US 20150267877A1

(19) United States

(12) Patent Application Publication

HIRAKA

(10) Pub. No.: US 2015/0267877 A1

(43) Pub. Date: Sep. 24, 2015

(54) LIGHT EMITTING DEVICE, SURFACE LIGHT SOURCE DEVICE AND DISPLAY APPARATUS

(71) Applicant: **Enplas Corporation**, Saitama (JP)

(72) Inventor: **Kensuke HIRAKA**, Saitama (JP)

(21) Appl. No.: **14/657,074**

(22) Filed: **Mar. 13, 2015**

(30) **Foreign Application Priority Data**

Mar. 18, 2014 (JP) 2014-055132

Publication Classification

(51) **Int. Cl.**

F21K 99/00 (2006.01)

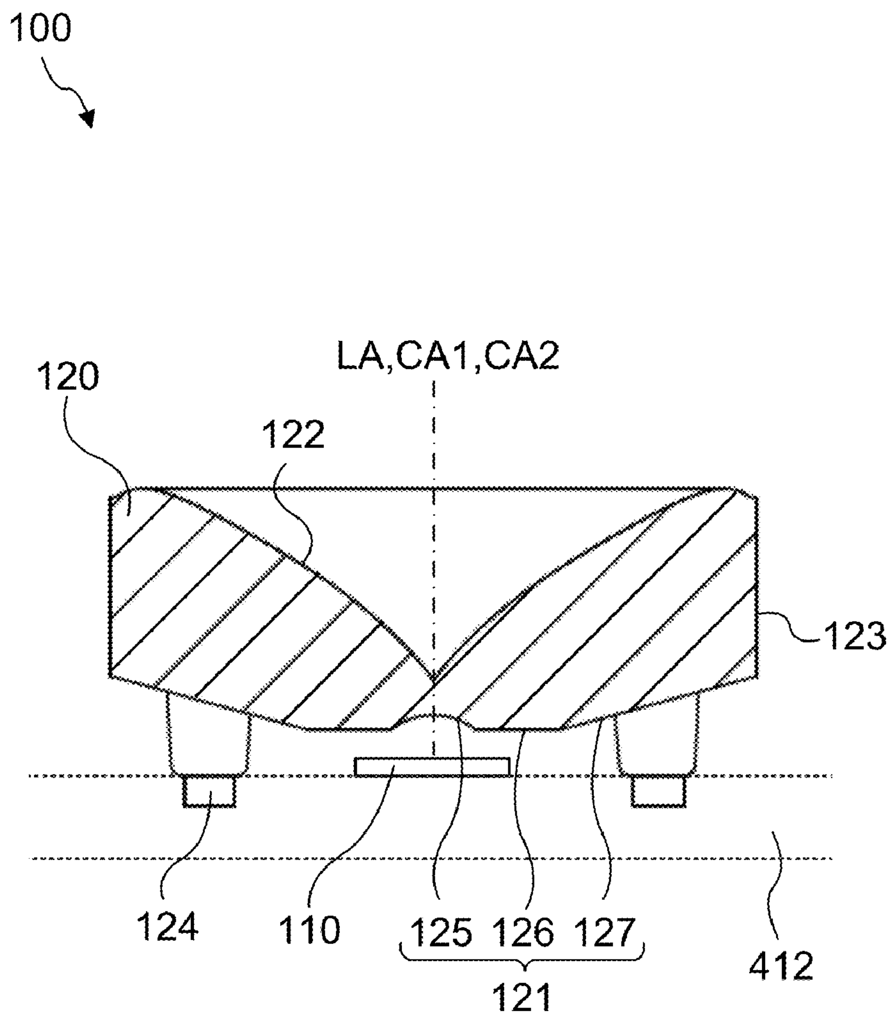
F21V 13/02 (2006.01)

(52) **U.S. Cl.**

CPC . *F21K 9/50* (2013.01); *F21V 13/02* (2013.01); *F21Y 2101/02* (2013.01)

(57) **ABSTRACT**

A light emitting device comprises a light emitting element and a light flux controlling member configured to control the distribution of light emitted from the light emitting element. The light flux controlling member comprises an incidence surface including an outer incidence surface including an inclining surface formed such that the distance from the light emitting element increases as the distance from the optical axis of the light emitted from the light emitting element increases and an inner incidence surface, a reflection surface disposed on a side of the light flux controlling member opposite to the incidence surface, and a emission surface disposed to surround the optical axis. Light emitted from the light emitting surface center of the light emitting element does not reach the inclining surface.



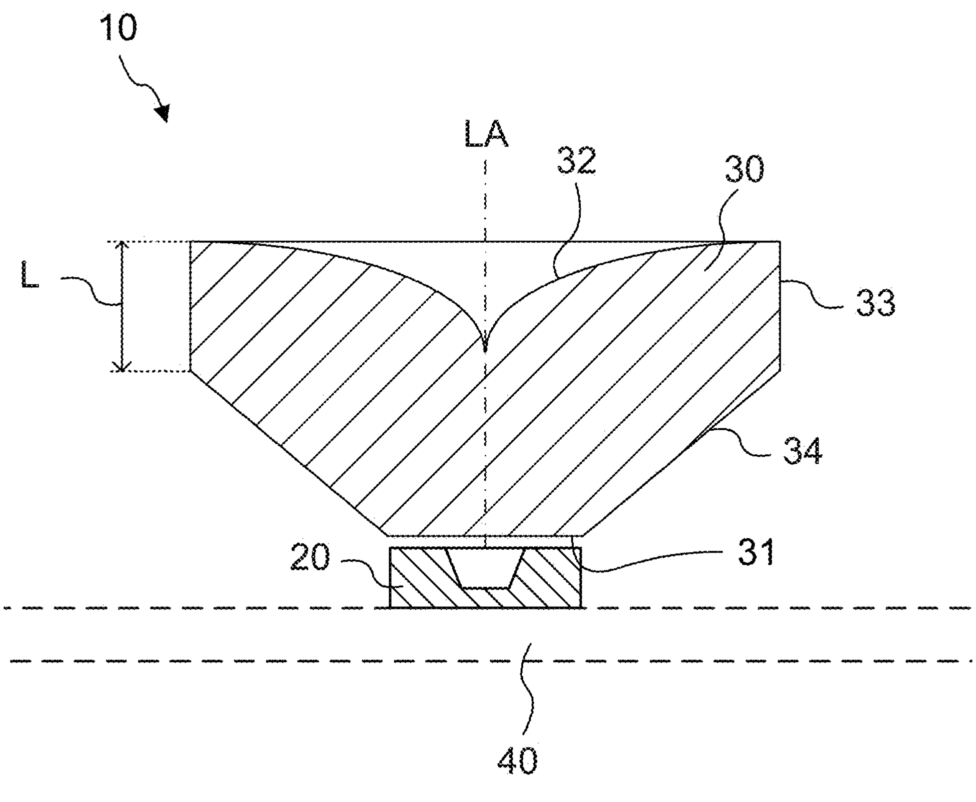


FIG. 1

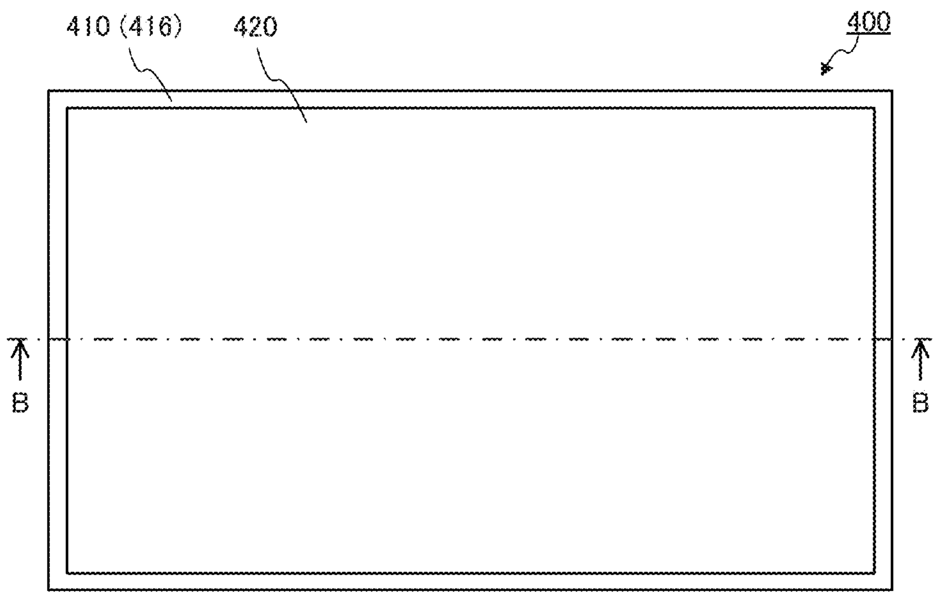


FIG. 2A

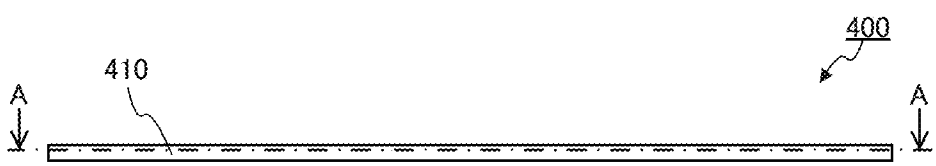


FIG. 2B

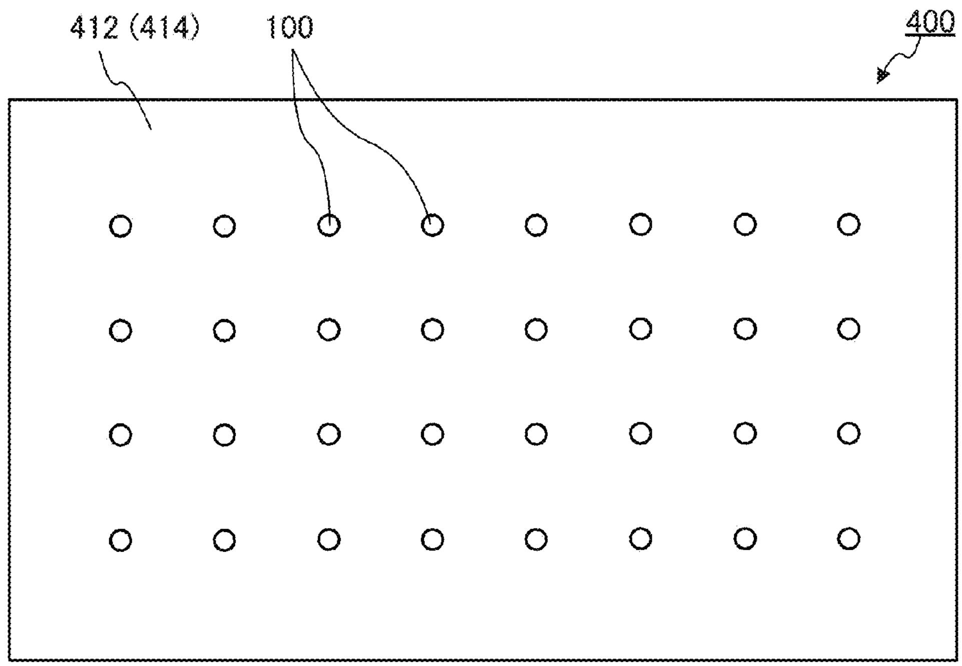


FIG. 3A

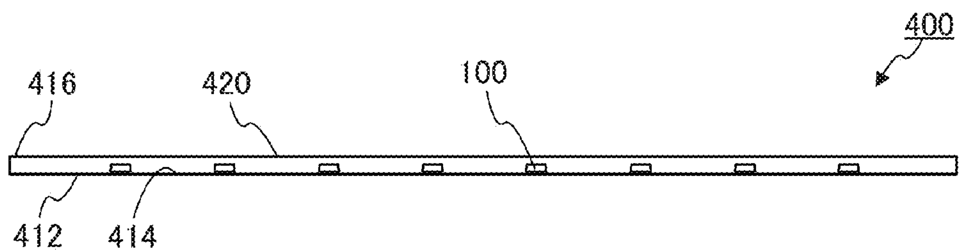


FIG. 3B

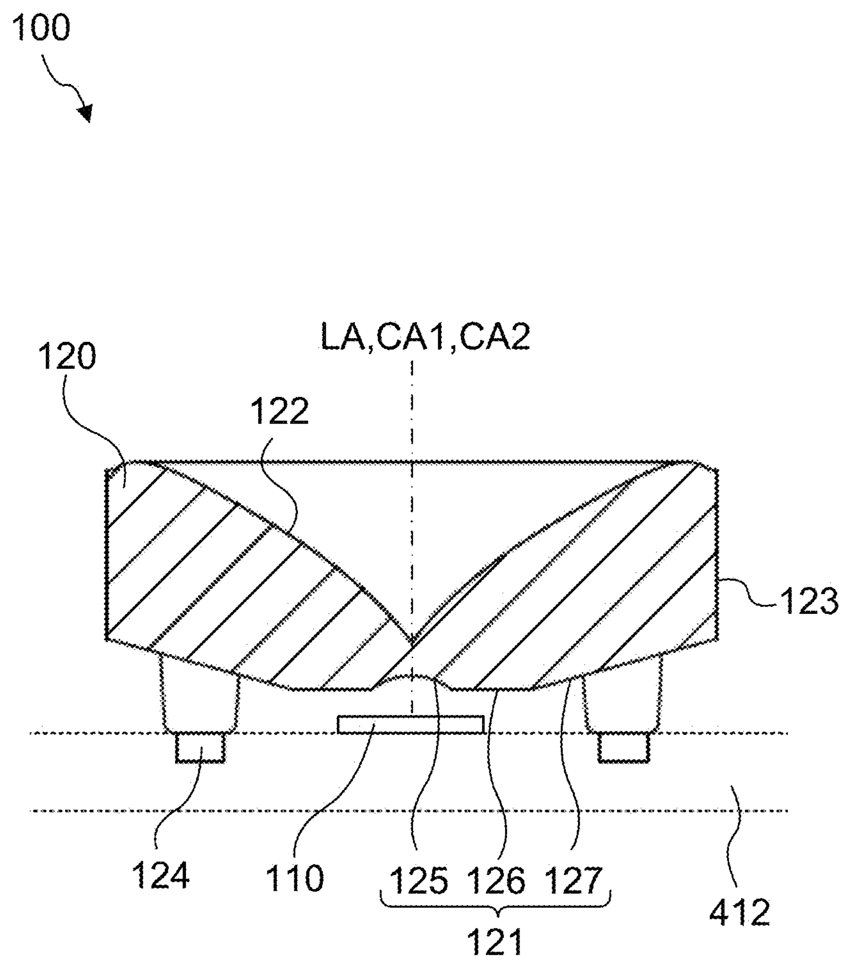


FIG. 4

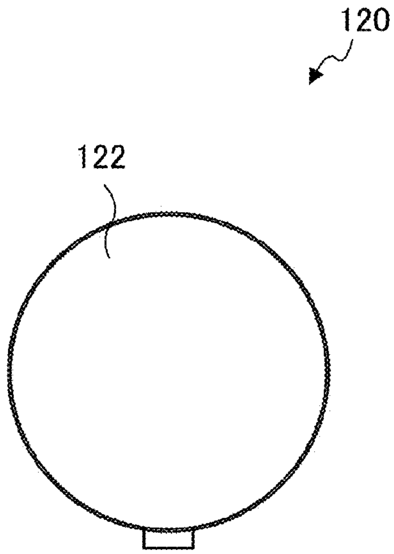


FIG. 5A

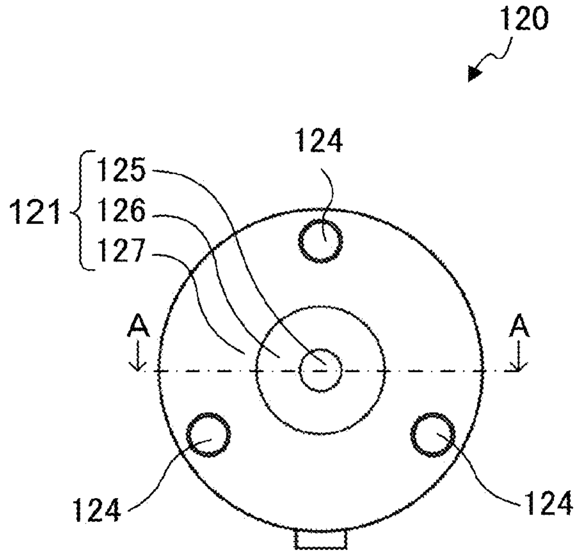


FIG. 5B

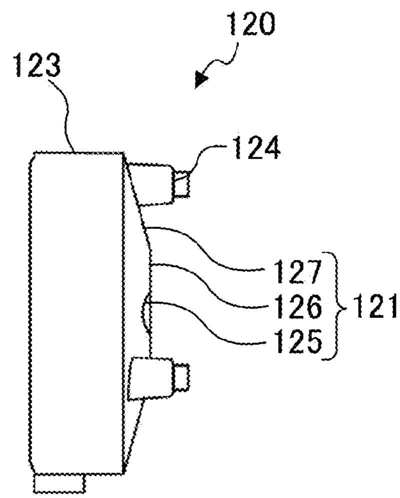


FIG. 5C

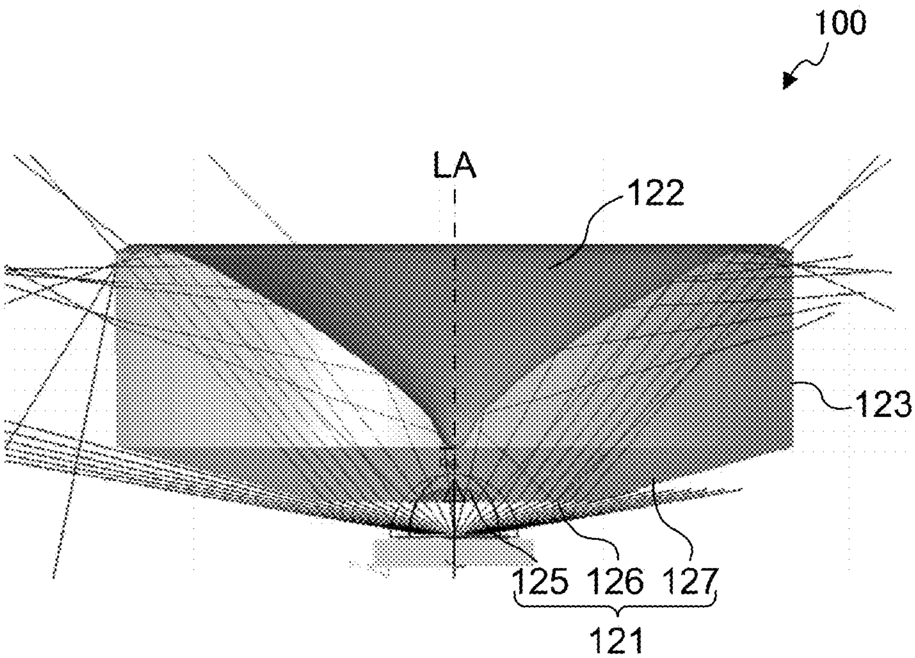


FIG. 6

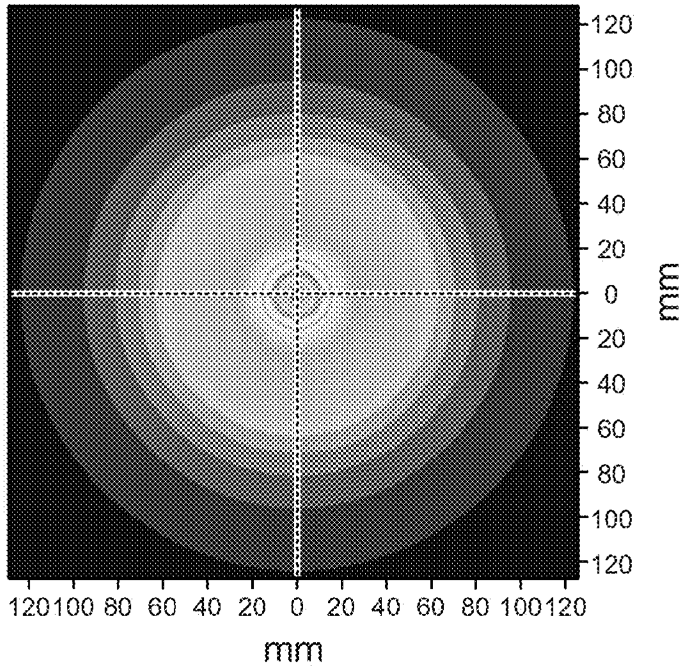

120
100
80
60
40
20
0
20
40
60
80
100
120
mm
120 100 80 60 40 20 0 20 40 60 80 100 120
mm

FIG. 7A

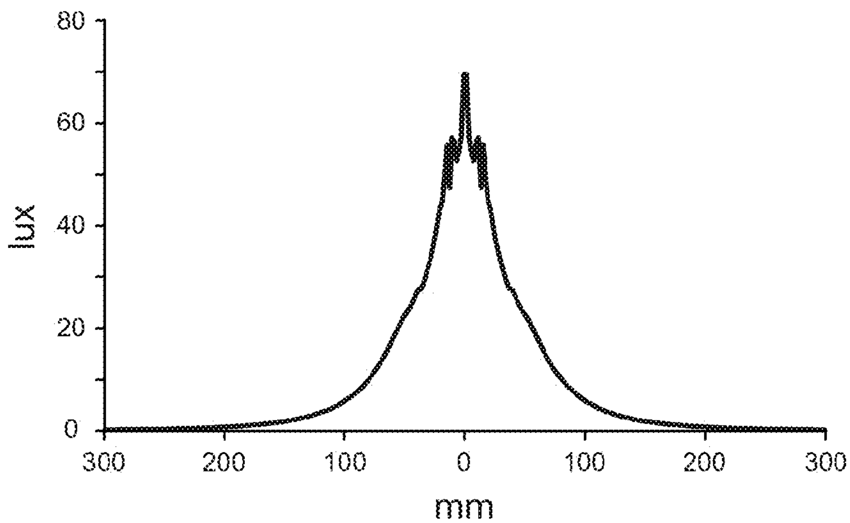

80
60
40
20
0
lux
300 200 100 0 100 200 300
mm

FIG. 7B

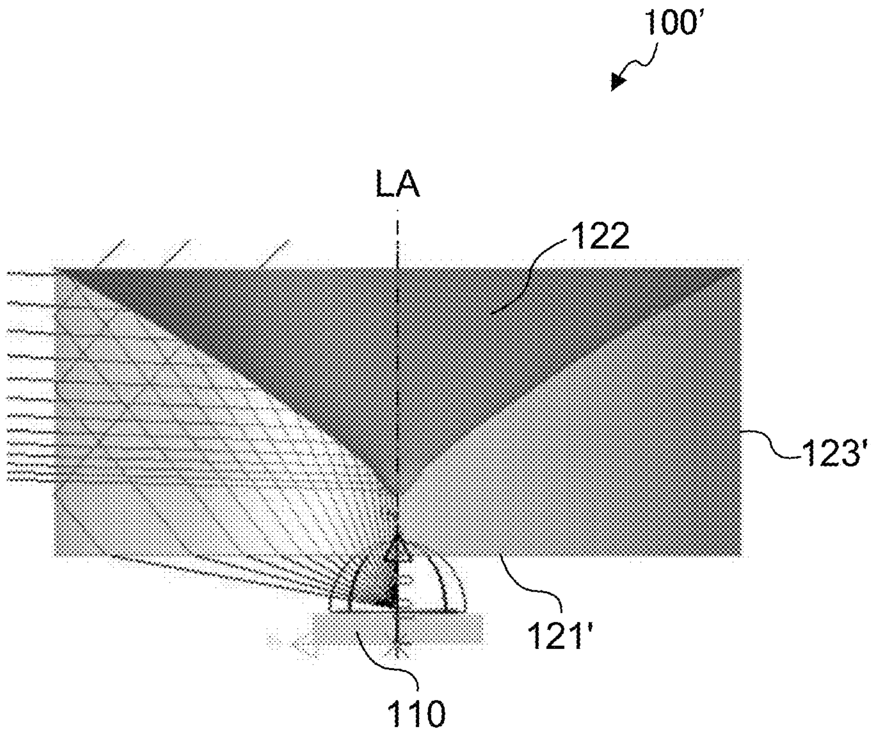


FIG. 8

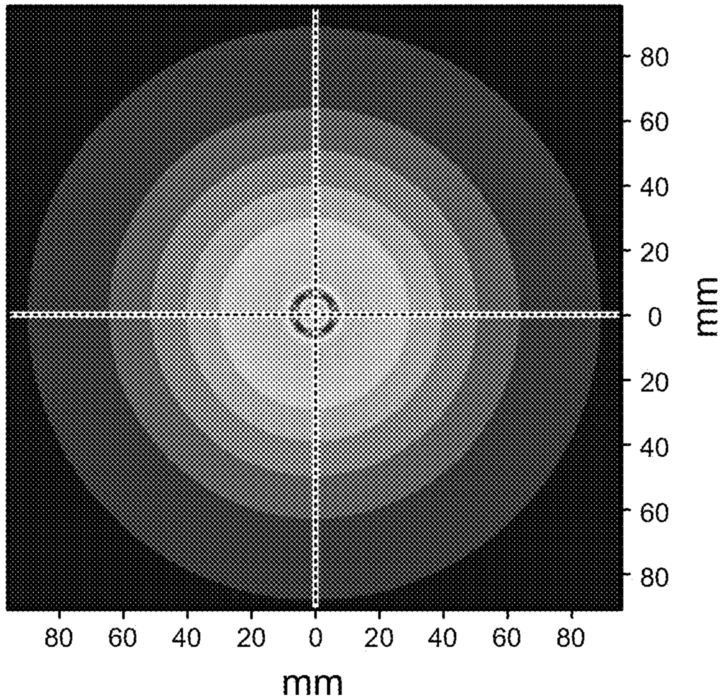

80
60
40
20
0
20
40
60
80
mm
80 60 40 20 0 20 40 60 80
mm

FIG. 9A

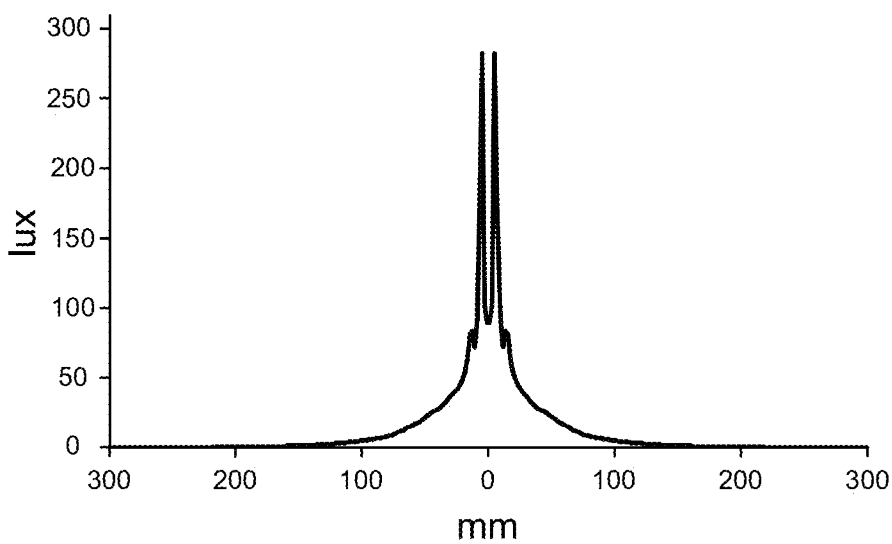

300
250
200
150
100
50
0
lux
300 200 100 0 100 200 300
mm

FIG. 9B

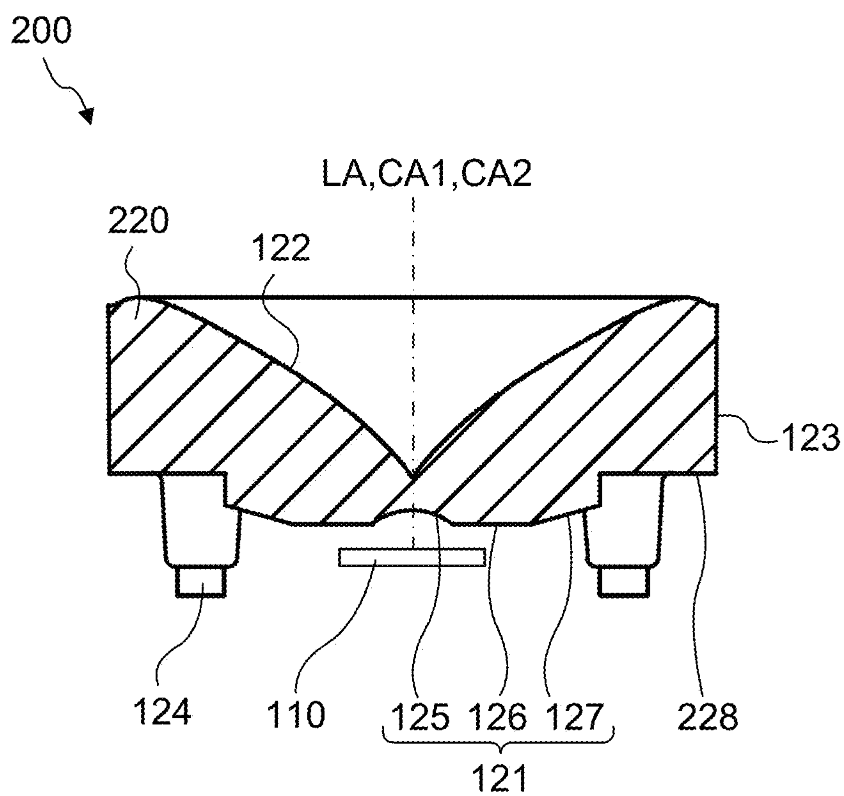


FIG. 10

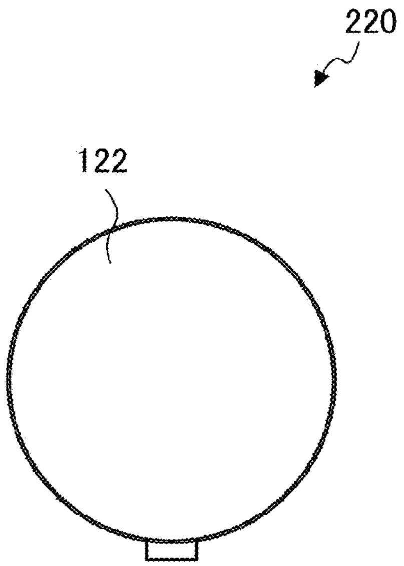


FIG. 11A

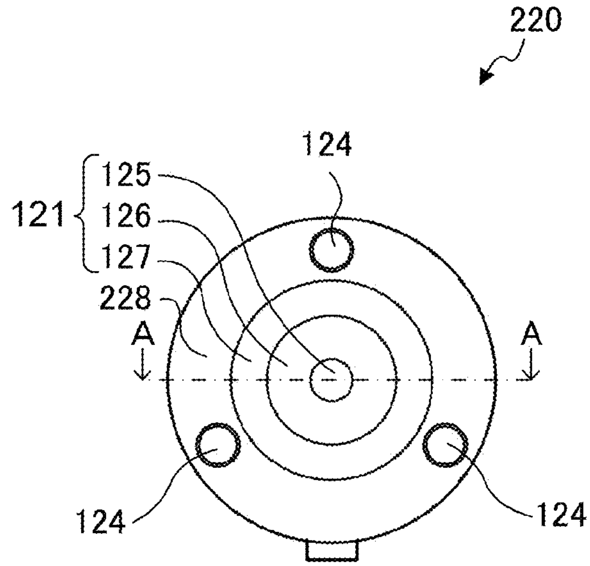


FIG. 11B

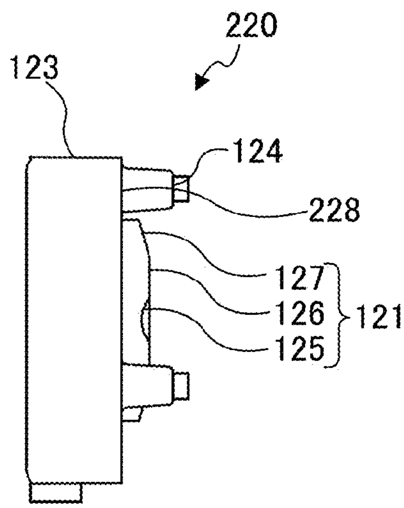


FIG. 11C

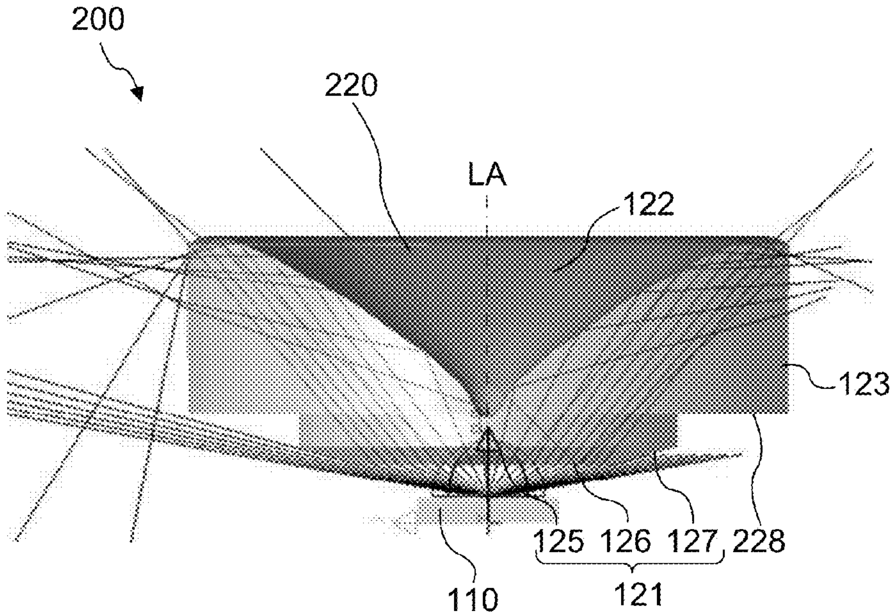


FIG. 12A

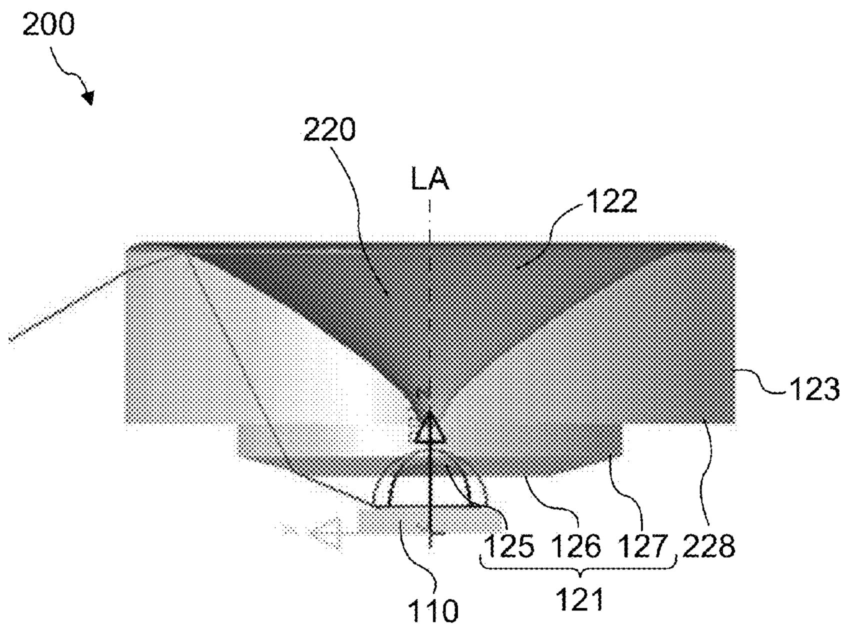


FIG. 12B

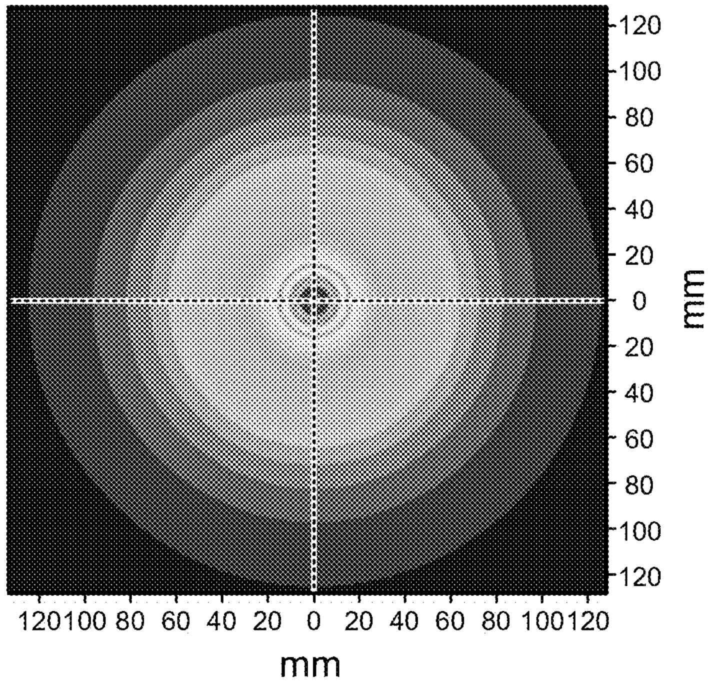


FIG. 13A

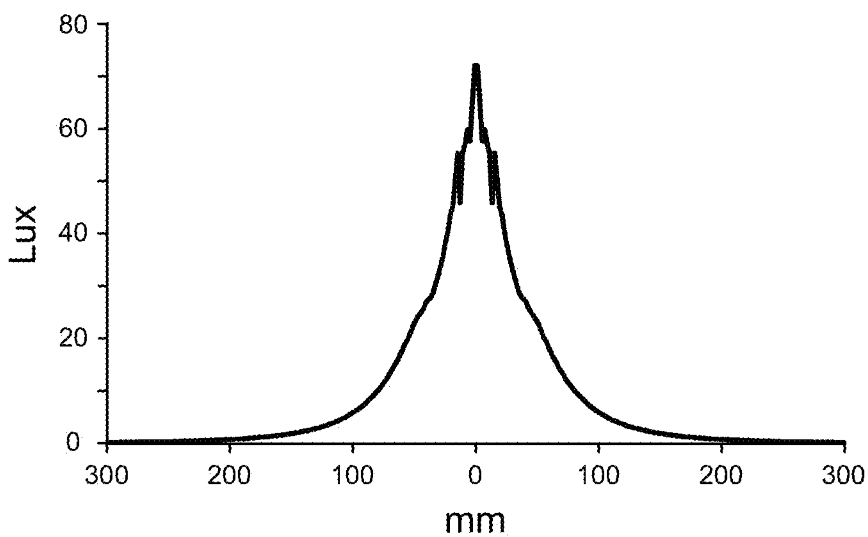


FIG. 13B

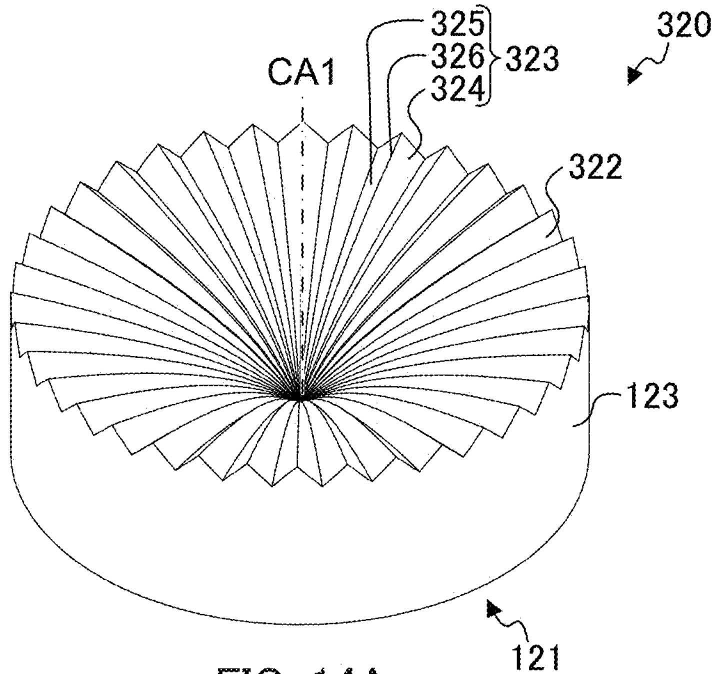


FIG. 14A

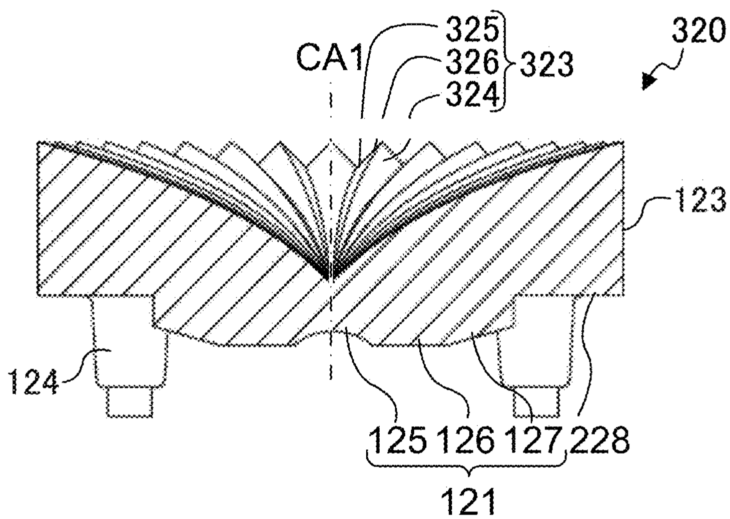


FIG. 14B

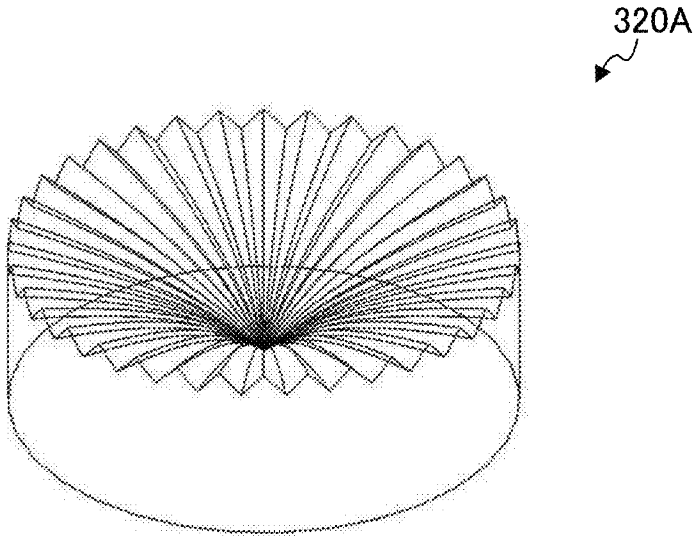


FIG. 15A

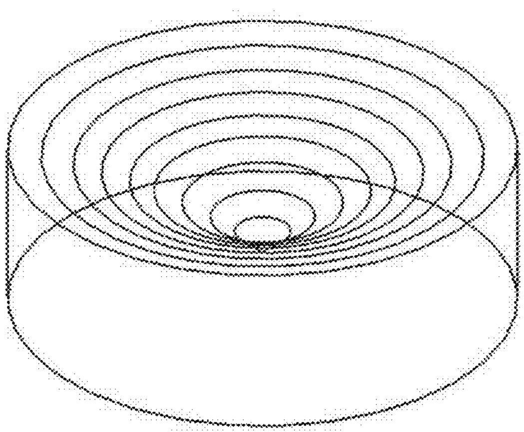


FIG. 15B

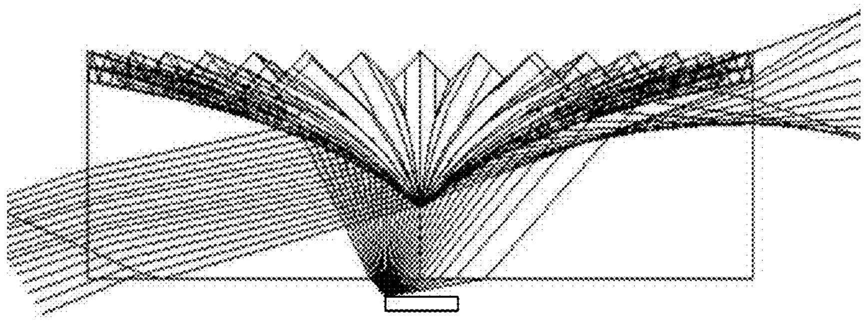


FIG. 16A

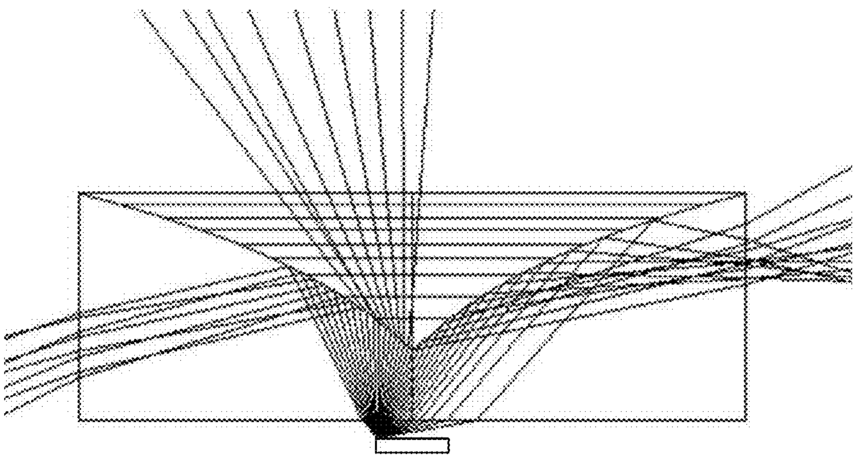


FIG. 16B

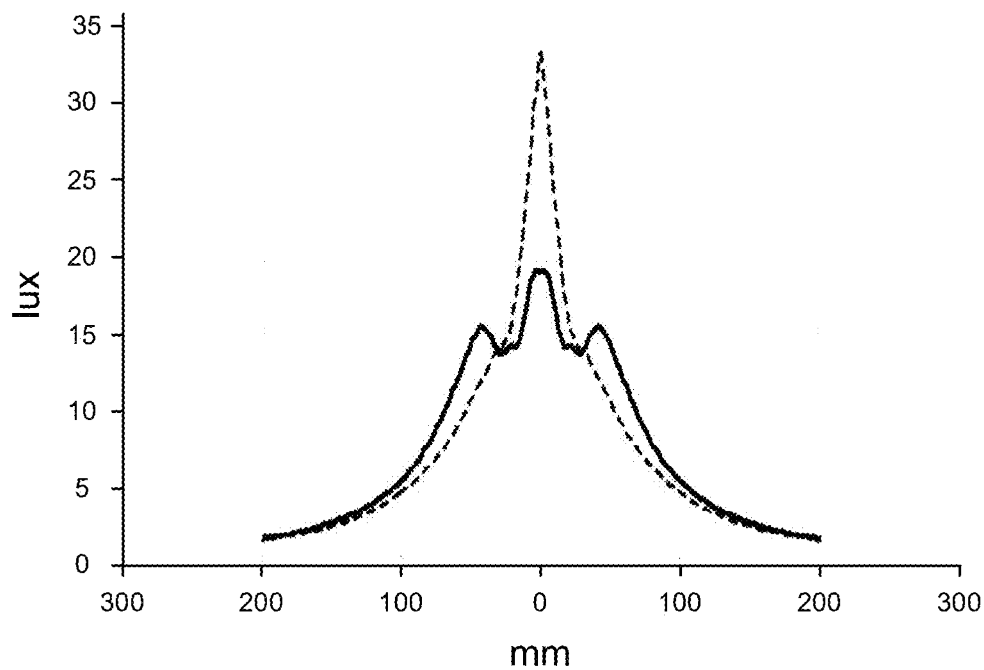


FIG. 17

LIGHT EMITTING DEVICE, SURFACE LIGHT SOURCE DEVICE AND DISPLAY APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is entitled to and claims the benefit of Japanese Patent Application No. 2014-055132, filed on Mar. 18, 2014, the disclosure of which including the specification, drawings and abstract is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to a light emitting device including a light flux controlling member configured to control the distribution of light emitted from a light emitting element, and a surface light source device and a display apparatus including the light emitting device.

BACKGROUND ART

[0003] In recent years, light emitting diodes (hereinafter referred to as "LED") have been used as a light source for lighting from the perspective of energy saving and miniaturization. Moreover, light source units for radiating light (light emitting device) each including an LED and an optical element for converting light direction (light flux controlling member) configured to control the distribution of light emitted from the LED combined with each other have been increasingly used instead of fluorescent lighting or halogen lamps (see for example PTL 1).

[0004] FIG. **1** is a cross-sectional view of a light source unit for radiating light **10** disclosed in PTL 1. Substrate **40** on which light source unit for radiating light **10** is mounted is shown by a broken line in FIG. **1**. As illustrated in FIG. **1**, light source unit for radiating light **10** disclosed in PTL 1 comprises LED **20** and optical element for converting light direction **30** disposed at a position intersecting optical axis LA of the light flux emitted from LED **20**. Optical element for converting light direction **30** comprises incidence surface **31** on the LED side (rear side), reflection surface **32** disposed on the opposite side to incidence surface **31** (front side), emission surface **33** on the lateral side, and inclining surface **34** connecting incidence surface **31** with emission surface **33**. In a plane including optical axis LA of light emitted from LED **20**, inclining surface **34** is disposed so that the distance from LED **20** increases as the distance from optical axis LA increases.

[0005] The light emitted from LED **20** is incident on incidence surface **31**, reflected laterally by reflection surface **32**, and then emitted from emission surface **33** laterally. It is to be noted that the light emitted from LED **20** does not enter optical element for converting light direction **30** from inclining surface **34**. The light emitted from LED **20** is thus controlled to be emitted laterally by optical element for converting light direction **30** in light source unit for radiating light **10** disclosed in PTL 1.

CITATION LIST

Patent Literature

[0006] PTL 1: Japanese Patent Application Laid-Open No. 2007-048883

SUMMARY OF INVENTION

Technical Problem

[0007] In light source unit for radiating light **10** disclosed in PTL 1, since optical element for converting light direction **30** is disposed adjacent to LED **20**, light emitted from LED **20** does not directly reach inclining surface **34**. However, when using LED **20** having a large light emitting surface, or disposing optical element for converting light direction **30** far from LED **20**, light emitted form LED **20** may directly reach inclining surface **34** and leaked light may be generated in the direction directly above LED **20** because the light flux cannot be controlled as intended.

[0008] An object of the present invention is to provide a light emitting device that allows for prevention of leaked light in the direction directly above the light emitting device, and reduction in the weight of a light flux controlling member at the same time. Another object of the present invention is to provide a surface light source device and a display apparatus including the light emitting device.

Solution to Problem

[0009] A light emitting device of the present invention comprises a light emitting element and a light flux controlling member configured to control the distribution of light emitted from the light emitting element, the light flux controlling member being disposed over the light emitting element, wherein the light flux controlling member comprises: an incidence surface configured such that light emitted from the light emitting element is incident on the incidence surface, the incidence surface comprising an outer incidence surface formed as an inclining surface such that the distance from the light emitting element increases as the distance from an optical axis of the light emitted from the light emitting element increases, and an inner incidence surface connected with an inside of the outer incidence surface; a reflection surface configured to laterally reflect the light incident on the incidence surface, the reflection surface being disposed on a side of the light flux controlling member opposite to the incidence surface such that the distance from the light emitting element increases in the direction from the center to the outer periphery of the reflection surface; and an emission surface configured to emit the light reflected by the reflection surface, the emission surface being disposed to surround the central axis: and light emitted from the light emitting surface center of the light emitting element does not reach the inclining surface.

[0010] A surface light source device of the present invention comprises the light emitting device of the present invention, and a light diffusion member configured to allow the light emitted from the light emitting device to pass therethrough while diffusing the light.

[0011] Further, a display apparatus of the present invention comprises the surface light source device of the present invention and a cover configured to allow light emitted from the surface light source device to pass therethrough while diffusing the light.

Advantageous Effects of Invention

[0012] The light emitting device, surface light source device and display apparatus of the present invention allow for prevention of light leakage in the direction directly above the light emitting device while reducing the weight of the light flux controlling member.

BRIEF DESCRIPTION OF DRAWINGS

[0013] FIG. **1** is a cross-sectional view of a light source unit for radiating light according to PTL 1;

[0014] FIGS. **2**A and **2**B illustrate a configuration of a surface light source device according to Embodiment 1;

[0015] FIGS. **3**A and **3**B illustrate the configuration of the surface light source device according to Embodiment 1;

[0016] FIG. **4** is a cross-sectional view of a light emitting device according to Embodiment 1;

[0017] FIGS. **5**A to **5**C illustrate a configuration of a light flux controlling member;

[0018] FIG. **6** is a view of optical paths in the light emitting device according to Embodiment 1;

[0019] FIGS. **7**A and **7**B illustrate a simulation of light brightness using the light emitting device according to Embodiment 1;

[0020] FIG. **8** is a view of optical paths in a light emitting device according to a comparative example;

[0021] FIGS. **9**A and **9**B illustrate a simulation of light brightness using the light emitting device according to the comparative example;

[0022] FIG. **10** is a cross-sectional view of a light emitting device according to Embodiment 2;

[0023] FIGS. **11**A to **11**C illustrate a configuration of a light flux controlling member according to Embodiment 2;

[0024] FIGS. **12**A and **12**B are views of optical paths in the light emitting device according to Embodiment 2;

[0025] FIGS. **13**A and **13**B illustrate a simulation of light brightness using the light emitting device according to Embodiment 2;

[0026] FIGS. **14**A and **14**B illustrate a configuration of a light flux controlling member according to Embodiment 3;

[0027] FIGS. **15**A and **15**B are perspective views of light flux controlling members used for a simulation;

[0028] FIGS. **16**A and **16**B are views of optical paths showing the effect of a reflection surface in a light emitting device according to Embodiment 3; and

[0029] FIG. **17** illustrates the simulation of light brightness showing the effect of the reflection surface in the light emitting device according to Embodiment 3.

DESCRIPTION OF EMBODIMENTS

[0030] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. In the following description, as representative examples of surface light source devices of the present invention, surface light source devices suitable for backlights of liquid crystal display apparatuses or the like will be described. These surface light source devices may be used as display apparatuses in combination with members to be irradiated (e.g. liquid crystal panels) to which light from the surface light source devices is radiated.

Embodiment 1

[0031] (Configurations of Surface Light Source Device and Light Emitting Device)

[0032] FIGS. **2**A to **4** illustrate a configuration of surface light source device **400** according to an embodiment of the present invention. FIG. **2**A is a plan view and FIG. **2**B is a front view of surface light source device **400** according to Embodiment 1 of the present invention. FIG. **3**A is a cross-sectional view taken along line A-A shown in FIG. **2**B, and FIG. **3**B is a cross-sectional view taken along line B-B shown in FIG. **2**A. FIG. **4** is a cross-sectional view of light emitting device **100** according to Embodiment 1 of the present invention.

[0033] As illustrated in FIGS. **2**A to **3**B, surface light source device **400** according to the present embodiment comprises casing **410**, light diffusion member **420**, and a plurality of light emitting devices **100**. Light emitting devices **100** are disposed in a matrix on inner surface **414** of bottom plate **412** in casing **410**. Inner surface **414** of bottom plate **412** functions as a diffusion and reflection surface. Further, top plate **416** of casing **410** has an opening. Light diffusion member **420** is disposed so as to cover the opening, and functions as a light emitting surface. The size of the light emitting surface is, for example but not limited to, about 700 mm in length and about 400 mm in width.

[0034] Light diffusion member **420** is a plate-shaped member having light diffusivity, which allows the light emitted from light emitting device **100** to pass therethrough while diffusing the light. Normally, the size of light diffusion member **420** is substantially the same as the size of a member to be irradiated such as a liquid crystal panel. For example, light diffusion member **420** is formed of a light-transmissive resin such as polymethylmethacrylate (PMMA), polycarbonate (PC), polystyrene (PS) or styrene-methylmethacrylate copolymer resin (MS). To confer light diffusivity, fine irregularities are formed on the surface of light diffusion member **420**, or light diffusion elements such as beads are dispersed in light diffusion member **420**.

[0035] As illustrated in FIG. **4**, light emitting device **100** comprises light emitting element **110** and light flux controlling member **120** disposed over light emitting element **110**. Light emitting element **110** is a light-emitting diode (LED) such as a white light-emitting diode. Light flux controlling member **120** controls the distribution of light emitted from light emitting element **110**. Light flux controlling member **120** is disposed such that central axis CA**1** thereof coincides with optical axis LA of light emitting element **110**.

[0036] (Configuration of Light Flux Controlling Member)

[0037] FIGS. **5**A to **5**C illustrate a configuration of light flux controlling member **120** according to Embodiment 1. FIG. **5**A is a plan view, FIG. **5**B is a bottom view and FIG. **5**C is a side view of light flux controlling member **120**.

[0038] As illustrated in FIGS. **4** to **5**C, light flux controlling member **120** comprises incidence surface **121** disposed on the rear side, reflection surface **122** disposed on the front side (opposite side to incidence surface **121**), and emission surface **123** disposed on the lateral side. Legs **124** for positioning a later-described light flux controlling member body to bottom plate **412** may be formed on incidence surface **121**. The material of light flux controlling member **120** is not particularly limited as long as light with desired wavelength can pass through. For example, the material of light flux controlling member **120** is a light-transmissive resin such as polymethylmethacrylate (PMMA), polycarbonate (PC) or epoxy resin (EP), or glass. Light flux controlling member **120** may be produced by injection molding.

[0039] Incidence surface **121** allows part of light emitted from light emitting element **110** to be incident thereon. Incidence surface **121** comprises an inner incidence surface including concave surface **125** and rear surface **126**, and an outer inclining surface including inclining surface **127**.

[0040] Concave surface **125** is formed at a central portion of the rear side (light emitting element **110** side) of light flux controlling member **120**. Concave surface **125** allows part of the light emitted from light emitting element **110** to be incident thereon. In the present embodiment, concave surface **125** is a rotationally symmetric (circularly symmetric) surface in a substantially spherical crown shape and is formed so that the distance from light emitting element **110** decreases as the distance from optical axis LA increases. Central axis CA**2** of concave surface **125** and central axis CA**1** of light flux controlling member **120** coincide with each other. Among light beams emitted from light emitting element **110**, a light beam having small angle with respect to optical axis LA is incident on concave surface **125**.

[0041] Rear surface **126** is disposed outside concave surface **125**. Rear surface **126** allows part of the light emitted from light emitting element **110** to be incident thereon. In the present embodiment, rear surface **126** is a flat surface perpendicular to central axis CA**1**. Rear surface **126** is extending in the directions orthogonal to central axis CA**1** from the outer rim part of concave surface **125**. Among light beams emitted from light emitting element **110**, a light beam having larger angle with respect to optical axis LA than the light incident on concave surface **125** is incident on rear surface **126**.

[0042] Inclining surface **127** is disposed outside rear surface **126**. Inclining surface **127** allows part of the light emitted from light emitting element **110** to be incident thereon. Inclining surface **127** is disposed so that the distance from light emitting element **110** increases as the distance from central axis CA (optical axis LA) increases. Inclining surface **127** is formed at an angle so as not to intersect an optical path of light that is emitted from the light emitting surface center of light emitting element **110** and incident on the outer edge of the inner incidence surface. That is, among light beams emitted from the light emitting surface center of light emitting element **110**, a light beam having larger angle with respect to optical axis LA than the light incident on rear surface **126** is not incident on inclining surface **127**, but part of light emitted from the edge of light emitting element **110** is incident on inclining surface **127**. In the present embodiment, legs **124** are formed on inclining surface **127**.

[0043] Reflection surface **122** laterally reflects the light incident on incidence surface **121**. Reflection surface **122** is a rotationally symmetric (circularly symmetric) surface about central axis CA**1** of light flux controlling member **120**. The generatrix line of the rotationally symmetric surface from the center to the outer periphery is a recessed curve with respect to light emitting element **110**, and reflection surface **122** is a curved surface formed by rotating the generatrix line by 360° about central axis CA**1** (see FIG. **4**). That is, reflection surface **122** comprises an aspherical curved surface whose height from light emitting element **110** increases in a direction from the center to the outer periphery. Further, the outer periphery of reflection surface **122** is formed at a position whose distance (height) from light emitting element **110** in the direction of optical axis LA of light emitting element **110** is larger than that of the center of reflection surface **122**. For example, reflection surface **122** is an aspherical curved surface whose height from light emitting element **110** increases in a direction from the center to the outer periphery, or an aspherical curved surface whose height from light emitting element **110** (bottom surface **412**; substrate) increases from the center to a predetermined position in a direction from the center to the outer periphery and then the height decreases from the predetermined position to the outer periphery in the same direction. In the former case, the inclining angle of reflection surface **122** with respect to the surface direction of bottom surface **412** decreases in the direction from the center to the outer periphery. In the latter case, reflection surface **122** has a point located between the center and the outer periphery, and closer to the outer periphery; the inclining angle of the point with respect to the surface direction of bottom surface **412** is zero (parallel to bottom surface **412**). Although "generatrix line" generally means a line for drawing a ruled surface, the term as used herein includes a curve for drawing reflection surface **122** that is a rotationally symmetric surface.

[0044] Emission surface **123** emits light reflected by reflection surface **122** to the outside of light flux controlling member **120**. Emission surface **123** is disposed so as to surround central axis CA**1**. In the present embodiment, emission surface **123** is a curved surface along central axis CA**1**. In a cross-section including central axis CA**1**, the top of emission surface **123** is connected with reflection surface **122**, and the bottom of emission surface **123** is connected with inclining surface **127**.

[0045] Leg **124** is a part for positioning the light flux controlling member body including incidence surface **121**, reflection surface **122** and emission surface **123** with respect to bottom surface **412**. In the present embodiment, three legs **124** are disposed on incidence surface **121** (inclining surface **127**).

[0046] (Simulation)

[0047] In light emitting device **100** of the present embodiment, optical paths of light emitted from light emitting element **110**, and brightness on a light diffusing plate disposed on and perpendicular to optical axis LA of the light emitted from light emitting element **110** were simulated. The diameter of light flux controlling member **120** used for the simulation was 13 mm, and the distance between light emitting element **110** and light flux controlling member **120** was set to 1.2 mm. For comparison, a light emitting device including a light flux controlling member which does not include concave surface **125** or inclining surface **127** (plane shaped incidence surface **121'**) (hereinafter referred to as "light emitting device of comparative example;" see FIG. **8**) instead of light flux controlling member **120** of the present embodiment was also simulated.

[0048] FIG. **6** is a view of optical paths of light emitted from the light emitting surface center of light emitting element **110** in the light emitting device according to Embodiment 1. FIG. **7**A is an illuminance distribution on the light diffusing plate, and FIG. **7**B is the illuminance distribution on the light diffusing plate in a cross-section including optical axis LA shown in FIG. **6**. The ordinate and abscissa in FIG. **7**A and the abscissa in FIG. **7**B represent a distance (mm) from the center of the light diffusing plate. The ordinate in FIG. **7**B represents illuminance (lux).

[0049] As illustrated in FIGS. **6** to **7**B, in light emitting device **100** according to Embodiment 1, emitted light having small angle with respect to optical axis LA is incident on concave surface **125** or rear surface **126**, and refracted toward reflection surface **122**. The light entered light flux controlling member **120** is reflected laterally by reflection surface **122**. Then, the light reflected by reflection surface **122** is emitted from emission surface **123** to the outside of light flux controlling member **120**. Emitted light having large angle with respect to optical axis LA, which does not reach concave surface **125** or rear surface **126**, propagates laterally without being reflected by reflection surface **122**. As illustrated, an extremely bright part was not caused over light emitting device **100** in the case of light emitting device **100** according to Embodiment 1.

[0050] FIG. **8** is a view of optical paths of light emitted from the light emitting surface center of light emitting element **110** in light emitting device **100'** according to the comparative example. FIG. **9**A illustrates an illuminance distribution on the light diffusing plate, and FIG. **9**B illustrates the illuminance distribution on the light diffusing plate in a cross-section including optical axis LA shown in FIG. **8**. The ordinate and abscissa in FIG. **9**A and the abscissa in FIG. **9**B represent a distance (mm) from the center of the light diffusing plate. The ordinate in FIG. **9**B represents illuminance (lux).

[0051] As illustrated in FIGS. **8** to **9**B, in light emitting device **100'** according to the comparative example, emitted light having small angle with respect to optical axis LA is incident on the central portion of incidence surface **121'** and refracted toward reflection surface **122**. The light entered light flux controlling member **120'** is reflected laterally by reflection surface **122**. Then, the light is emitted from emission surface **123'** to the outside of the light flux controlling member. On the other hand, emitted light having large angle with respect to optical axis LA is incident on outer periphery of incidence surface **121'** and refracted toward emission surface **123'**, and then reflected upward by emission surface **123'**. The reflected light is emitted from reflection surface **122** to the outside of light flux controlling member **120'**. Therefore, in light emitting device **100'** according to the comparative example, part of light emitted from the light emitting surface of light emitting element **110** is controlled to propagate upward, so that an extremely bright part is caused over light emitting device **100'**. Further, since inclining surface **127** is not formed, light flux controlling member **120'** is larger in volume and heavier.

[0052] (Effect)

[0053] Since inclining surface **127** is formed in light flux controlling member **120** according to Embodiment 1, the weight of light flux controlling member **120** can be reduced. Also, the occurrence of an extremely bright part over light emitting device **100'** can be prevented because the light emitted from the light emitting surface center of light emitting element **110** is not emitted upward as leaked light from light flux controlling member **120**.

Embodiment 2

[0054] A surface light source device according to Embodiment 2 differs from surface light source device **400** according to Embodiment 1 only in the configuration of light emitting device **200**. Accordingly, only light flux controlling member **220** according to Embodiment 2 will be described in the present embodiment.

[0055] (Configuration of Light Flux Controlling Member)

[0056] FIG. **10** is a cross-sectional view of light flux controlling member **200** according to Embodiment 2. FIG. **11**A is a plan view, FIG. **11**B is a bottom view and FIG. **11**C is a side view of light flux controlling member **220**.

[0057] As illustrated in FIGS. **10** to **11**C, light flux controlling member **220** comprises inspection reference surface **228** in addition to incidence surface **121**, reflection surface **122** and emission surface **123**.

[0058] Inspection reference surface **228** is disposed on the front side relative to inclining surface **127**, and outside inclining surface **127**. Light emitted from the light emitting surface center of light emitting element **110** does not directly reach inspection reference surface **228**. Inspection reference surface **228** is a flat surface perpendicular to central axis CA**1** (horizontal surface). Inspection reference surface **228** extends in the directions perpendicular to central axis CA**1** from the outer rim part of inclining surface **127**. Legs **124** are fixed on inspection reference surface **228**. Accordingly, the dimensions in the height direction of legs **124**, later-described emission surface **123** and the like of light flux controlling member **220** can be easily inspected with inspection reference surface **228** as a reference.

[0059] (Simulation)

[0060] In light emitting device **200** according to Embodiment 2, FIG. **12**A is a view of optical paths of light emitted from the light emitting surface center of light emitting element **110**, and FIG. **12**B is a view of an optical path of part of light emitted from the light emitting surface edge of light emitting element **110**.

[0061] As illustrated in FIG. **12**A, emitted light having small angle with respect to optical axis LA is incident on concave surface **125** or rear surface **126**, and refracted toward reflection surface **122**. The light entered light flux controlling member **220** is reflected by reflection surface **122** toward emission surface **123** disposed on the lateral side. Then, the light reflected by reflection surface **122** is emitted from emission surface **123** to outside of light flux controlling member **220**. Emitted light having large angle with respect to optical axis LA, which does not reach concave surface **125** or rear surface **126**, propagates laterally as it is. As illustrated above, in light emitting device **220** according to the present embodiment, light emitted from the light emitting surface center of light emitting element **110** can be controlled so as to propagate laterally.

[0062] Further, as illustrated in FIG. **12**B, part of light emitted from the light emitting surface edge is incident on inclining surface **127** and refracted toward reflection surface **122**. FIG. **12**B illustrates an optical path of light which enters light flux controlling member **220**, is reflected by reflection surface **122** toward emission surface **123** disposed on the lateral side, and emitted from emission surface **123** to outside of light flux controlling member **220**. In this way, part of light emitted from the light emitting surface edge of light emitting element **110** is controlled so as to propagate laterally. Therefore, in light emitting device **200** according to the present embodiment, large part of light emitted from light emitting element **110** can be controlled so as to propagate laterally. Accordingly, light emitting device **200** allows larger amount of light to propagate laterally with respect to optical axis LA, so that a bright part is not easily caused over light emitting device **200** and luminance unevenness can be reduced. When light emitted from the light emitting surface edge of light emitting element **110**, which enters from inclining surface **127** and is emitted without being reflected by reflection surface **122**, is present, the light is refracted and emitted in a direction away from optical axis LA, so that a bright part is not easily caused over light emitting device **200**. Even if light which propagates upward from light emitting device **200** is present, the light is emitted from the light emitting surface edge of light emitting element **110**, which means the light has lower intensity (is darker) than light emitted from periphery of optical axis LA, so that a bright part is not easily caused over light emitting device **200**.

[0063] FIG. **13**A illustrates an illuminance distribution on the light diffusing plate, and FIG. **13**B illustrates the illuminance distribution on the light diffusing plate in a cross-section including optical axis LA shown in FIG. **12**A. The ordinate and abscissa in FIG. **13**A and the abscissa in FIG. **13**B represent a distance (mm) from the center of the light diffusing plate. The ordinate in FIG. **13**B represents illuminance (lux).

[0064] As illustrated in FIGS. **13**A and **13**B, an extremely bright part was not caused over light emitting device **200** in the case of light emitting device **200** according to the present embodiment because most of the light emitted from light emitting element **110** is controlled to propagate laterally.

[0065] As described above, light emitting device **200** according to Embodiment 2 has the same effect as light emitting device **100** according to Embodiment 1. Further, in light emitting device **200** according to Embodiment 2, inspection reference surface **228** is formed at the outer peripheral portion of incidence surface **121** disposed on the rear side, and therefore the dimension in the height direction of light flux controlling member **220** can be easily controlled compare to light emitting device **100** according to Embodiment 1.

[0066] Moreover, in light emitting device **200** according to Embodiment 2, part of light emitted from the light emitting surface center of light emitting element **110** does not enter light flux controlling member **200** but propagates laterally as it is. Moreover, part of light emitted from the light emitting surface edge is incident on inclining surface **127**, reflected by reflection surface **122** and emitted laterally from emission surface **123**. Therefore, most part of light emitted from light emitting element **110** can be controlled to propagate laterally to central axis CA**1**.

Embodiment 3

[0067] A light emitting device according to Embodiment 3 differs from light emitting device **100** according to Embodiment 1 only in the shape of reflection surface **322** of light flux controlling member **320**. Hence, elements that overlap with those of light emitting device **100** of Embodiment 1 are provided with symbols that are the same as those of light emitting device **100**, and descriptions thereof will be omitted.

[0068] (Configuration of Light Flux Controlling Member)

[0069] FIGS. **14**A and **14**B illustrate a configuration of light flux controlling member **320** according to Embodiment 3. FIG. **14**A is a perspective view of light flux controlling member **320** and FIG. **14**B is a cross-sectional view passing central axis CA**1**. As illustrated in FIGS. **14**A and **14**B, light flux controlling member **320** according to Embodiment 3 comprises incidence surface **121**, inspection reference surface **228**, reflection surface **322** and emission surface **123**. Light flux controlling member **320** may comprise leg **124**.

[0070] Reflection surface **322** comprises a plurality of protrusions **323**. Each protrusion **323** is disposed from the center to the outer periphery of reflection surface **322**. Protrusions **323** are disposed such that a trough is formed between adjacent protrusions **323**. Any number of protrusions **323** may be provided accordingly. Each protrusion **323** comprises ridge line **326**, first inclining surface **324** and second inclining surface **325**. In a cross-section including central axis CA, ridge line **326** is a concave curve from the center to the peripheral portion with respect to light emitting element **110**.

[0071] First inclining surface **324** and second inclining surface **325** are disposed such that the boundary thereof serves as ridge line **326**. The cross-section area of protrusion **323** on a plane including a normal at ridge line **326**, and orthogonal to first inclining surface **324** and second inclining surface **325** gradually increases in the direction from the center to the outer periphery.

[0072] (Simulation)

[0073] The effect of reflection surface **322** in the light emitting device according to Embodiment 3 was simulated. FIGS. **15**A and **15**B are perspective views of light flux controlling members used for the simulation. FIG. **15**A is a perspective view of light flux controlling member **320**A including reflection surface **322** (protrusions **323**) of light flux controlling member **320** according to Embodiment 3, and FIG. **15**B is a perspective view of a comparative light flux controlling member not including reflection surface **322** (protrusions **323**). The diameter of light flux controlling member **320** used for the simulation was 13 mm, and the distance between light emitting element **110** and each light flux controlling member was set to be 1.2 mm.

[0074] FIG. **16**A is a view of optical paths of light emitted from the light emitting surface edge of light emitting element **110** using light flux controlling member **320**A, and FIG. **16**B is a view of optical paths of light emitted from the light emitting surface edge of light emitting element **110** using the comparative light flux controlling member.

[0075] The light entered light flux controlling member **320** on which reflection surface **322** is formed as illustrated in FIG. **16**A is reflected more than once by protrusions **323** of reflection surface **322** (retroreflection). Compared to the light flux controlling member including the reflection surface without protrusion **323** illustrated in FIG. **16**B, light flux controlling member **320**A including reflection surface **322** with protrusions **323** illustrated in FIG. **16**A has an increased effect of laterally reflecting light emitted from other than the light emitting surface center of light emitting element **110**, which entered light flux controlling member **320**A and reached the reflection surface. Specifically, the light entered the inside of light flux controlling member **320**A reaches first inclining surface **324** (or second inclining surface **325**). The light reached first inclining surface **324** (or second inclining surface **325**) is reflected toward second inclining surface **325** (or first inclining surface **324**), then re-reflected by second inclining surface **325** (or first inclining surface **324**). Then, the light is emitted from emission surface **123** to outside of light flux controlling member **320**A. As illustrated, in light emitting device **100** according to the present embodiment, light emitted from the light emitting surface edge of light emitting element **110** can be controlled so as to propagate laterally.

[0076] (Effect)

[0077] As described above, the light emitting device according to Embodiment 3 has the same effect as light emitting devices **100** and **200** according to Embodiments 1 and 2. Further, the light emitting device according to Embodiment 3 can control light to propagate laterally, which would pass through the light emitting device in the direction directly above the light emitting device. Therefore, the light emitting device according to Embodiment 3 can control larger amount of light to propagate laterally than light emitting devices **100** and **200** according to Embodiments 1 and 2.

[0078] Concave surface **125** may be a flat surface. In this case, concave surface **125** is formed on the same plane as rear surface **126**.

INDUSTRIAL APPLICABILITY

[0079] The light emitting devices according to the present invention are useful as light sources of surface light source devices, for example.

REFERENCE SIGNS LIST

[0080] **10** light source unit for radiating light
[0081] **20** LED
[0082] **30** optical element for converting light direction
[0083] **31** incidence surface
[0084] **32** reflection surface
[0085] **33** emission surface
[0086] **34** inclining surface
[0087] **40** substrate
[0088] **100**, **200** light emitting device
[0089] **110** light emitting element
[0090] **120**, **220**, **320**, **320**A light flux controlling member
[0091] **121** incidence surface
[0092] **122**, **322** reflection surface
[0093] **123** emission surface
[0094] **124** leg
[0095] **125** concave surface
[0096] **126** rear surface
[0097] **127** inclining surface
[0098] **323** protrusion
[0099] **324** first inclining surface
[0100] **325** second inclining surface
[0101] **326** ridge line
[0102] **228** inspection reference surface
[0103] **400** surface light source device
[0104] **410** casing
[0105] **412** bottom plate
[0106] **414** inner surface
[0107] **416** top plate
[0108] **420** light diffusion member

1. A light emitting device comprising:
a light emitting element; and
a light flux controlling member configured to control a distribution of light emitted from the light emitting element, the light flux controlling member being disposed over the light emitting element,
wherein the light flux controlling member comprises:
an incidence surface configured such that light emitted from the light emitting element is incident on the incidence surface, the incidence surface comprising an outer incidence surface formed as an inclining surface such that a distance from the light emitting element increases as a distance from an optical axis of the light emitted from the light emitting element increases, and an inner incidence surface connected with an inside of the outer incidence surface,
a reflection surface configured to laterally reflect the light incident on the incidence surface, the reflection surface being disposed on a side of the light flux controlling member opposite to the incidence surface such that a distance from the light emitting element increases in a direction from a center to an outer periphery of the reflection surface, and
an emission surface configured to emit the light reflected by the reflection surface, the emission surface being disposed to surround the central axis, and
wherein light emitted from a light emitting surface center of the light emitting element does not reach the inclining surface.

2. The light emitting device according to claim **1**, wherein the light flux controlling member further comprises:
a horizontal surface perpendicular to the optical axis, wherein the horizontal surface is disposed outside the outer incidence surface, and the light emitted from the light emitting surface center of the light emitting element does not directly reach the horizontal surface.

3. The light emitting device according to claim **1**, wherein the reflection surface comprises:
a plurality of protrusions, each protrusion being disposed to connect the center with the outer periphery of the reflection surface,
wherein the protrusion comprises:
a first inclining surface,
a second inclining surface that pairs with the first inclining surface, and
a ridge line that is a boundary of the first inclining surface and second inclining surface, wherein the ridge line is disposed to connect the center with the outer periphery of the reflection surface and is a concave curve with respect to the light emitting element.

4. The light emitting device according to claim **2**, wherein the reflection surface comprises:
a plurality of protrusions, each protrusion being disposed to connect the center with the outer periphery of the reflection surface,
wherein the protrusion comprises:
a first inclining surface,
a second inclining surface that pairs with the first inclining surface, and a ridge line that is a boundary of the first inclining surface and second inclining surface, wherein the ridge line is disposed to connect the center with the outer periphery of the reflection surface and is a concave curve with respect to the light emitting element.

5. A surface light source device comprising:
the light emitting device according to claim **1**; and
a light diffusion member configured to allow light emitted from the light emitting device to pass therethrough while diffusing the light.

6. A surface light source device comprising:
the light emitting device according to claim **2**; and
a light diffusion member configured to allow light emitted from the light emitting device to pass therethrough while diffusing the light.

7. A surface light source device comprising:
the light emitting device according to claim **3**; and
a light diffusion member configured to allow light emitted from the light emitting device to pass therethrough while diffusing the light.

8. A surface light source device comprising:
the light emitting device according to claim **4**; and
a light diffusion member configured to allow light emitted from the light emitting device to pass therethrough while diffusing the light.

9. A display apparatus comprising:
the surface light source device according to claim **5**; and
a display member configured such that light emitted from the surface light source device is radiated to the display member.

10. A display apparatus comprising;

the surface light source device according to claim **6**; and

a display member configured such that light emitted from the surface light source device is radiated to the display member.

11. A display apparatus comprising:

the surface light source device according to claim **7**; and

a display member configured such that light emitted from the surface light source device is radiated to the display member.

12. A display apparatus comprising:

the surface light source device according to claim **8**; and

a display member configured such that light emitted from the surface light source device is radiated to the display member.

* * * * *