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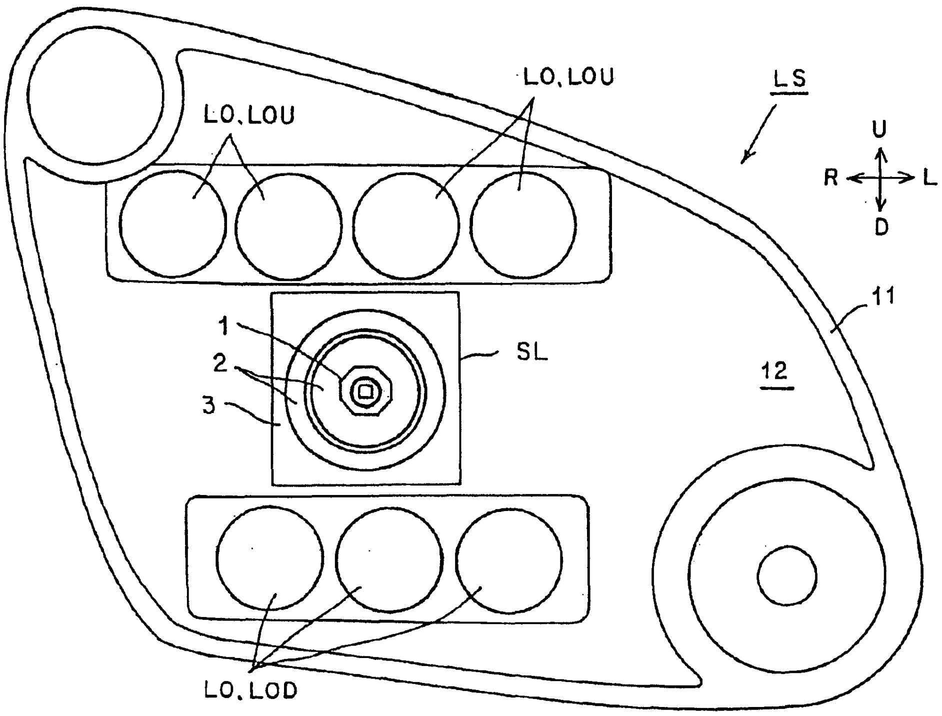
(54) **Vehicle lighting device and vehicle headlight unit including the lighting device**

(57) A vehicle lighting device includes a semiconductor light source (1) constituted of a rectangular light emitter (5) and a lens (2) constituted of a composite lens with multiple optical axes sharing a single focal point. The lens (2) emits a light from the rectangular light emitter (5) as a spot-type light distribution pattern extended in an arbitrary direction.

FIG.1



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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present document incorporates by reference the entire contents of Japanese priority document, 2005-024520 filed in Japan on January 31, 2005.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a vehicle lighting device that includes a semiconductor light-emitting device such as an LED or EL (including organic EL) as a light source, to thereby emit a spot-type light distribution pattern to be merged with a basic light distribution pattern emitted (irradiated, illuminated, projected) by a headlamp. The present invention also relates to a vehicle headlamp unit provided with the vehicle lighting device, so as to separately emit the basic light distribution pattern and the spot-type light distribution pattern and merge these patterns.

2. Description of the Related Art

[0003] The above vehicle lighting device and the vehicle headlamp unit including the lighting device (hereinafter referred to as "vehicle headlamp system") are known in the art. Examples of such a vehicle headlamp system can be found in Japanese Published Unexamined Patent Application 2004-71409 (hereinafter, " first publication") and in Japanese Published Unexamined Patent Application 2004-95480 (hereinafter, " second publication"). The vehicle headlamp systems in the first publication and the second publication have following characteristics. The vehicle headlamp system in the first publication includes a convex-type light emitter and a fan-type light emitter, both including a light emitting diode (LED) as a light source. The convex-type light emitter outwardly emits a spot-type light distribution. The fan-type light emitter outwardly emits a wide light distribution. Merging these light distributions provides a low-beam light distribution including a cut line. Even the vehicle headlamp system in the second publication utilizes the LED as the light source, and includes four types of lighting units. A first lighting unit outwardly emits a cutoff line forming pattern including a horizontal and an oblique cutoff line. A second lighting unit outwardly emits a generally semicircular hot zone forming pattern having a linear upper edge along the horizontal cutoff line. A third lighting unit outwardly emits a generally semicircular hot zone forming pattern having a linear upper edge along the oblique cutoff line. A fourth lighting unit outwardly emits a diffusion region forming pattern. Merging these four patterns provides a predetermined low-beam light distribution pattern.

[0004] In the vehicle headlamp system disclosed in the first publication, however, the convex-type light emitter is not provided with any other function but to simply outwardly emit only the spot-type light distribution, and in the vehicle headlamp system disclosed in the second publication, the second lighting unit and third lighting unit simply outwardly emit only the hot zone forming patterns, without any other function. Accordingly, in both the conventional vehicle headlamp systems, no spot-type light distribution or hot zone forming pattern extended in an arbitrary direction can be obtained.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to at least solve the problems in the conventional technology.

[0006] According to an aspect of the present invention, a vehicle lighting device that emits a spot-type light distribution pattern to be merged with a basic light distribution pattern emitted by a headlamp includes a semiconductor light source including a light emitter; and a lens that emits a light from the light emitter as the spot-type light distribution pattern. The spot-type light distribution pattern is formed of images in a shape of the light emitter extended in an arbitrary direction. The lens includes a composite lens with multiple axes sharing a single focal point formed by rotating a basic lens around a focal point of the basic lens or near the same so that an optical axis of the basic lens is distributed into a plurality of directions in which elongation of the shape of the light emitter is intended, cutting out corresponding parts from each of a plurality of the basic lenses, while using a fan at a maximum incidence angle of a light from the light emitter centered on the rotation center that has been divided into a plurality of parts according to a number of distributed optical axes of the basic lens as a template, and integrating the parts cut out from each of the basic lenses.

[0007] According to another aspect of the present invention, a vehicle headlamp unit that respectively emits a basic light distribution pattern and a spot-type light distribution pattern includes a headlamp that outwardly emits the basic light distribution pattern; and at least one vehicle lighting device that outwardly emit the spot-type light distribution pattern. The vehicle lighting device being the above vehicle lighting device. The basic light distribution pattern emitted from the headlamp is merged with the spot-type light distribution pattern emitted from the vehicle lighting device or vehicle lighting devices.

[0008] The other objects, features, and advantages of the present invention are specifically set forth in or will become apparent from the following detailed description of the invention when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a front view of a first embodiment of a vehicle headlamp system according to the present invention, with an outer lens removed;

Fig. 2 is a front view of a spot lamp unit, likewise;

Fig. 3 is a cross-sectional view along a line III-III of Fig. 2;

Fig. 4 is an explanatory drawing of a lens constituted of a composite lens with multiple optical axes sharing a single focal point and images of a light emitter of a semiconductor light source extended in the left and right direction obtained by the lens, likewise;

Fig. 5 is an explanatory drawing of a light distribution pattern obtained by the spot lamp unit, likewise;

Fig. 6A to Fig. 6B are explanatory drawings of lens configurations, likewise;

Fig. 7A to Fig. 7B are explanatory drawings of lens configurations, likewise;

Fig. 8 is a plan view of a lens, likewise;

Fig. 9 is a plan view of a modification of a lens, likewise;

Fig. 10 is a front view of a lens, likewise;

Fig. 11 is an explanatory graph of a passing light distribution pattern obtained by a headlamp unit, shown on a screen, likewise;

Fig. 12 is an explanatory graph of a spot-type light distribution pattern obtained by a spot lamp unit, shown on a screen, likewise;

Fig. 13 is an explanatory graph of an ideal passing light distribution pattern provided by merging the passing light distribution pattern obtained by a headlamp unit of Fig. 11 and the spot-type light distribution pattern obtained by a spot lamp unit of Fig. 12, shown on a screen, likewise;

Fig. 14A and Fig. 14B are explanatory drawings of a light incidence efficiency of an aspherical lens being a mere convex lens;

Fig. 15A and Fig. 15B are explanatory drawings of a light incidence efficiency and an image blur of an aspherical lens larger in the effective diameter than the aspherical lens being a mere convex lens shown in Fig. 14A and Fig. 14B;

Fig. 16A and Fig. 16B are explanatory drawings of a light incidence efficiency and an image blur prevention of a lens according to a first embodiment;

Fig. 17 is an explanatory drawing of a metal mold of a lens, likewise;

Fig. 18 is an explanatory drawing of a modification of a lens, likewise;

Fig. 19A and Fig. 19B are explanatory drawings of a modification of a lens, likewise;

Fig. 20 is a front view of a lens showing a second embodiment of a vehicle headlamp system according to the present invention;

Fig. 21 is an explanatory drawing of a lens constituted of a composite lens with multiple optical axes sharing a single focal point and images of a light emitter of a semiconductor light source extended in the left and right direction obtained by the lens, likewise;

Fig. 22 is an explanatory drawing of a light distribution pattern obtained by a spot lamp unit, likewise;

Fig. 23 is an explanatory drawing of a passing light distribution pattern obtained by a head lamp unit, shown on a screen, likewise;

Fig. 24 is an explanatory drawing of a passing light distribution pattern obtained by a spot lamp unit, shown on a screen, likewise; and

Fig. 25 is an explanatory graph of an ideal passing light distribution pattern by merging the passing light distribution pattern obtained by a headlamp unit of Fig. 23 and the passing light distribution pattern obtained by a spot lamp unit of Fig. 24, shown on a screen.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] Exemplary embodiments of a vehicle headlamp system according to the present invention will be explained in detail, referring to the accompanying drawings. It is to be noted, however, that the present invention is not limited to the embodiments. The following description of the vehicle headlamp system is based on the assumption that the vehicle (automobile) is to drive on the left side. The structure and light distribution pattern of the vehicle headlamp system for right-side traffic is generally mirror-symmetric. Fig. 5, Fig. 11, Fig. 12, Fig. 13, Fig. 22, Fig. 23, Fig. 24 and Fig. 25 are explanatory graphs of iso-intensity curves that show light distribution patterns on a screen obtained by a computer simulation process in a simplified manner, and the innermost iso-intensity curve represents a highest-intensity zone, and the other curves represent intensity zones where the light intensity declines as it goes outward. For example, the innermost iso-intensity curve in Fig. 5 and Fig. 22 delineates a zone of 10000 (candela), and the outer curves respectively delineate zones of 5000 (candela), 2000 (candela), and 300 (candela). In addition, the innermost iso-intensity curves in Fig. 11 and Fig. 23 delineate zones of 10000 (candela), and the outer curves respectively delineate zones of 5000 (candela), 2000 (candela), 1000 (candela), and 300 (candela). Furthermore, the innermost iso-intensity curves in Fig. 12 and Fig. 24 delineate zones of 10000 (candela), and the outer curves respectively delineate zones of 2000 (candela) and 300 (candela). Still furthermore, the innermost iso-intensity curves in Fig. 13 and Fig. 25 delineate zones of 20000 (candela), and the outer curves respectively delineate zones of 10000 (candela), 5000 (candela), 2000 (candela), 1000 (candela), and 300 (candela).

[0011] In the present specification and the drawings, a reference symbol "U" denotes an upper side from the viewpoint of the driver. A reference symbol "D" denotes a lower side from the viewpoint of the driver. A reference symbol "L" denotes a left side in a forward view from the viewpoint of the driver. A reference symbol "R" denotes a right side in a forward view from the viewpoint of the driver. A reference symbol "HL-HR" denotes a horizontal line in a left and right direction (left and right horizontal direction), or a left and right horizontal line on a screen placed 25 meters ahead, onto which the light distribution pattern is projected. A reference symbol "VU-VD" denotes a vertical line in an up and down direction (up and down vertical direction) likewise, or an up and down vertical line on a screen placed 25 meters ahead, onto which the light distribution pattern is projected. A reference symbol "HF-HB" denotes a horizontal line in a front and back direction (a front and back horizontal direction). The terms "left side," "right side," "right and left," "upper side," "lower side," "upper," and "lower" used in the claims are respectively equivalent to "left side," "right side," "right and left," "upper side," "lower side," "upper," and "lower" used herein and in the drawings.

[0012] Fig. 1 to Fig. 19B depict a first embodiment of a vehicle headlamp system according to the present invention. In the drawings, a reference symbol "LS" denotes a vehicle headlamp system of the embodiment. The vehicle headlamp system LS is to be mounted on both the left side front and right side front of a vehicle, respectively. The following description covers the vehicle headlamp unit LS to be mounted on the right side front. The vehicle headlamp unit LS to be mounted on the left side front has generally the same structure as that of the right side headlamp unit LS.

[0013] The vehicle headlamp system LS includes, as shown in Fig. 1, a headlamp unit L0 serving as a headlamp and a spot lamp unit SL serving as a vehicle lighting device. The headlamp unit L0 and the spot lamp unit SL are respectively accommodated in a light chamber 12 partitioned by a lamp housing 11 and a lamp lens (unillustrated, for example, a transparent outer lens).

[0014] The headlamp unit L0 outwardly emits a passing light distribution pattern LP as a basic light distribution pattern. The passing light distribution pattern LP includes, as shown in Fig. 11, an upper horizontal cutoff line CL1 located slightly above the left and right horizontal line HL-HR, an oblique cutoff line CL2, a lower horizontal cutoff line CL3 located slightly below the left and right horizontal line HL-HR, and an elbow point EP that is an intersection of the up and down vertical line VU-VD and the lower horizontal cutoff line CL3. In the passing light distribution pattern LP, an upper left region along the oblique cutoff line CL2 from the elbow point EP serves to secure a long-distance visibility.

[0015] The headlamp unit L0 includes, as shown in Fig. 1, an upper headlamp unit group LOU and a lower headlamp unit group L0D located above and below the spot lamp unit SL, respectively. The upper headlamp unit group LOU includes four headlamp units each constituted of a semiconductor light source such as an LED and primarily serves to diffuse a lower region of the passing light distribution pattern LP. On the other hand, the lower headlamp unit group L0D includes three headlamp units, also constituted of a semiconductor light source such as an LED, and primarily serves to emit the cutoff lines CL1, CL2, and CL3 of an upper region of the passing light distribution pattern LP.

[0016] The spot lamp unit SL outwardly emits, as shown in Fig. 14, a spot-type light distribution pattern SP at a predetermined position with respect to the passing light distribution pattern LP. The spot-type light distribution pattern SP is, as shown in Fig. 13, a light distribution pattern extended in a left and right direction and is a light distribution pattern that is slender to the left and right with an up and down width of approximately 2 degrees and a left and right width of approximately 12 degrees.

[0017] The spot lamp unit SL includes, as shown in Fig. 1 to Fig. 4, a semiconductor light source 1, a lens 2, and a holder 3. The semiconductor light source 1 can be a self-emission semiconductor light source (an LED in the first embodiment) such as an LED or an EL (organic EL). The semiconductor light source 1 includes a substrate 4, a light emitter 5 constituted of a light source chip (semiconductor chip) fixed on a surface of the substrate 4, a light transmitter 6 covering the light emitter 5, and a heat dissipator 7 fixed to the opposite surface of the substrate 4. The light emitter 5 is basically of a minute square, i.e. a rectangular shape having four straight sides (in this example, a square shape), approximately 1 millimeter on a side. One side of the light emitter 5 corresponds to the upper horizontal cutoff line CL1 of the passing light distribution pattern LP.

[0018] The lens 2 is, as shown in Fig. 3, an aspherical lens (refractive lens, projection lens), in which a plane of incidence (plane into which a light from the light emitter 5 is made incident) forms an aspherical plane and a plane of emergence (plane from which a light from the light emitter 5 is emitted) forms an aspherical convex surface. The lens 2 is integrally includes convex-shaped first and second aspherical lens units 21 and 22 having different effective diameters L1 and L2. Namely, the first aspherical lens unit 21 having the smaller effective diameter L1 is enclosed by the second aspherical lens unit 22 with the greater effective diameter L2. Furthermore, the lens 2 shares an optical axis of the first aspherical lens unit 21 and an optical axis of the second aspherical lens unit 22 as an identical optical axis Z-Z. Still furthermore, the lens 2 shares a focal point of the first aspherical lens unit 21 and a focal point of the second aspherical lens unit 22 as an identical focal point F0 on a plane vertical to the optical axis Z-Z. Still furthermore, for the lens 2, a height H1 of the first aspherical lens unit 21 is equivalent to or higher than a height H2 of the second aspherical lens unit 22.

[0019] The lens 2 emits a light from the light emitter 5 as the spot-type light distribution pattern SP. The spot-type light distribution pattern SP is, as shown in Fig. 4, of images I1, I2, I3, I4, and I5 in a shape of the light emitter 5 extended in an arbitrary direction, in this example, the left and right direction.

[0020] Hereinafter, a configuration of the lens 2 will be explained with reference to Fig. 6A to Fig. 10. First, the lens 2 shown in the vertical cross-sectional view (sectional view in the up and down direction) of Fig. 3, namely, a lens with a single focal point F0 and a single optical axis Z-Z is employed as a basic lens 2A. The basic lens 2A is rotated around the focal point F0 of the basic lens 2A or near the same so that the optical axis Z-Z of the basic lens 2A is distributed into a plurality of directions in which elongation of the shape (images I1, I2, I3, I4, and I5) of the light emitter 5 is intended. In this example, the optical axis Z-Z of the basic lens 2A is distributed into five axes in the left and right direction, namely, an optical axis Z1- Z1 of Fig. 6E, an optical axis Z2-Z2 of Fig. 6D, an optical axis Z3-Z3 of Fig. 6C, an optical axis Z4-Z4 of Fig. 6B, and an optical axis Z5-Z5 of Fig. 6A. The optical axis Z1-Z1 of Fig. 6E is distributed to the right with respect to the optical axis Z-Z of the basic lens 2A. The optical axis Z2-Z2 of Fig. 6D is distributed to the right with respect to the optical axis Z-Z of the basic lens 2A at an angle smaller than the angle of distribution of the optical axis Z1-Z1 of Fig. 6E. The optical axis Z3-Z3 of Fig. 6C is not distributed with respect to the optical axis Z-Z of the basic lens 2A but is coincident with the optical axis Z-Z of the basic lens 2A. The optical axis Z4-Z4 of Fig. 6B is distributed to the left with respect to the optical axis Z-Z of the basic lens 2A. The optical axis Z5-Z5 of Fig. 6A is distributed to the left with respect to the optical axis Z-Z of the basic lens 2A at an angle greater than the angle of distribution of the optical axis Z4-Z4 of Fig. 6B.

[0021] Next, as shown in Fig. 6C, a fan (circular arc) at a maximum incidence angle θ of a light from the light emitter 5 centered on the rotation center (focal point F0 of the basic lens 2A or near the same) that has been divided into a plurality of parts according to the number of distributed optical axes of the basic lens 2A is used as a template. In this example, the template has been divided into five at a distribution (equi-solid angle distribution) according to the five respective optical axes (Z1-Z2, Z2-Z2, Z3-Z3, Z4-Z4, and Z5-Z5). Based on the template divided into five, corresponding parts (sectors) S1, S2, S3, S4, and S5 are cut out from each of the five rotated basic lenses 2A. Namely, based on the first template (S1), the part (sector) S1 of the basic lens 2A of Fig. 6E is cut out as shown in Fig. 7E. In addition, based on the second template (S2), the part (sector) S2 of the basic lens 2A of Fig. 6D is cut out as shown in Fig. 7D. Furthermore, based on the third template (S3), the part (sector) S3 of the basic lens 2A of Fig. 6C is cut out as shown in Fig. 7C. Still furthermore, based on the fourth template (S4), the part (sector) S4 of the basic lens 2A of Fig. 6B is cut out as shown in Fig. 7B. Still furthermore, based on the fifth template (S5), the part (sector) S5 of the basic lens 2A of Fig. 6A is cut out as shown in Fig. 7A.

[0022] Then, by integrating the sectors S1, S2, S3, S4, and S5 cut out from each of the five basic lenses 2A, the lens 2 is formed. The lens 2 is, as shown in Fig. 8 and Fig. 10, constituted of a composite lens with multiple optical axes (Z1-Z1, Z2-Z2, Z3-Z3, Z4-Z4, and Z5-Z5) that shares a single focal point F0. The plane of incidence (a plane into which a light from the light emitter 5 is made incident; bottom surface) 23 of the lens 2 constituted of the composite lens shares, as shown by the alternate long and two short dashed line in Fig. 8, a plane of an identical aspherical surface.

[0023] In the first embodiment, the lens 2 integrally includes the two convex-shaped first and second aspherical lens units 21 and 22 having different effective diameters L1 and L2 is used. However, in the present embodiment, as shown in Fig. 9, a lens 20 that is a normal convex lens constituted of a convex-shaped aspherical lens with a single effective diameter may be used. Namely, similarly, in a case of the lens 20 as well, first, a basic lens is rotated around a focal point of the basic lens or near the same so that an optical axis of the basic lens is distributed into a plurality of directions in which elongation of the shape of the light emitter 5 is intended. Next, while using a fan at a maximum incidence angle θ of a light from the light emitter 5 centered on the rotation center that has been divided into a plurality of parts according to the number of distributed optical axes of the basic lens as a template, corresponding parts S21, S22, S23, S24, and S25 are cut out from each of the rotated basic lenses. Then, by integrating the parts S21, S22, S23, S24, and S25 cut out from each of the basic lenses, the lens 20 constituted of a composite lens with multiple optical axes sharing a single focal point is obtained.

[0024] The holder 3 holds the semiconductor light source 1 and lens 2 in a predetermined relative positional relationship. In this example, as shown in Fig. 2 to Fig. 4, the holder 3 holds the semiconductor light source 1 and lens 2 in a relative positional relationship where the light emitter 5 of the semiconductor light source 1 is almost coincident with the focal point F0 of the lens 2. As a result, the images emitted from the lens 2 are distributed as a most condensed image. As such, the spot lamp unit SL includes a direct-emission optical system that directly distributes a light from the light emitter 5 of the semiconductor light source 1 by the lens 2.

[0025] The vehicle headlamp system LS gives following effects.

[0026] When the spot lamp unit SL is turned on, a light from the light emitter 5 of the semiconductor light source 1 of the spot lamp unit SL is emitted as a spot-type light distribution pattern SP being the images I1 to I5 having a rectangular shape slender in the left and right direction in a shape of the emitter 5 extended in the left and right direction. As a result, because the vehicle headlamp system LS allows obtaining a spot-type light distribution pattern SP extended in the left and right direction, a spot-type light distribution pattern SP suitable for the vehicle headlamp system can be simply and securely obtained.

[0027] Namely, by adjusting the spot-type light distribution pattern SP shown in Fig. 5 in the up, down, left, and right directions, a spot-type light distribution pattern SP shown in Fig. 12 can be simply and securely obtained. The spot-type light distribution pattern SP shown in Fig. 12 is merged with a passing light distribution patterns LP shown in Fig. 11, whereby an ideal light distribution pattern (light distribution pattern in which the passing light distribution pattern LP and spot-type light distribution pattern SP are merged) shown in Fig. 13 can be obtained. In the ideal light distribution pattern, the spot-type light distribution pattern SP is arranged at a predetermined position of the passing light distribution pattern LP, namely, a position lower than the upper horizontal cutoff line CL1 and on the left side from the elbow point and oblique cutoff line CL2. Because this position is a part that serves a long-distance visibility, the vehicle headlamp system LS can reliably secure long-distance visibility without casting a glare toward drivers and fellow passengers on oncoming vehicles or preceding vehicles, pedestrians and the like, thus contributing to traffic safety.

[0028] In particular, the vehicle headlamp system LS includes the lens 2 that integrally includes the composite lens (five sectors S1 to S5 divided at an equivalent solid angle) with multiple optical axes (five axes) sharing a single focal point F0. As a result, in the vehicle headlamp system LS, because the five sectors S1 to S5 of the lens 2 have been divided at the equivalent solid angle, the images I1 to I5 emitted from the five sectors S1 to S5 are replicated and dispersed as five images to the left and right at an almost equal amount of light (intensity and illuminance), and because the lens 2 shares a single focal point F0, namely, a single light source point (light emitter 5 of the semiconductor light source 1), the five images I1 to I5 replicated and dispersed to the left and right never lose shape. Thereby, the vehicle headlamp system LS allows obtaining a spot-type light distribution pattern SP extended in the left and right direction, and an upper side of the spot-type light distribution pattern SP can be disposed along the upper horizontal cutoff line CL1. Consequently, the vehicle headlamp system LS according to the embodiment can securely prevent the emergence of glare toward drivers and fellow passengers on oncoming vehicles or preceding vehicles, pedestrians and the like.

[0029] Moreover, the vehicle headlamp system LS allows obtaining a spot-type light distribution pattern SP extended in the left and right direction by the single spot lamp unit SL by using a high-power light emitter as the light emitter 5 of the semiconductor light source 1. Accordingly, in the vehicle headlamp system LS, the number of components can be reduced to lower the manufacturing cost. Moreover, with the single spot lamp unit SL, storage space can be considerably reduced, and the number of components of a swivel mechanism or a sliding mechanism accompanied with the spot lamp unit SL can be considerably reduced, whereby the degree of freedom of design is increased.

[0030] In particular, the vehicle headlamp system LS includes the lens 2 that integrally includes the convex-shaped first and second aspherical lens units 21 and 22 having different effective diameters L1 and L2, namely, the lens 2 formed by enclosing the first aspherical lens unit 21 with the second aspherical lens unit 22 having the greater effective diameter L2, namely, a compound lens. Therefore, because the vehicle headlamp system LS can allow a light from the light emitter 5 of the semiconductor light source 1 to be efficiently made incident by use of the lens 2, a high-intensity (high-density) image (light distribution pattern) can be obtained, and moreover, a sharp outline can be obtained around the image by preventing an image blur owing to a spherical aberration and a chromatic aberration.

[0031] The advantageous effect will be explained with reference to Fig. 14A to Fig. 16B. First, in the aspherical lens L1 being a mere convex lens shown in Fig. 14A, because a maximum incidence angle θ1 that projects an appropriate-sized image I11 (see Fig. 14B) at an appropriate thickness T1 is smaller than a radiation angle θ3 of a light from the single light emitter 5 of the semiconductor light source 1 (θ1<<θ3), light incidence efficiency of the aspherical lens L1 is low. A reference symbol F1 in Fig. 14A is a focal point of the aspherical lens L1, and the light emitter 5 of the semiconductor light source 1 is positioned at the focal point F1.

[0032] Here, in order to improve the light incidence efficiency, an aspherical lens L3 (see Fig. 15A) whose distance from a focal point F3 to a plane of incidence is the same as that of the aspherical lens L1 and whose effective diameter is greater than the aspherical lens L1 is considered. Then, a maximum incident angle θ of the aspherical lens L3 becomes almost the same as the radiation angle θ3 of a light from the light emitter 5 of the semiconductor light source 1, whereby a high light incidence efficiency can be obtained. However, a thickness T3 of the aspherical lens L3 increases greater than the thickness T1 of the aspherical lens L1, is therefore unrealistic in molding, and leads to an image I31 (see Fig. 15B) smaller in size than the appropriate-sized image I11 (see Fig. 14B) that achieves an intended light distribution pattern. Moreover, a spherical aberration of the aspherical lens L3 is generated to cause an image blur I30 (see dotted line in Fig. 15B). Therefore, there is a problem in distributing a side of the image along a cutoff line of the basic distribution pattern. Here, the reference symbol F3 in Fig. 15A denotes a focal point of the aspherical lens L3, and the light emitter 5 of the semiconductor light source 1 is located at the focal point F3.

[0033] Therefore, in the first embodiment, the lens 2 (basic lens 2A) integrated by integrating the aspherical lens L3 (second aspherical lens unit 22) so as to enclose the aspherical lens L1 (first aspherical lens unit 21) is used. Thereby, as shown in Fig. 16A, despite maintaining the appropriate-sized image I11 (see Fig. 16B) at the appropriate thickness T1, the maximum incidence angle θ of the lens 2 can be made almost equal to the maximum incidence angle θ of the aspherical lens L3, in other words, light incidence efficiency can be improved. On the other hand, an image I20 (see Fig. 16B) of a size by an increment (equivalent to θ-θ1) with a spherical aberration can be kept within the appropriate-sized image I11 (see Fig. 16B) of the aspherical lens L1 (first aspherical lens unit 21). As a result, as shown in Fig. 16B, while the outline of the image I11 remains sharp, a highly-efficient light distribution such that the insides of the images I11 and 120 reach a high intensity (high density) can be obtained. Thereby, as mentioned above, high-intensity (high-density) spot-type light distribution patterns SP, SPL, and SPR extended in the left and right direction can be obtained at a high efficiency.

[0034] In addition, in the vehicle headlamp system LS, a plane of incidence 23 of the lens 2 constituted of a composite lens is shared by an identical aspherical plane. Namely, a plane of incidence of the first aspherical lens unit 21 and a plane of incidence of the second aspherical lens unit 22 are shared by an identical aspherical plane. Accordingly, in the vehicle headlamp system LS, most of the light made incident into the plane of incidence 23 of the lens 2 is distributed from aspherical convex surfaces, which are planes of emergence of the first aspherical lens unit 21 and second aspherical lens unit 22, as intended. Namely, the light made incident into the lens 2 is distributed with little light loss.

[0035] Furthermore, the vehicle headlamp system LS uses the lens 2 where the height H1 of the first aspherical lens unit 21 is equivalent to or higher than the height H2 of the second aspherical lens unit 22, namely, the lens 2 where a highest point of the convex surface (convex portion) of the second aspherical lens unit 22 is lower than a highest point of the convex surface (convex portion) of the first aspherical lens unit 21. Therefore, for the vehicle headlamp system LS, as shown in Fig. 17, in a metal mold 8 of the lens 2, a deepest point of a concave portion 82 to mold the second aspherical lens unit 22 is shallower than a deepest point of a concave portion 81 to mold the first aspherical lens unit 21. As a result, in the vehicle headlamp system LS, when processing the metal mold 8 of the lens 2, a shelter for an NC machining cutter chuck 80 can be secured, which allows a stable high-precision processing. Namely, when the deepest point of the concave portion 82 to mold the second aspherical lens unit 22 is made deeper than the deepest point of the concave portion 81 to mold the first aspherical lens unit 21, the angle of a valley portion of the concave portion 82 to mold the second aspherical lens unit 22 is reduced to make side walls of the valley portion almost vertical, so that the shelter for the NC machining cutter chuck 80 cannot be secured.

[0036] Here, lights that are emitted from the plane of emergence being the convex surface of the first aspherical lens unit 21 and the plane of emergence being the convex surface of the second aspherical lens unit 22 involve a scattered light at the planes of emergence. In particular, a scattered light that is generated, of the plane of emergence being the convex surface of the first aspherical lens unit 21, as shown in Fig. 18, near a junction with the second aspherical lens unit 22 can be again made incident from a boundary wall surface (a plane between the convex surface of the first aspherical lens unit 21 and convex surface of the second aspherical lens unit 22, logically, a plane from which a positive refracted light made incident from the plane of incidence 23 is not emitted outward) 24 of the second aspherical lens unit 22 to become a stray light 25 when emitted from the plane of emergence being the convex surface of the second aspherical lens unit 22. Therefore, in the vehicle headlamp system LS, the problem of a stray light can be solved by applying a surface treatment (see the thick solid line in Fig. 18) to lower light transmittance, for example, a grain finish, frosting, or painting to the boundary wall surface 24 of the second aspherical lens unit 22 of the lens 22, and moreover, a new external appearance can be obtained.

[0037] In addition, for the vehicle headlamp system LS, as shown in Fig. 19A, in the lens 2, while an axis Z22-Z22 that passes through a focal point F22 of the second aspherical lens unit 22 is offset upward in the vertical direction with respect to an axis Z21-Z21 that passes through a focal point F21 of the first aspherical lens unit 21, the first aspherical lens unit 21 is integrated with the second aspherical lens unit 22. Such a configuration allows the vehicle headlamp system LS, when the light emitter 5 of the semiconductor light source 1 positioned at a focal point F21 of the first aspherical lens unit 21 or near the same, to offset an image I22 (see Fig. 19B) obtained by the second aspherical lens unit 22 upward in the vertical direction with respect to an image I11 (see Fig. 19B) obtained by the first aspherical lens unit 21. Namely, in the images I21 and I22 emitted from the lens 2, a high-density zone can be shifted upward in the vertical direction, i.e. to the cutoff line side of a basic light distribution pattern, therefore, long-distance visibility can further be improved.

[0038] Fig. 20 to Fig. 25 depict a second embodiment of a vehicle headlamp system according to the present invention. In the drawings, the symbols identical to those of Fig. 1 to Fig. 19 denote identical components.

[0039] For the vehicle headlamp system according to the second embodiment, a lens 200 almost the same as the lens 2 used for the vehicle headlamp system LS in the first embodiment is used. Namely, the lens 200 used for the vehicle headlamp system in the second embodiment is a lens where, as shown in Fig. 20, the left and right parts of the lens 2 used for the vehicle headlamp system according to the first embodiment have been alternately displaced in the vertical direction. Namely, a right part 200R (sectors S1 and S2) of the lens 200 is displaced to the lower side with respect to a left part 200L (sectors S3, S4, and S5) of the lens 200L. The sector S3 belongs to the left part 200L for the most part, while a part belongs to the right part 200R. In addition, the sector 2 belongs to the right part 200R for the most part, while a part belongs to the left part 200L.

[0040] Because the vehicle headlamp system according to the second embodiment has such a structure as in the above, when the spot lamp unit SL is turned on, a light from the light emitter 5 of the semiconductor light source 1 is emitted, as shown in Fig. 21 and Fig. 22, as spot-type light distribution patterns SPL and SPR being images I1 to I5 having a rectangular shape slender in the left and right direction in a shape of the emitter 5 extended in the left and right direction. As the images, the images I1 and I2 corresponding to the right part 200R of the lens 200 and the images I3, I4, and I5 corresponding to the left part 200L of the lens 200 are displaced up and down from each other, and consequently, as the spot light distribution patterns, the right spot-type distribution pattern SPR corresponding to the right images I1 and I2 and the left spot-type light distribution pattern SPL corresponding to the left images I3, I4, and I5 are displaced up and down from each other.

[0041] Then, by adjusting the spot-type light distribution patterns SPL and SPR shown in Fig. 22 in the up, down, left, and right directions, spot-type light distribution patterns SPL and SPR shown in Fig. 24 where the left and right parts have been slightly displaced up and down from each other can be simply and securely obtained. The spot-type light distribution patterns SPL and SPR are merged with the passing light distribution pattern shown in Fig. 23, whereby an ideal light distribution pattern (light distribution pattern in which the passing light distribution pattern LP and spot-type light distribution patterns SPL and SPR are merged) shown in Fig. 25 can be obtained. In the ideal light distribution pattern, the spot-type light distribution patterns SPL and SPR are arranged at predetermined positions of the passing light distribution pattern LP, namely, the left part SPL is arranged at a position lower than the upper horizontal cutoff line CL1 and on the left side from the elbow point EP and oblique cutoff line CL2, and the right part SPR is arranged lower than the lower horizontal cutoff line CL3. Because this position is a part that serves a long-distance visibility, the vehicle headlamp system according to the second embodiment can reliably secure long-distance visibility without casting a glare toward drivers and fellow passengers on oncoming vehicles or preceding vehicles, pedestrians and the like, thus contributing to traffic safety. Moreover, by slightly raising the spot-type light distribution patterns SPL and SPR to the upper side, a motorway light distribution pattern (unillustrated, a light distribution pattern that is high in the possibility that the vehicle encounters a preceding vehicle or an oncoming vehicle and is appropriate for high-speed driving) can be obtained.

[0042] The vehicle headlamp system according to the second embodiment can achieve almost the same advantageous effect as that of the vehicle headlamp system LS.

[0043] Also, in the first and second embodiments, the headlamp unit L0 includes a plurality of lamp units, each with an LED as the light source. According to the present invention, however, the headlamp unit may be constituted of a single or a plurality of lamp units including a discharge light, a halogen bulb, an incandescent bulb, or the like as the light source.

[0044] Although the invention has been described with respect to a specific embodiment for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

Claims

1. A vehicle lighting device that emits a spot-type light distribution pattern to be merged with a basic light distribution pattern emitted by a headlamp, comprising:

a semiconductor light source (1) including a light emitter (5); and
a lens (2) that emits a light from the light emitter (5) as the spot-type light distribution pattern, wherein
the spot-type light distribution pattern is formed of images in a shape of the light emitter (5) extended in an arbitrary direction, and
the lens (2) includes a composite lens with multiple axes sharing a single focal point formed by rotating a basic lens around a focal point of the basic lens or near the same so that an optical axis of the basic lens is distributed into a plurality of directions in which elongation of the shape of the light emitter (5) is intended,
cutting out corresponding parts from each of a plurality of the basic lenses, while using a fan at a maximum incidence angle of a light from the light emitter (5) centered on the rotation center that has been divided into a plurality of parts according to a number of distributed optical axes of the basic lens as a template, and
integrating the parts cut out from each of the basic lenses.

2. The vehicle lighting device according to claim 1, wherein
of the lens constituted of the composite lens with multiple axes sharing a single focal point, a plane of incidence into which a light from the light emitter (5) is made incident shares an identical plane.

3. The vehicle lighting device according to claim 1, wherein
the lens (2) integrally includes convex-shaped first aspherical lens unit (21) having a first effective diameter and second aspherical lens unit (22) having a second effective diameter, wherein the first effective diameter is smaller than the second effective diameter, and
the first aspherical lens unit (21) is enclosed by the second aspherical lens unit (22).

4. The vehicle lighting device according to claim 1, wherein
the lens (2) integrally includes convex-shaped first

aspherical lens unit (21) having a first effective diameter and second aspherical lens unit (22) having a second effective diameter, wherein the first effective diameter is smaller than the second effective diameter, and
a height of the first aspherical lens unit (21) is any one of substantially equal and more than that of the second aspherical lens unit (22).

5. The vehicle lighting device according to claim 1, wherein
the lens (2) integrally includes convex-shaped first aspherical lens unit (21) having a first effective diameter and second aspherical lens unit (22) having a second effective diameter, and
a surface treatment to lower light transmittance is applied to a boundary surface between a plane of emergence of the first aspherical lens unit (21) from which a light from the light emitter (5) is emitted and a plane of emergence of the second aspherical lens unit (22) from which a light from the light emitter (5) is emitted.

6. The vehicle lighting device according to claim 1, wherein
the lens (2) integrally includes convex-shaped first aspherical lens unit (21) having a first effective diameter and second aspherical lens unit (22) having a second effective diameter, and
an optical axis that passes through a focal point of the second aspherical lens unit (22) is offset upward with respect to an optical axis that passes through a focal point of the first aspherical lens unit (21).

7. The vehicle lighting device according to claim 1, wherein
the basic light distribution pattern is a light distribution pattern having an upper horizontal cutoff line, an oblique cutoff line, and a lower horizontal cutoff line,
the light emitter (5) has a rectangular shape having four straight sides,
the lens (2) emits a light from the light emitter (5) as the spot-type light distribution pattern positioned lower than the upper horizontal cutoff line and on the left side or right side from an intersection of the oblique cutoff line and the lower horizontal cutoff line, being images having a rectangular shape in the rectangular shape of the light emitter (5) extended to the left and right along the upper horizontal cutoff line.

8. The vehicle lighting device according to claim 1, wherein
a left part and a right part of the lens (2) are alternately displaced in the vertical direction, and
of the spot-type light distribution pattern, a left part and a right part are alternately displaced in the vertical direction.

9. The vehicle lighting device according to claim 1, wherein
the basic light distribution pattern is a light distribution pattern having an upper horizontal cutoff line, an oblique cutoff line, and a lower horizontal cutoff line,
the light emitter (5) has a rectangular shape having four straight sides,
a left part and a right part of the lens (2) are alternately displaced in the vertical direction,
of the spot-type light distribution pattern, a left part and a right part are alternately displaced in the vertical direction,
one of the left part and right part is positioned lower than the upper horizontal cutoff line and on the left side or right side from an intersection of the oblique cutoff line and the lower horizontal cutoff line, and
the other is positioned lower than the lower horizontal cutoff line.

10. The vehicle lighting device according to claim 1, wherein the light emitter (5) is a high power light source.

11. A vehicle headlamp unit that respectively emits a basic light distribution pattern and a spot-type light distribution pattern, comprising:

a headlamp that outwardly emits the basic light distribution pattern; and
at least one vehicle lighting device that outwardly emits the spot-type light distribution pattern, wherein
the vehicle lighting device is the vehicle lighting device according to any one of claims 1 to 10, and
the basic light distribution pattern emitted from the headlamp is merged with the spot-type light distribution pattern emitted from the vehicle lighting device or vehicle lighting devices.

FIG.1

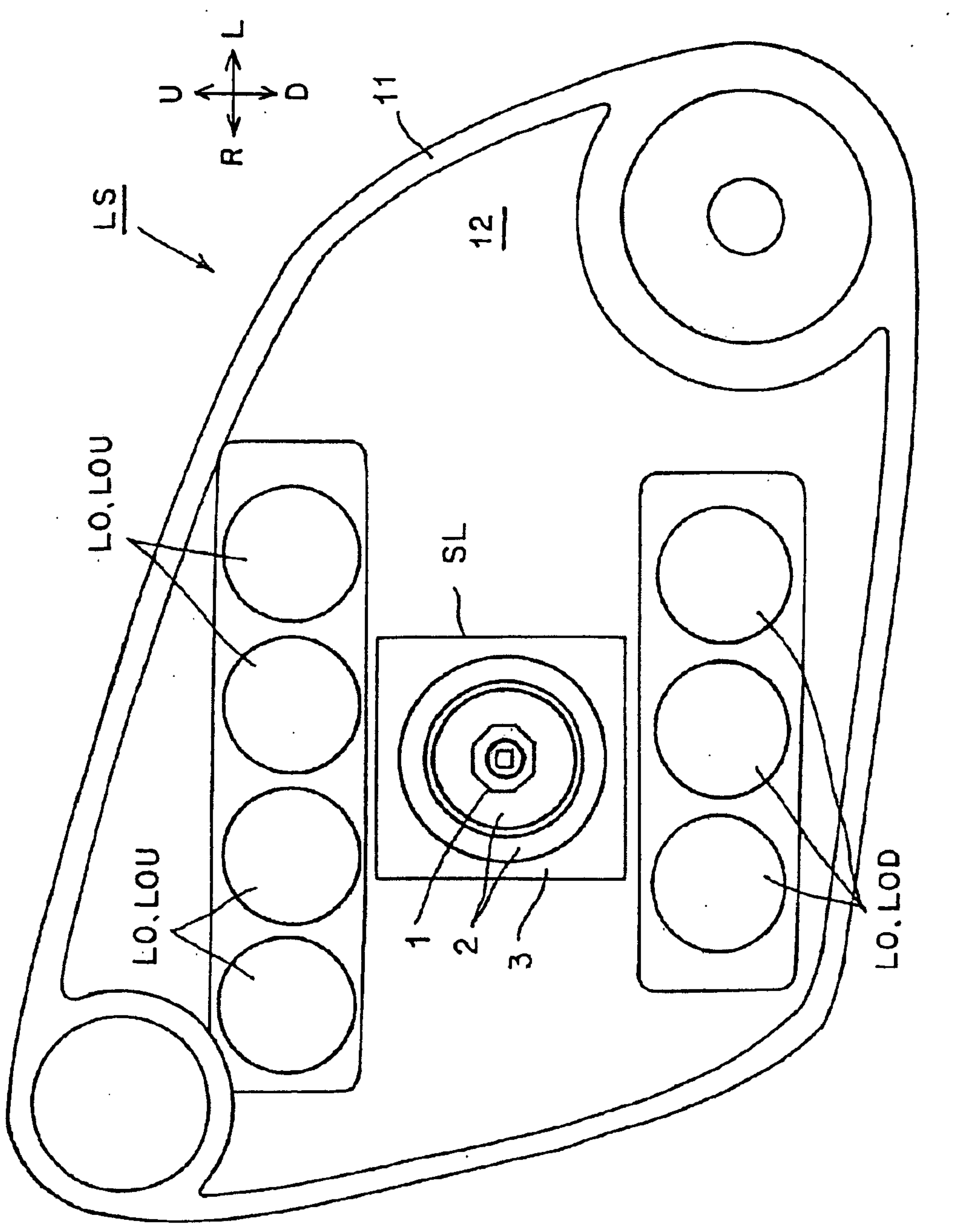


FIG.2

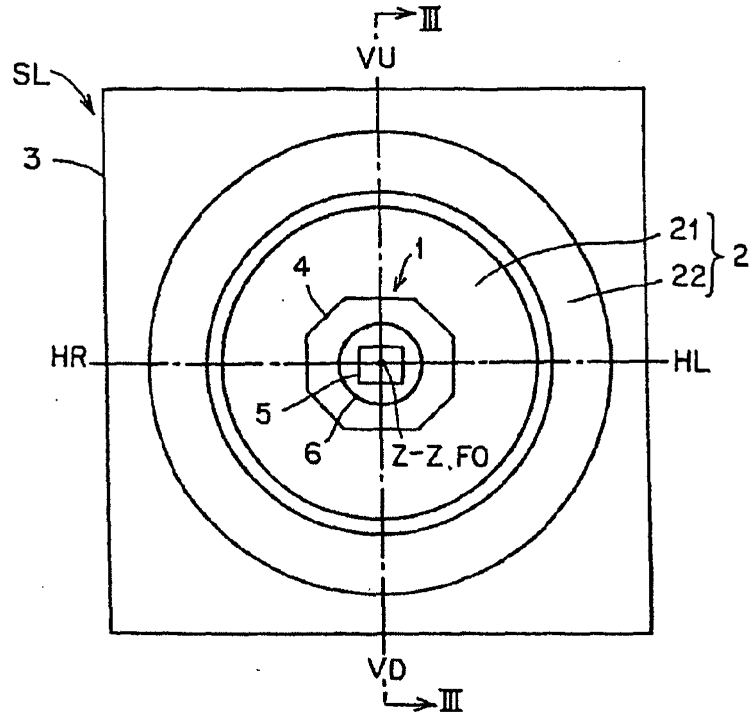

III
VU
SL
3
21
2
1
22
4
HR
HL
5
6
Z-Z, FO
VD
III

FIG.3

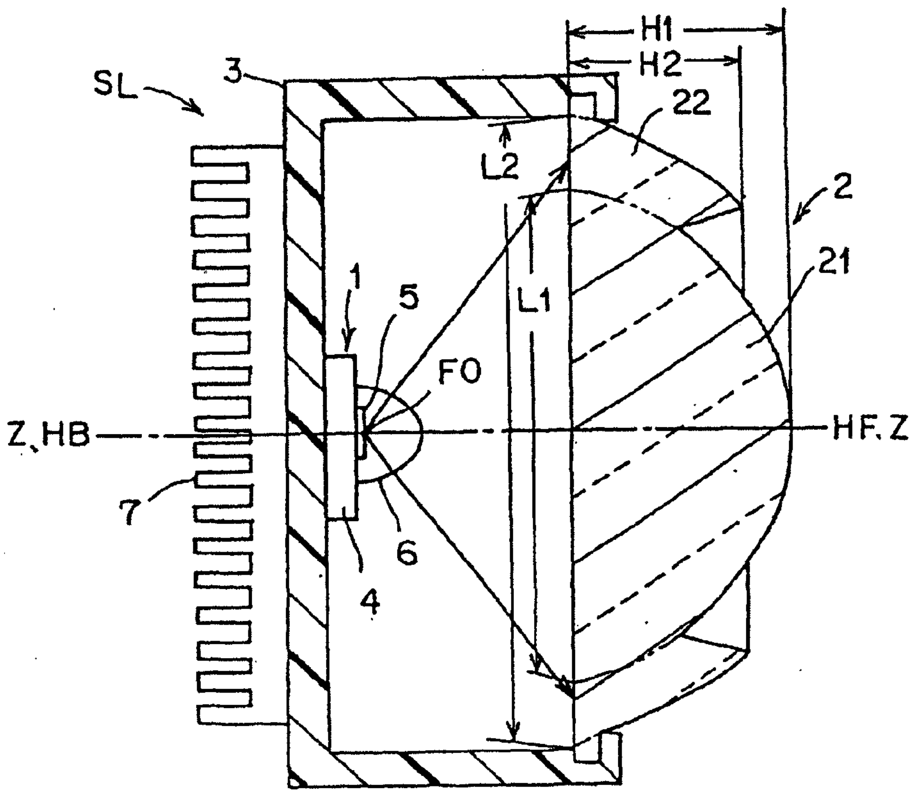

H1
H2
SL
3
22
L2
2
21
1
5
L1
FO
Z, HB
HF, Z
7
6
4

FIG.4

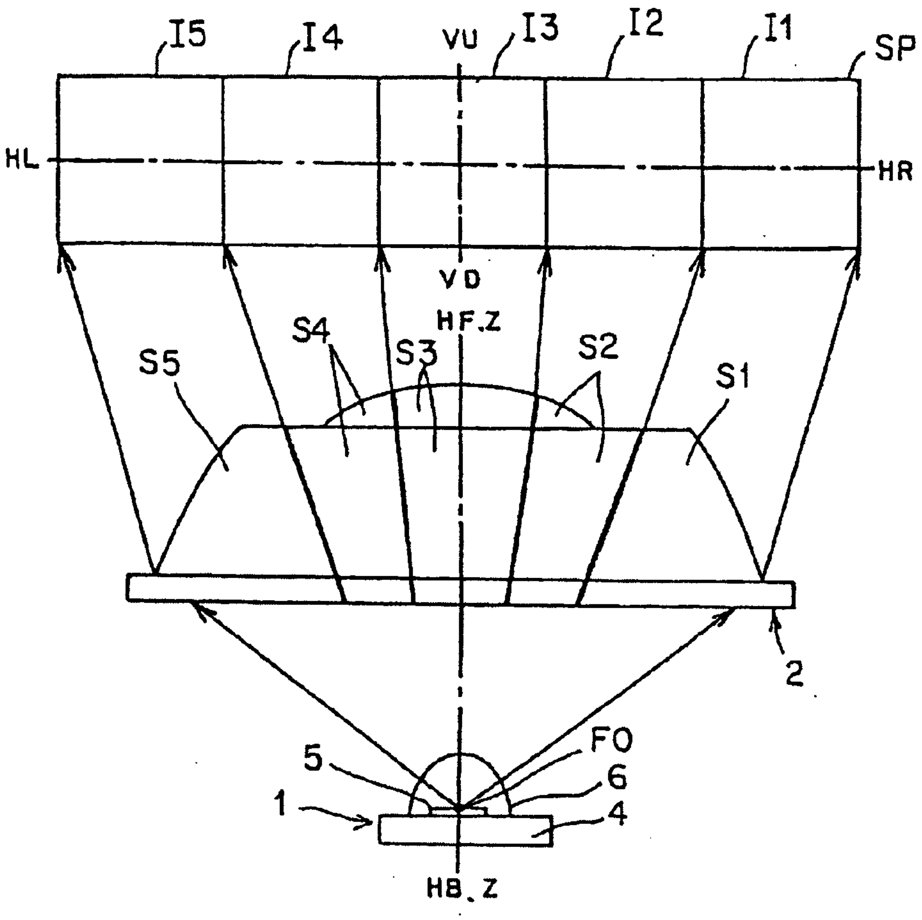
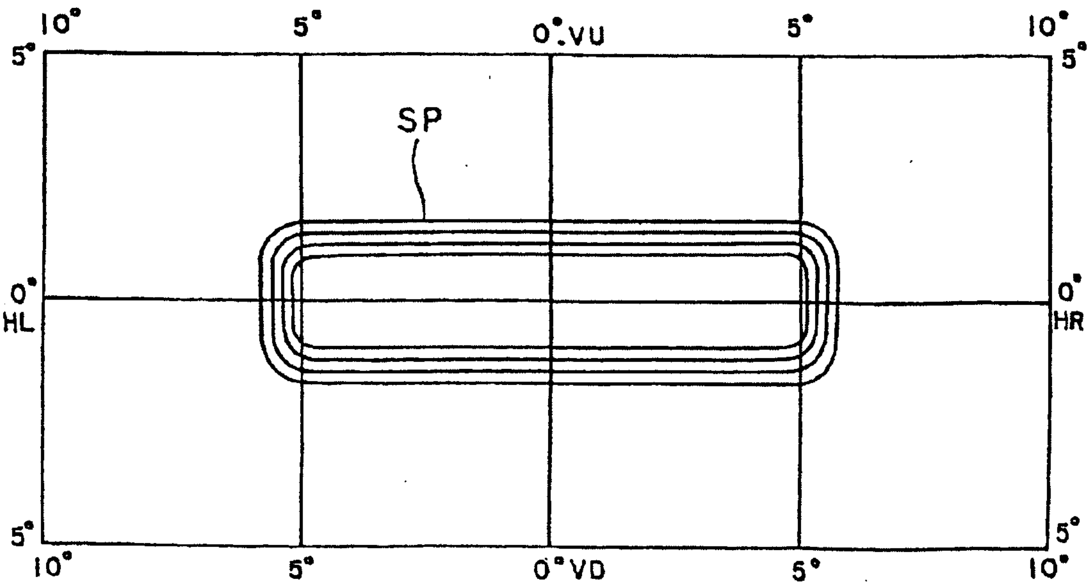

I5
I4
VU
I3
I2
I1
SP
HL
HR
VD
HF.Z
S4
S3
S2
S5
S1
2
5
FO
6
1
4
HB.Z

FIG.5


10°
5°
0°.VU
5°
10°
5°
5°
SP
0°
HL
0°
HR
5°
5°
10°
5°
0°VD
5°
10°

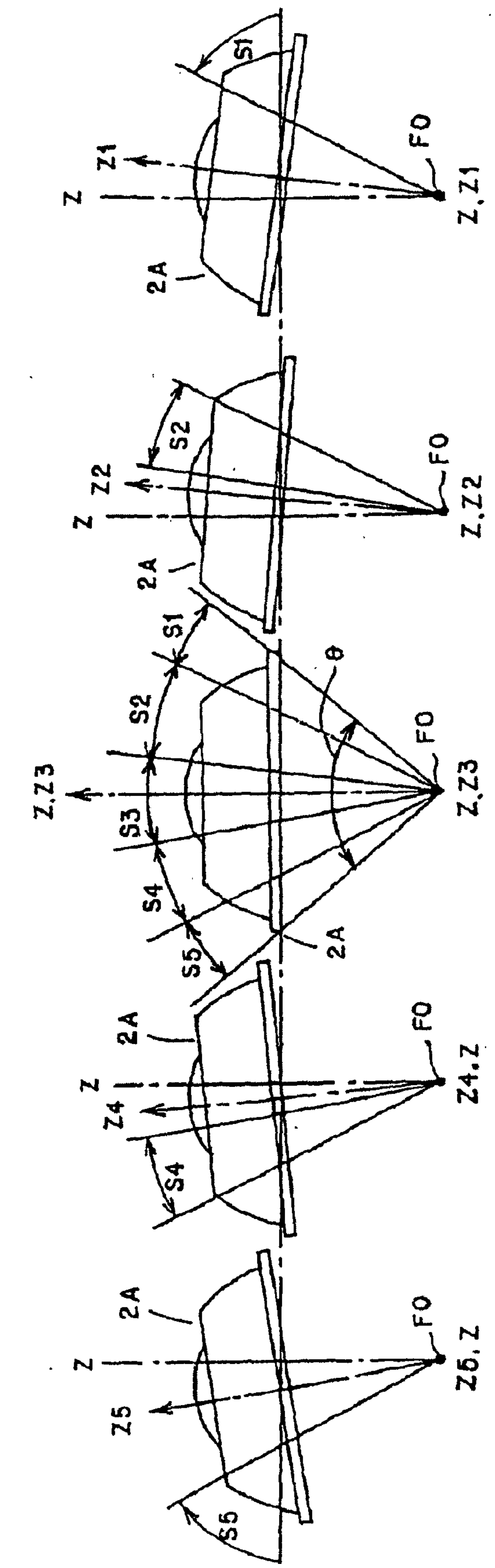


FIG.6A FIG.6B FIG.6C FIG.6D FIG.6E

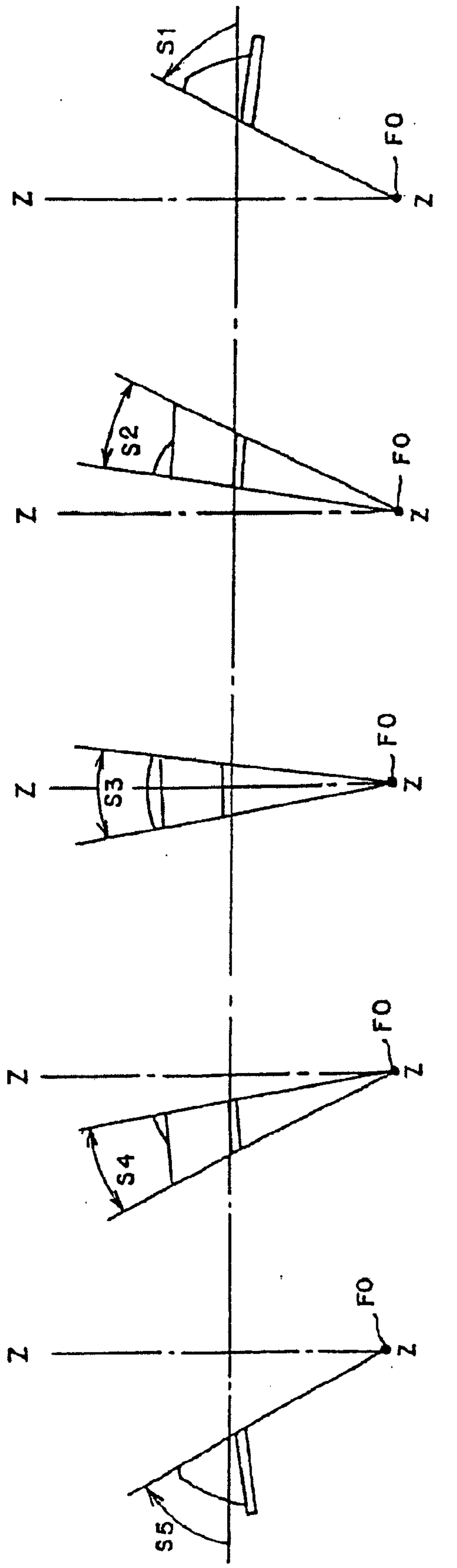


FIG.7A FIG.7B FIG.7C FIG.7D FIG.7E

FIG.8

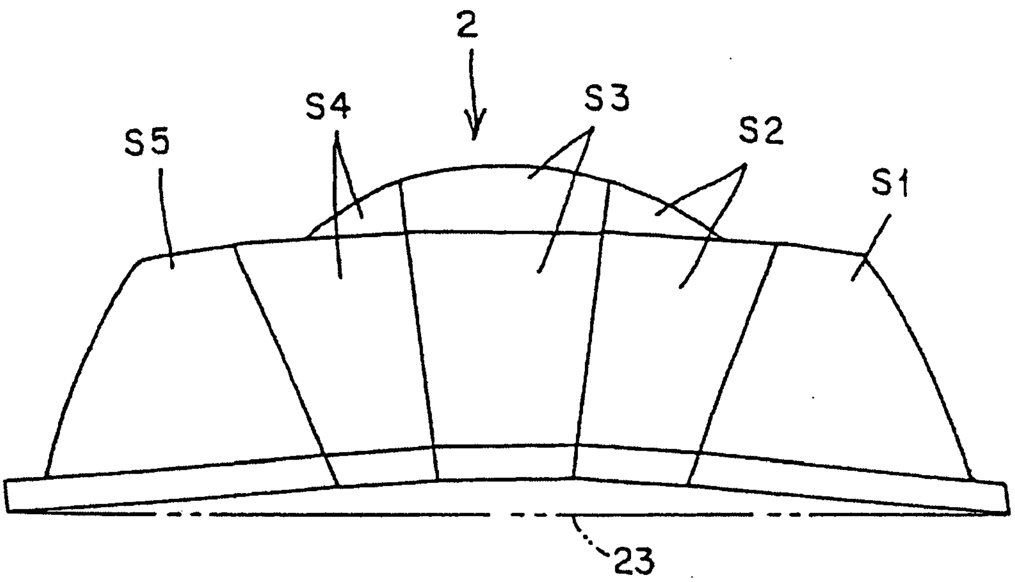


FIG.9

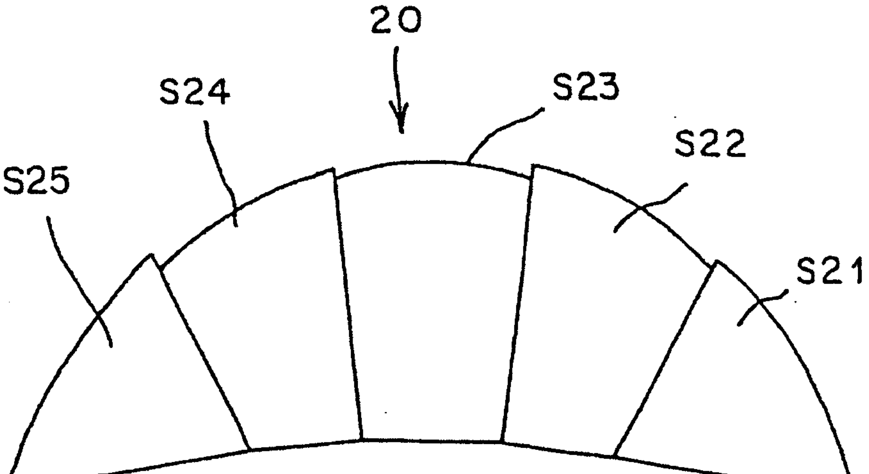
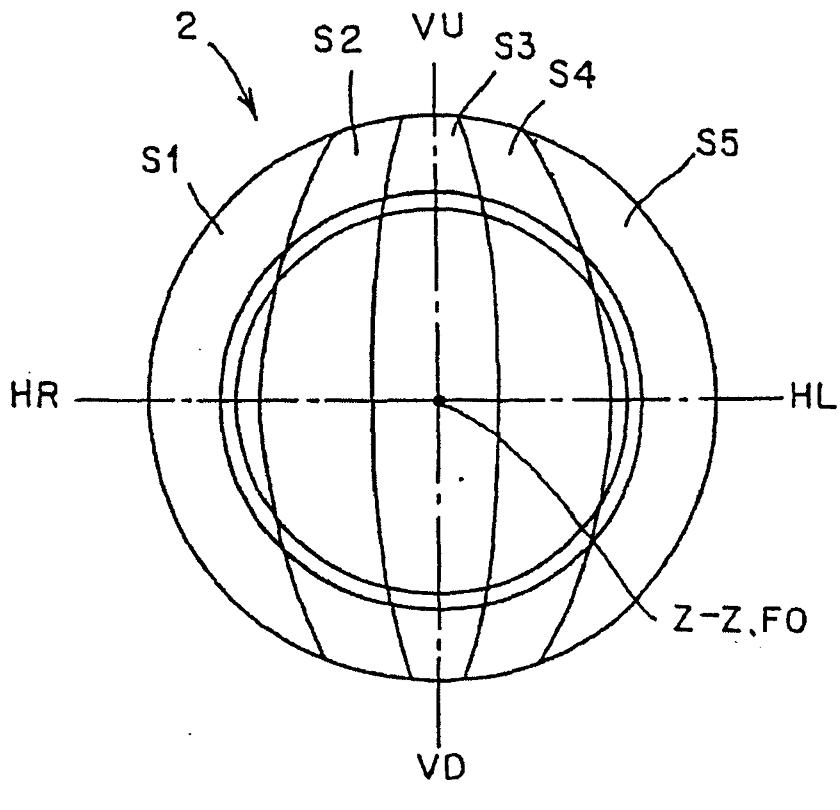


FIG.10



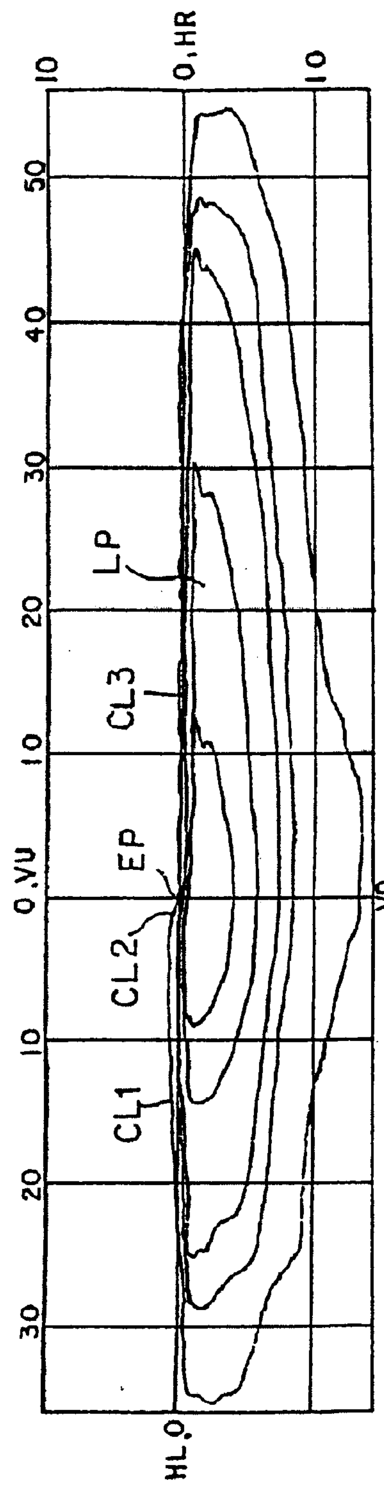


FIG.11

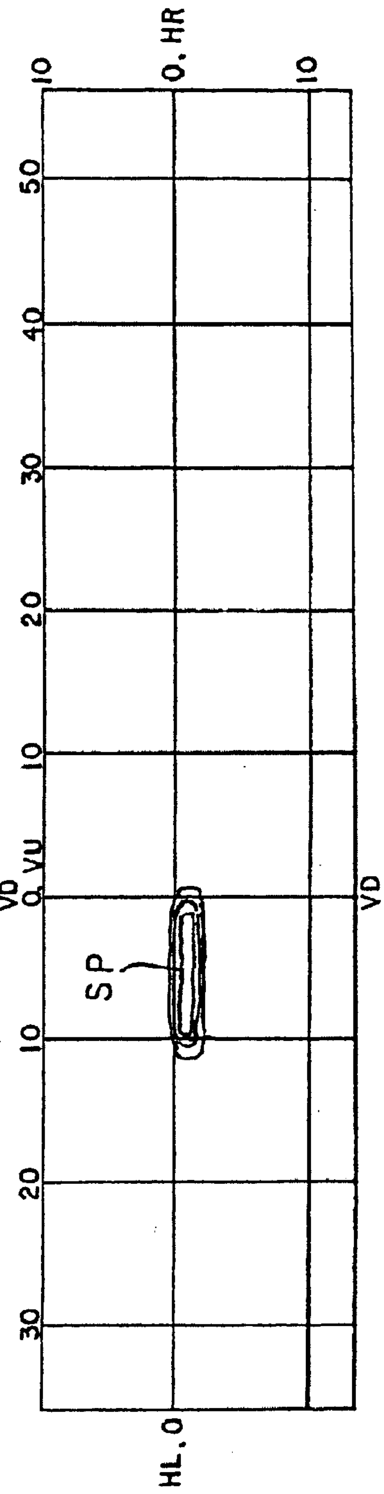


FIG.12

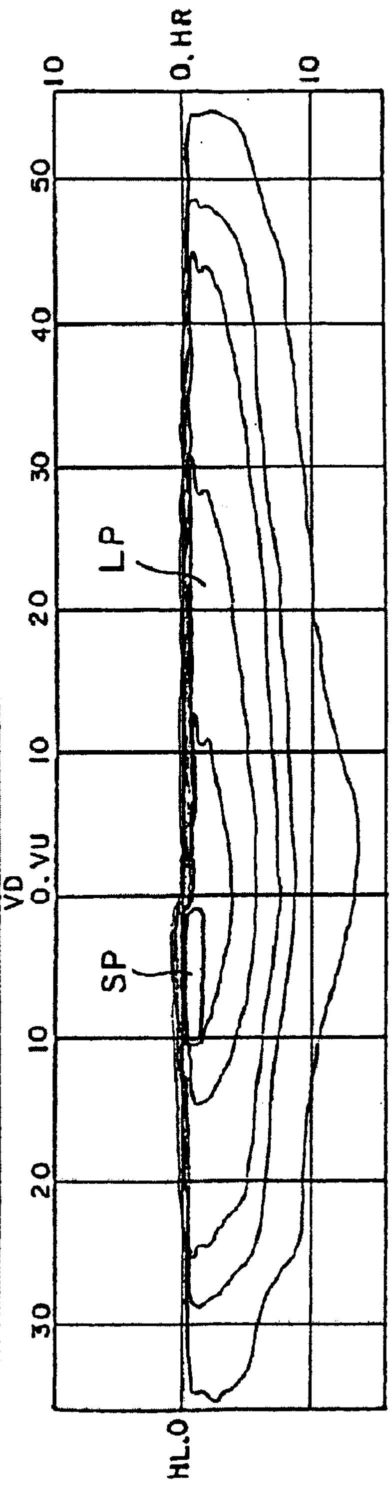


FIG.13

FIG.14A

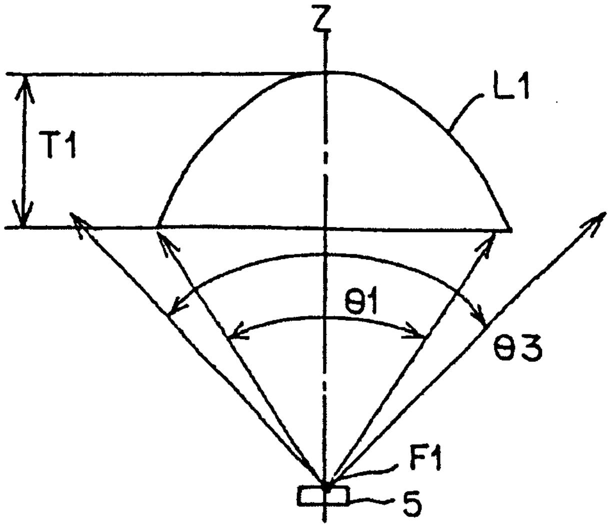


FIG.14B

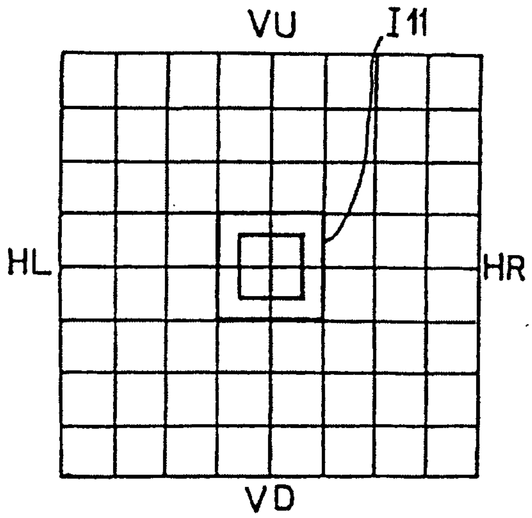


FIG.15A

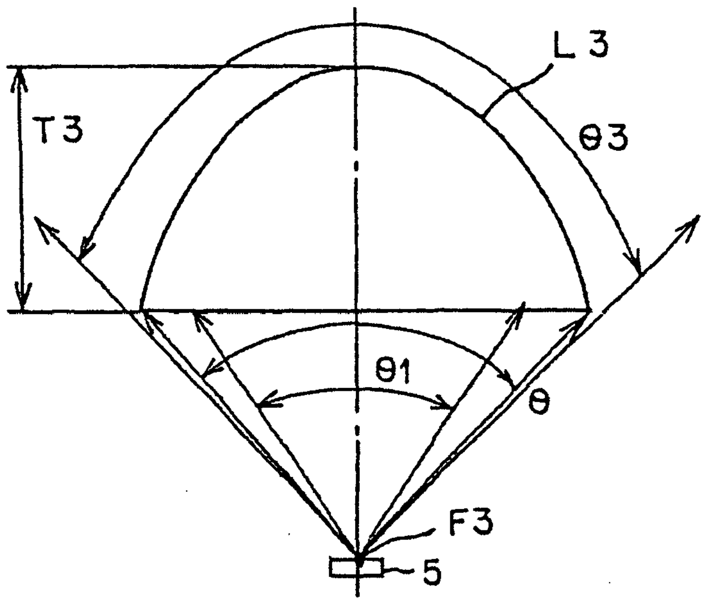


FIG.15B

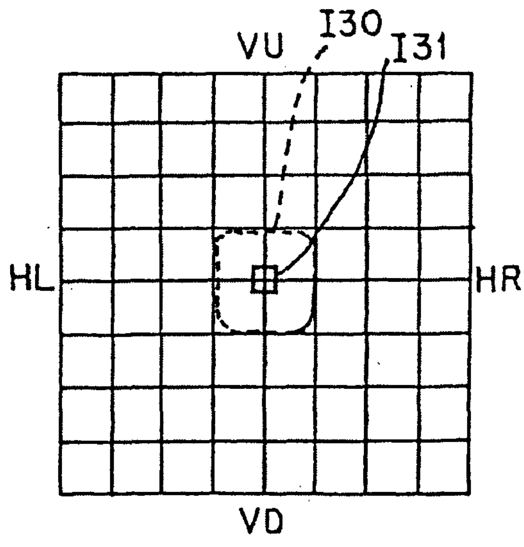


FIG.16A

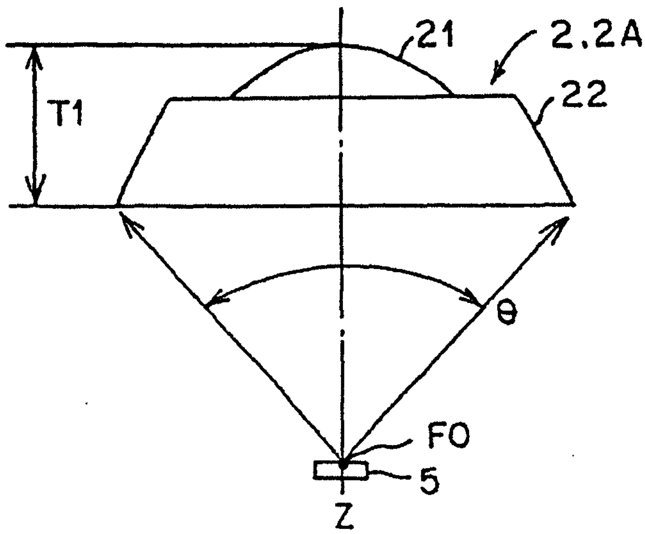


FIG.16B

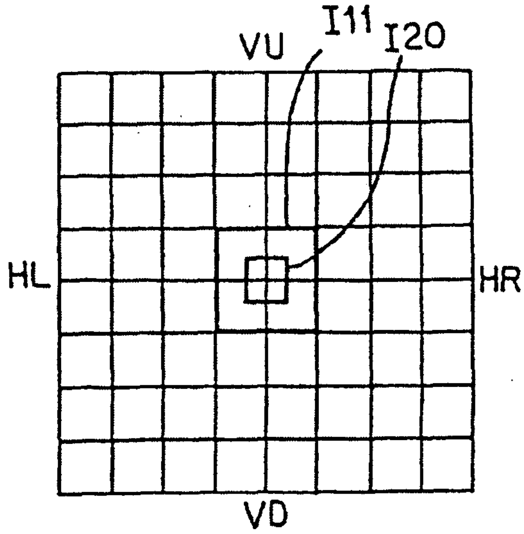


FIG.17

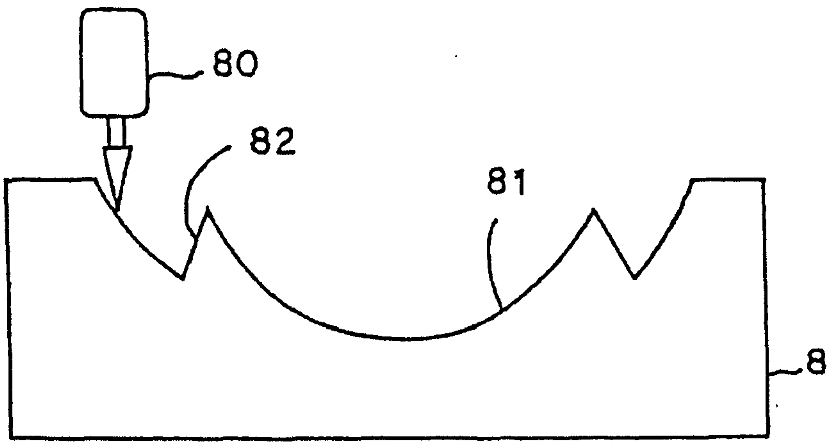


FIG.18

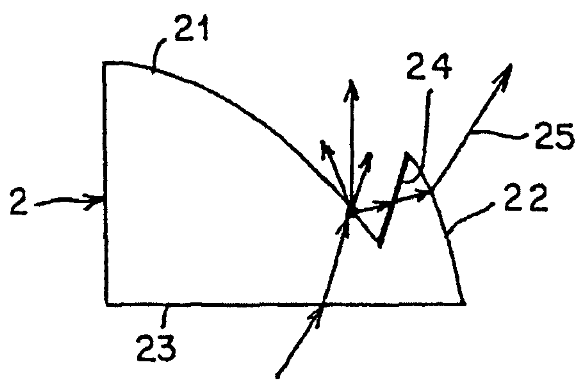


FIG.19A

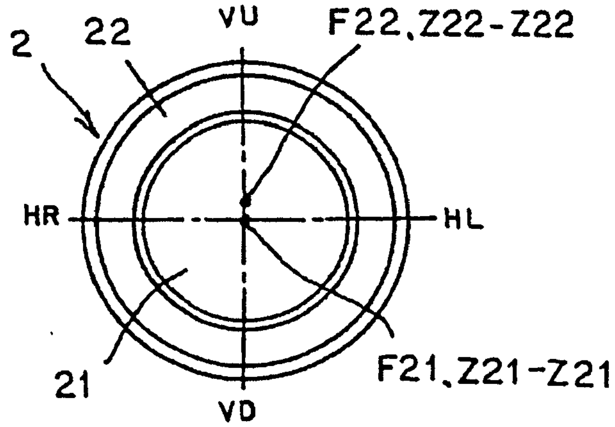


FIG.19B

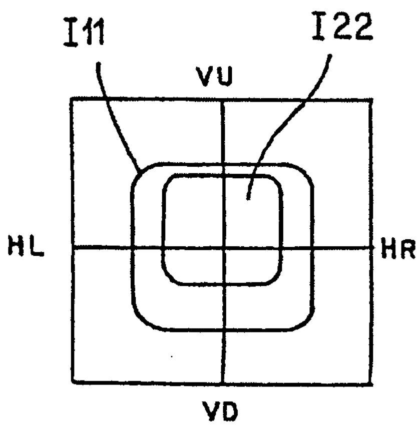


FIG.20

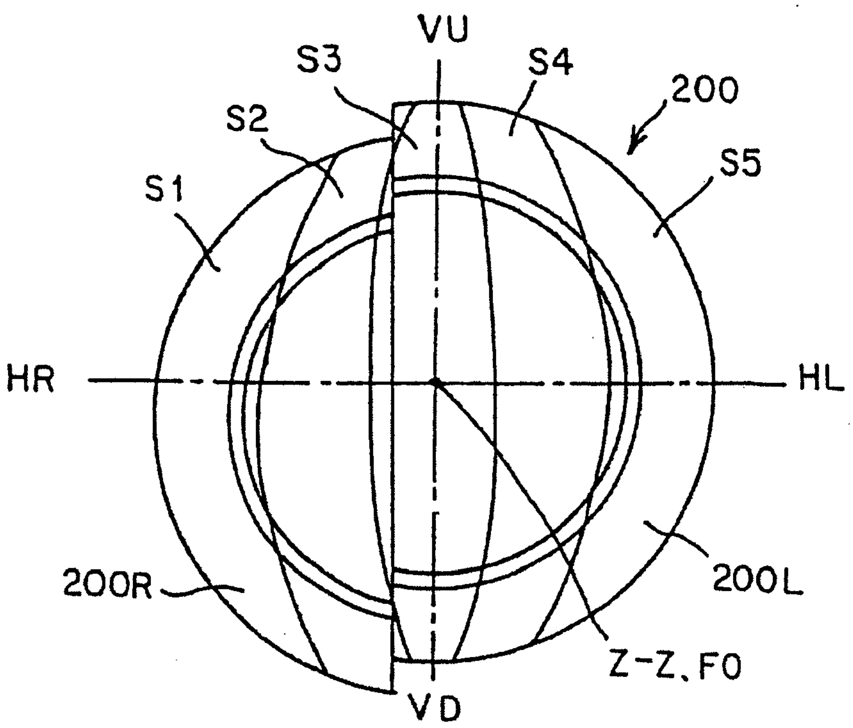


FIG.21

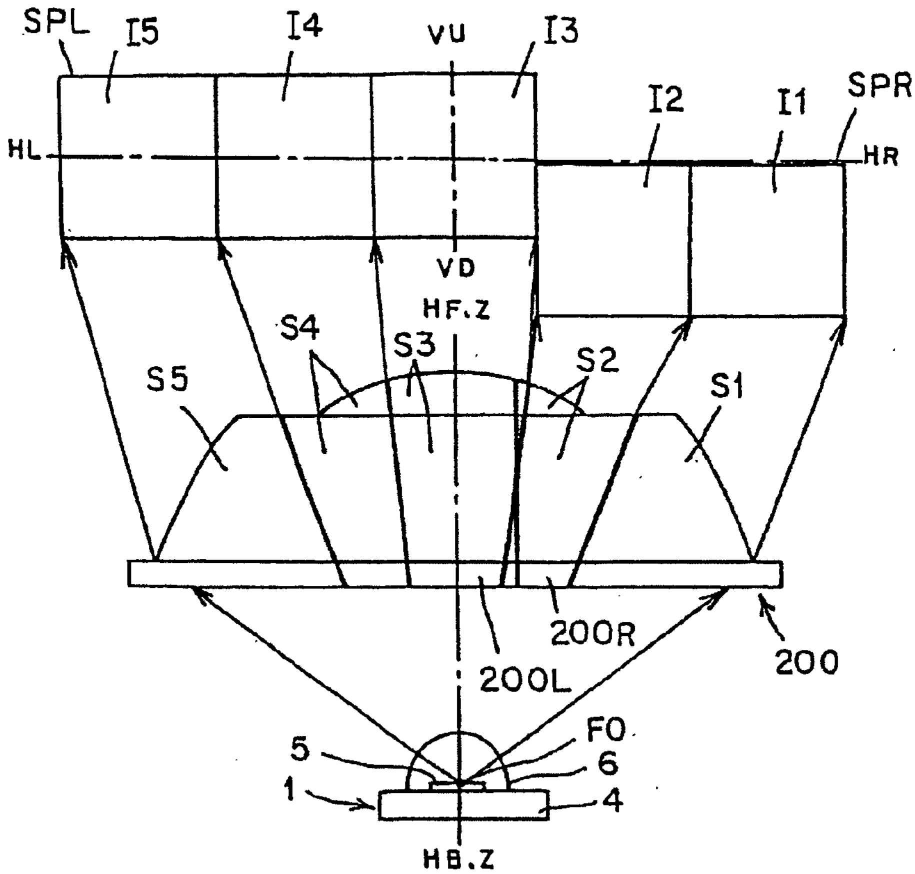
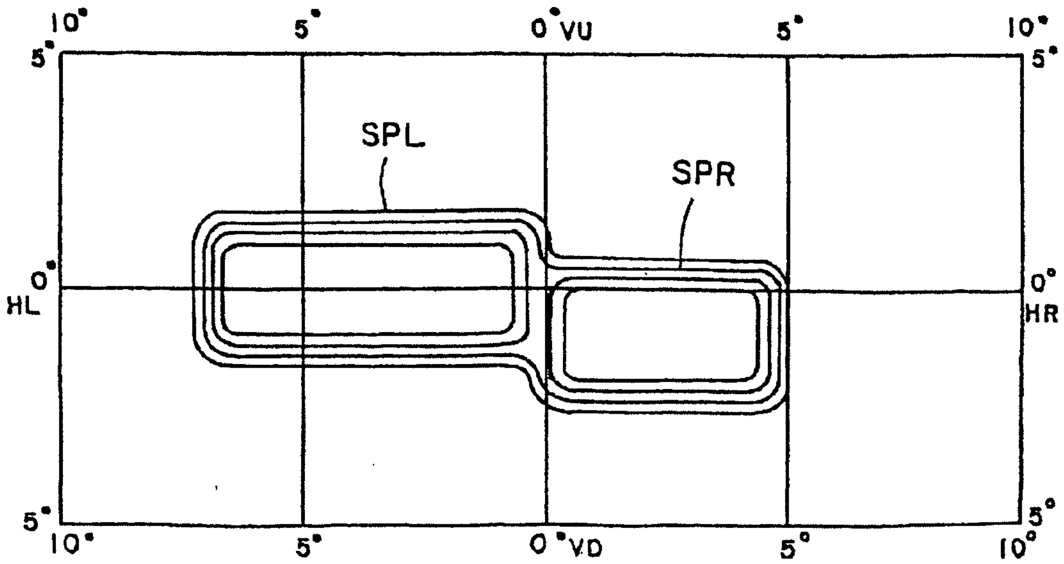

SPL
I5
I4
VU
I3
I2
I1
SPR
HL
HR
VD
HF.Z
S4
S3
S2
S5
S1
200R
200
200L
F0
5
6
1
4
HB.Z

FIG.22


10°
5°
0° VU
5°
10°
5°
SPL
SPR
0°
HL
HR
5°
10°
5°
0° VD
5°
10°

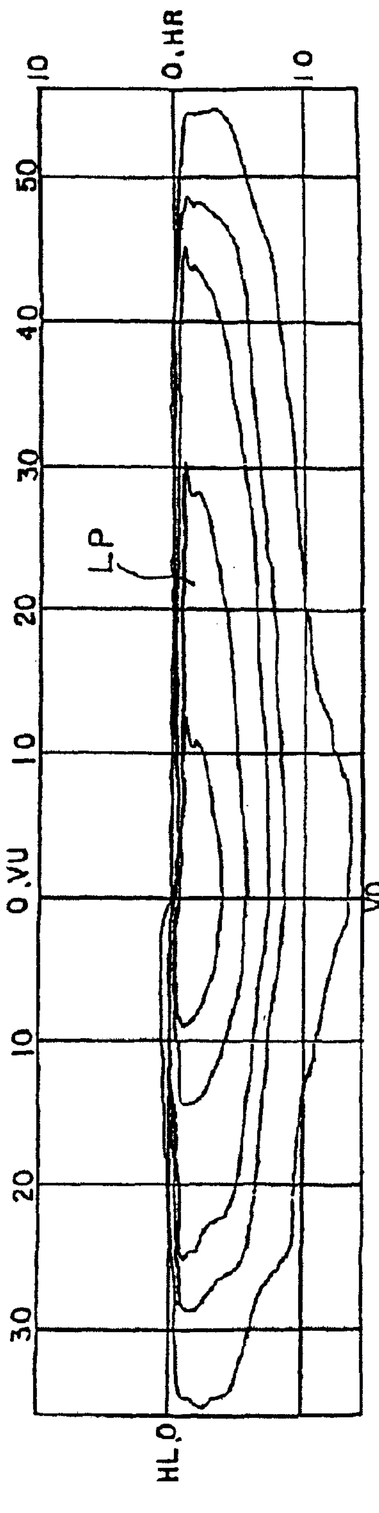


FIG.23

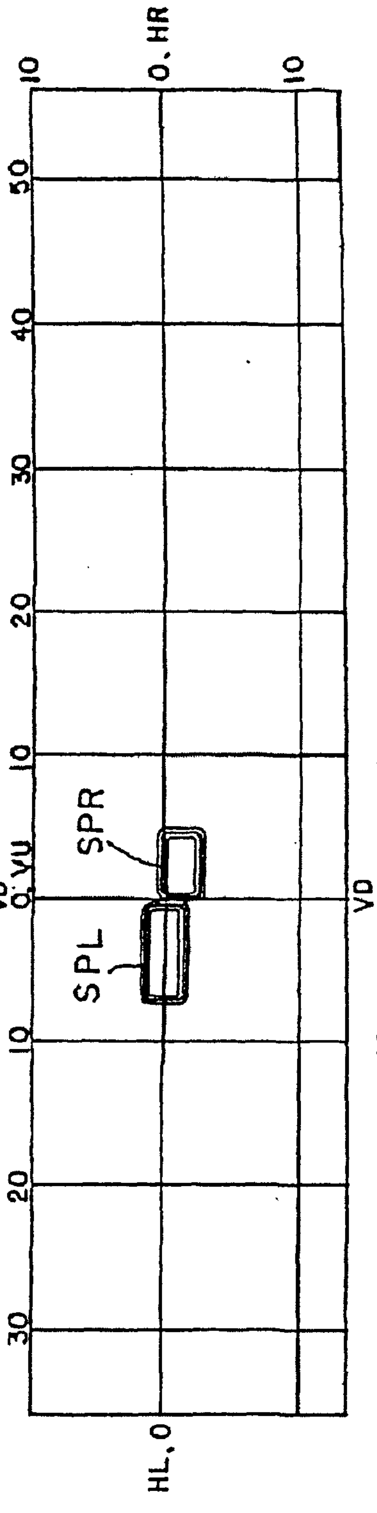


FIG.24

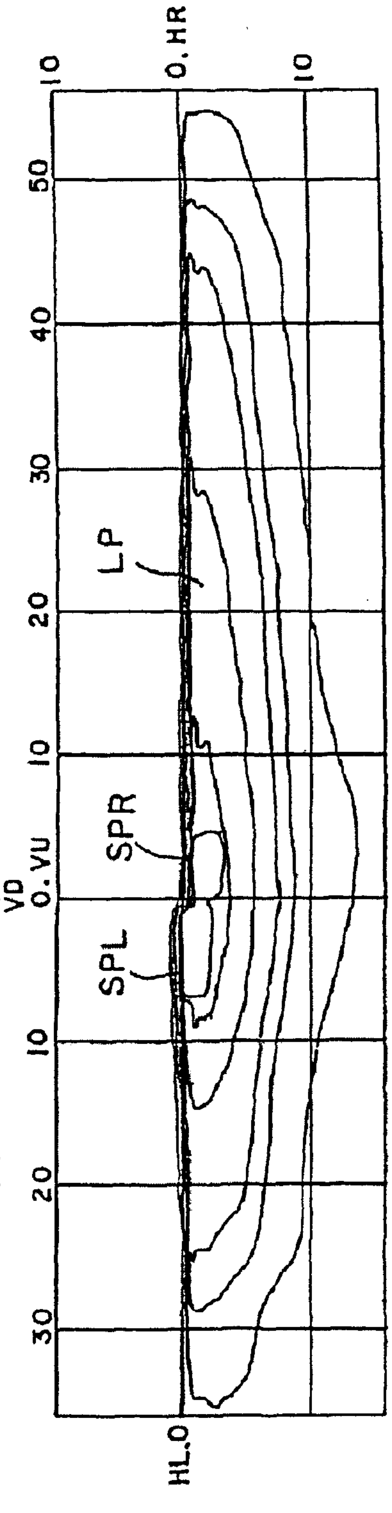


FIG.25