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(54) Title: ELLIPTICAL HUD EYE BOX ILLUMINATION

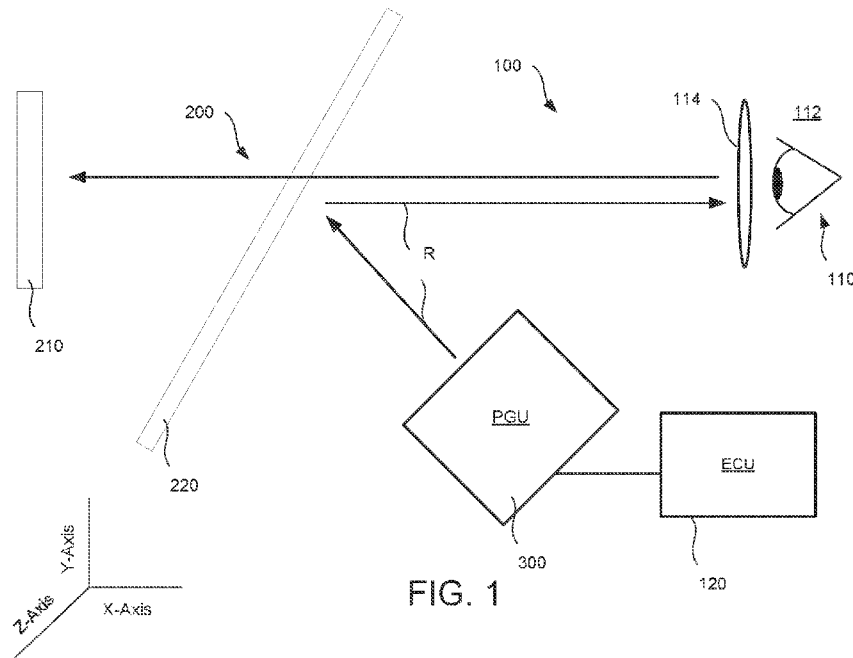


FIG. 1

(57) Abstract: A head up display comprises a picture generation unit to generate an image. The head up display also includes a combiner to reflect the image from the picture generation unit. The head up display also includes an optical system for the picture generation unit to back light a display, the optical system may include: an illumination source, a lens to columnate the light from the illumination source, an elliptical lens to direct the light, and an elliptical diffuser to the light from the lens along a horizontal axis to provide an overall single elliptical shape to the light.



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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## ELLIPTICAL HUD EYE BOX ILLUMINATION

### BACKGROUND

[0001] The present disclosure relates to see-through displays, such as head-up displays (HUD), for presenting a virtual image to an occupant on a transparent or translucent surface.

[0002] Modern vehicles typically include a head-up display in a passenger cabin to communicate information to an operator of the vehicle. The information can include a vehicle condition such as a fuel level or velocity of the vehicle, as well as warning icons, known as tell-tales. Typical head-up displays project an image including the information onto a predetermined area of a display screen adjacent to a windshield (i.e. a combiner), or directly onto the windshield. To ensure the projected image is easily viewed by the operator the display must be significantly brighter than the ambient light, which requires a comparatively high light intensity from the light source.

[0003] The image projected on the windshield/display screen is reflected back to be viewed by the vehicle operator. The location of the operator where the image that can be viewed is limited by the mirrors that are reflecting the projected image. As the operator moves their head they may be moving in and out of viewable area. The head motion box or eye box is defined as the area where both eyes can simultaneously view the reflection. Overall eye box size is limited by the mirror size and ability for adjustment. Therefore, the size of the HUD system increases as the eye box size increases.

[0004] Due to limited packaging space within the vehicle and increasing cost of the HUD system as the system volume increases it is therefore desirable to define the eye box to the smallest dimensions possible which will accommodate most vehicle operators. Eye box shaped to an ellipse have been shown to provide the most efficient size. Therefore, elliptical

diffusers have been used. However, use of an elliptical diffuser creates different fields of view for different portions of the diffuser.

### SUMMARY

[0005] A head up display comprises a picture generation unit to generate an image. The head up display also includes a combiner to reflect the image from the picture generation unit. The head up display also includes an optical system for the picture generation unit to back light a display, the optical system may include: an illumination source, a lens to columnate the light from the illumination source, an elliptical lens to direct the light, and an elliptical diffuser to the light from the lens along a horizontal axis to provide an overall single elliptical shape to the light.

[0006] Implementations may include one or more of the following features.

[0007] The display system where the picture generation unit further may include a mirror system to reflect the image from the display toward the combiner.

[0008] The lens is a total internal reflection lens.

[0009] One general aspect includes an optical system for a picture generation unit of a head up display. The optical system also includes an illumination source; a lens to columnate the light from the illumination source, an elliptical lens to direct the light. The system also includes an elliptical diffuser to the light from the lens along a horizontal to provide an overall single elliptical shape to the light, where the light provides a backlight to a display screen of the picture generation unit.

[0010] Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0011] One general aspect includes a method of providing an image from a head up display. The method of providing also includes a picture generation unit to generate an

image. The providing also includes providing light from an illumination source. The providing also includes columnating the light from the illumination source with a total internal reflection lens. The providing also includes shaping the columnated light with an elliptical lens. The providing also includes diffusing the light from the elliptical lens with an elliptical diffuser to create an elliptically patterned light shape. The providing also includes backlighting a display with the elliptically patterned light. The providing also includes generating an image from the display, where the image has an overall elliptical shape from the back light. The providing also includes reflecting the image with a combiner toward an eye box of the vehicle.

[0012] Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0013] Implementations may include one or more of the following features.

[0014] The method may include reflecting the image from the display toward the combiner with a mirror system. The lens is a total internal reflection lens.

[0015] Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0017] FIG. 1 illustrates an example schematic view of the head-up display system.

[0018] FIG. 2 illustrates an example schematic view of an embodiment of a picture generation unit for the head-up display system.

[0019] FIG. 3 illustrates an example schematic view of an embodiment of an optical system for the head-up display system.

[0020] FIG. 4 illustrates an example schematic view of an embodiment of method for displaying an image with the head-up display system of FIGs. 1-3.

#### DETAILED DESCRIPTION

[0021] FIG 1 schematically illustrates a vehicle 100 that includes a head-up display (HUD) system 200 for providing information or content to an observer 110. The observer 110 may be a driver of the vehicle 100. The HUD system 200 can be positioned, for example, within a passenger cabin 112 of the vehicle 100, and in some examples, in front of a steering wheel. The HUD system 200 is operable to display information or context in the form of one or more images or graphics. For instance, the content can include one or more conditions of the vehicle 100, such as fuel level, battery level, odometer readings, velocity or a warning. In other examples, the HUD system 200 is a multimedia device operable to display content in the form of navigational data, imagery, radio data or a menu for interacting with another system of the vehicle 100 or another system located remotely from the vehicle 100, for example.

[0022] The HUD system 200 includes a picture generation unit (PGU) 300, illustrated further in FIG. 2, for projecting an image 210 onto a combiner 220, which may be a portion of the windshield of the vehicle 100 having a material for promoting reflection applied thereto. The PGU 300 may be positioned adjacent the windshield, for example. The PGU 300 may be in communication with another digital system onboard the vehicle 100, such as a vehicle controller 120 to display content or information to the observer 110. The image is projected onto the combiner 220 at a location or area that is observable by the observer 110. The PGU 300 includes an optical system 310 having one or more mirrors and lenses as describer herein. Although a driver 18 is referenced herein, it should be understood that a passenger or other user may also use the disclosed HUD system 200.

[0023] The image 210 generated by the PGU 300 is reflected by the combiner 220 toward an eye box 114 within the vehicle 100. It should be understood that the eye box 114 is not a physical component, but a region within the passenger compartment in which both eyes of the observer 110 have line of sight to the image 210. The eye box 114 is most typically described in x,y distances referring to an x,y,z coordinate plane within the vehicle 100. The eye box 114 described herein has an elliptical shape. That is the image 210 being viewed by the observer 110 at the eye box 114 has an elliptical shape.

[0024] The longer axis of the eye box 114 extends in the horizontal, x direction which generally corresponds to the axis generated by drawing a line connecting both eyes of the observer 110 (when head is not tilted). The image 210 appears to the observer 110 as if it were several feet ahead of the vehicle 100. This location corresponds with the typical driver line of sight when operating the vehicle 100. A simplified reflective path from the PGU 300 to the combiner 220 to the observer 110 is illustrated with arrows R in the FIGs 1-2.

[0025] Referring mainly to FIGS. 2 and 3 the optical system 310 for the PGU 300 is shown. The optical path is illustrated in a straight line in FIG. 3 for simplification. However, the components of the optical system 310 may have varying angled relationships to one another to accommodate packaging and luminesce concerns with the specific PGU 300. As illustrated in FIG. 2 a mirror system 322 may be used to direct the image path R within the PGU 300. One skilled in the art would be able to determine the desired angular relationships between the components for a particular PGU 300.

[0026] The optical system 310 originates with an illumination source 312 when light is directed through a lens 314. In one embodiment the lens is a total internal reflection (TIR) Columnated light is emitted from the lens 314 and directed through an elliptical lens 316 and elliptical diffuser 318 and. Together the elliptical lens 316 and elliptical diffuser 318 generate an elliptical shaped backlight. The elliptical shaped backlight is used to illuminate a

display 320, such as an LCD display. A mirror system 322 for the PGU 300 may also be present to direct the image from the display 320 out of a PGU housing 324 to the combiner 220. The mirror system 322 is represented by one mirror in Figure 3, but may include further mirrors. The mirror system 322 does not change the shape of the elliptical image generated from the display 320. The mirror system 322 merely reflects the image along a new light path. The elliptically shaped image is then projected from the display 320, reflected by the mirror system 322, the combiner 220 and reaches the eye box 114.

[0027] In combination the elliptical lens 316 and diffuser 318 generate an overall elliptical shape to light from the lens 314. The elliptical lens aligns 316 shapes the light such that after passing through the elliptical diffuser 318 the field coverage from the different points on the diffuser 318 to maintain the elliptical shape.

[0028] The elliptical diffuser 318 is configured to spread the light along the horizontal axis. Thus, the elliptical diffuser 318 shapes the circular light pattern emitted from the lens 314 into a plurality of circular light patterns with the centers extending along the horizontal axis. However, the elliptical lens 316 bends the light such that the plurality of circular light patterns typically generated by the elliptical diffuser 318 shape into a single elliptical shaped light pattern. The elliptical shaped light pattern provides backlight to the display 320, which thereby generates an elliptical shaped image.

[0029] FIG. 4 illustrates a method of providing an image from a head up display 200. The method of providing also includes a picture generation unit 300 to generate an image 120. Light is provided an illumination source, shown at 402. The light from the illumination source 312 is columnated with a lens 314, shown at 404. The diffused light is shaped with an elliptical lens 316 into an elliptical pattern, shown at 406. The columnated light is diffused with an elliptical diffuser 318, shown at 408. A display 320 is back lit with the elliptically patterned light, shown at 410. An image 120 is generated by the display, shown at 412. The



image has an overall elliptical shape from the back light. The image is reflected with a combiner 220 toward an eye box 114 of the vehicle, shown at 416.

[0030] The method may include reflecting the image 120 from the display 220 toward the combiner 220 with a mirror system 322, step 414. Illustrated in Figure 4 before step 416 although this step is optional.

[0031] It should also be understood that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit therefrom. Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present invention.

[0032] Although the different examples have specific components shown in the illustrations, embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[0033] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that reason, the following claims should be studied to determine their true scope and content.

## CLAIMS

What is claimed is:

1. A head up display system comprising:
  - a picture generation unit to generate an image;
  - a combiner to reflect the image from the picture generation unit; and
  - an optical system for the picture generation unit to back light a display, the optical system comprising:
    - an illumination source;
    - a lens to columnate the light from the illumination source;
    - an elliptical lens to direct the light; and
    - an elliptical diffuser to the light from the lens along a horizontal axis to provide an overall single elliptical shape to the light.
2. The display system of claim 1, wherein the picture generation unit further comprises a mirror system to reflect the image from the display toward the combiner.
3. The display system of claim 1, wherein the lens is a total internal reflection lens.
4. An optical system for a picture generation unit of a head up display comprising:
  - an illumination source;
  - a lens to columnate the light from the illumination source;
  - an elliptical lens to direct the light; and
  - an elliptical diffuser to the light from the lens along a horizontal to provide an overall single elliptical shape to the light, wherein the light provides a backlight to a display screen of the picture generation unit.

5. A method of providing an image from a head up display comprising:
  - a picture generation unit to generate an image;
  - providing light from an illumination source;
  - columnating the light from the illumination source with a total internal reflection lens;
  - shaping the columnated light with an elliptical lens;
  - diffusing the light from the elliptical lens with an elliptical diffuser to create an elliptically patterned light shape;
  - backlighting a display with the elliptically patterned light;
  - generating an image from the display, wherein the image has an overall elliptical shape from the back light;
  - reflecting the image with a combiner toward an eye box of the vehicle.
  
6. The method of claim 5, further comprising reflecting the image from the display toward the combiner with a mirror system.
  
7. The method of claim 5, wherein the lens is a total internal reflection lens.

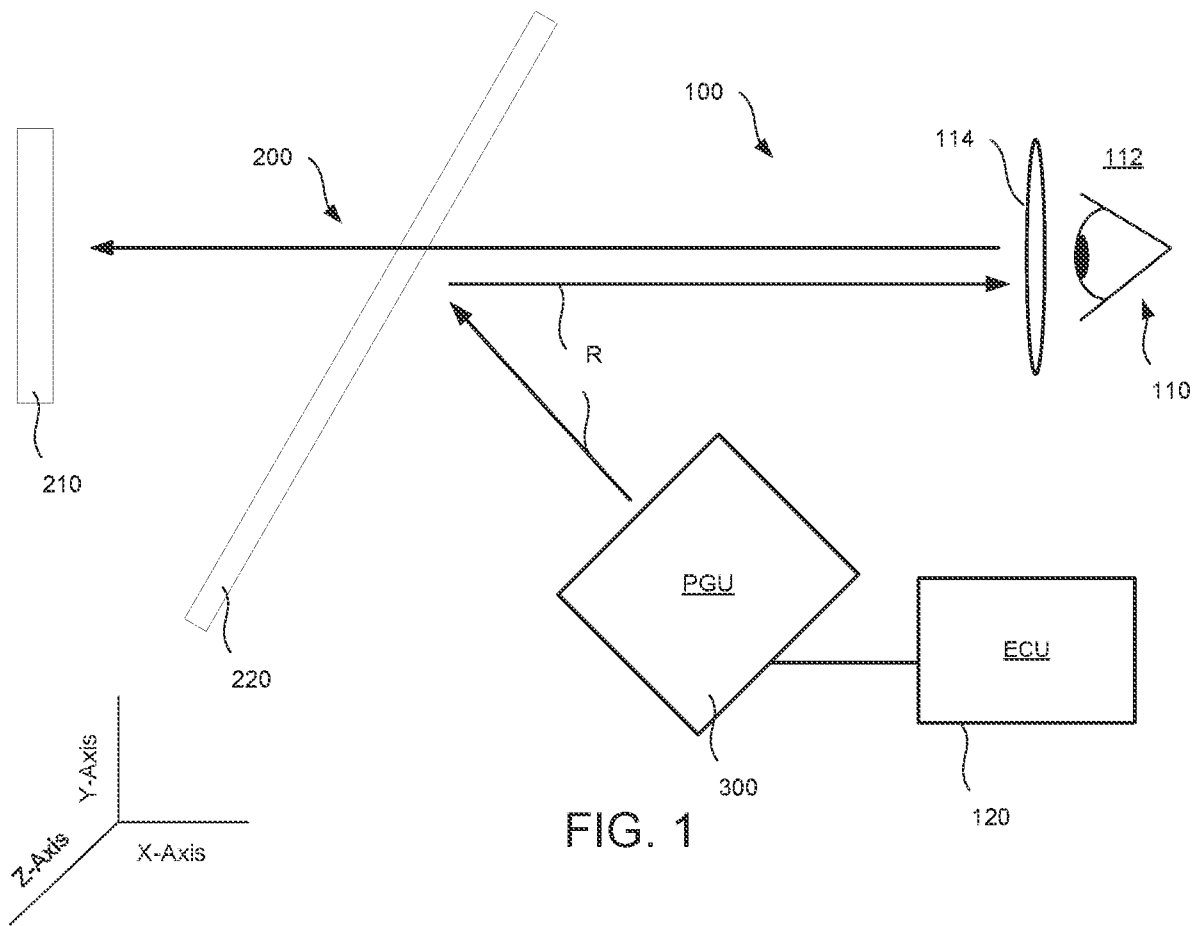


FIG. 1

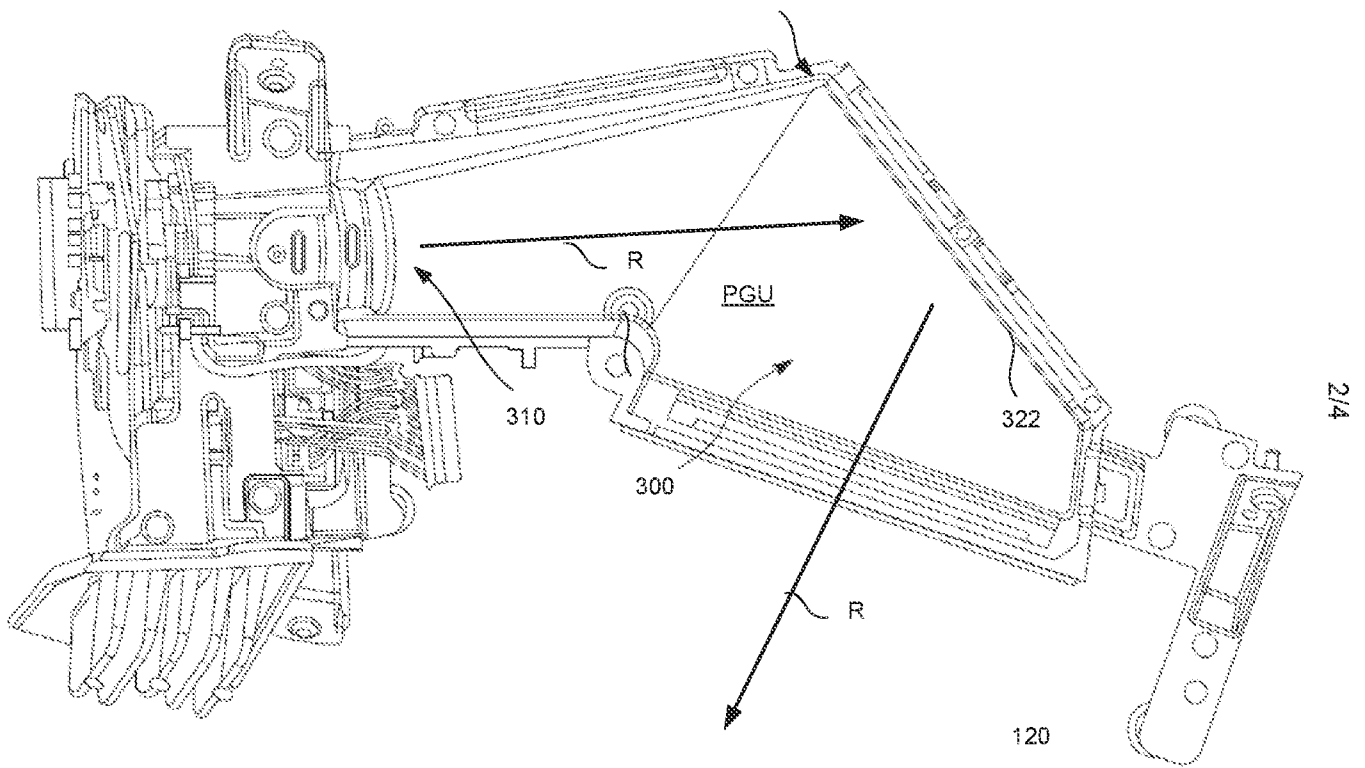


FIG. 2

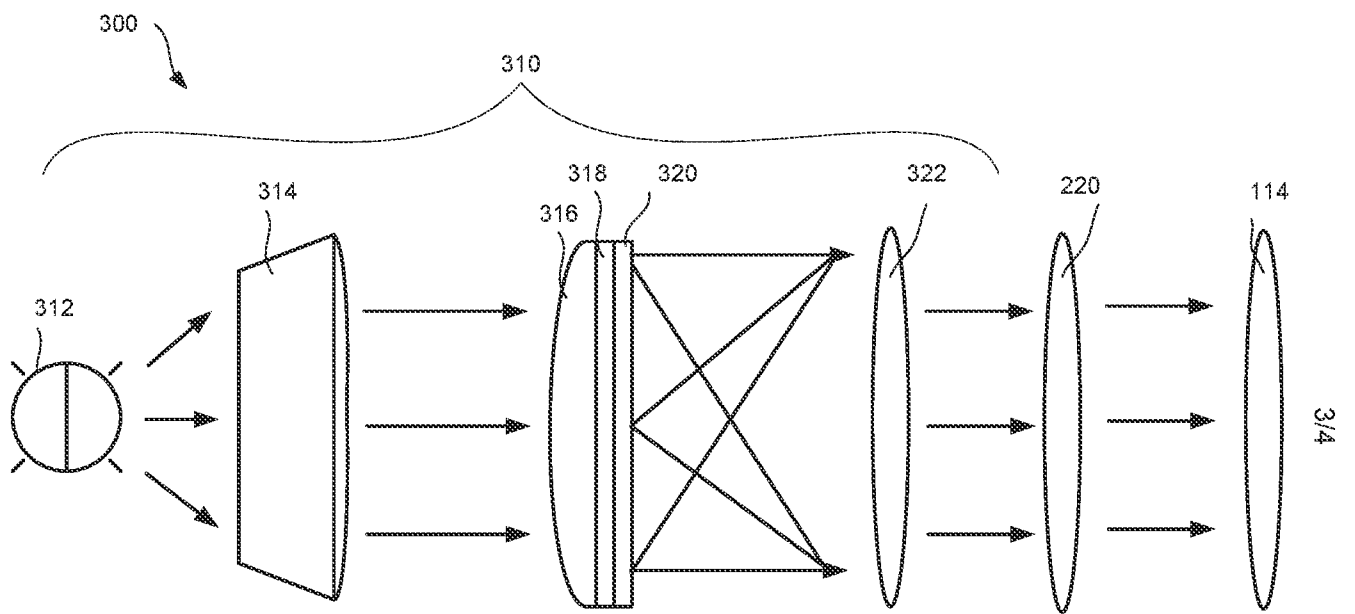


FIG. 3

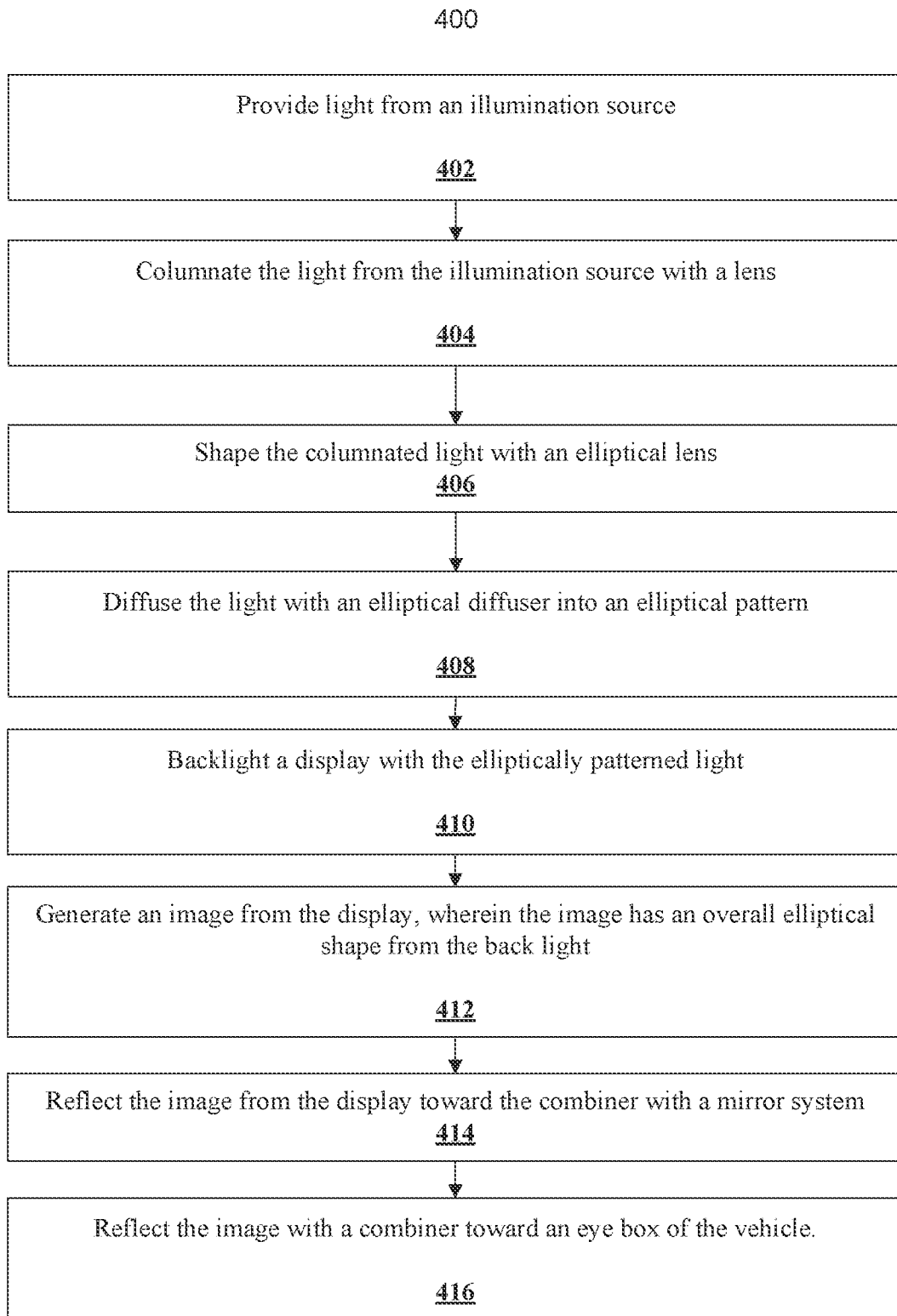


FIG. 4

**INTERNATIONAL SEARCH REPORT**

International application No  
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**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. G02B5/02 G02B27/01 G02B27/09  
 ADD.  
 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)  
 G02B  
 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/299342 A1 (ASAI YOSUKE [JP]) 13 October 2016 (2016-10-13) paragraph [0031] - paragraph [0050]; figures 1, 2, 7a-b	1-7
A	US 2014/268358 A1 (KUSAKA HIROMI [JP] ET AL) 18 September 2014 (2014-09-18) figures 1, 3	1-7

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016299342	A1	13-10-2016	EP 3076223 A1 05-10-2016
			JP 5866644 B1 17-02-2016
			JP 2016126314 A 11-07-2016
			US 2016299342 A1 13-10-2016
			WO 2016103549 A1 30-06-2016
-----			
US 2014268358	A1	18-09-2014	CN 104133292 A 05-11-2014
			EP 2796919 A1 29-10-2014
			JP 6207850 B2 04-10-2017
			JP 2014174494 A 22-09-2014
			US 2014268358 A1 18-09-2014
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