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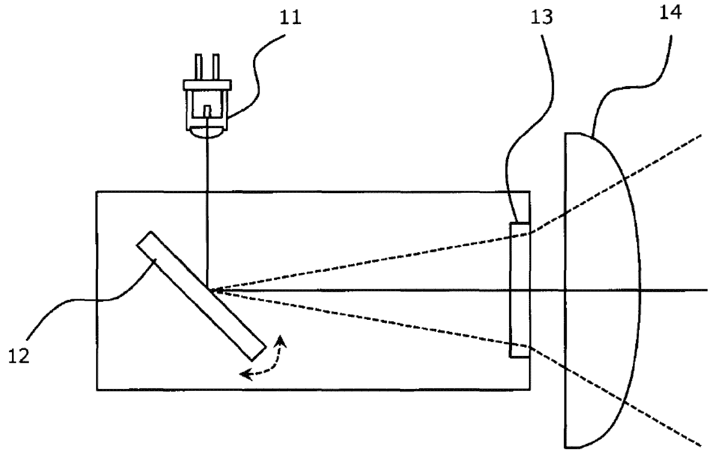
(54) **ILLUMINATION DEVICE**

(57) An illumination device that realizes a clear adaptive driving beam is provided. This illumination device includes: a light source that generates laser light; a movable mirror that has a mirror surface reflecting the laser light and is capable of driving the mirror surface; and a phosphor that is irradiated with the laser light reflected by the movable mirror and converts the laser light into fluorescence. In the laser light with which the phosphor is irradiated, a rise of an intensity distribution in a scanning direction of the phosphor is steeper than a rise of an intensity distribution in a vertical direction substantially perpendicular to the scanning direction.

FIG. 2



EP 3 279 551 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an illumination device.

BACKGROUND ART

[0002] In recent years, a laser light source has attracted attention as a light source to be applied to an automotive headlight since the laser light source has high efficiency and high directivity. It is known that, when the laser light source is applied, light can be distributed with a high degree of freedom by making use of the high directivity and by using a movable mirror.

[0003] PTL 1 is cited as a prior document related to the present invention. PTL 1 discloses a vehicle lighting fixture, which reciprocally rotates a mirror that reflects light from a semiconductor light source, controls ON/OFF of the semiconductor light source for each of a plurality of dimming sections obtained by dividing a motion cycle of the mirror, combines such ON/OFF control of the semiconductor light source with a periodic motion of the mirror, and adjusts an illuminance distribution around a vehicle.

Citation List

Patent Literature

[0004] PTL 1: Unexamined Japanese Patent Publication No. 2010-6109

SUMMARY OF THE INVENTION

[0005] In general, when the laser light source is applied to an automotive headlight, a phosphor is excited by laser light emitted from the laser light source, whereby a white light source is obtained.

[0006] However, PTL 1 mentioned above does not disclose a specific laser irradiation method for performing, for example, an adaptive driving beam (ADB) for a purpose of preventing an oncoming vehicle from being dazzled in the automotive headlight using the laser light source and the phosphor. That is, PTL 1 does not disclose a method for narrowing a boundary area between an area that is irradiated with headlight light and an area that is not irradiated with the headlight light. And it cannot realize clear and fine light distribution variation. Hence, there is a problem that a clear adaptive driving beam cannot be realized.

[0007] It is an object of the present invention to provide an illumination device that realizes the clear adaptive driving beam.

[0008] An illumination device according to an aspect of the present invention includes: a light source that generates laser light; a movable mirror that has a mirror surface reflecting the laser light and is capable of driving the mirror surface; and a phosphor that is irradiated with the laser light reflected by the movable mirror and converts the laser light into fluorescence. In the laser light with which the phosphor is irradiated, a rise of an intensity distribution in a scanning direction of the phosphor is steeper than a rise of an intensity distribution in a vertical direction substantially perpendicular to the scanning direction.

[0009] In accordance with the present invention, in the laser light directed onto the phosphor, the rise of the intensity distribution in the scanning direction is made steeper than the rise of the intensity distribution in the vertical direction substantially perpendicular to the scanning direction. Accordingly, if the scanning direction is set to a lateral direction in front of the vehicle, then a light distribution variation, which is clear and fine in the lateral direction, can be realized. Hence, the light distribution for the purpose of preventing the oncoming vehicle or the like from being dazzled can be set clearly and finely, and dimmed areas on a left outside and a right outside can be controlled finely. From these results, the clear adaptive driving beam can be realized.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a front view of a vehicle according to an exemplary embodiment of the present invention.
FIG. 2 is a configuration diagram of a headlight on a left side of the vehicle of FIG. 1 when viewed from a side.
FIG. 3 is diagrams for explaining intensity of laser excitation light on a phosphor.
FIG. 4 is diagrams showing laser irradiation intensity on the phosphor when the phosphor is scanned by using laser light.
FIG. 5 is a schematic diagram showing how a laser light source emits the laser light.
FIG. 6 is a diagram showing a light distribution pattern that gradually reduces luminosity in an area close to an outside of the phosphor.
FIG. 7 is a diagram showing a light distribution pattern that reduces the luminosity in the area close to the outside of the phosphor by using an optical path difference between a center and outside of the phosphor.
FIG. 8 is a configuration diagram of a headlight when two light sources are used.
FIG. 9 is a diagram showing a light distribution pattern when two light sources are used.
FIG. 10 is diagrams showing a light distribution pattern in which a spot area directed onto the phosphor is formed into a rectangular shape.
FIG. 11 is a block diagram showing a configuration for controlling the headlight according to the exemplary embodiment of the present invention.

FIG. 12 is a flowchart showing a control procedure in a controller of FIG. 10.

FIG. 13 is a diagram showing a road surface irradiation pattern formed by the headlight.

DESCRIPTION OF EMBODIMENT

[0011] Hereinafter, an exemplary embodiment of the present invention will be described in detail with reference to the drawings.

EXEMPLARY EMBODIMENT

[0012] FIG. 1 is a front view of a vehicle according to an exemplary embodiment of the present invention. In FIG. 1, headlights 2 are disposed on both right and left sides of a front portion of a body of vehicle 1.

[0013] Headlights 2 are disposed such that an irradiation direction of light is directed to a front of the vehicle.

[0014] Sensor 3 senses whether or not another vehicle, a person or an object is present in front of the vehicle, and when any one of them is present, also senses a position of the sensed one of them. Sensor 3 is any of a camera, a radar, and a sonar, and for example, is disposed behind a windshield rearview mirror.

[0015] FIG. 2 is a configuration diagram of headlight 2 on a left side of the vehicle of FIG. 1 when viewed from a side. Hereinafter, a configuration of each of headlights 2 will be described with reference to FIG. 2. However, a configuration of the headlight on a right side of the vehicle is the same as the configuration of the headlight on the left side of the vehicle, and accordingly, a detailed description of the configuration of the headlight on the right side of the vehicle will be omitted here. Headlight 2 includes: laser light source 11; movable mirror 12; phosphor 13; and light projecting lens 14.

[0016] Laser light source 11 generates laser light, and irradiates movable mirror 12 with the generated laser light. Laser light is, for example, blue or blue purple.

[0017] Movable mirror 12 is, for example, a MEMS (Micro Electro Mechanical System) mirror, and vibrates a mirror surface at a high speed about one axis or two axes by control of a controller (not shown). Movable mirror 12 reflects the laser light, which is generated from laser light source 11, and scans phosphor 13. Note that the description will be made below on the assumption that the mirror surface vibrates about one axis in a vertical direction.

[0018] Phosphor 13 is irradiated with the laser light reflected by movable mirror 12, and generates white light. Here, phosphor 13 converts the laser light, which is blue, into the white light, and becomes a white light source. That is, phosphor 13 converts such blue laser light into blue diffused light and yellow fluorescence, and generates the white light. Moreover, when the laser light is blue purple, phosphor 13 generates the white light by generating blue fluorescence and yellow fluorescence. Note that phosphor 13 may convert the laser light not only into the white light but also into faint yellow light, orange light and the like.

[0019] Light projecting lens 14 condenses the while light, which is emitted by phosphor 13, and irradiates the front of the vehicle.

[0020] FIG. 3 is diagrams for explaining intensity of laser excitation light on phosphor 13. Part (a) of FIG. 3 shows a state in which phosphor 13 is irradiated with the laser light. As shown by part (a) of FIG. 3, when phosphor 13 is irradiated with the laser light, an elliptical spot area is formed, which is longer (hereinafter, referred to as "longitudinally long") in the vertical direction than in a scanning direction (horizontal direction) of scanning phosphor 13.

[0021] Part (b) of FIG. 3 shows a horizontal intensity distribution, and part (c) of FIG. 3 shows a vertical intensity distribution. In each of part (b) of FIG. 3 and part (c) of FIG. 3, a width between where beam intensity becomes $1/e^2$ (approximately 13%) of a peak value is referred to as a beam width. From part (b) of FIG. 3, a horizontal beam width is 0.17 mm, and from part (c) of FIG. 3, a vertical beam width is 0.39 mm. As described above, in the laser light directed onto phosphor 13, the horizontal beam width is narrower than the vertical beam width. This indicates that a rise of the intensity distribution in the scanning direction of scanning the phosphor is steeper than a rise of the intensity distribution in the vertical direction substantially perpendicular to the scanning direction.

[0022] FIG. 4 is diagrams showing laser irradiation intensity on phosphor 13 when phosphor 13 is scanned by using the laser light. FIG. 4 shows a case where a light shielding area (an area for stopping the irradiation of the laser light) is provided in a vicinity of a center of phosphor 13 so that a spot shape of the laser light on phosphor 13 can be easily understood. Part (a) of FIG. 4 shows laser irradiation intensity when phosphor 13 is scanned in a longitudinally long spot area, and part (b) of FIG. 4 shows laser irradiation intensity when phosphor 13 is scanned in a spot area that is laterally long (longer in the horizontal direction than in the vertical direction). In each of part (a) of FIG. 4 and part (b) of FIG. 4, an axis of ordinates of the graph shows light intensity at a half of a height of phosphor 13, and an axis of abscissas of the graph shows a position of phosphor 13 in the horizontal direction.

[0023] As seen from part (a) of FIG. 4 and part (b) of FIG. 4, clarity and fineness of a light distribution variation in the horizontal direction depend on the spot shape of the laser light directed onto the phosphor. With a spot shape that is thin in the horizontal direction, an irradiation area can be finely adjusted in the horizontal direction. That is, as shown in part (a) of FIG. 4, phosphor 13 is scanned by the longitudinally long spot area thin in the horizontal direction, whereby the irradiation area can be formed finely in the horizontal direction. Meanwhile, as seen from part (b) of FIG. 4, when phosphor 13 is scanned by a laterally long spot area thick in the horizontal direction, the irradiation area cannot be finely adjusted in the horizontal direction.

[0024] FIG. 5 is a schematic diagram showing how laser light source 11 emits the laser light. When a current flows through a semiconductor laser serving as laser light source 11, laser light is irradiated from active layer La sandwiched between p-type clad layer Lp and n-type clad layer Ln. Active layer La is extremely thin with respect to a current injection width, and accordingly, as shown in FIG. 5, the laser light immediately after being emitted from active layer La has a near field pattern that has an ellipse shape in which a major axis is located along a line where an emitting portion of active layer La is formed. In this exemplary embodiment, phosphor 13 is irradiated with the near field pattern. Hence, laser light source 11 is disposed so that a plane of the active layer is perpendicular to the scanning direction. In this way, an elliptical spot area can be formed without requiring a special optical member.

[0025] Note that, after being emitted from active layer La, the laser light has a far field pattern that has an ellipse shape, in which an orientation is changed by 90° due to diffraction, and that has a major axis that is perpendicular to a line where the emitting portion of active layer La is formed. Therefore, when phosphor 13 is irradiated with the far field pattern, laser light source 11 just needs to be disposed so that the plane of the active layer is parallel to the scanning direction.

[0026] Next, with reference to the drawings, a description will be made of a case of changing a light distribution pattern of headlight 2.

[0027] FIG. 6 is a diagram showing a light distribution pattern that gradually reduces luminosity in an area close to an outside of phosphor 13. Laser light source 11 is gradually darkened as getting closer to an outside of a scanning range of phosphor 13 by reducing the luminosity (the intensity of the laser light) in an area closer to the outside than a center of the scanning range concerned. Looking at this state as a whole from a bird's-eye view, an outline of the outside light looks blurred, and there is no sudden reduction of the luminosity at an edge of a viewing field of a driver. Moreover, in headlight 2, phosphor 13 is scanned by the longitudinally long elliptical spot area, and accordingly, such blurring of the outline of the outside light can be finely controlled. That is, headlight 2 can combine a clear adaptive driving beam and a blurred natural light distribution with each other. As a result, the driver can drive the vehicle with ease.

[0028] FIG. 7 is a diagram showing a light distribution pattern that reduces the luminosity in the area close to the outside of phosphor 13 by using an optical path difference between the center and outside of phosphor 13. Here, laser light source 11 is disposed so that an optical path length when the laser light is directed onto the center of the scanning range of phosphor 13 is shorter than an optical path length when the laser light is directed onto the area close to the outside of the scanning range of phosphor 13. Due to a difference between the optical path lengths, that is, the optical path difference, as shown in FIG. 7, a spot width of the laser light becomes small at the center of the scanning range of phosphor 13, and the intensity of the laser light is increased, and at the area close to the outside of phosphor 13, the optical path becomes longer than at the center of phosphor 13, and accordingly, the spot width of the laser light is widened, and the intensity of the laser light is decreased. In this way, there is no sudden reduction of the luminosity at the edge of the viewing field of a driver. That is, headlight 2 can combine the clear adaptive driving beam and the blurred natural light distribution with each other. As a result, the driver can drive the vehicle with ease. Moreover, it is unnecessary to finely control the light distribution in the area close to the outside of phosphor 13.

[0029] FIG. 8 is a configuration diagram of headlight 2 when two light sources are used. Headlight 2 shown in FIG. 8 is obtained by adding laser light source 15 for a fixed light source to the configuration of FIG. 2. Laser light source 15 generates laser light, and irradiates phosphor 13 with the generated laser light. Laser light is, for example, blue or blue purple. Laser light source 15 performs the irradiation with the far field pattern.

[0030] FIG. 9 is a diagram showing a light distribution pattern when two light sources are used. As mentioned above, laser light source 15 is used as the fixed light source, and phosphor 13 is scanned by using the longitudinally long spot area formed by laser light source 11. Laser light source 15 irradiates the center and its vicinity of the scanning range of phosphor 13. Moreover, laser light source 15 does not form a light shielding area for an oncoming vehicle or the like, but forms a light distribution pattern having a wider irradiation range in a lateral direction than an irradiation range in the vertical direction by means of one light source, and accordingly, it is preferable that the spot area directed by laser light source 15 onto phosphor 13 be an ellipse longer in the horizontal direction than in the vertical direction. In this way, distance visibility of the driver can be enhanced, and in particular, safety during high speed traveling can be enhanced. Moreover, the light distribution in the area close to the outside of phosphor 13 can be finely controlled. Note that laser light source 11 corresponds to an example of a first light source according to the present invention, and laser light source 15 corresponds to a second light source according to the present invention.

[0031] FIG. 10 is diagrams showing a light distribution pattern in which the spot area directed onto phosphor 13 is formed into a rectangular shape. Part (a) of FIG. 10 shows a state in which phosphor 13 is irradiated with the laser light. Part (b) of FIG. 10 shows a horizontal intensity distribution, and part (c) of FIG. 10 shows a vertical intensity distribution. Formation of such a spot area as shown in part (a) of FIG. 10 can be realized by passing the laser light through a collimator lens or a cylindrical lens. Also in this light distribution pattern, the rise of the intensity distribution in the scanning direction of scanning the phosphor can be made steeper than the rise of the intensity distribution in the vertical direction substantially perpendicular to the scanning direction. The light distribution pattern is effective, for example, for a case of such an optical configuration in which the near field pattern of laser light source 11 cannot be taken over on the phosphor as in a mode of guiding the laser light, which is emitted from laser light source 11, by means of a fiber.

[0032] As described above, headlight 2 prepares a variety of light distribution patterns, and switches the light distribution pattern in response to positions of another vehicle and a person, whereby dazzling to another vehicle or a person in front of the vehicle can be prevented, and a good viewing field of the driver can be maintained.

[0033] FIG. 11 is a block diagram showing a configuration for controlling headlight 2 according to the exemplary embodiment of the present invention. Operating unit 21 is a switch that switches ON/OFF of headlight 2.

[0034] Memory 22 stores a plurality of light distribution patterns of laser light source 11, which correspond to positions where another vehicle such as a preceding vehicle and an oncoming vehicle or a person is present in front of the headlight, that is, in the irradiation direction of the white light.

[0035] Sensor 3 senses whether or not another vehicle or a person is present in front of the vehicle, and when another vehicle or a person is present, also senses a position of the sensed vehicle or person.

[0036] Laser light source 11 switches an output of the laser light in accordance with the control of controller 23.

[0037] Movable mirror 12 switches a vibration speed of the mirror concerned in accordance with the control of controller 23.

[0038] When operating unit 21 switches headlight 2 to ON, controller 23 receives an input of an ON signal, acquires, from sensor 3, sensing information as to whether or not another vehicle or a person is present in front of the headlight, and also acquires position information on the other vehicle or the person when the other vehicle or the person is present. When the other vehicle or the person is present in front of the headlight, controller 23 reads out the light distribution pattern of laser light source 11, which corresponds to the position of the other vehicle or the person, from memory 22, and controls the output of laser light source 11 in accordance with the readout light distribution pattern. That is, controller 23 controls the intensity of the laser light in response to an irradiation position in the scanning direction. Moreover, when the other vehicle or the person is present in front of the headlight, controller 23 controls laser light source 11 to stop or suppress the irradiation of the laser light onto the position of the other vehicle or the person, which is defined as the light shielding area.

[0039] FIG. 12 is a flowchart showing a control procedure in controller 23 of FIG. 11. In step S01, controller 23 determines whether or not to have received the ON signal, which indicates that headlight 2 is ON, from operating unit 21. When controller 23 has received the ON signal (step S01: YES), controller 23 proceeds to step S02, and when controller 23 has not received the ON signal (step S01: NO), controller 23 end the processing.

[0040] In step S02, controller 23 activates laser light source 11 and movable mirror 12, and in step S03, controller 23 acquires such sensing information, which indicates that the other vehicle (a preceding vehicle or an oncoming vehicle), the person, an obstacle or the like is detected in front of the headlight, from sensor 3.

[0041] In step S04, controller 23 determines whether or not a place concerned is to be shielded or dimmed based on the sensing information acquired in step S03. That is, when the sensing information indicates the other vehicle or the person, controller 23 determines that the place concerned is to be shielded or dimmed. When the place is to be shielded or dimmed (step S04: YES), controller 23 proceeds to step S05, and when the place is not to be shielded or dimmed (step S04: NO), controller 23 proceeds to step S06.

[0042] In step S05, controller 23 reads out, from memory 22, such a light distribution pattern that suppresses the distribution of the irradiation light, and controls laser light source 11 in accordance with the readout light distribution pattern.

[0043] In step S06, controller 23 reads out, from memory 22, such a light distribution pattern that does not suppress the distribution of the irradiation light, and controls laser light source 11 in accordance with the readout light distribution pattern.

[0044] In step S07, controller 23 determines whether or not to have received an OFF signal, which turns OFF headlight 2, from operating unit 21. When controller 23 has received the OFF signal (step S07: YES), controller 23 proceeds to step S08, and when controller 23 has not received the OFF signal (step S07: NO), controller 23 returns to step S03.

[0045] In step S08, controller 23 stops laser light source 11 and movable mirror 12, and ends the processing of the control procedure.

[0046] FIG. 13 is a diagram showing a road surface irradiation pattern formed by headlight 2. As shown in FIG. 13, a front left side of vehicle 1 forms a long irradiation area, and a front right side of vehicle 1 forms a short irradiation area. In this way, a pedestrian or an obstacle, which passes through the front left side of vehicle 1, can be illuminated from a distant position, and meanwhile, dazzling can be prevented from being given to a vehicle that faces the right side of vehicle 1 or a nearby pedestrian (not shown).

[0047] As described above, in accordance with this exemplary embodiment, the rise of the intensity distribution in the scanning direction for the spot area formed by the laser light directed onto the phosphor is made steeper than the rise of the intensity distribution in the vertical direction substantially perpendicular to the scanning direction, and the phosphor is scanned by using this spot area, whereby the clear adaptive driving beam can be realized.

INDUSTRIAL APPLICABILITY

[0048] The present invention is useful for realizing the clear adaptive driving beam.

REFERENCE MARKS IN THE DRAWINGS

[0049]

1	vehicle
2	headlight
3	sensor
11, 15	laser light source
12	movable mirror
13	phosphor
14	light projecting lens
21	operating unit
22	memory
23	controller

Claims

1. An illumination device comprising:

   a light source that generates laser light;
   a movable mirror that has a mirror surface reflecting the laser light and is capable of driving the mirror surface; and
   a phosphor that is irradiated with the laser light reflected by the movable mirror and converts the laser light into fluorescence,
   wherein, in the laser light with which the phosphor is irradiated, a rise of an intensity distribution in a scanning direction of the phosphor is steeper than a rise of an intensity distribution in a vertical direction substantially perpendicular to the scanning direction.

2. The illumination device according to claim 1, wherein a spot area of the laser light with which the phosphor is irradiated is a substantial ellipse longer in the vertical direction than in the scanning direction.

3. The illumination device according to claim 1, wherein the light source has an active layer that emits the laser light, and is disposed so that a plane of the active layer is perpendicular to the scanning direction.

4. The illumination device according to claim 1, further comprising a controller that controls intensity of the laser light according to an irradiation position in the scanning direction.

5. The illumination device according to claim 1, wherein the light source irradiates the phosphor with the laser light so that intensity of the laser light is lower in an area close to an outside of a scanning range of the phosphor than in a center of the scanning range.

6. The illumination device according to claim 5, wherein the light source decreases the intensity of the laser light by control of an output of the laser light.

7. The illumination device according to claim 5, wherein

   the light source is disposed so that an optical path length is shorter when the center of the scanning range of the phosphor is irradiated with the laser light than when the area close to the outside of the scanning range of the phosphor is irradiated with the laser light, and
   due to a difference in the optical path length, the laser light is irradiated so that the intensity of the laser light is lower in the area close to the outside of the scanning range of the phosphor than in the center of the scanning range.

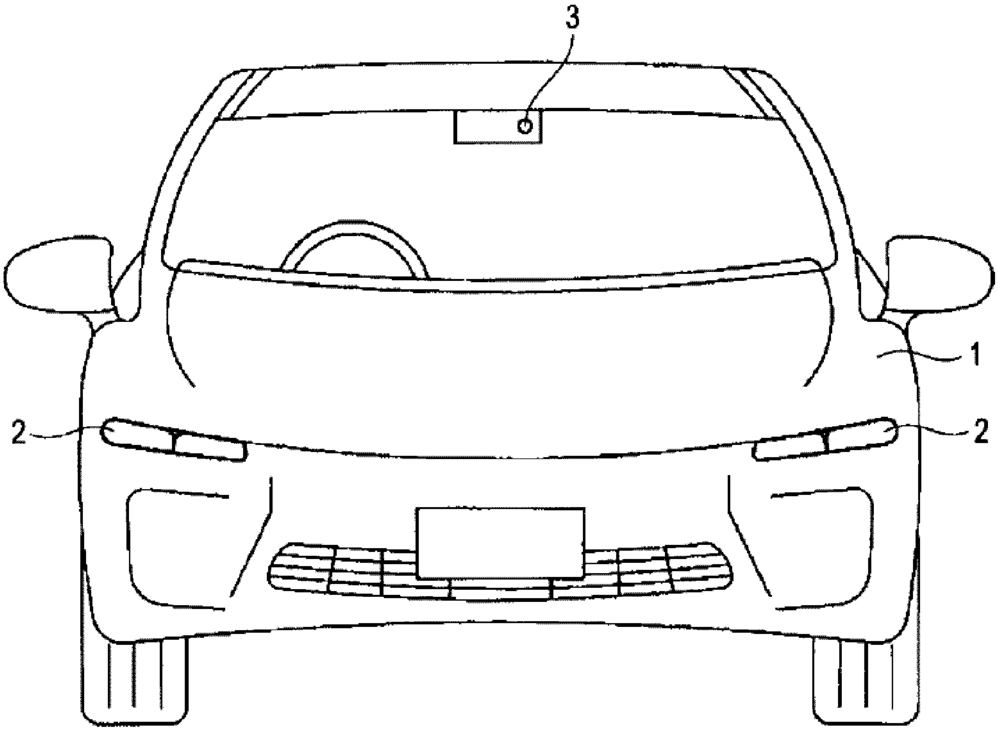
8. The illumination device according to claim 1, wherein

   the light source includes:

   a first light source that generates first laser light as the laser light; and
   a second light source that fixedly irradiates an area of the phosphor that is closer to the center than the outside with second laser light.

9. The illumination device according to claim 8, wherein a spot area of the second laser light with which the phosphor is irradiated is a substantial ellipse longer in the scanning direction than in the vertical direction.

FIG. 1



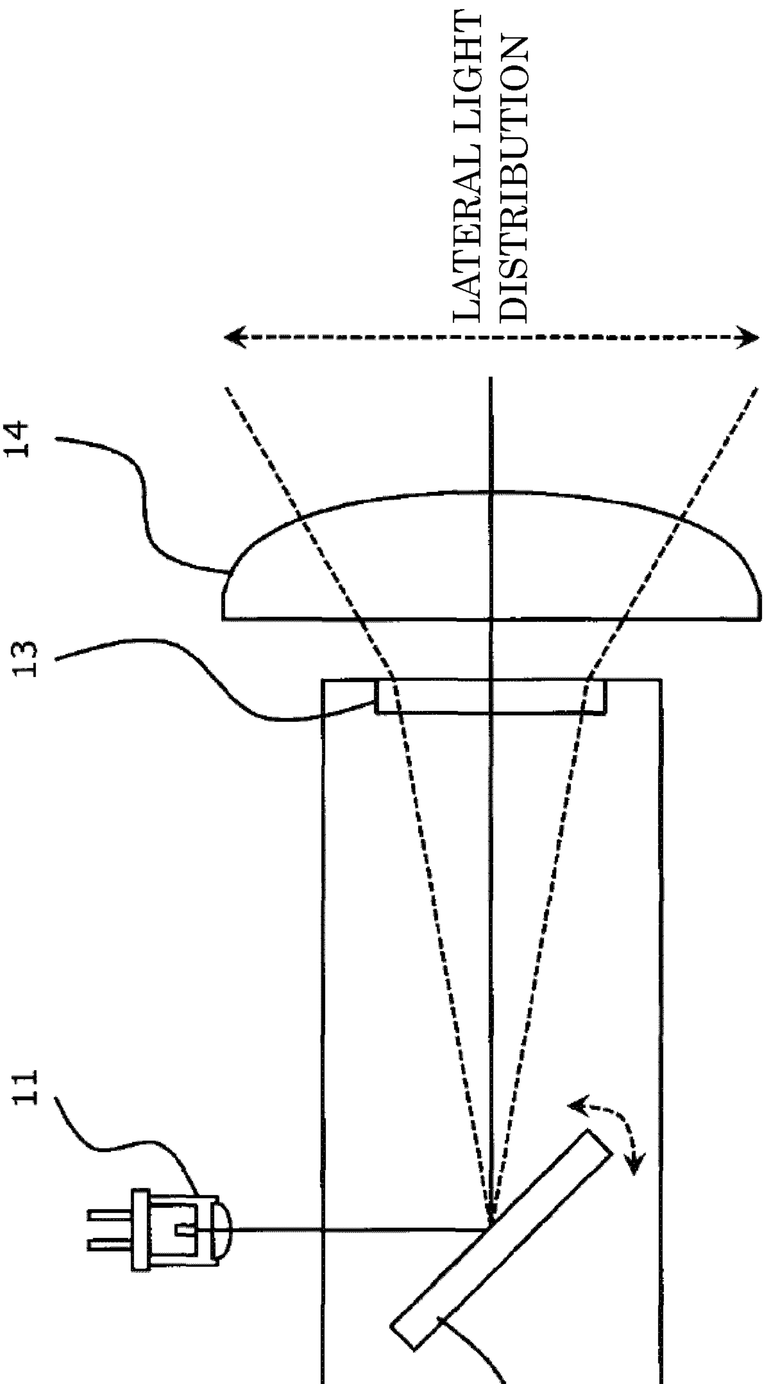


FIG. 2

FIG. 3

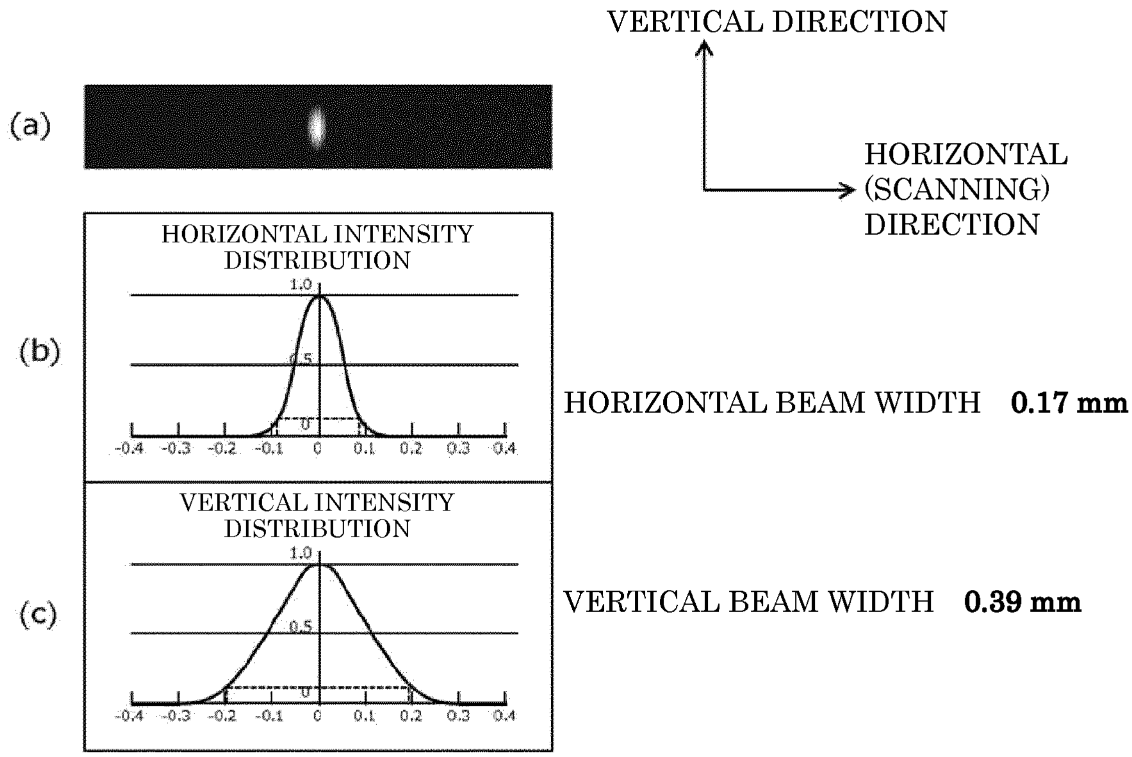

VERTICAL DIRECTION
HORIZONTAL (SCANNING) DIRECTION
(a)
(b)
HORIZONTAL INTENSITY DISTRIBUTION
1.0
0.5
0
-0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4
(c)
VERTICAL INTENSITY DISTRIBUTION
1.0
0.5
0
-0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4
HORIZONTAL BEAM WIDTH **0.17 mm**
VERTICAL BEAM WIDTH **0.39 mm**

FIG. 4

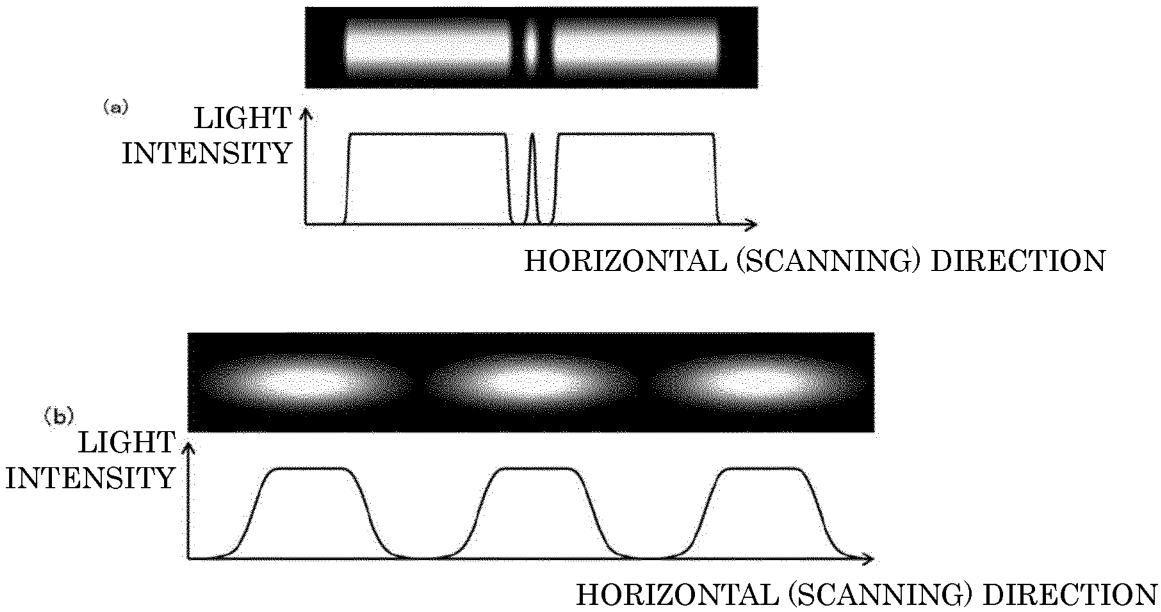

(a)
LIGHT INTENSITY
HORIZONTAL (SCANNING) DIRECTION
(b)
LIGHT INTENSITY
HORIZONTAL (SCANNING) DIRECTION

FIG. 5

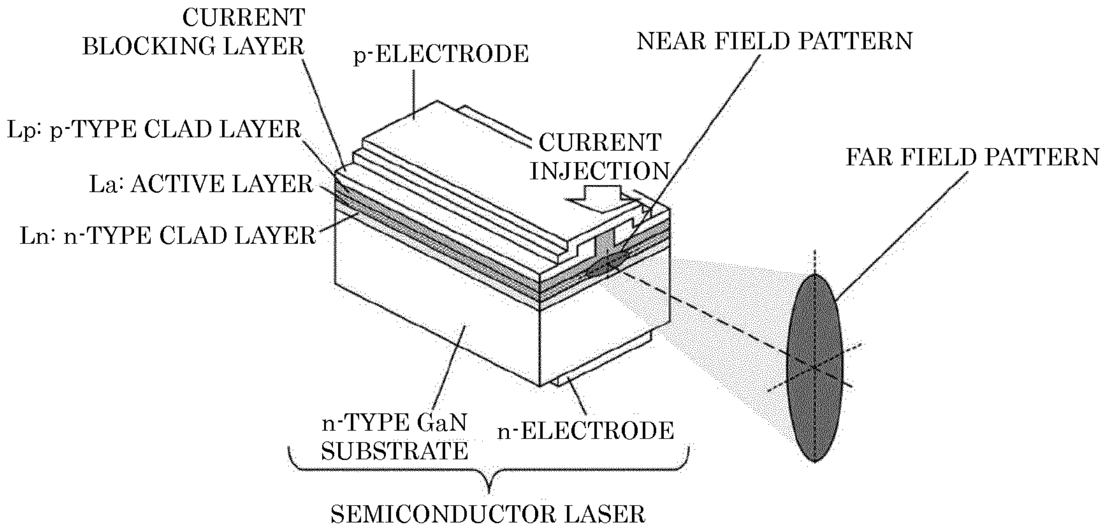


FIG. 6

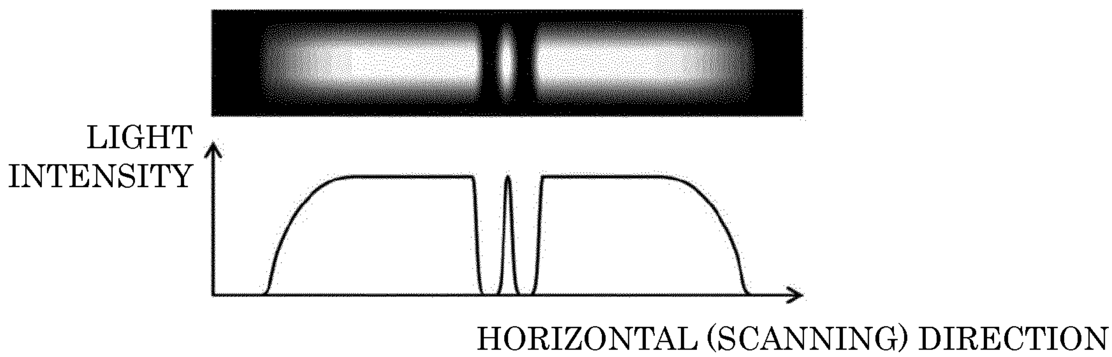


FIG. 7

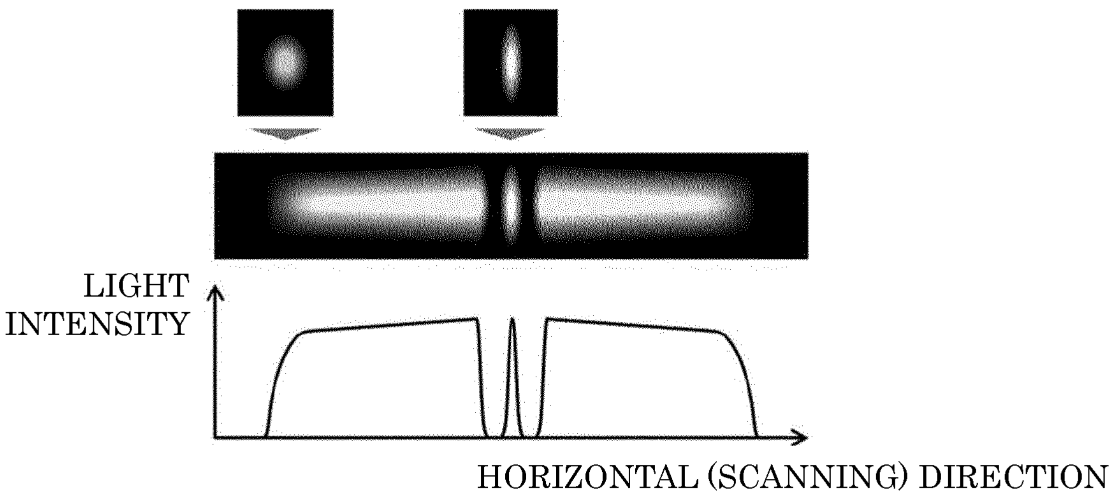


FIG. 8

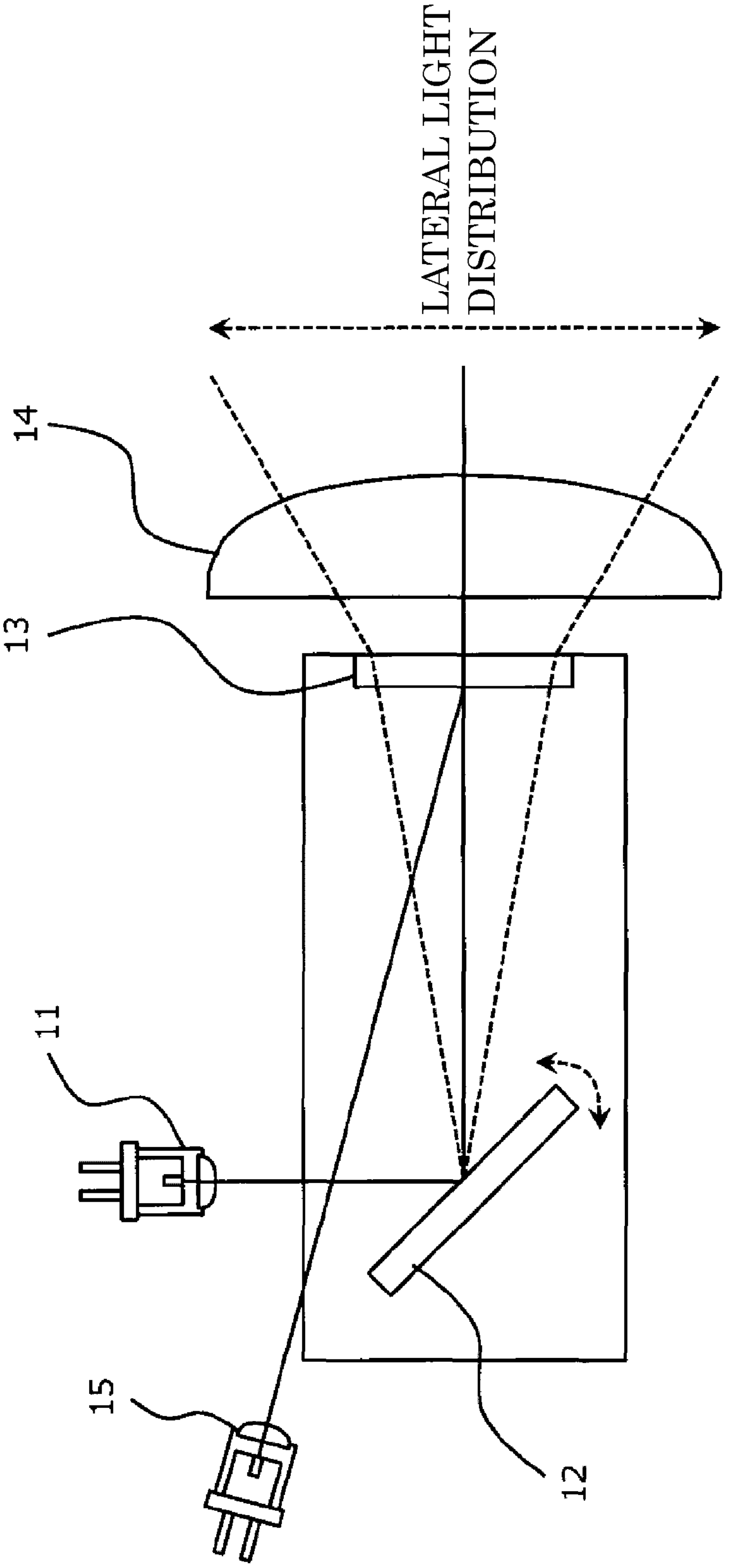


FIG. 9

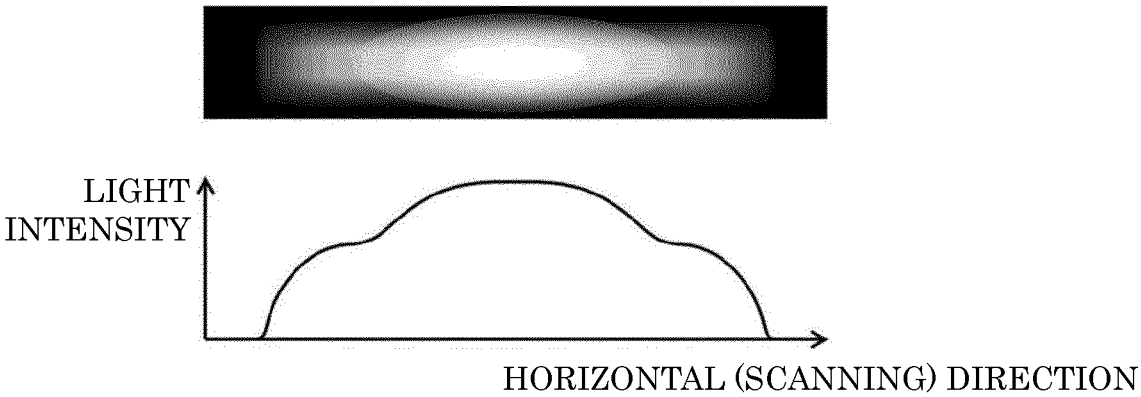

LIGHT
INTENSITY
HORIZONTAL (SCANNING) DIRECTION

FIG. 10

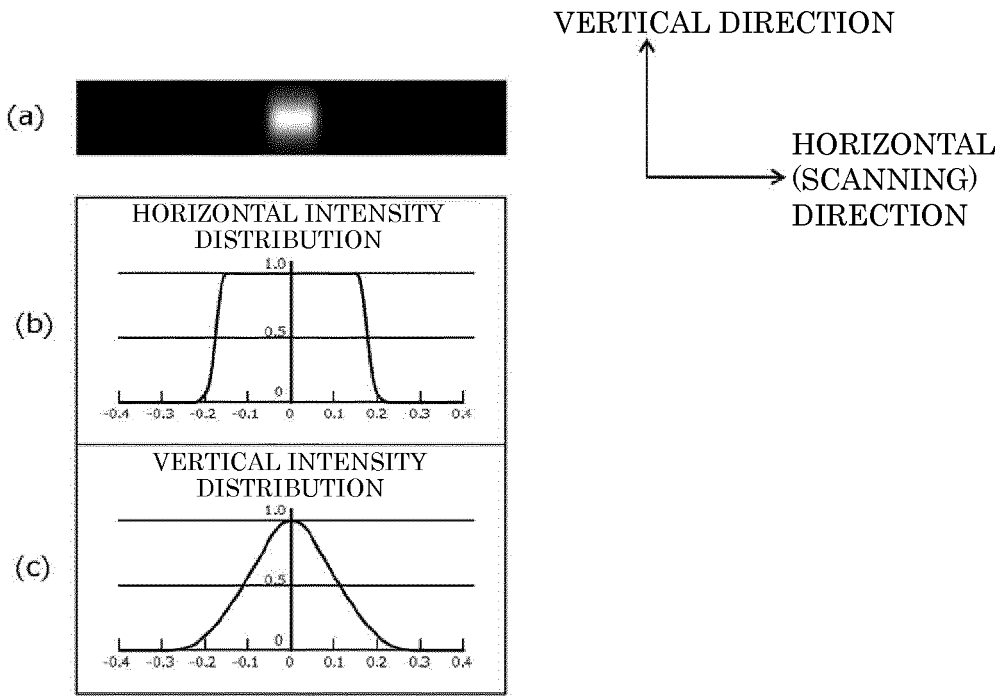
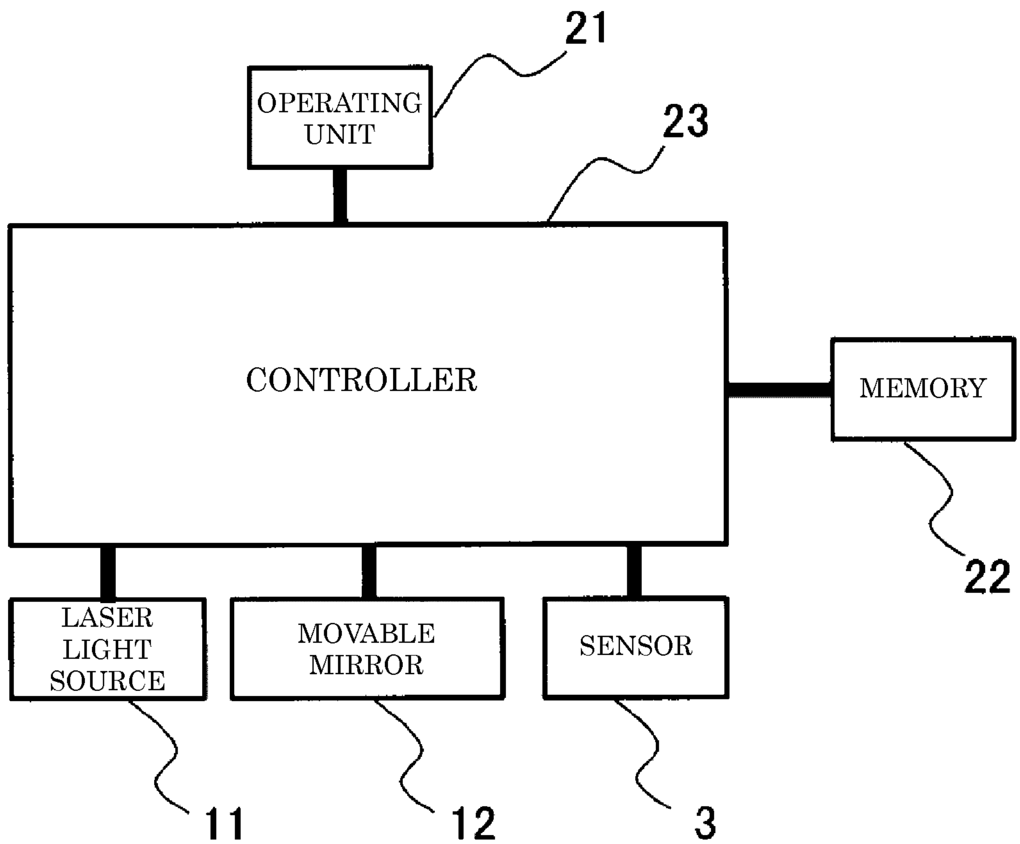

VERTICAL DIRECTION
HORIZONTAL
(SCANNING)
DIRECTION
(a)
(b)
HORIZONTAL INTENSITY
DISTRIBUTION
1.0
0.5
0
-0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4
(c)
VERTICAL INTENSITY
DISTRIBUTION
1.0
0.5
0
-0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4

FIG. 11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OPERATING UNIT
23
CONTROLLER
MEMORY
22
LASER LIGHT SOURCE
MOVABLE MIRROR
SENSOR
11
12
3

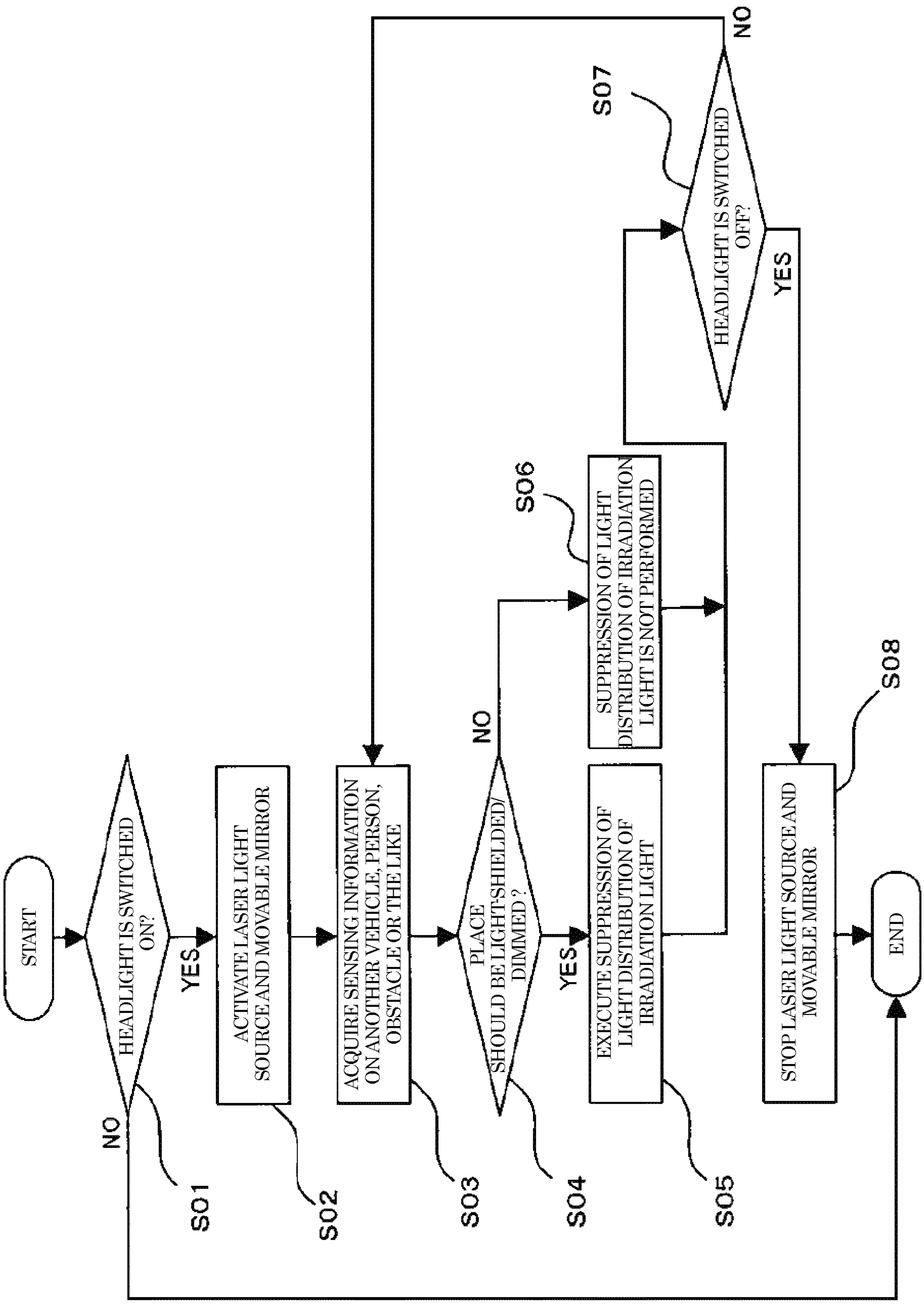
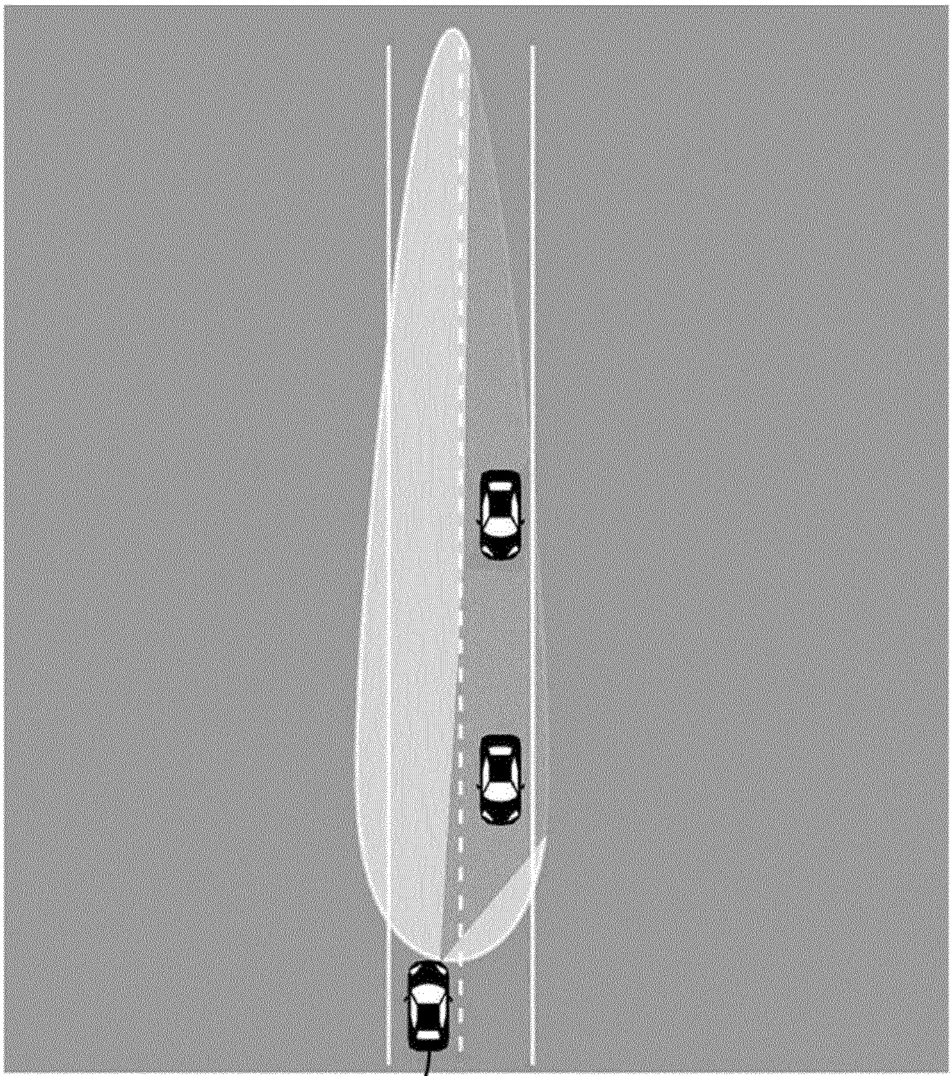

START
HEADLIGHT IS SWITCHED ON?
YES
NO
S01
ACTIVATE LASER LIGHT SOURCE AND MOVABLE MIRROR
S02
ACQUIRE SENSING INFORMATION ON ANOTHER VEHICLE, PERSON, OBSTACLE OR THE LIKE
S03
PLACE SHOULD BE LIGHT-SHIELDED/ DIMMED ?
S04
YES
NO
EXECUTE SUPPRESSION OF LIGHT DISTRIBUTION OF IRRADIATION LIGHT
S05
SUPPRESSION OF LIGHT DISTRIBUTION OF IRRADIATION LIGHT IS NOT PERFORMED
S06
HEADLIGHT IS SWITCHED OFF?
S07
YES
NO
STOP LASER LIGHT SOURCE AND MOVABLE MIRROR
S08
END

FIG. 12

FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/001422

A. CLASSIFICATION OF SUBJECT MATTER
F21S8/10(2006.01)i, *B60Q1/04*(2006.01)i, *B60Q1/076*(2006.01)i, *F21S8/12* (2006.01)i, *F21W101/10*(2006.01)n, *F21Y115/30*(2016.01)n

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F21S8/10, B60Q1/04, B60Q1/076, F21S8/12, F21W101/10, F21Y115/30

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

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Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2009-48786 A (Koito Manufacturing Co., Ltd.), 05 March 2009 (05.03.2009), paragraphs [0029] to [0031]; fig. 8 to 9 & US 2009/0046474 A1 paragraphs [0053] to [0055]; fig. 8 to 9	1-7 8-9
Y	JP 2013-171645 A (Stanley Electric Co., Ltd.), 02 September 2013 (02.09.2013), paragraphs [0010] to [0025]; fig. 1 (Family: none)	1-7

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 June 2016 (06.06.16)	14 June 2016 (14.06.16)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/001422

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2015-501062 A (Sharp Corp.), 08 January 2015 (08.01.2015), paragraphs [0050] to [0053]; fig. 6a & WO 2013/094222 A paragraphs [0050] to [0053]; fig. 6a & US 2014/0362600 A1	1-7
Y	JP 2014-60452 A (Seiko Epson Corp.), 03 April 2014 (03.04.2014), paragraphs [0032] to [0036]; fig. 2 (Family: none)	2-3
Y	WO 2014/024385 A1 (Koito Manufacturing Co., Ltd.), 13 February 2014 (13.02.2014), paragraphs [0055] to [0059]; fig. 8 & US 2015/0137680 A1 paragraphs [0068] to [0072]; fig. 8A, 8B & CN 104520146 A	5-6
A	JP 2010-36835 A (Koito Manufacturing Co., Ltd.), 18 February 2010 (18.02.2010), paragraph [0029]; fig. 7 (Family: none)	1-9
A	WO 2012/144144 A1 (Koito Manufacturing Co., Ltd.), 26 October 2012 (26.10.2012), paragraphs [0054] to [0068]; fig. 19 to 20 & US 9045080 B2 column 12, lines 10 to 51; fig. 19 to 20 & EP 2700538 A1 & CN 103492228 A	1-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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