



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
11.09.2019 Bulletin 2019/37

(21) Application number: **17866521.2**

(22) Date of filing: **02.11.2017**

(51) Int Cl.:
F21S 41/00 (2018.01) **F21S 43/00** (2018.01)
F21S 45/00 (2018.01) **F21V 5/04** (2006.01)
F21W 103/00 (2018.01) **F21W 104/00** (2018.01)
F21W 105/00 (2018.01) **F21W 102/00** (2018.01)
F21Y 115/10 (2016.01) **F21Y 115/30** (2016.01)

(86) International application number:
PCT/JP2017/039831

(87) International publication number:
WO 2018/084269 (11.05.2018 Gazette 2018/19)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **02.11.2016 JP 2016215539**
30.03.2017 JP 2017069223

(71) Applicant: **Ichikoh Industries, Ltd.**
Isehara-shi, Kanagawa 259-1192 (JP)

(72) Inventors:
• **OKUBO, Yasuhiro**
Isehara-shi
Kanagawa 259-1192 (JP)
• **HAMAMOTO, Takanori**
Isehara-shi
Kanagawa 259-1192 (JP)

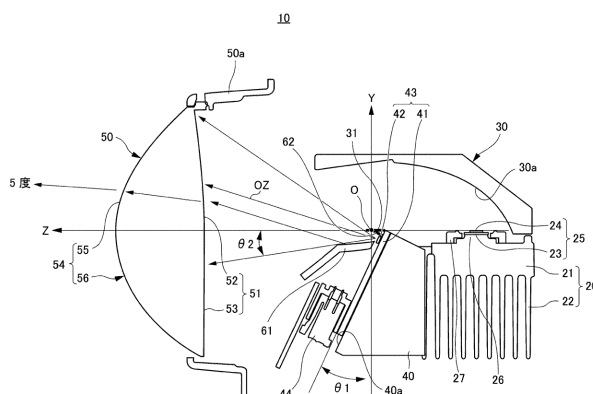
(74) Representative: **Sharman, Thomas Alexander**
Reddie & Grose LLP
The White Chapel Building
10 Whitechapel High Street
London E1 8QS (GB)

(54) **VEHICLE LAMP**

(57) A vehicle lamp includes a first light emitting chip for a low beam, a plurality of second light emitting chips for a high beam, aligned in a horizontal direction, a lens to illuminate forward light from the first and second light emitting chips, a reflector to reflect light from the first light emitting chip toward the lens, and a shade to partially block light reflected by the reflector, wherein the lens includes upper and lower incident surfaces respectively

vertically above and below a basic optical axis passing a rear basic focal point of the lens, the upper incident surface has a shape with radius increasing from the basic optical axis toward an outer edge, and the lower incident surface has a shape with radius increasing from a center toward an outside in the horizontal direction, and with a linear vertical cross section.

FIG. 3



Description

TECHNICAL FIELD

[0001] The present invention relates to a vehicle lamp. 5

BACKGROUND ART

[0002] Patent Literature 1 discloses a vehicle lamp which is provided with a lamp unit capable of forming both a low beam light distribution pattern and a high beam light distribution pattern, and in which a variable high beam (Adaptive Driving Beam) control to change a light distribution pattern according to the position of a preceding vehicle or oncoming vehicle by using a plurality of light emitting chips is possible for the high beam light distribution pattern. 10 15

CITATION LIST

PATENT LITERATURE 20

[0003] PTL 1: Japanese Unexamined Patent Application Publication No. 2016-39020 25

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] In the configuration in which a large number of light emitting chips are arranged side by side as described above, some of the light emitting chips are also present at a position away from a focal point of a projection lens, and as a result, due to an off-axis aberration, the light distribution may be collapsed in the light distribution pattern by the light from the light emitting chips located at the position away from the lens focal point; however, in the vehicle lamp of Patent Literature 1, the problem of this off-axis aberration is not taken into consideration. 30 35 40

[0005] The present invention has been achieved in view of such circumstances, and an object thereof is to provide a vehicle lamp which is provided with a lamp unit capable of forming both a low beam light distribution pattern and a high beam light distribution pattern, and in which a collapsed light distribution is suppressed. 45

MEANS FOR SOLVING THE PROBLEM

[0006] The present invention is grasped by the following configuration to achieve the above-mentioned object. 50

(1) A vehicle lamp according to the present invention includes: a first light emitting chip for a low beam light distribution; a plurality of second light emitting chips for a high beam light distribution, the second light emitting chips being aligned in a horizontal direction; a lens configured to illuminate forward light 55

from the first light emitting chip and the second light emitting chips; a reflector configured to reflect the light from the first light emitting chip toward the lens; and a shade configured to block part of the light reflected by the reflector, wherein the lens includes: an upper incident surface vertically above a basic optical axis passing through a rear basic focal point of the lens; and a lower incident surface vertically below the basic optical axis, the upper incident surface has a shape with a radius of curvature increasing from a side of the basic optical axis toward an outer edge of the upper incident surface, and the lower incident surface has a shape with a radius of curvature increasing from a center side in the horizontal direction toward an outer side in the horizontal direction, and with a linear vertical cross section.

(2) In the configuration of (1), the second light emitting chips are arranged behind and vertically below the rear basic focal point of the lens, and each of the second light emitting chips is arranged such that a light emitting surface thereof is inclined vertically upward so that a light-emitting optical axis passing through a light emitting center intersects the upper incident surface.

(3) In the configuration of (1) or (2), a first reflection unit configured to reflect vertically upward part of light emitted from the second light emitting chips toward the lower incident surface; and a second reflection unit configured to reflect vertically downward part of light emitted vertically upward from the second light emitting chips are provided.

(4) In the configuration of (3), the first reflection unit reflects light so that an amount of light beams incident on the lower incident surface, among light beams emitted directly toward the lower incident surface from the second light emitting chips, is reduced to 1/3 to 6/7.

(5) In the configuration of any one of (1) to (4), light diffusion structures are provided which are formed on the lower incident surface and the upper incident surface, the light diffusion structures being configured to diffuse light incident on the lens, wherein the light diffusion structure formed on a horizontal center side of the upper incident surface is set to diffuse more light than the light diffusion structure formed on the lower incident surface.

(6) A vehicle lamp of the present invention includes: a first light emitting chip for a low beam light distribution; a plurality of second light emitting chips for a high beam light distribution, the second light emitting chips being aligned in a horizontal direction; a lens configured to illuminate forward light from the first light emitting chip and the second light emitting chips;

a reflector configured to reflect the light from the first light emitting chip toward the lens; and a shade configured to block part of the light reflected by the reflector, wherein the lens includes: an upper incident surface vertically above a basic optical axis passing through a rear basic focal point of the lens; and a lower incident surface vertically below the basic optical axis, and in a vertical cross section along a basic optical axis passing through a rear basic focal point of the lens, an upper end of the upper incident surface is located forward of a lower end of the lower incident surface.

EFFECT OF THE INVENTION

[0007] According to the present invention, it is possible to provide a vehicle lamp which is provided with a lamp unit capable of forming both a low beam light distribution pattern and a high beam light distribution pattern, and in which a collapsed light distribution is suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a plan view of a vehicle provided with a vehicle lamp according to an embodiment of the present invention.

FIG. 2 is a plan view of a lamp unit according to the embodiment of the present invention as viewed from a front side.

FIG. 3 is a cross-sectional view of the lamp unit according to the embodiment of the present invention.

FIGS. 4(a) and 4(b) are views each explaining a shape of an incident surface of a lens according to the embodiment of the present invention, where FIG. 4(a) is a vertical cross-sectional view along a basic optical axis passing through a rear basic focal point of the lens, and FIG. 4(b) is a horizontal cross-sectional view along the basic optical axis passing through the rear basic focal point of the lens.

FIG. 5 is a view for explaining a method of designing the incident surface used for suppressing a collapsed light distribution due to an off-axis aberration.

FIG. 6 is a view illustrating a case where a light distribution pattern on a screen is vertically separated.

FIGS. 7(a) and 7(b) are views each explaining a shape of an exit surface of the lens according to the embodiment of the present invention, where FIG. 7(a) is a view where the lens is seen from a rear side, and FIG. 7(b) is a vertical cross-sectional view along the basic optical axis passing through the rear basic focal point of the lens.

FIGS. 8(a), 8(b), and 8(c) are views each illustrating a light distribution pattern on a screen formed before a first reflection unit and a second reflection unit according to the embodiment of the present invention are arranged, where FIG. 8(a) is a view illustrating

a light distribution pattern formed by light irradiated from an upper exit surface, FIG. 8(b) is a view illustrating a light distribution pattern formed by light irradiated from a lower exit surface, and FIG. 8(c) is a view illustrating a light distribution pattern formed by light from second light emitting chip, the light distribution pattern being multiplexed with the light distribution patterns in FIG. 8(a) and FIG. 8(b).

FIG. 9 is a view for explaining a light diffusion structure formed on the incident surface according to the embodiment of the present invention.

FIGS. 10(a), 10(b), and 10(c) are views each illustrating a light distribution pattern on the screen of the vehicle lamp according to the embodiment of the present invention, where FIG. 10(a) illustrates a light distribution pattern formed by light irradiated from an upper exit surface, FIG. 10(b) illustrates a light distribution pattern formed by light irradiated from a lower exit surface, and FIG. 10(c) is a view illustrating a light distribution pattern formed by light from the second light emitting chip, the light distribution pattern being multiplexed with the light distribution patterns in FIG. 10(a) and FIG. 10(b).

FIG. 11 is a view illustrating a light distribution pattern formed by light from a second light emitting chip arranged at a position farthest to the left (inner side of the vehicle) from a vertical axis (Y axis) passing through the rear basic focal point of the lens in FIG. 2.

MODE FOR CARRYING OUT THE INVENTION

[0009] With reference to the accompanying drawings, a mode for carrying out the present invention (hereinafter, referred to as an "embodiment") will be described in detail below.

[0010] It is noted that the same numeral is attached to the same element throughout the description of the embodiment.

[0011] Further, in the embodiment and the drawings, unless otherwise noted, "front" and "rear" respectively indicate a "forward direction" and "rearward direction" of a vehicle, and "upper", "lower", "left", and "right" respectively indicate a direction viewed from a driver on the vehicle.

[0012] A vehicle lamp according to the embodiment of the present invention is a vehicle head lamp (101R, 101L) provided on each of the left and right of the front of a vehicle 102 illustrated in FIG. 1, and hereinafter, will be simply referred to as "vehicle lamp".

[0013] The vehicle lamp of the present embodiment includes a housing (not illustrated) opened forward of the vehicle and an outer lens (not illustrated) attached to the housing to cover the opening, where a lamp unit 10 (see FIG. 2) and the like are arranged in a lamp chamber formed by the housing and the outer lens.

[0014] It is noted that in the following description of the lamp unit 10, the vehicle lamp on the right side of the vehicle will be mainly described as an example, but the

description applies commonly to the left and right vehicle lamps unless otherwise particularly mentioned.

(Lamp unit 10)

[0015] FIG. 2 is a plan view of the lamp unit 10 as viewed from the front side, and FIG. 3 is a cross-sectional view of the lamp unit 10.

[0016] It is noted that in FIG. 2, a lens 50 is omitted to easily understand the inside and FIG. 3 is a vertical cross-sectional view along a basic optical axis (see Z axis) passing through a rear basic focal point O of the lens 50.

[0017] As illustrated in FIG. 3, the lamp unit 10 mainly includes a heat sink 20, a first light source 25, a reflector 30, a shade 31, an attachment member 40, a second light source 43, a power feeding connector 44, the lens 50, a first reflection unit 61, and a second reflection unit 62.

(Heat sink 20)

[0018] The heat sink 20 includes a base unit 21 and a plurality of radiation fins 22 extending vertically downward, the plurality of radiation fins 22 being integrally formed vertically beneath the base unit 21.

[0019] Further, a mounting unit 26 configured to mount the first light source 25 is formed on a vertically upper surface of the base unit 21, where the first light source 25 is to be attached by a holder 27.

[0020] It is preferable that the heat sink 20 is formed of a metal or a resin having a high thermal conductivity to efficiently dissipate a heat generated by the first light source 25, and in the present embodiment, the heat sink 20 made of aluminum by die casting is used.

(First light source 25)

[0021] The first light source 25 is a light source for emitting light to form a low beam light distribution pattern, and includes a first substrate 23 arranged on the mounting unit 26 and a first light emitting chip 24 arranged on the first substrate 23 to emit light vertically upward.

[0022] In the present embodiment, although an LED chip which is a semiconductor type light emitting element is employed for the first light emitting chip 24, the first light emitting chip 24 is not necessarily limited to an LED chip, for example, and may be an LD chip (laser diode chip) which is a semiconductor type light emitting element.

(Reflector 30)

[0023] The reflector 30 is a member for reflecting light emitted vertically upward from the first light emitting chip 24 toward the lens 50, and a reflecting surface 30a of the reflector 30 is attached to the base unit 21 of the heat sink 20 to cover above the first light emitting chip 24 in a semi-dome form to open forward.

(Shade 31)

[0024] The shade 31 is arranged between the first light source 25 and the lens 50, as illustrated in FIG. 3, and is a member for shielding part of light reflected by the reflector 30 toward the lens 50 to form a cutoff line of the low beam light distribution pattern.

[0025] More specifically, as illustrated in FIG. 2, the shade 31 is arranged so that an edge 31a on the front side of the shade 31 has a shape matching the cutoff line, and the rear basic focal point O of the lens 50 is located in the vicinity of a portion forming an upper end of the oblique cutoff line of the edge 31a on the front side of the shade 31.

[0026] Specifically, as illustrated in FIG. 3, the shade 31 is arranged so that the rear basic focal point O of the lens 50 is located about 1.0 mm behind the edge 31a on the front side of the shade 31.

20 (Attachment Member 40)

[0027] The attachment member 40 is a member to which the shade 31, the second light source 43 described later, the power feeding connector 44, the first reflection unit 61, and the second reflection unit 62 are attached.

[0028] In the present embodiment, although the attachment member 40 is formed as a separate member from the heat sink 20 and the attachment member 40 is fixed to the heat sink 20, the attachment member 40 may not be formed as a separate member from the heat sink 20, and it is possible to design a structure where the attachment member 40 is integrally formed with the heat sink 20.

[0029] As illustrated in FIG. 3, in the attachment member 40, a first surface 40a located on the front side is a surface on which the second light source 43 is arranged, and although a reason is explained later, the first surface 40a is formed to be directed obliquely vertically upward at an angle θ_1 with respect to the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50.

[0030] It is noted that in the present embodiment, the first surface 40a is inclined obliquely vertically upward such that the angle θ_1 is about 25°.

(Second light source 43)

[0031] The second light source 43 is a light source for emitting light to form a high beam light distribution pattern, and as illustrated in FIG. 3, includes a second substrate 41 arranged on the first surface 40a of the attachment member 40 and a plurality of second light emitting chips 42 (see FIG. 2) provided on the second substrate 41 to be aligned in the horizontal direction.

[0032] In the present embodiment, similarly to the first light emitting chip 24, the second light emitting chip 42 also employs an LED chip which is a semiconductor type light emitting element, but the second light emitting chip

42 is not necessarily limited to an LED chip and may be an LD chip (laser diode chip) which is a semiconductor type light emitting element.

[0033] In the present embodiment, as illustrated in FIG. 2, in a front view seen from the vehicle front side, the four second light emitting chips 42 are provided at the outer side (on the left side in FIG. 2) of the vehicle on the basis of the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50 and the seven second light emitting chips 42 are provided at the inner side (on the right side in FIG. 2) of the vehicle, that is, a total of eleven second light emitting chips 42 are aligned in the horizontal direction; however, the number of the second light emitting chips 42 may be increased or decreased according to a horizontal light distribution range required for the high beam light distribution pattern to be formed.

[0034] In a case of the vehicle lamp on the left side of the vehicle, in a front view seen from the front side of the vehicle illustrated in FIG. 2, the arrangement of the second light emitting chips 42 on the left and right sides in the horizontal direction may be reversed on the basis of the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50.

[0035] However, a relationship between the inner side and the outer side of the vehicle is reversed when a relationship between the left side and the right side of the vehicle is reversed, and thus, if the arrangement state of the second light emitting chips 42 is described on the basis of the inner side and the outer side of the vehicle, as described above, the four second light emitting chips 42 are provided at the outer side (on the left side in FIG. 2) of the vehicle on the basis of the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50, and the seven second light emitting chips 42 are provided at the inner side of the vehicle (on the right side in FIG. 2).

[0036] Further, in the present embodiment, the two second light emitting chips 42 on the innermost side (on the right side in FIG. 2) of the vehicle are arranged to differ in arrangement pitch in the horizontal direction from the remaining nine second light emitting chips 42, specifically, to slightly widen in pitch; however, the arrangement pitch in the horizontal direction among the second light emitting chips 42 may be set so that the light distribution patterns formed by the light from the adjacent second light emitting chips 42 appropriately overlap on the screen.

[0037] Further, in the present embodiment, the second light source 43 is illustrated as an example where the plurality of second light emitting chips 42 are arranged on the second substrate 41 which is one common substrate; however, a configuration may be adopted where a substrate is arranged for each of the second light emitting chips 42 to form a second light source unit provided with a plurality of light sources.

[0038] In the lamp unit 10 of the present embodiment, a variable high beam (Adaptive Driving Beam) control to change the high beam light distribution pattern can be

performed by controlling turning on/off of the second light emitting chip 42 according to a location of a preceding vehicle or an oncoming vehicle to suppress generation of glare light to the preceding vehicle or the oncoming vehicle.

(Power feeding connector 44)

[0039] The power feeding connector 44 is a connector to which an external connector for feeding power is connected, is arranged on the second substrate 41, and is electrically connected to a conductive pattern to the second light emitting chip 42 formed on the second substrate 41, as illustrated in FIG. 3.

(Lens 50)

[0040] The lens 50 is a member which is made of glass, resin, or the like, and which performs light distribution control to illuminate the light beams from the first light emitting chip 24 and the second light emitting chip 42 so that a predetermined light distribution pattern is formed forward, and is attached with the heat sink 20 via a lens holder 50a.

[0041] It is noted that a specific configuration for the light distribution control in the lens 50 will be mentioned later.

[0042] Although a material to form the lens 50 is not particularly limited, but the lens 50 is preferably made of resin from a viewpoint that the resin has a good moldability.

[0043] For example, from a viewpoint of easily suppressing generation of blue spectral color, an acrylic-based resin having a small wavelength dependency of a refractive index is preferable.

[0044] On the other hand, if the ADB control is performed, the number of the second light emitting chips 42 increases, and therefore, the lens 50 may be required to have heat resistance.

[0045] In such a case, a polycarbonate-based resin excellent in heat resistance may be employed.

(First reflection unit 61)

[0046] The first reflection unit 61 is a member for reflecting part of the light emitted vertically downward from each of the second light emitting chips 42, and is attached to the attachment member 40.

[0047] In the present embodiment, although a reason will be described later, the first reflection unit 61 reflects the light emitted vertically downward at an angle θ_2 larger than about 17° with respect to the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens 50.

(Second reflection unit 62)

[0048] The second reflection unit 62 is a member for

reflecting part of light emitted vertically upward from each of the second light emitting chips 42.

[0049] The second reflection unit 62 is provided vertically below the shade 31, and is attached, together with the shade 31, to the attachment member 40.

[0050] It is noted that in the present embodiment, the second reflection unit 62 is arranged such that the reflecting surface of the second reflection unit 62 is substantially parallel to a light emission optical axis OZ passing through a light emission center of the second light emitting chips 42.

[0051] Next, the embodiment will be described in more detail while describing a configuration related to the light distribution control.

[0052] FIGS. 4(a) and 4(b) are views each explaining a shape of an incident surface 51 of the lens 50, where FIG. 4(a) is a vertical cross-sectional view along the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens 50 and FIG. 4(b) is a horizontal cross-sectional view along the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens 50.

[0053] Moreover, FIG. 5 is a view for explaining a method of designing the incident surface used for suppressing a collapsed light distribution due to an off-axis aberration.

[0054] It is noted that a lens L illustrated in FIG. 5 illustrates a horizontal cross-sectional view of a lens having a basic shape for forming the lens 50.

[0055] FIG. 5 illustrates an example of a state where a beam of light parallel to an optical axis P of the lens L enters the lens L from one surface S1 and exits from the other surface S2. It is noted that an extended line of the beam of light before entering the one surface S1 and an extended line of the beam of light after exiting from the other surface S2 are indicated with a dashed line, and a point D is a point at which these extended lines intersect (see a point at which the dashed lines intersect).

[0056] If an incident position of the beam of light entering the one surface S1 is changed along the one surface S1 to evaluate the point D as in the above, a trajectory of the point D is as indicated with a dotted line, and the trajectory indicated with the dotted line is a principal surface SML of the lens L.

[0057] Further, a point at which the optical axis P of the lens L and the principal surface SML intersect is a principal point SP of the lens L.

[0058] When the principal surface SML is a true circle (circle of Apollon) around a basic focal point BF, the off-axis aberration is not present, and thus, to suppress the off-axis aberration of the lens L, the other surface S2 may be formed so that a distance K between the basic focal point BF of the lens L and the point D is constant at a focal length F.

[0059] Here, if an offense against the sine condition $OSC = K - F$ is defined as an evaluation amount representing a degree of off-axis aberration, when the offense against the sine condition OSC is evaluated along the principal surface SML, more off-axis aberration is sup-

pressed as values of the offense against the sine condition are closer to zero.

[0060] It is noted that since it is possible to express $K = W/\sin \theta'$, the offense against the sine condition OSC can be described as an offense against the sine condition $OSC = W/\sin \theta' - F$.

[0061] If the shape of the incident surface is evaluated so that the offense against the sine condition OSC is small, the shape obtained will have a radius of curvature continuously larger toward a radial direction (that is, an outer peripheral edge direction of the lens 50) with respect to a point M (see FIG. 4) at which the basic optical axis (see Z axis) passing through the rear basic focal point O (see FIG. 3) of the lens 50 intersects the incident surface 51.

[0062] On the other hand, the lens 50 of the present embodiment is obtained by partially modifying a basic shape being the shape evaluated based on the offense against the sine condition OSC, considering performing light distribution control for a low beam light distribution pattern and light distribution control for a high beam light distribution pattern.

[0063] Specifically, as illustrated in FIG. 4(a), the lens 50 includes the incident surface 51 on which the light is incident, the incident surface 51 includes an upper incident surface 52 vertically above the basic optical axis (see Z axis) passing through the rear basic focal point O (see FIG. 3) of the lens 50 and a lower incident surface 53 vertically below the basic optical axis (see Z axis), and as described above, and the upper incident surface 52 has a shape with the radius of curvature increasing from the basic optical axis (see Z axis) side toward the outer edge of the upper incident surface 52.

[0064] Therefore, when viewed in the cross section illustrated in FIG. 4(a), in the upper incident surface 52 having a curved surface shape projecting rearward, the radius of curvature Rvc is about 150 mm on the point M (see FIG. 4) side where the basic optical axis (see Z axis) and the incident surface 51 intersect, the radius of curvature continuously increases as the upper incident surface 52 moves vertically upward, and the radius of curvature Rvt is about 300 mm on the outer edge side of the upper incident surface 52.

[0065] On the other hand, when viewed in the cross section (vertical cross section) illustrated in FIG. 4(a), the lower incident surface 53 is linear from the point M to a lower end (lower end Rvb) of the lower incident surface 53 to suppress an influence on the low beam light distribution pattern.

[0066] It is needless to say that a curve having a sufficiently large radius of curvature is linear, as is clear from the fact that as the radius of curvature approaches infinity, the curve is as linear as possible.

[0067] For example, in the present embodiment, a diameter of the lens 50 is about 68 mm, and thus, when viewed in the vertical cross section along the basic optical axis (see Z axis) passing through the rear basic focal point O (see FIG. 3) of the lens 50, a vertical width of the

lower incident surface 53 is about 34 mm, and even if the lower incident surface 53 is a curved surface projecting rearward, when the radius of curvature of the lower incident surface 53 is sufficiently large with respect to the width of the lower incident surface 53 of the vertical cross section along the basic optical axis (see Z axis) (for example, in a case of having a radius of curvature equal to or greater than 20 times the vertical width of the lower incident surface 53), that is, when the lower incident surface 53 is a sufficiently gentle curved surface having a constant radius of curvature of about 1000 mm, the lower incident surface 53 can be said to be sufficiently linear.

[0068] The upper incident surface 52 and the lower incident surface 53 have the shapes as described above, and thus, as illustrated in FIG. 4(a), in the vertical cross section of the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens (see FIG. 3), an upper end UE of the upper incident surface 52 is located forward of the lower end Rvb of the lower incident surface 53.

[0069] On the other hand, in the cross section (horizontal cross section) illustrated in FIG. 4(b), in the upper incident surface 52, a radius of curvature R_{hc} is about 250 mm at the point M (see FIG. 4) side where the basic optical axis (see Z axis) and the incident surface 51 intersect and the radius of curvature continuously increases as the upper incident surface 52 moves horizontally outward, and at the outer edge side of the upper incident surface 52, the radii of curvature R_{hl} and R_{hr} are both about 450 mm.

[0070] For the lower incident surface 53, in the horizontal cross section, the radius of curvature similarly becomes large continuously toward the outer peripheral edge side.

[0071] That is, the upper incident surface 52 has a shape in which the radius of curvature increases from the side of the basic optical axis (see Z axis) toward the outer edge of the upper incident surface 52 (a shape in which the radius of curvature increases radially).

[0072] On the other hand, in consideration of influence on the low beam light distribution pattern and suppression of collapsed light distribution, the lower incident surface 53 has a radius of curvature increasing from a horizontal center (Z axis) side toward the horizontal outer side, and has a shape in which the vertical cross section is linear.

[0073] When the incident surface 51 on an adjustable surface in a convex shape is formed on the rear side provided with the upper incident surface 52 and the lower incident surface 53 having such a shape, it is possible to suppress collapsed light distribution due to an off-axis aberration.

[0074] Incidentally, as illustrated in FIG. 3, behind the rear basic focal point O of the lens 50 (in this example, about 2.1 mm behind the rear basic focal point O), the second light emitting chips 42 are aligned on a horizontal line passing through a point at a position vertically below the rear basic focal point O of the lens 50 (in this example,

about 1.8 mm below the rear basic focal point O), and assuming that light emitted from each of the second light emitting chips 42 is not disturbed by any object, and each of the second light emitting chips 42 is not inclined vertically upward as in the present embodiment, if the light is illuminated toward the lens 50, the light distribution pattern formed by the light emitted from each of the second light emitting chips 42 may be vertically separated.

[0075] Specifically, as in a light distribution pattern on a screen illustrated in FIG. 6, the light distribution pattern may be vertically separated.

[0076] It is noted that FIG. 6 simulates a case where the light from the second light emitting chip 42 arranged in close proximity to the left side (inner side of the vehicle) of the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50 in FIG. 2 is not reflected by the first reflection unit 61 nor the second reflection unit 62, and further, the second light emitting chip 42 are arranged without being inclined obliquely vertically upward, and the light is illuminated toward the incident surface 51. It is noted that a VU-VL line in FIG. 6 indicates a vertical reference line on the screen, and an HL-HR line indicates a horizontal reference line on the screen.

[0077] Further, in FIG. 6, the light distribution pattern on the screen is indicated by an isophotal contour.

[0078] In the following figures illustrating the light distribution pattern on the screen, the vertical reference line on the screen is indicated by the VU-VL line, and the horizontal reference line on the screen is indicated by the HL-HR line, and the light distribution pattern is indicated by an isophotal contour.

[0079] That is, a light distribution pattern formed by the light illuminated forward after being incident on the lens 50 from the upper incident surface 52 appears on the vertical lower side on the screen, and a light distribution pattern formed by the light illuminated forward after being incident on the lens 50 from the lower incident surface 53 appears on the vertical upper side on the screen, possibly resulting in formation of a vertically separated light distribution pattern.

[0080] Therefore, in the present embodiment, as described below, when a direction in which the light of the second light emitting chips 42 is emitted is adjusted, and further, a light amount is adjusted by the first reflection unit 61 to adjust a shape of an exit surface 54 from which the light of the lens 50 is illuminated forward, a better light distribution pattern generally in a rectangular shape is formed, which will be specifically described below.

[0081] FIGS. 7(a) and 7(b) are views each explaining the shape of the exit surface 54 of the lens 50, where FIG. 7(a) is a view where the lens 50 is seen from a rear side (view where the incident surface 51 is seen from the front side), and FIG. 7(b) is a vertical cross-sectional view along the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens 50.

[0082] As illustrated in FIG. 7(b), the lens 50 includes the exit surface 54 including an upper exit surface 55 vertically above the basic optical axis (see Z axis) passing

through the rear basic focal point O (see FIG. 3) of the lens 50 and a lower exit surface 56 vertically below the basic optical axis (see Z axis).

[0083] Further, as illustrated in FIG. 7(a), the lower exit surface 56 includes, as viewed from the incident surface 51 side, a first lower exit surface 56a on a horizontal center side, an exit surface 56b on a left outside in the horizontal direction (inner side of the vehicle), and an exit surface 56c on a right outside (outer side of the vehicle) in the horizontal direction.

[0084] It is noted that hereinafter, if the exit surface 56b and the exit surface 56c are collectively referred to, the second lower exit surfaces 56b and 56c may be mentioned.

[0085] That is, the lower exit surface 56 includes the first lower exit surface 56a on the horizontal center side, and the two second lower exit surfaces 56b and 56c located at the horizontal outer side of the first lower exit surface 56a.

[0086] The first lower exit surface 56a is a region from which light from the first light emitting chip 24 (see FIG. 3) configured to emit light for forming the low beam light distribution pattern is mainly illuminated forward, the second lower exit surfaces 56b and 56c located horizontally outside the first lower exit surface 56a are regions where light from the first light emitting chip 24 (see FIG. 3) is hardly illuminated forward, that is, regions not greatly contributing to the formation of the low beam light distribution pattern.

[0087] Specifically, assuming that a point light source exists at the rear basic focal point O (see FIG. 7(b)) of the lens 50, a region where the light whose angle widened to the left and right in the horizontal direction of the light emitted from the point light source (the angle to the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens 50) is within 28 degrees is incident from the incident surface 51 and illuminated forward is defined as the first lower exit surface 56a, and regions horizontally outside the above region are defined as the second lower exit surfaces 56b and 56c.

[0088] When the shapes of the second lower exit surfaces 56b and 56c having a low degree of contribution to the low beam light distribution pattern are adjusted, the separation as illustrated in FIG. 6 in the high beam light distribution pattern is suppressed and the light distribution pattern is brought closer to a rectangular light distribution pattern while not affecting the low beam light distribution pattern.

[0089] Although described later, a similar operation is performed also on the upper exit surface 55.

[0090] That is, as illustrated in FIG. 7(a), as it is closer to the outer peripheral edge side from a position Q1 on the side of the first lower exit surface 56a on the vertical upper side, assuming that the point light source is present at the rear basic focal point O of the lens 50 (see FIG. 7(b)), the second lower exit surfaces 56b and 56c are formed in a shape allowing the light from the point light source to be illuminated vertically downward on the

screen.

[0091] To be more specifically described, a position of the outer peripheral edge at the horizontal outer side from the position Q1 is defined as a position Q2, a position of the peripheral edge vertically below the position Q1 is defined as a position Q3, and a position which is a vertex of a right angled triangle other than the position Q2 and the position Q3 obtained when a right angled triangle formed by connecting the position Q1, the position Q2, and the position Q3 is symmetrical with a straight line connecting the position Q2 and the position Q3, is defined as a position Q4.

[0092] Assuming a rectangular shape obtained by connecting these four positions (the position Q1, the position Q2, the position Q3, and the position Q4), the more light is illuminated vertically downward on the screen as approaching from the position Q1 to the position Q2, and at the position Q2, the second lower exit surfaces 56b and 56c are shaped to illuminate the light at 1.5 degrees downward of a horizontal reference line on the screen (in FIG. 7, the downward direction is indicated by a minus sign).

[0093] Similarly, the more light is illuminated vertically downward on the screen as approaching from the position Q1 to the position Q3, and at the position Q3, the second lower exit surfaces 56b and 56c are shaped to illuminate the light at 1.5 degrees downward of a horizontal reference line on the screen (in FIG. 7, the downward direction is indicated by a minus sign).

[0094] In addition, the more light is illuminated vertically downward on the screen as approaching from the position Q1 to the position Q4, and if the lens 50 is virtually present to the position Q4, then at the position Q4, the second lower exit surfaces 56b and 56c are shaped to illuminate the light 1.5 degrees downward of a horizontal reference line on the screen (in FIG. 7, the downward direction is indicated by a minus sign).

[0095] However, in reality, the lens 50 does not exist up to the position Q4, so the illuminated light does not reach 1.5 degrees downward of the horizontal reference line at the outer peripheral edge which is an end of the actual lens 50.

[0096] In the above, the portions from the position Q1 toward the position Q2, the position Q3, and the position Q4 are described, and the same applies to from the Q1 to each point on the line connecting the position Q2 and the position Q4 and to each point on the line connecting the position Q4 and the position Q3.

[0097] Therefore, as illustrated in FIG. 7(a), toward the outer peripheral edge radially from the position Q1 on the side of the first lower exit surface 56a on the vertical upper side (that is, the position on the basic optical axis Z side (point M side)), assuming that the point light source is present at the rear basic focal point O of the lens 50 (see FIG. 7(b)), the second lower exit surfaces 56b and 56c are formed in a shape allowing the light from the point light source to be illuminated vertically downward on the screen.

[0098] Further, the light illuminated forward from the lower exit surface 56 forms a light distribution pattern appearing on the vertical upper side on the screen, and as described above, when the shapes of the second lower exit surfaces 56b and 56c are adjusted, the light is distributed so that the upper side of the upper light distribution pattern illustrated in FIG. 6 is located on the lower side and horizontally widened slightly, and thus, the upper light distribution pattern is closer to a rectangular light distribution pattern and expanded toward the lower light distribution pattern appearing on the screen, and a light is distributed to be controlled in a direction in which the two separate light distribution patterns are integrated.

[0099] On the other hand, the light illuminated forward from the upper exit surface 55 forms a light distribution pattern appearing on the vertical lower side on the screen, and when the shape of the upper exit surface 55 is adjusted to expand upward the lower light distribution pattern illustrated in FIG. 6 to obtain a shape closer to a rectangular shape, the lower light distribution pattern can be integrated with the light distribution pattern appearing on the vertical upper side on the screen formed by the light from the lower exit surface 56, and the light distribution pattern obtained when the two light distribution patterns are multiplexed can be brought closer to a rectangular shape.

[0100] The upper exit surface 55 will be described below.

[0101] As illustrated in FIG. 7(b), assuming that the point light source is present at the rear basic focal point O, if the light from the point light source is illuminated toward the front of the lens 50, as the upper exit surface 55 moves vertically upward, the upper exit surface 55 is formed in a shape to distribute the light downward on the center side of the lens 50 and distribute the light upward on the upper side of the lens 50.

[0102] More specifically, on the vertical lower side of the upper exit surface 55 (boundary side with the lower exit surface 56), as illustrated by a beam of light L1 (overlapping with the Z axis) illustrated in FIG. 7(b), although the light from the point light source is illuminated in the substantially horizontal direction, the upper exit surface 55 is formed in a shape to continuously illuminate the light from the point light source vertically downward as the upper exit surface 55 moves vertically upward, and at the lowest illumination position, as indicated by a beam of light L2, the upper exit surface 55 is designed to illuminate the light at 1.2 degrees vertically downward of the horizontal reference line on the screen (in FIG. 7, the downward direction is indicated by a minus sign).

[0103] Thereafter, the upper exit surface 55 is formed in a shape to continuously illuminate the light from the point light source vertically upward as the upper exit surface 55 moves further vertically upward, and at the vertically uppermost position of the upper exit surface 55, as indicated by a beam of light L3, the upper exit surface 55 is designed to illuminate the light at 0.7 degree vertically upward of the horizontal reference line on the

screen.

[0104] As described above, assuming that the point light source is present at the rear basic focal point O, as the upper exit surface 55 moves vertically upward, when the upper exit surface 55 is shaped to illuminate the light from the point light source vertically upward after illuminating the light vertically downward, the light can be distributed so that a vertically lower rounded portion in the lower light distribution pattern illustrated in FIG. 6 is placed in the upper side to widen a light distribution range vertically upward while bringing the light distribution pattern on the vertical lower side close to a rectangular shape.

[0105] Further, if such a light distribution pattern can be formed where the light illuminated from the upper exit surface 55 is distributed vertically upward after continuously distributing the light vertically downward as the upper exit surface 55 moves vertically upward, the influence of a spectrum of the lens 50 can be suppressed, and a spectral color appearing at a lower end of the light distribution pattern formed by the light illuminated from the upper exit surface 55 can also be suppressed.

[0106] Further, if the exit surface 54 on an adjustable surface in a convex shape is formed on the front side provided with the lower exit surface 56 and the upper exit surface 55 having the shapes as described above, and as illustrated in FIG. 3, the second light emitting chip 42 is arranged so that the light emitting surface thereof is inclined vertically upward so that the light emission optical axis OZ passing through a light emission center of the second light emitting chip 42 intersects with an intermediate portion in the vertical direction of the upper incident surface 52 to increase an amount of light illuminated from the upper exit surface 55, light distribution patterns as illustrated in FIGS. 8(a), 8(b), and 8(c) are formed.

[0107] FIGS. 8(a), 8(b), and 8(c) are views each illustrating a light distribution pattern on a screen formed before the first reflection unit 61 and the second reflection unit 62 according to the present embodiment are provided, where FIG. 8(a) is a view illustrating a light distribution pattern formed by the light illuminated from the upper exit surface 55, FIG. 8(b) is a view illustrating a light distribution pattern formed by the light illuminated from the lower exit surface 56, and FIG. 8(c) is a view illustrating a light distribution pattern formed by the light from the second light emitting chip 42, the light distribution pattern being multiplexed with the light distribution patterns in FIG. 8(a) and FIG. 8(b).

[0108] As can be seen from FIGS. 8(a), 8(b), and 8(c), the light distribution pattern formed by the light illuminated from the upper exit surface 55 (see FIG. 8(a)) and the light distribution pattern formed by the light illuminated from the lower exit surface 56 (see FIG. 8(b)) are shaped to be generally highly close to a rectangular shape, and can be sufficiently overlapped in the vertical direction if these light distribution patterns are multiplexed.

[0109] Therefore, as illustrated in FIG. 8(c), the light

distribution pattern formed by multiplexing the light distribution patterns illustrated in FIGS. 8(a) and 8(b) will not generate a crack as illustrated in FIG. 6, and is formed to be generally highly close to a rectangular shape.

[0110] On the other hand, as seen in the light distribution pattern of FIG. 8(b), there is a high intensity band on the vertical upper side, and therefore, even in the light distribution pattern of FIG. 8(c), there is a small high intensity band on the vertical upper side.

[0111] Therefore, in the present embodiment, as illustrated in FIG. 3, the separation of the high intensity band is further suppressed by mainly providing the first reflection unit 61.

[0112] Specifically, as described above with reference to FIG. 3, among the light beams emitted vertically downward from each of the second light emitting chips 42, the light beams emitted vertically downward at an angle $\theta 2$ larger than about 17° with respect to the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens 50 is reflected toward the upper incident surface 52 to limit the light incident on the lens 50 from the lower incident surface 53.

[0113] That is, the first reflection unit 61 reflects vertically upward some of the light beams toward the lower incident surface 53, among the light beams illuminated from each of the second light emitting chips 42 to the lens 50, to increase an amount of light incident on the upper incident surface 52 compared to an amount of light incident on the lower incident surface 53.

[0114] In the present embodiment, the first reflection unit 61 reflects the light beams toward the upper incident surface 52, among the light beams emitted directly toward the lower incident surface 53 from the second light emitting chips 42, so that the amount of light incident on the lower incident surface 53 is half or less (in the present example, substantially reduced to half) of that.

[0115] It is noted that the amount of light is not reduced necessarily to half or less, and for example, the amount of light is preferably reduced to about $1/3$ to $6/7$.

[0116] In this way, the amount of light in the light distribution pattern formed by the light illuminated from the lower exit surface 56 after being incident on the lens 50 from the lower incident surface 53, that is, the light distribution pattern appearing on the upper side on the screen, can be reduced to half.

[0117] It is noted that as illustrated in FIG. 3, the light reflected by the first reflection unit 61 is to be illuminated from the upper exit surface 55 upward by about 5 degrees than the horizontal reference line on the screen, and is distributed to a vertically upper outer periphery of the light distribution pattern illustrated in FIG. 8(a).

[0118] Further, in the embodiment, a light diffusion structure configured to diffuse the light is provided on the incident surface 51 to obtain uniform light distribution.

[0119] FIG. 9 is a view for explaining the light diffusion structure formed on the light incident surface 51.

[0120] In FIG. 9, a view illustrating a shape of the light diffusion structure is also illustrated as an enlarged view.

[0121] As illustrated in FIG. 9, the light diffusion structure divides the incident surface 51 into four regions (a first region 57a, a second region 57b, a third region 57c, and a fourth region 57d) to adjust a light diffusion amount.

[0122] The light diffusion structure formed in each of the regions (the first region 57a, the second region 57b, the third region 57c, and the fourth region 57d) has a structure formed with a plurality of recesses and projections, as illustrated in the enlarged view, where an amount of recesses and projections (height of recesses and projections) is set according to each region to adjust the light diffusion amount.

[0123] It is noted that in the present embodiment, the light diffusion structure formed with rounded recesses and projections is illustrated, but the light diffusion structure may have a ridge line having a rectangular shape or a diamond shape, and may have a concave or convex structure of a square pyramid.

[0124] In addition, a basic shape of the incident surface 51 may be retained between the projections and between the recesses and the projections, and the light diffusion amount may be adjusted by adjusting a density of the projections and that of the recesses and the projections.

[0125] Specifically, in the first region 57a corresponding to the lower incident surface 53, the amount of recesses and projections is set to $5\ \mu\text{m}$ in consideration of an influence on the low beam light distribution pattern, and gradation is added to the light distribution pattern illustrated in FIG. 8(b) to make less noticeable the high intensity band seen in FIG. 8(b).

[0126] On the other hand, as regions corresponding to the upper incident surface 52, the three regions, that is, the second region 57b on the horizontal center side, the third region 57c on the right side (outer side of the vehicle) in the horizontal direction of the second region 57b, and the fourth region 57d on the left side (inner side of the vehicle) in the horizontal direction of the second region 57b, are set, and the amount of recesses and projections of the second region 57b is set to $6\ \mu\text{m}$, which means that the light diffusion amount is set larger than that of the light diffusion structure formed on the lower incident surface 53.

[0127] The gradation is strongly added by increasing the light diffusion amount of the second region 57b, and the inner side in the light distribution pattern of FIG. 8(a) is expanded outward to bring the light distribution shape much closer to a rectangular shape and to realize uniform light amount.

[0128] On the other hand, in the third region 57c and the fourth region 57d located at the horizontal outer side of the second region 57b, the amount of recesses and projections is kept to $4\ \mu\text{m}$ and the amount of gradation is kept small to retain the rectangular shape of the light distribution pattern and to increase the uniformity of the light distribution when the amount of gradation matches with the gradation in the second region 57b.

[0129] FIGS. 10(a), 10(b), and 10(c) are views each illustrating a light distribution pattern on the screen of the

vehicle lamp according to the present embodiment, where FIG. 10(a) illustrates a light distribution pattern formed by light illuminated from the upper exit surface 55, FIG. 10(b) illustrates a light distribution pattern formed by light illuminated from the lower exit surface 56, and FIG. 10(c) is a view illustrating a light distribution pattern formed by the light from the second light emitting chip 42, the light distribution pattern being multiplexed with the light distribution patterns in FIG. 10(a) and FIG. 10(b).

[0130] As illustrated in FIGS. 10(a), 10(b), and 10(c), when the first reflection unit 61 and the light diffusion structure are provided, the light diffusion pattern of FIG. 10(a) is closer to a rectangular shape than that of FIG. 8(a), and likewise, the light distribution pattern of FIG. 10(b) is closer to a rectangular shape than that of FIG. 8(b).

[0131] Further, as can be seen from FIG. 10(c), the light distribution pattern multiplexed with these light distribution patterns is a good pattern in that it has one high intensity band and a generally fine rectangular shape.

[0132] The aforementioned light distribution patterns are all formed by the light from the second light emitting chip 42 arranged in proximity to the left side (inner side of the vehicle) of the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50, in a front view seen from the vehicle front side in FIG. 2, but the influence of the collapsed light distribution due to the off-axis aberration tends to appear in the light distribution pattern formed by the light from the second light emitting chip 42 farthest from the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50.

[0133] Therefore, FIG. 11 illustrates a light distribution pattern formed by the light from the second light emitting chip 42 arranged at a position farthest to the left side (inner side of the vehicle) from the vertical axis (see Y axis) passing through the rear basic focal point O of the lens 50, in a front view seen from the vehicle front side in FIG. 2.

[0134] As can be seen from FIG. 11, in the present embodiment, the incident surface 51 is formed according to the shape as described above to suppress the off-axis aberration, and thus, the light distribution pattern has a fine rectangular shape, and the collapsed light distribution due to the off-axis aberration is greatly suppressed.

[0135] Thus, the present invention has been described above based on the specific embodiment; however, the present invention is not limited to the above embodiment.

[0136] For example, in the above embodiment, as described with reference to FIG. 4(a), in the upper incident surface 52, the radius of curvature Rvc is about 150 mm on the point M (see FIG. 4) side, and the radius of curvature continuously increases as the upper incident surface 52 moves vertically upward, and the radius of curvature Rvt on the outer edge side is about 300 mm, and therefore, the upper incident surface 52 has a gradually changing curved surface where an average radius of curvature obtained by averaging the radii of curvature from

the point M to the outer edge is relatively small.

[0137] On the other hand, the lower incident surface 53 is linear from the point M to the lower end Rvb to suppress the influence on the low beam light distribution pattern, and the average radius of curvature obtained by averaging the radii of curvature from point M to the lower end Rvb (including a complete straight line (having the infinite radius of curvature) from point M to the lower end Rvb) is larger than the average curvature radius of the upper incident surface 52.

[0138] The lower incident surface 53 may have an average curvature radius which is larger than that of the upper incident surface 52 and which can suppress the influence on the low beam light distribution pattern, and the lower incident surface 53 may have a radius of curvature gradually changed in radius of curvature from the point M toward the lower end Rvb.

[0139] For example, the lower incident surface 53 may be a curved surface where the radius of curvature is gradually changed in that the radius of curvature Rvc of the lower incident surface 53 on the point M (see FIG. 4) side is about 150 mm, the radius of curvature increases continuously as the lower incident surface 53 moves vertically downward, and the radius of curvature at the lower end Rvb is about 1000 mm.

[0140] In this case also, similarly to the above embodiment, the lower incident surface 53 has a larger average radius of curvature than the upper incident surface 52, and thus, in the vertical cross section of the basic optical axis (see Z axis) passing through the rear basic focal point O of the lens (see FIG. 3), the upper end UE (see FIG. 4) of the upper incident surface 52 is located forward of the lower end Rvb (see FIG. 4) of the lower incident surface 53.

[0141] Further, as described above, when the lower incident surface 53 is a gradually changed curved surface, the influence of the off-axis aberration can be further suppressed, and the light distribution pattern can be formed closer to a rectangular shape than the light distribution pattern illustrated in FIG. 11.

[0142] As described above, in the present invention, a modification and an improvement without departing from a technical idea are also included in the technical scope of the invention, which is apparent to the person skilled in the art from the description of the claims.

[0143] In the following, the invention described in the claims initially attached to the request for prior-priority application is appended. The claim numbers described in the appendices are as in the claims initially attached to the request for the prior-priority application.

<Claim 1>

[0144] A vehicle lamp, comprising:

a first light emitting chip for a low beam light distribution;

a plurality of second light emitting chips for a high beam light distribution, the second light emitting chips being aligned in a horizontal direction;
 a lens configured to illuminate forward light from the first light emitting chip and the second light emitting chips;
 a reflector configured to reflect the light from the first light emitting chip toward the lens; and
 a shade configured to block part of the light reflected by the reflector,

wherein
 the lens includes:

an upper incident surface vertically above a basic optical axis passing through a rear basic focal point of the lens; and
 a lower incident surface vertically below the basic optical axis,
 the upper incident surface has a shape with a radius of curvature increasing from a side of the basic optical axis toward an outer edge of the upper incident surface, and
 the lower incident surface has a shape with a radius of curvature increasing from a center side in the horizontal direction toward an outer side in the horizontal direction, and with a linear vertical cross section.

<Claim 2>

[0145] The vehicle lamp according to claim 1, wherein the lens includes:

an upper exit surface vertically above the basic optical axis; and
 a lower exit surface vertically below the basic optical axis,
 the upper exit surface is shaped to distribute vertically downward light illuminated forward from the lens on a vertical center side of the lens, and to distribute vertically upward the light on a vertical upper side of the lens,
 the lower exit surface includes:

a first lower exit surface on a horizontal center side; and
 two second lower exit surfaces located horizontally outward of the first lower exit surface, and the second lower exit surfaces are each shaped to illuminate vertically downward light from the rear basic focal point, as a side of an outer peripheral edge of the second lower exit surface is approached, from a position on a side of the basic optical axis toward the outer peripheral edge of the second lower exit surface.

<Claim 3>

[0146] The vehicle lamp according to claim 1 or 2, wherein the second light emitting chips are arranged behind and vertically below the rear basic focal point of the lens, and
 each of the second light emitting chips is arranged such that a light emitting surface thereof is inclined vertically upward so that a light-emitting optical axis passing through a light emitting center intersects the upper incident surface.

<Claim 4>

[0147] The vehicle lamp according to any one of claims 1 to 3, comprising:

a first reflection unit configured to reflect vertically upward part of light emitted from the second light emitting chips toward the lower incident surface; and
 a second reflection unit configured to reflect vertically downward part of light emitted vertically upward from the second light emitting chips.

<Claim 5>

[0148] The vehicle lamp according to claim 4, wherein the first reflection unit reflects light so that an amount of light beams incident on the lower incident surface, among light beams emitted directly toward the lower incident surface from the second light emitting chips, is reduced to 1/3 to 2/3.

<Claim 6>

[0149] The vehicle lamp according to any one of claims 1 to 5, comprising: light diffusion structures formed on the lower incident surface and the upper incident surface, the light diffusion structures being configured to diffuse light incident on the lens, wherein
 the light diffusion structure formed on a horizontal center side of the upper incident surface is set to diffuse more light than the light diffusion structure formed on the lower incident surface.

REFERENCE SIGNS LIST

[0150]

10	Lamp unit
20	Heat sink
21	Base unit
22	Radiation fin
23	First substrate
24	First light emitting chip
25	First light source
26	Mounting unit
27	Holder

30	Reflector			the first light emitting chip and the second light emitting chips;
30a	Reflecting surface			a reflector configured to reflect the light from the first light emitting chip toward the lens; and
31	Shade			a shade configured to block part of the light reflected by the reflector, wherein
31a	Edge			the lens includes:
40	Attachment member	5		
40a	First surface			
41	Second substrate			
42	Second light emitting chip			
43	Second light source			
44	Power feeding connector	10		an upper incident surface vertically above a basic optical axis passing through a rear basic focal point of the lens; and
50	Lens			a lower incident surface vertically below the basic optical axis,
50a	Lens holder			
51	Incident surface			
52	Upper incident surface			
53	Lower incident surface	15		the upper incident surface has a shape with a radius of curvature increasing from a side of the basic optical axis toward an outer edge of the upper incident surface, and
54	Exit surface			the lower incident surface has a shape with a radius of curvature increasing from a center side in the horizontal direction toward an outer side in the horizontal direction, and with a linear vertical cross section.
55	Upper exit surface			
56	Lower exit surface			
56a	First lower exit surface			
56b, 56c	Second lower exit surface (exit surface)	20		
57a	First region			
57b	Second region			
57c	Third region			
57d	Fourth region	25		
61	First reflection unit		2.	The vehicle lamp according to claim 1, wherein the second light emitting chips are arranged behind and vertically below the rear basic focal point of the lens, and
62	Second reflection unit			each of the second light emitting chips is arranged such that a light emitting surface thereof is inclined vertically upward so that a light-emitting optical axis passing through a light emitting center intersects the upper incident surface.
101L, 101R	Vehicle head lamp			
102	Vehicle			
BF	Basic focal point	30		
D	Point			
F	Focal length			
K	Distance			
L	Lens			
M	Point	35	3.	The vehicle lamp according to claim 1, comprising:
O	Rear basic focal point			
OSC	Offense against sine condition			a first reflection unit configured to reflect vertically upward part of light emitted from the second light emitting chips toward the lower incident surface; and
OZ	Light-emitting optical axis			a second reflection unit configured to reflect vertically downward part of light emitted vertically upward from the second light emitting chips.
P	Optical axis			
Q1, Q2, Q3, Q4	Position	40		
S1	One surface			
S2	Other surface			
SML	Primary surface			
SP	Principal point			
$\theta 1, \theta 2$	Angle	45	4.	The vehicle lamp according to claim 3, wherein the first reflection unit reflects light so that an amount of light beams incident on the lower incident surface, among light beams emitted directly toward the lower incident surface from the second light emitting chips, is reduced to 1/3 to 6/7.

Claims

1. A vehicle lamp, comprising:
 - a first light emitting chip for a low beam light distribution;
 - a plurality of second light emitting chips for a high beam light distribution, the second light emitting chips being aligned in a horizontal direction;
 - a lens configured to illuminate forward light from
5. The vehicle lamp according to claim 1, comprising: light diffusion structures formed on the lower incident surface and the upper incident surface, the light diffusion structures being configured to diffuse light incident on the lens, wherein the light diffusion structure formed on a horizontal center side of the upper incident surface is set to

diffuse more light than the light diffusion structure formed on the lower incident surface.

6. A vehicle lamp, comprising:

5

a first light emitting chip for a low beam light distribution;

a plurality of second light emitting chips for a high beam light distribution, the second light emitting chips being aligned in a horizontal direction;

10

a lens configured to illuminate forward light from the first light emitting chip and the second light emitting chips;

a reflector configured to reflect the light from the first light emitting chip toward the lens; and

15

a shade configured to block part of the light reflected by the reflector, wherein the lens includes:

20

an upper incident surface vertically above a basic optical axis passing through a rear basic focal point of the lens; and

a lower incident surface vertically below the basic optical axis, and

25

in a vertical cross section along a basic optical axis passing through a rear basic focal point of the lens, an upper end of the upper incident surface is located forward of a lower end of the lower incident surface.

30

35

40

45

50

55

FIG. 1

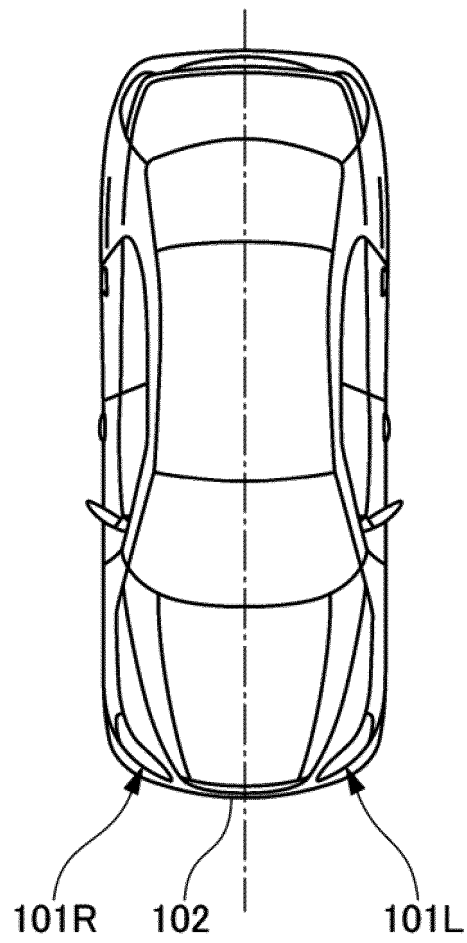


FIG. 2

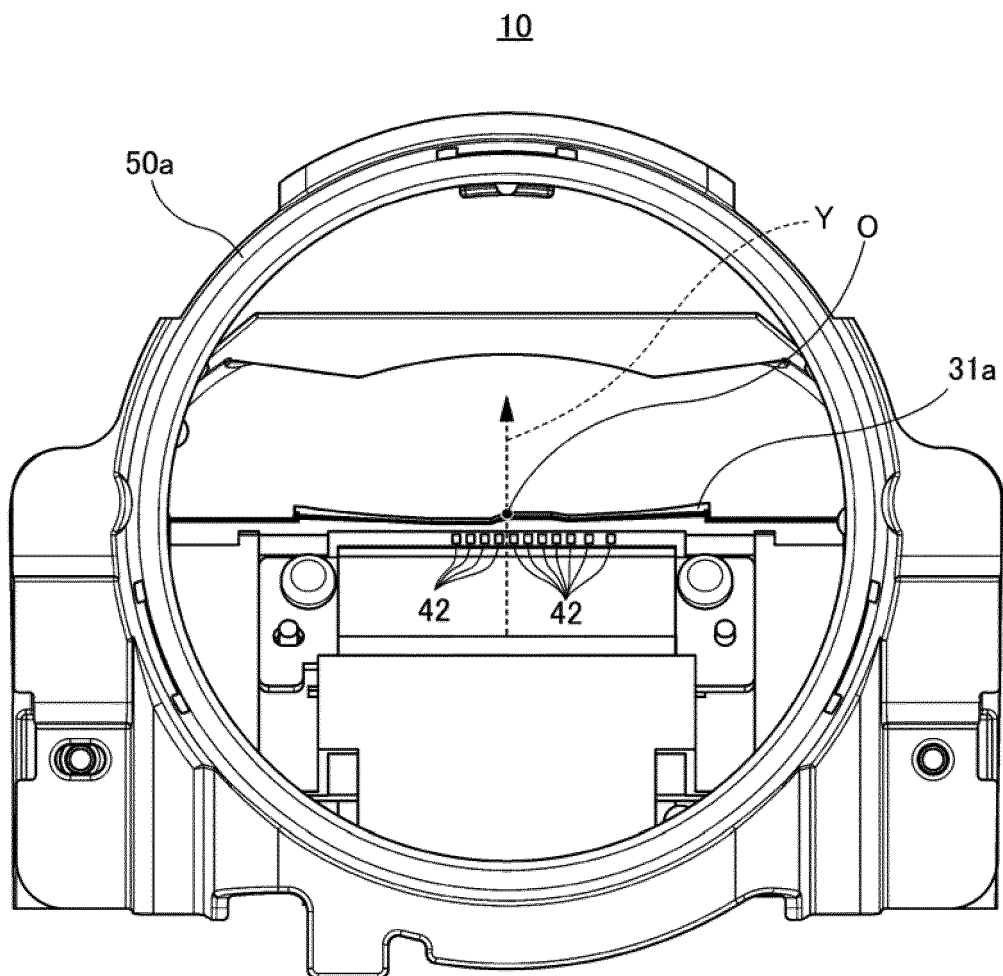


FIG. 3

10

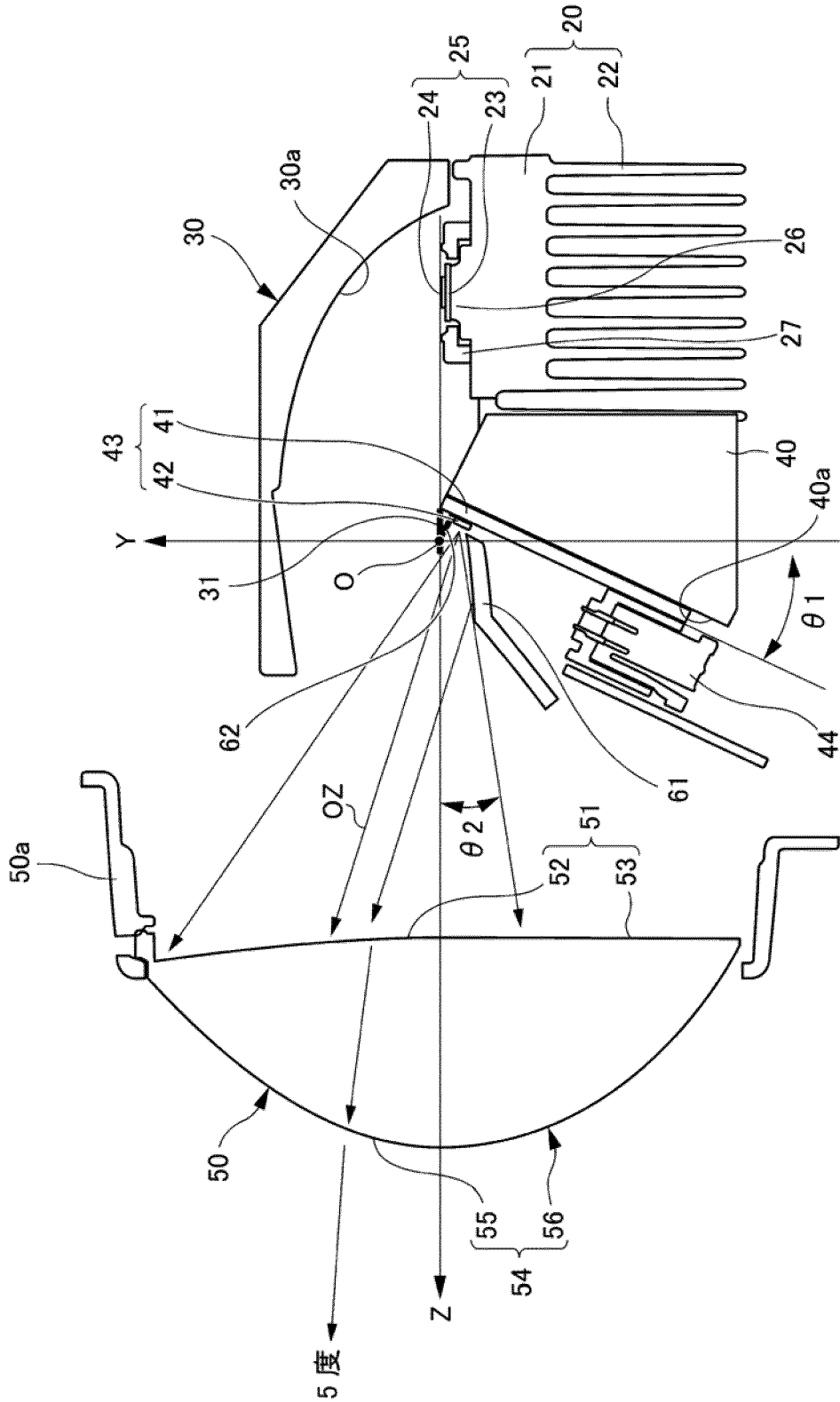


FIG. 4(a)

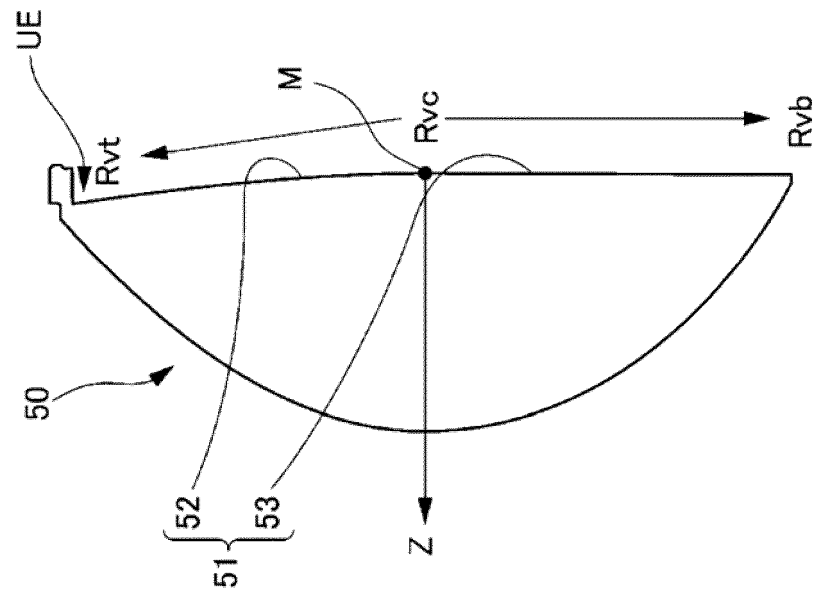


FIG. 4(b)

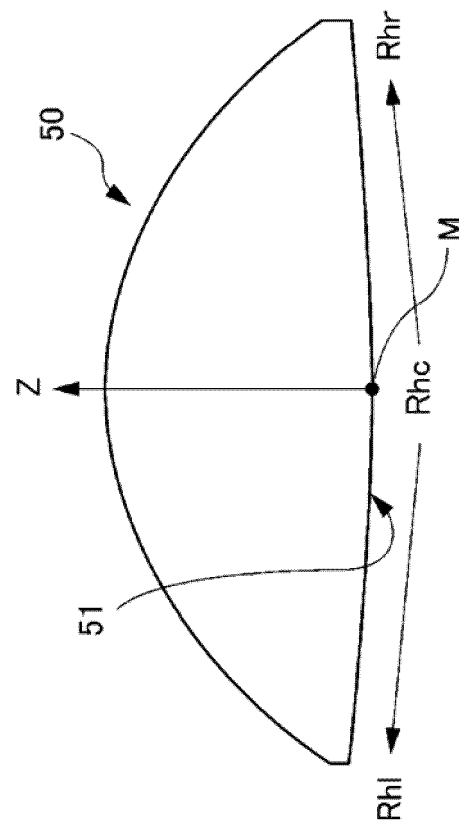


FIG. 5

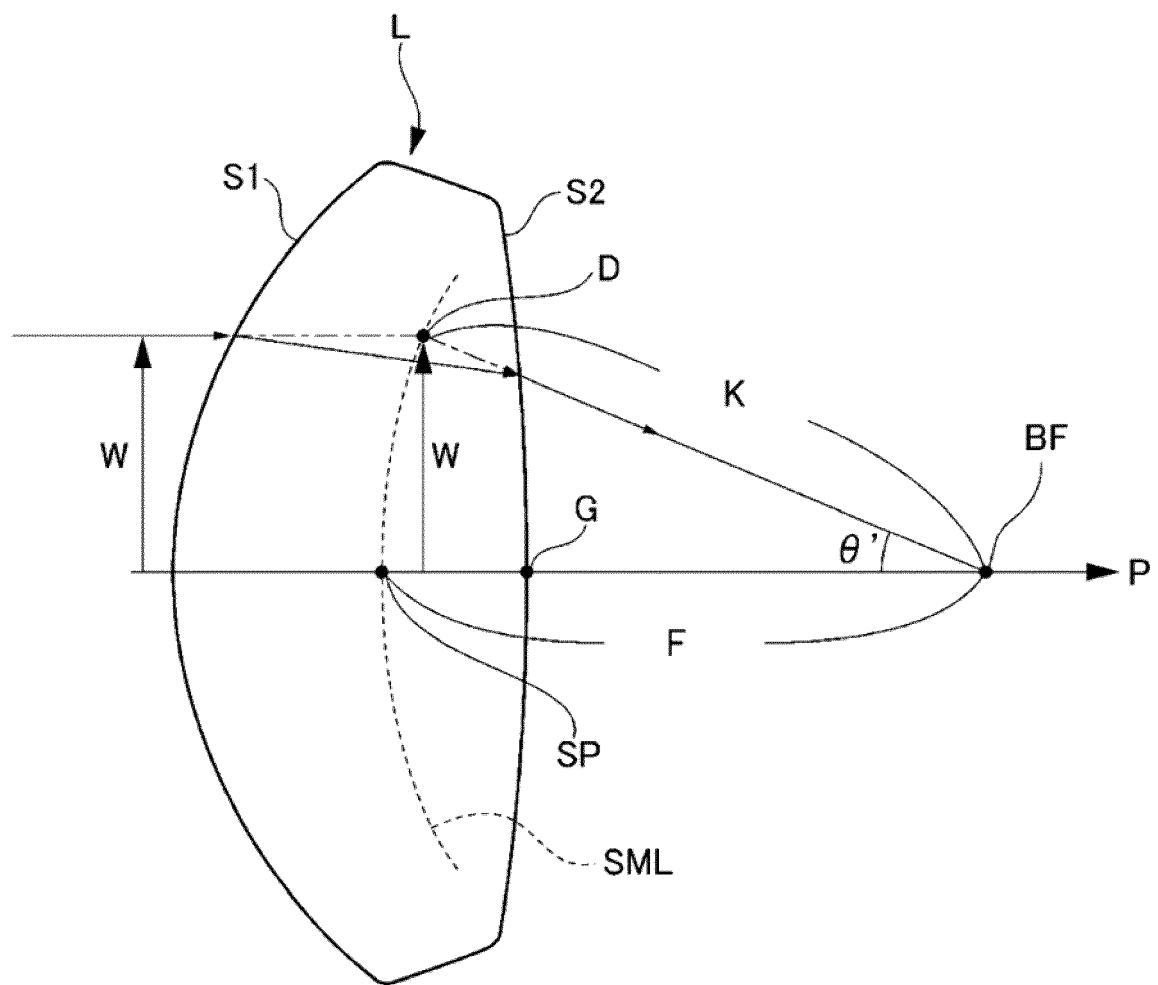


FIG. 6

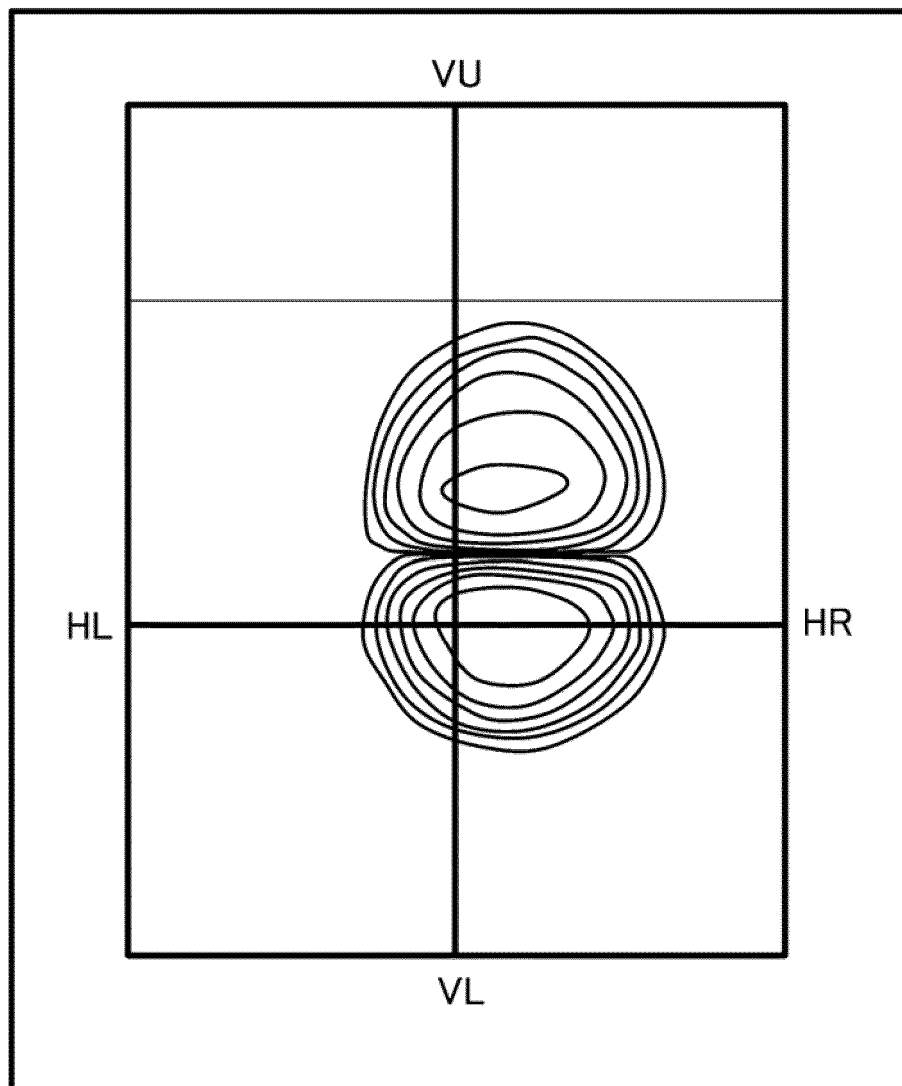


FIG. 7(a)

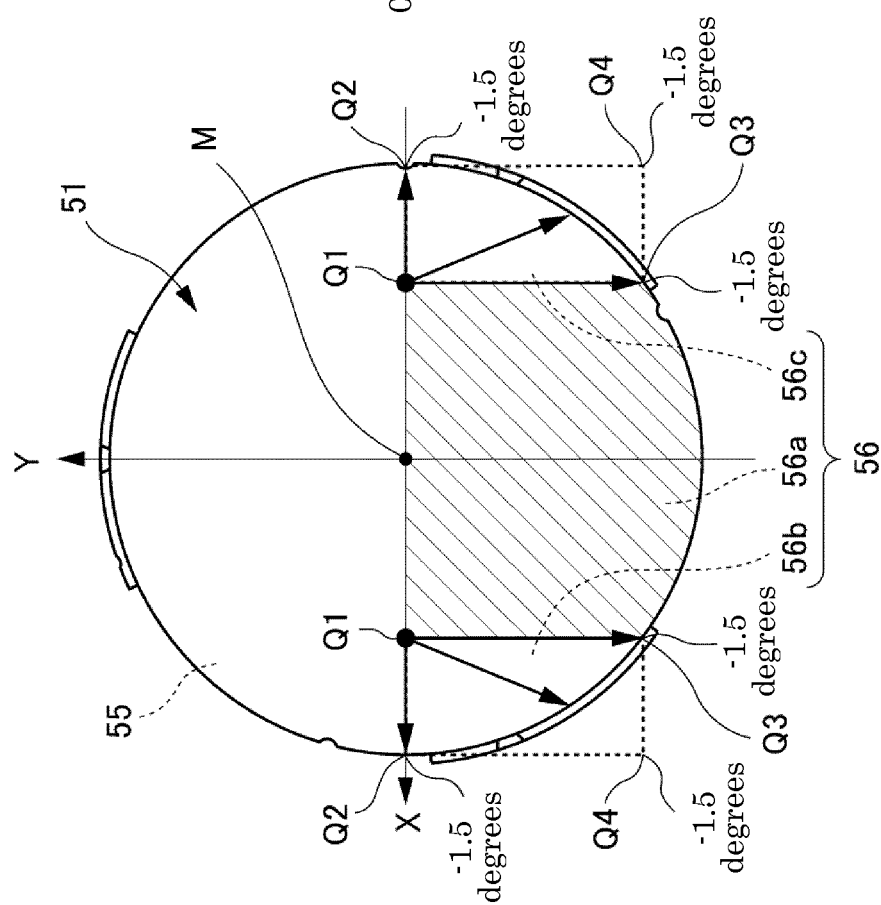


FIG. 7(b)

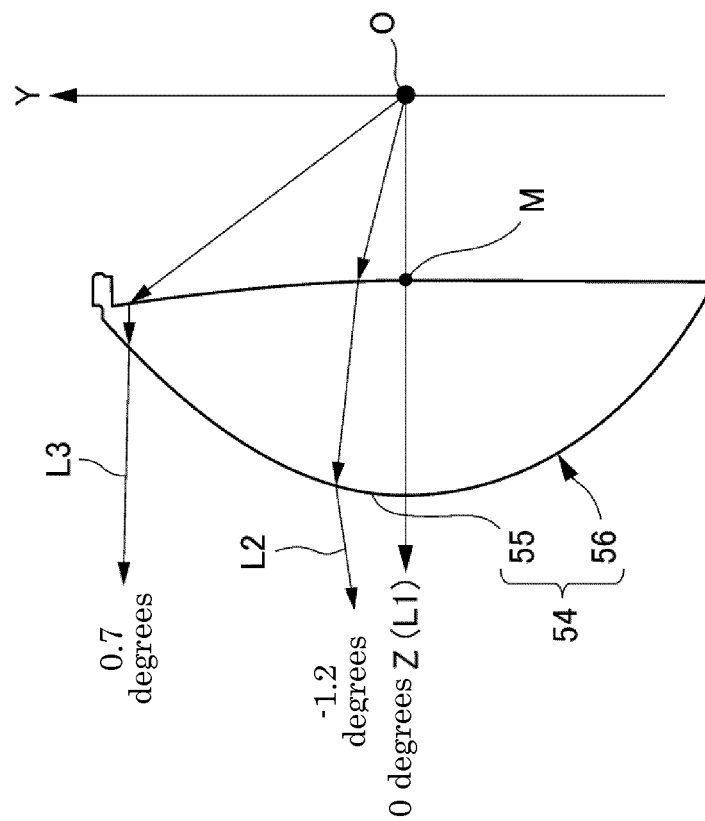


FIG. 8(a)

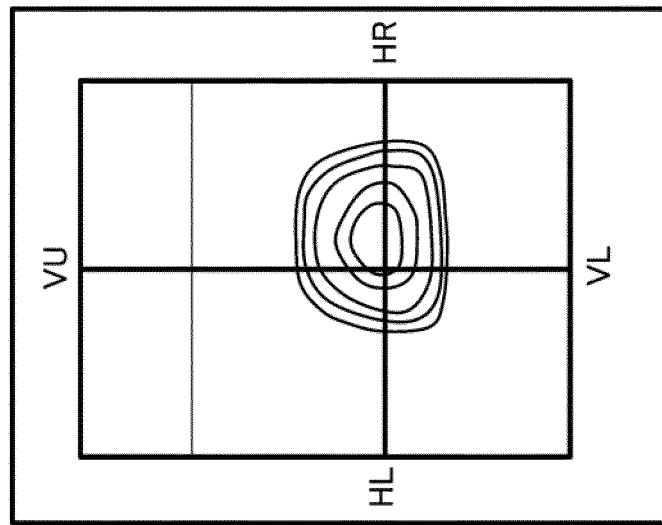


FIG. 8(b)

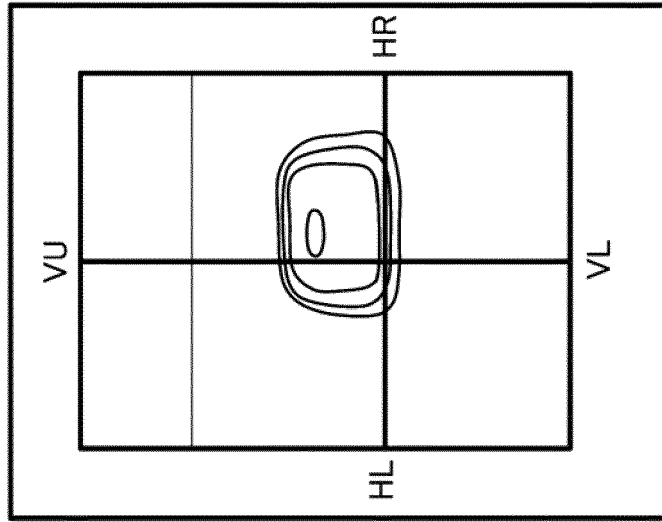


FIG. 8(c)

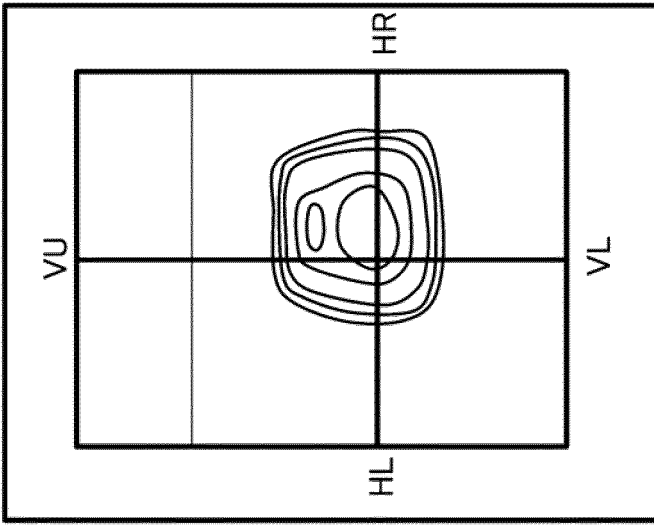


FIG. 9

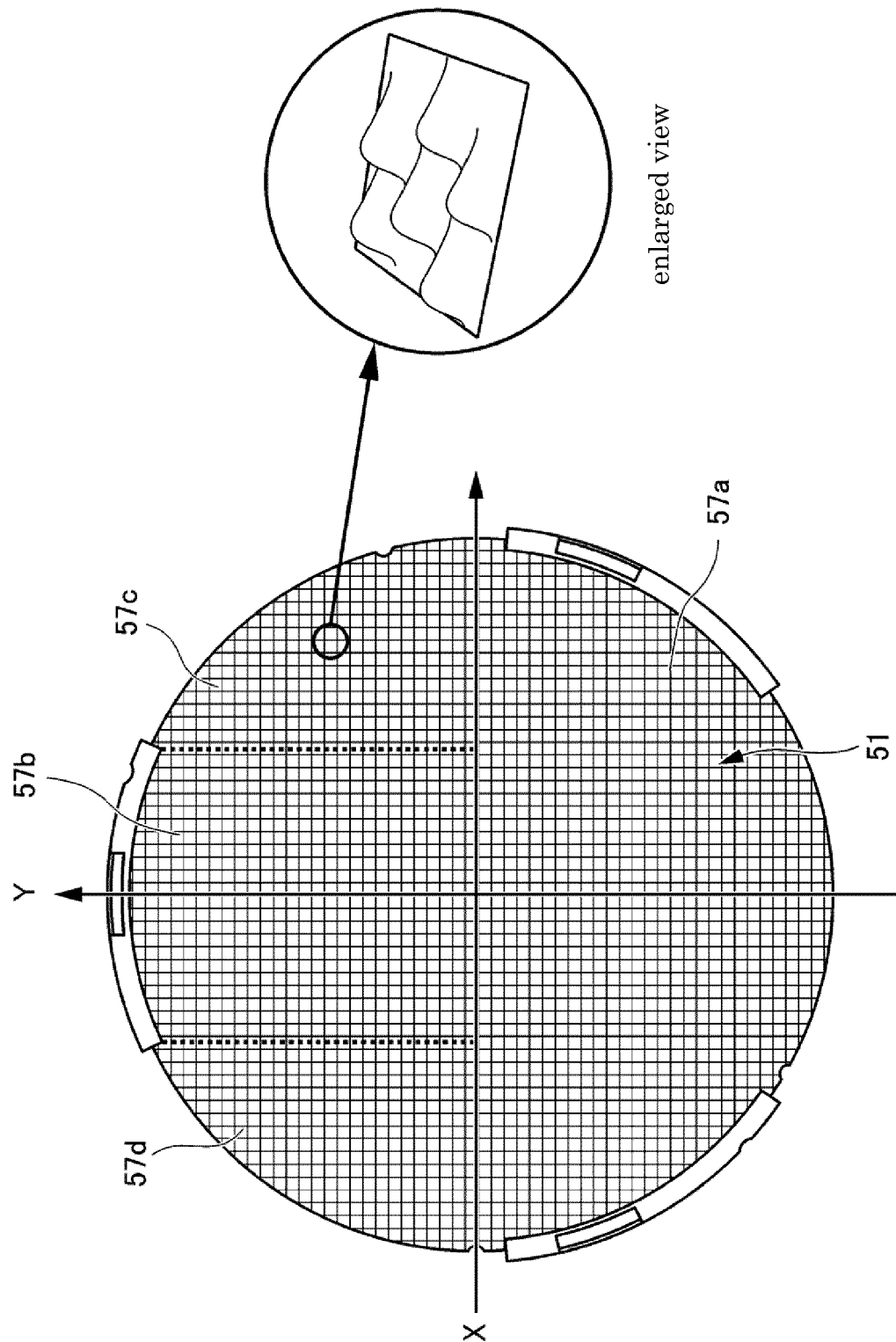


FIG. 10(a)

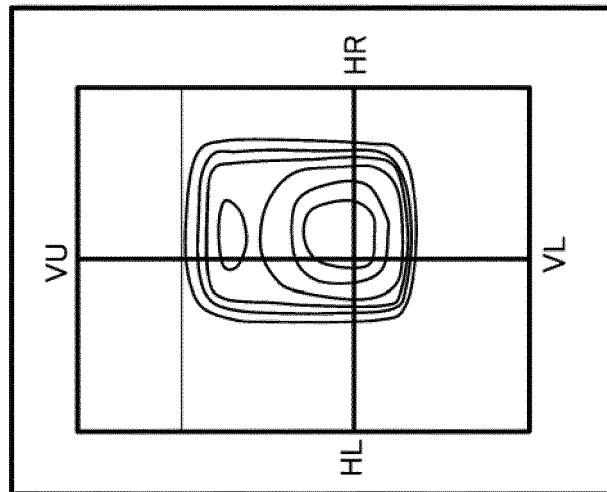


FIG. 10(b)

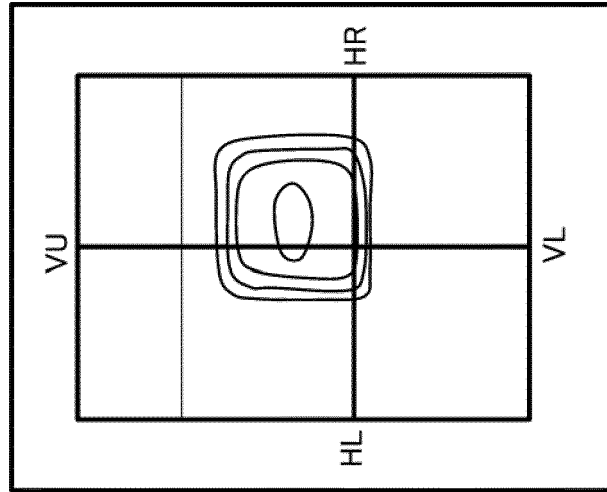


FIG. 10(c)

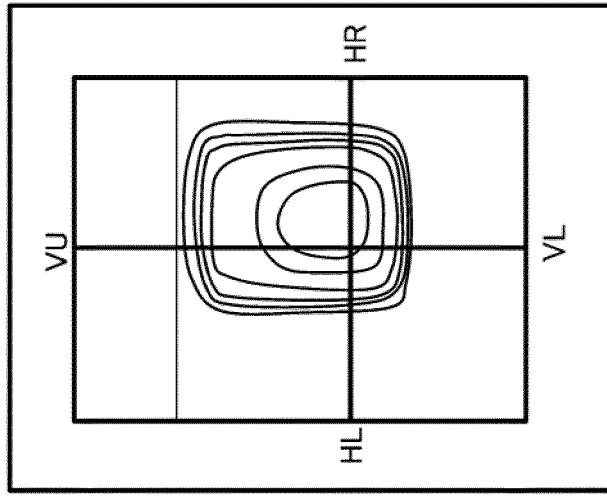
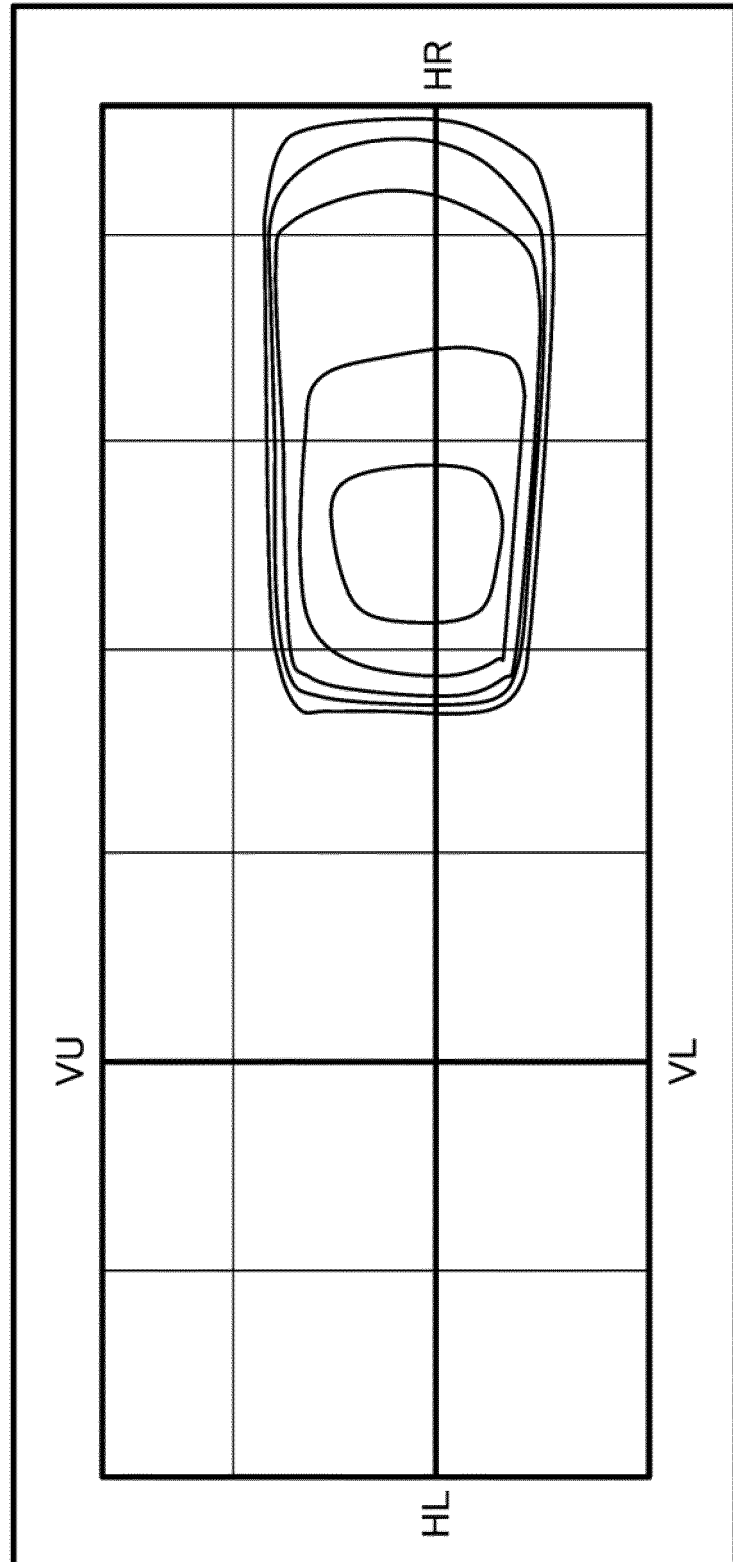


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/039831

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F21S41/00(2018.01)i, F21S43/00(2018.01)i, F21S45/00(2018.01)i,
F21V5/04(2006.01)i, F21W103/00(2018.01)i, F21W104/00(2018.01)i,
F21W105/00(2018.01)i, F21W102/00(2018.01)n, F21Y115/10(2016.01)n,
F21Y115/30(2016.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. F21S41/00, F21S43/00, F21S45/00, F21V5/04, F21W103/00, F21W104/00,
F21W105/00, F21W102/00, F21Y115/10, F21Y115/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2016-39020 A (KOITO MANUFACTURING CO., LTD.) 22 March 2016, paragraphs [0027]-[0043], fig. 1-3 & US 2017/0227184 A1, paragraphs [0068]-[0085], fig. 1-3 & WO 2016/021698 A1 & EP 3179158 A1 & CN 106574762 A	6 1-5
Y A	US 2015/0146446 A1 (VARROC LIGHTING SYSTEMS, S.R.O.) 28 May 2015, paragraphs [0022]-[0025], fig. 1 & DE 102014116862 A1 & CZ 20130925 A3	6 1-5



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2017/039831
--

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-76375 A (KOITO MANUFACTURING CO., LTD.) 20 April 2015, entire text, all drawings & US 2015/0103551 A1 & EP 2860441 A1	1-6
A	JP 2014-157733 A (ICHIKOH INDUSTRIES LTD.) 28 August 2014, entire text, all drawings (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/039831

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
[see extra sheet]

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/039831

(Invention 1) Claims 1-5

Claims 1-5 have a special technical feature where "an upper incident surface has a shape where the radius of curvature increases going toward an outside margin section of the upper incident surface from a basic optical axis side, and a lower incident surface has a shape where the radius of curvature increases going toward a horizontal direction outside from a horizontal direction middle side, and a vertical cross-section is rectilinear," and is therefore classified as Invention 1.

(Invention 2) Claim 6

Claim 6 shares, with claim 1, which is classified as Invention 1, a technical feature of being "provided with a first light-emitting chip for low-beam distribution, a plurality of second light-emitting chips lined up in a horizontal direction for high-beam distribution, a lens for irradiating a front side with light of the first light-emitting chip and the second light-emitting chips, a reflector for reflecting light from the first light-emitting chip toward the lens, and a shade for blocking some of the light reflected at the reflector, wherein the lens has an upper incident surface that is on a vertical direction upper side from a basic optical axis passing through a rear basic focal point of the lens, and a lower incident surface that is on a vertical direction lower side from the basic optical axis." However, this technical feature does not make a contribution over the prior art in the light of the content disclosed in document 1 (Japanese Patent Application Laid-Open Publication No. 2016-39020 A), which has been submitted by the applicant as a prior art document, and thus this technical feature cannot be said to be a special technical feature. Moreover, no other identical or corresponding special technical feature exists between these inventions.

In addition, claim 6 is not a dependent claim of claim 1. Furthermore, claim 6 is not substantially identical to or similarly closely related to any of the claims classified as Invention 1.

As such, claim 6 cannot be identified as Invention 1.

Claim 6 has a special technical feature where "an upper end section of an upper incident surface is located more to the front side than a lower end section of a lower incident surface in a vertical cross-section along a basic optical axis passing through a rear basic focal point of a lens," and is therefore classified as Invention 2.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2016039020 A [0003]