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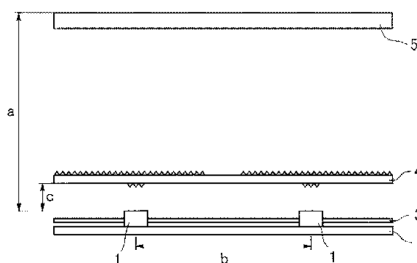
(54) [Title of the Invention] Backlight unit

(57) [Abstract]

[Problem] This is a backlight unit for display devices, and LED is used as a light source to provide a unit that reduces the eye-catching lamp image.

[Means for Solving] Multiple LEDs 1 are placed on the base 2 at equal intervals, and a diffusing plate 4 with a lens having a total light transmittance of 80 to 98% and a light diffusivity of 0.5 to 30% is placed on the side close to the LED 1, a diffusing plate 5 with a total light transmittance of 40 to 80% and a light diffusivity of 70 to 90% is placed on the side far to the LED 1, and a reflector 3 with a reflectance of 80% or more is placed between the diffusing plate 4 and the base 2.

[Representative Drawing] FIG. 1



[Scope of Patent Claims]

[Claim 1]

A backlight unit characterized by having multiple LEDs, the base placed on the back side of the LED, arranged on the light emitting side of the LED, at least two diffusing plates made of a thermoplastic transparent resin mixed with a light diffusing agent, and a reflector disposed between the base and a diffuser closest to the base; where a diffusing plate on the side closer to the LED is a diffusing plate with lenses having a total light transmittance of 80 to 98% and a light diffusivity of 0.5 to 30% and having a lens shape on at least one surface, and a diffusing plate on the far side from the LED has a total light transmittance of 40-80% and a light diffusivity of 70-90%, and the reflectance of the reflector is 80% or more.

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[Claim 2]

The backlight unit according to claim 1, wherein the light diffusing agent is an organic crosslinked particulate.

[Claim 3]

The backlight unit according to claim 2, wherein the organic crosslinked particulate is at least one type selected from acrylic-based resin particulates, styrene-based resin particulates, silicone-based crosslinked particulates.

[Detailed Description of the Invention]

[Technical Field]

[0001]

The present invention relates to a backlight unit of a display device with an LED (Light Emitting Diode) as a light source.

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[Background Art]

[0002]

In recent years, display devices and lighting devices using LEDs as light sources have attracted attention. LEDs have a longer lifespan and are energy-saving compared to conventional fluorescent lamps and incandescent bulbs. In addition, since environmental pollutants are not used, they are environmentally friendly and are expected to be applied to various light sources in the future.

[0003]

LEDs have strong directivity, and taking advantage of these characteristics, they are now widely used as lighting for spots and lighting for display devices that display characters and designs. A non-self-luminous display device requires a light source device called a backlight, and LEDs are used as this light source device. There are two types of such backlights, called edge-lit backlights and direct backlights, but many display devices use direct backlights that can achieve high brightness but large in size.

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[0004]

The direct backlight generally has a structure (a cross-sectional view) as shown in FIG. 2, and was configured with the base 2, reflector 3, LED 1, diffusing plate 5, and the like, with an optical film or display plate, or liquid crystal panel, etc. added as necessary for the application.

[0005]

Cold cathode tubes are widely used as conventional light sources, and as reported in patent literatures 1 to 3, for example, many studies have been conducted to blend various light diffusing agents, organic/inorganic, as well as conventional white pigments.

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[0006]

In addition, in order to reduce the lamp image even in units using cold cathode tubes, technology with lens function is also being studied. For example, patent literatures 4 to 7, etc., have reported that light exit patterns are controlled by designing prism shapes.

[0007]

However, if the LEDs are highly directional (the angle of the luminous flux being emitted is narrow) and if trying to reduce unevenness in brightness using only the technologies reported so far, the number of LEDs will increase.

[0008]

On the other hand, in the market, there is a demand to reduce the number of LEDs in order to reduce energy consumption and cost, and this cannot be achieved with conventional technology.

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As shown in FIG. 2, if the distance between the LEDs 1 is widened, the highly directional light is emphasized, and even when viewed as a surface, it looks like an eye-catching lamp image, which is disliked by an increasing number of users.

[0009]

[Patent Literature 1] Japanese Unexamined Patent Application Publication Number 2120343

[Patent Literature 2] Japanese Unexamined Patent Application Publication Number H10-3811

[Patent Literature 3] Japanese Unexamined Patent Application Publication Number H11-5241

[Patent Literature 4] Japanese Unexamined Patent Application Publication Number H2-257188

[Patent Literature 5] Japanese Unexamined Patent Application Publication Number H5-45505

[Patent Literature 6] Japanese Unexamined Patent Application Publication Number H5-333333

[Patent Literature 7] Japanese Unexamined Patent Application Publication Number H6-18707

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0010]

The direct backlight unit, which uses LEDs with strong directivity as the light source, is becoming smaller and lighter, the distance from the light source to the diffusing plate is short, when viewed as a surface, there is brightness unevenness, producing bright and dark eye-catching lamp image.

[0011]

The challenge of the present invention is to provide a backlight unit that reduces the above-described eye-catching lamp image.

[Means for Solving the Problems]

[0012]

The present inventor, as a result of intensive research to solve the aforementioned problem, believes that the LED eye-catching lamp image has a strong directivity, and found that the cause was that there was a lot of light from the front and less diffused light, leading to the present invention.

[0013]

That is, the backlight unit of the present invention has multiple LEDs, the base placed on the back side of the LED, arranged on the light emitting side of the LED, at least two diffusing plates made of a thermoplastic transparent resin mixed with a light diffusing agent, a reflector disposed between the base and a diffusing plate closest to the base; where a diffusing plate on the side closer to the LED is a diffusing plate with lenses having a total light transmittance of 80 to 98% and a light diffusivity of 0.5 to 30% and having a lens shape on at least one surface, and a diffusing plate on the far side from the LED has a total light transmittance of 40-80% and a light diffusivity of 70-90%, and the reflectance of the reflector is 80% or more.

[0014]

In the backlight unit of the present invention, the light diffusing agent is an organic crosslinked particulate; in particular, a preferred embodiment includes that the organic crosslinked particulates are at least one selected from acrylic resin particulates, styrene resin particulates, and silicone crosslinked particulates.

[Effects of the Invention]

[0015]

According to the present invention, in a backlight unit using LEDs of point sources, the eye-catching lamp image can be reduced, the brightness irregularity can be minimized as a surface, and by using it as illumination of a display device, a display device with excellent display characteristics can be configured.

[Best Embodiments of the Invention]

[0016]

The present invention will be described in particular in detail below, with particular focus on its preferred form.

[0017]

FIG. 1 is a schematic diagram illustrating a cross-sectional configuration of a preferred embodiment of a backlight unit of the present invention.

[0018]

The backlight of the present invention has a plurality of LEDs 1 as shown in FIG. 1; a base 2 arranged on the back side of the LED 1, at least two diffusing plates 4 and 5 arranged on the light emitting side of the LED 1, and a reflector 3 arranged between the substrate 2 and the LED 1, which is a diffusing plate with a lens in which the diffusing plate 4 on the side closer to the LEDs 1 has a lens shape on at least one surface.

[0019]

Usually, a plurality of LEDs are arranged two-dimensionally on the main surface of the substrate 2 at regular intervals. In the present invention, b is the distance between the center of two adjacent LEDs 1, a is the distance from the surface of the LED 1 to the light emitting surface of the diffusing plate at the most exiting side, and c is the distance from the surface of the LED 1 to the lensed diffusing plate 4.

[0020]

Preferably, a is 10 mm or more and b is 10 to 100 mm. If a is less than 10 mm, the eye-catching lamp image is unlikely to disappear and is undesirable. In addition, if b is less than 10 mm, the number of LEDs 1 becomes excessive, and if b is more than 100 mm, even if the number of diffusing plates 4 with lenses is increased, it is difficult to eliminate luminance unevenness, which is not preferable. Also, the ratio of a/b is preferably in the range of 0.2 to 1.0. If a/b is less than 0.2, the brightness unevenness is unlikely to resolve, and if it exceeds 1.0, the distance from LED 1 to the diffusing plate is sufficient, and it is difficult to demonstrate the superiority of the units of the present invention. The ratio of a/b further preferably ranges from 0.5 to 0.7. c is 0.1 mm or more, and if it is less than 0.1 mm, the Diffusing plate 4 with lenses may come into contact with the LEDs 1 when the Diffusing plate 4 with lenses is bent, which is not preferable. The ratio of c/b is preferably in the range of 2×10^{-3} to 0.4. Less than 2×10^{-3} is undesirable because the eye-catching lamp image is unlikely to disappear, causing uneven brightness, which is not preferable. More preferably, it is in the range of 0.02 to 0.2, and considering the balance of the units, this range is particularly good.

[0021]

The LED 1 used in the present invention is not limited to a so-called general-purpose LED such as a surface mount type, a bullet type, or a power LED, and may be selected according to the required brightness.

[0022]

The diffusing plates 4, 5 used in the present invention are made of a thermoplastic transparent resin with a light diffusing agent. Examples of thermoplastic transparent resins used in the present invention include methacrylic resin, polycarbonate resin, polystyrene resin, impact-resistant polystyrene, MS resin copolymerized with acrylonitrile and styrene, ABS resin made by copolymerizing three components of acrylonitrile, butadiene and styrene, MS resin made by copolymerizing methyl methacrylate and styrene, MBS resin made by copolymerizing three components of methyl methacrylate, butadiene and styrene, polyethylene, polyethylene terephthalate, alicyclic acrylic resin, alicyclic polyolefin resin, olefin-maleimide alternating copolymers, cyclohexadiene-based polymers, and the like. Preferably, it is a methacrylic resin, an MS resin in terms of light resistance. As a methacrylate resin used in the present invention, a resin mainly consisting of methyl methacrylate is more preferred.

[0023]

Resins that are predominantly methyl methacrylates include methyl methacrylate monopolymers or aromatic vinyl compounds such as methyl methacrylate and methyl acrylate, ethyl acrylate, butyl acrylate, acrylonitrile, acrylic acid, methacrylic acid, 2-hydroxyacrylate, maleic anhydride, α -methylstyrene, and the like. These methyl methacrylates and copolymerizable monomers can be used in combination of one or more. In addition, a methacrylic resin composition with impact resistance imparted by multilayered acrylic rubber, etc. can also be used.

[0024]

There is no particular limitation in the method of making such a methacrylate resin, and any known method may be used, such as suspension polymerization, emulsion polymerization, mass polymerization, or solution polymerization.

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[0025]

MS resins that may be used in the present invention show resins that are mainly copolymers of methyl methacrylate and styrene, but also include polypolymers, etc., in which any one or more of the copolymerizable monomers as illustrated in the methacrylate resins described above are added. When the entire MS resin is set at 100 parts by weight, it is more preferable that the ratio of methyl methacrylate exceeds 60 parts by weight because of good light resistance.

[0026]

In the present invention, the thermoplastic transparent resins used in each of the diffusing plates 4, 5 may be the same or different from each other.

[0027]

In addition, light diffusing agents formulated in the above-mentioned thermoplastic transparent resins may be organic, inorganic, or any other diffusing agent, and may include, for example, calcium carbonate, barium sulfate, titanium oxide, silicone-based particulates, acrylic-based particulates, styrene-based particulates, MS-based particulates, glass-based particulates, etc. However, the light diffusing agents used in the present invention are preferred to be organic crosslinked particulate. Using organic crosslinked particulates, it is possible to design an excellent resin plate that has a low dispersal unevenness of light diffusing agents in the matrix methacrylic resin, a high light permeability, and an excellent light diffusion. Particularly preferred organic crosslinked particulates are acrylic-based resin particulates, styrene-based resin particulates, and silicone-based crosslinked particulates. Examples of acrylic particulates include monofunctional vinyl monomers such as methyl methacrylate, and crosslinked particulates copolymerized with polyfunctional vinyl monomers. Examples of styrene resin particulates include styrene monomers and polyfunctional vinyl monomers, copolymerized crosslinked particulates with a functional vinyl monomer, and examples of silicone-based crosslinked particulates include polymerized crosslinked particulates of siloxane monomers. These are all obtained as spherical particles by means of polymerization methods such as suspension polymerization, emulsion polymerization, etc.

[0028]

The light diffusing agents used in the diffusing plates 4 and 5 may be the same as each other, different, alone or in combination. Although the refractive index of such light diffusing agents is not particularly limited, the refractive index of 1.4 to 1.6 is preferred because there may be optical problems such as a significant decrease in transmittance if the refractive index is too far away from the thermoplastic transparent resin that serves as the base.

[0029]

In addition, there is no particular limitation on the particle size of the particulates of the light diffusing agent, but if it is too large it may be difficult to shape the lens, and if it is small, it has little diffusing effect, so it is preferably in the range of 0.2 to 100 μm .

[0030]

Methods for blending light diffusing agents into thermoplastic transparent resins include known methods, preferably mixing with a drum blender or Henschel mixer, then melt kneading at a temperature of 220°C to 250°C with a vented single-screw or twin-screw extruder to obtain pellets. The required transmission rate for the diffusing plate of the backlight unit is 40% or more, and less than 40% is too dark for a direct backlight installed in the display device.

[0031]

The permeability of these diffusing plates can be varied by the amount of organic crosslinked particulates blended.

[0032]

The transmittance of the diffusing plate used in the present invention is 80 to 98% of the total light transmittance of the lensed diffusing plate 4 near the LED 1, and 40 to 80% of the total light transmittance of the diffusing plate 5 on the far side than the LED 1. The total light transmittance is measured in accordance with [JIS K-7105].

[0033]

In addition, in the present invention, the light diffusivity of the lensed diffusing plate 4 close to the LED 1 is 0.5 to 30%, and the light diffusivity of the diffusing plate 5 on the side farther than the LED is 70 to 90%.

[0034]

Lensed diffusing plate 4 has a lens shape on at least one side, and various lens combinations

are conceivable, such as general uneven R lens shape, prism shape, pyramid shape, glider lens shape, Fresnel lens shape, moseye lens shape, lenticular lens shape, etc., but preferably, with Fresnel lens, the light incident surface of the diffusion plate 4 in the vicinity of the LED 1, located in the center directly above the LED 1, is Fresnel with convex toward the light, cone with an apex angle of 50 to 70°, more preferably a pitch of 0.1 to 0.3 mm and a diameter of 3 to 10 mm. The light emitting surface is preferably Fresnel with a convex apex angle of 40 to 70°, more preferably 45 to 65°, a pitch of 0.1 to 0.5 mm, and a diameter of 20 to 50 mm.

[0035]

The lens shape may be shaped on either one or both sides of the diffusing plate 4 with lens. However, in the case of swelling on both sides, it is necessary to match the phases in order to prevent moire caused by the front and back lenses. In addition, if only one surface is loaded, the lens surface may be loaded on either the LED 1 side or the light emitting surface side.

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[0036]

Injection molding method, press molding method, extrusion method, or any other method of applying lens shape to the diffusing plate 4 may be used, but injection molding method is preferred as a method of molding accurately.

[0037]

Further, reflector 3 has a reflectance of 80% or more, preferably 90% or more, and by dropping light diagonally down with convex Fresnel on the light incident surface and starting light again with the reflector, the brightness between LEDs can be increased, reducing the eye-catching lamp image.

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[0038]

The thickness of the diffusing plate 4 with lenses is preferably in the range of 0.5 to 8.0 mm, including the lens top, in terms of both strength and weight. More preferably, it is in the range of 0.75 to 5.0 mm.

[0039]

In addition, the thickness of the diffusing plate 5 is preferably in the range of 1.0 to 5.0 mm in terms of strength and weight. More preferably, it is in the range of 1.5 to 3.0 mm.

[0040]

As a backlight unit, even if only one diffusing plate 4 with lens used as the diffusing plate reduces the brightness unevenness, eliminating the eye-catching image, but the required lens shape becomes complicated, the thickness of the diffusing plate 4 becomes thicker, which becomes difficult to process.

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[0041]

As in the present invention, by using a combination of a lensed diffusing plate 4 and a diffusing plate 5, light diffused in a lens shape that is easy to process can become more wide-angled in the air layer between the diffusing plate 4 and 5, reducing brightness irregularities and consequently reducing the eye-shaped image.

[0042]

In the present invention, one diffusing plate 4 and one diffusing plate 5 with a lens should be used, but it is acceptable to use two or more diffusing plates 4 and 5 respectively. In that case, in each diffusing plate 4, 5, the structural components of the thermoplastic transparent resin and each powder of light may be the same, different, the thickness of the plate may be the same, or different. In addition, if multiple diffusing plates 4 with lenses are used, it may be the same lens shape as each other or different lens shapes. Furthermore, when a plurality of diffusing plates 4 and 5 are configured as a set, they may be stacked and used, but it is preferable to provide an air layer between the plates in terms of widening the angle of light.

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[0043]

The backlight unit of the present invention may further be used with a diffusing film, prism collection film, reflective polarizing film, printed sheet such as a letter plate, liquid crystal panel, etc., on the diffusing plate 5. In addition, diffusing plates 4 and 5 may be treated as necessary, such as antistatic, hard coat, ultraviolet absorber, antireflective heat stabilizer, synovial agent, flame retardant agent, etc., and various additives may be used concomitantly.

[Examples of Embodiment]

[0044]

The present invention will be described below based on examples.

[0045]

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[Example of Embodiment 1]

For the diffusing plate 4, with respect to 100 parts by weight of methacrylic resin, 3.0 parts by weight of MS-based crosslinked particulates ("XX51F" manufactured by Sekisui Kasei Co., Ltd.) with an average particle size of about 5 μm was mixed in a drum blender, using a 30 mm twin-screw extruder, the mixture was kneaded and granulated at a resin temperature of 230-250°C to obtain a composition. This was molded using an injection molding machine at a resin temperature of 240 to 250 °C to obtain a diffusing plate 4 with a lens. With respect 100 parts by weight of methacrylic resin, for the diffusing plate 5, 1.5 parts by weight of silicone-based crosslinked particulates ("MSP — S020" manufactured by Nikko Rica Co., Ltd.) with an average particle diameter of about 2 μm and 5.0 parts by weight of MS-based crosslinked particulates ("GSM0561" manufactured by Ganz Kasei Co., Ltd.) with an average particle diameter of about 5 μm were used. Others were kneaded in the same manner as the diffusing plate 4 to obtain a composition, using the same.

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[0046]

As shown in FIG. 1, two general-purpose LED 1 were set in series with $b = 50$ mm apart, and a voltage of 0.65 V is applied to turn on LED 1. A diffusing plate 4 with a lens and a plate thickness of 1.5 mm as the first diffusing plate 4 with a plate thickness of 1.5 mm, and a diffusing plate 5 having a thickness of 2.0 mm as the second plate was installed at a distance of $c = 3.0$ mm from the two LEDs 1 in the vertical direction. Reflector 3 had a reflectance of 93% and was set 0.2 mm below the top surface of LED 1. The diffusing plate 4 with lens had a total light transmittance of 96.5%, a light diffusivity of 15%, and a double-sided Fresnel lens. The light incident surface, in the central part directly above LED 1, used a Fresnel with a convex shape facing LED 1, a cone with an apex angle of 60°, a pitch of 0.2 mm, and a diameter of 5 mm. For the light emitting surface, Fresnel with a convex angle of 50°, a pitch of 0.3 mm, and a diameter of 40 mm was used. The diffusing plate 5 was a flat plate without a lens shape, with a total light transmittance of 60% and a light diffusivity of 83%.

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[0047]

The brightness measurements were made by setting each diffusing plate 4, 5 and measuring the brightness directly above each LED 1 and between the left and right LEDs 1. The luminance meter was made by Topcon "BM7" and the measurement conditions were a measurement distance of 350 mm and a viewing angle of 0.2°. The results are shown in Table 2 with the comparative examples in relative brightness. Relative brightness is expressed as the ratio when the maximum value on the LED 1 of Comparative Example 4 is set to "1".

[0048]

In addition, the total light transmittance was measured at a thickness of 3 mm in accordance with "JIS K-7105".

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[0049]

The light diffusivity is measured by 3 mm thickness using a diagonal luminance meter (made by Optex) and is shown using the data calculated from the following equation.

[0050]

$$\text{Light diffusivity} = \{(20^\circ \text{ intensity} + 70^\circ \text{ intensity}) / (5^\circ \text{ intensity} \times 2)\} \times 100$$

[0051]

[Example of Embodiment 2]

The distance of the diffusing plate 5 from the LED 1 was set to $a = 25$ mm, and all except that the ratio of (a/b) was 0.5 were set in the same manner as in Example 1, and the comparison was measured.

[0052]

[Example of Embodiment 3]

The distance of the diffusing plate 5 from the LED 1 was set to $a = 35$ mm, and all but the ratio of (a/b) was 0.7 were set in the same manner as in Example 1, and the comparison was measured.

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[0053]

[Example of Embodiment 4]

The distance of the diffusing plate 4 from the LED 1 was set to $c = 1.0$ mm, and all but the ratio of (c/b) was 0.02 were set in the same manner as in Example 1, and the comparison was measured.

[0054]

[Example of Embodiment 5]

The distance of the diffusing plate 4 from the LED 1 was set to $c = 10$ mm, and all but the ratio of (c/b) was 0.2 were set as in Example 1, and the comparison was measured.

[0055]

[Example of Embodiment 6]

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All but the apex angle of the Fresnel on the incident side of diffusing plate 4 was set to 50°, and the comparison was measured in the same manner as in Example 1.

[0056]

[Example of Embodiment 7]

All but the apex angle of the Fresnel on the incident side of diffusing plate 4 was set to 65°, and the comparison was measured in the same manner as in Example 1.

[0057]

[Example of Embodiment 8]

All but the diameter of the Fresnel on the incident side of diffusing plate 4 was set to 3 mmφ, and the comparison was measured in the same manner as in Example 1.

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[0058]

[Example of Embodiment 9]

All but the diameter of the Fresnel on the incident side of diffusing plate 4 was set to 10 mmφ, and the comparison was measured in the same manner as in Example 1.

[0059]

[Example of Embodiment 10]

All but the apex angle of the Fresnel on the light emitting side of diffusing plate 4 was set to 45°, and the comparison was measured in the same manner as in Example 1.

[0060]

[Example of Embodiment 11]

All but the apex angle of the Fresnel on the light emitting side of diffusing plate 4 was set to 65°, and the comparison was measured in the same manner as in Example 1.

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[0061]

[Example of Embodiment 12]

All but the pitch of the Fresnel on the incident side of diffusing plate 4 was set to 0.1 mm, and the comparison was measured in the same manner as in Example 1.

[0062]

[Example of Embodiment 13]

All but the pitch of the Fresnel on the incident side of diffusing plate 4 was set to 0.3 mm, and the comparison was measured in the same manner as in Example 1.

[0063]

[Example of Embodiment 14]

All but the pitch of the Fresnel on the light eside of diffusing plate 4 was set to 0.1 mm, and the comparison was measured in the same manner as in Example 1.

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[0064]

[Example of Embodiment 15]

All but the pitch of the Fresnel on the light emitting side of diffusing plate 4 was set to 0.5 mm, and the comparison was measured in the same manner as in Example 1.

[0065]

[Example of Embodiment 16]

All but the diameter of the Fresnel on the light emitting side of diffusing plate 4 was set to 20 mmφ, and the comparison was measured in the same manner as in Example 1.

[0066]

[Example of Embodiment 17]

All but the diameter of the Fresnel on the light emitting side of diffusing plate 4 was set to 50 mmφ, and the comparison was measured in the same manner as in Example 1.

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[0067]

[Example of Embodiment 18]

All but the light diffusivity of diffusing plate 4 was set to 0.5%, and the comparison was measured in the same manner as in Example 1.

[0068]

[Example of Embodiment 19]

All but the light diffusivity of diffusing plate 4 was set to 30% as in Example 1, and the comparison was measured in the same manner as in Example 1.

[0069]

[Example of Embodiment 20]

All but the plate thickness of diffusing plate 4 was set to 0.75 mm, and the comparison was measured as in Example 1.

[0070]

[Example of Embodiment 21]

All but the plate thickness of diffusing plate 4 was set to 5.0 mm, and the comparison was measured as in Example 1.

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[0071]

[Example of Embodiment 22]

All but the total light transmittance of diffusing plate 5 was set to 50%, and the comparison was measured as in Example 1.

[0072]

[Example of Embodiment 23]

All but the total light transmittance of diffusing plate 5 was set to 70%, and the comparison was measured as in Example 1.

[0073]

[Example of Embodiment 24]

All but the plate thickness of diffusing plate 5 was set to 1.0 mm, and the comparison was measured as in Example 1.

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[0074]

[Example of Embodiment 25]

All but the plate thickness of diffusing plate 5 was set to 3.0 mm, and the comparison was measured as in Example 1.

[0075]

[Example of Embodiment 26]

All but the reflectance of reflector 5 was set to 80%, and the comparison was measured in the same manner as in Example 1.

[0076]

[Example of Embodiment 27]

Except that the light incident side of the diffusing plate 4 was a flat plate without a lens function, and comparative measurements were performed in the same manner as in Example 1.

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[0077]

[Example of Embodiment 28]

Except that the light emitting side of the diffusing plate 4 was a flat plate without a lens function, and comparative measurements were performed in the same manner as in Example 1.

[0078]

[Comparative Example 1]

Except that the light incident side and the light emitting side of the diffusing plate 4 was set to a flat plate without a lens function, and comparative measurements were performed in the same manner as in Example 1.

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[0079]

[Comparative Example 2]

All but the reflectance of the reflector was set to 75%, and the comparison was measured in the same manner as Example 1.

[0080]

[Comparative Example 3]

All but the reflectors were set, and were compared and measured in the same manner as Example 1.

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[0081]

[Comparative Example 4]

All but diffusing plate 5 alone without using diffusing plate 4 were set, and the comparison was measured in the same manner as Example 1.

[0082]

The configuration of the above examples and comparative examples is shown in Table 1, and the evaluation results are shown in Table 2. The evaluation criteria for the eye-catching lamp image are as follows.

[0083]

◎: Good condition that glows evenly as a surface

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○: Less luminosity and good condition

△: Slightly uneven brightness is noticeable depending on the viewing angle

×: Uneven brightness and visible eye-catching lamp image

[0084]

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[Table 1]

	Diffusing Plate 4										Diffusing Plate 5				Reflector
	Incident side Fresnel			Light emitting side Fresnel			Total light transmittance (%)	Light diffusivity (%)	Plate thickness (mm)	Distance from LED (c/b)	Total light transmittance (%)	Light diffusivity (%)	Plate thickness (mm)	Distance from LED (a/b)	Reflectivity (%)
	Apex angle	Pitch	Diameter	Apex angle	Pitch	Diameter									
	(°)	(mm)	(mm)	(°)	(mm)	(mm)									
Example 1	80	0.2	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 2	80	0.2	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.5	93
Example 3	80	0.2	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.7	93
Example 4	80	0.2	5	50	0.3	40	88.5	15	1.5	0.02	80	83	2	0.8	93
Example 5	80	0.2	5	50	0.3	40	88.5	15	1.5	0.20	80	83	2	0.8	93
Example 6	50	0.2	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 7	85	0.2	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 8	80	0.2	3	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 9	80	0.2	10	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 10	80	0.2	5	45	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 11	80	0.2	5	85	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 12	80	0.1	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 13	80	0.3	5	50	0.3	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 14	80	0.2	5	50	0.1	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 15	80	0.2	5	50	0.5	40	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 16	80	0.2	5	50	0.3	20	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 17	80	0.2	5	50	0.3	50	88.5	15	1.5	0.08	80	83	2	0.8	93
Example 18	80	0.2	5	50	0.3	40	84.5	0.5	1.5	0.08	80	83	2	0.8	93
Example 19	80	0.2	5	50	0.3	40	92.4	30	1.5	0.08	80	83	2	0.8	93
Example 20	80	0.2	5	50	0.3	40	98.5	15	0.75	0.08	80	83	2	0.8	93
Example 21	80	0.2	5	50	0.3	40	81.5	15	5.0	0.08	80	83	2	0.8	93
Example 22	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	50	87	2	0.8	93
Example 23	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	70	73	2	0.8	93
Example 24	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	80	83	1	0.8	93
Example 25	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	80	83	3	0.8	93
Example 26	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	80	83	2	0.8	80
Example 27	—	—	—	50	0.3	40	98.5	15	1.5	0.08	80	83	2	0.8	93
Example 28	80	0.2	5	—	—	—	88.5	15	1.5	0.08	80	83	2	0.8	93
Comparative Example 1	—	—	—	—	—	—	98.5	15	1.5	0.08	80	83	2	0.8	93
Comparative Example 2	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	80	83	2	0.8	75
Comparative Example 3	80	0.2	5	50	0.3	40	98.5	15	1.5	0.08	80	83	2	0.8	—
Comparative Example 4	—	—	—	—	—	—	—	—	—	—	80	83	2	0.8	93

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[0085]

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[Table 2]

	Assessment Results			Eye-catching Lamp image
	Relative brightness			
	On the left lamp	Central part	On the right lamp	
Example 1	0.670	0.550	0.690	⊗
Example 2	0.683	0.503	0.721	○
Example 3	0.690	0.541	0.683	⊗~○
Example 4	0.688	0.533	0.708	⊗~○
Example 5	0.662	0.541	0.683	⊗~○
Example 6	0.685	0.503	0.726	○
Example 7	0.690	0.508	0.711	○
Example 8	0.688	0.487	0.703	○
Example 9	0.693	0.485	0.708	○
Example 10	0.698	0.497	0.726	○
Example 11	0.701	0.503	0.723	○
Example 12	0.675	0.541	0.698	⊗~○
Example 13	0.678	0.541	0.698	⊗~○
Example 14	0.683	0.538	0.703	⊗~○
Example 15	0.688	0.503	0.711	○
Example 16	0.708	0.492	0.721	○
Example 17	0.708	0.500	0.716	○
Example 18	0.713	0.480	0.723	○
Example 19	0.703	0.482	0.711	○
Example 20	0.688	0.503	0.728	○
Example 21	0.683	0.487	0.723	○
Example 22	0.688	0.482	0.685	○
Example 23	0.673	0.492	0.716	○
Example 24	0.688	0.538	0.698	⊗~○
Example 25	0.678	0.505	0.688	⊗~○
Example 26	0.708	0.470	0.728	○
Example 27	0.792	0.452	0.825	△
Example 28	0.708	0.470	0.746	△
Comparative Example 1	0.815	0.386	0.838	×
Comparative Example 2	0.799	0.376	0.830	×
Comparative Example 3	0.898	0.335	0.937	×
Comparative Example 4	0.987	0.279	1.000	×

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[Brief Description of the Drawings]

[0086]

[FIG. 1] A schematic diagram showing a cross-sectional configuration of the backlight unit of the present invention.

[FIG. 2] A schematic diagram showing the configuration of a conventional backlight unit.

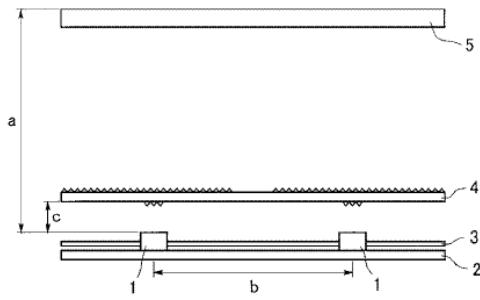
[Explanation of References]

[0087]

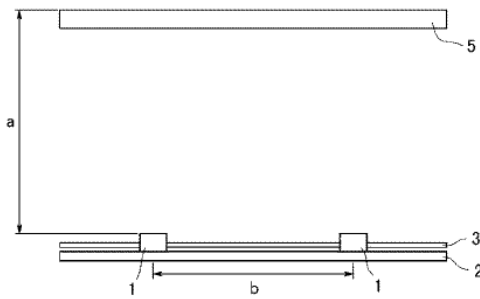
- 1 LED
- 2 Base
- 3 Reflector
- 4 Diffusing Plate with Lens
- 5 Diffusing plate

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[FIG. 1]



[FIG. 2]





City of New York, State of New York, County of New York

I, Dan McCourt, hereby certify that the document “**JP2007329016A (Kobayashi)**” is, to the best of my knowledge and belief, a true and accurate translation from Japanese into English.

A handwritten signature in black ink that reads 'Dan M'.

Dan McCourt

Sworn to before me this
May 5, 2023

A handwritten signature in black ink, appearing to be 'Wendy Poon'.

Signature, Notary Public



Stamp, Notary Public