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(71) Applicant: **Koito Manufacturing Co., Ltd.**
Tokyo 108-8711 (JP)

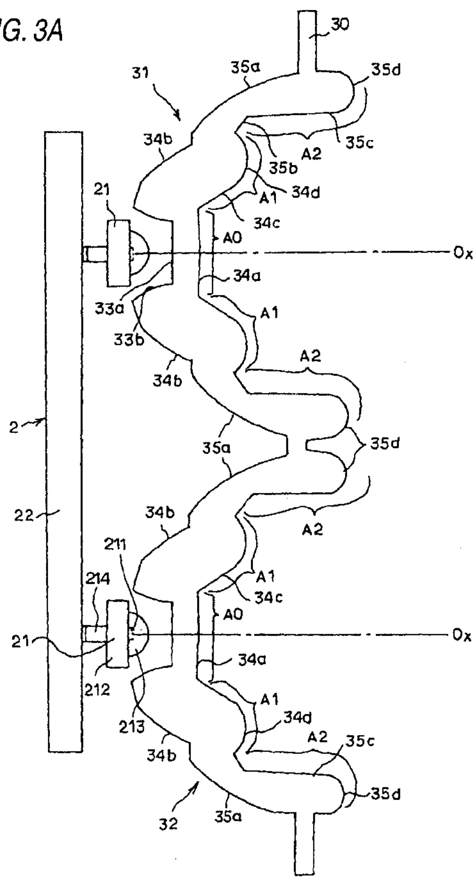
(72) Inventors:
- **Sugiura, Tamaaki**
  Shimizu-shi Shizuoka (JP)
- **Yuasa, Haruma**
  Shimizu-shi Shizuoka (JP)
- **Nakada, Asami**
  Shimizu-shi Shizuoka (JP)
- **Koizumi, Hiroya**
  Shimizu-shi Shizuoka (JP)
- **Nobuhara, Kenji**
  Shimizu-shi Shizuoka (JP)

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser**
Anwaltssozietät
Leopoldstrasse 4
80802 München (DE)

(54) Vehicle lamp

(57) A vehicle lamp is provided with a light source (21) and a lens (31, 32, 31A, 32A). The lens (31, 32, 31A, 32A) is formed in a bowl shape having a central bottom (34a) faces to the light source (21). The lens (31, 32, 31A, 32A) is provided with a forward illuminating region (A0, A1, A2) and a sideward illuminating region (A3). The forward illuminating region (A0, A1, A2) is positioned on the bottom (34a) and a part (34c, 34d, 35d, 30c) of peripheral regions of the lens and configured to irradiate a part of a light from the light source (21) in a forward direction along an optical axis (Ox) of the lamp. The sideward illuminating region (A3) is positioned on an another part (35f, 35g, 35h, 37c) of the peripheral regions of the lens and configured to irradiate an another part of the light from the light source (21) in a sideward direction of the lamp.

FIG. 3A



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Description

BACKGROUND OF THE INVENTION

<FIELD OF THE INVENTION>

[0001] This invention relates to a vehicle lamp capable of irradiating light onto a forward region along an optical axis of the lamp and also onto a sideward region apart from the optical axis at a large angle.

<BACKGROUND ART>

[0002] In recent years, there has been proposed a vehicle lamp using a light emitting element such as an LED as a light source. In this kind of lamp, a quantity of light emitted from the light emitting element is less than that that from a bulb (electric bulb) so that in order to enhance a luminous intensity of the lamp, it is desired to enhance a using efficiency of light emitted from the light emitting element. For this purpose, techniques disclosed in Patent References 1 and 2 have been proposed. In both techniques, a forward region of the lamp is illuminated by the light ejected in the optical axial direction, and the light ejected sideward at a large angle from the optical axis is refracted or reflected to be also used as illuminating light directed toward the forward region.

Patent Reference 1: US 2005/0152153 A1
Patent Reference 2: US 2006/0034094 A1

[0003] Some lamps for a motor vehicle require that light should be irradiated forward or rearward over a wide horizontal angular range. For example, a stop lamp requires a light distribution characteristic of horizontally illuminating light with a predetermined luminous intensity (e.g. 0.3cd) into a ranges of 45° in both horizontal directions around the optical axis directed rearward of the motor vehicle. A tail lamp requires the light-distributing characteristic of light with a predetermined luminous intensity (e.g. 0.05cd) into a region of 45° in an inward direction of the motor vehicle and a region of 80° in an outward direction thereof. So, when the lamps described in Patent References 1 and 2 are adopted to the tail lamp or stop lamp, since these lamps are designed for using efficiency of light in illuminating light to the forward region of the lamp, a sideward illumination of light is insufficient. Accordingly, it is difficult to adopt the lamps to the tail lamp or the stop lamp. Particularly, in recent years, the tail lamp and the stop lamp are combined so that they are constructed as a tail & stop lamp in which the light quantity of the tail lamp is increased in operating a brake. Where the lamps in Patent References 1 and 2 is adopted to the tail & stop lamp, even if the region of applying light forward can be expanded so that the light distributing characteristic is satisfied as the stop lamp, it is difficult to satisfy the light distributing characteristic of illuminating light at a large angle required for the tail lamp. In order to satisfy the light distribution characteristic of illuminating light sideward, the lamp can be constructed in which another lens for sideward lighting is provided in addition to the lenses used in the lamp. However, owing to the lens added, the lamp structure may be complicated, thereby increasing cost of the lamp.

SUMMARY OF THE INVENTION

[0004] One or more embodiments of the invention provide a vehicle lamp capable of lighting sideward a large angle with respect to an optical axis like a tail & stop lamp without complicating a lamp structure.

[0005] In accordance with one or more embodiments of the invention, a vehicle lamp is provided with: a light source (21); and a lens (31, 32, 31A, 32A), wherein the lens (31, 32, 31A, 32A) is formed in a bowl shape having a central bottom (34a) faces to the light source (21). The lens (31, 32, 31A, 32A) is provided with: a forward illuminating region (A0, A1, A2) positioned on the bottom (34a) and a part (34d, 35d) of peripheral regions of the lens and configured to irradiate a part of a light from the light source (21) in a forward direction along an optical axis (Ox) of the lamp; and a sideward illuminating region (A3) positioned on an another part (35f, 35g, 35h, 37c) of the peripheral regions of the lens and configured to irradiate an another part of the light from the light source (21) in a sideward direction of the lamp.

[0006] The lens (31, 32, 31A, 32A) may have four regions including upper, lower, right and left regions when viewed from a front side of the lamp. The upper and lower regions (A2) are configured as said forward illuminating region. The right and left regions (A3) are configured as said sideward illuminating region. In this configuration, both light distributions of forward illumination and sideward illumination can be obtained by a single lens.

[0007] The sideward illuminating region (A3) may include a reflecting face (35f, 35g, 35h, 37c) which guides the light from the light source through the lens while internally reflecting the light, and the light is reflected in the sideward direction on the reflecting face (35f, 35g, 35h, 37c) provided at a lens opening edge of said another part of the peripheral regions. Specifically, the sideward illuminating region (A3) may include: a first sideward illuminating region (A3R1, A3L1) configured to irradiate the light in a range to at least 80° sideward on one side or the other side with respect to the optical axis (Ox) of the lamp; and a second sideward illuminating region (A3R2, A3L2) configured to irradiate the light in a range to at least 45° sideward on said one side with respect to the optical axis (Ox) of the lamp. In such a configuration, the light distribution required by the tail lamp and stop lamp of a motor vehicle can be obtained.

[0008] A wall thickness of said opening edge of the lens may be larger than a light flux width (D0) of the guided light by a required dimension (D1) toward both sides. In this configuration, even if a recession CR called "cutter R" is created in molding the lens using transparent resin, the light distribution as designed can be obtained.

[0009] The lens (31, 32, 31A, 32) may further include a light guiding concave area (33) for guiding the light from the light source (21) to the lens. The light guiding concave area (33) may include a light incident face (33b) configured to guide the light to the sideward illuminating region (A3) and formed as a convex face. In this configuration, the light from the light source can be condensed on the convex face to increase the quantity of light to be guided to the side illuminating region of the lens so that the illuminating area can be enlarged.

[0010] Said lens (31, 32, 31A, 32) may be one of a plurality of lenses that configure a composite lens (3) in which the plurality of lenses (31, 32, 31A, 32) are arranged lengthwise and breadthwise when viewed from the front side of the lamp and are unified through a flat plate area (30). A sub-light-emitting region (A4) configured to reflect a part of the light guided through the lens in the forward direction may be provided on the flat plate area (30). In this configuration, on the flat plate area other than the lenses, the light is applied from the sub-light-emitting region so that the illuminating area of the entire lamp can be enlarged. In the following description, regarding light reflection on the inner face of the lens, any light exclusive or not exclusive a part thereof is fully reflected, but in the description, the light refection will be simply referred to as "refection".

[0011] In accordance with one or more embodiments of the invention, by providing only one lens in the lamp, the lamp forward region including the optical axis of the lamp or along the optical axis can be illuminated and also the sideward region at a large angle of 45° to 80° with respect to the optical axis can also be illuminated. So, the lamp requiring the illumination at a large angle can be realized by a simple configuration. Further, by forming the light incident face at a part of the light guiding concave area as a convex face or providing a sub-light emitting region on the flat plate area between the lenses, the light guiding efficiency can be enhanced, or the light emitting area can be enlarged to enlarge the illuminating area of the lamp.

[0012] Other aspects and advantages of the invention will be apparent from the following description, the drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a front view of a first embodiment of the invention.
Fig. 2 is a partially exploded perspective view showing a schematic configuration of a main part of the first embodiment.
Fig. 3A is an enlarged sectional view of an inner lens along line III-III in Fig. 1.
Fig. 3B is a light path view of a light ray in Fig. 3A.
Fig. 4A is an enlarged sectional view of an inner lens along line IV-IV in Fig. 1.
Fig. 4B is a light path view of a light ray in Fig. 4A.
Figs. 5A and 5B are enlarged sectional views of an opening edge of an inner lens.
Fig. 6A is a sectional view of an inner lens according to a second embodiment.
Fig. 6B is a light path view of a light ray in Fig. 6A.
Figs. 7A and 7B are views comparatively showing regions illuminated by a convex plane and a concave plane of a light incident plane of a light guiding concave area in the second embodiment.
Fig. 8 is a front view of a third embodiment.
Fig. 9A is an enlarged sectional view along line IX-IX in Fig. 8.
Fig. 9B is a light path view of a light ray in Fig. 9A.
Fig. 10 is a front view of a modification of the third embodiment.
Figs. 11A and 11B are sectional views of a sub-lens step.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENT

[0014] Now referring to the drawings, explanations will be given of various exemplary embodiments of this invention.

<First Embodiment>

[0015] Fig. 1 is a partially broken front view of a first embodiment in which this invention is applied to a right side rear combination lamp RCL of a motor vehicle. A lamp body 11 having a square vessel shape and an outer lens 12 attached to the front opening of the lamp body 11 constitute a lamp housing 1; the lamp housing 1 integrally incorporates a tail & stop lamp T&SL, a backup lamp BUL, and a turn signal lamp TSL. The backup lamp BUL and turn signal lamp TSL, which are not directly related to this invention, will not be explained here. The tail & stop lamp T&SL, as seen from a schematic exploded perspective view of Fig. 2, a light source component 2 consisting of a plurality of light emitting elements 21 such as LEDs arranged/loaded on a circuit board 22, and a composite inner lens 3 made of a light-transmitting material, which includes a plurality of inner lenses 31, 32 (described later in detail) arranged on the front side of the light source 2 and integrated through a flat plate area 30. In the tail & stop lamp T&SL, the light ejected from the light emitting elements 21 is caused to be incident to the composite inner lens 3; the light is refracted or internally reflected to be guided through the interior of the composite inner lens 3 so as to be ejected with a required light distributing characteristic. Further, the light emitting source 2 is changed in its light emitting intensity by switching the current to be supplied to the light emitting elements 21 so that when the light is emitted with a low luminous intensity, the tail & stop lamp T&SL serves as a tail lamp and when the light is emitted with a high luminous intensity, the tail & stop lamp T&SL serves as a stop lamp.

[0016] Fig. 3A is an enlarged sectional view of an inner lens along line III-III in Fig. 1. Likewise, Fig. 4A is an enlarged sectional view of an inner lens along line IV-IV in Fig. 1. Further, Figs. 3B and 4B are light path views of a light ray ejected when the light emitting elements emit light in Figs. 3A and 4A. In Figs. 3A and 4A, sectional hatching is omitted in order to avoid complication of illustration and in Figs. 3B and 4B, only reference symbols of main components are indicated on the same purpose. In these figures, the light emitting element 21 has a structure in which an LED chip 211 is mounted on the surface of a base 212 and covered with a semi-sphere sealing resin 213. By passing a current through an electrode 214 formed on the base 212, the LED chip 211 emits light which will be ejected with a required characteristic through the sealing resin 213. By controlling the current to be passed, the light emitting intensity can be changed between a low luminous intensity and a high luminous intensity. In the first embodiment, four light emitting elements 21 are arranged as cells on the circuit board 22; and the composite inner lens 3 is constructed as a composite lens having four inner lenses 31, 32 integrally arranged vertically and horizontally so as to correspond to these four light emitting elements, respectively.

[0017] The structure of the above composite inner lens 3 will be explained in detail. In the above four inner lenses 31, 32, the inner lenses 31 or 32 with the same reference symbol arranged vertically have the same structure, whereas the inner lenses 31 and 32 arranged horizontally have the structures partially different, as described below. First, referring to Figs. 3A and 3B, the structure of the inner lens 31 will be descried. The inner lens 31 is generally formed in a bowl shape; its central axis constitutes an optical axis Ox of the rear combination lamp RCL and coincides with the optical axis of the above light emitting element 21. On the bottom including the optical axis Ox of the inner lens 31, a light-guiding concave area 33 concaved in a shape described below is formed; the light emitting element 21 is arranged within the light-guiding concave area 33 so that the light ejected from the light emitting element 21 is guided from the inner face of the light guiding concave area 33 into the inner lens 31.

[0018] The light guiding concave area 33 is constructed so that its upper bottom 33a is formed as a flat plane substantially vertical to the optical axis Ox and its inner periphery 33b is formed as a curve circumferentially enveloping the curve having a curvature of radius slightly larger than that of the convex face with a focal point located at the light emitting point of the light emitting element 21. Thus, of the light ejected from the light emitting element 21, the light projected onto the upper bottom 33a is refracted by this upper bottom 33a and guided through the inner lens 31, whereas the light projected onto the inner periphery 33b is likewise refracted and guided toward the peripheral side of the inner lens 31 as the light ray converged with a restricted rate of diffusion, now the light ray approximate to a parallel light ray.

[0019] The inner bottom 34a of the inner lens 31 is formed in a plane substantially vertical to the optical axis Ox so as to correspond to the upper bottom 33a of the light-guiding bottom 33a. The light which is incident on the upper bottom 33a of the light-guiding concave area 33 and guided through the inner lens 31 is slightly refracted by the inner bottom 34a and permeates through the inner lens 31 so that it is ejected forward within ranges of about 20° each vertically with respect to the optical axis Ox to constitute a central forward illuminating region A0.

[0020] The peripheral area around the central forward illuminating region A0 of the inner lens 31 is partitioned in two regions in the direction of the optical axis Ox; and the peripheral area located on the bottom side constitutes an inner belt forward illuminating segment A1. In the inner belt forward illuminating region A1, its outer periphery 34b is constituted as a parabolic face of reflecting the light emitted from the light emitting element 21 toward the optical axis Ox direction (forward direction), which reflects a part of the light incident from the inner periphery 33b of the light guiding concave area 33 and guided as parallel light directed along the optical axis Ox. Further, the inner periphery 34c of the inner belt forward illuminating region A1 is constituted as a conical face having an apex of the light emitting point of the light emitting element 21 and its front end 34d has a convex spherical face directed toward the optical axis Ox in its section to form a ring-shaped face around the optical axis Ox, and collectively refracts the parallel light reflected on the outer periphery 34b and ejects the light forward within ranges of about 20° each horizontally with respect to the optical axis Ox.

[0021] The peripheral area of the inner belt forward illuminating region A1 is further circumferentially partitioned into four segments vertically and horizontally when seen from the front. The vertical peripheral regions A2 and the right/left peripheral region A3 have different sectional shapes. The upper/lower region A2 has a shape symmetrical with respect to the optical axis Ox to constitute a peripheral forward illuminating region. In the peripheral forward illuminating region A2, its outer periphery 35a is constituted as a rotary parabolic face having a focal point of the light emitting point of the light emitting element 21 like the outer periphery 34b of the inner belt forward illuminating region A1, which reflects a part of the light incident from the inner periphery 33b of the light guiding concave area 33 and guided as parallel light directed along the optical axis Ox. On the other hand, the inner periphery 35b is adjacent to the inner periphery 34d of the central forward illuminating region A0 and constituted as a conical face having an apex at the light emitting element 21; the region contiguous thereto is constituted as a cylindrical face 35c in parallel to the optical axis. Further, the opening end 35d of the upper/lower peripheral region A2 is formed as a convex sphere face directed to the optical axis Ox and collectively refracts the parallel light reflected on the outer periphery 35a and ejects the light in the direction along the optical axis Ox. The construction described above also applies to that of the inner lens 32 so that it will not be explained adding the same reference symbols.

[0022] On the other hand, in the inner lens 31, as seen from Figs. 4A and 4B, the right/left peripheral region A3 is constituted as a sideward illuminating region. The structure of the outer periphery 35a of the sideward illuminating region A3 is the same as that of the upper/lower peripheral forward illuminating region A2. Namely, the outer periphery 35a is constituted as a parabolic face of reflecting the light emitted from the light emitting element 21 toward the optical axis Ox direction (forward direction), which reflects a part of the light incident from the inner periphery 33b of the light guiding concave area 33 and guided as parallel light directed along the optical axis Ox. Further, the structure of the inner periphery 35b is also the same as that of the upper/lower peripheral forward illuminating region A2. On the other hand, in the sideward illuminating region A3, its right peripheral area and its left peripheral area are different in their structure. The right peripheral area is constituted as a first sideward illuminating area A3R1 which is composed of a cylindrical face 35e in parallel to the optical axis Ox and a convex reflecting face 35f which has a shape circumferentially enveloping a convex face with a required radius of curvature and reflects the parallel light ref lected on the outer periphery 35a collectively rightward within a range of about 45° to 90° with respect to the optical axis Ox. Further, the left peripheral area is constituted as a second sideward illuminating area A3R2 which is a convex reflecting face 35g which has a shape circumferentially enveloping a convex face with a required radius of curvature in the inner face at the opening edge and reflects the parallel light reflected on the outer periphery 35a collectively leftward. Further, a minute gap 36 is assured between the left opening edge of the inner lens 31 and that of the inner lens 32 adjacent thereto on the left side. The outer face 36a of the opening edge facing the gap 36 is formed as a cylindrical face nearly in parallel to the optical axis Ox so that the light reflected on the convex reflecting face 35g is refracted leftward within a range of 15° to 55° with respect to the optical axis Ox and ejected.

[0023] On the other hand, in comparison to the inner lens 31, the inner lens 32 has the same structure as the inner lens in their structure of the central forward illuminating region A0, inner belt forward illuminating region A1 and the peripheral forward illuminating regions A2 located vertically around the region A1. So, an explanation will not be given of the equivalent elements adding the same reference symbols, but given of the structure of the right and left peripheral areas which is different from that of the inner lens 31. In Figs. 4A and 4B, in the left peripheral area serving as a first sideward illuminating region A3L1 of the inner lens 32, its outer periphery 35a is formed in a parabolic face of reflecting the light emitted from the light emitting element 21 toward the optical axis Ox direction (forward direction) as same as inner lens 31 and its inner periphery 35e is formed in a cylindrical face in parallel to the optical axis, which reflects a part of the light incident from the inner periphery 33b of the light guiding concave area 33 and guided as parallel light along the optical axis Ox. The outer convex reflecting face 35h at the opening edge is formed in a convex face having a required radius of curvature, which reflects the parallel light reflected on the outer periphery 35a correctively rightward in a range of about 45° to 90° with respect to the optical axis Ox. The second sideward illuminating region A3L2 in the right peripheral area is formed in a convex face having a required radius of curvature as a shape line-symmetrical to the second sideward illuminating region A3R2 of the inner lens 31 and formed in a convex reflecting face 35g of reflecting the parallel light reflected on the outer periphery 35a correctively rightward with respect to the optical axis Ox. In this inner lens 32 also, the outer face 36a at the opening edge facing the minute gap 36 assured between itself and the inner lens 31 contiguous thereto is formed as a cylindrical face nearly in parallel to the optical axis Ox so that the light reflected on the convex reflecting face 35h is refracted rightward within a range of 15° to 55° with respect to the optical axis Ox and ejected.

[0024] In the tail & stop lamp T&SL constructed as described above, referring to Figs. 3B and 4B, when a current is passed through the light emitting element 21 to emit light, of the light ejected from the light emitting element 21, the light directed within ranges of about 20° vertically and about 30° horizontally with respect to the optical axis Ox is slightly refracted on the upper bottom 33a of the light guiding concave area 33 of the inner lens 31, 32 and guided through the interior of the inner lens 31, 32, and further slightly refracted on the inner bottom 34a of the inner lens 31, 32 and ejected. Thus, the light is applied forward of the lamp or rearward of the motor vehicle within the horizontal angular range of about 30° with respect to the optical axis Ox in the region including the optical axis Ox through the central forward illuminating region A0 of the inner lens 31, 32.

[0025] Further, of the light ejected from the light emitting element 21, the light ejected at an angle larger than about 20° vertically and about 30° horizontally with respect to the optical axis Ox is straightly introduced into the inner lens 31, 32 at the inner periphery 33b of the light guiding concave area 33 thereof. The light is reflected as the parallel light along the optical axis Ox by the rotary parabolic shape of the outer periphery 34b of the inner belt forward illuminating region A1 and guided through the inner lens 31, 32. The light guided is ejected in the state condensed on the convex spherical face 34d in the direction along the optical axis Ox. The light ejected is once condensed at the position immediately ahead of the convex spherical face 34d and thereafter diffused. Thus, the light is applied rearward of the motor vehicle within an elliptical range of 20° vertically and 30° horizontally with respect to the optical axis Ox around the optical axis Ox.

[0026] In each of the upper and lower peripheral forward illuminating regions A2 of the inner lens 31, 32, the light introduced from the inner periphery 33b of the light guiding concave area 33 of the inner lens 31, 32 is reflected as the parallel light along the optical axis Ox by the rotary parabolic shape of the outer periphery 35a of the peripheral forward illuminating region A2 and guided through the interior of the inner lens 31, 32. The light guided is ejected in the state condensed on the convex spherical face 35d formed at the opening end in the direction along the optical axis Ox. The light ejected is once condensed at the position immediately ahead of the convex spherical face 35d and thereafter diffused. Thus, the light is applied rearward of the motor vehicle within ranges of 30° each horizontally with respect to the optical axis Ox.

[0027] On the other hand, in the sideward illuminating region A3 formed of each the left and right peripheral areas of the inner lens 31, 32, the light introduced from the inner periphery 33b of the light guiding concave area 33 of the inner lens 31, 32 is reflected as the parallel light along the optical axis Ox by the rotary parabolic shape of the outer periphery 35a of the sideward illuminating region A3 and guided through the inner lens 31, 32. Regarding the inner lens 31 arranged on the right side, in the right peripheral area serving as the first sideward region A3R1, the light reflected on the outer periphery 35a is fully reflected rightward within a range of about 45° to 90° with respect to the optical axis Ox by the convex reflecting face 35f formed within the opening edge. The light reflected is once condensed and thereafter ejected as diffused light rightward of the motor vehicle. In the left peripheral area serving as the second sideward illuminating region A3R2, the light reflected on the outer periphery 35a is reflected on the convex reflecting face 35g and refracted at the opening edge outer face 36a to be once condensed, and thereafter is ejected as diffused light leftward of the motor vehicle within a range of about 15° to 55° with respect to the optical axis Ox. In this case, the illuminating light, when reflected on the convex reflecting face 35g, is once condensed and refracted by the opening edge outer face 36a. For this reason, the light condensing point of the light once condensed can be located forward of the opening edge of the adjacent left inner lens 32. Further, since the illuminating light is diffused from this condensing point, it can be prevented from interfering the opening edge of the left inner lens 32 to become an obstacle of light irradiation.

[0028] On the other hand, in the sideward illuminating region A3L1, A3L2 formed of each the left and right peripheral areas of the left inner lens 32, the light introduced from the inner periphery 33b of the light guiding concave area 33 of the inner lens 32 is reflected as the parallel light along the optical axis Ox by the rotary parabolic shape of the outer periphery 35a of the sideward illuminating region A3L1, A3L2 and guided through the inner lens 32. In the left peripheral area serving as the first sideward region A3L1, the light reflected on the outer periphery 35a is reflected rightward within a range of about 45° to 90° with respect to the optical axis Ox by a convex reflecting face 35h. The light reflected is once condensed and thereafter ejected as diffused light rightward of the motor vehicle. In the right peripheral area serving as the second sideward illuminating region A3L2, the light reflected on the outer periphery 35a is reflected on the convex reflecting face 35g and refracted at an opening edge outer face 36a to be once condensed, and thereafter is ejected as diffused light rightward of the motor vehicle within a range of about 15° to 55° with respect to the optical axis Ox. In this case also, the illuminating light, when reflected on the convex reflecting face 35g, is once condensed and refracted by the opening edge outer face 36a. For this reason, the light condensing point of the light once condensed can be located forward of the opening edge of the adjacent right inner lens 31. Further, since the illuminating light is diffused from this condensing point, it can be prevented from interfering the opening edge of the right inner lens 31 to become an obstacle of light illumination.

[0029] In this way, when the light emitting elements 21 each is caused to emit light with a low luminous intensity in order that the tail & stop lamp T&SL serves as a tail lamp, the light is distributed rearward of the motor vehicle by the light ejected from the central forward illuminating region A0, inner belt forward illuminating region A1 and peripheral forward illuminating region A2. The light is also distributed rightward of the motor vehicle within a range to about 90° by the light ejected from the first sideward illuminating region A3R1, A3L1 formed of the right/left peripheral area of the inner lens 31, 32. Further, the light is also distributed leftward of the motor vehicle within a range to about 55° by the light ejected from the second sideward illuminating region A3R2, A3L2. Thus, the light distribution required by the tail lamp can satisfactorily realized.

[0030] Further, when the light emitting elements 21 each is caused to emit light with a high luminous intensity in order that the tail & stop lamp T&SL serves as a stop lamp, the light is distributed rearward of the motor vehicle by the light ejected from the central forward illuminating region A0, inner belt forward illuminating region A1 and peripheral forward illuminating region A2. In this case also, the light rightward of the motor vehicle within a range to about 90° and leftward of the motor vehicle within a range to about 55° by the light ejected from the first and second sideward illuminating regions A3R1, A3R2; A3L1, A3L2 formed of the right/left peripheral areas of the inner lens 31, 32. Thus, the light distribution required by the stop lamp can satisfactorily realized.

[0031] The above explanation was given of the right tail & stop lamp. However, regarding the left tail & stop lamp, it is needless to say that by forming the shape of the inner lenses horizontally symmetrically, the light can be distributed leftward of the motor vehicle within a range to about 90° and rightward of the motor vehicle within a range to about 55°.

[0032] Now, in the first embodiment, it should be noted that the wall thickness size of the opening edge in the sideward illuminating region of the right/left peripheral area of the inner lens 31, 32 has allowances made larger by a required size toward both sides than the light flux width of the parallel light reflected from the outer periphery 35a of the rotary parabolic shape. Fig. 5A is an enlarged sectional view of a part of the first sideward illuminating region, now, a part of the left first sideward illuminating region A3L1 of the left inner lens 32. The allowances are provided considering that as shown in Fig. 5A, a recession CR called "cutter R" is created at the opening edge in resin-molding the cylindrical face 35e and convex reflecting face 35h of the inner lens 32 using a resin molding die. This recession CR is probably attributed to the machining accuracy of the corner in die manufacturing and so-called "Sink Marks" created during the resin molding. If this recession CR is generated, the shape at the tip side of the cylindrical face 35e formed at the opening edge collapses so that the reflection cannot be done as designed on the entire convex reflecting face 35h, thereby affecting the light distribution. Referring to Fig. 5A, if the recession CR as indicated by solid line is created against the designed shape of the convex reflecting face 35h as indicated by broken line, the light guided toward the area indicated by broken line will not be suitably reflected on the convex reflecting face 35h, thus leading to loss of the light distribution. So, as shown in Fig. 5B, an allowance M having a predetermined size D1 is provided on each of both sides against the necessary solid thickness D0 of the inner lens 32. By providing this allowance M, even if the recession CR due to the cutter R is generated so that the shape at the tip of the convex reflecting face 35h collapses, the parallel light incident on the convex reflecting face 35h will not enter the recession CR. Thus, the entire light is reflected on the convex reflecting face 35h so that the light distribution will not be affected. The allowance M differs according to the resin material of the inner lens and size of the convex reflecting face at the opening edge, but generally, assuring about 0.5mm is effective. This configuration can be likewise applied to the other opening edge of the inner lens 31, 32.

<Second Embodiment>

[0033] Fig. 6A is a sectional view of an inner lens 31A according to a second embodiment of this invention. In the second embodiment, the invention is applied to the stop lamp. In the stop lamp, it is required that the light is applied within ranges of about 45° each horizontally with respect to the optical axis. The construction of the central forward illuminating region A0 and inner belt forward illuminating region A1 of the inner lens 31 is the same as that in the first embodiment. Further, the construction of the peripheral forward illuminating region A2 formed at each the upper and lower parts of the inner lens is also the same as in the first embodiment. However, it should be noted that the concrete shape is slightly different from that in the first embodiment. Namely, although this embodiment is the same as the first embodiment in their basis configuration, but is different from the first embodiment in that as described below referring to Fig. 6B, the direction of the illuminating light is directed toward horizontally opposite directions with respect to the optical axis Ox. Like portions indicated by the like reference symbols in the first embodiment will not be explained. In this embodiment, the sideward illuminating region A3 formed at the right/left peripheral area of the inner lens is so constructed that the outer periphery 37a and inner periphery 37b at the peripheral area are formed in a simple parallel conical face and the light is reflected on these conical faces 37a, 37b so as to be guided through the interior of the peripheral area. Further, the inner periphery 37b is extended to the opening edge whereas the outer periphery 37a is not extended; an ejecting face 37c having a peripheral angle crossing the inner periphery 37b with a large angle is provided so that at the opening edge, the light reflected on the inner periphery 37b is ejected outwardly without being fully reflected.

[0034] In this way, as seen from Fig. 6B, the light ejected from the light emitting element 21 is applied forward of the lamp within ranges of about 20° each horizontally with respect to the optical axis in the central forward illuminating region A0 and inner belt forward illuminating region A1 and peripheral forward illuminating region (not shown) of the inner lens 31 as in the first embodiment. On the other hand, in the sideward illuminating region A3 of the inner lens 31A, the light introduced in the inner lens 31A, while being repeatedly fully reflected on the outer periphery 37a and inner periphery 37b, is guided through the interior of the inner lens 31A. The light, thereafter, is reflected at the opening edge by the inner periphery 37b and refracted on the ejecting face 37c and resultantly applied toward the directions of 45° each horizontally with respect to the optical axis Ox. Thus, the light is applied rearward of the vehicle within ranges of 45°, thereby satisfying the required light distribution.

[0035] Now, it should be noted that in the first embodiment, the sectional shape of the inner periphery 33b of the light guiding concave area 33 of the inner lens 31, 32 is formed in a convex shape for the light emitting element 21, i.e. light source. Likewise, in the second embodiment also, the sectional shape of the inner periphery 33b of the light guiding concave area 33 of the inner lens 31A is formed in a convex shape for the light emitting element 21 serving as the light source. In such a configuration, the light ejected from the light emitting element 21 is guided with high efficiency through the interior of the inner lens 31, 32, 31A so that the illuminating luminous intensity can be enhanced and the illuminating range can be widened with the same luminous intensity.

[0036] For example, regarding the inner lens 31A according to the second embodiment, referring to Fig. 7A, of the light ejected from the light emitting element 21, the light ejected at a large angle with respect to the optical axis Ox is incident on the inner periphery 33b. The inner periphery 33b is convex in section, now formed in an arc section having a radius slightly larger than a radius of curvature with the focal point located at the light emitting point of the light emitting element 21 so that the light incident on the inner periphery 33b is condensed and guided through the inner lens 31A. In this case, the light ejected from the light emitting element 21 is restricted in its degree of diffusion on the inner periphery 33b to provide light rays approximate to the parallel light on any plane passing the optical axis, which results in wholly conical illuminating light. Thus, the projecting angle (incident angle) to the inner periphery of the inner lens 31A becomes large so that the rate of the light reflected on each the outer periphery 37a and inner periphery 37b at the peripheral area of the inner lens 31A is become high, thereby increasing the light guiding efficiency. Accordingly, the light guiding efficiency of the light guided to the sideward illuminating region A3 of the inner lens 31A is enhanced so that the quantity of light ejected from the sideward illuminating regionA3 increases. As a result, the illuminating luminous intensity around the optical axis Ox, as seen from the lower stage of Fig. 7A, has a characteristic that an illuminating area S1 until the peak value of the luminous intensity becomes half covers a wide range, thereby permitting a wide area to be illuminated with high luminous intensity.

[0037] On the other hand, it is assumed that as shown in Fig. 7B, the inner lens 31B is designed in which the inner periphery 33b of the light guiding concave area 33 is formed in a concave face. In this case, of the light ejected from the light emitting element 21, the light ejected at a large angle with respect to the optical axis Ox is incident on the inner periphery 33b. The inner periphery 33b is formed in an concave arc in section so that the light incident on the inner periphery 33b is increased in its degree of diffusion and guided into the inner lens 31B. Thus, the projecting angle (incident angle) to the inner periphery of the inner lens 31B becomes small so that the light leaking from the outer peripheries 34b and 37a of the inner lens 31B increases and the rate of the light reflected on the inner peripheries of the inner lens 31B become low, thus attenuating the light guiding efficiency. Accordingly, the quantity of light guided to the sideward illuminating region A3 of the inner lens 31B decreases so that the quantity of light ejected from the sideward illuminating region A3 in the front direction decreases. As a result, in the inner lens 31B, the illuminating luminous intensity around the optical axis Ox, as seen from the lower stage of Fig. 7(b), has a characteristic that an illuminating area S2 until the peak value of the luminous intensity becomes half covers a narrower range than that of the inner lens 31A so that the wide area cannot be illuminated with high luminous intensity.

<Third Embodiment>

[0038] In the tail & stop lamp T&ST according to the first embodiment, on the flat plate area 30 which integrates the inner lenses 31 and 32, it is difficult for the light to be guided to the area between the inner lenses 31 and 32 so that this area is darker than the area of the inner lens 31, 32. Therefore, the light emitting area of the tail & stop lamp T&SL is correspondingly reduced so that visibility of the lamp attenuates. In the third embodiment, as shown in Fig. 8, in the area adjacent to each the inner lenses 31 and 32 of the tail & stop lamp T&SL, a sub-light-emitting region A4 is formed. In Fig. 8, like reference symbols refer to like parts in Fig. 1. Now, in the region of the flat plate area 30 sandwiched by the inner lenses 31 and 32 which are disk-shaped, the sub-light-emitting region A4 is formed in a spool shape, whereas in the peripheral area of the tail & stop lamp T&ST, it is formed in a spool-shape which is vertically half-cut.

[0039] Fig. 9A is a sectional view taken in line IX-IX in Fig. 8 in which like reference symbols refer to like parts in the first embodiment. The flat plate area 30 between the inner lenses 31, 32 adjacent in an oblique direction when viewed from the front connects the sideward illuminating regions A3 of both inner lenses to each other; in an inner face of the sub-light emitting region A4, which is square or triangular, partitioned by the flat plate area 30 at the connecting portion, sub-lens steps 30a which are step-like in section is formed. The sub-lens steps 30a have a pattern in which a plurality of analogous spool shapes or their half-cut shapes having different sizes from viewed from the front are arranged coaxially. The wall thickness of the flat plate area 30 is made stepwise smaller at a position farther from each inner lens 31, 32 to provide reflecting faces 30b between the respective steps each having a slope inclined with respect to the optical axis Ox. Further, correspondingly, at a part of the sideward illuminating region A3 of the inner lens 31, 32, i.e. in each the peripheral areas opposite to the above sub-light-emitting region A4, a sideward step 30c is formed which is a tapered face whose outer face is tiled inwardly.

[0040] In the third embodiment, as shown in Fig. 9B, a part of the light ejected from the light emitting element 21 and guided through the inner lens 31, 32 to the sideward illuminating region A2 is reflected on the inner face of the sideward step 30c at about 90° with respect to the optical axis Ox and guided toward the flat plate area 30 connecting the inner lenses 31, 32. The light guided to the flat plate area 30 is reflected on each the reflecting faces 30b of the sub-lens steps 30a and ejected forward along the optical axis Ox from the front of the flat plate area 30. Thus, when the tail & stop lamp T&SL is turned on, the inner lens 31, 32 emits light and also the sub-light-emitting region A4 is placed in a light emitting state by the light guided through the inner lens 31, 32.
Accordingly, the entire light emitting area of the tail & stop lamp T&SL is enlarged to improve the visibility of the lamp.

[0041] In the first, second and third embodiments, the inner lens 31, 32 is formed in a bowl shape which is disklike when viewed from the front; however it can be constructed as an inner lens formed in a square or polygonal bowl-shape, i.e. a pyramid shaped vessel. For example, as shown in Fig. 10, the inner lenses 31c, 32C each being hexagonal in its front shape are arranged as cells and in the flat plate area 30 between the inner lenses 31C and 32C, sub-light emitting regions A4 are arranged. In this case, the shape of the sub-light-emitting region A4 is rhombic or triangular when the rhombus is half-cut. The hexagonal inner lens 31C, 32C can be made by circumferentially arranging the reflecting faces each being inverted-triangular to provide a shape of square petals. The sectional shape of the inner lens 31, 32 is nearly the same as that of the inner lens 31, 32 in the first embodiment.

[0042] Now, the front shape of the sub-lens steps constituting the sub-light emitting region A4 (lens steps indicated by 30a in Figs. 9A, 9B), as shown in Fig. 10, may be horizontally grid-like pattern in which steps extending horizontally are vertically arranged. Otherwise, although not shown, it may be a pattern in which a plurality of steps are arranged as dots. Further, the sectional shape of the sub-lens step, as shown in Fig. 11A, may be a sub-lens step 30d with a plurality of V-grooves formed on the inner face of the flat plate area 30 or a sub-lens step 30e with a plurality of arc-grooves formed thereon.

[0043] In the first and second embodiments, the sideward region ranging from 45° to 90° is illuminated as the first sideward illuminating region and the sideward region ranging from 15° to 55° is illuminated as the second sideward illuminating region. However, the angular range of these illuminating regions can be appropriately changed according to the light distribution required of the lamp. This can be realized by appropriately changing the shape of the convex reflecting face formed at the opening edge of the sideward illuminating region. Further, in each of the embodiments, the LED was employed as the light source but the other light emitting element such as a laser diode and further this invention can be also applied to the lamp using a light bulb as the light source.

<Industrial Applicability>

[0044] This invention can be applied to various lamps for vehicles not limited to a lamp for a motor vehicle as long as it is a lamp requiring that the light ejected from a light source through a single lens is applied forward of the lamp and also applied in a wide sideward range.

<Description of Reference Numerals and Signs>

[0045]

1	lamp housing
2	light source
3	composite inner lens
11	lamp body
12	front lens
21	light emitting element
22	circuit board
30	flat plate area
31, 32	inner lens
31C, 32C	inner lens
A0	central forward illuminating region
A1	inner belt forward illuminating region
A2	peripheral forward illuminating region
A3	sideward illuminating region
A3R1,	A3L1first sideward illuminating region
A3R2,	A3L2second sideward illuminating region
A4	sub-light-emitting region

Claims

1. A vehicle lamp comprising:

a light source (21); and
a lens (31, 32, 31A, 32A), wherein the lens (31, 32, 31A, 32A) is formed in a bowl shape having a central bottom (34a) faces to the light source (21),
wherein the lens (31, 32, 31A, 32A) includes:

a forward illuminating region (A0, A1, A2) positioned on the bottom (34a) and a part (34c, 34d, 35d, 30c) of peripheral regions of the lens and configured to irradiate a part of a light from the light source (21) in a forward direction along an optical axis (Ox) of the lamp; and
a sideward illuminating region (A3) positioned on an another part (35f, 35g, 35h, 37c) of the peripheral regions of the lens and configured to irradiate an another part of the light from the light source (21) in a sideward direction of the lamp.

2. The vehicle lamp according to claim 1, wherein the lens (31, 32, 31A, 32A) has four regions including upper, lower, right and left regions when viewed from a front side of the lamp,
wherein the upper and lower regions (A2) are configured as said forward illuminating region, and
wherein the right and left regions (A3) are configured as said sideward illuminating region.

3. The vehicle lamp according to claim 1 or 2, wherein the sideward illuminating region (A3) includes a reflecting face (35f, 35g, 35h, 37c) which guides the light from the light source through the lens while internally reflecting the light, and the light is reflected in the sideward direction on the reflecting face (35f, 35g, 35h, 37c) provided at a lens opening edge of said another part of the peripheral regions.

4. The vehicle lamp according to claim 3, wherein the sideward illuminating region (A3) includes:

a first sideward illuminating region (A3R1, A3L1) configured to irradiate the light in a range to at least 80° sideward on one side or the other side with respect to the optical axis (Ox) of the lamp; and
a second sideward illuminating region (A3R2, A3L2) configured to irradiate the light in a range to at least 45° sideward on said one side with respect to the optical axis (Ox) of the lamp.

5. The vehicle lamp according to claim 3 or 4, wherein a wall thickness of said opening edge of the lens is larger than a light flux width (D0) of the guided light by a required dimension (D1) toward both sides.

6. The vehicle lamp according to any one of claims 1 to 5,
wherein the lens (31, 32, 31A, 32) further includes a light guiding concave area (33) for guiding the light from the light source (21) to the lens, and
wherein the light guiding concave area (33) includes a light incident face (33b) configured to guide the light to the sideward illuminating region (A3) and formed as a convex face.

7. The vehicle lamp according to any one of claims 1 to 6,
wherein said lens (31, 32, 31A, 32) is one of a plurality of lenses that configure a composite lens (3) in which the plurality of lenses (31, 32, 31A, 32) are arranged lengthwise and breadthwise when viewed from the front side of the lamp and are unified through a flat plate area (30), and
a sub-light-emitting region (A4) configured to reflect a part of the light guided through the lens in the forward direction is provided on the flat plate area (30).

FIG. 1

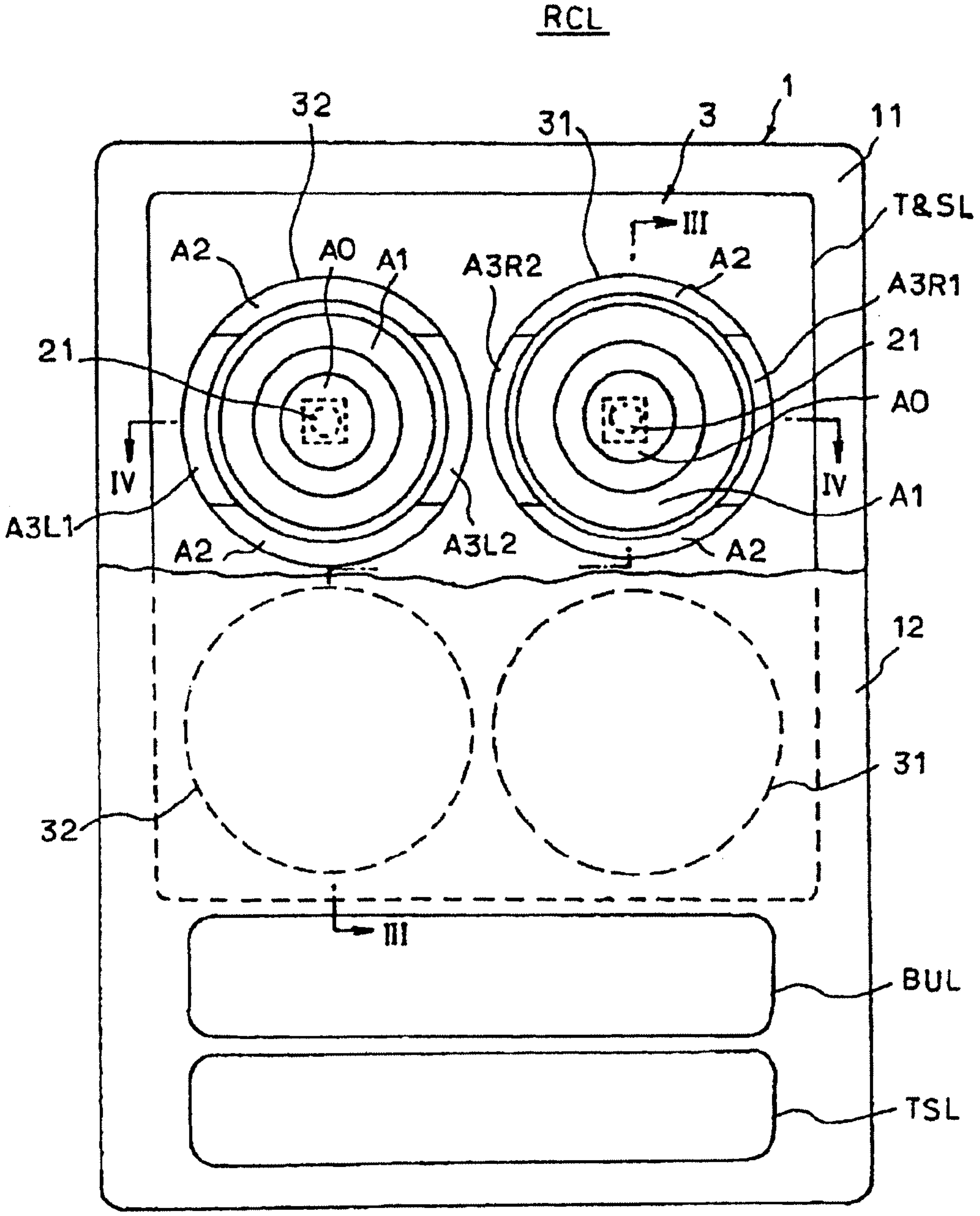

RCL
1
11
3
31
32
T&SL
III
A2
A0
A1
A3R2
A3R1
21
IV
A3L1
A3L2
12
BUL
TSL

FIG. 2

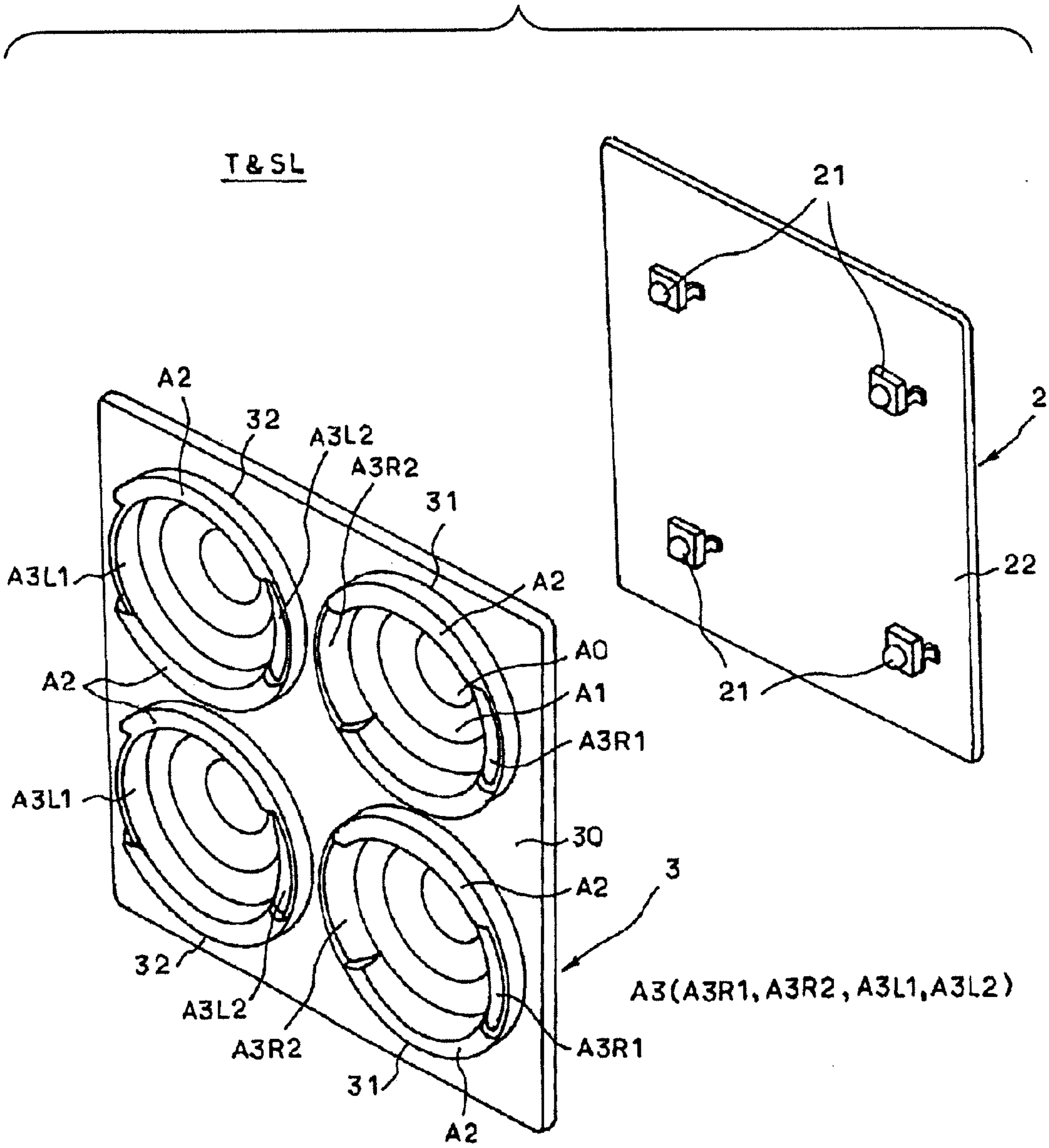

T & SL
21
21
2
22
A2
32
A3L2
A3R2
31
A3L1
A2
A0
A2
A1
A3R1
A3L1
30
A2
3
32
A3L2
A3R2
31
A2
A3R1
A3(A3R1, A3R2, A3L1, A3L2)

FIG. 3A

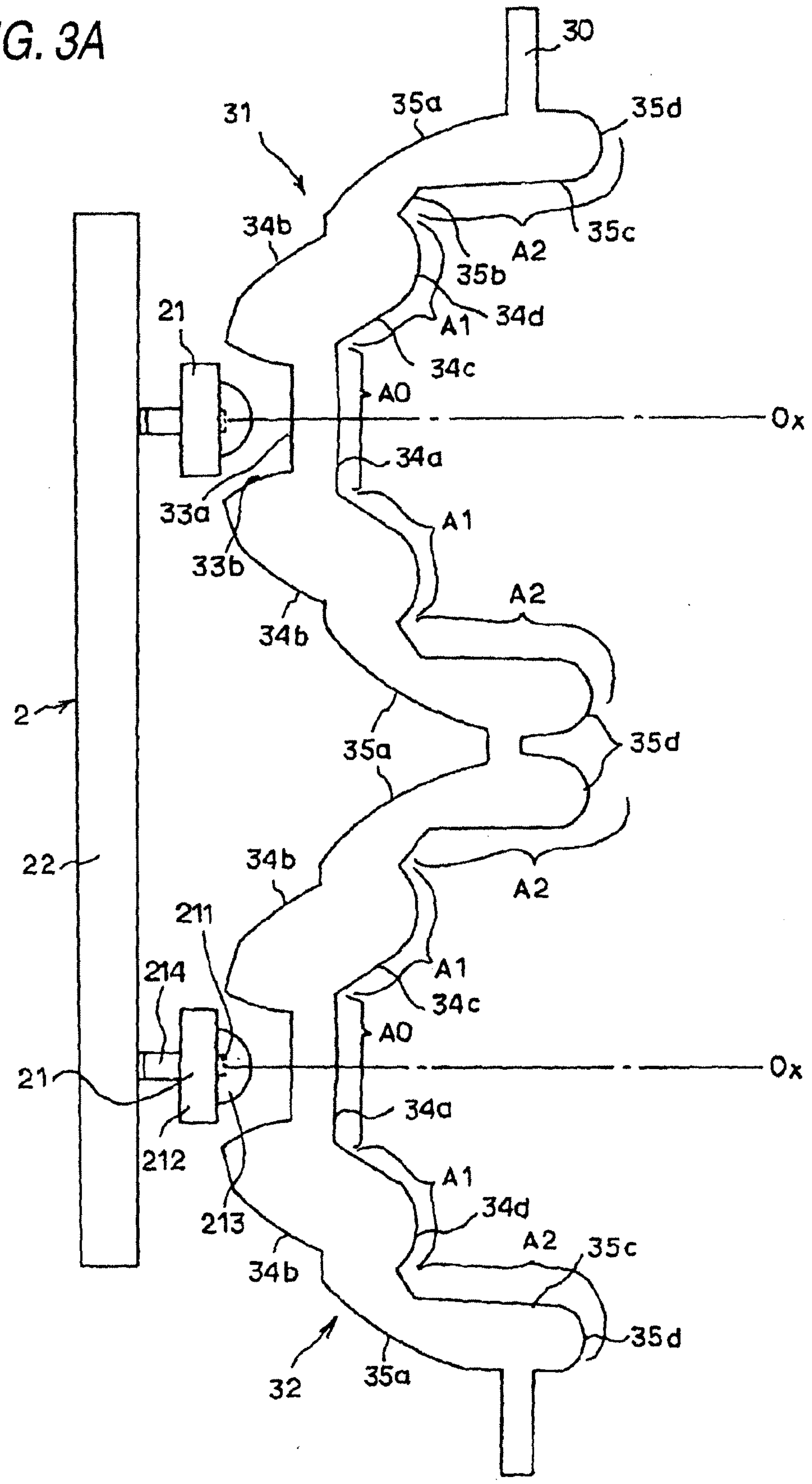

30
31
35a
35d
35c
34b
A2
35b
34d
A1
21
34c
A0
Ox
34a
33a
A1
33b
A2
34b
2
35a
35d
22
34b
A2
211
A1
214
34c
A0
Ox
21
34a
212
A1
34d
213
A2
35c
34b
35d
32
35a

FIG. 3B

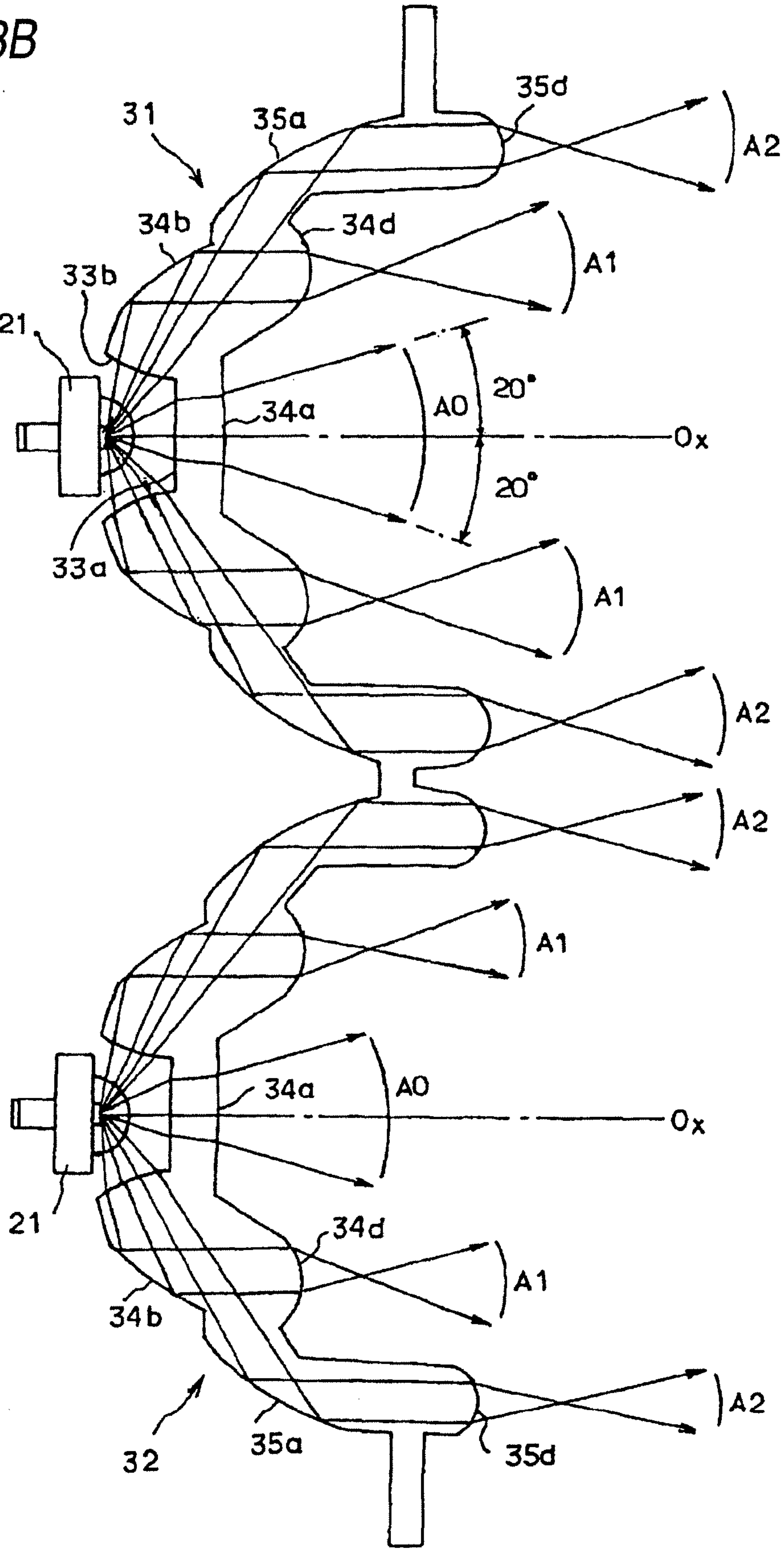

31
35a
35d
A2
34b
34d
A1
33b
21
A0
20°
34a
Ox
20°
33a
A1
A2
A2
A1
A0
34a
Ox
21
34d
A1
34b
A2
32
35a
35d

FIG. 4A

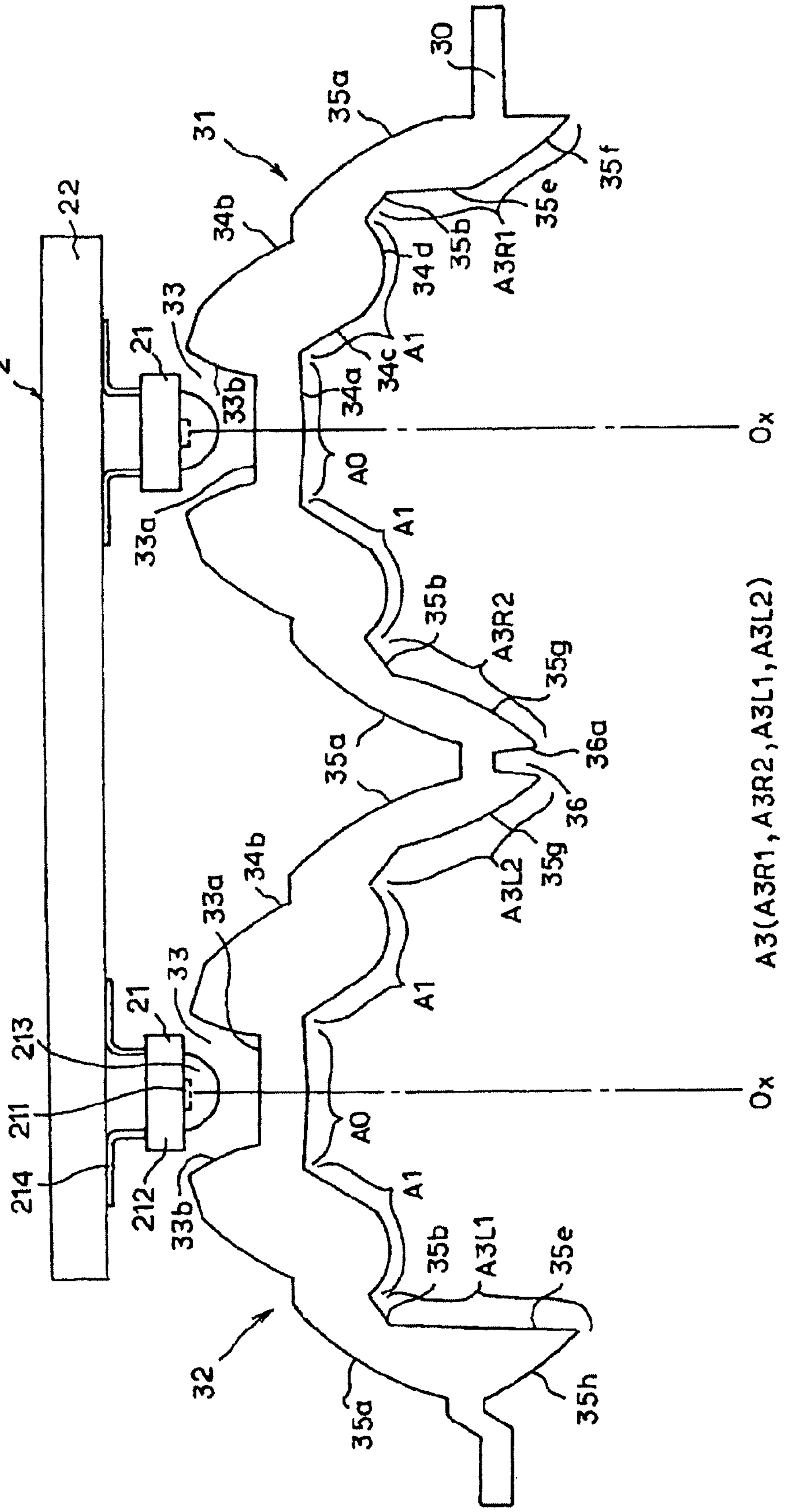
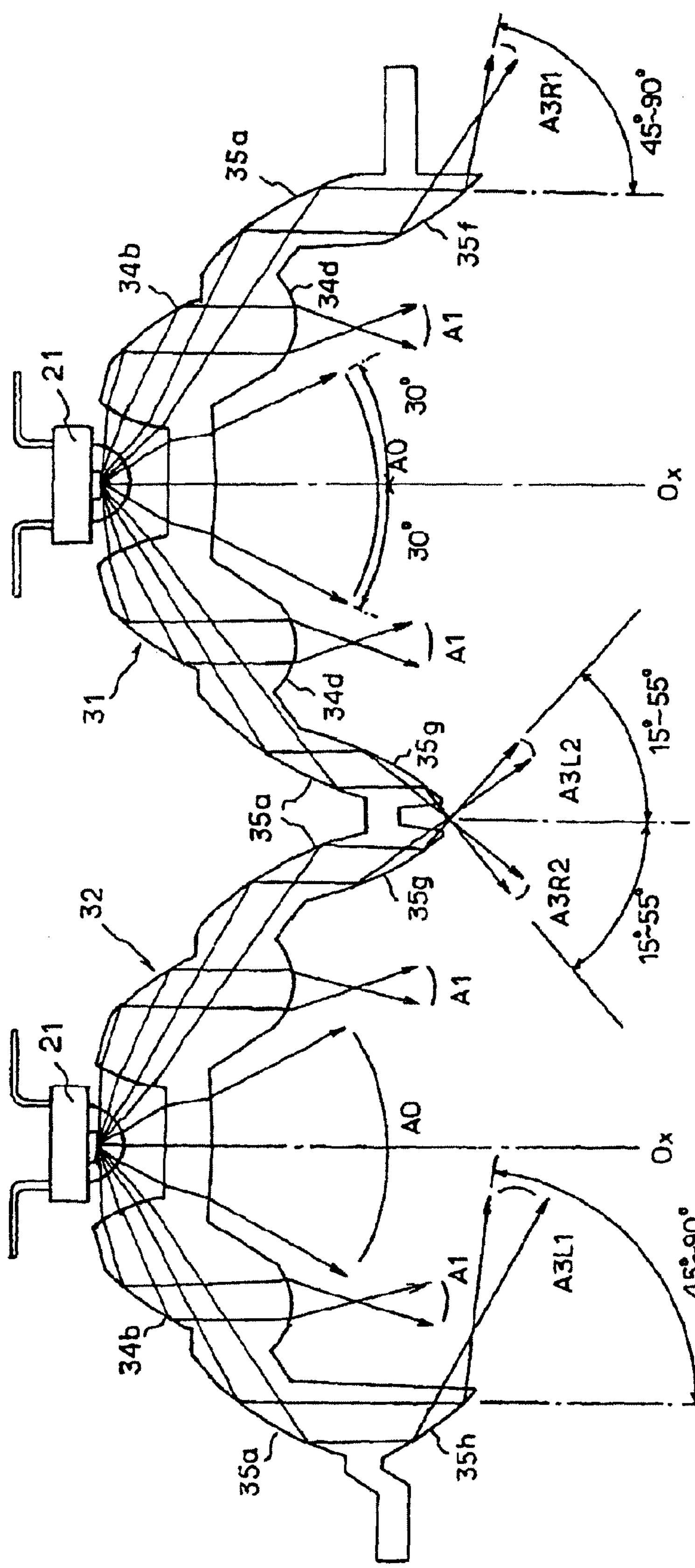

2
22
21
33
33a
33b
34a
34b
34c
34d
35a
35b
35e
35f
35g
35h
36
36a
30
31
32
211
212
213
214
A0
A1
A3R1
A3R2
A3L1
A3L2
Ox
A3(A3R1, A3R2, A3L1, A3L2)

FIG. 4B


21
21
31
32
34b
34b
34d
34d
35a
35a
35a
35f
35g
35g
35h
A0
A0
A1
A1
A1
A1
30°
30°
A3R1
45°~90°
A3L1
45°~90°
A3L2
15°~55°
A3R2
15°~55°
Ox
Ox

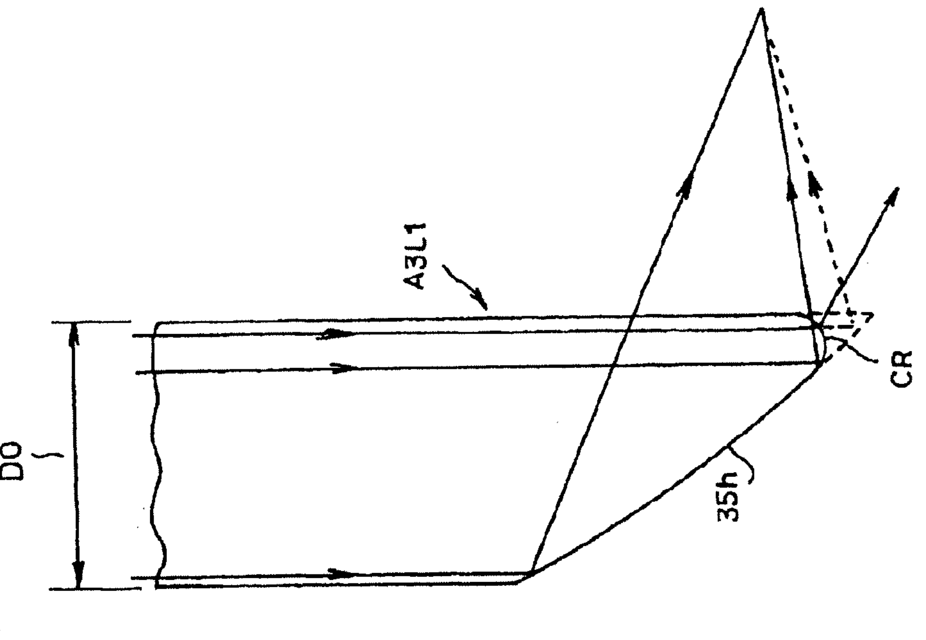


FIG. 5A

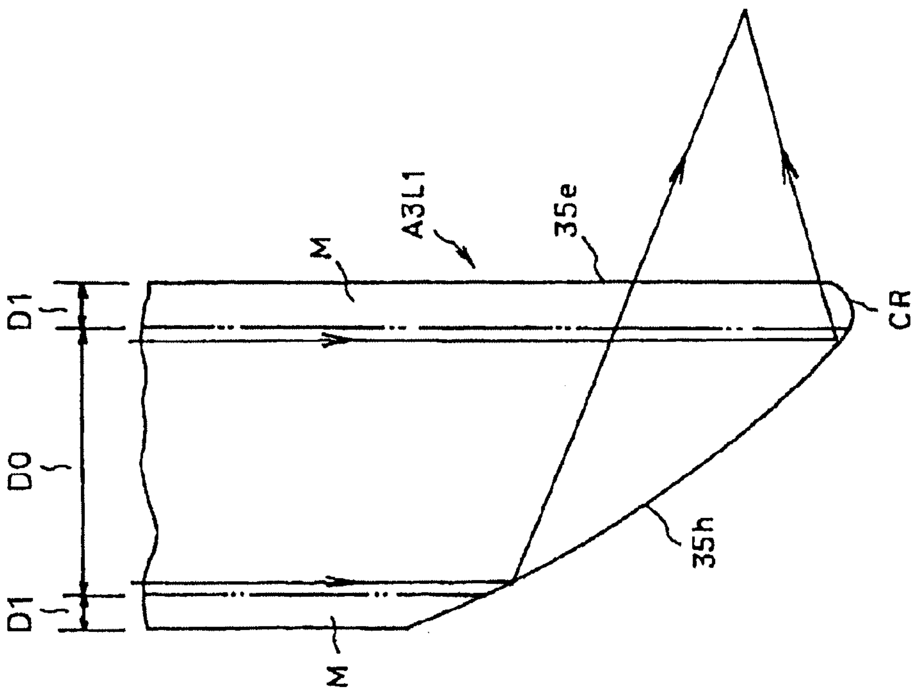


FIG. 5B

FIG. 6A

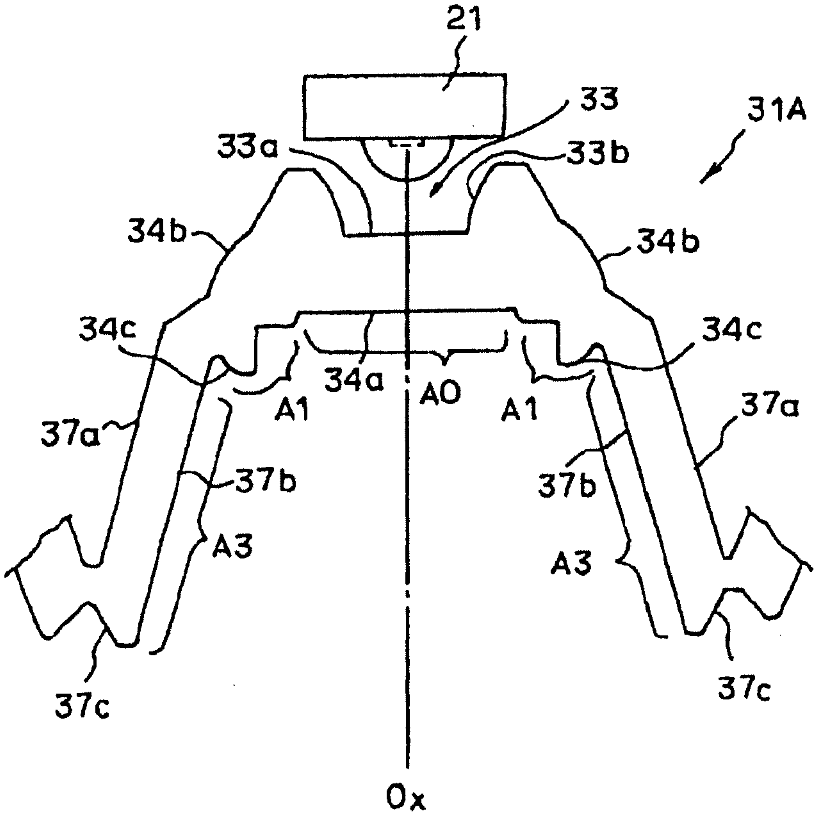

21
33
31A
33a
33b
34b
34b
34c
34c
34a
A0
A1
A1
37a
37a
37b
37b
A3
A3
37c
37c
Ox

FIG. 6B

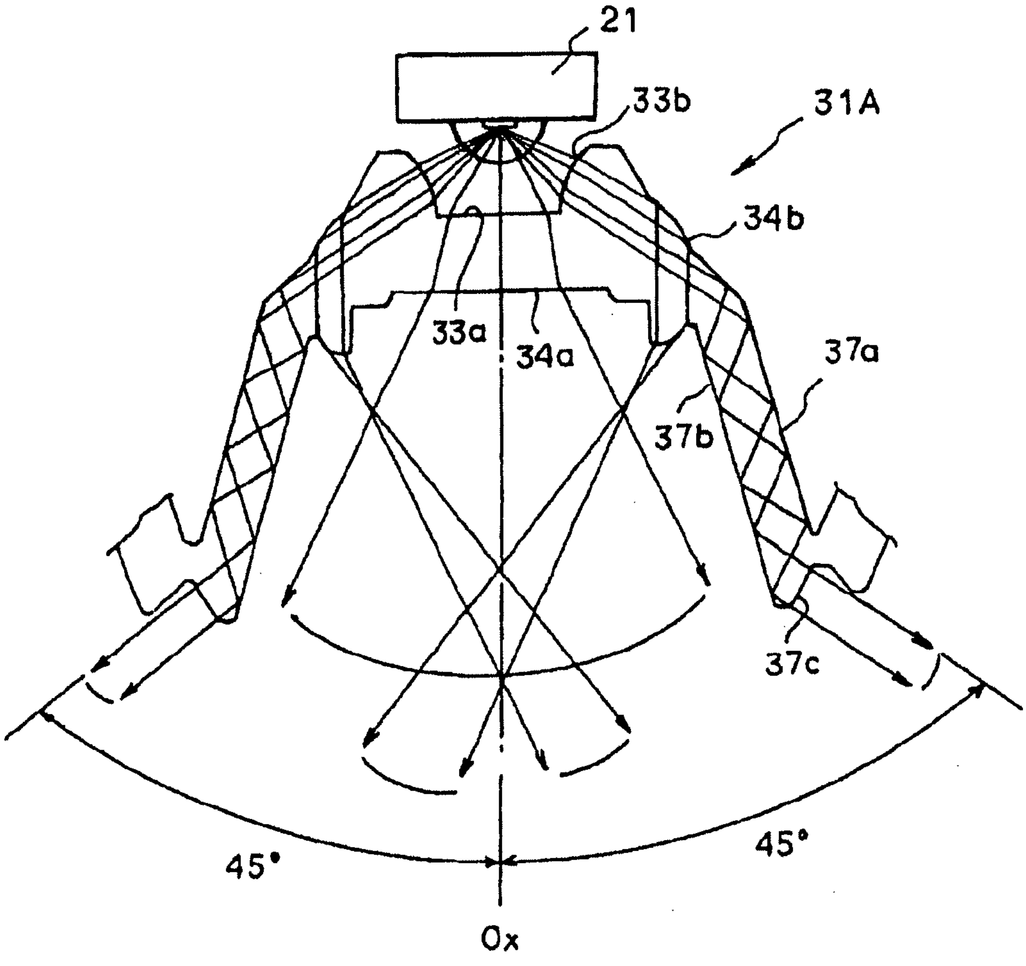


FIG. 7A

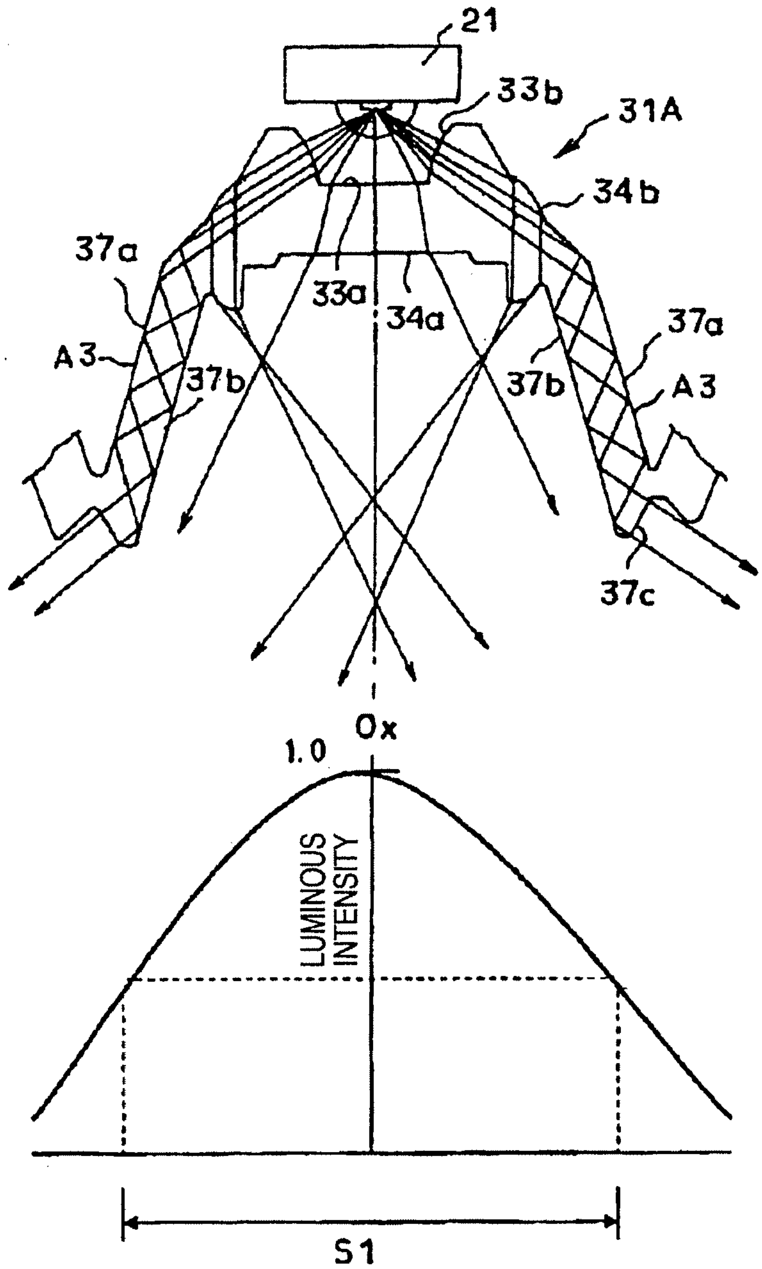

21
33b
31A
34b
37a
33a
34a
37a
A3
37b
37b
A3
37c
Ox
1.0
LUMINOUS INTENSITY
S1

FIG. 7B

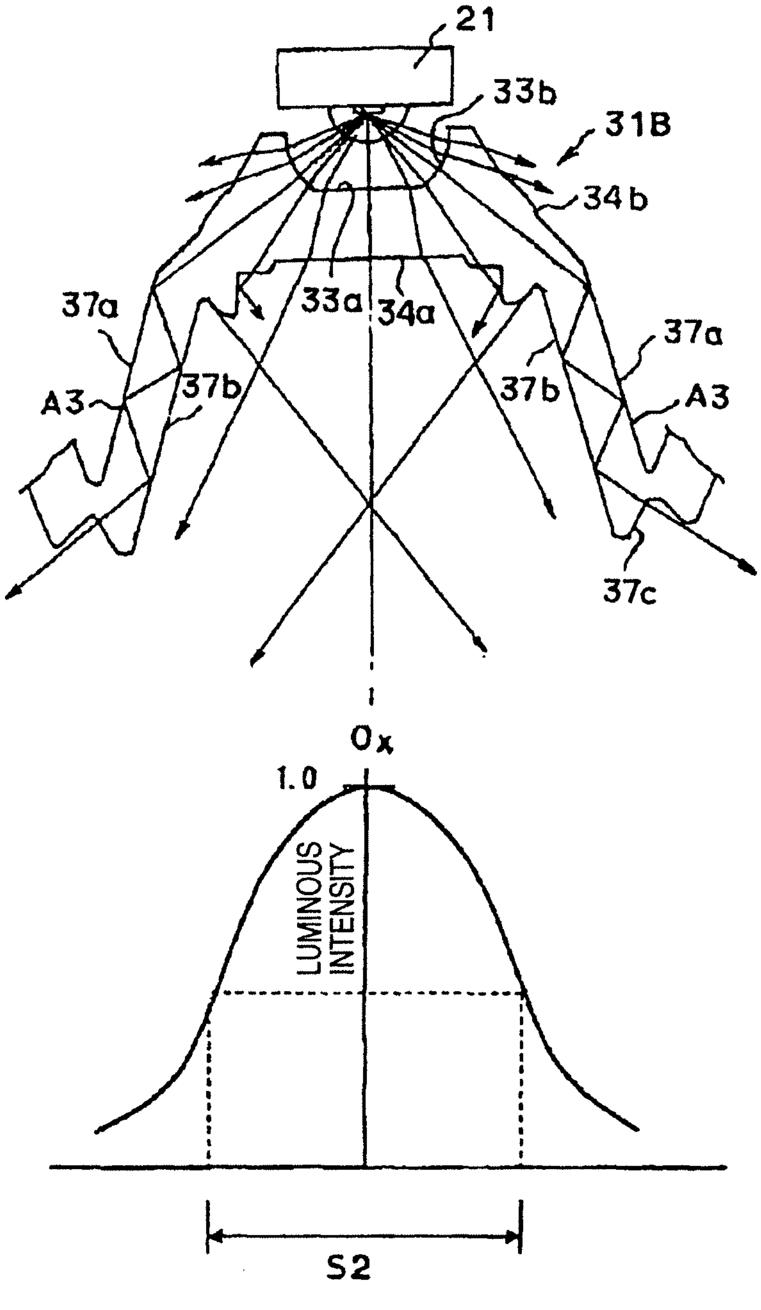

21
33b
31B
34b
37a
33a
34a
37a
A3
37b
37b
A3
37c
Ox
1.0
LUMINOUS INTENSITY
S2

FIG. 8

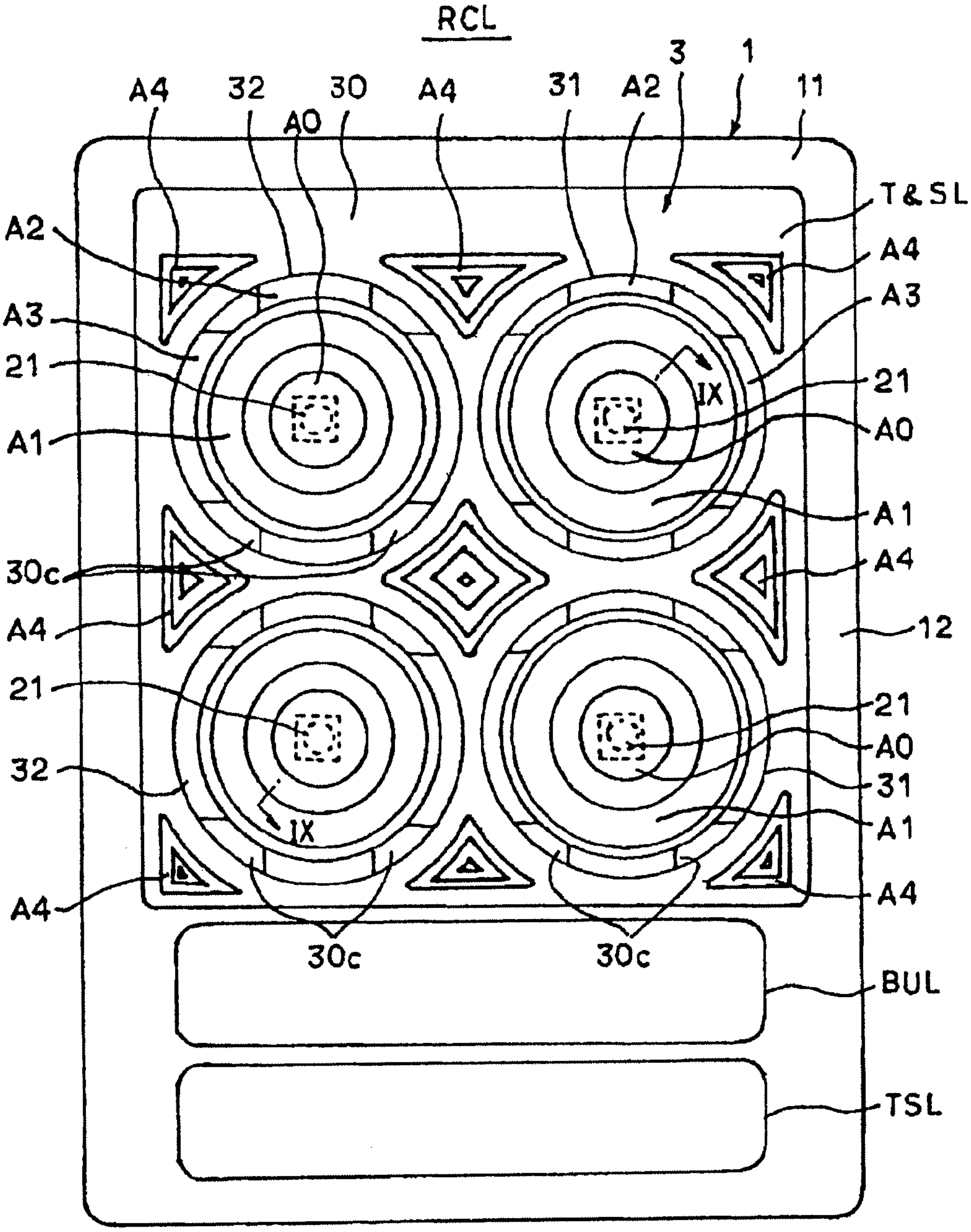

RCL
A4
32
30
A4
31
A2
3
1
11
A0
30
A2
T&SL
A4
A3
A3
21
21
IX
A0
A1
A1
30c
A4
A4
12
21
21
A0
32
31
IX
A1
A4
A4
30c
30c
BUL
TSL

FIG. 9A

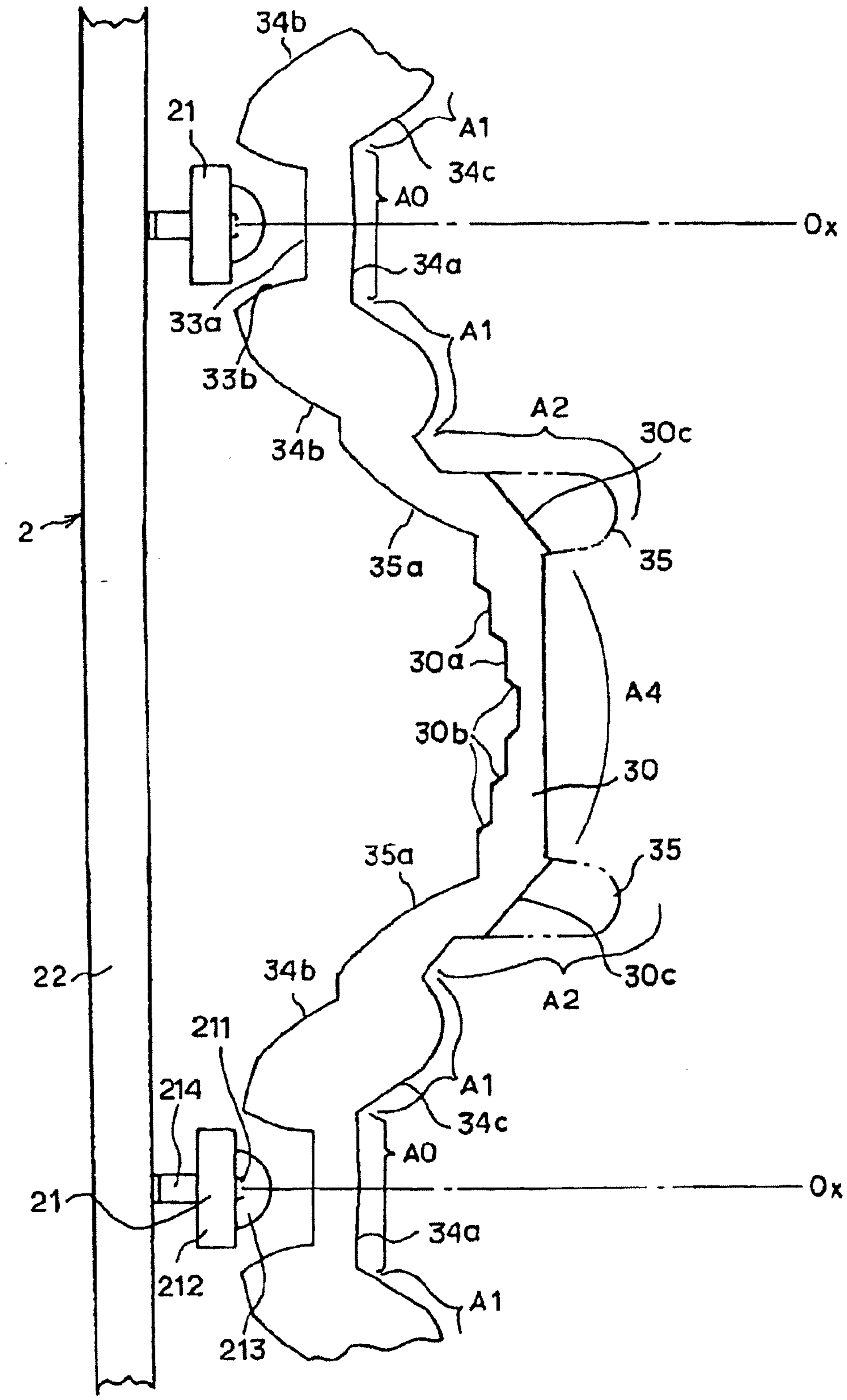

34b
21
A1
34c
A0
Ox
34a
33a
A1
33b
34b
A2
30c
2
35a
35
30a
A4
30b
30
35a
35
34b
30c
22
A2
211
214
A1
34c
A0
21
Ox
34a
212
A1
213

FIG. 9B

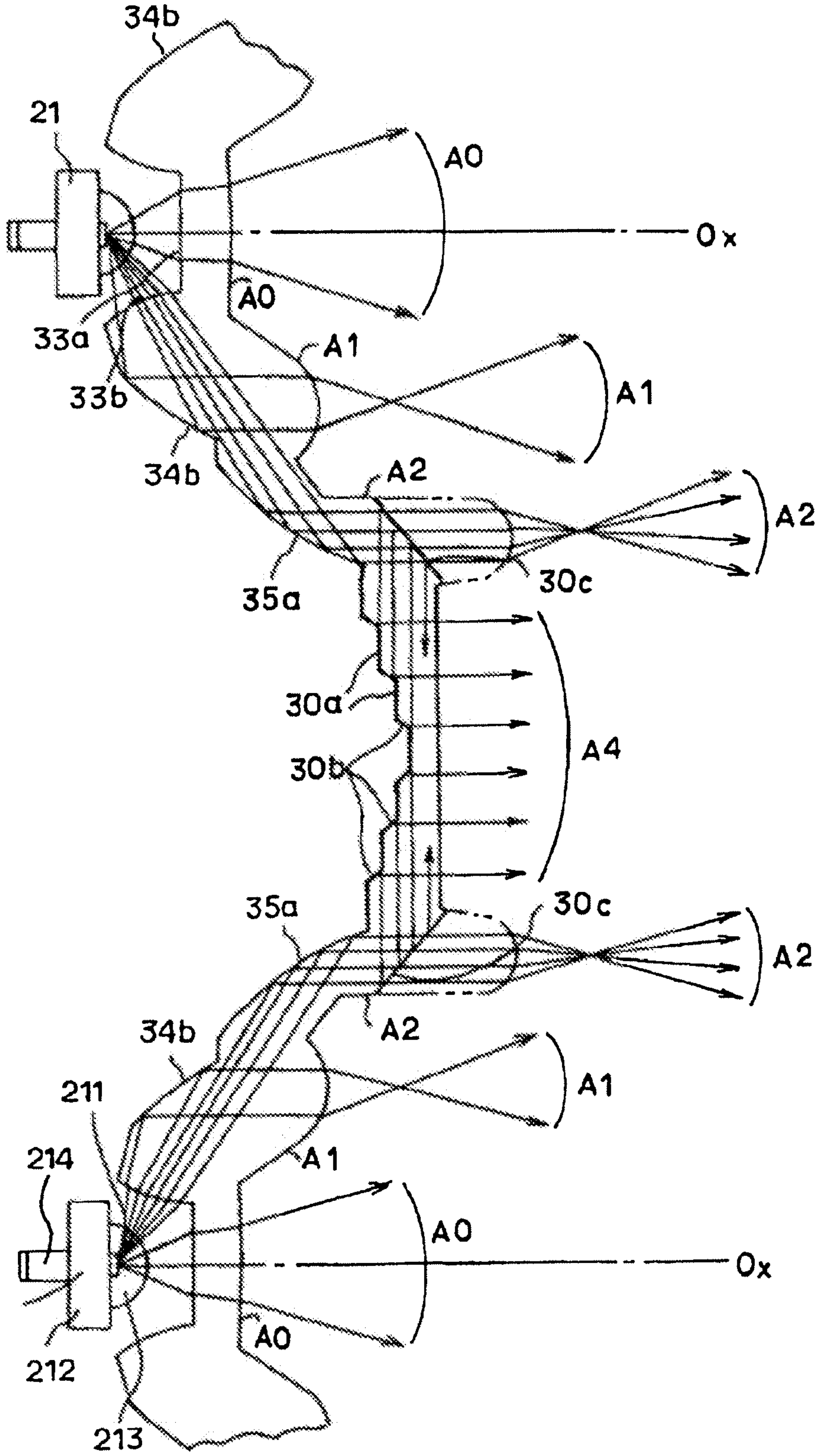

34b
21
A0
0x
A0
33a
A1
A1
33b
34b
A2
A2
35a
30c
30a
A4
30b
35a
30c
A2
34b
A2
A1
211
214
A1
A0
0x
A0
212
213

FIG. 10

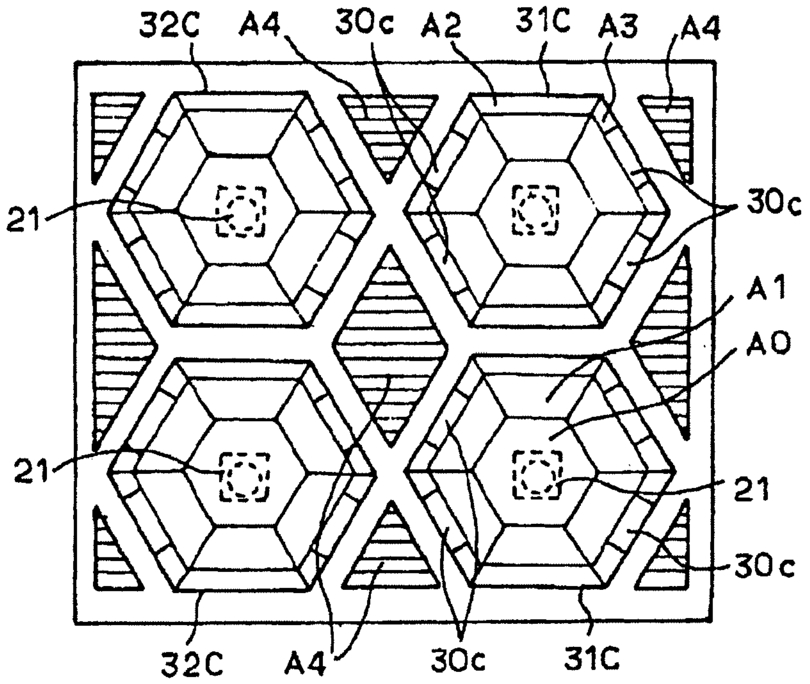


FIG. 11A

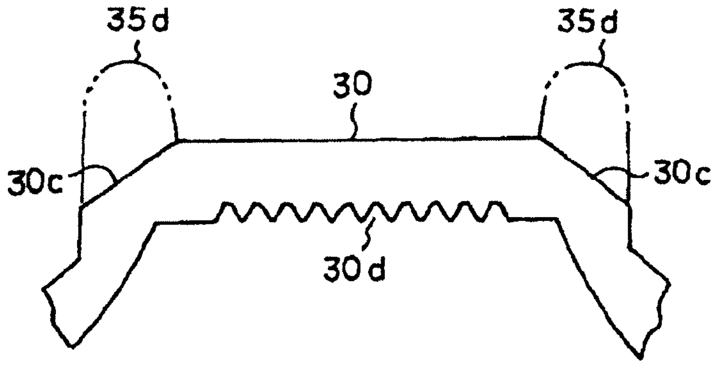
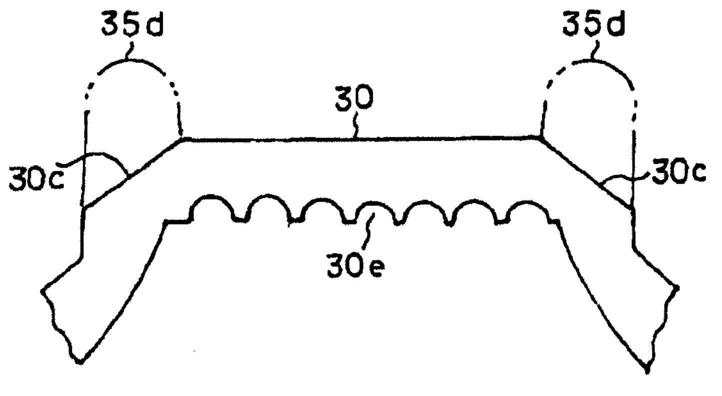


FIG. 11B



REFERENCES CITED IN THE DESCRIPTION

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- US 20060034094 A1 **[0002]**