50 (Step S31). For example, signal generator 31 obtains the environmental information indicating one of the set temperature of air conditioner 50, the air temperature, the season, and the time of day. Here, signal generator 31 may obtain information indicating the set temperature of air conditioner 50 as the environmental information from air conditioner 50 installed in the indoor space. Alternatively, signal generator 31 may obtain the environmental information from, for example, an external device via communicator 32 using a wide area communication network (not illustrated), such as the Internet.

[0116]

Next, on the basis of the obtained environmental information, signal generator 31 determines the color of light to be emitted from first lighting fixture 10 (Step S32). For example, signal generator 31 determines on the basis of the obtained environmental information whether to cause first lighting fixture 10 to emit warm color light or cool color light, by reference to the information table. Then, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit the light of the determined color (Step S33). More specifically, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit the light of the color determined on the basis of the obtained light amount information.

[0117]

35 Next, signal generator 31 transmits the generated first light

modulation signal to light source controller 15 of first lighting fixture 10 (Step S34). Light source controller 15 obtains the first light modulation signal, and then adjusts the amount of light for each of first light source 11, second light source 12, third light source 13, and fourth light source 14 on the basis of the obtained first light modulation signal. As a result, toning is performed to cause the color of light emitted from first lighting fixture 10 to be a warm color or a cool color, on the basis of the environmental information.

[0118]

For example, assume that the environmental information indicates the set temperature of air conditioner 50 or the air temperature. In this case, if the set temperature of air conditioner 50 or the air temperature is a predetermined value or greater, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit cool color light. For example, as the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to vary within the cool light color range, signal generator 31 generates the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to change between the first light color and the second light color. Furthermore, if the set temperature of air conditioner 50 or the air temperature is smaller than the predetermined value, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit warm color light. For example, as the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to vary within the warm light color range, signal generator 31 generates the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to change between the third light color and the fourth light color.

[0119]

Thus, when the set temperature of air conditioner 50 or the air temperature is high, the emission of the cool color light causes the person to feel the cool feeling. This makes the person feel comfortable even when an air conditioner or the like is not used or when the set temperature of the air conditioner is high. As a result,

energy used by the air conditioner or the like can be reduced. When the set temperature of air conditioner 50 or the air temperature is low, the emission of the warm color light causes the person to feel the warm feeling. This makes the person feel comfortable even when an air conditioner of the like is not used or when the set temperature of the air conditioner is low. As a result, energy used by the air conditioner or the like can be reduced.

[0120]

The predetermined value used for the determination is set as appropriate according to an environment or a season, for example. Each of FIG. 12A and FIG. 12B is a diagram illustrating an example of a relationship between room temperature and comfort. Each of FIG. 12A and FIG. 12B illustrates an example of a result of evaluation performed to find out how the color of light emitted into the indoor space influences the relationship between room temperature and comfort. Each of FIG. 12A and FIG. 12B illustrates the example of the result of evaluation made by a test subject in the indoor space in which a room temperature and a light color vary. The result shows an evaluation level of comfort for each room temperature and each light color. Each of the vertical axes in FIG. 12A and FIG. 12B represents the evaluation level of comfort. The evaluation level for the greatest discomfort is -3, and the evaluation level for the greatest comfort is 3. Each of the horizontal axes in FIG. 12A and FIG. 12B represents a room temperature of the indoor space. In each of FIG. 12A and FIG. 12B, the solid line shows the result obtained when warm color light was emitted into the indoor space, and the dotted line shows the result obtained when cool color light was emitted into the indoor space. FIG. 12A shows the result of evaluation performed in summer. FIG. 12B shows the result of evaluation performed in winter.

[0121]

As shown by the result of evaluation in summer in FIG. 12A, at 25 degrees or lower, the evaluation level of comfort is higher in the indoor space illuminated by the warm color light. Moreover, at 25 degrees or higher, the evaluation level of comfort is higher in the

indoor space illuminated by the cool color light. As shown by the result of evaluation in winter in FIG. 12B, at 24 degrees or lower, the evaluation level of comfort is higher in the indoor space illuminated by the warm color light. Moreover, at 24 degrees or higher, the evaluation level of comfort is higher in the indoor space illuminated by the cool color light. Thus, to raise the level of comfort for the person, the predetermined value used for the determination is set at between 24 degrees and 25 degrees. On the basis of the information indicating the season, signal generator 31 may determine the predetermined value that is higher in summer than in winter.

[0122]

For example, assume that the environmental information indicates a season. In this case, if the season is spring or summer, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit cool color light. If the season is autumn or winter, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit warm color light. For the environmental information indicating the season as described, the same advantageous effect can be achieved as with the environmental information indicating the set temperature of air conditioner 50 or the air temperature.

[0123]

For example, assume that the environmental information indicates a time of day. In this case, if the time of day indicates daytime, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit cool color light. If the time of day indicates nighttime, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit warm color light. For the environmental information indicating the time of day as described, the same advantageous effect can be achieved as with the environmental information indicating the set temperature of air conditioner 50 or the air temperature.

[0124]

As described, signal generator 31 generates the first light

modulation signal that causes first lighting fixture 10 to emit the light of the color determined on the basis of the obtained light amount information. This enables first lighting fixture 10 to emit the light of the color that causes the person to feel the comfort appropriate to the environment, with no user intervention. Hence, lighting system 1 can effectively cause the person to feel the warm or cool feeling.
[0125]

Note that signal generator 31 may generate the second light modulation signal and transmit the generated second light modulation signal to second lighting fixture 20 via communicator 32, similarly to Step S31 to Step S34. As a result, second lighting fixture 20 emits the light of the color determined on the basis of the environmental information as well. This produces a consistent atmosphere in the space equipped with lighting system 1.
[0126]

Furthermore, signal generator 31 may determine the color of the light emitted from first lighting fixture 10 on the basis of environmental information including a combination of at least two of the set temperature of air conditioner 50, the air temperature, the season, or the time of day included in the environmental information.
[0127]

Next, example operation 4 performed by signal generator 31 is described. FIG. 13 is a flowchart of example operation 4 performed by signal generator 31.
[0128]

First, signal generator 31 obtains, from microphone 36, the music information related to music played in the space equipped with lighting system 1 (Step S41). Note that signal generator 31 may obtain the music information related to music played by audio device 60, from audio device 60 via communicator 32.
[0129]

Next, signal generator 31 generates the first light modulation signal that causes the color of light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color in the cycle based on the characteristics of the music

included in the obtained music information (Step S42). To be more specific, signal generator 31 obtains beats per minute (BPM) of the music included in the obtained music information, using a publicly-known tempo analysis method, for example. Then, on the basis of the BPM of the music, signal generator 31 determines the cycle of repeatedly changing the light from first lighting fixture between the first light color and the second light color. For example, signal generator 31 determines the cycle (a toning cycle) that is an integral multiple of a beat interval of the music, that is, a reciprocal of the BPM. Signal generator 31 generates the first light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color in the determined cycle.

[0130]

Next, signal generator 31 transmits the generated first light modulation signal to light source controller 15 of first lighting fixture 10 (Step S43). Light source controller 15 obtains the first light modulation signal, and then adjusts the amount of light for each of first light source 11 and second light source 12 on the basis of the obtained first light modulation signal. As a result, dimming is performed on the light emitted from first lighting fixture 10 on the basis of the music information.

[0131]

In this way, the cycle of variation in the color of the light emitted from first lighting fixture 10 is consistent with the music played in the space equipped with lighting system 1. Thus, even if the color of the light emitted from first lighting fixture 10 varies, the person feels less of discomfort. Hence, lighting system 1 can more effectively cause the person to feel the warm or cool feeling.

[0132]

Note that, similarly to Step S42, signal generator 31 may generate the first light modulation signal that causes the color of the light emitted from first lighting fixture to repeatedly change between the third light color and the fourth light color in the cycle based on the characteristics of the music included in the obtained music

information.

[0133]

Furthermore, signal generator 31 may generate the first light modulation signal that causes first lighting fixture 10 to emit light of a color based on the characteristics of the music included in the obtained music information. For example, for minor music included in the obtained music information, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit cool color light. For major music included in the obtained music information, signal generator 31 generates the first light modulation signal that causes first lighting fixture 10 to emit warm color light.

[0134]

[Advantageous effects etc.]

As described above, lighting system 1 includes: first lighting fixture that is adjustable for an amount and a color of light emitted from the first lighting fixture; and signal generator 31 that generates a light modulation signal used for adjusting the amount and the color of the light emitted from first lighting fixture 10. First lighting fixture 10 includes: first light source 11 that emits first light of a first light color; and second light source 12 that emits second light of a second light color higher in hue than the first light color. First lighting fixture 10 further includes light source controller 15 that obtains the light modulation signal from signal generator 31, and adjusts an amount of light for each of first light source 11 and second light source 12 on the basis of the light modulation signal. Signal generator 31 generates the light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color. The color of the light emitted from first lighting fixture 10 increases in hue as the color changes from the first light color to the second light color.

[0135]

With this, first lighting fixture 10 emits the light of a color high in hue to cause the person to feel a warm or cool feeling and

temporarily changes this color of the light to a color lower in hue. For the person staying in a space illuminated by the light of a single color, the effect of causing the warm or cool feeling by the emitted light color decreases over time because of the chromatic adaptation.

5 However, the variation in the color of the light from first lighting fixture 10 reduces the chromatic adaptation. Thus, the decrease in the effect of causing the warm or cool feeling because of the chromatic adaptation can be reduced. Hence, lighting system 1 can effectively cause the person to feel the warm or cool feeling.

10 [0136]

As a result, a comfortable space can be made without using an air conditioner, for example. This reduces energy consumption. Moreover, the comfortable space can be made without increasing a temperature difference between inside and outside of the space.

15 This can reduce a load resulting from the body temperature regulation of the person.

[0137]

Furthermore, lighting system 1 further includes second lighting fixture 20 that emits white light, for example. First lighting fixture 10 emits the light outside a range of light emission of second lighting fixture 20.

20 [0138]

With this, lighting system 1 causes second lighting fixture 20 to emit the white light appropriate to work or the like performed by the person within the emission range of second lighting fixture 20 while causing first lighting fixture 10 emit the light to the surroundings of the person. This effectively makes the person feel the warm or cool feeling.

[0139]

30 Furthermore, first lighting fixture 10 further includes: third light source 13 that emits third light of a third light color; and fourth light source 14 that emits fourth light of a fourth light color higher in hue than the third light color. Light source controller 15 adjusts an amount of light for each of first light source 11, second light source 35 12, third light source 13, and fourth light source 14 on the basis of

the light modulation signal. Signal generator 31 generates the light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the first light color and the second light color or between the third light color and the fourth light color. The color of the light emitted from first lighting fixture 10 increases in hue as the color changes from the third light color to the fourth light color. One of the second light color and the fourth light color is a cool light color and the other is a warm light color.

10 [0140]

With this, first lighting fixture 10 repeatedly changes the color of the emitted light not only between the first light color and the second light color but also between the third light color and the fourth light color. The repeated changing of the light color emitted from first lighting fixture 10 between the third light color and the fourth light color also effectively makes the person feel the warm or cool feeling as in the aforementioned repeated changing between the first light color and the second light color. One of the second light color and the fourth light color is a cool light color and the other is a warm light color. This enables first lighting fixture 10 to cause the person to feel the cool feeling by the emission of the cool color light and the warm feeling by the emission of the warm color light. Thus, first lighting fixture 10 can be used in both cases of causing the person to feel the warm feeling and causing the person to feel the cool feeling.

[0141]

[Other Embodiments]

Although the present invention has been described by way of Embodiment above, it should be obvious that the present invention is not limited to Embodiment described above.

[0142]

For example, although lighting system 1 according to Embodiment described above includes lighting control device 30 and operator 40, this is not intended to be limiting. The components included in lighting control device 30 may be included in first light

source 10, second lighting fixture 20, or operator 40. For example, signal generator 31 may be included in first light source 10, second lighting fixture 20, or operator 40. Alternatively, signal generator 31 may be included in light source controller 15. Operator 40 may
5 be included in first light source 10, second lighting fixture 20, or lighting control device 30.

[0143]

Furthermore, lighting system 1 need not include second lighting fixture 20. For example, lighting system 1 may be a single
10 lighting unit that includes first lighting fixture 10 and lighting control device 30 that includes at least signal generator 31.

[0144]

Moreover, first lighting fixture 10 includes first light source 11, second light source 12, third light source 13, and fourth light source
15 14. However, this is not intended to be limiting. For example, third light source 13 may include a light source that is the same as first light source 11. In this case, signal generator 31 generates the first light modulation signal that causes the color of the light emitted from first lighting fixture 10 to repeatedly change between the first light
20 color and the second light color or between the first light color and the fourth light color.

[0145]

Furthermore, in the above embodiments, a process executed by a specific component may be executed by a different component.
25 Moreover, the order in which processes are executed may be changed, and a plurality of processes may be executed in parallel.

[0146]

Moreover, in the above embodiments, each of the components may be realized by executing a software program suited to the component. The components may be implemented by a program
30 executor such as a CPU or a processor reading out and executing the software program recorded in a recording medium such as a hard disk or a semiconductor memory.

[0147]

35 Furthermore, the respective components may be implemented

using hardware. The respective components may be circuits (or integrated circuits). These circuits as a whole may compose a single circuit or may be individual circuits. Moreover, each of the structural components may be implemented by a general-purpose processor or a dedicated processor.

[0148]

Furthermore, the generic or specific aspects of the present invention may be implemented as a system, an apparatus, a method, an integrated circuit, a computer program, or a computer-readable recording medium such as a CD-ROM, or may be implemented as any combination of a system, an apparatus, a method, an integrated circuit, a computer program, and a recording medium.

[0149]

For example, the present invention may be implemented as the lighting system in the above embodiments, as a program for causing a computer to execute a lighting program, or as a non-transitory computer-readable recording medium having such a program recorded thereon.

[0150]

Other forms realized through various modifications to the embodiments conceived by a person of ordinary skill in the art or through any combination of the components and functions in the embodiments described above, so long as they do not depart from the essence of the present invention, are included in the present invention.

[Reference Signs List]

[0151]

- | | |
|----|-------------------------|
| 1 | lighting system |
| 10 | first lighting fixture |
| 11 | first light source |
| 12 | second light source |
| 13 | third light source |
| 14 | fourth light source |
| 15 | light source controller |

20 second lighting fixture
31 signal generator
50 air conditioner
A work area

5

[CLAIMS]

[Claim 1]

A lighting system comprising:

5 a first lighting fixture that is adjustable for an amount and a color of light emitted from the first lighting fixture; and

a signal generator that generates a light modulation signal for adjusting the amount and the color of the light emitted from the first lighting fixture,

wherein the first lighting fixture includes:

10 a first light source that emits first light of a first light color;

a second light source that emits second light of a second light color higher in hue than the first light color; and

15 a light source controller that obtains the light modulation signal from the signal generator, and adjusts an amount of light for each of the first light source and the second light source, based on the light modulation signal,

20 the signal generator generates the light modulation signal that causes the color of the light emitted from the first lighting fixture to repeatedly change between the first light color and the second light color, and

the color of the light emitted from the first lighting fixture increases in hue as the color changes from the first light color to the second light color.

25 [Claim 2]

The lighting system according to claim 1,

30 wherein the signal generator generates the light modulation signal that causes a speed of hue change when the first light color changes to the second light color to be faster than a speed of hue change when the second light color changes to the first light color.

[Claim 3]

The lighting system according to one of claim 1 and claim 2,

35 wherein the signal generator generates the light modulation signal that causes the color of the light emitted from the first lighting

fixture to repeatedly change between the first light color and the second light color in a cycle of 30 minutes or less.

[Claim 4]

5 The lighting system according to any one of claim 1 to claim 3,
 wherein the signal generator obtains music information
 related to music played in a space in which the lighting system is
 provided, and generates the light modulation signal that causes the
10 color of the light emitted from the first lighting fixture to repeatedly
 change between the first light color and the second light color in a
 cycle based on characteristics of the music included in the music
 information obtained.

[Claim 5]

15 The lighting system according to any one of claim 1 to claim 4,
 further comprising:
 a second lighting fixture that emits white light,
 wherein the first lighting fixture emits the light outside a range
 of light emission of the second lighting fixture.

20

[Claim 6]

 The lighting system according to claim 5,
 wherein the second lighting fixture emits light to a work area
 in which a worker performs work.

25

[Claim 7]

 The lighting system according to one of claim 5 and claim 6,
 wherein the second lighting fixture is adjustable for an amount
 of light, and

30 the signal generator obtains light amount information
 indicating the amount of light emitted from the second lighting
 fixture, and generates, based on the light amount information
 obtained, the light modulation signal that causes the first lighting
 fixture to emit the amount of light positively correlated with the
35 amount of light emitted from the second lighting fixture.

[Claim 8]

The lighting system according to any one of claim 1 to claim 7,
wherein the first lighting fixture further includes:

5 a third light source that emits third light of a third light color;
and

 a fourth light source that emits fourth light of a fourth light
color higher in hue than the third light color,

 the light source controller adjusts an amount of light for each
10 of the first light source, the second light source, the third light source,
and the fourth light source, based on the light modulation signal,

 the signal generator generates the light modulation signal that
causes the color of the light emitted from the first lighting fixture to
repeatedly change between the first light color and the second light
15 color or between the third light color and the fourth light color,

 the color of the light emitted from the first lighting fixture
increases in hue as the color changes from the third light color to the
fourth light color, and

 one of the second light color and the fourth light color is a cool
20 light color and an other is a warm light color.

[Claim 9]

The lighting system according to claim 8, the lighting system
further comprising:

25 a second lighting fixture that emits white light,

 wherein the first lighting fixture emits the light outside a range
of light emission of the second lighting fixture, and

 the signal generator obtains light color information indicating
a correlated color temperature of light emitted from the second
30 lighting fixture, and generates, based on the light color information
obtained, the light modulation signal that causes the first lighting
fixture to emit light of the cool light color if the correlated color
temperature of the white light emitted from the second lighting
fixture is 5000 K or higher and to emit light of the warm light color if
35 the correlated color temperature of the white light emitted from the

second lighting fixture is lower than 5000 K.

[Claim 10]

5 The lighting system according to claim 8,
 wherein the signal generator obtains environmental
information indicating at least one of a set temperature of an air
conditioner, an air temperature, a season, or a time of day, and
generates the light modulation signal that causes the first lighting
10 fixture to emit light of a light color determined based on the
 environmental information obtained.