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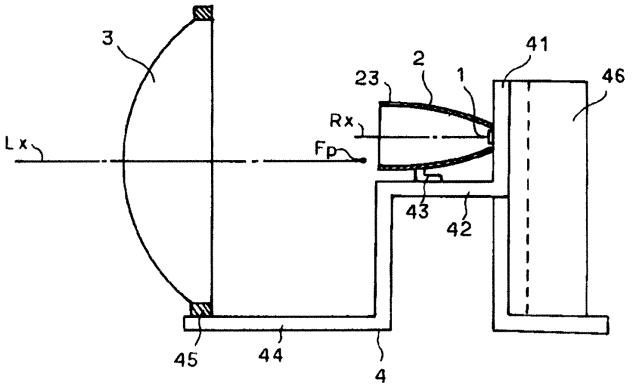
(54) VEHICLE HEADLAMP

(57) A compact vehicle headlamp capable of obtaining a light distribution suitable for a front illumination of a vehicle is provided.

A vehicle headlamp is provided with a cylindrical pyramid reflector 2 having a front opening 21 larger than a rear opening 22, an LED 1 mounted on the rear opening 22 of the reflector 2, and a projector lens 3 arranged to face the front opening 21 of the reflector 2. The reflector 2 includes upper, lower, left and right reflective surfaces 2r, 2d, 21, 2r each of which has a parabola shape with a focal point on the LED 1. An emitting angle of a light emitted from the reflector 2 is set greater in a lateral direction than in a vertical direction. A front end edge of the lower reflective surface 2d is formed in a shape corresponding to a cut-off line of a low beam light distribution. A notch 23 is formed on the upper reflective surface 2u and extends rearward from a front end edge.

FIG.1



EP 2 525 141 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a headlamp of a vehicle such as an automobile and, more particularly, to a headlamp (headlight) using a semiconductor light-emitting element such as LED (Light Emitting Diode) as a light source.

BACKGROUND ART

[0002] An automobile headlamp using a semiconductor light-emitting element such as an LED as a light source has been variously suggested. In recent years, a compactness and lightweight of the headlamp are further demanded. In order to meet such a demand, it is considered that the headlamp is configured using CPC (Compound Parabolic Concentrator).

[0003] As disclosed in Patent Document 1, the CPC is configured as a conical-cylindrical reflector having a ridge line formed in a parabolic shape or a shape similar thereto and configured in such a way that an LED is provided in a small-diameter rear opening, a light emitted from the LED is reflected on an inner surface of the CPC and thus emitted from a large-diameter front opening. By using the CPC thus configured, the light emitted from the LED can be projected with high efficiency and thus it is possible to realize an illumination with high brightness despite of the compactness of an entire structure.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004] Patent Document 1: Japanese Patent Laid-Open Publication No. 2007-235079

SAMMARY OF THE INVENTION

PROBLEM TO BE SOLVED

[0005] The present inventor has found that it is possible to illuminate a light with high brightness on a predetermined region around an optical axis owing to the reflective property of the CPC when a vehicle headlamp is configured using the CPC mentioned above. As a result, it was found that a purpose of the compactness and lightweight can be effectively achieved.

However, radiation characteristics of the light by the CPC have a high light-converging property and a uniform property. Accordingly, the light irradiating regions are distributed in a circular shape and a clear circular bright-dark boundary part is tend to be generated on a boundary between an irradiated region and un-irradiated region, even though the light from the CPC is adapted to be projected through a lens.

[0006] Therefore, in a case where the CPC is used to form a low beam light distribution of an automobile, it is difficult to obtain the light distribution which is narrow in a vertical direction and wide in a lateral direction. Further, it is also difficult to use the bright-dark boundary part as a so-called cut line along an upper edge of an irradiated region.

Further, the bright-dark boundary part also occurs in a region just front of an own vehicle and thus the illumination of a region on a side of the own vehicle of the bright-dark boundary part becomes insufficient. Accordingly, it is apparent that there is a problem to be solved from these points when the CPC is applied in the vehicle headlamp.

[0007] An object of the present invention is to provide a compact and lightweight vehicle headlamp capable of obtaining a light distribution suitable for a front illumination of a vehicle by utilizing a reflector formed in CPC or a shape similar thereto.

MEANS FOR SOLVING THE PROBLEM

[0008] According to the present invention, a vehicle headlamp is provided with a cylindrical pyramid reflector having a front opening larger than a rear opening, a light emitting element mounted on the rear opening of the reflector, and a projector lens arranged to face the front opening of the reflector. The reflector includes an upper reflective surface, a lower reflective surface, a right reflective surface, and a left reflective surface each of which has an axial cross-section in a shape of a parabola with a focal point on the light emitting element. An emitting angle of a light emitted from the front opening is set greater in a lateral direction than in a vertical direction.

[0009] In the present invention, it is preferable that a front end edge of the lower reflective surface of the reflector is formed in a shape corresponding to a cut-off line of a low beam light distribution, and a rear focal point of the projector lens is arranged in a vicinity of the front end edge.

Moreover, it is preferable that a notch is formed on the upper reflective surface of the reflector and extends rearward from a front end edge of the upper reflective surface.

In addition, it is preferable that the reflector, the light emitting element and the projector lens are integrally assembled to form a lamp unit.

ADVANTAGE OF THE INVENTION

[0010] According to the present invention, since a light can be irradiated to provide a light distribution pattern having an irradiation range which is wider in a lateral direction than in a vertical direction, it is possible to structure a headlamp having a light distribution suitable for a front illumination of a vehicle

Further, since a front end edge of a lower reflective surface of a reflector is formed in a shape corresponding to a cut-off line and a rear focal point of a projector lens is arranged in a vicinity of the front end edge, it is possible

to structure a headlamp capable of achieving a low beam light distribution with a required cut-off line.
Furthermore, since a notch is formed on an upper reflective surface of the reflector, it is possible to structure a headlamp capable of achieving a light distribution in which a clear bright-dark boundary is not generated in an illumination just front of an own vehicle, the brightness is suppressed and thus the brightness gradient is alleviated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

[FIG. 1] FIG. 1 is a vertical sectional view taken along an optical axis of a lamp unit according to an embodiment of the present invention.
[FIG. 2] FIG. 2 is an external perspective view illustrating an essential portion of the lamp unit.
[FIG. 3] FIGS. 3(a) and 3(b) are an enlarged perspective view and front view of a reflector.
[FIG. 4] FIGS. 4(a) and 4(b) are a vertical sectional view and a horizontal sectional view indicating optical path diagrams of the reflector.
[FIG. 5] FIGS. 5(a) to 5(c) are pattern diagrams of a low beam light distribution and a high beam light distribution.
[FIG. 6] FIGS. 6(a) to 6(c) are plan views illustrating modifications of a notch.

DESCRIPTION OF THE EMBODIMENT

[0012] An embodiment of the present invention will be described by referring to the accompanying drawings. FIG. 1 is a vertical sectional view taken along an optical axis of a lamp, illustrating a schematic configuration of an embodiment of the present invention which is applied to a vehicle headlamp, in particular, a headlamp having a low beam light distribution. Although not illustrated in the drawings, a lamp housing is structured by a container-shaped lamp body and a transparent front cover mounted on a front opening of the lamp body. A lamp unit LU illustrated in FIG. 1 is housed in the lamp housing.
[0013] The lamp unit LU includes a light source 1, a reflector 2 and a projector lens 3. Light emitted from the light source 1 is reflected by the reflector 2 and then refracted by the projector lens 3. In this way, the light is irradiated on a front region of a vehicle through the front cover. The projector lens 3 according to the embodiment is configured as an approximately cylindrical lens which has a light-converging function in a vertical direction and a light-diffusing function in a lateral direction.
[0014] FIG. 2 is an external perspective view illustrating an essential portion of the lamp unit LU. By referring to FIGS. 1 and 2, the lamp unit LU includes a unit base 4 made of a metal plate, etc., and the light source 1 is supported on a rear wall 41 of the unit base. The reflector 2 is supported on a rear horizontal wall 42 of the unit base through a retainer 43. Further, the projector lens 3 is supported on a front horizontal wall 44 of the unit base 4 through a lens frame 45. A heat sink 46 is integrally provided on a rear surface of the rear wall 41 of the unit base 4 and dissipates a heat generated in the light source 1.
[0015] The light source 1 is configured by a LED. In the present embodiment, the light source is constituted with a surface-emitting type LED of which a light emitting surface is a rectangle. As illustrated in an enlarged perspective view of FIG. 3 (a), the reflector 2 is configured in a cylindrical pyramid type which includes four reflective surfaces 2u, 2d, 21, 2r in an upper side, a lower side, a left side and a right side as seen from a front. The reflector is dimensioned so that a front opening 21 thereof is larger than a rear opening 22 thereof. The dimension of the rear opening 22 is substantially equal to an external dimension of the LED 1 and the LED 1 is mounted on the rear opening. The projector lens 3 is configured by a convex lens and opposed to the front opening 21 of the reflector 2.
[0016] The reflector 22 will be described in detail. As illustrated in FIG. 3 (b), the reflector 22 is configured in a horizontally long rectangular type which is longer in a lateral direction than in a vertical direction as seen from the front. Two upper and lower reflective surfaces 2u and 2d constituting the reflector 2 are line-symmetric with respect to a center axis of the reflector 2, that is, an optical axis Rx of the reflector.
[0017] As illustrated in FIG. 4 (a), both upper and lower reflective surfaces cut in a vertical direction are shaped in a parabola. The upper reflective surface 2u is formed as a parabola in which a focal point Fu is provided on a lower edge of the rear opening 22. The lower reflective surface 2d is formed as a parabola in which a focal point Fd is provided on an upper edge of the rear opening 22. These reflective surfaces are configured to extend in horizontal left and right direction, respectively.
[0018] As illustrated in FIG. 4 (b), two left and right reflective surfaces 21 and 2r are also line-symmetric with respect to the optical axis Rx of the reflector. Both left and right reflective surfaces cut in a horizontal direction are shaped in a parabola. The left reflective surface 2l is formed as a parabola in which a focal point Fl is provided on a right end of the LED 1 mounted on the rear opening 22. The right reflective surface 2r is formed as a parabola in which a focal point Fr is provided on a left end of the LED 1. These reflective surfaces are configured to extend in vertical upper and lower direction, respectively.
[0019] Further, the left and right reflective surfaces 2l, 2r have large inclination angles relative to the optical axis Rx of the reflector and are configured to reflect light in a larger angle than the upper and lower reflective surfaces 2u, 2d when reflecting light from the LED 1, as will be described later.
[0020] As illustrated in FIG. 3 (b), a front end edge of the lower reflective surface 2d of the reflector 2 has left and right edges having different height, as seen from a front of the front opening 21. Specifically, the right edge

r is located lower than the left edge l with respect to a center position in a left and right direction. Further, a central edge c including the center position is slanted in upper left direction, as seen from the front.

[0021] Owing to the inclined shape of the central edge c, a stepped portion 2dd is provided in a central position of the lower reflective surface 2d in a lateral direction and extends rearward from the front opening 21 along the optical axis Rx of the reflector. This stepped portion constitutes a so-called cut-off line when the illumination of the low beam light distribution is performed.

[0022] Further, the upper reflective surface 2u of the reflector 2 is formed with an arc-shaped notch 23 extending rearward from the front opening 21. The shape and dimensions of the notch 23 are determined in accordance with the light distribution property of the low beam light distribution to be designed, as can be seen from the following description.

[0023] The LED 1 is arranged in the rear opening 22 of the reflector 2 in such a way that the center of the light emitting surface is matched with the optical axis Rx of the reflector. Further, the projector lens 3 is so configured that a central axis of the lens (that is, optical axis of the lens) is parallel-shifted from the optical axis Rx of the reflector vertically downward. The rear focal point Fp of the projector lens 3 is arranged to be matched or substantially matched with the central edge c of the front end edge of the lower reflective surface 2d in the front opening 21 of the reflector 2. Here, the optical axis of the lens serves as the optical axis Lx of the lamp in the lamp unit.

[0024] According to the lamp unit LU thus configured, a portion of the light emitted from the light emitting surface of the LED 1 is respectively projected on the left reflective surface 2l and the right reflective surface 2r when light is emitted from the LED 1, as illustrated in horizontal optical paths in FIG. 4 (b). These left and right reflective surfaces 2l, 2r are configured as a paraboloid in which the left and right ends Fl, Fr of the LED 1 on the rear opening 22 correspond to a focal point. By this configuration, a portion of the light emitted from the light emitting surface of the LED 1 is respectively reflected as parallel flux and emitted from the front opening 21 of the reflector 2 toward the projector lens 3 when light is emitted from the LED 1.

[0025] Further, the other portion of the light emitted from the LED 1 is emitted as a direct light and directed toward the projector lens 3 through the front opening 21. It is possible to match the emitting angle $\theta 2$ of the reflected angle and the emitting angle $\theta 21$ of the direct light by properly designing the length of the reflector 2 along the optical axis Rx of the reflector and the dimension of the front opening 21 in a lateral direction.

[0026] Thereby, these lights are incident on the projector lens 3 as a light flux with an incident angle less than $\theta 2$ (=$\theta 21$), and then refracted by the projector lens and projected toward the front. Accordingly, illumination light has a wide horizontal angle calculated from the incident angle $\theta 2$ ad the focal length and refractive index of the projector lens 3. For example, the light is irradiated on the region of 45° in the left and right direction, respectively.

[0027] Meanwhile, a portion of the light emitted from the light emitting surface of the LED 1 is respectively projected on the upper reflective surface 2u and the lower reflective surface 2d, as illustrated in vertical optical paths in FIG. 4 (a). Since these upper and lower reflective surfaces 2u, 2d are configured as a paraboloid in which the upper and lower edges of the rear opening 22 respectively correspond to focal points Fu, Fd, a portion of the light emitted from the light emitting surface of the LED 1 is respectively reflected as parallel flux and emitted from the front opening 21 of the reflector 2 toward the projector lens 3.

[0028] Further, the other portion of the light emitted from the LED 1 is emitted as a direct light and directed toward the projector lens 3 through the front opening 21. It is possible to match the emitting angle $\theta 1$ of the reflected angle and the emitting angle $\theta 11$ of the direct light by properly designing the length of the reflector 2 along the optical axis Rx of the reflector and the dimension of the front opening 21 in a vertical direction.

[0029] Thereby, these lights are incident on the projector lens 3 as a light flux with an incident angle less than $\theta 1$ (=$\theta 11$), and then refracted by the projector lens and projected toward the front. For example, the light is irradiated on the region of 22° in the upper and lower direction, respectively. However, since the upper reflective surface 2u is provided with the notch 23 extending rearward from the front opening 21, the light passing through the notch 23 is emitted in an incident angle $\theta 21$ larger than $\theta 1$ and incident on an upper region of the projector lens 3.

[0030] The light emitted from the front opening 21 of the reflector 2 is irradiated to the front by the projector lens 3 to form a predetermined light distribution pattern. Light on an upper limit region of the light distribution pattern in the light emitted from the front opening 21, that is, light emitted along the front end edge of the lower reflective surface 2d of the reflector 2 before being upside down by the projector lens 3, is shaped in such a way that the left and right edges r, l of the front end edge are different in height and the central edge c is inclined. Further, the front end edge is arranged in the vicinity of the rear focal point Fp of the projector lens 3. Accordingly, light is irradiated on the optical axis of the projector lens 3 (in other words, the optical axis Lx of the lamp) in a light pattern corresponding to the shape of the front end edge.

[0031] By these configurations, as illustrated in the light distribution pattern of FIG. 5 (a), a low beam light distribution pattern Lo having a cut-off line COL corresponding to the shape of the front end edge is formed in the upper limit region of the bright-dark boundary.

[0032] Further, since the notch 23 is formed on the front end edge, light which is emitted from the front opening 21 and then incident on an upper region of the projector lens 3, that is, light which is emitted along the front

end edge of the upper reflective surface 2u of the reflector 2 and reflected at the lower reflective surface 2d and the direct light emitted upward from the LED 1 are emitted upward through the notch 23 and incident on the upper region of the projector lens 3 in an angle θ12 larger than the incident angle θ1.

[0033] The light passing through the notch 23 is irradiated on a lower region of the optical axis of the lens (that is, the optical axis Lx of the lamp) by the projector lens 3. Thereby, there is achieved a light distribution pattern in which a lower illumination region of the low beam light distribution pattern Lo illustrated FIG. 5 (a) (that is, a near-forward region a vehicle) is expanded to a nearer-forward region An of a vehicle, the bright-dark boundary is not highlighted and the gradient of brightness is relaxed.

[0034] As such, the low beam light distribution pattern Lo obtained by the lamp unit LU according to the present embodiment is adapted to form a light distribution suitable for the front illumination of a vehicle, which is narrow in a vertical direction and wide in a lateral direction. Further, a region close to the optical axis Lx of the lamp irradiating a far-forward region is formed with a predetermined cut-off line shape having a distinct bright-dark boundary and a lower region thereof irradiating a near-forward region forms illumination in which the gradient of brightness is relaxed and the irradiating range is wide.

[0035] Thereby, a dazzling of a preceding vehicle or an oncoming vehicle is prevented while brightly irradiating the far-forward region. Further, the near-forward region is widely irradiated in a proper brightness, instead of excessive brightness. Accordingly, it is possible to achieve a proper low beam light distribution.

[0036] In this lamp unit LU, all of the light emitted from the LED 1 is utilized for the low beam light distribution and therefore it is possible to improve the utilization efficiency of light. Accordingly, it is possible to achieve a light distribution pattern capable of irradiating light in high brightness, even if a small LED or a lower power consumption LED is employed. Further, there is no need a shade for achieving the low beam light distribution pattern and therefore it is possible to realize the compactness and lightweight of the lamp unit.

[0037] Herein, the shape of the front end edge of the lower reflective surface 2d in the reflector 2 is not limited to the shape illustrated in the foregoing embodiment. Although not illustrated in the drawings, the left edge of the front end edge relative to the center position in a left and right direction may be simply inclined. In this case, it is possible to achieve the low beam light distribution pattern Lo2 having the cut-off line COL in which a left side region relative to the optical axis Lx of the lamp is slanted in upper left direction, as illustrated in FIG. 5 (b).

[0038] Further, the notch 23 formed on the upper reflective surface 2u of the reflector 2 is not limited to the arc-shaped notch illustrated in the foregoing embodiment. For example, a rectangular notch 23A illustrated in a plan view in FIG. 6 (a) or a triangular notch 23B illustrated in FIG. 6 (b) may be employed. Further, the notch can be designed in an appropriate shape depending on the brightness or width of the light upon irradiating near-forward region.

[0039] Further, a notch 23c in which the cut-out amount of a central region is small may be employed, as illustrated in FIG. 6 (c). In particular, in a case where the notch 23c of FIG. 6 (c) is used, illumination brightness of the region Ann just before own vehicle illustrated by a dashed line in FIG. 5 (a) is slightly reduced and therefore it is possible to avoid the deterioration of visibility due to excessive illumination brightness of the region Ann just before own vehicle. In particular, this notch is preferable to avoid the deterioration of visibility and the dazzling of another vehicle due to the reflected light from road surface in the rain.

[0040] An example of realizing the low beam light distribution has been described in the foregoing embodiment. However, it is also possible to realize a high beam light distribution Hi having a light distribution pattern illustrated in FIG. 5 (c), by forming the front end edge of the lower reflective surface 2d of the reflector 2 into a simple linear shape and properly adjusting the position of the rear focal point of the projector lens 3. The light distribution pattern illustrated in FIG. 5 (c) includes a region above the optical axis Lx of the lamp and has no cut-off line in an upper edge region thereof. Also in this case, when the notch 23 is formed on the upper reflective surface 2u of the reflector 2, alleviated illumination with brightness gradient having no bright-dark boundary can be realized for the nearer-forward region An of a vehicle.

[0041] The light emitting element used in the present invention is not limited to the LED. For example, a semiconductor light emitting element such as a laser diode may be used as the light source of the headlamp of the present invention.

[0042] While description has been made in connection with particular embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modification may be made therein without departing from the present invention.

The present application claims a priority from Japanese Patent Application No. 2010-3564 filed on January 12, 2010, the entire contents of which are incorporated herein by reference. Further, all references cited in the Japanese patent application are incorporated herein as a whole.

INDUSTRIAL APPLICABILITY

[0043] The present invention may be employed in a compact vehicle headlamp using a light emitting element as a light source.

DESCRIPTION OF REFERENCE NUMERALS

[0044]

1: Light source (LED)
2: Reflector
3: Projector lens
4: Unit base
21: Front opening
22: Rear opening
23: Notch
2u: Upper reflective surface
2d: Lower reflective surface
2r: Right reflective surface
2l: Left reflective surface
Rx: Optical axis of reflector
Lx: Optical axis of lamp (Optical axis of lens)

Claims

1. A vehicle headlamp comprising:

a cylindrical pyramid reflector having a front opening larger than a rear opening;
a light emitting element mounted on the rear opening of the reflector; and
a projector lens arranged to face the front opening of the reflector,
wherein the reflector includes an upper reflective surface, a lower reflective surface, a right reflective surface, and a left reflective surface each of which has an axial cross-section in a shape of a parabola with a focal point on the light emitting element, and
wherein an emitting angle of a light emitted from the front opening is set greater in a lateral direction than in a vertical direction.

2. The vehicle headlamp according to claim 1, wherein a front end edge of the lower reflective surface of the reflector is formed in a shape corresponding to a cut-off line of a low beam light distribution, and
wherein a rear focal point of the projector lens is arranged in a vicinity of the front end edge.

3. The vehicle headlamp according to claim 1 or 2, wherein a notch is formed on the upper reflective surface of the reflector and extends rearward from a front end edge of the upper reflective surface.

4. The vehicle headlamp according to any one of claims 1 to 3, wherein the reflector, the light emitting element and the projector lens are integrally assembled to form a lamp unit.

FIG. 1

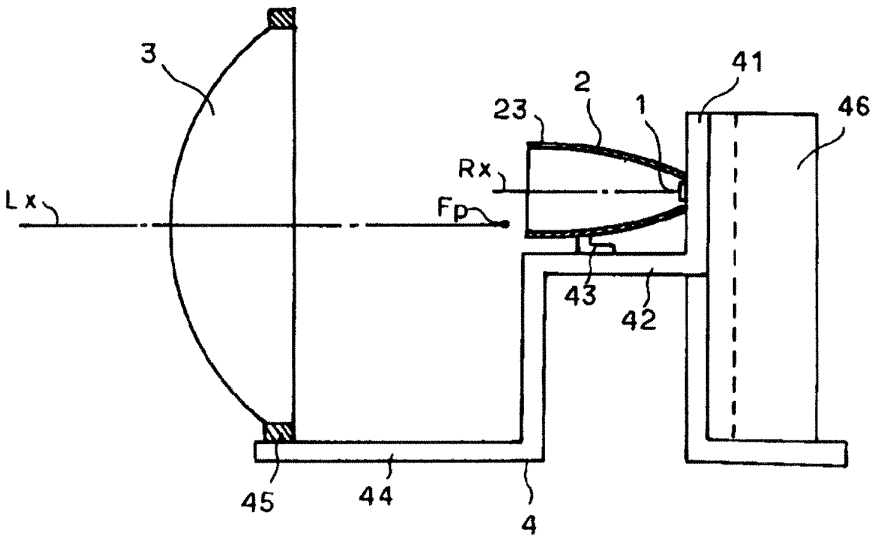


FIG.2

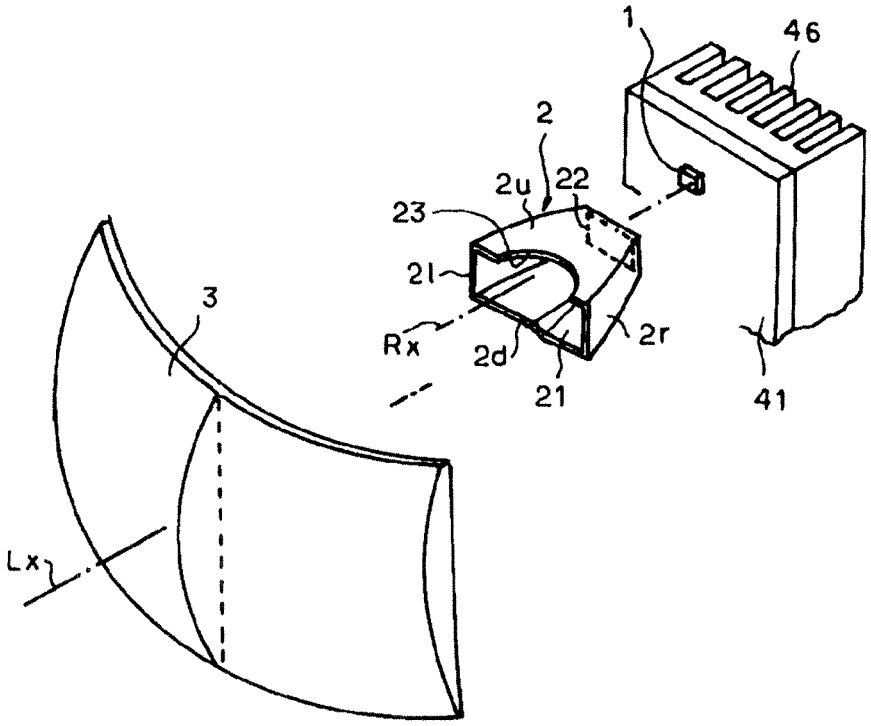


FIG.3(a)

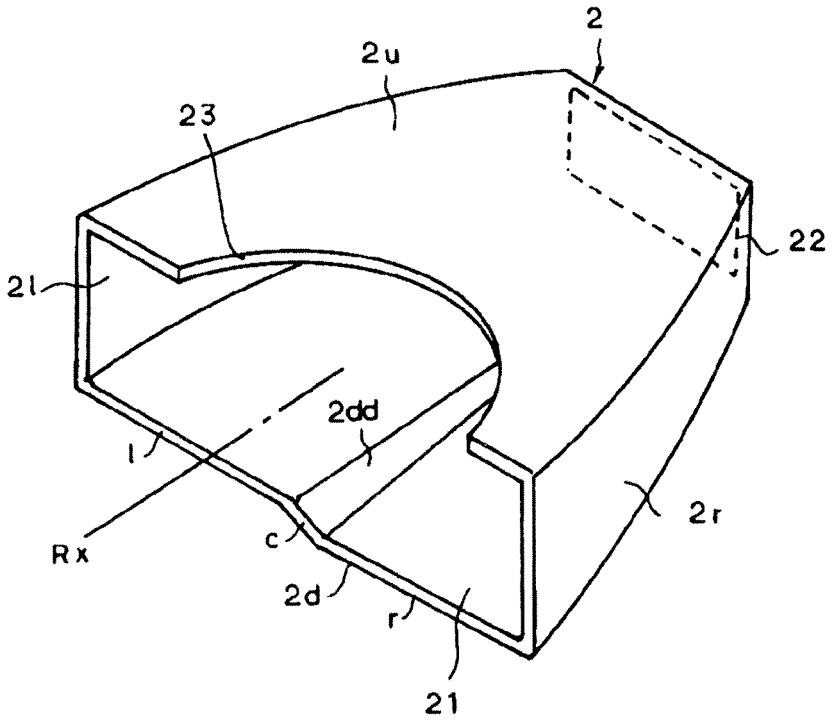


FIG.3(b)

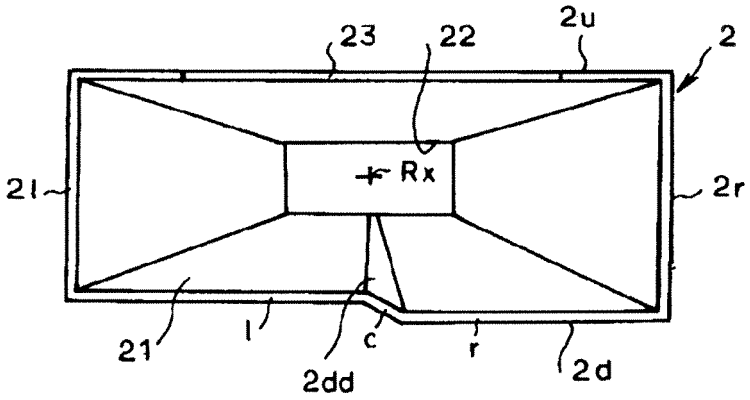


FIG.4(a)

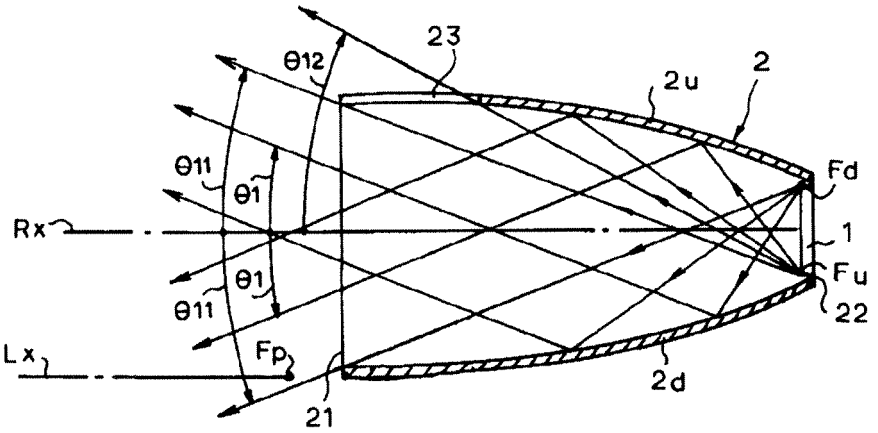

23
θ12
2u
2
θ11
θ1
Fd
Rx
1
θ1
Fu
θ11
22
Lx
Fp
2d
21

FIG.4(b)

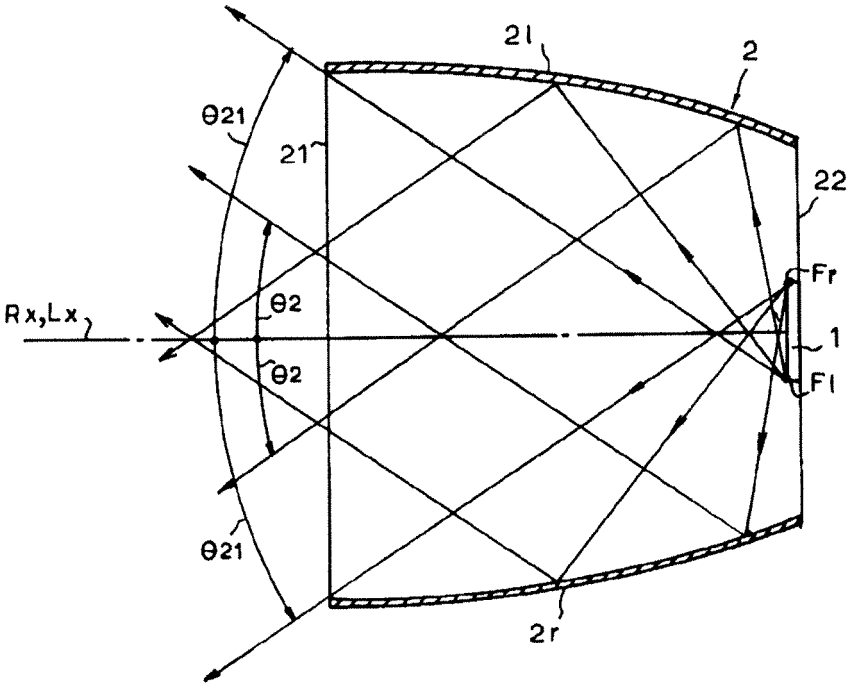

21
2
θ21
21
22
Fr
Rx,Lx
θ2
1
θ2
Fl
θ21
2r

FIG.5(a)

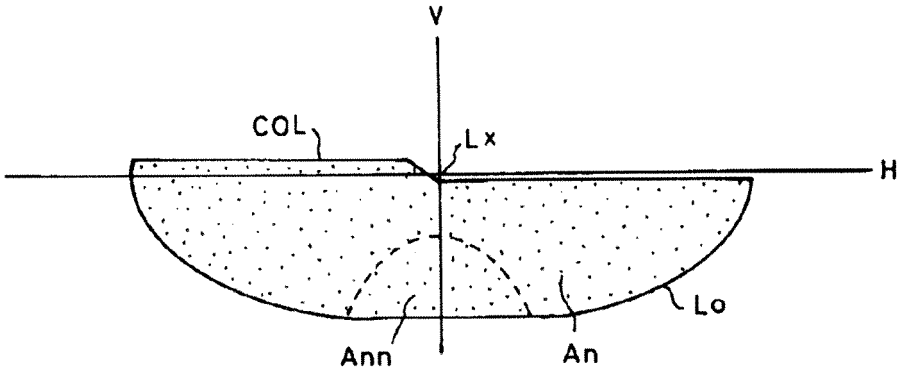


FIG.5(b)

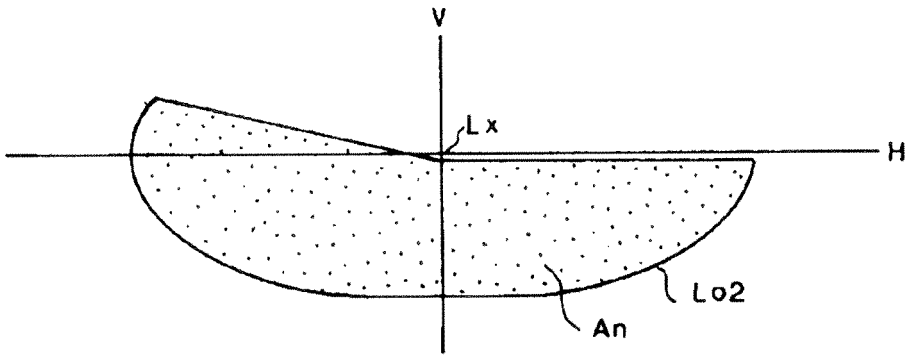


FIG.5(c)

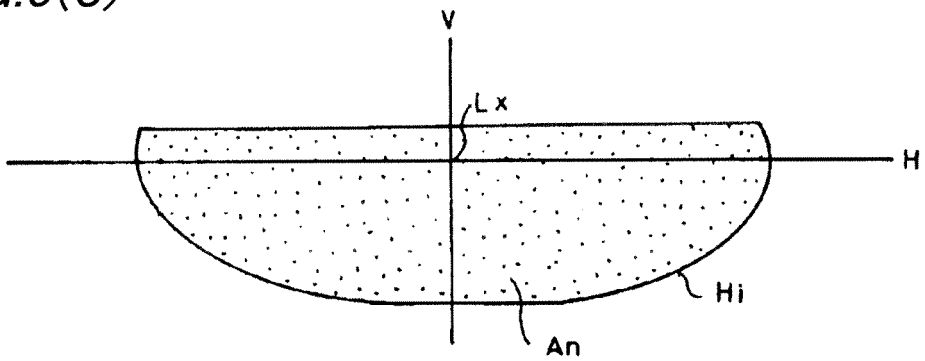


FIG.6(a)

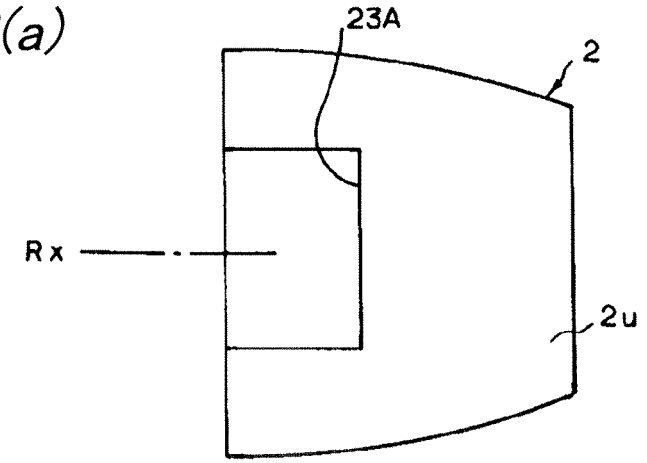


FIG.6(b)

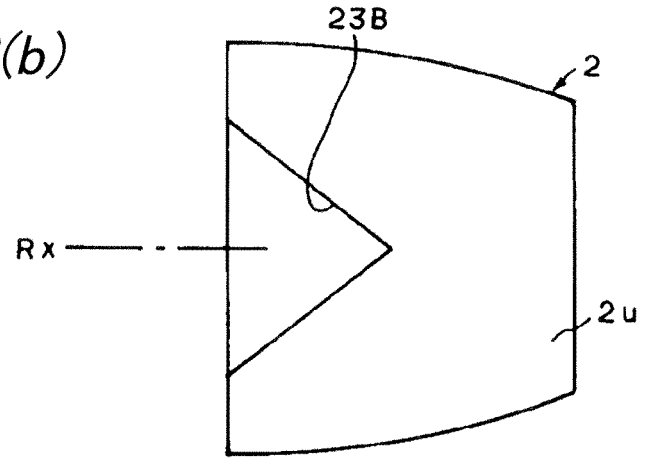
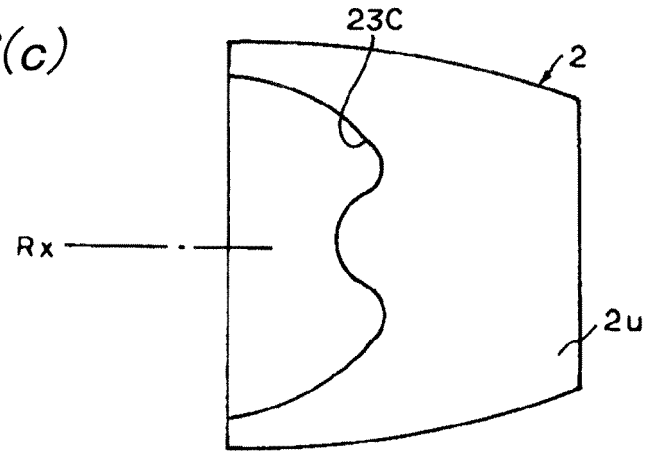


FIG.6(c)



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/050116

A. CLASSIFICATION OF SUBJECT MATTER
F21S8/12(2006.01)i, *F21W101/10*(2006.01)n, *F21Y101/02*(2006.01)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)
F21S8/12, F21W101/10, F21Y101/02

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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.
X Y A	JP 2008-535166 A (Patent Treuhand Gesellschaft fur elektrische Gluhlampen mbH), 28 August 2008 (28.08.2008), entire text; all drawings & WO 2006/102882 A1	1 2,4 3
Y A	JP 2005-267998 A (Koito Manufacturing Co., Ltd.), 29 September 2005 (29.09.2005), entire text; all drawings & US 2005/0207162 A1 & GB 2412159 A & DE 102005012649 A & FR 2867839 A & CN 1670425 A	2,4 3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 April, 2011 (04.04.11)	12 April, 2011 (12.04.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/050116

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 2009-134964 A (Stanley Electric Co., Ltd.), 18 June 2009 (18.06.2009), entire text; all drawings (Family: none)	1-4
A	JP 2008-282575 A (Stanley Electric Co., Ltd.), 20 November 2008 (20.11.2008), entire text; all drawings (Family: none)	1-4
A	JP 2002-50214 A (Ichikoh Industries Ltd.), 15 February 2002 (15.02.2002), entire text; all drawings (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007235079 A **[0004]**
- JP 2010003564 A **[0042]**