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Illumination device including third prism sheet and display device including the same

Abstract

An illumination device that includes a light source, a light guide plate featuring a first end face, a first main surface, a second main surface, and a first prism sheet is provided. The first prism sheet includes a third main surface, facing the second main surface of the light guide plate, and a fourth main surface. The second main surface of the light guide plate is provided with a first inclined surface that has an inclination rising from a side opposite the light source side toward the light source side in a first direction. The fourth main surface of the first prism sheet is provided with multiple first prisms extending along the first direction and disposed along a second direction. Each first prism includes a first base parallel to the second direction, and a pair of first oblique sides rising from both ends of the first base.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application claims the benefit of priority to Japanese Patent Application Number 2023-142029 filed on Sep. 1, 2023. The entire contents of the above-identified application are hereby incorporated by reference.

BACKGROUND

Technical Field

(2) The techniques disclosed in the present specification relate to illumination devices and display devices.

(3) In the related art, an illumination device disclosed in JP 3755778 B is known as an example. JP 3755778 B describes the illumination device used for a vehicle instrument. The vehicle instrument disclosed in JP 3755778 B is disposed below a windshield, covers a front side of a dial on which a display portion indicated by a pointer is formed is covered with a front cover, and indirectly illuminates the display portion and an indicator of the pointer by turning on a light source. In this vehicle instrument, an anti-reflection film is formed on the surface of the front cover to omit a hood

above the front cover, and a louver for regulating an emission angle so that emission light is not directed toward the windshield side is formed on each of an upper face of the indicator of the pointer and a white diffusion layer facing a display slit formed in a black non-transmissive layer in accordance with the display portion of the dial.

SUMMARY

(4) In a vehicle instrument disclosed in JP 3755778 B, a louver prevents occurrence of a phenomenon in which external light from the outside of a vehicle is reflected to a driver side and reflection of a light emitting display on a windshield. However, since such a louver has a high component price, there has been a demand for regulating an emission angle of light and preventing occurrence of reflection on the windshield without using the louver.

(5) The techniques described herein have been made based on the circumstances described above, and an object thereof is to regulate an emission angle of light without using a louver.

(6) (1) An illumination device described in the present specification includes a light source, a light guide plate including a first end face that is at least some of outer peripheral end faces of the light guide plate and faces the light source and on which light is incident, a first main surface that is one main surface of the light guide plate, and a second main surface that is the other main surface of the light guide plate, and a first prism sheet including a third main surface that is one main surface of the first prism sheet and disposed to face the second main surface and a fourth main surface that is the other main surface of the first prism sheet, in which the second main surface of the light guide plate is provided with a first inclined surface that is an inclination rising from a side opposite to the light source side toward the light source side in a first direction including a direction from the light source toward the light guide plate, the fourth main surface of the first prism sheet is provided with a plurality of first prisms extending along the first direction and arranged along a second direction intersecting the first direction and along the fourth main surface, and the first prism includes a first base parallel to the second direction and a pair of first oblique sides rising from both ends of the first base.

(7) (2) In addition to (1) described above, the illumination device may further include a light absorption sheet including a fifth main surface that is one main surface of the light absorption sheet and disposed to face the fourth main surface and having light absorbability higher than any of the light guide plate and the first prism sheet.

(8) (3) In addition to (1) described above, the illumination device may further include a light reflective sheet including a sixth main surface that is one main surface of the light reflective sheet and disposed to face the fourth main surface and having light reflectivity higher than any of the light guide plate and the first prism sheet.

(9) (4) In addition to any one of (1) to (3) described above, the illumination device may further include a second prism sheet including a seventh main surface that is one main surface of the second prism sheet and an eighth main surface that is the other main surface of the second prism sheet and disposed to face the first main surface, and a third prism sheet including a ninth main surface that is one main surface of the third prism sheet and a tenth main surface that is the other main surface of the third prism sheet and disposed to face the seventh main surface, in which the seventh main surface of the second prism sheet may be provided with a plurality of second prisms extending along the second direction and disposed side by side along the first direction, and the ninth main surface of the third prism sheet may be provided with a plurality of third prisms extending along the second direction and disposed side by side along the first direction.

(10) (5) In addition to (4) described above, in the illumination device, the second prism may include a second base parallel to the first direction and a pair of second oblique sides rising from both ends of the second base, and among the pair of second oblique sides, the second oblique side on the side of the light source in the first direction may form a larger angle with respect to the second base than the second oblique side opposite to the light source side in the first direction.

(11) (6) In addition to (4) or (5) described above, in the illumination device, the third prism may

include a third base parallel to the first direction and a pair of third oblique sides rising from both ends of the third base, and angles between the pair of third oblique sides and the third base are the same angle.

(12) (7) In addition to any one of (1) to (6) described above, in the illumination device, the first inclined surface includes a plurality of the first inclined surfaces, the plurality of first inclined surfaces are disposed side by side along the first direction, and the plurality of first inclined surfaces increase in area while getting farther from the light source.

(13) (8) A display device according to the techniques described in the present specification includes the illumination device according to any of (1) to (7) described above, and a display panel configured to perform display by using light from the illumination device.

(14) According to the techniques described herein, an emission angle of light can be regulated without using a louver.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) The disclosure will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

(2) FIG. 1 is an exploded perspective view of a liquid crystal display device according to a first embodiment.

(3) FIG. 2 is a cross-sectional view of a backlight device constituting the liquid crystal display device according to the first embodiment taken along a Y-axis direction.

(4) FIG. 3 is a cross-sectional view of a backlight device according to the first embodiment taken along an X-axis direction.

(5) FIG. 4 is a perspective view of a light guide plate constituting the backlight device according to the first embodiment as viewed from the side of a second main surface.

(6) FIG. 5 is a bottom view illustrating a configuration of the second main surface of the light guide plate according to the first embodiment.

(7) FIG. 6 is a schematic view illustrating a state in which the liquid crystal display device according to the first embodiment is mounted on a passenger car.

(8) FIG. 7 is a cross-sectional view of a backlight device of a type B according to the first embodiment taken along the Y-axis direction.

(9) FIG. 8 is a graph showing a light distribution in the Y-axis direction in Comparative Experiment 1 according to the first embodiment.

(10) FIG. 9 is a table showing experimental results of Comparative Experiment 2 according to the first embodiment.

(11) FIG. 10 is a cross-sectional view of a backlight device according to a second embodiment taken along the Y-axis direction.

(12) FIG. 11 is a graph showing a light distribution in the Y-axis direction in Comparative Experiment 3 according to the second embodiment.

(13) FIG. 12 is a table showing experimental results of Comparative Experiment 4 according to the second embodiment.

(14) FIG. 13 is a graph showing a light distribution in the Y-axis direction in Comparative Experiment 5 according to the second embodiment.

(15) FIG. 14 is a cross-sectional view of a backlight device according to a third embodiment taken along the Y-axis direction.

(16) FIG. 15 is a graph showing a light distribution in the Y-axis direction in Comparative Experiment 6 according to the third embodiment.

(17) FIG. 16 is a table showing experimental results of Comparative Experiment 7 according to the

third embodiment.

DESCRIPTION OF EMBODIMENTS

First Embodiment

(18) The first embodiment will be described with reference to FIGS. **1** to **9**. In the present embodiment, a liquid crystal display device (display device) **10** is exemplified. Note that some drawings show an X-axis, a Y-axis, and a Z-axis, and directions of these axes are drawn so as to be common in all the drawings. Furthermore, a vertical direction is based on the vertical direction of FIGS. **2**, **3**, and **7**, an upper side in the same drawings is referred to as a front side, and a lower side in the same drawings is referred to as a back side.

(19) As illustrated in FIG. **1**, the liquid crystal display device **10** includes a liquid crystal panel (display panel) **11** that displays an image, and a backlight device (illumination device) **12** that is disposed on the back side of the liquid crystal panel **11** and irradiates the liquid crystal panel **11** with light to be used for display. In the present embodiment, the liquid crystal display device **10** for vehicle application is exemplified. For example, the liquid crystal display device **10** for vehicle application is mounted on a car navigation system displaying a map and the like as an image, a multi-function display displaying an operation situation and the like of equipment such as an air conditioner in addition to a map and the like as an image, an instrument panel displaying gauges, alerts, and the like as an image, and an infotainment system displaying television images, audio information, and the like in addition to a map and the like as an image.

(20) The liquid crystal panel **11** has a horizontally elongated rectangular plate shape as a whole. A long-side direction, a short-side direction, and a plate-thickness direction (normal direction of a main surface) of the liquid crystal panel **11** coincide with an X-axis direction, a Y-axis direction, and a Z-axis direction, respectively. In the liquid crystal panel **11**, a center side portion of the main surface is a display region AA that can display an image, and an outer circumferential end side portion surrounding the display region AA and having a frame shape is a non-display region NAA. The liquid crystal panel **11** includes a pair of substrates and a liquid crystal layer sealed between the pair of substrates. Among the pair of substrates constituting the liquid crystal panel **11**, the one disposed on the front side is a CF substrate (counter substrate), and the one disposed on the back side is an array substrate (TFT substrate). Color filters that exhibit red (R), green (G), blue (B), and the like, a light blocking portion (black matrix) that partitions adjacent color filters, and the like are provided on the CF substrate. The array substrate (TFT substrate) is provided with at least a gate wiring line and a source wiring line that are orthogonal to each other, a switching element (for example, a TFT) connected to the gate wiring line and the source wiring line, and a pixel electrode connected to the switching element and constituting a pixel. Further, an alignment film is provided on each inner surface of the array substrate and the CF substrate constituting the liquid crystal panel **11**. Furthermore, a polarizer is attached to each outer surface of the array substrate and the CF substrate constituting the liquid crystal panel **11**.

(21) Next, the backlight device **12** will be described. As illustrated in FIG. **1**, the backlight device **12** includes at least an LED **13** as a light source, an LED substrate (light source substrate) **14** on which the LED **13** is mounted, a light guide plate **15** that guides light from the LED **13**, a first prism sheet **16** disposed on the back side (side opposite to a light emission side) of the light guide plate **15**, a light absorption sheet **17** disposed on the back side of the first prism sheet **16**, a second prism sheet **18** disposed on the front side (light emission side) of the light guide plate **15**, and a third prism sheet **19** disposed on the front side of the second prism sheet **18**. Among them, the first prism sheet **16** and the light absorption sheet **17** will be described later, and the other configurations (the LED **13**, the LED substrate **14**, the second prism sheet **18**, and the third prism sheet **19**) will be sequentially described. The backlight device **12** according to the present embodiment is an edge light type of a one-side light entering type in which light of the LED **13** is incident on the light guide plate **15** only from one side.

(22) As illustrated in FIG. **1**, the LED **13** is configured such that an LED chip is sealed with a

sealing material on a substrate portion affixed to the LED substrate **14**. The LED **13** is configured such that the LED chip emits, for example, blue light in a single light, and a phosphor is dispersed and mixed in the sealing material to emit white light as a whole. Examples of the phosphor include yellow phosphor, green phosphor, and red phosphor. The LED **13** is a so-called side light emitting type in which a side face thereof adjacent to a mounting face of the LED substrate **14** is a light-emitting face **13A**. The LED substrate **14** is disposed in an orientation in which a main surface of the LED substrate **14** is parallel to a main surface of the light guide plate **15**, and the main surface of the LED substrate **14** on the front side is a mounting face for the LED **13**. A plurality of LEDs **13** are disposed side by side at substantially equal intervals along the X-axis direction on the mounting face of the LED substrate **14**. The arrangement direction of the plurality of LEDs **13** coincides with the X-axis direction.

(23) The light guide plate **15** is made of a synthetic resin material that has a sufficiently higher refractive index than that of the air and that is substantially transparent.

(24) Specifically, the light guide plate **15** is made of, for example, an acrylic resin such as PMMA as the synthetic resin material, and has the refractive index of, for example, about 1.49. As illustrated in FIG. **1**, the light guide plate **15** has a plate shape, and the main surface of the light guide plate **15** is parallel to a main surface of the liquid crystal panel **11**. Note that the light guide plate **15** is configured such that a long-side direction of the main surface, a short-side direction of the main surface, and a plate-thickness direction that is the normal direction of the main surface coincide with the X-axis direction (second direction), the Y-axis direction (first direction), and the Z-axis direction (third direction), respectively. The light guide plate **15** is disposed immediately below the liquid crystal panel **11**. Among outer peripheral end faces of the light guide plate **15**, an end face on the side of one long side is a light incident end face (first end face) **15A** which faces the light-emitting faces **13A** of the LEDs **13** and on which light from the light-emitting faces **13A** is directly incident. A long-side direction and a short-side direction of the light incident end face **15A** coincide with the X-axis direction and the Z-axis direction, respectively. Among a pair of main surfaces of the light guide plate **15**, the main surface on the front side facing the liquid crystal panel **11** is a first main surface **15B** that emits light guided therein, and the main surface on the back side facing the light absorption sheet **17** is a second main surface **15C**. The light guide plate **15** has a function of introducing light emitted from the LED **13** toward the light guide plate **15** from the light incident end face **15A**, propagating the light therein, and then, emitting the light toward the front side (light emission side) from the first main surface **15B**. A detailed structure of the light guide plate **15** will be described later. Note that the normal direction of the light incident end face **15A** coincides with the Y-axis direction (first direction) including a direction from the LEDs **13** toward the light guide plate **15**.

(25) As illustrated in FIG. **1**, the second prism sheet **18** and the third prism sheet **19** have a sheet shape, and respective main surfaces thereof are parallel to the respective main surfaces of the liquid crystal panel **11** and the light guide plate **15**. Note that the respective main surfaces of the second prism sheet **18** and the third prism sheet **19** are parallel to the X-axis direction and the Y-axis direction, and a normal direction (thickness direction) of the main surfaces coincides with the Z-axis direction. The second prism sheet **18** and the third prism sheet **19** are layered on the front side of the light guide plate **15**, and have a function of imparting a predetermined optical action to light emitted from the first main surface **15B** of the light guide plate **15** to emit the light, and the like.

(26) As illustrated in FIG. **1** and FIG. **2**, the second prism sheet **18** includes a second base material **18A** having a sheet shape and second prisms **18B** provided on the second base material **18A**. A pair of main surfaces of the second base material **18A** include a second light emission main surface (seventh main surface) **18A1** and a second light incident main surface (eighth main surface) **18A2**. The second light emission main surface **18A1** is a main surface of the second base material **18A** on the front side (light emission side) facing the third prism sheet **19**, and emits light toward the third prism sheet **19**. The second light incident main surface **18A2** is a main surface of the second base

material **18A** on the back side (side opposite to the light emission side) facing the first main surface **15B** of the light guide plate **15**, and light emitted from the first main surface **15B** is incident on the second light incident main surface **18A2**.

(27) The second base material **18A** is made of substantially transparent synthetic resin, and specifically, is formed of, for example, a crystalline transparent resin material such as polyethylene terephthalate (PET). The second base material **18A** is formed into a sheet shape by stretching the crystalline transparent resin material serving as a raw material in a biaxially stretching process in manufacturing, which is suitable for reducing manufacturing costs. The second prism **18B** is formed of an ultraviolet-curing resin material being substantially transparent and being a type of photo-curable resin material. In manufacturing the second prism sheet **18**, for example, the uncured ultraviolet-curing resin material is filled into a mold for molding, and the second base material **18A** is applied to an opening end of the mold to dispose the uncured ultraviolet-curing resin material so as to contact the main surface on the front side, and in this state, when the ultraviolet-curing resin material is irradiated with ultraviolet rays through the second base material **18A**, the ultraviolet-curing resin material is cured, and the second prism **18B** is integrally provided with the second base material **18A**. The ultraviolet-curing resin material constituting the second prism **18B** is, for example, an acrylic resin such as PMMA. A refractive index of the ultraviolet-curing resin material constituting the second prism **18B** is preferably set within a range from 1.49 to 1.52, and is most preferably set to 1.49.

(28) As illustrated in FIG. 2, the second prism **18B** is provided on the second light emission main surface **18A1** on the front side of the second base material **18A**. Specifically, the second prism **18B** is provided so as to protrude from the second light emission main surface **18A1** of the second base material **18A** toward the front side (side opposite to the light guide plate **15** side) along the Z-axis direction. The second prism **18B** has a substantially triangular shape (is substantially mountain shaped) in a cross section taken along the Y-axis direction and extends linearly along the X-axis direction (second direction), and a plurality of the second prisms **18B** are disposed side by side along the Y-axis direction (first direction) on the second light emission main surface **18A1** of the second base material **18A**. The plurality of second prisms **18B** are continuously arranged along the Y-axis direction with substantially no interval therebetween. The second prism **18B** includes a second base **18B1** parallel to the Y-axis direction, and a pair of second oblique sides **18B2** and **18B3** rising from both ends of the second base **18B1**. Among the pair of second oblique sides **18B2** and **18B3** of the second prism **18B**, the oblique side located on the side of the LED **13** (left side in FIG. 2) in the Y-axis direction is referred to as a second LED-side oblique side (one of the second oblique side) **18B2**, and the oblique side located on the side opposite to the LED **13** side (right side in FIG. 2) in the Y-axis direction is referred to as a second opposite-to-LED-side oblique side (the other of the second oblique side) **18B3**. Among the pair of oblique sides, the second opposite-to-LED-side oblique side **18B3** is exposed mainly to light traveling in a direction (right side in FIG. 2) away from the LED **13** in the Y-axis direction out of light incident on the second prism **18B**, refracting the light. On the other hand, the second LED-side oblique side **18B2** is exposed mainly to light traveling in a direction (left side in FIG. 2) approaching the LED **13** in the Y-axis direction out of the light incident on the second prism **18B**, refracting the light. In any case, most of the light refracted by the pair of second oblique sides **18B2** and **18B3** of the second prism **18B** is selectively raised in the Y-axis direction and condensed.

(29) As illustrated in FIG. 2, in the second prism **18B**, when an inclination angle (third bottom angle) $\theta 1$ of the second LED-side oblique side **18B2** with respect to the second base **18B1**, and an inclination angle (fourth bottom angle) $\theta 2$ of the second opposite-to-LED-side oblique side **18B3** with respect to the second base **18B1** are compared, the former is set to be larger than the latter. That is, the second prism **18B** has an asymmetric cross-sectional shape, which is that of a scalene triangle. Specifically, the inclination angle $\theta 1$ of the second LED-side oblique side **18B2** with respect to the second base **18B1** in the second prism **18B** is preferably within a range from 50° to

60°, and is most preferably set to 55°. On the other hand, the inclination angle $\theta 2$ of the second opposite-to-LED-side oblique side **18B3** with respect to the second base **18B1** in the second prism **18B** is preferably within a range from 35° to 50°, and is most preferably set to 45°. Further, an angle (second apex angle) $\theta 3$ formed by the pair of second oblique sides **18B2** and **18B3** of the second prism **18B** is preferably set within a range from 70° to 95°, and is most preferably set to 80°. Note that all the plurality of second prisms **18B** arranged along the X-axis direction have substantially the same height dimension, substantially the same width dimension for the second base **18B1**, substantially the same inclination angles for the second oblique sides **18B2** and **18B3** with respect to the second base **18B1**, and the like, and are arranged such that the arrangement intervals between adjacent second prisms **18B** are substantially constant and equal.

(30) As illustrated in FIG. 1 and FIG. 2, the third prism sheet **19** includes a third base material **19A** having a sheet shape and third prisms **19B** provided on the third base material **19A**. A pair of main surfaces of the third base material **19A** includes a third light emission main surface (ninth main surface) **19A1** and a third light incident main surface (tenth main surface) **19A2**. The third light emission main surface **19A1** is a main surface of the third base material **19A** on the front side and emits light toward the outside. The third light incident main surface **19A2** is a main surface of the third base material **19A** on the back side facing the second prism sheet **18**, and light emitted from the second prism sheet **18** is incident on the third light incident main surface **19A2**.

(31) The third base material **19A** is made of substantially transparent synthetic resin, and is specifically formed of, for example, a crystalline transparent resin material such as PET that is the same as the second base material **18A**. The third prism **19B** is formed of an ultraviolet-curing resin material being substantially transparent and being a type of photo-curable resin material. A manufacturing method of the third prism sheet **19** is similar to the manufacturing method of the second prism sheet **18** described above. The ultraviolet-curing resin material constituting the third prism **19B** is, for example, an acrylic resin such as PMMA, and a refractive index of the ultraviolet-curing resin material is set higher than the refractive index of the material of the second prism **18B**, and is set to, for example, approximately 1.61.

(32) As illustrated in FIG. 2, the third prism **19B** is provided on the third light emission main surface **19A1** on the front side of the third base material **19A**. Specifically, the third prism **19B** is provided so as to protrude from the third light emission main surface **19A1** of the third base material **19A** toward the front side (side opposite to the second prism sheet **18** side) along the Z-axis direction. The third prism **19B** has a substantially triangular shape (is substantially mountain shaped) in a cross section taken along the Y-axis direction and extends linearly along the X-axis direction (second direction), and a plurality of the third prisms **19B** are disposed side by side along the Y-axis direction (first direction) on the third light emission main surface **19A1** of the third base material **19A**. The plurality of third prisms **19B** are continuously arranged along the Y-axis direction with substantially no interval therebetween. The third prism **19B** includes a third base **19B1** parallel to the Y-axis direction, and a pair of third oblique sides **19B2** and **19B3** rising from both ends of the third base **19B1**. Among the pair of third oblique sides **19B2** and **19B3** of the third prism **19B**, the oblique side located on the side of the LED **13** (left side in FIG. 2) in the Y-axis direction is referred to as a third LED-side oblique side (one of the third oblique side) **19B2**, and the oblique side located on the side opposite to the LED **13** side (right side in FIG. 2) in the Y-axis direction is referred to as a third opposite-to-LED-side oblique side (the other of the third oblique side) **19B3**. Among the pair of oblique sides, the third opposite-to-LED-side oblique side **19B3** is exposed mainly to light traveling in a direction (right side in FIG. 2) away from the LED **13** in the Y-axis direction out of light incident on the third prism **19B**, refracting the light. On the other hand, the third LED-side oblique side **19B2** is exposed mainly to light traveling in a direction (left side in FIG. 2) approaching the LED **13** in the Y-axis direction out of the light incident on the third prism **19B**, refracting the light. In any case, most of the light refracted by the pair of third oblique sides **19B2** and **19B3** of the third prism **19B** is selectively raised in the Y-axis direction and condensed.

(33) As illustrated in FIG. 2, in the third prism **19B** an inclination angle (fifth bottom angle) $\theta 4$ of the third LED-side oblique side **19B2** with respect to the third base **19B1** and an inclination angle (sixth bottom angle) $\theta 5$ of the third opposite-to-LED-side oblique side **19B3** with respect to the third base **19B1** are identical. That is, the third prism **19B** has a symmetric cross-sectional shape, which is that of an isosceles triangle. Moreover, the inclination angle $\theta 4$ of the third LED-side oblique side **19B2** with respect to the third base **19B1** in the third prism **19B** is made smaller than the inclination angle $\theta 1$ of the second LED-side oblique side **18B2** with respect to the second base **18B1** in the second prism **18B** provided on the second prism sheet **18**. Specifically, the respective inclination angles $\theta 4$ and $\theta 5$ of the pair of third oblique sides **19B2** and **19B3** with respect to the third base **19B1** in the third prism **19B** are preferably within a range from 40° to 50° , and are most preferably set to 45° . On the other hand, an angle (third apex angle) $\theta 6$ formed by the pair of third oblique sides **19B2** and **19B3** of the third prism **19B** is preferably set within a range from 80° to 100° , and is most preferably set to 90° , that is, a right angle. Note that all the plurality of third prisms **19B** arranged along the X-axis direction have substantially the same height dimension, substantially the same width dimension for the third base **19B1**, substantially the same inclination angles for the third oblique sides **19B2** and **19B3** with respect to the third base **19B1**, and the like, and are arranged such that the arrangement intervals between adjacent third prisms **19B** are substantially constant and equal. In addition, the height dimension and the arrangement intervals of the third prisms **19B** preferably differ from the height dimension and the arrangement intervals of the second prism **18B**, respectively, in terms of suppressing the occurrence of interference fringes called moire.

(34) The actions and effects of the second prism sheet **18** and the third prism sheet **19** having the configurations described above will be described. Light emitted from the LED **13** and incident on the light incident end face **15A** of the light guide plate **15** is propagated inside the light guide plate **15**, emitted from the first main surface **15B**, and incident on the second prism sheet **18**. Most of the light incident on the second prism sheet **18** is incident on and refracted by the second opposite-to-LED-side oblique side **18B3** that is the oblique side located on the side opposite to the LED **13** side in the Y-axis direction among the pair of second oblique sides **18B2** and **18B3** of the second prism **18B**, and then is raised and emitted, or is directed toward the second LED-side oblique side **18B2** that is the oblique side located on the side of the LED **13** side in the Y-axis direction. As described above, in the second prism **18B**, the inclination angle $\theta 1$ formed by the second LED-side oblique side **18B2** that is the oblique side located on the side of the LED **13** in the Y-axis direction with respect to the second base **18B1** is larger than the inclination angle $\theta 2$ formed by the second opposite-to-LED-side oblique side **18B3** that is the oblique side located on the side opposite to the LED **13** side in the Y-axis direction with respect to the second base **18B1**. Thus, as compared with the case in which the inclination angles $\theta 1$ and $\theta 2$ are the same or the case in which the inclination angle $\theta 2$ is larger than the inclination angle $\theta 1$, the light incident on the second prism sheet **18** is less likely to be incident on the second LED-side oblique side **18B2** of the second prism **18B** that is the oblique side located on the side of the LED **13**. When the incident light incident on the second prism sheet **18** is incident on the second LED-side oblique side **18B2** of the second prism **18B** that is the oblique side located on the side of the LED **13**, the light is not raised when being emitted from the second prism **18B**, and tends to be more likely to be emitted as side lobe light. Thus, when the incident light incident on the second prism sheet **18** becomes less likely to be directly incident on the second LED-side oblique side **18B2** of the second prism **18B** that is the oblique side located on the side of the LED **13**, the occurrence of side lobe light is suppressed, and as a result, the usage efficiency of light is improved.

(35) Most of the light emitted from the second prism sheet **18** and incident on the third prism sheet **19** is incident on and refracted by the third opposite-to-LED-side oblique side **19B3** that is the oblique side located on the side opposite to the LED **13** side in the Y-axis direction among the pair of third oblique sides **19B2** and **19B3** of the third prism **19B**, and then is raised and emitted, or is

directed toward the third LED-side oblique side **19B2** that is the oblique side located on the side of the LED **13** in the Y-axis direction. As described above, in the third prism **19B**, the respective inclination angles $\theta 4$ and $\theta 5$ formed by the pair of third oblique sides **19B2** and **19B3**, with respect to the third base **19B1** are equal to each other. Thus, compared with the case in which the inclination angles $\theta 4$ and $\theta 5$ are different from each other, the light refracted by the third opposite-to-LED-side oblique side **19B3** that is the oblique side located on the side opposite to the LED **13** side in the Y-axis direction and directed toward the third LED-side oblique side **19B2** that is the oblique side located on the side of the LED **13** in the Y-axis direction is easily returned to the side of the second prism sheet **18** by the third LED-side oblique side **19B2** that is the oblique side located on the side of the LED **13** in the Y-axis direction. As a result, the amount of light returned from the third prism sheet **19** toward the second prism sheet **18** side (hereinafter referred to as recursive light) is increased. This recursive light reaches the third prism sheet **19** again by being reflected or the like inside the backlight device **12**, and is raised and emitted by either of the pair of third oblique sides **19B2** and **19B3** of the third prism **19B**, so the usage efficiency of light is improved.

(36) Here, a detailed structure of the light guide plate **15** will be described. As illustrated in FIGS. 2 and 3, a first light guide plate lens **20**, a second light guide plate lens **21**, and a third light guide plate lens (first lens) **22** are provided on the light guide plate **15**.

(37) As illustrated in FIG. 3, the first light guide plate lens **20** is provided on the first main surface **15B** of the light guide plate **15**. The first light guide plate lens **20** extends along the Y-axis direction (first direction), and a plurality of first light guide plate lenses **20** are disposed side by side along the X-axis direction (second direction). The plurality of first light guide plate lenses **20** are continuously arranged along the X-axis direction with substantially no interval therebetween. In the present embodiment, the first light guide plate lens **20** is a so-called cylindrical lens. The first light guide plate lens **20** has a convex shape protruding from the first main surface **15B** to the front side. Specifically, the first light guide plate lens **20** has a semi-circular shape in a cross section taken along the X-axis direction and a semi-cylindrical shape linearly extending along the Y-axis direction, and a surface of the first light guide plate lens **20** is a circular arc-shaped face **20A**. When an angle formed by a tangent line at a base end portion of the circular arc-shaped face **20A** with respect to the X-axis direction is defined as a “contact angle”, the contact angle of the first light guide plate lens **20** is, for example, approximately 51° . The arrangement interval between the first light guide plate lenses **20** (interval between center positions along the X-axis direction) is, for example, approximately 0.041 mm. All the plurality of first light guide plate lenses **20** arranged along the X-axis direction have substantially the same contact angle, substantially the same width dimension, substantially the same arrangement interval, and substantially the same height dimension. In order to integrally provide the light guide plate **15** with the first light guide plate lens **20** having such a configuration, for example, the light guide plate **15** may be manufactured by injection molding, and a transfer shape for transferring the first light guide plate lens **20** may be formed in advance in a molding die for the light guide plate **15** at a molding face for molding the first main surface **15B**.

(38) As illustrated in FIG. 3, the second light guide plate lens **21** is provided on the second main surface **15C** of the light guide plate **15**. The second light guide plate lens **21** extends along the Y-axis direction, and a plurality of second light guide plate lenses **21** are disposed side by side along the X-axis direction. In the present embodiment, the second light guide plate lens **21** is a convex-shaped prism protruding from the second main surface **15C** to the back side. Specifically, the second light guide plate lens **21** has a substantially triangular shape (is substantially mountain shaped) in a cross section taken along the X-axis direction and extends linearly along the Y-axis direction. The width dimension (dimension along the X-axis direction) of the second light guide plate lens **21** is constant throughout its entire length along the Y-axis direction. Each second light guide plate lens **21** has an approximately isosceles triangle cross-sectional shape and includes a pair

of fourth inclined surfaces **21A**. An apex angle (angle formed by the pair of fourth inclined surfaces **21A**) of the second light guide plate lens **21** is preferably set to an obtuse angle (angle greater than 90°), specifically, within a range from 100° to 150° , and is most preferably set to 140° . All the plurality of second light guide plate lenses **21** arranged along the X-axis direction have substantially the same apex angle, substantially the same width dimension, substantially the same arrangement interval, and substantially the same height dimension. In the present embodiment, the arrangement interval of the second light guide plate lenses **21** is greater than the arrangement interval of the first light guide plate lenses **20**. In order to integrally provide the light guide plate **15** with the second light guide plate lens **21** having such a configuration, for example, the light guide plate **15** may be manufactured by injection molding, and a transfer shape for transferring the second light guide plate lens **21** may be formed in advance in a molding die for the light guide plate **15** at a molding face for molding the second main surface **15C**.

(39) According to the light guide plate **15** having such a configuration, as illustrated in FIG. 3, light propagating inside the light guide plate **15** is totally reflected in a repetitive manner by being incident on the circular arc-shaped face **20A** of each of the first light guide plate lenses **20** on the side of the first main surface **15B** along the Z-axis direction, and travels in a zigzag manner substantially along the X-axis direction. Light propagating inside the light guide plate **15** is totally reflected in a repetitive manner by being incident on the pair of fourth inclined surfaces **21A** of each of the second light guide plate lenses **21** on the side of the second main surface **15C** along the Z-axis direction, and travels in a zigzag manner substantially along the Y-axis direction. In this way, light propagating inside the light guide plate **15** is restricted from spreading in the X-axis direction, and thus unevenness of darkness and luminance is less likely to occur between a vicinity of the LED **13** and surroundings thereof in the X-axis direction. On the other hand, in the first main surface **15B**, light that is not totally reflected by the circular arc-shaped face **20A** of the first light guide plate lens **20** is refracted by the circular arc-shaped face **20A** and promoted to be emitted from the first main surface **15B**.

(40) As illustrated in FIG. 2, the third light guide plate lens **22** is provided on the second main surface **15C** of the light guide plate **15**. A plurality of the third light guide plate lenses **22** are disposed side by side along the Y-axis direction. The third light guide plate lens **22** protrudes from the second main surface **15C** toward the back side along the Z-axis direction. The third light guide plate lens **22** includes a first inclined surface **22A** disposed on the side opposite to the LED **13** side (right side in FIG. 2) in the Y-axis direction, a second inclined surface **22B** disposed on the side of the LED **13** (left side in FIG. 2) in the Y-axis direction, and a third inclined surface **22C** located between the first inclined surface **22A** and the second inclined surface **22B** in the Y-axis direction. The first inclined surface **22A** has an inclination rising to a back side (the first prism sheet **16** side, a protruding direction of the third light guide plate lens **22** from the second main surface **15C**) from the side opposite to the LED **13** side (right side in FIG. 2) toward the side of the LED **13** (left side in FIG. 2) along the Y-axis direction in the light guide plate **15**. The second light guide plate inclined surface **22B** has an inclination rising to a back side from the side of the LED **13** (left side in FIG. 2) toward the side opposite to the LED **13** (right side in FIG. 2) along the Y-axis direction in the light guide plate **15**. The third light guide plate inclined surface **22C** has an inclination rising to a back side from the side opposite to the LED **13** (right side in FIG. 2) toward the side of the LED **13** (left side in FIG. 2) along the Y-axis direction in the light guide plate **15**.

(41) As illustrated in FIG. 2, the first inclined surface **22A** and the second inclined surface **22B** reflect light propagating inside the light guide plate **15**, raise the light toward the front side so as to be at an angle close to the Z-axis direction, and thus can promote emission from the first main surface **15B**. Specifically, the first inclined surface **22A** mainly functions to reflect and raise light traveling away from the LED **13** in the Y-axis direction. On the other hand, the second inclined surface **22B** mainly functions to reflect and raise light traveling toward the LED **13** in the Y-axis direction. The first inclined surface **22A** has a gradient in which a distance from the first main

surface **15B** (a portion on which the third light guide plate lens **22** is not installed) becomes smaller while getting farther from the LED **13** in the Y-axis direction. The first inclined surface **22A** has an inclination angle (first angle) $\theta 7$ of, for example, approximately 8° formed with respect to the Y-axis direction. The second inclined surface **22B** has a gradient in which a distance from the first main surface **15B** becomes larger while getting farther from the LED **13** in the Y-axis direction, that is, a gradient opposite to the gradient of the first inclined surface **22A**. The second inclined surface **22B** has a steep, near-vertical gradient at an inclination angle (second angle) $\theta 8$ of, for example, approximately 80° with respect to the Y-axis direction, and the inclination angle is greater than the inclination angle $\theta 7$ of the first inclined surface **22A**.

(42) Further, as illustrated in FIGS. **2**, **4**, and **5**, the plurality of third light guide plate lenses **22** arranged along the Y-axis direction are designed such that the height dimension (dimension along the Z-axis direction) and the length dimension (dimension along the Y-axis direction) respectively increase while getting farther from the LED **13** in the Y-axis direction. More specifically, comparing the third light guide plate lens **22** closer to the LED **13** in the Y-axis direction and the third light guide plate lens **22** farther from the LED **13** in the Y-axis direction, the respective areas of the first inclined surface **22A** and the second inclined surface **22B** of the latter are larger than those of the former. In other words, on the second main surface **15C**, the plurality of first inclined surfaces **22A** and the plurality of second inclined surfaces **22B** arranged at intervals in the Y-axis direction are configured such that the areas thereof increase while getting farther from the LED **13** in the Y-axis direction. In this way, on a side closer to the LED **13** in the Y-axis direction, light is less likely to be incident on the first inclined surface **22A** and the second inclined surface **22B** of the third light guide plate lens **22**, and light emission is suppressed, while on a side farther from the LED **13** in the Y-axis direction, light is more likely to be incident on the first inclined surface **22A** and the second inclined surface **22B** of the third light guide plate lens **22**, and light emission is promoted. As a result, the amount of emission light from the first main surface **15B** is made uniform between the side of the LED **13** and the side opposite to the LED **13** in the Y-axis direction.

(43) As illustrated in FIG. **2**, in the third inclined surface **22C**, an end portion on the side opposite to the LED **13** side along the Y-axis direction (right side in FIG. **2**) is continuous with the first inclined surface **22A**, and an end portion on the side of the first LED **13** along the Y-axis direction (left side in FIG. **2**) is continuous with the second inclined surface **22B**. The third inclined surface **22C** has a gradient in which a distance from the first main surface **15B** (a portion on which the third light guide plate lens **22** is not installed) becomes larger while getting farther from the LED **13** in the Y-axis direction. That is, the third inclined surface **22C** has a gradient similar to that of the second inclined surface **22B**. The third inclined surface **22C** has an inclination angle (third angle) $\theta 9$ of, for example, approximately 1.4° with respect to the Y-axis direction, and the inclination angle is smaller than any of the inclination angles $\theta 7$ and $\theta 8$ of the first inclined surface **22A** and the second inclined surface **22B**, respectively. The third inclined surface **22C** having such a configuration reflects light traveling away from the LED **13** inside the light guide plate **15**, and thus the light is directed toward the first main surface **15B**, but an angle of incidence of the light with respect to the first main surface **15B** does not exceed a critical angle. Thus, the light is totally reflected by the first main surface **15B**, and is guided so as to get farther from the LED **13**. Accordingly, emission light from the first main surface **15B** is less likely to be biased toward the side of the LED **13** in the Y-axis direction. As described above, in the second main surface **15C** of the light guide plate **15**, the inclination angle $\theta 9$ of the third inclined surface **22C** with respect to the Y-axis direction is the smallest, the inclination angle $\theta 7$ of the first inclined surface **22A** with respect to the Y-axis direction is larger than the inclination angle $\theta 9$, and the inclination angle $\theta 8$ of the second inclined surface **22B** with respect to the Y-axis direction is the largest. Further, a plurality of the third inclined surface **22C** arranged along the Y-axis direction are designed such that the length dimension decreases while getting farther from the LED **13** in the Y-axis direction.

The reason is that the length dimension of the third light guide plate lens **22** increases while getting farther from the LED **13** in the Y-axis direction, and an occupancy range of the third light guide plate lens **22** increases.

(44) As illustrated in FIGS. **3** to **5**, the third light guide plate lens **22** having the configuration described above is sandwiched between two second light guide plate lenses **21** adjacent to each other in the X-axis direction. Thus, the third light guide plate lens **22** is repeatedly disposed alternately with the second light guide plate lens **21** in the X-axis direction. In the third light guide plate lens **22**, a maximum value of a protrusion dimension (height dimension) from the second main surface **15C** is set smaller than a corresponding protrusion dimension of the second light guide plate lens **21**. Thus, even the third light guide plate lens **22** located on the farthest side from the LED **13** in the Y-axis direction does not protrude farther toward the back side than the second light guide plate lens **21**.

(45) As illustrated in FIG. **6**, the liquid crystal display device **10** for vehicle application according to the present embodiment is installed in a posture in which the X-axis direction and the Z-axis direction substantially match the horizontal direction and the Y-axis direction is parallel to the vertical direction. Here, the “posture in which the Y-axis direction is parallel to the vertical direction” may be a posture in which the Y-axis direction matches the vertical direction, but may also be a posture in which the Y-axis direction includes the vertical direction as a component of a vector, that is, a posture in which the Y-axis direction is slightly inclined with respect to the vertical direction. The Z-axis direction matches a front direction of the liquid crystal display device **10** for vehicle application. A driver (user) DR is present on the front side (right side in FIG. **6**) of the liquid crystal display device **10** for vehicle application. The liquid crystal display device **10** for vehicle application is installed such that the line of sight of the driver DR is inclined upward with respect to the front direction (Z-axis direction). An angle (peak angle) that corresponding to the peak luminance in the light distribution pertaining to the emission light from the liquid crystal display device **10** for vehicle application matches an angle θ_{vp} formed by the line of sight of the driver DR with respect to the front direction of the liquid crystal display device **10** for vehicle application. That is, the liquid crystal display device **10** for vehicle application is installed so that the driver DR can visually recognize the display image in the brightest state.

(46) As illustrated in FIG. **6**, a windshield FG of a passenger car is present above the liquid crystal display device **10** for vehicle application in the Y-axis direction. The LED **13** is located near a lower end portion of the liquid crystal display device **10** in the Y-axis direction in FIG. **6**, and the light-emitting face **13A** is oriented upward in the Y-axis direction in FIG. **6**. Here, among the emission light from the liquid crystal display device **10** for vehicle application, part of the light directed toward the windshield FG is reflected by the windshield FG and is directed toward the driver DR. Such reflected light may be visually recognized by the driver DR as “reflection” which is an image reflected on the windshield FG. Here, the front direction of the liquid crystal display device **10** for vehicle application is defined as 0° (reference), an angle on the upper side (side away from the LED **13**) in the Y-axis direction in FIG. **6** with respect to the front direction is defined as “+ (plus)”, and an angle on the lower side (side closer to the LED **13**) in the Y-axis direction in FIG. **6** with respect to the front direction is defined as “- (minus)”. Light recognized as the above-described “reflection” is light emitted in the range of “ $+50^\circ$ to $+80^\circ$ ” among the emission light from the liquid crystal display device **10** for vehicle application. In the present embodiment, light in the emission angle range ($+50^\circ$ to $+80^\circ$) that is recognized as the “reflection” is defined as “side lobe light”. In order to suppress such side lobe light, a louver has been used in the related art. However, since the louver has a high component price, there has been a demand for suppressing the side lobe light by regulating the emission angle of light at a low cost without using the louver, and preventing the reflection on the windshield FG. In the present embodiment, the above-described angle θ_{vp} (peak angle) is, for example, “ $+6^\circ$ ”.

(47) Thus, as illustrated in FIGS. **1** and **3**, the backlight device **12** according to the present

embodiment includes the first prism sheet **16** and the light absorption sheet **17**. First, the first prism sheet **16** will be described in detail. The first prism sheet **16** is disposed so as to overlap the back side of the light guide plate **15**. The first prism sheet **16** includes a first base material **16A** having a sheet shape, and a first prism **16B** provided on the first base material **16A**. A pair of main surfaces of the first base material **16A** includes a third main surface **16A1** and a fourth main surface **16A2**. The third main surface **16A1** is a main surface of the first base material **16A** on the front side facing the light guide plate **15**, and emits light toward the light guide plate **15**. The fourth main surface **16A2** is a main surface of the first base material **16A** on the back side facing the light absorption sheet **17**.

(48) The first base material **16A** is made of substantially transparent synthetic resin, and is specifically formed of, for example, a crystalline transparent resin material such as PET that is the same as the second base material **18A**. The first prism **16B** is formed of an ultraviolet-curing resin material being substantially transparent and being a type of photo-curable resin material. A manufacturing method of the first prism sheet **16** is similar to the manufacturing method of the second prism sheet **18** described above. The ultraviolet-curing resin material constituting the first prism **16B** is, for example, a crystalline transparent resin material such as PET, and a refractive index of the ultraviolet-curing resin material is set to, for example, approximately 1.65.

(49) As illustrated in FIG. 3, the first prism **16B** is provided on the fourth main surface **16A2** of the first base material **16A** on the back side. Specifically, the first prism **16B** is provided so as to protrude from the fourth main surface **16A2** of the first base material **16A** toward the back side (light absorption sheet **17** side) along the Z-axis direction. The first prism **16B** has a substantially triangular shape (is substantially mountain shaped) in a cross section taken along the X-axis direction and also extends linearly along the Y-axis direction (first direction), and a plurality of the first prisms **16B** are continuously disposed side by side with substantially no interval along the X-axis direction (second direction) on the fourth main surface **16A2** of the first base material **16A**. The plurality of first prisms **16B** are continuously arranged along the X-axis direction with substantially no interval therebetween. The first prism **16B** includes a first base **16B1** parallel to the X-axis direction, and a pair of first oblique sides **16B2** and **16B3** rising from both ends of the first base **16B1**. Among the pair of first oblique sides **16B2** and **16B3** of the first prism **16B**, the oblique side located on one side (left side in FIG. 3) in the X-axis direction is referred to as one first oblique side **16B2**, and the oblique side located on the other side (right side in FIG. 3) in the X-axis direction is referred to as the other first oblique side **16B3**.

(50) As illustrated in FIG. 3, in the first prism **16B**, an inclination angle (first bottom angle) $\theta 10$ of the one first oblique side **16B2** with respect to the base **16B1**, and an inclination angle (second bottom angle) $\theta 11$ of the other first oblique side **16B3** with respect to the base **16B1**, are identical.

(51) That is, the first prism **16B** has a symmetric cross-sectional shape, which is that of an isosceles triangle. Specifically, the respective inclination angles $\theta 10$ and $\theta 11$ of the pair of first oblique sides **16B2** and **16B3** with respect to the base **16B1** in the first prism **16B** are preferably within a range from 40° to 50° , and are most preferably 45° . On the other hand, an angle (third apex angle) $\theta 12$ formed by the pair of first oblique sides **16B2** and **16B3** of the first prism **16B** is preferably within a range from 80° to 100° , and is most preferably 90° , that is, a right angle. Note that all the plurality of first prisms **16B** arranged along the X-axis direction have substantially the same height dimension, substantially the same width dimension for the first base **16B1**, substantially the same inclination angles for the first oblique sides **16B2** and **16B3** with respect to the first base **16B1**, and the like, and are arranged such that the arrangement intervals between adjacent first prisms **16B** are substantially constant and equal.

(52) According to such a configuration, as illustrated in FIG. 2, when the light emitted from the LED **13** and incident on the light incident end face **15A** of the light guide plate **15** reaches the first inclined surface **22A** having an inclination rising from the side opposite to the LED **13** side toward the LED **13** side in the Y-axis direction on the second main surface **15C** in the process of

propagating inside the light guide plate **15**, a large amount of the light is reflected by the first inclined surface **22A**, but the remaining light is refracted and emitted from the first inclined surface **22A** toward the back side. Among the light, the light reflected by the first inclined surface **22A** is directed toward the first main surface **15B**, and is reflected again by the first main surface **15B** or emitted from the first main surface **15B**. On the other hand, the light emitted from the first inclined surface **22A** is directed toward the first prism sheet **16**. The light directed from the first inclined surface **22A** toward the first prism sheet **16** is reflected by the third main surface **16A1** of the first prism sheet **16** (the interface between the first base material **16A** and the air layer) or is incident on the first prism sheet **16**. When the light reflected by the third main surface **16A1** of the first prism sheet **16** is incident on the second main surface **15C** of the light guide plate **15**, the light is emitted from the first main surface **15B** as it is or emitted from the first main surface **15B** after propagating inside the light guide plate **15**.

(53) As illustrated in FIG. 3, the light incident on the first prism sheet **16** is reflected by the first base **16B1** (the interface between the first base material **16A** and the first prism **16B**) of the first prism **16B** or by the pair of first oblique sides **16B2** and **16B3** of the first prism **16B**, so that the light is emitted from the first prism sheet **16** and is directed toward the second main surface **15C** of the light guide plate **15**. Specifically, the light incident on the third main surface **16A1** of the first base material **16A** is emitted from the third main surface **16A1** toward the front side (light guide plate **15** side) through any path of being totally reflected at the interface between the first base material **16A** and the first prism **16B**, being incident on the first prism **16B**, being reflected by the one first oblique side **16B2**, traveling toward the other first oblique side **16B3**, and being reflected by the other first oblique side **16B3**, traveling toward the one first oblique side **16B2**, and being reflected by the one first oblique side **16B2**. When the light emitted from the first prism sheet **16** to the front side is incident on the second main surface **15C** of the light guide plate **15**, the light is emitted from the first main surface **15B** as it is or emitted from the first main surface **15B** after propagating inside the light guide plate **15**.

(54) The light reaching the second main surface **15C** in the process of propagating inside the light guide plate **15** and refracted by the first inclined surface **22A** is angled in accordance with the refractive index of the light guide plate **15** and the inclination angle θ_7 of the first inclined surface **22A** with respect to the Y-axis direction. Specifically, in the present embodiment, the emission light from the second main surface **15C** of the light guide plate **15** contains the largest amount of light that forms an angle of about 10° (80° with respect to the Z-axis direction) on the first prism sheet **16** side (lower side in FIG. 2) with respect to the Y-axis direction. That is, the emission light from the second main surface **15C** of the light guide plate **15** has such high directivity that the light with an angle of about 10° on the first prism sheet **16** side with respect to the Y-axis direction exhibits peak luminance, and hardly contains diffused light. As a result, the emission light from the second main surface **15C** of the light guide plate **15** is specularly reflected by the third main surface **16A1** of the first prism sheet **16** and the first base **16B1** of the first prism **16B** with high efficiency (specifically, an average reflectivity of the P-wave and the S-wave is about 40%), and is efficiently totally reflected by the pair of first oblique sides **16B2** and **16B3** of the first prism **16B**, and diffused light is hardly contained in any of the reflected light. Thus, light emitted in the range of “ $+50^\circ$ to $+80^\circ$ ”, that is, the side lobe light is less likely to be contained in the emission light from the backlight device **12**. As described above, the emission angle of light can be regulated without using the louver as in the related art, and the side lobe light can be reduced.

(55) Next, the light absorption sheet **17** will be described in detail. As illustrated in FIGS. 1 to 3, the light absorption sheet **17** has a main surface parallel to each of the main surfaces of the light guide plate **15** and the first prism sheet **16**, and is also disposed so as to cover the fourth main surface **16A2** of the first prism sheet **16**. The light absorption sheet **17** is disposed to overlap substantially all over the fourth main surface **16A2** of the first prism sheet **16**. The light absorption

sheet **17** is made of, for example, PET having a surface exhibiting black, and has light absorbability higher than that of any of the light guide plate **15** and the first prism sheet **16**. Among the pair of main surfaces of the light absorption sheet **17**, the main surface on the front side is a light absorption main surface (fifth main surface) **17A** that is disposed to face the fourth main surface **16A2** of the first prism sheet **16** and absorbs light.

(56) According to such a configuration, the light emitted from the fourth main surface **16A2** of the first prism sheet **16** toward the back side is directed toward the light absorption sheet **17** and is efficiently absorbed by the light absorption main surface **17A**. Here, since the light emitted from the fourth main surface **16A2** of the first prism sheet **16** has characteristics similar to diffused light in many cases, by absorbing the light by the light absorption sheet **17**, the emission angle pertaining to the emission light from the backlight device **12** can be more satisfactorily regulated. Thus, the side lobe light can be further reduced. Since the amount of emission light from the fourth main surface **16A2** of the first prism sheet **16** is small, even when the light is absorbed by the light absorption sheet **17**, the influence on the luminance pertaining to the emission light from the backlight device **12** is small.

(57) Next, in order to validate the advantages of the backlight device **12** and the liquid crystal display device **10** according to the present embodiment, the following Comparative Experiments 1 and 2 were performed. First of all, a description will be given on Comparative Experiment 1. In Comparative Experiment 1, light distributions pertaining to emission light of backlight devices of following Example 1 and Comparative Examples 1 to 4 were obtained. In Example 1, the backlight device **12** has the same configuration as that described before Comparative Experiment 1. In Comparative Examples 1 to 4, the backlight devices have configurations different from the configuration of Example 1. Specifically, as illustrated in FIG. 7, each of the backlight devices of Comparative Examples 1, 2, and 4 includes at least a light guide plate **1**, a light reflective sheet **2** layered on the back side of the light guide plate **1**, a light diffuser sheet **3** layered on the front side of the light guide plate **1**, and a prism sheet **4** layered on the front side of the light diffuser sheet **3** in addition to the LED as the light source. The light guide plate **1** included in the backlight device of each of Comparative Examples 1, 2, and 4 has, on a main surface **1B** on the back side, a light reflective portion **5** that raises light toward the front side by diffusing and reflecting the light. The light reflective portion **5** is formed of rough surfaces (fine unevenness) selectively provided on the main surface **1B** on the back side of the light guide plate **1**. Part of the light diffused and reflected by the light reflective portion **5** is emitted from the main surface **1A** on the front side of the light guide plate **1**. The light reflective sheet **2** has a surface exhibiting white and high light reflectivity. Light emitted from the main surface **1B** on the back side of the light guide plate **1** can be diffused and reflected by the light reflective sheet **2** to be incident on the light guide plate **1** again. The light diffuser sheet **3** contains a diffusing agent that diffuses and reflects the light. Since the prism sheet **4** has substantially the same configuration as the third prism sheet **19** (see FIG. 3) described before Comparative Experiment 1, a detailed description of the configuration of the prism sheet **4** is omitted here.

(58) The backlight device of Comparative Example 1 includes the louver as in the related art in addition to the configuration illustrated in FIG. 7. In the backlight device of Comparative Example 1, the louver is layered on the front side with respect to the prism sheet **4**. The louver has a configuration in which light blocking portions and light transmitting portions are alternately and repeatedly arranged along the Y-axis direction, and an emission angle of light transmitted through the light transmitting portion is regulated by two light blocking portions sandwiching the light transmitting portion. On the other hand, the backlight device of Comparative Example 2 has a configuration as illustrated in FIG. 7. The backlight device of Comparative Example 4 includes the first prism sheet **16** (see FIGS. 2 and 3) in addition to the configuration illustrated in FIG. 7. In the backlight device of Comparative Example 4, the first prism sheet **16** is interposed between the light guide plate **1** and the light reflective sheet **2** (see FIG. 7). On the other hand, the backlight device of

Comparative Example 3 has a configuration in which the first prism sheet **16** is removed from the backlight device **12** (see FIGS. 2 and 3) in Example 1, and the light reflective sheet **2** (see FIG. 7) is provided instead of the light absorption sheet **17**. Hereinafter, as in Example 1 and Comparative Example 3, a type of the backlight device including the light guide plate **15**, the second prism sheet **18**, and the third prism sheet **19** illustrated in FIGS. 2 and 3 in addition to the LED **13** is referred to as a “type A”. As in Comparative Examples 1, 2, and 4, a type of the backlight device including the light guide plate **1**, the light reflective sheet **2**, the light diffuser sheet **3**, the prism sheet **4**, and the light reflective portion **5** illustrated in FIG. 7 in addition to the LED is referred to as a “type B”. Thus, Example 1 and Comparative Example 3 are classified into the type A, and Comparative Examples 1, 2, and 4 are classified into the type B. It can be said that Example 1 has a configuration in which the first prism sheet **16** and the light absorption sheet **17** are included in the type A. It can be said that Comparative Example 3 has a configuration in which the first prism sheet **16** is not included and the light reflective sheet **2** is included in the type A.

(59) In Comparative Experiment 1, by using the backlight devices of Example 1 and Comparative Examples 1 to 4 as described above, luminance pertaining to the emission light was measured in a state where the LED was turned on, and graphs pertaining to light distributions (luminance angle distributions) in the Y-axis direction were produced. Experimental results pertaining to light distributions in Comparative Experiment 1 are as shown in FIG. 8. In the graphs pertaining to light distributions shown in FIG. 8, a horizontal axis is an angle (in units of “°”) in the Y-axis direction with respect to the front direction (Z-axis direction), and a vertical axis is relative luminance (in units of “%”) with peak luminance as a reference (100%). Among the positive and negative symbols provided to the angles in the horizontal axis in FIG. 8, “– (negative)” refers to the lower side (side opposite to the windshield FG side) in FIG. 6 in the Y-axis direction (vertical direction) with respect to 0° (front direction) as a reference value when the backlight device **12** is viewed from the front, and “+ (positive)” refers to the upper side (windshield FG side) in FIG. 6 in the Y-axis direction with respect to 0° (front direction) as the reference value when the backlight device **12** is viewed from the front. In FIG. 8, the graph of Example 1 is shown by a solid line, the graph of Comparative Example 1 is shown by a broken line, the graph of Comparative Example 2 is shown by a one dot chain line, the graph of Comparative Example 3 is shown by a thick two dot chain line, and the graph of Comparative Example 4 is shown by a thin two dot chain line.

(60) The experimental results of Comparative Experiment 1 will be described. According to FIG. 8, in each light distribution in Comparative Examples 1, 2, and 4, the peak angle that is the angle at which light exhibits the peak luminance is “+3°”, and a half width (full width at half maximum; FWHM) is wider than a half width of the light distribution in Example 1. The reason why the half width of each light distribution in Comparative Examples 1, 2, and 4 is wider than the half width of the light distribution in Example 1 is presumed to be that the light is diffused and reflected by each of the light reflective sheet **2**, the light diffuser sheet **3**, and the light reflective portion **5** included in the backlight device of the type B. On the other hand, in the light distribution in Example 1, the peak angle that is the angle at which light exhibits the peak luminance is “+6°”. In the light distribution in Comparative Example 3, the peak angle that is the angle at which light exhibits the peak luminance is “+8°”. Each of the light distributions of Example 1 and Comparative Example 3 has a narrower half width than the half widths of Comparative Examples 1, 2, and 4. The reason why the half width of each of the light distributions in Example 1 and Comparative Example 3 is narrower than the half width of each of the light distributions in Comparative Examples 1, 2, and 4 is presumed to be that a high light condensing effect is imparted in the Y-axis direction by the two prism sheets **18** and **19** included in the backlight device of the type A and that diffuse and reflection hardly occurs in any of the light guide plate **15** and the prism sheets **18** and **19**. The reason why the peak angle of the light distribution in Comparative Example 3 is larger than the peak angle of the light distribution in Example 1 is presumed to be due to an influence in which the first prism sheet **16** is not included, so that reflected light by the first prism sheet **16** is not present, and the light is

diffused and reflected by the light reflective sheet **2**.

(61) According to the light distribution in Comparative Example 1, the side lobe light, each of which is light emitted in the range of “+50° to +80°”, is suppressed to be sufficiently low. The reason for this is presumed to be that even when the light is diffused and reflected by each of the light reflective sheet **2**, the light diffuser sheet **3**, and the light reflective portion **5** included in the backlight device of the type B, the emission angle range of light is favorably regulated in the Y-axis direction by the louver. According to the light distribution in each of Comparative Examples 2 and 4, the side lobe light has a relative luminance of approximately 20% or more, and the reflection caused by the side lobe light is easily visually recognized. The reason for this is presumed to be that Comparative Example 2 does not include a configuration for limiting the emission angle range of light diffused and reflected by each of the light reflective sheet **2**, the light diffuser sheet **3**, and the light reflective portion **5** included in the backlight device of the type B. In the light distribution in Example 1, the side lobe light, which is the light emitted in the range of “+50° to +80°”, is suppressed to be sufficiently low to an extent close to the light distribution in Comparative Example 1. The reason for this is presumed to be that the diffuse reflection hardly occurs in any of the light guide plate **15** and each of the prism sheets **18** and **19** included in the backlight device of the type A, and in particular, the light emitted from the first inclined surface **22A** toward the back side is appropriately angled, so that the light can be efficiently specularly reflected or totally reflected by the first prism sheet **16**. Further, it is presumed that the absorption of the diffused light emitted from the first prism sheet **16** by the light absorption sheet **17** also contributes to the suppression of the side lobe light. In the light distribution in Comparative Example 3, the side lobe light is suppressed as compared with each of the light distributions of Comparative Examples 2 and 4, but the side lobe light is slightly increased as compared with each of the light distributions of Example 1 and Comparative Example 1. The reason for this is presumed to be that since Comparative Example 3 is the backlight device of the type A, the emission angle range of light is regulated, but the light reflected by the first prism sheet **16** is not present, and the light is diffused and reflected by the light reflective sheet **2**.

(62) Next, a description will be given on Comparative Experiment 2. In Comparative Experiment 2, ratios pertaining to the side lobe light were extracted from the light distributions obtained using the backlight devices of Example 1 and Comparative Examples 1 to 4 described in Comparative Experiment 1. In Comparative Experiment 2, by using the backlight devices of Example 1 and Comparative Examples 1 to 4, the luminance pertaining to the emission light was measured in a state where the LED was turned on, the light distributions in the Y-axis direction were obtained, and the relative luminance (unit is “%”) at each angle of +50°, +60°, +70°, and +80° in the light distributions in the Y-axis direction was extracted. The relative luminance at each angle of +50°, +60°, +70°, and +80° uses peak luminance at the peak angle as a reference (100%). Here, the significance of extracting the relative luminance at each angle of +50°, +60°, +70°, and +80° is to present an index regarding whether the “reflection” caused by the side lobe light (light emitted in the range of +50° to +80°) is easily visually recognized. That is, in order that the “reflection” is less likely to be visually recognized, the relative luminance at each angle of +50°, +60°, +70°, and +80° is preferably 3% or less.

(63) Experimental results of Comparative Experiment 2 are as shown in a table in FIG. **9**. The table in FIG. **9** shows information (peak angle, backlight type, presence of the louver, presence of the first prism sheet **16**, presence of the light absorption sheet **17**, presence of the light reflective sheet **2**) regarding the configurations of Example 1 and Comparative Examples 1 to 4 and the relative luminance at each angle of +50°, +60°, +70°, and +80°, which are experimental results. The peak angle is “+6°” in Example 1, “+3°” in Comparative Examples 1, 2, and 4, and “+8°” in Comparative Example 3. The backlight type indicates a type of the backlight device, and is either the type A or the type B described above. The louver is included only in Comparative Example 1. The first prism sheet **16** is included in Example 1 and Comparative Example 4. The light

absorption sheet **17** is included only in Example 1. The light reflective sheet **2** is included in Comparative Examples 1 to 4.

(64) The experimental results of Comparative Experiment 2 will be described. According to FIG. **9**, in Comparative Examples 2 to 4, since the relative luminance exceeds 3% at any angle of $+50^\circ$, $+60^\circ$, $+70^\circ$, and $+80^\circ$, it can be said that the reflection caused by the side lobe light is easily visually recognized. In particular, in Comparative Examples 2 and 4, the relative luminance exceeds 20% at each angle of $+50^\circ$, $+60^\circ$, and $+70^\circ$, and it can be said that the reflection tends to be particularly easily visually recognized. In Comparative Example 3, the relative luminance at each angle exceeds 3% as the reference value but is suppressed to 5% or less, so that the reflection is suppressed as compared with Comparative Examples 2 and 4. The reason for this is presumed to be that, in Comparative Example 3, although the first prism sheet **16** is not included, Comparative Example 3 is the type A, so that the directivity of the emission light is high. In Comparative Example 4, the first prism sheet **16** was included, but the largest amount of side lobe light was generated. It is presumed that this suggests that since a large amount of diffuse reflection light is generated in the backlight device of the type B, the emission angle range of light is difficult to be controlled even when the first prism sheet **16** is used in combination. On the other hand, in Example 1 and Comparative Example 1, the relative luminance is 3% or less at any angle of $+50^\circ$, $+60^\circ$, $+70^\circ$, and $+80^\circ$, it can be said that the reflection caused by the side lobe light is less likely to be sufficiently visually recognized. In Comparative Example 1, the side lobe light is most suppressed. The reason for this is presumed to be that the emission angle range of light is well regulated by the louver. On the other hand, in Example 1, although the louver is not used, the side lobe light is suppressed to an extent close to Comparative Example 1. This is presumed to be that by using the first prism sheet **16** and the light absorption sheet **17** in the backlight device of the type A, the emission angle range of light can be regulated while suppressing the generation of the diffuse reflection light. As described above, according to Example 1, the reflection caused by the side lobe light can be sufficiently suppressed at low cost without using the louver.

(65) As described above, the backlight device (illumination device) **12** of the present embodiment includes the LED (light source) **13**, the light guide plate **15** including the light incident end face (first end face) **15A** that is at least some of outer peripheral end faces of the light guide plate **15** and faces the LED **13** and on which light is incident, the first main surface **15B** that is the one main surface of the light guide plate **15**, and the second main surface **15C** that is the other main surface of the light guide plate **15**, the first prism sheet **16** including the third main surface **16A1** that is the one main surface of the first prism sheet **16** and disposed to face the second main surface **15C** and the fourth main surface **16A2** that is the other main surface of the first prism sheet **16**, in which the second main surface **15C** of the light guide plate **15** is provided with the first inclined surface **22A** that is the inclination rising from the side opposite to the LED **13** side toward the LED **13** side in the first direction including the direction from the LED **13** toward the light guide plate **15**, the fourth main surface **16A2** of the first prism sheet **16** is provided with the plurality of first prisms **16B** extending along the first direction and arranged along the second direction intersecting the first direction and along the fourth main surface **16A2**, and the first prism **16B** includes the first base **16B1** parallel to the second direction and the pair of first oblique sides **16B2** and **16B3** rising from both ends of the first base **16B1**.

(66) Light emitted from the LED **13** is incident on the light incident end face **15A** of the light guide plate **15** and propagates inside the light guide plate **15**. When the light propagating inside the light guide plate **15** reaches the first inclined surface **22A** having an inclination rising from the side opposite to the LED **13** side toward the LED **13** side in the first direction on the second main surface **15C**, a large amount of the light is reflected by the first inclined surface **22A**, and the remaining light is refracted and emitted from the first inclined surface **22A**. The light reflected by the first inclined surface **22A** is directed toward the first main surface **15B**, and is reflected again by the first main surface **15B** or emitted from the first main surface **15B**. The light emitted from the first

inclined surface **22A** is directed toward the first prism sheet **16**. The light directed toward the first prism sheet **16** is reflected by the third main surface **16A1** of the first prism sheet **16** or is incident on the first prism sheet **16**. When the light reflected by the third main surface **16A1** of the first prism sheet **16** is incident on the second main surface **15C** of the light guide plate **15**, the light is emitted from the first main surface **15B** as it is or emitted from the first main surface **15B** after propagating inside the light guide plate **15**. The light incident on the first prism sheet **16** is reflected by the first base **16B1** of the first prism **16B** or by the pair of first oblique sides **16B2** and **16B3** of the first prism **16B**, so that the light is emitted from the first prism sheet **16** and is directed toward the second main surface **15C** of the light guide plate **15**. When the light emitted from the first prism sheet **16** to the light guide plate **15** side is incident on the second main surface **15C** of the light guide plate **15**, the light is emitted from the first main surface **15B** as it is or emitted from the first main surface **15B** after propagating inside the light guide plate **15**.

(67) The light reaching the second main surface **15C** in the process of propagating inside the light guide plate **15** and refracted by the first inclined surface **22A** is angled in accordance with the refractive index of the light guide plate **15** and the inclination angle of the first inclined surface **22A** with respect to the first direction. That is, the diffused light is hardly contained in the emission light from the second main surface **15C** of the light guide plate **15**. Thus, the diffused light is hardly contained in the light reflected by the third main surface **16A1** of the first prism sheet **16**, the light reflected by the first base **16B1** of the first prism **16B**, and the light reflected by the pair of first oblique sides **16B2** and **16B3** of the first prism **16B**, so that the side lobe light emitted at an angle close to the first direction is less likely to be contained in the emission light from the backlight device **12**. Thus, the emission angle of light can be regulated without using the louver as in the related art, and the side lobe light can be reduced.

(68) In addition, the light absorption sheet **17** including the light absorption main surface (fifth main surface) **17A** that is the one main surface and disposed to face the fourth main surface **16A2** and having light absorbability higher than any of the light guide plate **15** and the first prism sheet **16** is included. The light emitted from the fourth main surface **16A2** of the first prism sheet **16** is directed toward the light absorption sheet **17**. The light absorption sheet **17** has the light absorbability higher than any of the light guide plate **15** and the first prism sheet **16**, so that the light absorption sheet **17** can efficiently absorb the light emitted from the fourth main surface **16A2** by the light absorption main surface **17A**. Here, since the light emitted from the fourth main surface **16A2** of the first prism sheet **16** has characteristics similar to diffused light in many cases, by absorbing the light by the light absorption sheet **17**, the emission angle pertaining to the emission light from the backlight device **12** can be more satisfactorily regulated, and the side lobe light can be further reduced. Since the amount of emission light from the fourth main surface **16A2** of the first prism sheet **16** is small, even when the light is absorbed by the light absorption sheet **17**, the influence on the luminance pertaining to the emission light from the backlight device **12** is small.

(69) The second prism sheet **18** including the second light emission main surface (seventh main surface) **18A1** that is the one main surface of the second prism sheet **18** and the second light incident main surface (eighth main surface) **18A2** that is the other main surface of the second prism sheet **18** and disposed to face the first main surface **15B**, and the third prism sheet **19** including the third light emission main surface (ninth main surface) **19A1** that is the one main surface of the third prism sheet **19** and the third light incident main surface (tenth main surface) **19A2** that is the other main surface of the third prism sheet **19** and disposed to face the second light emission main surface **18A1**, in which the second light emission main surface **18A1** of the second prism sheet **18** is provided with the plurality of second prisms **18B** extending along the second direction and disposed side by side along the first direction, and the third light emission main surface **19A1** of the third prism sheet **19** is provided with the plurality of third prisms **19B** extending along the second direction and disposed side by side along the first direction. When the light emitted from the first main surface **15B** of the light guide plate **15** is incident on the second light incident main

surface **18A2** of the second prism sheet **18**, the light is emitted from the second light emission main surface **18A1** while being selectively imparted with a condensing action in the first direction by the plurality of second prisms **18B** extending along the second direction on the second light emission main surface **18A1**. When the light emitted from the second light emission main surface **18A1** of the second prism sheet **18** is incident on the third light incident main surface **19A2** of the third prism sheet **19**, the light is emitted from the third light emission main surface **19A1** while being selectively imparted with the condensing action in the first direction by the plurality of third prisms **19B** extending along the second direction on the third light emission main surface **19A1**. As described above, since the emission light from the light guide plate **15** is selectively imparted with the condensing action in the first direction by the second prisms **18B** and the third prisms **19B**, the emission angle of light can be more satisfactorily regulated, and the side lobe light can be further reduced.

(70) In addition, the second prism **18B** includes the second base **18B1** parallel to the first direction and the pair of second oblique sides **18B2** and **18B3** rising from both ends of the second base **18B1**, and among the pair of second oblique sides **18B2** and **18B3**, the second LED-side oblique side **18B2** that is the second oblique side located on the side of the LED **13** in the first direction forms a larger angle with respect to the second base **18B1** than the second opposite-to-LED-side oblique side **18B3** that is the second oblique side located on the side opposite to the LED **13** side in the first direction. In this way, the light incident on the second light incident main surface **18A2** of the second prism sheet **18** is less likely to be incident on the second LED-side oblique side **18B2** that is the second oblique side located on the side of the LED **13** in the first direction than the second opposite-to-LED-side oblique side **18B3** that is the second oblique side located on the side opposite to the LED **13** side in the first direction among the pair of second oblique sides **18B2** and **18B3** of the second prism **18B**. When the incident light incident on the second prism sheet **18** is incident on the second LED-side oblique side **18B2** that is the second oblique side located on the side of the LED **13**, the light is not raised when being emitted from the second prism **18B**, and tends to be more likely to be emitted as side lobe light. Thus, when the incident light incident on the second prism sheet **18** becomes less likely to be directly incident on the second LED-side oblique side **18B2** that is the second oblique side located on the side of the LED **13**, the occurrence of the side lobe light can be suppressed. Most of the incident light incident on the second prism sheet **18** is refracted and emitted by the second opposite-to-LED-side oblique side **18B3** that is the second oblique side located on the side opposite to the LED **13** side, is incident on the third prism sheet **19**, and is easily effectively used.

(71) The third prism **19B** includes the third base **19B1** parallel to the first direction, and the pair of third oblique sides **19B2** and **19B3** rising from both ends of the third base **19B1**, and the pair of third oblique sides **19B2** and **19B3** form the same angle with respect to the third base **19B1**. Among the light incident on the third light incident main surface **19A2** of the third prism sheet **19**, the light incident on the third opposite-to-LED-side oblique side **19B3** that is the third oblique side located on the side opposite to the LED **13** side in the first direction among the pair of third oblique sides **19B2** and **19B3** of the third prism **19B** is refracted and emitted at the third opposite-to-LED-side oblique side **19B3** or is reflected at the third opposite-to-LED-side oblique side **19B3** and directed toward the third LED-side oblique side **19B2** that is the third oblique side located on the side of the LED **13**. Here, since the pair of third oblique sides **19B2** and **19B3** form the same angle with respect to the third base **19B1**, when the light reflected by the third opposite-to-LED-side oblique side **19B3** that is the third oblique side located on the side opposite to the LED **13** side is incident on the third LED-side oblique side **19B2** that is the third oblique side located on the side of the LED **13**, the light is reflected there and easily returns to the second prism sheet **18** side. The light (recursive light) returned to the second prism sheet **18** side reaches the third prism sheet **19** again by being reflected or the like inside the backlight device **12**, and is raised and emitted by either of the pair of third oblique sides **19B2** and **19B3** of the third prism **19B**. Thus, the usage

efficiency of light can be improved.

(72) In addition, a plurality of the first inclined surfaces **22A** are disposed side by side along the first direction, and the plurality of first inclined surfaces **22A** are configured to increase in area while getting farther from the LED **13**. Most of the light reaching the second main surface **15C** in the process of propagating inside the light guide plate **15** is reflected by the first inclined surface **22A**. Since the plurality of first inclined surfaces **22A** arranged along the first direction are configured to increase in area while getting farther from the LED **13**, the amount of light reflected by the first inclined surfaces **22A** tends to increase while getting farther from the LED **13**. Thus, the amount of emission light from the first main surface **15B** of the light guide plate **15** is made uniform in the first direction, which is suitable for suppressing luminance unevenness.

(73) Further, the liquid crystal display device (display device) **10** according to the present embodiment includes the backlight device **12** described above, and the liquid crystal panel (display panel) **11** configured to perform display by using light from the backlight device **12**. According to the liquid crystal display device **10** having such a configuration, since the emission angle of light can be regulated without using the louver as in the related art, display with excellent display quality can be achieved.

Second Embodiment

(74) A second embodiment will be described with reference to FIG. **10** to FIG. **13**. In the second embodiment, a case in which a light reflective sheet **23** is used instead of the light absorption sheet **17**. Further, repetitive descriptions of structures, actions, and effects similar to those of the first embodiment described above will be omitted.

(75) As illustrated in FIG. **10**, a backlight device **112** according to the present embodiment includes the light reflective sheet **23** instead of the light absorption sheet **17** (see FIGS. **2** and **3**) described in the first embodiment. The light reflective sheet **23** is disposed overlapping a back side (the side opposite to a light guide plate **115** side) with respect to a first prism sheet **116**. The light reflective sheet **23** is disposed such that its main surface is parallel to the main surfaces of the light guide plate **115** and the first prism sheet **116** and covers a fourth main surface **116A2** of the first prism sheet **116**. The light reflective sheet **23** is disposed to overlap substantially all over the fourth main surface **116A2** of the first prism sheet **116**. The light reflective sheet **23** is made of, for example, PET having a surface exhibiting white, and has light reflectivity higher than that of any of the light guide plate **115** and the first prism sheet **116**. Among the pair of main surfaces of the light reflective sheet **23**, the main surface on the front side is a light reflective main surface (sixth main surface) **23A** that is disposed to face the fourth main surface **116A2** of the first prism sheet **116** and reflects light.

(76) According to such a configuration, the light emitted from the fourth main surface **116A2** of the first prism sheet **116** toward the back side is directed toward the light reflective sheet **23** and is efficiently reflected by the light reflective main surface **23A**. The amount of emission light from the fourth main surface **116A2** of the first prism sheet **116** is small, but the luminance pertaining to the emission light from the backlight device **112** can be improved by reflecting the light by the light reflective sheet **23**.

(77) Next, Comparative Experiments 3 to 5 were performed. First, Comparative Experiment 3 will be described. In Comparative Experiment 3, a light distribution pertaining to the emission light of the backlight device of Example 2 was obtained. In Example 2, the backlight device **112** has the same configuration as that described before the present paragraph. That is, Example 2 is the backlight device of the type A, and is different from Example 1 described in Comparative Experiments 1 and 2 in that the light reflective sheet **23** is included instead of the light absorption sheet **17**. Similarly to Comparative Experiment 1, in Comparative Experiment 3, by using the backlight device of Example 2, luminance pertaining to the emission light was measured in a state where the LED was turned on, and graphs pertaining to the light distributions (luminance angle distributions) in the Y-axis direction were produced. Experimental results pertaining to the light

distributions in Comparative Experiment 3 are as shown in FIG. 11. The graphs pertaining to the light distributions shown in FIG. 11 are the same as FIG. 8. In FIG. 11, in addition to the graph of Example 2, graphs of Example 1 and Comparative Example 3, which are the experimental results of Comparative Experiment 1, are also shown for reference. In FIG. 11, the graph of Example 2 is shown by a solid line, the graph of Example 1 is shown by a one dot chain line, and the graph of Comparative Example 3 is shown by a two dot chain line.

(78) The experimental results of Comparative Experiment 3 will be described. According to FIG. 11, in the light distribution in Example 2, the peak angle that is the angle at which light exhibits the peak luminance is “+90”, and the half width is slightly wider than the half width of the light distribution in Example 1 and equal to the half width of Comparative Example 3. The reason why the half width of the light distribution in Example 2 is slightly wider than the half width of the light distribution in Example 1 is presumed to be that the light is diffused and reflected by the light reflective sheet 23 of Example 2, so that the emission angle range of light is slightly widened. The peak angle of the light distribution in Example 2 is larger than any of the peak angle (+6° of the light distribution in Example 1 and the peak angle) (+8° of the light distribution in Comparative Example 3. In the light distribution in Example 2, the side lobe light, each of which is light emitted in the range of “+50° to +80°”, is suppressed to be sufficiently low to an extent close to the light distribution in Example 1.

(79) Next, a description will be given on Comparative Experiment 4. In Comparative Experiment 4, ratios pertaining to the side lobe light were extracted from the light distribution obtained using the backlight device of Example 2. Similarly to Comparative Experiment 2, in Comparative Experiment 4, by using the backlight device of Example 2, the luminance pertaining to the emission light was measured in a state where the LED was turned on, the light distributions in the Y-axis direction were obtained, and the relative luminance (unit is “%”) at each angle of +50°, +60°, +70°, and +80° in the light distributions in the Y-axis direction was extracted. As described in Comparative Experiment 2, in order that the “reflection” is less likely to be visually recognized, the relative luminance at each angle of +50°, +60°, +70°, and +80° is preferably 3% or less.

(80) Experimental results of Comparative Experiment 4 are as shown in a table in FIG. 12. In the table in FIG. 12, in addition to the experimental results of Example 2, the experimental results of Example 1 and Comparative Example 3, which are the experimental results of Comparative Experiment 2, are also shown for reference. Similarly to the table in FIG. 9, the table in FIG. 12 shows information (peak angle, backlight type, presence of the louver, presence of the first prism sheet 16, presence of the light absorption sheet 17, presence of the light reflective sheet 2) regarding the configurations of Examples 1 and 2, and Comparative Example 3, and the relative luminance at each angle of +50°, +60°, +70°, and +80°, which are experimental results.

(81) The experimental results of Comparative Experiment 4 will be described. According to FIG. 12, Example 2 exceeds 3% as the reference value at +60° and +70°, but is suppressed to 3% or less at +50° and +80°. That is, in Example 2, the reflection is easily visually recognized as compared with Example 1 in which the reflectance is 3% or less at all angles, but the reflection is suppressed as compared with Comparative Example 3 in which the reflectance is more than 3% at all angles. The reason why such a result was obtained is presumed to be that since Example 2 is common to Example 1 in that Example 2 is the backlight device of the type A and in that Example 2 includes the first prism sheet 116, even when the light is diffused and reflected by the light reflective sheet 23, the emission angle range of light can be regulated to a certain extent. As described above, according to Example 2, the cost can be reduced without using the louver, and the reflection caused by the side lobe light can be suppressed to a certain extent while obtaining the luminance improving effect by the light reflective sheet 23.

(82) Next, a description will be given on Comparative Experiment 5. In Comparative Experiment 5, the light distributions pertaining to the emission light of the backlight devices of Examples 1 and 2 were obtained in the same manner as in Comparative Experiment 3 described above, and the

vertical axis in the graphs of the light distributions was set to “luminance” of an absolute value. Similarly to Comparative Experiment 1, in Comparative Experiment 5, by using the backlight devices of Examples 1 and 2, luminance pertaining to the emission light was measured in a state where the LED was turned on, and graphs pertaining to the light distributions in the Y-axis direction were produced. Experimental results pertaining to the light distributions in Comparative Experiment 5 are as shown in FIG. 13. In the graphs according to the light distributions shown in FIG. 13, a horizontal axis is an angle (in units of “°”) in the Y-axis direction with respect to the front direction (Z-axis direction), and a vertical axis is luminance (in units of “cd/m²”). In FIG. 13, the graph of Example 2 is shown by a solid line, and the graph of Example 1 is shown by a one dot chain line.

(83) The experimental results of Comparative Experiment 5 will be described. According to FIG. 13, the peak luminance pertaining to the light distribution in Example 1 is slightly lower than 2000 cd/m², whereas the peak luminance pertaining to the light distribution in Example 2 is about 2300 cd/m². That is, the peak luminance pertaining to the light distribution in Example 2 is higher than the peak luminance pertaining to the light distribution in Example 1. The reason for this is presumed to be that, in Example 1, the light emitted from the first prism sheet 16 to the back side is absorbed by the light absorption sheet 17 and is not used as the emission light, whereas, in Example 2, the light emitted from the first prism sheet 16 to the back side is reflected by the light reflective sheet 23 and is used as the emission light. As described above, according to Example 2, the effect of improving the peak luminance pertaining to the emission light can be obtained.

(84) As described above, according to the present embodiment, the light reflective sheet 23 including one main surface serving as the light reflective main surface (sixth main surface) 23A disposed to face the fourth main surface 116A2 and having light reflectivity higher than any of the light guide plate 115 and the first prism sheet 116. The light emitted from the fourth main surface 116A2 of the first prism sheet 116 is directed toward the light reflective sheet 23. The light reflective sheet 23 has the light reflectivity higher than any of the light guide plate 115 and the first prism sheet 116, so that the light reflective sheet 23 can efficiently reflect the light emitted from the fourth main surface 116A2 by the light reflective main surface 23A. The amount of emission light from the fourth main surface 116A2 of the first prism sheet 116 is small, but the luminance pertaining to the emission light from the backlight device 112 can be improved by reflecting the light by the light reflective sheet 23.

Third Embodiment

(85) A third embodiment will be described with reference to FIG. 14 to FIG. 16. In the third embodiment, a case in which a configuration of a light guide plate 215 is changed will be described. Further, repetitive descriptions of structures, actions, and effects similar to those of the first embodiment described above will be omitted.

(86) As illustrated in FIG. 14, in the backlight device 212 according to the present embodiment, a material and a refractive index of the light guide plate 215 are changed from those of the first embodiment. The light guide plate 215 according to the present embodiment is made of a material having a refractive index higher than the light guide plate 15 (see FIGS. 2 and 3) described in the first embodiment. Specifically, in the present embodiment, the light guide plate 215 is made of, for example, polycarbonate (PC) as the synthetic resin material, and has the refractive index of, for example, about 1.52. In this way, the angle imparted when light is incident on the light guide plate 215 or when light is emitted from the light guide plate 215 is different from the angle imparted in the first embodiment. The critical angle in the light guide plate 215 is also different from the critical angle in the first embodiment. Accordingly, in the present embodiment, the angle (peak angle) at which light exhibits the peak luminance in the light distribution pertaining to the emission light in the backlight device 212 is “+4°”.

(87) Next, Comparative Experiments 6 and 7 similar to Comparative Experiments 1 and 2 described in the first embodiment were performed. In Comparative Experiment 6, a light

distribution pertaining to the emission light of the backlight device of following Example 3 was obtained. In Example 3, the backlight device **212** has the same configuration as that described before the present paragraph. That is, Example 3 is the backlight device of the type A, and the material and the refractive index of the light guide plate **215** are different from those of Example 1 described in Comparative Experiment 1.

(88) Similarly to Comparative Experiment 1, in Comparative Experiment 6, by using the backlight device of Example 3, luminance pertaining to the emission light was measured in a state where the LED was turned on, and graphs pertaining to the light distributions (luminance angle distributions) in the Y-axis direction were produced. Experimental results pertaining to the light distributions in Comparative Experiment 6 are as shown in FIG. **15**. The graphs pertaining to the light distributions shown in FIG. **15** are the same as FIG. **8**. In FIG. **15**, in addition to the graph of Example 3, graphs of Example 1 and Comparative Example 1, which are the experimental results of Comparative Experiment 1, are also shown for reference. In FIG. **15**, the graph of Example 3 is shown by a solid line, the graph of Example 1 is shown by a one dot chain line, and the graph of Comparative Example 1 is shown by a broken line.

(89) The experimental results of Comparative Experiment 6 will be described. According to FIG. **15**, in the light distribution in Example 3, the peak angle that is the angle at which light exhibits the peak luminance is “+4°”, and a half width is slightly wider than a half width of the light distribution in Example 1. The reason why the half width of the light distribution in Example 3 is slightly wider than the half width of the light distribution in Example 1 is presumed to be that the refractive index of the light guide plate **215** of Example 3 is made higher than the refractive index of the light guide plate **15** of Example 1, so that the emission angle range of light is slightly widened. The peak angle of the light distribution in Example 3 is larger than the peak angle (+3°) of the light distribution in Comparative Example 1, but smaller than the peak angle (+6°) of the light distribution in Example 1. In the light distribution in Example 3, the side lobe light, each of which is light emitted in the range of “+50° to +80°”, is suppressed to be sufficiently low to an extent close to the light distribution in Example 1.

(90) Next, a description will be given on Comparative Experiment 7. In Comparative Experiment 7, ratios pertaining to the side lobe light were extracted from the light distribution obtained using the backlight device of Example 3 described in Comparative Experiment 6. Similarly to Comparative Experiments 2 and 4, in Comparative Experiment 7, by using the backlight device of Example 3, the luminance pertaining to the emission light was measured in a state where the LED was turned on, the light distribution in the Y-axis direction was obtained, and the relative luminance (unit is “%”) at each angle of +50°, +60°, +70°, and +80° in the light distributions in the Y-axis direction was extracted. As described in Comparative Experiment 2, in order that the “reflection” is less likely to be visually recognized, the relative luminance at each angle of +50°, +60°, +70°, and +80° is preferably 3% or less.

(91) Experimental results of Comparative Experiment 7 are as shown in a table in FIG. **16**. In the table in FIG. **16**, in addition to the experimental results of Example 5, the experimental results of Examples 1 and 2 and Comparative Example 1, which are the experimental results of Comparative Experiments 2 and 4, are also shown for reference. Similarly to the table in FIG. **9**, the table in FIG. **16** shows information (peak angle, backlight type, presence of the louver, presence of the first prism sheet **16**, presence of the light absorption sheet **17**, presence of the light reflective sheet **2**) regarding the configurations of Examples 1 to 3 and Comparative Examples 1 and the relative luminance at each angle of +50°, +60°, +70°, and +80°, which are experimental results.

(92) The experimental results of Comparative Experiment 7 will be described. According to FIG. **16**, in Example 3, the relative luminance is suppressed to 3% or less at any angle of +50°, +60°, +70°, and +80°. Specifically, in Example 3, the amount of side lobe light is slightly larger than in Example 1 at all angles, but the side lobe light is suppressed more than in Example 2. The peak angle of the light distribution in Example 3 has a value closer to the peak angle of the light

distribution in Comparative Example 1 than in Examples 1 and 2. As described above, in Example 3, the peak angle of the light distribution is close to that of Comparative Example 1, and the side lobe light is suppressed to an extent close to that of Example 1.

Other Embodiments

(93) The techniques disclosed herein are not limited to the embodiments described above and illustrated in the drawings, and the following embodiments, for example, are also included within the technical scope.

(94) (1) In the third embodiment, the case is described in which the material and the refractive index of the light guide plate **215** are changed from those of the first embodiment. Alternatively, for example, the material and the refractive index of the second prism sheet **18** may be changed from those of the first embodiment, or the inclination angles $\theta 1$ and $\theta 2$ formed by the second oblique sides **18B2** and **18B3**, respectively, with respect to the second base **18B1** and the angle $\theta 3$ formed by the pair of second oblique sides **18B2** and **18B3** may be changed from those of the first embodiment, so that the peak angle pertaining to the light distribution of the emission light can be adjusted. Note that, in the configuration described in each embodiment, a specific numerical value of the peak angle (θ_{vp}) pertaining to the light distribution of the emission light can be appropriately changed other than the above.

(95) (2) In the first prism sheets **16** and **116**, specific numerical values of the inclination angles $\theta 10$ and $\theta 11$ formed by the first oblique sides **16B2** and **16B3**, respectively, with respect to the first base **16B1** and the angle $\theta 12$ formed by the pair of first oblique sides **16B2** and **16B3** can be changed as appropriate.

(96) (3) In the second prism sheet **18**, specific numerical values of the inclination angles $\theta 1$ and $\theta 2$ formed by the second oblique sides **18B2** and **18B3**, respectively, with respect to the second base **18B1** and the angle $\theta 3$ formed by the pair of second oblique sides **18B2** and **18B3** can be changed as appropriate.

(97) (4) In the third prism sheet **19**, specific numerical values of the inclination angles $\theta 4$ and $\theta 5$ formed by the third oblique sides **19B2** and **19B3**, respectively, with respect to the third base **19B1** and the angle $\theta 6$ formed by the pair of third oblique sides **19B2** and **19B3** can be changed as appropriate.

(98) (5) Numerical values of the inclination angles $\theta 7$ to $\theta 9$ formed by the first inclined surface **22A**, the second inclined surface **22B**, and the third inclined surface **22C**, respectively, included in the third light guide plate lens **22** with respect to the Y-axis direction can be changed as appropriate.

(99) (6) In the configurations described in the first and third embodiments, the light absorption sheet **17** may exhibit a color (for example, gray) other than black.

(100) (7) In the configuration described in the second embodiment, the light reflective sheet **23** may exhibit a color (for example, silver) other than white.

(101) (8) Numerical values of installation numbers of the LEDs **13** and **113**, an arrangement interval of the first light guide plate lenses **20**, a contact angle of the first light guide plate lens **20**, and an apex angle of the second light guide plate lens **21** can be changed as appropriate.

(102) (9) The material and the refractive index of each of the first prism sheets **16** and **116**, the second prism sheet **18**, and the third prism sheet **19** can be appropriately changed other than the above.

(103) (10) The material and the refractive index of each of the light guide plates **15**, **115**, and **215** can be appropriately changed other than the above.

(104) (11) The specific cross-sectional shape of the first light guide plate lens **20** can be changed as appropriate. For example, the cross-sectional shape of the first light guide plate lens **20** may be a triangular shape.

(105) (12) The specific cross-sectional shape of the second light guide plate lens **21** can be changed as appropriate. For example, the cross-sectional shape of the second light guide plate lens **21** may

be a semi-circular shape (cylindrical lens) or the like.

(106) (13) The specific cross-sectional shape of the third light guide plate lens **22** can be changed as appropriate.

(107) (14) In addition to a configuration in which each of the thicknesses of the light guide plates **15**, **115**, and **215** is constant throughout its entire length, the configuration may be such that the thickness decreases while getting farther from the LED **13**, and the opposite main surface is inclined.

(108) (15) The planar shape of each of the light guide plates **15**, **115**, and **215** may be a trapezoidal shape, inverted trapezoidal shape, arch shape, semi-circular shape, semi-elliptical shape, trapezoidal shape with an arc-shaped upper base, or the like in addition to a rectangular shape. Along with the change of the planar shape of each of the light guide plates **15**, **115**, and **215**, the planar shape of each of the backlight devices **12**, **112**, and **212** and the liquid crystal display device **10** can also be changed.

(109) (16) The LED **13** may be a top light emitting type in addition to the side light emitting type.

(110) (17) A light source such as an organic electro luminescence (EL) may be used instead of the LED **13**.

(111) (18) A reflective polarizing sheet instead of a polarizer may be attached to the main surface on the back side (outer side) of the array substrate constituting the liquid crystal panel **11**. The reflective polarizing sheet includes a polarization layer having a specific polarization axis (transmission axis), a multilayer film in which layers having mutually different refractive indices are alternately layered, a protection layer, and the like. The polarization layer has a polarization axis and an absorption axis orthogonal to the polarization axis, so that linearly polarized light parallel to the polarization axis can be selectively transmitted and circularly polarized light can be converted to linearly polarized light along the polarization axis. The polarization axis of the polarization layer has an orthogonal relationship to the polarization axis of the polarizer attached to the main surface at the outer side of the CF substrate. The multilayer film has a multilayer structure, and has a reflection characteristic that the reflectivity for the s-waves included in light is generally higher than the reflectivity for the p-waves. The reflective polarizing sheet being provided with the multilayer film can reflect s-waves that are originally to be absorbed by the polarization layer toward the back side to allow the s-waves to be reused, thereby enhancing the usage efficiency (and then, luminance) of light.

(112) (19) The liquid crystal display device **10** for vehicle application may be installed at a position other than the front of the driver's seat of a passenger car. For example, the liquid crystal display device **10** may be installed at a position of the front of the front passenger seat or at a position between the front passenger seat and the driver's seat.

(113) (20) The liquid crystal display device **10** may be used for applications other than the vehicle application.

(114) (21) The illumination device may be used in a display device of a type other than the liquid crystal display device **10**.

(115) While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

Claims

1. An illumination device comprising: a light source; a light guide plate including: a first end face that includes at least some of outer peripheral end faces of the light guide plate and that faces the light source and on which light is incident, a first main surface that is one main surface of the light guide plate, and a second main surface that is another main surface of the light guide plate; and a

first prism sheet including: a third main surface that is one main surface of the first prism sheet and that is disposed to face the second main surface, and a fourth main surface that is another main surface of the first prism sheet, wherein the second main surface of the light guide plate is provided with an inclined surface that has an inclination rising from a side opposite a light source side toward the light source side in a first direction including a direction from the light source toward the light guide plate, the fourth main surface of the first prism sheet is provided with a plurality of first prisms extending along the first direction and is arranged along a second direction intersecting the first direction and along the fourth main surface, and each of the plurality of first prisms includes a first base parallel to the second direction and a pair of first oblique sides rising from both ends of the first base.

2. The illumination device according to claim 1, further comprising: a light absorption sheet including a fifth main surface that is one main surface of the light absorption sheet and that is disposed to face the fourth main surface, and having a light absorbability higher than any of the light guide plate and the first prism sheet.

3. The illumination device according to claim 1, further comprising: a light reflective sheet including a sixth main surface that is one main surface of the light reflective sheet and that is disposed to face the fourth main surface, and having a light reflectivity higher than any of the light guide plate and the first prism sheet.

4. The illumination device according to claim 1, further comprising: a second prism sheet including: a seventh main surface that is one main surface of the second prism sheet, and an eighth main surface that is another main surface of the second prism sheet and that is disposed to face the first main surface; and a third prism sheet including: a ninth main surface that is one main surface of the third prism sheet, and a tenth main surface that is another main surface of the third prism sheet and that is disposed to face the seventh main surface, wherein the seventh main surface of the second prism sheet is provided with a plurality of second prisms extending along the second direction and is disposed side by side along the first direction, and the ninth main surface of the third prism sheet is provided with a plurality of third prisms extending along the second direction and is disposed side by side along the first direction.

5. The illumination device according to claim 4, wherein each of the plurality of second prisms includes a second base parallel to the first direction and a pair of second oblique sides rising from both ends of the second base, and among the pair of second oblique sides, a second oblique side on the light source side in the first direction forms a larger angle with respect to the second base than another second oblique side opposite the light source side in the first direction.

6. The illumination device according to claim 4, wherein each of the plurality of third prisms includes a third base parallel to the first direction and a pair of third oblique sides rising from both ends of the third base, and angles between each of the pair of third oblique sides and the third base are equal.

7. The illumination device according to claim 1, wherein the inclined surface includes a plurality of first inclined surfaces, the plurality of first inclined surfaces is disposed side by side along the first direction, and the plurality of first inclined surfaces increases in area while getting farther from the light source.

8. A display device comprising: the illumination device according to claim 1; and a display panel configured to display by using light from the illumination device.
