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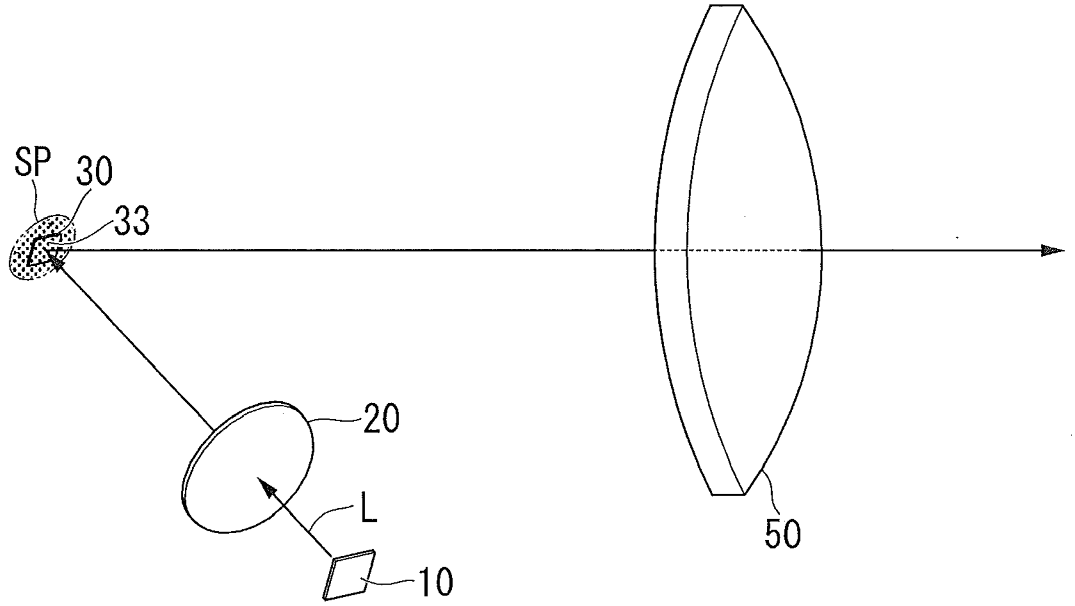
(54) VEHICLE LAMP AND VEHICLE IRRADIATION SYSTEM

(57) A vehicle lamp (1) includes a light source (10) configured to radiate white light, a light concentrator (20) configured to concentrate light radiated from the light source (10), a reflection pattern formation device (30) configured to have a plurality of optical elements arrayed in a matrix shape and form a reflection pattern by reflecting light concentrated by the light concentrator (20) according to a collective reflection plane (33) formed by a plurality of optical elements, and a projection optical system (50) configured to radiate the reflection pattern in a forward direction, wherein the collective reflection plane (33) is positioned inside a light concentration spot (SP) of the light concentrator (20) in the collective reflection plane (33).

FIG. 2



EP 3 181 996 A1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a vehicle lamp and a vehicle irradiation system.

Description of Related Art

[0002] In Japanese Unexamined Patent Application, First Publication No. H09-104288, a vehicle irradiation device (a vehicle lamp) using a digital mirror device (DMD) capable of easily changing a light distribution pattern is disclosed.

SUMMARY OF THE INVENTION

[0003] In this vehicle irradiation device, light from a light source is concentrated by a reflection plane having a concave shape for causing the light from the light source to be incident on the DMD. However, if light in the reflection plane is reflected, there is a problem in that loss of light in the reflection plane occurs and deterioration of utilization efficiency of the light is caused.

[0004] An objective of the present invention is to provide a vehicle lamp capable of easily changing a light distribution pattern using a DMD and increasing utilization efficiency of light in a light concentration process.

[0005] According to an aspect of the present invention, a vehicle lamp includes a light source configured to radiate white light; a light concentrator configured to concentrate light radiated from the light source; a reflection pattern formation device configured to have a plurality of optical elements arrayed in a matrix shape and form a reflection pattern by reflecting light concentrated by the light concentrator according to a collective reflection plane formed by the plurality of optical elements; and a projection optical system configured to radiate the reflection pattern in a forward direction, wherein the collective reflection plane is positioned inside a light concentration spot of the light concentrator in the collective reflection plane.

[0006] According to the above-described configuration, the vehicle lamp capable of easily changing a light distribution pattern using a reflection pattern formation device (for example, a DMD) can be provided.

[0007] Also, according to the above-described configuration, it is possible to improve the utilization efficiency of light in a light concentration process compared to the case in which the reflection plane having a concave shape is used because light is concentrated onto the collective reflection plane of the reflection pattern formation device using a condensing lens.

[0008] On the other hand, because color aberration occurs if white light is concentrated by the condensing lens, color unevenness occurs in light reflected by the DMD. According to the above-described configuration, the collective reflection plane is positioned inside a light concentration spot, so that it is possible to prevent light of a color unevenness region occurring in an outer edge of the light concentration spot from being incident on the collective reflection plane. Therefore, a vehicle lamp capable of radiating light having little color unevenness can be provided.

[0009] Also, in the above-described vehicle lamp, the light concentration spot may include a white light spot region positioned at a center of the light concentration spot and a color unevenness region surrounding the white light spot region, and the collective reflection plane may be positioned inside of the white light spot region.

[0010] According to the above-described configuration, light is not incident on the collective reflection plane in the color unevenness region, and color-unevenness-suppressed light can be radiated in the forward direction of the vehicle.

[0011] Also, in the above-described vehicle lamp, the white light spot region may be a region irradiated with light included in a chromaticity range surrounded by straight lines connecting coordinate values (0.31,0.28), (0.44,0.38), (0.50,0.38), (0.50,0.44), (0.455,0.44), and (0.31,0.35) on xy chromaticity coordinates.

[0012] According to the above-described configuration, the vehicle lamp can provide light for enabling an object to be sufficiently recognized without causing discomfort to an oncoming vehicle as light of a head lamp.

[0013] According to another aspect of the present invention, a vehicle irradiation system includes the above-described vehicle lamp; and a sensor device configured to perform monitoring in a forward direction of a vehicle, wherein the vehicle lamp has a controller connected to the reflection pattern formation device, and wherein the controller controls the reflection pattern according to a traffic state in the forward direction of the vehicle detected by the sensor device.

[0014] According to the above-described configuration, the vehicle irradiation system which changes a light distribution pattern radiated in a forward direction according to a traffic state can be provided. Thereby, it is possible to improve visibility for a driver and prevent glare from being given to an oncoming vehicle C.

[0015] According to an aspect of the present invention, it is possible to provide a vehicle lamp capable of easily changing a reflection pattern using a DMD and increasing utilization efficiency of light in a light concentration process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

FIG. 1 is a schematic diagram of a vehicle irradiation system including a vehicle lamp of an embodiment.
FIG. 2 is a perspective view of the vehicle lamp of the embodiment.

FIG. 3 is a schematic cross-sectional view of a reflection pattern formation device of the embodiment.

FIG. 4 is a front view of the reflection pattern formation device of an embodiment.

FIG. 5 is a graph of xy chromaticity coordinates indicating a preferred white color range.

FIG. 6 is a schematic diagram illustrating an example of a light distribution pattern formed by the vehicle lamp of the embodiment.

FIG. 7 is a schematic diagram illustrating an arrangement of a vehicle lamp of an example.

FIG. 8 is a front view of a collective reflection plane indicating simulation results of light incident on the collective reflection plane of an example.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Hereinafter, a vehicle lamp 1 of an embodiment will be described with reference to the drawings.

[0018] In the following description, a forward/backward direction is a forward/backward direction of a vehicle equipped with a vehicle lamp 1. Also, the vehicle lamp 1 is assumed to radiate light in the forward direction of the vehicle. Further, unless otherwise specified, the forward/backward direction is assumed to be one direction within a horizontal plane. Further, unless otherwise specified, a left/right direction is one direction within the horizontal plane and is a direction orthogonal to the forward/backward direction.

[0019] Also, in the drawings used in the following description, a characteristic part is enlarged for convenience to allow characteristics to be easily understood, and dimension ratios of each component or the like do not always coincide with real dimension ratios thereof.

[0020] FIG. 1 is a schematic diagram of a vehicle irradiation system 2 including the vehicle lamp 1. Also, FIG. 2 is a perspective view schematically illustrating the vehicle lamp 1.

[0021] The vehicle irradiation system 2 includes the vehicle lamp 1, an image processor 61, and a forward monitoring sensor 62. The vehicle lamp 1 includes a light source 10, a condensing lens 20, a reflection pattern formation device 30, a projection lens (a projection optical system) 50, and a controller 60. Light radiated from the light source 10 is transferred by the condensing lens 20, the reflection pattern formation device 30, and the projection lens 50 in this order and is radiated in a forward direction.

[0022] The light source 10 radiates white light L along a light emission center axis L10. A semiconductor light emitting element such as a light emitting diode (LED), a laser diode (LD), or an electroluminescence (EL) element, a light bulb, an incandescent lamp (a halogen lamp), a discharge lamp, or the like can be adopted as the light source 10. Also, it is preferable that the light source 10 be provided with a heat sink that emits heat generated together with light emission. The light source 10 is connected to the controller 60, and radiates the white light L according to a signal from the controller 60. The white light L radiated from the light source 10 is included in a white color range W1 (see FIG. 5) of the xy chromaticity coordinates to be described below.

[0023] The condensing lens (a light concentrator) 20 concentrates light emitted from the light source 10 and guides the light to a collective reflection plane 33 of the reflection pattern formation device 30. An optical axis L20 of the condensing lens 20 is coincident with a light emission center axis L10 of the light source 10.

[0024] Also, an example in which one condensing lens 20 is used as the light concentrator is shown in the present embodiment, but the light concentrator may be a light concentration optical system in which a plurality of condensing lens are arranged along an optical axis.

[0025] The reflection pattern formation device 30 is arranged on the optical axis L20 of the condensing lens 20. The reflection pattern formation device 30 reflects white light L emitted from the light source 10 and concentrated by the condensing lens 20. The reflection pattern formation device 30 is obtained by arranging, for example, a plurality of micro-mirrors each called a digital mirror device (DMD) in an array (matrix) shape. It is possible to selectively change a reflection direction of light emitted from the light source 10 by controlling each of angles of reflection planes 32a (see FIG. 3) of the plurality of micro-mirrors. That is, it is possible to reflect a part of the light emitted from the light source 10 to the projection lens 50 and reflect other light in a direction outside the projection lens 50.

[0026] FIG. 3 is a schematic cross-sectional view of the reflection pattern formation device 30. The reflection pattern formation device 30 includes a micro-mirror array 34 in which a plurality of (for example, 100 or 1,000,000) micro-mirror elements (optical elements) 32 are arranged in a matrix shape and a transparent cover member 36 arranged on a forward side of the reflection plane 32a of the mirror element 32 (the left in FIG. 3). A plurality of reflection planes 32a of the micro-mirror array 34 generally constitute a collective reflection plane 33. The micro-mirror array 34 is connected to the controller 60.

[0027] Each mirror element 32 is rotatable over a movable angle θ_{DMD} around a rotary axis. Each of the plurality of mirror elements 32 is connected to the controller 60. Each mirror element 32 is rotated by voltage application from the controller 60 and can individually perform switching between an OFF state (indicated by a solid line in an optical path Loff of FIG. 3) and an ON state (indicated by a solid line in an optical path Lon of FIG. 3). The collective reflection plane 33 of the reflection pattern formation device 30 may be arranged to be tilted even when it is arranged perpendicular to an optical axis L50. As illustrated in FIG. 1, the collective reflection plane 33 in the present embodiment is tilted at a tilt angle θ_{tilt} in a direction orthogonal to the optical axis L50. Here, it is preferable that the tilt angle θ_{tilt} of the collective reflection plane 33 have a following relationship with respect to a difference angle $\theta_{L20-L50}$ between the optical axis L20 of the condensing lens 20 and the optical axis L50 of the projection lens 50 and the movable angle θ_{DMD} of the mirror element 32. That is, the mirror element 32 reflects incident light outside the vehicle lamp 1 in the OFF state. Also, the mirror element 32 reflects incident light to the projection lens 50 in the ON state.

[0028] The reflection pattern formation device 30 forms a reflection pattern configured by reflection light of the ON state. This reflection pattern is radiated in the forward direction as a light distribution pattern P (see FIG. 6) via the projection lens 50.

[0029] FIG. 4 is a front view of the reflection pattern formation device 30 and illustrates a positional relationship between the reflection pattern formation device 30 and a light concentration spot SP of light incident on the reflection pattern formation device 30. The condensing lens 20 concentrates light onto the collective reflection plane 33 of the reflection pattern formation device 30 and forms the light concentration spot SP in the collective reflection plane 33.

[0030] As illustrated in FIG. 4, the light concentration spot SP has a white light spot region A1 positioned at the center of the light concentration spot SP and a color unevenness region A2 surrounding the white light spot region A1. The condensing lens 20 causes color unevenness due to color aberration in the light concentration spot SP. Light has a refractive index differing according to a wavelength. Accordingly, if white light L passes through the condensing lens 20, light (purple light, blue light, or the like) of a short wavelength is concentrated onto an outer edge of the light concentration spot SP and forms a color unevenness region A2. Also, a long wavelength (red light or the like) may be provided at an outer edge of the light concentration spot SP according to a positional relationship between the condensing lens 20 and the collective reflection plane 33.

[0031] As illustrated in FIG. 4, it is preferable that the collective reflection plane 33 be positioned inside the white light spot region A1 of the light concentration spot SP. Thereby, light is not incident on the collective reflection plane 33 in the color unevenness region A2, and color-unevenness-suppressed light can be radiated in the forward direction of the vehicle. The vehicle lamp 1 can improve visibility in the forward direction by radiating color-unevenness-suppressed light without giving discomfort to a driver of an oncoming vehicle.

[0032] FIG. 5 is a diagram illustrating a white color range W1 of a headlight (the vehicle lamp) prescribed by the Japanese law based on the ECE law. As illustrated in FIG. 5, the white color range W1 of the head lamp (a chromaticity range of light color of the head lamp) is prescribed by the law (see FIG. 1). It is preferable that the vehicle lamp 1 have a white color range included in the white color range W1 defined in the law. That is, in the present embodiment, it is preferable that light of the white light spot region A1 be included in a chromaticity range surrounded by straight lines connecting coordinate values (0.31,0.28), (0.44,0.38), (0.50,0.38), (0.50,0.44), (0.455,0.44), and (0.31,0.35) on xy chromaticity coordinates. The law is defined as a performance criterion of the vehicle lamp. Therefore, the vehicle lamp 1 satisfying the law can radiate light for enabling an object to be sufficiently recognized without giving discomfort to an oncoming vehicle as light of a head lamp.

[0033] Also, the vehicle lamp 1 of the present embodiment can radiate only light of a white color range according to the law of each country in a forward direction. According to SAE International, the light is recommended to be included in a white color range W2 illustrated in FIG. 5. That is, it is preferable that light of the white light spot region A1 be included in the white color range W2 in which a straight line indicated by each of the following Equations 1 to 6 is a boundary line. The white color range W2 surrounded by straight lines of Equations 1 to 6 is substantially coincident with the white color range W1.

$$X = 0.31 \qquad \text{(Equation 1)}$$

$$X = 0.50 \qquad \text{(Expression 2)}$$

$$Y = 0.15+0.64X \qquad \text{(Equation 3)}$$

$$Y = 0.05+0.75X \qquad \text{(Equation 4)}$$

$$Y = 0.44 \qquad \text{(Equation 5)}$$

$$Y = 0.38 \qquad \text{(Equation 6)}$$

[0034] Also, if the collective reflection plane 33 is included inside the light concentration spot SP, it is possible to exhibit a certain color unevenness suppression effect even when light is incident on a part of the color unevenness region A2. The color unevenness region A2 is positioned at an outer edge of the light concentration spot SP. Therefore, if the collective reflection plane 33 is positioned inside the light concentration spot SP, this means that light is emitted from at least a part of the color unevenness region A2 outside the collective reflection plane 33 and is not incident on the collective reflection plane 33. Thereby, it is possible to radiate light having little color unevenness in the forward direction of the vehicle.

[0035] A reflection pattern formed in the reflection pattern formation device 30 is incident on the projection lens (the projection optical system) 50. Also, the projection lens 50 radiates the reflection pattern in the forward direction. In the present embodiment, the projection lens 50 is provided so that its optical axis L50 is directed in the forward/backward direction of the vehicle. However, the optical axis L50 may be directed in other directions. Also, the optical axis L50 passes through the center of the collective reflection plane 33 in the present embodiment, but it may not necessarily pass through the center. The projection lens (the projection optical system) 50 includes, for example, a free curved surface lens in which a forward side surface and a backward side surface have a free curved surface shape. A light source image formed on a backward focal plane including a backward focus of the projection lens 50 is projected onto a virtual vertical screen in front of the lamp as an inverted image. The projection lens 50 is arranged so that its backward focus is arranged in the vicinity of the collective reflection plane 33 of the reflection pattern formation device 30. Also, the projection lens 50 may be a reflector.

[0036] The controller 60 transmits control signals of various types to the reflection pattern formation device 30 and forms a desired reflection pattern. The reflection pattern corresponds to a light distribution pattern P radiated in the forward direction. Therefore, the controller 60 can form a desired light distribution pattern by controlling the reflection pattern formation device 30.

[0037] FIG. 6 is a schematic diagram illustrating an example of the light distribution pattern P formed by the vehicle lamp 1 according to the present embodiment. In FIG. 6, the light distribution pattern P formed on a virtual vertical screen virtually arranged in the forward direction of the vehicle is schematically illustrated.

[0038] As illustrated in FIG. 1, the controller 60 is connected to a forward monitoring sensor (a sensor device) 62 which performs monitoring in the forward direction of the vehicle via the image processor 61. The forward monitoring sensor 62 is, for example, a camera which performs imaging in the forward direction of the vehicle. A captured image acquired by the forward monitoring sensor 62 in the forward direction is analyzed in the image processor 61. The image processor 61 specifies a vehicle and a pedestrian included in the captured image, detects positions of the vehicle and the pedestrian, and further transmits information thereof to the controller 60.

[0039] The controller 60 transmits control signals of various types to the light source 10 and the reflection pattern formation device 30 according to a signal of an oncoming vehicle C (or a pedestrian) received from the image processor 61 and forms the light distribution pattern P according to information of the forward direction. More specifically, the controller 60 forms a light shielding region P1 in which light is not projected to a position overlapping the oncoming vehicle C in the forward direction using position information of the oncoming vehicle C. That is, according to the vehicle irradiation system 2 of the present embodiment, the controller 60 controls the reflection pattern according to a traffic state in the forward direction of the vehicle detected by the forward monitoring sensor 62. Thereby, the vehicle lamp 1 can improve visibility for the driver and prevent glare from being given to the driver of the oncoming vehicle C. Also, the vehicle lamp 1 can effectively improve the visibility for the driver by performing control in a light distribution pattern for a high beam.

[0040] Also, the controller 60 may form a light distribution pattern for a low beam which is radiated only below a horizontal line H in the forward direction of the vehicle and may form a so-called left high light distribution pattern in which a light irradiation region is above the horizontal line H in the forward direction of the vehicle and on the left thereof and a light shield region is formed on the right. Further, the controller 60 may form various light distribution patterns such as not only the left high light distribution pattern but also the right high light distribution pattern and the like. Further, it is possible to draw a character, a shape, etc. on a traveling path plane by light using in the present configuration.

[0041] According to the vehicle lamp 1 and the vehicle irradiation system 2 of the present embodiment, it is possible to improve the utilization efficiency of light in a light concentration process compared to a conventional structure in which light is concentrated using a reflection plane of a concave shape because light is concentrated onto the collective reflection plane 33 of the reflection pattern formation device 30 using the condensing lens 20.

[0042] According to the vehicle lamp 1 and the vehicle irradiation system 2 of the present embodiment, it is possible to prevent light of the color unevenness region A2 occurring in an outer edge of the light concentration spot SP from being incident on the collective reflection plane 33.

[0043] Therefore, it is possible to radiate light having little color unevenness.

[0044] While preferred embodiments of the invention have been described and illustrated above, it should be understood that these are exemplary of the invention and are not to be considered as limiting. Additions, omissions, substitutions, and other modifications can be made without departing from the scope of the present invention. Accordingly, the invention is not to be considered as being limited by the foregoing description, and is only limited by the scope of the appended claims.

[0045] For example, an example in which the forward monitoring sensor 62 which captures an image is adopted as a sensor device which performs monitoring in a forward direction of the vehicle has been described in the above-described embodiment, but the sensor device may be an ultrasonic wave sensor.

[Examples]

[0046] Hereinafter, the configuration of the present invention according to simulations as examples will be more specifically described.

[0047] Also, the present invention is not limited to the following examples and modifications can be appropriately made without departing from the scope of the present invention.

[0048] FIG. 7 illustrates an arrangement of a light source 110, a light concentrator 120, and a reflection pattern formation device 130 in a vehicle lamp 101 of the present example. The light concentrator 120 includes a first condensing lens 121 and a second condensing lens 122. Also, FIG. 7 is a schematic diagram and dimensions of each component and scales of a positional relationship are different from real dimensions and scales.

[0049] A position and dimensions of each part in the vehicle lamp 101 of the present example will be specifically described.

[0050] As illustrated in FIG. 7, the light source 110, the first condensing lens 121, the second condensing lens 122, and the reflection pattern formation device 130 are arranged so that optical axes (center axes) thereof are coincident with each other. The light source 110 includes a square light emission region 111 of 0.5 mm×0.5 mm. The first condensing lens 121 is a convex lens in which a diameter is 2.7 mm and a thickest part is 4 mm. The second condensing lens 122 is a convex lens in which a diameter is 5.2 mm and a thickest part is 10 mm. The reflection pattern formation device 130 has a digital mirror device having a square collective reflection plane 133 of 2.6 mm×2.6 mm. The light source 110 and the first condensing lens 121 are arranged to be separated by 0.6 mm. The second condensing lens 122 is arranged to be separated by 2.2 mm. The second condensing lens 122 and the reflection pattern formation device 130 are arranged to be separated by 26 mm.

[0051] FIG. 8 illustrates a simulation result of light incident on the collective reflection plane 133 of the reflection pattern formation device 130. In FIG. 8, the horizontal axis represents a dimension in a horizontal direction and the vertical axis represents a dimension in a vertical direction. As illustrated in FIG. 8, the collective reflection plane 133 of the present modified example is positioned inside the light concentration spot.

[0052] All light beams radiated to the collective reflection plane 133 have 61 lumens (lm) and a light beam of light incident on the collective reflection plane 133 among the light beams has 54 lm. That is, light of 88 % in a total proportion is incident on the collective reflection plane 133.

[0053] In a graph of xy color coordinates of FIG. 5, xy color coordinates at a measurement point M1 (see FIG. 8) positioned at a vertical direction edge as the center of the collective reflection plane 133 in the horizontal axis direction is plotted as P(M1). Also, the xy color coordinates of P(M1) are (0.318,0.320).

[0054] As illustrated in FIG. 5, the measurement point M1 positioned at an edge of the collective reflection plane 133 is included in a white color range W1 on xy chromaticity coordinates. Because color aberration is larger when it is closer to an outer edge of the light concentration spot, the white light of the white color range W1 is obviously radiated in the entire region of the collective reflection plane 133 positioned inside an edge part. According to the present modified example, a configuration in which only white light is reflected by the collective reflection plane 133 was confirmed.

Claims

1. A vehicle lamp comprising:

   a light source configured to radiate white light;
   a light concentrator configured to concentrate light radiated from the light source;
   a reflection pattern formation device configured to have a plurality of optical elements arrayed in a matrix shape and form a reflection pattern by reflecting light concentrated by the light concentrator according to a collective reflection plane formed by the plurality of optical elements; and
   a projection optical system configured to radiate the reflection pattern in a forward direction,
   wherein the collective reflection plane is positioned inside a light concentration spot of the light concentrator in the collective reflection plane.

2. The vehicle lamp according to claim 1,
   wherein the light concentration spot includes a white light spot region positioned at a center of the collective light spot and a color unevenness region surrounding the white light spot region, and
   wherein the collective reflection plane is positioned inside of the white light spot region.

3. The vehicle lamp according to claim 2, wherein the white light spot region is a region irradiated with light included in a chromaticity range surrounded by straight lines connecting coordinate values (0.31,0.28), (0.44,0.38), (0.50,0.38), (0.50,0.44), (0.455,0.44), and (0.31,0.35) on xy chromaticity coordinates.

4. A vehicle irradiation system comprising:

   the vehicle lamp according to any one of claims 1 to 3; and
   a sensor device configured to perform monitoring in a forward direction of a vehicle,
   wherein the vehicle lamp has a controller connected to the reflection pattern formation device, and
   wherein the controller controls the reflection pattern according to a traffic state in the forward direction of the vehicle detected by the sensor device.

FIG. 1

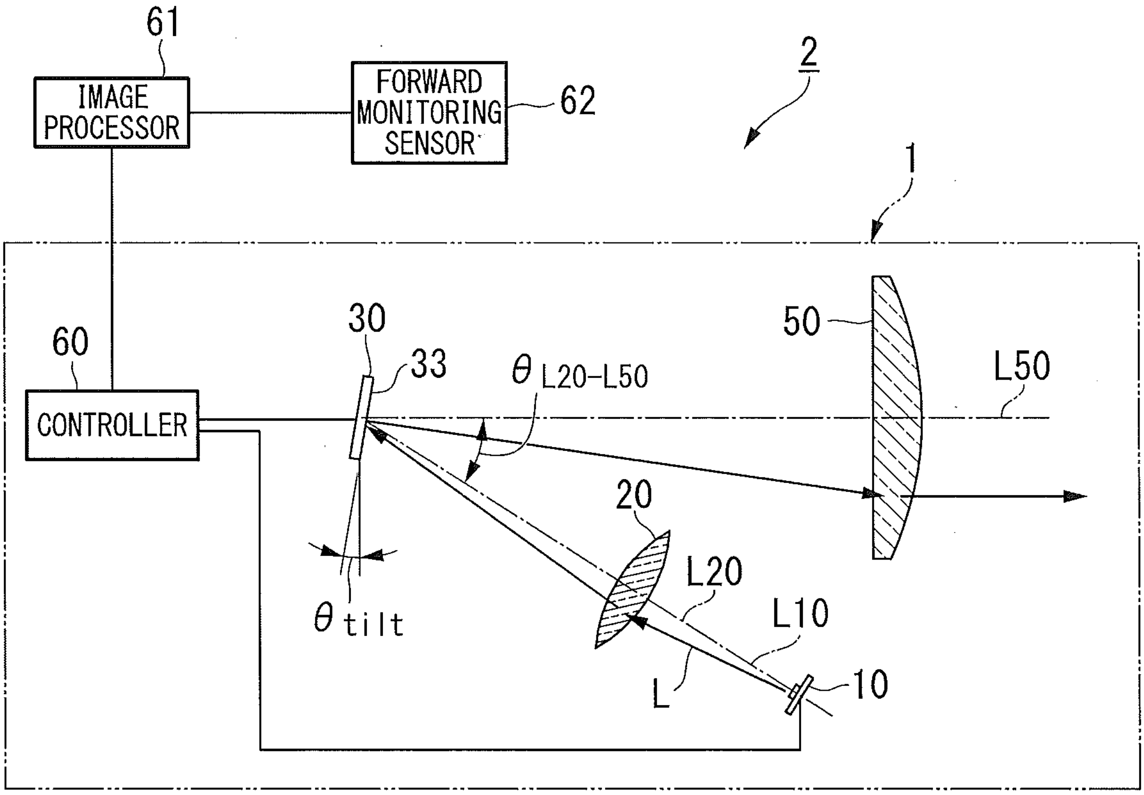

61
IMAGE PROCESSOR
FORWARD MONITORING SENSOR
62
2
1
30
33
60
CONTROLLER
θ L20-L50
50
L50
20
L20
L10
θ tilt
L
10

FIG. 2

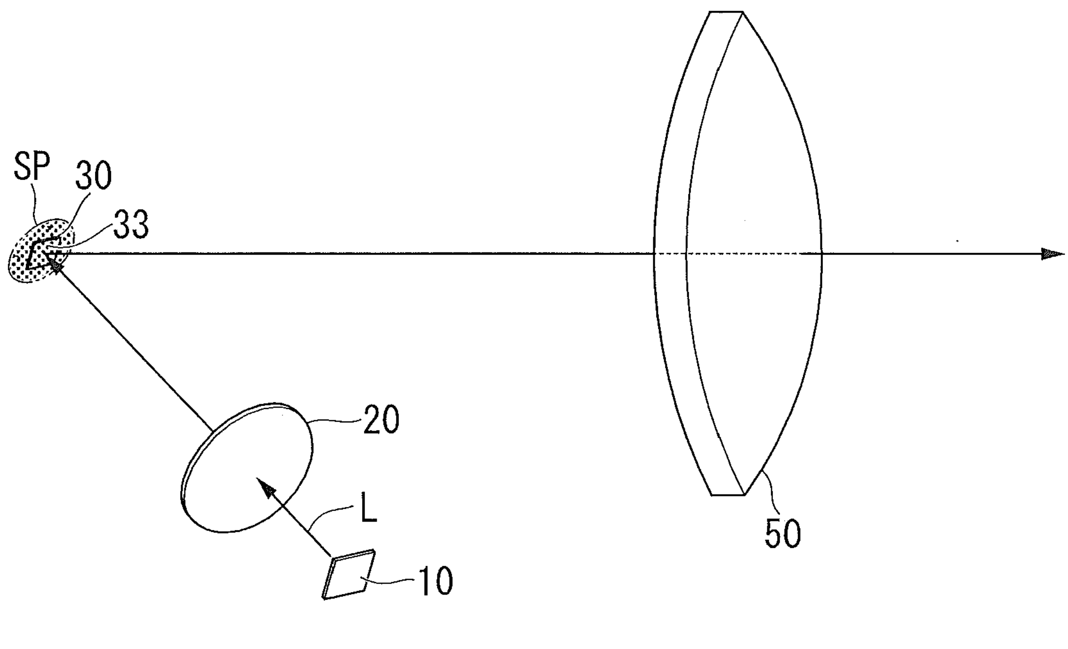

SP
30
33
20
L
10
50

FIG. 3

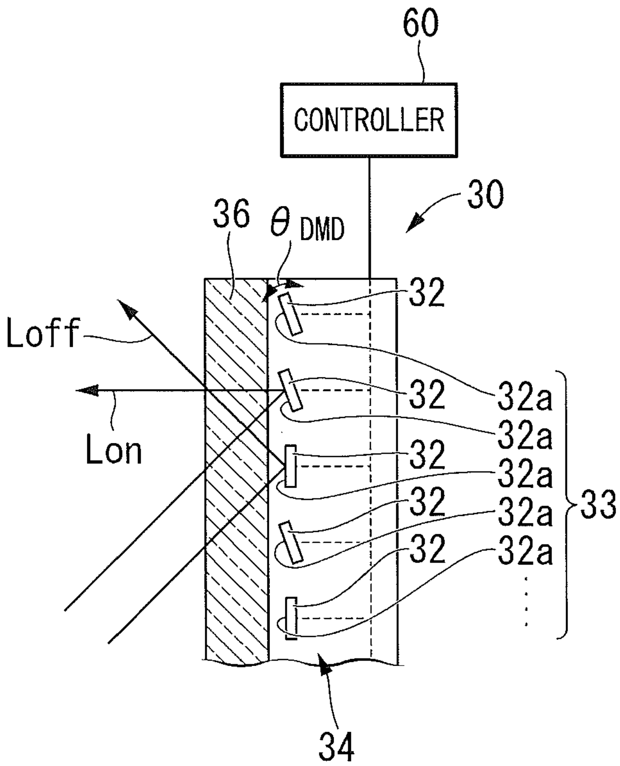

60
CONTROLLER
30
36
θ_{DMD}
32
Loff
32
32a
32a
Lon
32
32a
32
32a
33
32
32a
34

FIG. 4

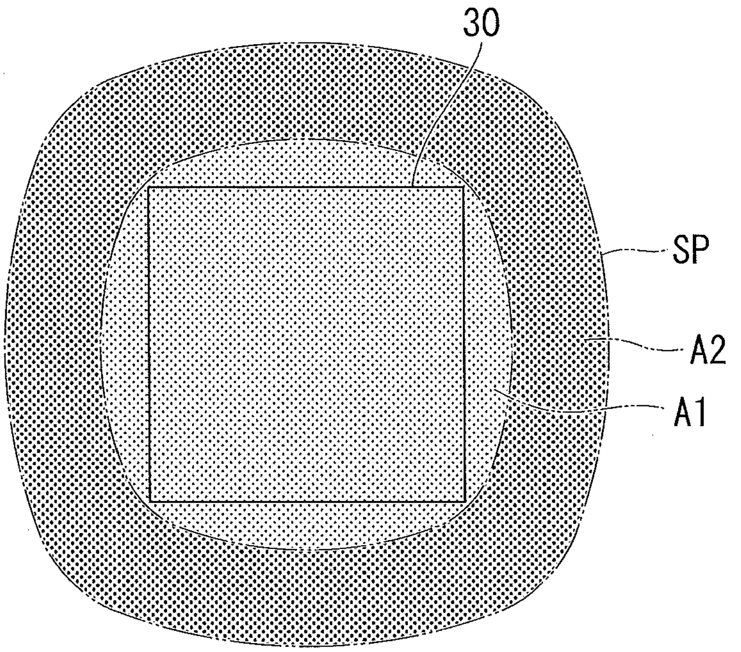

30
SP
A2
A1

FIG. 5

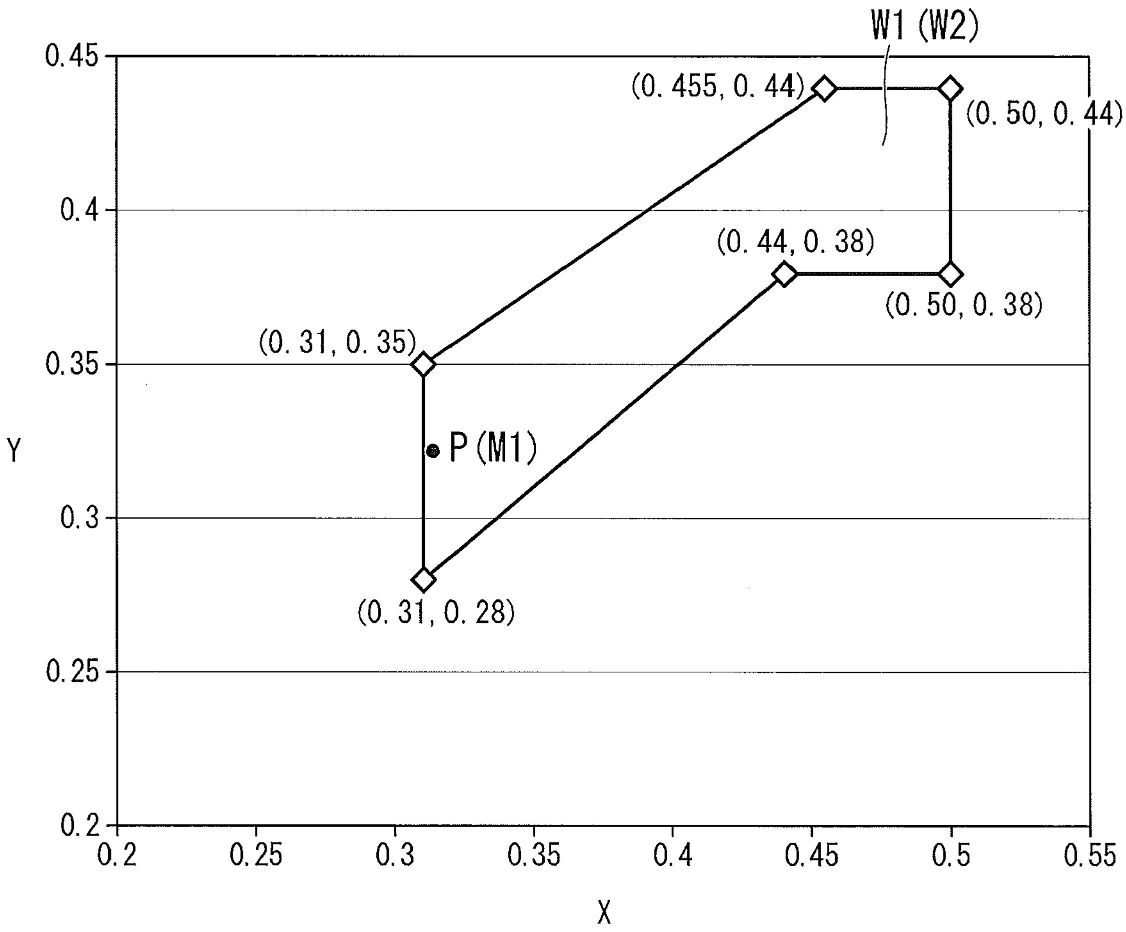

W1 (W2)
0.45
0.4
0.35
0.3
0.25
0.2
Y
(0. 455, 0. 44)
(0. 50, 0. 44)
(0. 44, 0. 38)
(0. 50, 0. 38)
(0. 31, 0. 35)
P (M1)
(0. 31, 0. 28)
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
X

FIG. 6

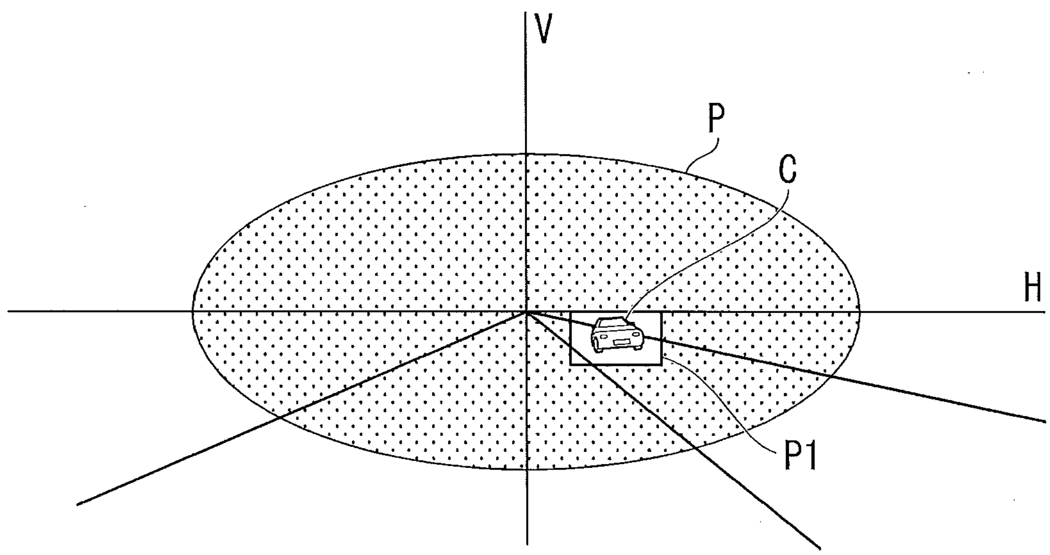

V
P
C
H
P1

FIG. 7

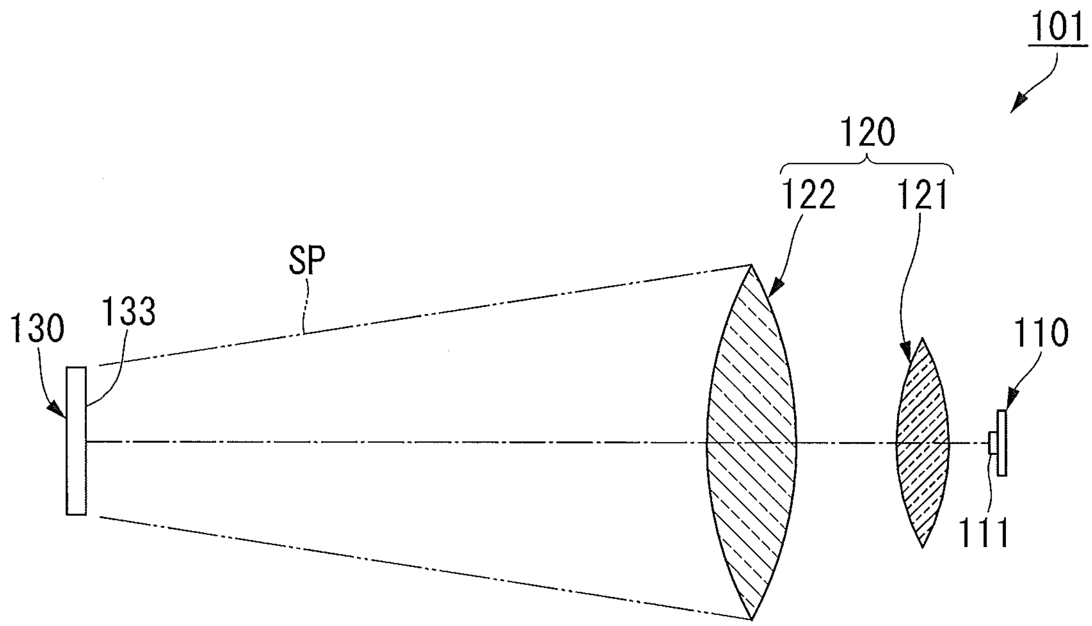
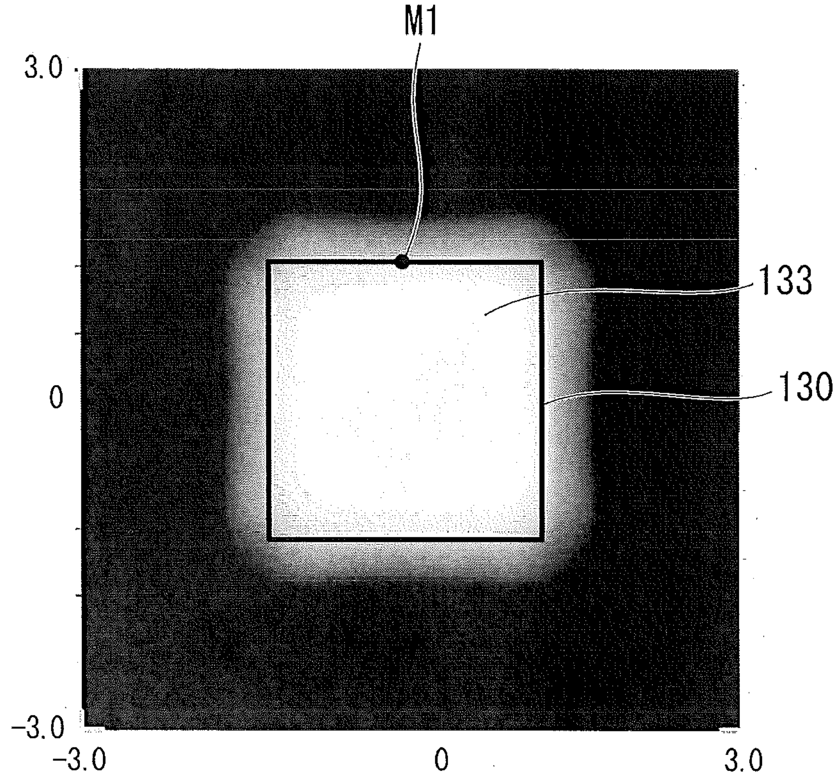


FIG. 8



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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 4042

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2015/160454 A1 (BHAKTA VIKRANT R [US]) 11 June 2015 (2015-06-11) * paragraphs [0005] - [0087]; figures 1-8 * -----	1-4	INV. F21S8/12
X	US 2015/285458 A1 (DASSANAYAKE MAHENDRA SOMASARA [US] ET AL) 8 October 2015 (2015-10-08) * paragraphs [0015] - [0022]; figures 1-4 * -----	1-4	
X	EP 2 772 682 A2 (KOITO MFG CO LTD [JP]) 3 September 2014 (2014-09-03) * paragraphs [0004] - [0036]; figures 1-4 * -----	1-4	
X	JP 2004 136838 A (TOYOTA IND CORP) 13 May 2004 (2004-05-13) * the whole document * -----	1-3	
X	JP 2012 014972 A (SEIKO EPSON CORP) 19 January 2012 (2012-01-19) * the whole document * -----	1-3	TECHNICAL FIELDS SEARCHED (IPC) F21S B60Q

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 April 2017	Sarantopoulos, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
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D : document cited in the application
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& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 20 4042

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-04-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015160454 A1	11-06-2015	EP 3079946 A1	19-10-2016
		US 2015160454 A1	11-06-2015
		WO 2015089018 A1	18-06-2015
US 2015285458 A1	08-10-2015	CN 104972959 A	14-10-2015
		DE 102015205266 A1	08-10-2015
		RU 2015112827 A	27-10-2016
		US 2015285458 A1	08-10-2015
EP 2772682 A2	03-09-2014	CN 104006342 A	27-08-2014
		EP 2772682 A2	03-09-2014
		JP 2014165130 A	08-09-2014
JP 2004136838 A	13-05-2004	NONE	
JP 2012014972 A	19-01-2012	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H09104288 B **[0002]**