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Blind spot assist device

Abstract

A blind spot assist device includes a first optical element and a second optical element. The first optical element reflects a part of incident light having a first angle of incidence at different second angles such that light is incident at the first angle on the first optical element from an outdoor view and reflected at the second angles on the first optical element. The second optical element is positioned to face the first optical element and reflects incident lights having different angles of incidence at a third angle such that lights reflected by the first optical element are incident at the second angles on the second optical element and reflected at the third angle on the second optical element toward a user.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION
(1) This application is based on and incorporates herein by reference Japanese Patent Application No. 2021-103414 filed on Jun. 22, 2021.
TECHNICAL FIELD
(2) The present disclosure relates to a blind spot assist device.
BACKGROUND
(3) A blind spot assist device includes a semi-transparent mirror and a plane mirror arranged facing

the semi-transparent mirror to assist a user to see an outdoor view in a blind spot.
SUMMARY
(4) According to at least one embodiment of the disclosure, a blind spot assist device includes a first optical element and a second optical element. The first optical element reflects a part of incident light having a first angle of incidence at different second angles such that light is incident at the first angle on the first optical element from an outdoor view and reflected at the second angles on the first optical element. The second optical element is positioned to face the first optical element and reflects incident lights having different angles of incidence at a third angle such that lights reflected by the first optical element are incident at the second angles on the second optical element and reflected at the third angle on the second optical element toward a user.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.
(2) FIG. **1** is a diagram showing an arrangement of a blind spot assist device relative to a blind spot area, according to the first embodiment.
(3) FIG. **2** is a side view illustrating a configuration of the blind spot assist device according to the first embodiment.
(4) FIG. **3** is a diagram illustrating a condition of a length of a facing portion of a first optical element of the blind spot assist device according to the first embodiment.
(5) FIG. **4** is a side view illustrating a configuration of a blind spot assist device according to a second embodiment.
(6) FIG. **5** is a diagram illustrating a comparison in interval between a first optical element and a second optical element according to the first and second embodiments.
(7) FIG. **6** is a side view illustrating a configuration of a blind spot assist device according to a third embodiment.
(8) FIG. **7** is a side view illustrating a configuration of a blind spot assist device according to a fourth embodiment.
(9) FIG. **8** is a top view illustrating a configuration of a first optical element according to a fifth embodiment.
(10) FIG. **9** is a side view illustrating a configuration of a blind spot assist device according to the fifth embodiment.
DETAILED DESCRIPTION
(11) To begin with, examples of relevant techniques will be described.
(12) A blind spot assist device according to a comparative example includes a semi-transparent mirror and a plane mirror arranged facing the semi-transparent mirror. In the blind spot assist device, light incident on the semi-transparent mirror from an object located in a blind spot area is repeatedly reflected between the semi-transparent mirror and the plane mirror, and accordingly multiple lights showing an image of the object are reflected from the semi-transparent mirror. Therefore, a user can visually recognize the image of the object in a wide range.
(13) When a distance between the semi-transparent mirror and the plane mirror is reduced, the blind spot assist device can be made thinner, but a luminance may decrease and a luminance unevenness may increase due to increase in number of the reflections of the light. On the other hand, when the distance between the semi-transparent mirror and the plane mirror is increased, the luminance can be increased and the luminance unevenness can be decreased, but the blind spot assist device may become large.

(14) In contrast, according to one aspect of the present disclosure, a blind spot assist device is capable of being reduced in thickness while realizing increase of luminance and decrease of luminance unevenness.
(15) According to one aspect of the disclosure, a blind spot assist device includes a first optical element and a second optical element. The first optical element reflects a part of incident light having a first angle of incidence at different second angles such that light is incident at the first angle on the first optical element from an outdoor view and reflected at the second angles on the first optical element. The second optical element is positioned to face the first optical element and reflects incident lights having different angles of incidence at a third angle such that lights reflected by the first optical element are incident at the second angles on the second optical element and reflected at the third angle on the second optical element toward a user.
(16) In the blind spot assist device according to the aspect, the first optical element reflects the incident light at the different second angles, and the second optical element reflects the multiple incident lights toward the user. Therefore, the light reflected by the first optical element is incident on different regions of the second optical element, is reflected toward the user in a wide range. When a predetermined condition is satisfied, the light reflected by the second optical element does not return to the first optical element. Therefore, in order to widen a visible range of the outdoor view, repetition of light reflection between the first optical element and the second optical element can be reduced while a distance between the first optical element and the second optical element is reduced. As a result, the blind spot assist device can be made thinner while improving a luminance and reducing a luminance unevenness.
(17) According to another aspect of the disclosure, a blind spot assist device includes a first optical element and a second optical element. The first optical element transmits a part of incident light having a first angle of incidence and reflects another part of the incident light at different second angles such that light is incident at the first angle on the first optical element from an outdoor view and partially reflected at the second angles on the first optical element. The second optical element is positioned to face the first optical element and reflects incident lights having different angles of incidence at a third angle such that lights reflected by the first optical element are incident at the second angles on the second optical element and reflected at the third angle on the second optical element toward a user.
(18) The blind spot assist device according to the other aspect has the same effects as the blind spot assist device described above, and can further expand the visible range of the outdoor view.
(19) Hereinafter, embodiments of the present disclosure will be described with reference to the drawings. Hereinafter, multiple embodiments for implementing the present disclosure will be described referring to drawings. In the respective embodiments, a part that corresponds to a matter described in a preceding embodiment may be assigned the same reference numeral, and redundant explanation for the part may be omitted. When only a part of a configuration is described in an embodiment, another preceding embodiment may be applied to the other parts of the configuration. The parts may be combined even if it is not explicitly described that the parts can be combined. The embodiments may be partially combined even if it is not explicitly described that the embodiments can be combined, provided there is no harm in the combination.
First Embodiment
(20) A blind spot assist device **101** according to a first embodiment is used for a user to visually recognize an outdoor view in a blind spot area. The blind spot assist device **101** is installed in, for example, a vehicle, and supplements a blind spot that cannot be seen by a user (specifically, a driver). FIG. **1** shows the blind spot assist device **101** attached to a front pillar **400** of the vehicle. More specifically, when a driver's seat is on a right side of the vehicle, the blind spot assist device **101** is attached to the front pillar **400** on the right side. When the driver's seat is on a left side of the vehicle, the blind spot assist device **101** is attached to the front pillar **400** on the left side.
(21) The user can directly see an outdoor view spreading outside a front glass and a side glass

through the front glass and the side glass. The front pillar **400** is provided between the front glass and the side glass. The front pillar **400** blocks the user's field of view and creates a blind spot area **200**. That is, the blind spot area **200** is between an area visible through the front glass and an area visible through the side glass. The user cannot directly see an outdoor view in the blind spot area **200**.

(22) Next, an configuration of the blind spot assist device **101** will be described with reference to FIG. **2**. The blind spot assist device **101** includes a first optical element **11** and a second optical element **20**. The first optical element **11** and the second optical element **20** are plate-shaped members, and are arranged parallel to each other and apart from each other at a predetermined interval W. More specifically, the first optical element **11** and the second optical element **20** are fixed to the front pillar **400** via a holder. The first optical element **11** is arranged between the user and the second optical element **20**. The second optical element **20** is arranged between the front pillar **400** and the first optical element **11**.

(23) The first optical element **11** and the second optical element **20** are reflection optical elements. The first optical element **11** and the second optical element **20** may be mirrors. The first optical element **11** and the second optical element **20** each include a transparent resin material and a reflection angle adjusting member provided on the resin material. The reflection angle adjusting member may be a member such as a hologram sheet, a prism sheet, or a diffractive optical element, or a mirror-coated member obtained by coating of, for example, a hologram sheet, a prism sheet, or a diffractive optical element. The first optical element **11** and the second optical element **20** are arranged so that their reflection angle adjusting members face each other.

(24) As shown in FIG. **2**, the first optical element **11** reflects a part of incident light, incident at a first angle θ from the outdoor view, at second angles different from each other. The second angles include φ**1***a*, φ**2**, . . . φn. The relationship between the first angle and the second angles satisfies θ=φ**1***a*<φ**2**< . . . <φn. Where, n is an integer greater than or equal to 2.

(25) The first optical element **11** includes multiple first reflection angle adjusting members stacked in a direction perpendicular to a facing surface of the first optical element **11** that faces the second optical element **20**. The first reflection angle adjusting members include a member that reflects the incident light having the incident angle θ at the reflection angle φ**1***a*, and a member that reflects the incident light having the incident angle θ at a reflection angle φs. Where, s is an integer greater than or equal to 2 and less than or equal to n.

(26) The second optical element **20** reflects multiple incident lights, which are reflected by the first optical element **11** and incident at the second angles, at a third angle in a direction toward the user. Both the third angle and the first angle are θ.

(27) The second optical element **20** includes multiple second reflection angle adjusting members stacked in a direction perpendicular to a facing surface of the second optical element **20** that faces the first optical element **11**. The second reflection angle adjusting members include a member that reflects the incident light having the incident angle φ**1***a* at the reflection angle θ, and a member that reflects the incident light having an incident angle φt at the reflection angle θ. Where, t is an integer greater than or equal to 2 and less than or equal to n.

(28) A relationship between multiple first reflectances of the first optical element **11** and multiple second reflectances of the second optical element **20** satisfies R**11**×R**21**=R**12**×R**22**= . . . =R**1***n*×R**2***n*. R**11** is a first reflectance of the first optical element **11** when the light is reflected by the first optical element **11** at the second angle φ**1***a*. R**1***s* is a first reflectance of the first optical element **11** when the light is reflected by the first optical element **11** at the second angle φs. R**21** is a second reflectance of the second optical element **20** when the light incident at the second angle φ**1***a* is reflected by the second optical element **20**. R**2***t* is a second reflectance of the second optical element **20** when the light incident at the second angle φt is reflected by the second optical element **20**.

(29) The light reflected by the first optical element **11** at the second angle φ**1***a* is reflected on a

region of the second optical element **20** closest to the first optical element **11** (leftmost region in FIG. **2**). Further, the light reflected by the first optical element **11** at the second angle φn is reflected on a region of the second optical element **20** farthest from the first optical element **11** (rightmost region in FIG. **2**). That is, the multiple lights reflected by the first optical element **11** are reflected in different regions of the second optical element **20** because the second angles are different from each other. A region of the second optical element **20**, in which light is reflected, becomes farther from the first optical element **11** with increase in the second angle of the light. In the following, the right side of the drawing is referred to as a right side of the blind spot assist device **101**, and the left side of the drawing is referred to as a left side of the blind spot assist device **101**.

(30) As shown in FIG. **3**, the first optical element **11** includes a base portion **11***a* and an extension portion **11***b*. The base portion **11***a* is a portion of the first optical element **11** facing the second optical element **20**. The extension portion **11***b* extends from the base portion **11***a* to the left side. The base portion **11***a* has a length D. The length D corresponds to a distance from an intersection P**2** to a right end P**3** of the first optical element **11**. The intersection P**2** corresponds to a point where a perpendicular from a left end P**1** of the second optical element **20** to the first optical element **11** intersects the first optical element **11**.

(31) In order not to repeat the reflection between the first optical element **11** and the second optical element **20**, it is necessary to prevent the light reflected by the second optical element **20** from being incident on the first optical element **11** again. The light reflected by the second optical element **20** does not enter the first optical element **11** again under a condition where the length D, the interval W, the first angle θ, and the minimum second angle φ**1***a* satisfy an equation (1) shown below. When the formula (1) is satisfied, repeated reflections between the first optical element **11** and the second optical element **20** can be avoided.

$D<2W\tan\theta+W\tan\varphi 1a \qquad (1)$

(32) As shown in FIG. **3**, an external light arriving at the blind spot assist device **101** may have a certain spread, and the first angle θ may have a range from θ**1** to θ**2**. The range from θ**1** to θ**2** is an angle range centered at θ**0**. The first angle θ**1** is an incident angle of a light ray L**1** and is the smallest incident angle. The first angle θ**2** is an incident angle of a light ray L**2**, and is the largest incident angle. The first angle θ**0** is an incident angle of a light ray L**0**, and is the incident angle at the center.

(33) When the first angle θ has such range, each of the second angles φ**1***a*, φ**2**, φn also has a range. When the light ray L**1** is reflected, the second angles are φ**11**, φ**12**, φ**13**, . . . φ**1***n*, and satisfy φ**11**<φ**12**<φ**13**< . . . <φ**1***n*. When the light ray L**2** is reflected, the second angles are φ**21**, φ**22**, φ**23**, . . . φ**2***n*, and satisfy φ**21**<φ**22**<φ**23**< . . . <φ**2***n*. When the light ray L**0** is reflected, the second angles are φ**01**, φ**02**, φ**03**, . . . φ**0***n*, and satisfy φ**01**<φ**02**<φ**03**< . . . <φ**0***n*.

(34) When the external light has a certain spread, and the first angle θ**1** of the light ray L**2** having the smallest incident angle and the second angle φ**11** satisfy the equation (1), repetition of reflection of the light ray L**2** between the first optical element **11** and the second optical element **20** can be avoided. That is, when the following equation (2) is satisfied, repeated reflections between the first optical element **11** and the second optical element **20** can be avoided.

$D<2W\tan\theta 1+W\tan\varphi 11 \qquad (2)$

(35) When the second angles are appropriately set, the n lights reflected by the second optical element **20** are continuous in the right-left direction in the drawings. Therefore, the blind spot assist device **101** reflects light showing an outdoor view in the θ direction in a wide range along the right-left direction of the user's eyes. Therefore, an eye box in which the outdoor view can be visually recognized can be expanded without repeating the reflection. The user can visually recognize, via the blind spot assist device **101**, the outdoor view in the θ direction in a wide range in the right-left direction such that the outdoor view is continuous with an outdoor view that can be directly seen.

(36) Further, according to the blind spot assist device **101**, it is not necessary to repeat reflection of

light between the first optical element **11** and the second optical element **20** in order to widen the eye box. Therefore, even if the distance W between the first optical element **11** and the second optical element **20** is reduced, the repetition of reflection can be reduced, and decrease in luminance and unevenness in luminance can be reduced.
(37) Further, the relationship between the first reflectances and the second reflectances satisfy R**11**×R**21**=R**12**×R**22**= . . . =R**1***n*×R**2***n*. Therefore, luminance losses of the multiple lights reflected from the second optical element **20** becomes constant, and the luminance unevenness is further reduced.
(38) Further, the first optical element **11** reflects the light incident from the outdoor view only once. Therefore, an aperture width (that is, a length in the right-left direction) can be shortened as compared with a case where repeated reflection of the light is required. The aperture width of the first optical element **11** can be shorter than that of the second optical element **20**. More specifically, the aperture width of the first optical element **11** can be shortened to a length of a projection component W cos θ of the incident width W of the light incident on the blind spot assist device **101** from the outdoor view. As a result, the blind spot assist device **101** can be miniaturized.
(39) According to the first embodiment described in detail above, the following effects are provided.
(40) (1) The lights reflected by the first optical element **11** are incident on different regions of the second optical element **20**, and reflected in the direction toward the user in a wide range. Therefore, the incident light from the outdoor view can be reflected in the wide range without repeated reflections of the light between the first optical element **11** and the second optical element **20**. Therefore, it is not necessary to repeat reflection of the light between the first optical element **11** and the second optical element **20** in order to widen the eye box. Therefore, the reflection of the light between the first optical element **11** and the second optical element **20** can be limited to one time while reducing the distance between the first optical element **11** and the second optical element **20**. As a result, the blind spot assist device **101** can be made thinner while improving the luminance and reducing the luminance unevenness.
(41) (2) Since the relationship between the first angle and the second angles satisfy θ=φ**1***a*<φ**2**< . . . <φn, the lights reflected by the first optical element **11** are incident on the different regions of the second optical element **20** and reflected in a wide range in the right-left direction. Therefore, the user can visually recognize the outdoor view in the blind spot area with a wide eye box.
(42) (3) Since the relationship between the first reflectances and the second reflectances satisfy R**11**×R**21**=R**12**×R**22**= . . . =R**1***n*×R**2***n*, losses of the luminance of the lights reflected toward the user can be made constant, and thereby the luminance unevenness can be reduced.
Second Embodiment
(43) Since the basic configuration of a second embodiment is similar to the first embodiment, the difference will be described below. Note that the same reference numerals as those in the first embodiment indicate the same configuration, and refer to the preceding descriptions.
(44) The blind spot assist device **101** according to the first embodiment described above includes the first optical element **11**. On the other hand, a blind spot assist device **102** according to a second embodiment includes a first optical element **12**.
(45) As shown in FIG. **4**, an arrangement of the first optical element **12** is the same as the arrangement of the first optical element **11**. In the first embodiment, the first optical element **11** reflects a part of incident light, incident from the outdoor view at the first angle θ, at the second angles φ**1***a*, φ**2**, . . . , φn. In the first embodiment, the relationship between the first angle and the second angles satisfy θ=φ**1***a*<φ**2**< . . . <φn. On the other hand, as shown in FIG. **4**, the first optical element **12** reflects a part of incident light, incident from the outdoor view at the first angle θ, at second angles φ**1***b*, φ**2**, . . . , φn. In the second embodiment, the relationship between the first angle and the second angles satisfy θ<φ**1***b*<φ**2**< . . . <φn.
(46) Further, a first reflectance of the first optical element **12** when the light is reflected at the

second angle φ**1***b* is R**11**, and a second reflectance of the second optical element **20** when the light is incident at the second angle φ**1***b* is R**21**. Therefore, similar to the first embodiment, the relationship between the first reflectances and the second reflectances satisfy R**11**×R**21**=R**12**×R**22**= . . . =R**1***n*×R**2***n*.
(47) That is, the first optical element **12** reflects incident light at the second angles larger than the first angle θ. As a result, a distance W between the first optical element **12** and the second optical element **20** can be further reduced.
(48) As shown in FIG. **5**, in the first embodiment, the light incident at the first angle θ is reflected at the second angle θ (=φ**1***a*). Therefore, the distance W between the first optical element **11** and the second optical element **20** becomes H/tan θ. Where, H is an aperture width (that is, a length in the right-left direction) of the first optical element **11**, **12**. On the other hand, in the second embodiment, the light incident at the first angle θ is reflected at the second angle φ**1***b*. Therefore, the interval W becomes H/tan φ**1***b*. When θ<φ**1***b*, the interval W in the second embodiment can be reduced by H(1/tan θ−1/tan θ**1**) than the interval Win the first embodiment. As a result, the blind spot assist device **102** can be made thinner.
(49) According to the second embodiment described in detail above, the effects (1) and (3) of the above-described first embodiment are obtained, and further, the following effect can be obtained.
(50) (4) Since the relationship between the first angle and the second angles satisfy θ<φ**1***b*<φ**2**< . . . <φn, the distance between the first optical element **12** and the second optical element **20** can be further reduced, and thereby the blind spot assist device **102** can be made thinner.
Third Embodiment
(51) Since the basic configuration of a third embodiment is similar to the first embodiment, the differences will be described below. Note that the same reference numerals as those in the first embodiment indicate the same configuration, and refer to the preceding descriptions.
(52) The blind spot assist device **101** according to the first embodiment described above includes the first optical element **11** that is a reflection optical element. On the other hand, a blind spot assist device **103** according to the third embodiment includes a first optical element **13** that is a transmission and reflection optical element. The first optical element **13** may be a semi-transparent mirror that transmits a part of incident light and reflects another part of the incident light.
(53) As shown in FIG. **6**, an arrangement of the first optical element **13** is the same as the arrangement of the first optical element **11**. The first optical element **13** transmits a part of light incident from an outdoor view at a first angle θ with a predetermined transmittance T**1**. As a result, an eye box through which the outdoor view can be can be visually recognized in the θ direction is expanded as compared with the first and second embodiments.
(54) Further, the first optical element **13** reflects another part of the light at second angles φ**1***a*, φ**2**, . . . , φn which are different from each other. The second angles φ**1***a*, φ**2**, . . . , φn satisfy θ=φ**1***a*<φ**2**< . . . <φn, similar to the first embodiment. The relationship among the predetermined transmittance, first reflectances and second reflectances satisfy T**1**=R**11**×R**21**=R**12**×R**22**= . . . =R**1***n*×R**2***n*.
(55) According to the third embodiment described in detail above, the effects (1) and (2) of the above-described first embodiment are obtained, and further, the following effects can be obtained.
(56) (5) The eye box through which the outdoor view can be visually recognized in the θ direction can be further enlarged.
(57) (6) Since the relationship among the predetermined transmittance, the first reflectances and the second reflectances satisfy T**1**=R**11**×R**21**=R**12**×R**22**==R**1***n*×R**2***n*, losses of the luminance of the lights reflected toward the user can be made constant, and thereby the luminance unevenness can be reduced.
Fourth Embodiment
(58) Since the basic configuration of a fourth embodiment is similar to the third embodiment, the differences will be described below. Note that the same reference numerals as those in the third embodiment indicate the same configuration, and refer to the preceding descriptions.

(59) The blind spot assist device **103** according to the third embodiment described above includes the first optical element **13**. On the other hand, a blind spot assist device **104** according to a fourth embodiment includes a first optical element **14**.
(60) As shown in FIG. **7**, an arrangement of the first optical element **14** is the same as the arrangement of the first optical element **11**. The first optical element **14** is a transmission and reflection optical element, similar to the first optical element **13**. The first optical element **14** may be a semi-transparent mirror that transmits a part of incident light and reflects another part of the incident light. The first optical element **14** transmits a part of light incident from an outdoor view at a first angle θ with a predetermined transmittance T**1**. Further, the first optical element **14** reflects another part of the light at second angles φ**1***a*, φ**2**, . . . , φn which are different from each other. The second angles φ**1***b*, φ**2**, . . . , φn satisfy θ<φ**1***b*<φ**2**< . . . <φn, similar to the second embodiment. The relationship among the predetermined transmittance, first reflectances and second reflectances satisfy T**1**=R**11**×R**21**=R**12**×R**22**= . . . =R**1***n*×R**2***n*. That is, the fourth embodiment corresponds to a combination of the second embodiment and the third embodiment.
(61) According to the fourth embodiment described in detail above, the effect (1) of the above-described first embodiment, the effect (4) of the second embodiment and the effects (5) and (6) of the third embodiment can be obtained.
Fifth Embodiment
(62) Since the basic configuration of a fifth embodiment is similar to the third embodiment, the differences will be described below. Note that the same reference numerals as those in the third embodiment indicate the same configuration, and refer to the preceding descriptions.
(63) The first optical element **13** according to the third embodiment described above includes the first reflection angle adjusting members that are stacked and reflect incident light having the same incident angle at different reflection angles. The second optical element **20** according to the third embodiment described above includes the second reflection angle adjusting members that are stacked and reflect incident light having different incident angles at the same reflection angle.
(64) On the other hand, as shown in FIG. **8**, a first optical element **15** according to the fifth embodiment is different from the first optical element **13** according to the third embodiment in that the first optical element **15** has (n+1) types of regions from a region A**0** to a region An, and first reflection angle adjusting members are arranged in different regions of the first optical element **15**. Further, as shown in FIG. **9**, a second optical element **21** according to the fifth embodiment is different from the second optical element **20** according to the third embodiment in that the second optical element **21** has n regions from a region B**1** to a region Bn, and second reflection angle adjusting members are arranged in different regions of the second optical element **21**.
(65) More specifically, the first optical element **15** includes multiple groups of the regions, and each of the groups consists of (n+1) regions from the region A**0** to the region An. Each of the regions has a square shape. The region A**0** is provided with a refraction angle adjusting member that refracts light at the refraction angle φ**0** when the light is incident on the refraction angle adjusting member at the first angle θ. Further, a region Am is provided with a first reflection angle adjusting member that reflects light at the second angle φm when the light is incident on the first reflection angle adjusting member at the first angle θ. Where, m is an integer greater than or equal to 1 and less than or equal to n. φ**1** may be equal to θ or larger than θ. That is, φ**1** may be either φ**1***a* or φ**1***b*.
(66) In the first optical elements **11**, **12**, **13**, and **14** according to the first to fourth embodiments, the incident light from the outdoor view is divided into n pieces and reflected. On the other hand, in the first optical element **15** according to the fifth embodiment, the incident light from the outdoor view is reflected on each region without being divided. Therefore, for example, when the first optical element **15** is divided into regions smaller than the resolution of human eyes such that an area of each region is reduced, the loss of luminance due to reflection of light by the first optical element **15** can be reduced. As a result, the user can clearly see the outdoor view.

(67) The second optical element **21** is divided into n regions from the region B**1** to the region Bn. A region Bk is a region on which the light reflected at the second angle φk is incident. Where, k is an integer greater than or equal to 1 and less than or equal to n. In the second optical element **20** according to the first to fourth embodiments, since lights incident at the second angles are reflected, a reflectance decreases and a loss of luminance increases. In the second optical element **21** according to the fifth embodiment, since a performance of asymmetric reflection is optimized for each region, the reflectance increases and the loss of luminance decreases.
(68) According to the fourth embodiment described in detail above, the effects (1) and (2) of the above-described first embodiment, the effect (4) of the second embodiment and the effects (5) and (6) of the third embodiment can be obtained, and further, the following effects can be obtained.
(69) (7) Since the first optical element **15** is divided into the (n+1) types of regions and reflects the incident light at the second angles different for each region, the loss of luminance due to the reflection by the first optical element **15** can be reduced.
(70) (8) Since the second optical element **21** is divided into n regions and reflects light in different regions depending on the incident angle, the performance of asymmetric reflection can be optimized for each region and the reflectance can be increased. As a result, the loss of luminance can be reduced.
Other Embodiments
(71) Although the embodiments of the present disclosure have been described above, the present disclosure is not limited to the embodiments described above, and various modifications can be made to implement the present disclosure.
(72) Each of the above embodiments shows an example in which the blind spot assist device **101**, **102**, **103**, **104**, **105** is attached to the front pillar **400** of the vehicle. But, the attachment position of the blind spot assist device **101**, **102**, **103**, **104**, **105** is not limited to the front pillar **400** and may be another position in the vehicle. Further, the blind spot assist device **101**, **102**, **103**, **104**, **105** may be attached to an object other than the vehicle for use.
(73) In the fifth embodiment, the first optical element **15** is the transmission and reflection optical element having the region A**0**, but the first optical element **15** may not have the region A**0**. That is, the first optical element **15** may be a reflection optical element having n types of regions from the region A**1** to the region An. In this case, the number of regions forming each group of the regions is n.
(74) The blind spot assist device **105** according to the fifth embodiment includes the first optical element **15** and the second optical element **21**, but may include the first optical element **15** and the second optical element **20**. Alternatively, the blind spot assist device **105** may include any one of the first optical elements **11**, **12**, **13**, and **14** and the second optical element **21**.
(75) The multiple functions of one component in the above embodiment may be realized by multiple components, or a function of one component may be realized by multiple components. In addition, multiple functions of multiple components may be realized by one component, or a single function realized by multiple components may be realized by one component. A part of the configuration of the above embodiments may be omitted. Further, at least part of the configuration of the above-described embodiment may be added to or replaced with the configuration of another embodiment described above.
(76) While the present disclosure has been described with reference to embodiments thereof, it is to be understood that the disclosure is not limited to the embodiments and constructions. To the contrary, the present disclosure is intended to cover various modification and equivalent arrangements. In addition, while the various elements are shown in various combinations and configurations, which are exemplary, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the present disclosure.

Claims

1. A blind spot assist device comprising: a first optical element configured to reflect a part of incident light having a first angle of incidence at different second angles such that light is incident at the first angle on the first optical element from an outdoor view and reflected at the second angles on the first optical element; and a second optical element positioned to face the first optical element and configured to reflect incident lights having different angles of incidence at a third angle such that lights reflected by the first optical element are incident at the second angles on the second optical element and reflected at the third angle on the second optical element toward a user.
2. The blind spot assist device according to claim 1, wherein the third angle is equal to the first angle, a relationship between the first angle and the second angles satisfies $\theta=\varphi_1<\varphi_2< \ldots <\varphi_n$, n is an integer greater than or equal to 2, θ is the first angle, and $\varphi_1, \varphi_2, \ldots, \varphi_n$ are the second angles.
3. The blind spot assist device according to claim 1, wherein the third angle is equal to the first angle, a relationship between the first angle and the second angles satisfies $\theta<\varphi_1<\varphi_2< \ldots <\varphi_n$, n is an integer greater than or equal to 2, θ is the first angle, and $\varphi_1, \varphi_2, \ldots, \varphi_n$ are the second angles.
4. The blind spot assist device according to claim 3, wherein the first optical element has n types of regions from a 1st region to a n-th region, a m-th region of the first optical element is configured to reflect the incident light having θ of incidence at φ_m, and m is an integer between 1 and n inclusive.
5. The blind spot assist device according to claim 3, wherein the second optical element has n regions from a 1st region to a n-th region, a k-th region of the second optical element is configured to reflect the incident light having φ_k of incidence at θ, and k is an integer between 1 and n inclusive.
6. The blind spot assist device according to claim 3, wherein the first optical element is configured to reflect a part of incident light by first reflectances when the incident light is incident at the first angle on the first optical element, the second optical element is configured to reflect the incident lights having the second angles of incidence by second reflectances, the first reflectances correspond to the second angles, respectively, the second reflectances correspond to the second angles, respectively, a relationship between the first reflectances and the second reflectances satisfies
$R_{11}\times R_{21}=R_{12}\times R_{22}= \ldots =R_{1n}\times R_{2n}$, $R_{11}, R_{12}, \ldots, R_{1n}$ are the first reflectances, and $R_{21}, R_{22}, \ldots, R_{2n}$ are the second reflectances.
7. A blind spot assist device comprising: a first optical element configured to transmit a part of incident light having a first angle of incidence and reflect another part of the incident light at different second angles such that light is incident at the first angle on the first optical element from an outdoor view and partially reflected at the second angles on the first optical element; and a second optical element positioned to face the first optical element and configured to reflect incident lights having different angles of incidence at a third angle such that lights reflected by the first optical element are incident at the second angles on the second optical element and reflected at the third angle on the second optical element toward a user.
8. The blind spot assist device according to claim 7, wherein the third angle is equal to the first angle, a relationship between the third angle and the second angles satisfies $\theta=\varphi_1<\varphi_2< \ldots <\varphi_n$, n is an integer greater than or equal to 2, θ is the first angle, and $\varphi_1, \varphi_2, \ldots,$ on are the second angles.
9. The blind spot assist device according to claim 7, wherein the third angle is equal to the first angle, a relationship between the first angle and the second angles satisfies $\theta<\varphi_1<\varphi_2< \ldots <\varphi_n$, n is an integer greater than or equal to 2, θ is the first angle, and $\varphi_1, \varphi_2, \ldots, \varphi_n$ are the second angles.
10. The blind spot assist device according to claim 9, wherein the first optical element has (n+1) types of regions from a 0th region to a n-th region, the 0th region of the first optical element is

configured to transmit the incident light having θ of incidence at a refraction angle $\varphi \mathbf{0}$, a m-th region of the first optical element is configured to reflect the incident light having θ of incidence at φm, and m is an integer between 1 and n inclusive.

11. The blind spot assist device according to claim 9, wherein the first optical element is configured to transmit a part of incident light at a predetermined transmittance and reflect another part of the incident light by first reflectances when the incident light is incident at the first angle on the first optical element, the second optical element is configured to reflect the incident lights having the second angles of incidence by second reflectances, the first reflectances correspond to the second angles, respectively, the second reflectances correspond to the second angles, respectively, a relationship among the predetermined transmittance, the first reflectances and the second reflectances satisfies

$T1=R11\times R21=R12\times R22= \ldots =R1n\times R2n$, T**1** is the predetermined transmittance, R**11**, R**12**, . . . , R**1**n are the first reflectances, and R**21**, R**22**, . . . , R**2**n are the second reflectances.