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(54) **HEAD-UP DISPLAY APPARATUS FOR VEHICLE**

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(57) **ABSTRACT**

A head-up display apparatus for a vehicle is configured to output a display that has a convex shape in an upward direction as a whole such that a width of the display in a left/right direction, when the display is viewed from a predetermined view point, indicates a width of the vehicle. The image includes a meter that indicates an amount of a predetermined parameter.

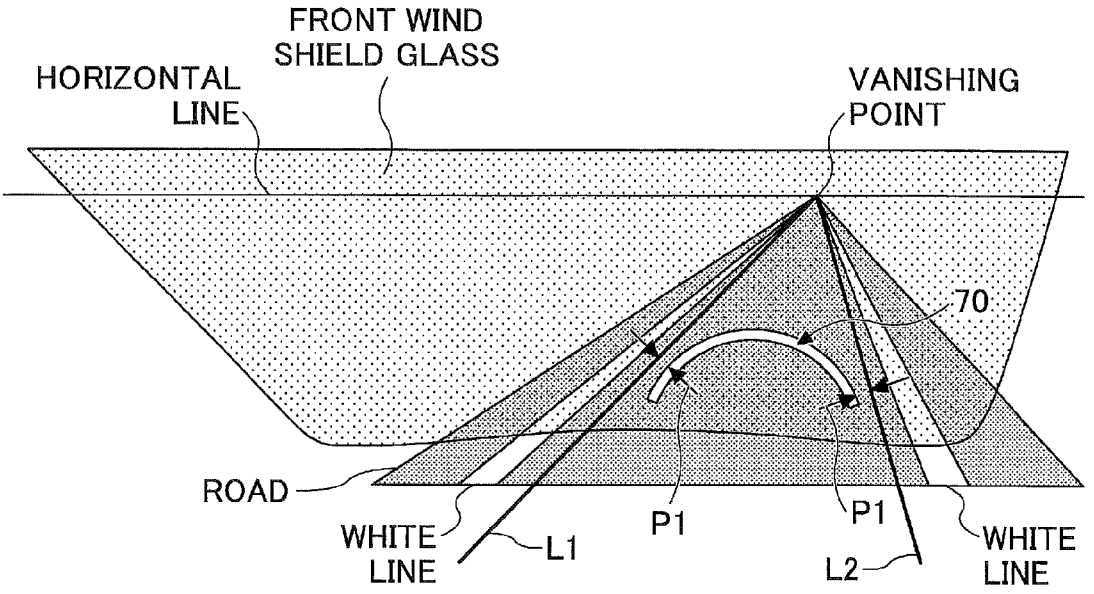


FIG.1

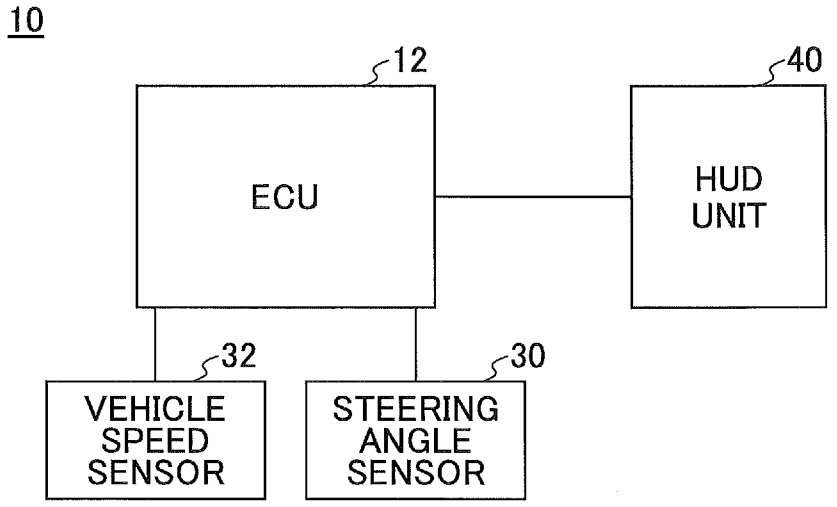

10
12
ECU
40
HUD UNIT
32
VEHICLE SPEED SENSOR
30
STEERING ANGLE SENSOR

FIG.2

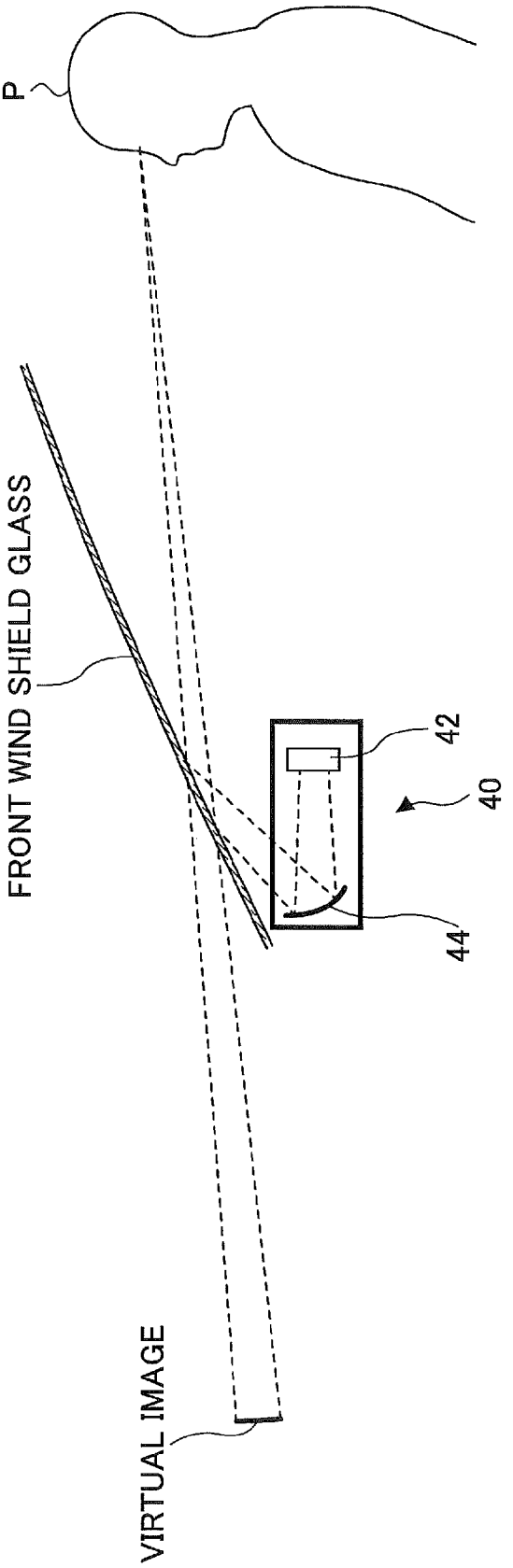


FIG.3

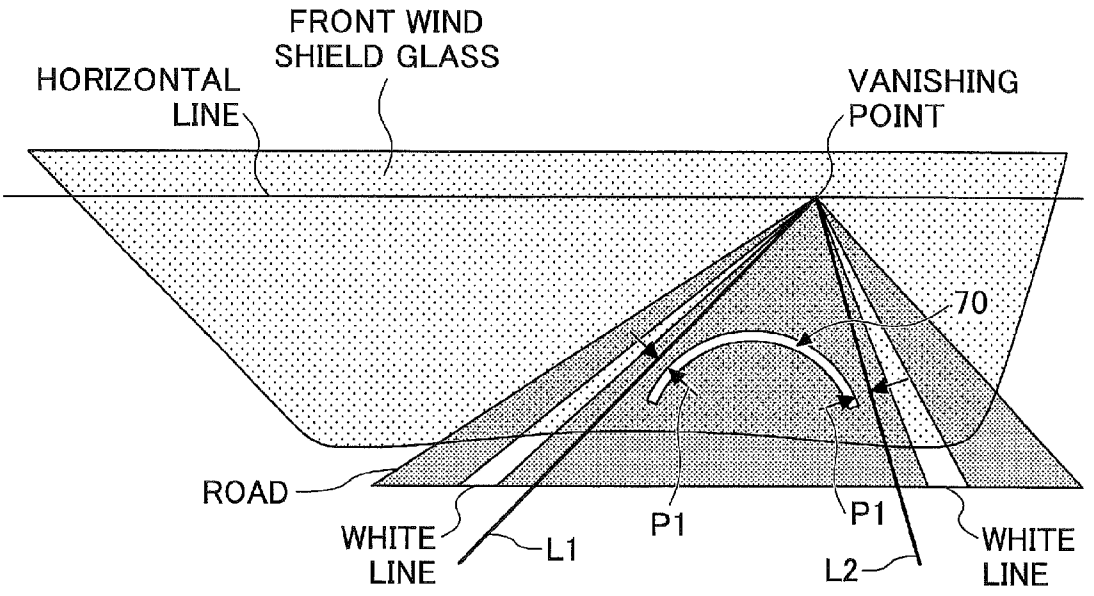

FRONT WIND
SHIELD GLASS
HORIZONTAL
LINE
VANISHING
POINT
70
ROAD
WHITE
LINE
L1
P1
P1
L2
WHITE
LINE

FIG.4

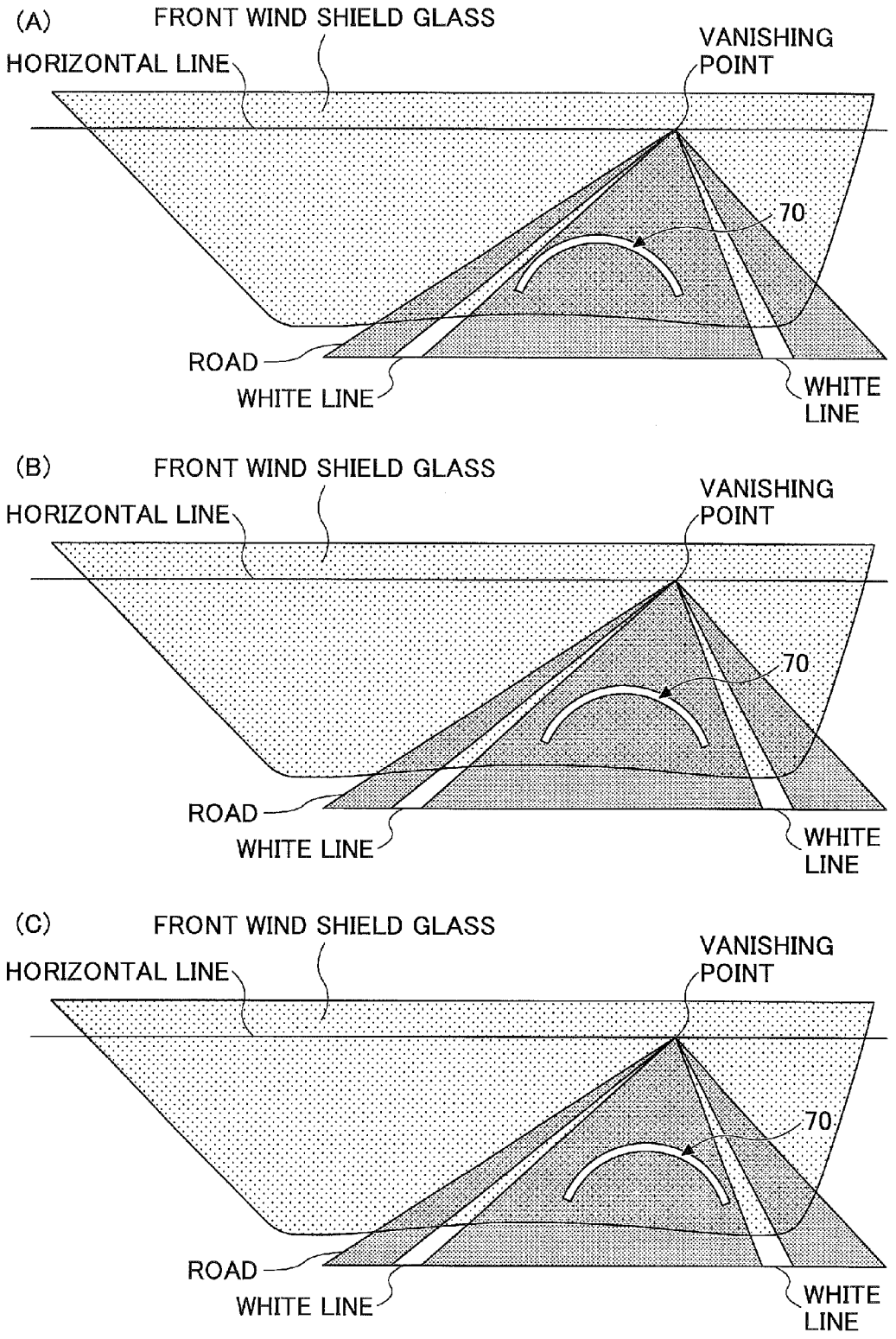

(A)
FRONT WIND SHIELD GLASS
HORIZONTAL LINE
VANISHING POINT
70
ROAD
WHITE LINE
WHITE LINE
(B)
FRONT WIND SHIELD GLASS
HORIZONTAL LINE
VANISHING POINT
70
ROAD
WHITE LINE
WHITE LINE
(C)
FRONT WIND SHIELD GLASS
HORIZONTAL LINE
VANISHING POINT
70
ROAD
WHITE LINE
WHITE LINE

FIG.5

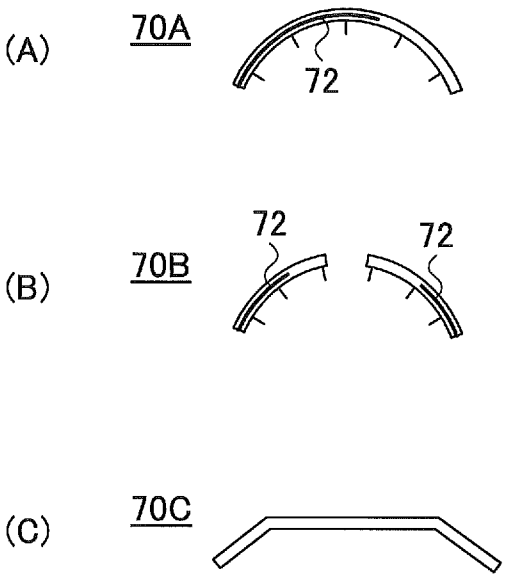


FIG.6

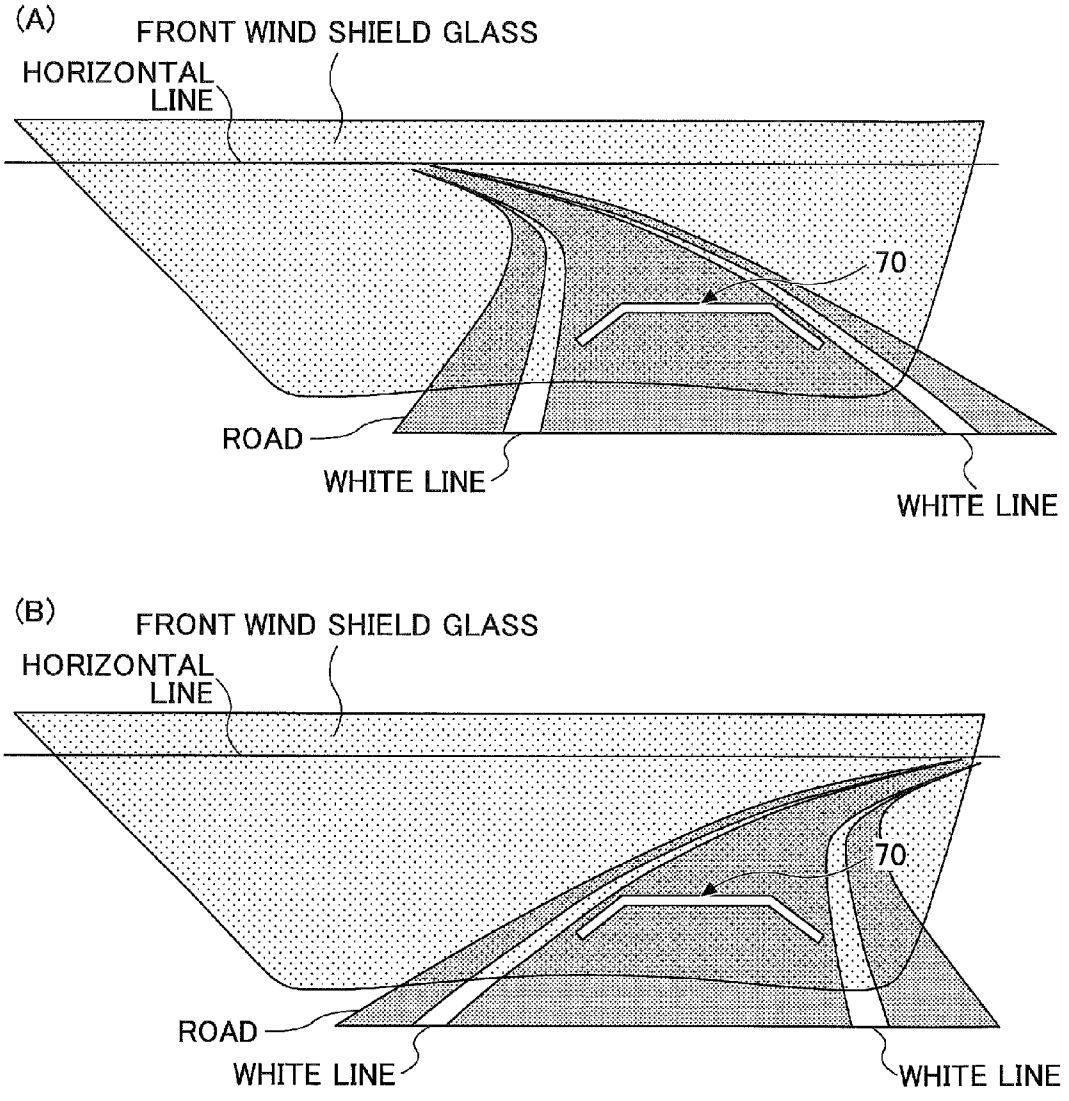

(A)
FRONT WIND SHIELD GLASS
HORIZONTAL LINE
70
ROAD
WHITE LINE
WHITE LINE
(B)
FRONT WIND SHIELD GLASS
HORIZONTAL LINE
70
ROAD
WHITE LINE
WHITE LINE

FIG.7

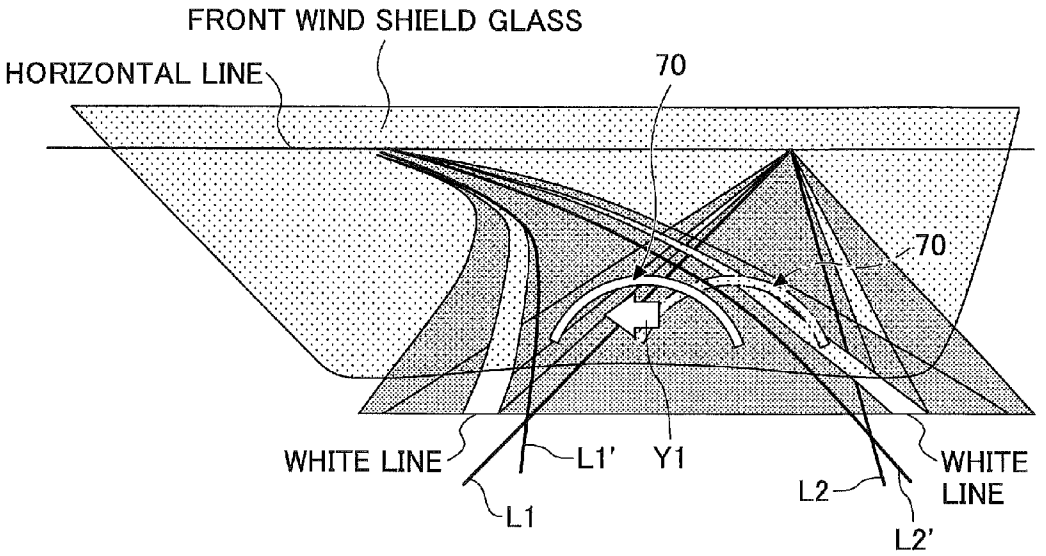

FRONT WIND SHIELD GLASS
HORIZONTAL LINE
70
70
WHITE LINE
L1'
Y1
WHITE LINE
L2
L1
L2'

FIG.8

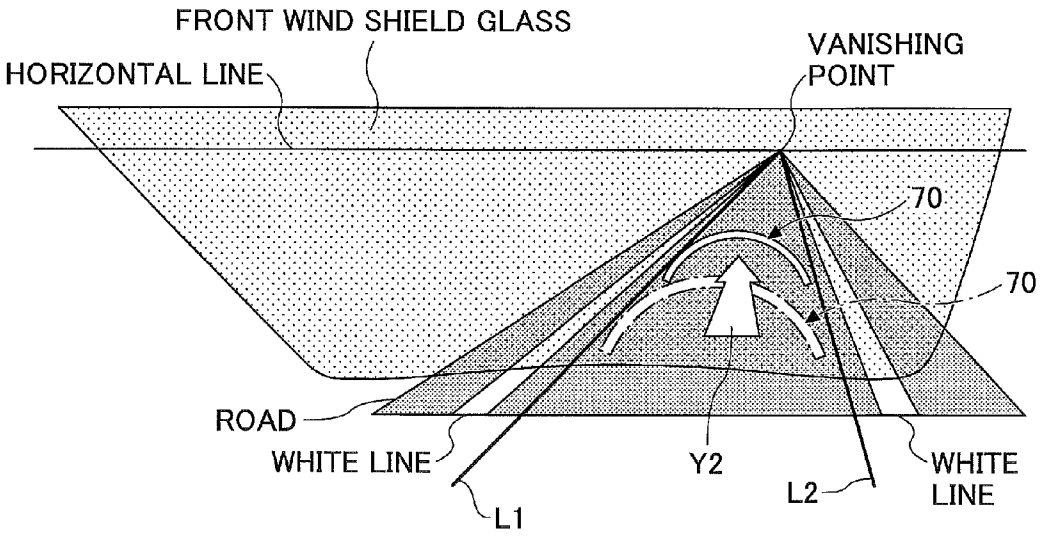
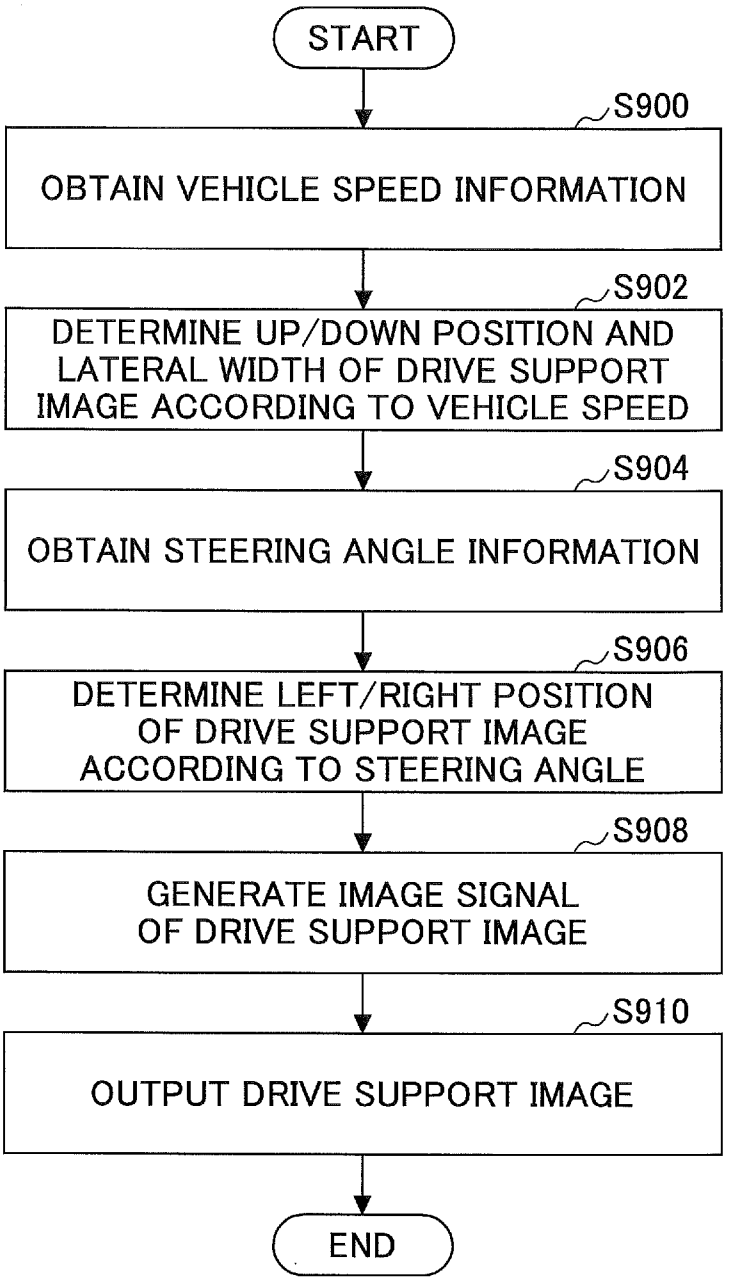

FRONT WIND SHIELD GLASS
HORIZONTAL LINE
VANISHING POINT
70
70
ROAD
WHITE LINE
Y2
WHITE LINE
L2
L1

FIG.9


START
S900
OBTAIN VEHICLE SPEED INFORMATION
S902
DETERMINE UP/DOWN POSITION AND LATERAL WIDTH OF DRIVE SUPPORT IMAGE ACCORDING TO VEHICLE SPEED
S904
OBTAIN STEERING ANGLE INFORMATION
S906
DETERMINE LEFT/RIGHT POSITION OF DRIVE SUPPORT IMAGE ACCORDING TO STEERING ANGLE
S908
GENERATE IMAGE SIGNAL OF DRIVE SUPPORT IMAGE
S910
OUTPUT DRIVE SUPPORT IMAGE
END

HEAD-UP DISPLAY APPARATUS FOR VEHICLE

TECHNICAL FIELD

[0001] The disclosure is related to a head-up display apparatus for a vehicle.

BACKGROUND ART

[0002] A traveling trajectory control support apparatus is known that displays a marking as a future traveling trajectory image for supporting a driver such that the marking can be viewed via a front glass by the driver who sees a road (see Patent Document 1, for example).

[0003] [Patent Document 1] Japanese Laid-open Patent Publication No. 2007-512636

DISCLOSURE OF INVENTION

Problem to be Solved by Invention

[0004] However, the image (i.e., the marking) according to Patent Document 1 does not include information about a width of a vehicle. Thus, there is a problem that the image does not function effectively as a drive support with respect to a driver whose sense of a width of the vehicle is not well developed.

[0005] Therefore, an object of the disclosure is to provide a head-up display apparatus for a vehicle that can perform a drive support such that an appropriate sense of a width of the vehicle is given to a driver.

Means to Solve the Problem

[0006] According to one aspect of the disclosure, a head-up display apparatus for a vehicle is provided, wherein the head-up display apparatus is configured to output a display that has a convex shape in an upward direction as a whole such that a width of the display in a left/right direction, when the display is viewed from a predetermined view point, indicates a width of the vehicle.

Advantage of the Invention

[0007] According to the disclosure, a head-up display apparatus for a vehicle can be obtained that can perform a drive support such that an appropriate sense of a width of the vehicle is given to a driver.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a diagram illustrating an example of a system configuration of a head-up display apparatus **10**.

[0009] FIG. **2** is a cross-sectional view schematically illustrating an example of a cross-section of a HUD unit **40**.

[0010] FIG. **3** is a diagram schematically illustrating an example of a displayed state of a drive support image **70** displayed by the HUD unit **40**.

[0011] FIG. **4** is a diagram schematically illustrating an example of a displayed state of the drive support image **70** according to a lateral position of a vehicle with respect to a lane marker.

[0012] FIG. **5** is a diagram illustrating variations of the drive support image **70**.

[0013] FIG. **6** is a diagram schematically illustrating an example of the displayed states of the drive support image **70** for a curved road.

[0014] FIG. **7** is a diagram schematically illustrating an example of the displayed state (movement manner) of the drive support image **70** according to a steering angle.

[0015] FIG. **8** is a diagram schematically illustrating an example of the displayed state (movement manner) of the drive support image **70** according to a vehicle speed.

[0016] FIG. **9** is an example of a flowchart of a process executed by an ECU **12**.

DESCRIPTION OF REFERENCE SYMBOLS

[0017] **10** head-up display apparatus
[0018] **12** ECU
[0019] **30** steering angle sensor
[0020] **32** vehicle speed sensor
[0021] **40** HUD unit
[0022] **42** display device
[0023] **44** concave mirror
[0024] **70** (**70**A, **70**B, **70**C) drive support image
[0025] **72** state image

BEST MODE FOR CARRYING OUT THE INVENTION

[0026] In the following, embodiments are described in detail with reference to appended drawings.

[0027] FIG. **1** is a diagram illustrating an example of a system configuration of a head-up display apparatus **10**. The head-up display apparatus **10** includes an electronic control unit **12** (referred to as "ECU **12**", hereinafter). The operation of the head-up display apparatus **10** is controlled by the ECU **12**. The ECU **12** includes a microprocessor that includes a CPU, a ROM, a RAM, etc., which are interconnected via buses (not illustrated). In the ROM are stored the computer readable programs to be carried out by the CPU. Functions of the ECU **12** (including functions described hereinafter) may be implemented by any hardware, any software, any firmware or any combination thereof. For example, any part of or all the functions of the ECU **12** may be implemented by an ASIC (application-specific integrated circuit), a FPGA (Field Programmable Gate Array) or a DSP (digital signal processor). Further, the ECU **12** may be implemented by a plurality of ECUs.

[0028] The ECU **12** is coupled to a steering sensor **30** that detects a steering angle of a steering wheel (not illustrated). An output signal (steering information) of the steering sensor **30** is transmitted to the ECU **12**. The ECU **12** may calculate the steering angle from the steering angle value of the steering sensor **30** based on a nominal steering angle (i.e., the steering angle value when the vehicle travels in a straight line) stored in the ROM, etc.

[0029] The ECU **12** is coupled to a vehicle speed sensor **32** that detects the vehicle speed. The vehicle speed sensor **32** outputs an electric signal according to rotational speed of vehicle wheels (vehicle speed pulses). An output signal (vehicle speed information) of the vehicle speed sensor **32** is transmitted to the ECU **12**. The ECU **12** may calculate the vehicle speed based on the output signal of the vehicle speed sensor **32**. Further, the ECU **12** may obtain vehicle speed information from other ECUs (the vehicle speed information from an ABS (anti-lock brake system), for example). Further, the ECU **12** may calculates the vehicle speed from a rpm of an output shaft of a transmission, instead of the vehicle speed sensor **32**.

[0030] The ECU **12** is coupled to an HUD (Head-Up Display) unit **40**. The HUD unit **40** outputs a drive support image described hereinafter based on an image signal from the ECU **12**. The drive support image generated by the HUD unit **40** is described hereinafter in detail.

[0031] FIG. **2** is a cross-sectional view schematically illustrating an example of a cross-section of the HUD unit **40**. The HUD unit **40** is provided in an instrument panel, as illustrated in FIG. **2**, for example.

[0032] The HUD unit **40** includes a display device (projector) **42**. The display device **42** generates visible light rays (display light) for transmitting information to a driver. The display light is generated according to an image signal from the ECU **12**. It is noted that a configuration of the display device **42** may be arbitrary. The display device **42** may be a dot-matrix VFD (Vacuum Fluorescent Display), for example.

[0033] The display device **42** generates the display light related to the drive support image **70** described hereinafter in detail. Further, the display device **42** may project the display light including information (i.e., front circumstance information) that is included in a video signal received from an infrared camera (not illustrated) that captures a scene in front of the vehicle. Further, the display device **42** may project the display light for transmitting navigation information from a navigation apparatus. Further, the display device **42** may project the display light for transmitting meter information (vehicle speed information, etc., for example) from a navigation apparatus. Further, the display device **42** may project the display light for transmitting information about states of an air conditioner, an audio apparatus, etc.

[0034] The display light emitted from the display device **42** reaches an image projection surface of a front wind shield glass. The display light is diffracted by the image projection surface of the front wind shield glass toward a viewer P (a driver, in particular) such that an image (virtual image) is generated in front of the viewer P. It is noted that in FIG. **2** a projection range (optical path) of the display light viewed from the viewer P (precisely, a position P of eyes of the viewer P) is illustrated in a dotted line. It is noted that, in the example illustrated in FIG. **2**, the HUD unit **40** includes a concave mirror **44**, and the display light from the display device **42** is reflected at the concave mirror **44** to reach the front wind shield glass. The display light may be converted to an enlarged image by the concave mirror **44** according to a curvature of the front wind shield glass.

[0035] It is noted that a combiner may be provided on the front wind shield glass. The combiner may be of arbitrary type. For example, the combiner may be formed of a half mirror or may be a holographic combiner using a hologram. In the case of the holographic combiner, the hologram may be inserted between layers of the front wind shield glass. Further, the combiner may be formed of a reflective film evaporated on a surface of glass on the side thereof to which another glass is bonded to form layers of the front wind shield glass. Alternatively, the combiner may not be provided on or in the image projection surface of the front wind shield glass. In this case, the front wind shield glass may have an intermediate film (inserted between the glass layers) with varied thickness in order to prevent double images (i.e., an image that can be viewed as if it were double due to the reflections at the front and back surfaces of the front wind shield glass). For example, the intermediate film may have the thickness that gradually reduces from the upper side to the lower side of the front wind shield glass (i.e., a wedge shaped cross section).

[0036] FIG. **3** is a diagram schematically illustrating an example of a drive support image **70** displayed by the HUD unit **40**. It is noted that FIG. **3** illustrates a displayed state of the drive support image **70** from a predetermined view point. In FIG. **3**, a scene (actual image) viewed from the driver includes two white lines and a horizontal line. Two left and right lines L**1** and L**2** are neither actual images nor displayed images. The lines L**1** and L**2** are illustrated for the purpose of explanation. An arrow P**1** is not a displayed image, and is also illustrated for the purpose of explanation.

[0037] The drive support image **70** is an image extending in a left/right direction, as illustrated in FIG. **3**. The drive support image **70** is output such that a width of the drive support image **70** in the left/right direction indicates a width of the vehicle when the drive support image **70** is viewed from a predetermined view point. The predetermined view point is arbitrary. Typically, the view point of the driver is assumed as the predetermined view point. The view point of the driver differs according to a height, a driving position of the driver, etc. Thus, the predetermined view point may be set based on a representative height and a representative driving position of the driver. Alternatively, the predetermined view point may be set for each of a plurality of heights and driving positions of the driver. In the following, for the sake of reducing the complexity of the explanation, it is assumed that the predetermined view point is set based on the representative height and the representative driving position of the driver.

[0038] In FIG. **3**, the two left and right lines L**1** and L**2** indicate the width of the vehicle. In other words, the two left and right lines L**1** and L**2** substantially correspond to trajectories (predicted trajectories) of left and right wheels of the vehicle. In this example, the two left and right lines L**1** and L**2** correspond to a case where the vehicle travels in a straight line at an ideal middle position between the left and right white lines on a straight road. In FIG. **3**, the two left and right lines L**1** and L**2** are illustrated when viewed from the predetermined view point. The drive support image **70** may be output such that left and right ends thereof are inwardly away from the two left and right lines L**1** and L**2** by a predetermined distance P**1**, respectively. In this case, the drive support image **70** may be output at the midpoint between the two left and right lines L**1** and L**2** which are illustrated when viewed from the predetermined view point. With this arrangement, when the drive support image **70** is viewed from the predetermined view point, the lateral width of the drive support image **70** can indicate the width of the vehicle at a predetermined vehicle ahead position (i.e., the width of the vehicle when it is assumed that the vehicle reaches the predetermined vehicle ahead position, and viewed from the current predetermined view point). The drive support image **70** thus viewed in such a way can be generated in advance based on drawing data (a relationship between the predicted trajectories of the left and right wheels according to the steering angle and the predetermined view point, for example) on a CAD (Computer-Aided Design) tool, for example. In this case, portions that are used as a reference to determine the predetermined distance P**1**, of the predicted trajectories of the left and right wheels that extend forward toward an infinite-point, may be near the position of the virtual image, or may be forward with respect to the virtual image (near a position at which a line connecting from the predetermined view point to the virtual image, that is to say, a line of sight intersects with the road). In other words, the predetermined vehicle ahead position may be near the position of the virtual image, etc. It is noted that a fine-tuning

of the output position of the drive support image **70** may be implemented by a fine-tuning of an angle of the concave mirror **44** or an output (pixel positions) of the display device **42**. It is noted that the predetermined distance P**1** may be arbitrary, as long as the lateral width of the drive support image **70** can suggest the width of the vehicle at the predetermined vehicle ahead position (near the position of the virtual image, etc.) (i.e., as long as the lateral width of the drive support image **70** gives an indication of the width of the vehicle). For example, the predetermined distance P**1** may be 0, or slightly greater than 0. Further, the predetermined distance P**1** may be slightly smaller than 0 (i.e., a negative value, and thus the left and right ends are outwardly away from the two left and right lines L**1** and L**2**). It is noted that when the predetermined distance P**1** is 0, the lateral width of the drive support image **70** indicates the width of the vehicle at the predetermined vehicle ahead position as well as the positions of the left and right wheels of the vehicle at the predetermined vehicle ahead position.

[0039] The drive support image **70** has a shape that is convex upward as a whole, as illustrated in FIG. **3**. In other words, the drive support image **70** has a shape whose width becomes smaller as the position thereof moves upward. In the example illustrated in FIG. **3**, the drive support image **70** is an arc shape whose center of a curvature is located on the lower side. It is noted that the arc shape is not necessarily a portion of a perfect circle, and may be an oval shape whose longitudinal axis extends in the lateral direction, for example.

[0040] According to the example illustrated in FIG. **3**, since the drive support image **70** that is upwardly concave and horizontally oriented is displayed to correspond to the width of the vehicle, the driver can visually understand the width of the vehicle ahead of a line of sight of the driver. With this arrangement, the driver can learn to have an appropriate sense of the width of the vehicle and can visually understand a relative position of the host vehicle in the width direction with respect to the lane marker (the white line, for example).

[0041] It is noted that, preferably, the shape of the drive support image **70** is substantially symmetric with respect to the center thereof in the left/right direction, as illustrated in FIG. **3**. Further, preferably, the drive support image **70** is output such that a line connecting the opposite ends thereof is parallel with the horizontal line, as illustrated in FIG. **3**. With this arrangement, it becomes easier to visually understand the relative position of the host vehicle in the width direction with respect to the lane marker.

[0042] FIG. **4** is a diagram schematically illustrating an example of a displayed state of the drive support image **70** according to the lateral position of the vehicle with respect to the lane marker. In FIG. **4**, (A) illustrates a way in which the drive support image **70** is viewed when the host vehicle is closer to the left side lane marker, (B) illustrates a way (corresponding to FIG. **3**) in which the drive support image **70** is viewed when the host vehicle is at the middle position between the lane markers, and (C) illustrates a way in which the drive support image **70** is viewed when the host vehicle is closer to the right side lane marker. It is noted that FIG. **4** illustrates a displayed state (appearance) of the drive support image **70** from the predetermined view point.

[0043] For example, when the host vehicle is closer to the left side lane marker, the drive support image **70** is seen at a position closer to the left side lane marker correspondingly, when viewed from the predetermined view point, as illustrated in FIG. **4** (A). In other words, the drive support image **70** is seen such that the distance with respect to the left side lane marker is shorter than that with respect to the right side lane marker. With this arrangement, the driver can easily understand that the host vehicle travels at a position in the traveling lane that is closer to the left side lane marker.

[0044] Similarly, when the host vehicle is closer to the right side lane marker, the drive support image **70** is seen at a position closer to the right side lane marker correspondingly, when viewed from the predetermined view point, as illustrated in FIG. **4** (C). In other words, the drive support image **70** is seen such that the distance with respect to the right side lane marker is shorter than that with respect to the left side lane marker. With this arrangement, the driver can easily understand that the host vehicle travels at a position in the traveling lane that is closer to the right side lane marker.

[0045] FIG. **5** is a diagram illustrating variations of the drive support image **70**. It is noted that, only for the explanation of FIG. **5**, the variations of the drive support image **7** are referred to as "drive support images **70**A, **70**B and **70**C".

[0046] In the example illustrated in FIG. **5** (A), a drive support image **70**A includes an arc-shaped gauge image. In other words, the drive support image **70**A includes a meter that indicates an amount of a predetermined parameter. The predetermined parameter is arbitrary. For example, the predetermined parameter may be selected from the vehicle speed, various temperatures, an oil amount, a water amount, a fuel amount, a generated electricity amount, a charged amount, an ecology drive degree, etc. It is noted that, in the case of the gauge image, the drive support image **70**A may include a numeral display, etc., in the meter. Further, in the case of the gauge image, the drive support image **70**A may include a state image **72** that indicates the current amount of the predetermined parameter such that the state image **72** is associated with the meter. In the example illustrated in FIG. **5** (A), the state image **72** is rendered (superimposed) in the arc of the drive support image **70**A. In this case, the state image **72** may be rendered with a color that is different from a color in the arc of the drive support image **70**A. It is noted that the state image **72** may be rendered such that the state image **72** is offset from the arc of the drive support image **70**A.

[0047] If the drive support image **70**A includes the state image **72**, it is preferred that the shape of the drive support image **70**A except for the state image **72** is symmetric with respect to the center thereof in the left/right direction. In this sense, it is preferred that the shape of the drive support image **70**A is "substantially" symmetric with respect to the center thereof in the left/right direction.

[0048] In the example illustrated in FIG. **5** (B), a drive support image **70**B includes arc-shaped gauge images that have a separation at the center therebetween in the left/right direction. The drive support image **70**B includes a meter that indicates the amount of the predetermined parameter, as illustrated in FIG. **5** (B). In the example illustrated in FIG. **5** (B), the left and right arc-shaped gauge, images of the drive support image **70**B includes respective meters that indicate respective amounts of the predetermined parameters. However, a combination of the left and right arc-shaped gauge images may form a single meter. Further, the drive support image **70**B may include a state image **72** that indicates the current amount of the predetermined parameter such that the state image **72** is associated with the meter. Further, the drive support image **70**B may include a numeral display, etc., in the meter. Further, it is preferred that the shape of the drive support image **70**B is "substantially" symmetric (symmetric

expect for the state image **72**) with respect to the center thereof in the left/right direction.

[0049] According to the examples illustrated in FIG. **5** (A) and FIG. **5** (B), the drive support image **70**A and **70**B can implement the support function described above that enables the driver to acquire an appropriate sense of the width of the vehicle as well as the function as the gauge image. With this arrangement, it becomes possible to use limited space to effectively transmit more information to the driver. However, in the example illustrated in FIG. **5** (B), the drive support image **70**B may be a simple mark that does not include the meters.

[0050] In the example illustrated in FIG. **5** (C), the drive support image **70**C has a shape obtained by removing a lower base from a trapezoid shape whose lower base is longer than an upper base. The drive support image **70**C illustrated in FIG. **5** (C) is a simple mark that does not include the meter; however, the drive support image **70**C may also include the meter that indicates the amount of the predetermined parameter. Further, the drive support image **70**C illustrated in FIG. **5** (C) is a single image without space in the left/right direction; however, as is the case with FIG. **5** (B), the drive support image **70**C may have a separation at the center in the left/right direction.

[0051] It is noted that the drive support images **70**A, **70**B and **70**C each have the upwardly convex shapes as a whole. In the example illustrated in FIG. **5** (C), the drive support image **70**C is based on the trapezoid shape whose lower base is longer than the upper base, and thus is upwardly convex. It is noted that the shape of the drive support image **70**C may be other than the trapezoid shape, as long as it is upwardly convex (i.e., the shape is configured such that the width becomes narrower as the position thereof moves upwardly). Further, in the example illustrated in FIG. **5** (C), the shape of the drive support image **70**C is the trapezoid shape without the lower base thereof; however, the shape of the drive support image **70**C may have the lower base.

[0052] FIG. **6** is a diagram schematically illustrating an example of the drive support image **70** for a curved road. In FIG. **6**, (A) illustrates an example of the displayed state of the drive support image **70** for the left curved road, and (B) illustrates an example of the displayed state of the drive support image **70** for the right curved road. Similarly, FIG. **6** illustrates the displayed state of the drive support image **70** from the predetermined view point. In the example illustrated in FIG. **6**, the drive support image **70** is a gauge image that has a shape obtained by removing the lower base from the trapezoid shape whose lower base is longer than the upper base.

[0053] Since the drive support image **70** has the shape that is upwardly convex, as illustrated in FIG. **6**, the drive support image **70** is easily adapted to the curved road. In other words, it is difficult for the drive support image **70** with the upwardly convex shape to intersect with the lane markers (white lines, for example) of the curved road, which enables keeping the visibility of the drive support image **70** (understandability of the information thereof). This holds true for the left curved road as well as the right curved road.

[0054] FIG. **7** is a diagram schematically illustrating an example of the displayed state (movement manner) of the drive support image **70** according to a steering angle. Similarly, FIG. **7** illustrates the displayed state of the drive support image **70** from the predetermined view point. It is noted that the two left and right lines L**1**' and L**2**' are neither actual images nor displayed images, and are illustrated for the purpose of explanation, as is the case with the lines L**1** and L**2**. It is noted that the two left and right lines L**1**' and L**2**' indicate the width of the vehicle and substantially correspond to trajectories (predicted trajectories) of left and right wheels of the vehicle, as is the case with the lines L**1** and L**2**.

[0055] Preferably, the drive support image **70** is moved in the left/right direction according to a change in the traveling direction of the host vehicle (steering angle). Specifically, it is preferred that the drive support image **70** is moved in the left/right direction with respect to the displayed position thereof in the case where the host vehicle travels in the straight line on the straight road, according to a difference between the lines L**1** and L**2** in the case where the host vehicle travels in the straight line on the straight road and the lines L**1**' and L**2**' in the case where the host vehicle travels on the curved road.

[0056] In the example illustrated in FIG. **7**, the output position of the drive support image **70** in the case where the host vehicle travels on the left curved road is moved by a predetermined amount Y**1** in the left direction with respect to the output position (alternate long and short dashed line) of the drive support image **70** where the host vehicle travels in the straight line on the straight road. In this case, the drive support image **70** may be inclined with respect to the horizontal line; however, it is preferred that the drive support image **70** is moved by a predetermined amount Y**1** in the left direction without inclination with respect to the horizontal line. The predetermined amount Y**1** may be determined based on the steering angle information from the steering sensor **30**. More specifically, the driver operates the steering wheel according to the curvature radius of the traveling road, and thus the lines L**1** and L**2** are varied according to the steering operation (In the example illustrated in FIG. **7**, the lines L**1** and L**2** are changed to the lines L**1**' and L**2**'). Thus, the output position of the drive support image **70** in the left/right direction (i.e., the projected position on the front wind shield glass in the left/right direction) is changed according to the steering operation. It is noted that the drive support image **70** may not have different shapes before and after the change of the output position of the drive support image **70** in the left/right direction; however, the change of the output position of the drive support image **70** in the left/right direction may involve a slight change of the shape of the drive support image **70**.

[0057] The relationship between the steering angle and the output position of the drive support image **70** (i.e., the predetermined amount Y**1**) can be generated in advance based on the drawing data (the relationship between the predicted trajectories of the left and right wheels according to the steering angle and the predetermined view point, for example) on the CAD tool, for example. Thus, the output positions of the drive support image **70** in the left/right direction may be mapped with a plurality of steering angles and stored. In this case, the output position of the drive support image **70** in the left/right direction may be determined according to the steering angle. It is noted that the output position of the drive support image **70** in the left/right direction for steering angles (that are not defined in the mapped data) between the mapped steering angles may be derived with interpolation or the like.

[0058] It is noted that the output position of the drive support image **70** in the left/right direction finally determines positions of pixels that generate the display light related to the drive support image **70**, and thus the mapped data between the steering angles and the image signals may be stored.

[0059] The drive support image **70** may be moved in the left/right direction based on a lane mark recognition result by an image sensor including a camera, instead of the steering angle information. In this case, the lane marks (white lines, bots dots, cat's eyes, etc.) on the left and right sides may be recognized from the camera image, a shift between a center line of the lane marks on the left and right sides and a center line on the camera (i.e., a center line of the vehicle in the front/back direction) is calculated, and the output position of the drive support image **70** in the left/right direction (i.e., the projected position on the front wind shield glass in the left/right direction) may be determined according to the calculated shift.

[0060] According to the example illustrated in FIG. **7**, since the drive support image **70** is moved according to the change (i.e., the steering angle) in the traveling direction of the host vehicle, a support function of the drive support image **70** can be effective even during the traveling on the curved road or the like. With this arrangement, during the traveling on the curved road or the like, the driver can easily perform an appropriate steering operation while viewing the drive support image **70**.

[0061] In the example illustrated in FIG. **7**, it is necessary to move the output of the drive support image **70** in the left/right direction, and such a movement may be implemented by changing output pixels of the display device **42** (i.e., the pixel positions that generate the display light related to the drive support image **70**) in the left/right direction. For this reason, the display device **42** may be configured such that the display device **42** has a sufficient size (i.e., a display light output area) in the left/right direction. Alternatively, such a movement may be mechanically implemented by moving the position of the display device **42** in the left/right direction.

[0062] FIG. **8** is a diagram schematically illustrating an example of the displayed state (movement manner) of the drive support image **70** according to the vehicle speed. Similarly, FIG. **8** illustrates the displayed state of the drive support image **70** from the predetermined view point.

[0063] Preferably, the drive support image **70** is moved in the up/down direction according to the vehicle speed of the host vehicle. In this case, the drive support image **70** is moved upward as the vehicle speed becomes greater. In the example illustrated in FIG. **8**, the displayed state of the drive support image **70** in the case where the vehicle travels in a straight line on the straight road is illustrated. In the example illustrated in FIG. **8**, the drive support image **70** may be moved upward by a predetermined amount Y**2** from a reference position when the vehicle speed is increased. In this case, the drive support image **70** is moved upward by the predetermined amount Y**2** without inclination with respect to the horizontal line. The predetermined amount Y**2** may be determined based on the vehicle speed information from the vehicle speed sensor **32**. The relationship between the vehicle speed and the output position of the drive support image **70** (i.e., the pixel positions that generate the display light related to the drive support image **70**) in the up/down direction can be generated in advance based on the drawing data (the relationship between the predicted trajectories of the left and right wheels and a direction of a line of sight of the driver from the predetermined view point that changes according to the vehicle speed, for example) on the CAD tool, for example. Thus, the output positions of the drive support image **70** in the up/down direction may be mapped with a plurality of vehicle speeds and stored. In this case, the output position of the drive support image **70** in the up/down direction (i.e., the projected position on the front wind shield glass in the up/down direction) may be determined according to the vehicle speed. It is noted that the output position of the drive support image **70** in the up/down direction for vehicle speeds (that are not defined in the mapped data) between the mapped vehicle speeds may be derived with interpolation or the like.

[0064] Further, preferably, the drive support image **70** has the width (i.e., the lateral width) increased in the left/right direction when the drive support image **70** is moved in the up/down direction according to the vehicle speed of the host vehicle. Specifically, the lateral width W (not illustrated) of the drive support image **70** is increased or decreased according to the vehicle speed of the host vehicle. This is because a distance between the left and right lines L**1** and L**2** (i.e., a distance in the left/right direction) becomes shorter as the position becomes farther. It is noted that increasing or decreasing the lateral width of the drive support image **70** may be implemented by zooming in or out the drive support image **70** itself, or by merely increasing or decreasing the lateral width thereof. Further, a convex degree of the drive support image **70** may be varied according to the movement of the drive support image **70** in the up/down direction. In this case, the convex degree of the drive support image **70** may be varied such that the convex degree (i.e., a degree of a sharpness) becomes greater as the position moves upward. Similarly, a relationship between the vehicle speed and the lateral width W of the drive support image **70** can be generated in advance based on the drawing data on the CAD tool. Thus, the lateral widths W of the drive support image **70** (i.e., the pixel positions that generate the display light related to the drive support image **70**) may be mapped with a plurality of vehicle speeds and stored. In this case, the lateral width W of the drive support image **70** (i.e., a projected width on the front wind shield glass) may be determined according to the vehicle speed. It is noted that the lateral width W of the drive support image **70** for vehicle speeds (that are not defined in the mapped data) between the mapped vehicle speeds may be derived with interpolation or the like.

[0065] It is noted that the output position in the up/down direction of the drive support image **70**, the lateral width W of the drive support image **70**, etc., finally determine positions of pixels that generate the display light related to the drive support image **70**, and thus the mapped data between the vehicle speeds and the image signals may be stored.

[0066] According to the example illustrated in FIG. **8**, since the drive support image **70** is moved in the up/down direction according to the vehicle speed of the host vehicle, it becomes possible to output the drive support image **70** at a position adapted to a line of sight that changes according to the vehicle speed. Specifically, the line of sight of the driver moves farther as the vehicle speed becomes greater; however, since the drive support image **70** is moved upward according to the movement of a line of sight of the driver, the support function of the drive support image **70** can be maintained even when the vehicle speed changes. With this arrangement, the driver can easily perform an appropriate steering operation while viewing the drive support image **70** without changing a line of sight even when the vehicle speed changes.

[0067] Further, according to the example illustrated in FIG. **8**, the lateral width of the drive support image **70** is changed according to the vehicle speed of the host vehicle, the problem due to the movement of the drive support image **70** in the up/down direction (i.e., the problem that the drive support image **70** is not output such that the drive support image **70**

indicates the width of the vehicle) can be prevented. Specifically, according to the example illustrated in FIG. **8**, the vehicle width transmission function of the drive support image **70** can be maintained even when the drive support image **70** is moved in the up/down direction due to the change of the vehicle speed.

[0068] In the example illustrated in FIG. **8**, it is necessary to move the output of the drive support image **70** in the up/down direction, and such a movement may be implemented by changing output pixels of the display device **42** (i.e., the pixel positions that generate the display light related to the drive support image **70**) in the up/down direction. For this reason, the display device **42** may be configured such that the display device **42** has a sufficient size in the up/down direction (i.e., the front/back direction of the vehicle). Alternatively, such a movement may be mechanically implemented by moving the position of the display device **42** such that a distance (i.e., an optical path length) from the display device **42** to the image projection surface of the front wind shield glass is changed.

[0069] Further, in the example illustrated in FIG. **8**, it is necessary to change the output width of the drive support image **70**, and such a change may be implemented by changing output pixels of the display device **42** (i.e., the pixel positions that generate the display light related to the drive support image **70**) in the up/down direction. For this reason, the display device **42** may be configured such that the display device **42** has a sufficient size (i.e., the display light output area) in the left/right direction.

[0070] It is noted that the example illustrated in FIG. **8** can be combined with the example illustrated in FIG. **7** described above. In this case, a relationship between the steering angle, the vehicle speed and the image signal is mapped in advance as a three-dimensional map, and the image signal may be output according to the steering angle and the vehicle speed. It is noted that the image signal generates the display light related to the drive support image **70**, and determines the output position and the lateral width of the drive support image **70**.

[0071] FIG. **9** is an example of a flowchart of a process executed by the ECU **12**. The process routine illustrated in FIG. **9** may be performed repeatedly every predetermined cycle during the ON state of the head-up display apparatus **10**.

[0072] In step S**900**, the vehicle speed information related to the latest vehicle speed is obtained.

[0073] In step S**902**, the output position of the drive support image **70** in the up/down direction and the lateral width of the drive support image **70** according to the vehicle speed is determined based on the vehicle speed information obtained in step S**900** (see FIG. **8**).

[0074] In step **904**, the steering angle information related to the latest steering angle is obtained.

[0075] In step S**906**, the output position of the drive support image **70** in the left/right direction according to the steering angle is determined based on the steering angle information obtained in step S**904** (see FIG. **7**).

[0076] In step S**908**, the image signal related to the drive support image **70** is generated based on the determination results of step S**902** and step S**904** described above. It is noted that, in the case where the three-dimensional map is stored that represents the relationship between the steering angle, the vehicle speed and the image signal, the image signal is generated according to the vehicle speed and the steering angle obtained in step S**900** and step S**904** described above. In the case of the drive support image **70** being the gauge image, the state image **72** of the drive support image **70** may be generated according to the current amount of the parameter (see FIG. **3** (A), etc.).

[0077] In step S**910**, the image signal generated in step S**908** is transmitted to the HUD unit **40** and the drive support image **70** is output via the HUD unit **40**.

[0078] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiment(s) of the present inventions have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention. Further, all or part of the components of the embodiments described above can be combined.

[0079] For example, according to the embodiment described above, the relationship between the steering angle and the output position of the drive support image **70** in the left/right direction is derived from the drawing data on the CAD tool (the relationship between the predicted trajectories of the left and right wheels according to the steering angle and the predetermined view point, for example) in advance and stored as mapped data. The output position of the drive support image **70** in the left/right direction is determined using the mapped data at the time of performing the control. However, such mapped data may not be stored, and instead of it, the predicted trajectories of the left and right wheels of the vehicle according to the steering angle may be calculated based on the steering angle information at the time of performing the control. In this case, the output position of the drive support image **70** in the left/right direction may be determined according to the calculated predicted trajectories.

[0080] Further, according to the embodiment, the manner in which the drive support image **70** is output is determined based on the fixed predetermined view point; however, the manner (i.e., the output position, the lateral width, etc.) in which the drive support image **70** is output may be determined according to the view point of the driver that is detected based on a camera that is installed in a cabin for detecting the view point of the driver. In this case, the manner in which the drive support image **70** is output may be determined according to the idea described above.

1. A head-up display apparatus for a vehicle, the head-up display apparatus being configured to output an image whose shape is convex upwardly as a whole such that a width of the image in a left/right direction, when the image is viewed from a predetermined view point, indicates a width of the vehicle.

2. The head-up display apparatus for the vehicle of claim **1**, wherein the image includes a meter that indicates an amount of a predetermined parameter that is related to a state of the vehicle or a traveling state.

3. The head-up display apparatus for the vehicle of claim **1**, wherein the head-up display apparatus is configured to vary an output position of the image in the left/right direction based on sensor information, the sensor information representing at least one of a direction of the vehicle, and a position of the vehicle with respect to a lane maker.

4. The head-up display apparatus for the vehicle of claim **3**, wherein the head-up display apparatus is configured to determine the output position of the image in the left/right direction such that a center of the image in the left/right direction is on a center line of the vehicle in a front/back direction.

5. The head-up display apparatus for the vehicle of claim **3**, wherein the head-up display apparatus is configured to vary the output position of the image in the left/right direction based on steering angle information that represents the direction of the vehicle.

6. The head-up display apparatus for the vehicle of claim **5**, wherein the head-up display apparatus is configured to vary the output position of the image in the left/right direction such that the image is between the predicted trajectories of left and right of the vehicle and equally away from the predicted trajectories in the left/right direction, the predicted trajectories being varied according to the steering angle.

7. The head-up display apparatus for the vehicle of claim **1**, wherein the head-up display apparatus is configured to vary the output position of the image in an up/down direction according to a vehicle speed.

8. The head-up display apparatus for the vehicle of claim **1**, wherein the shape of the image includes an arc and convex shape in an upward direction, or a shape obtained by removing a lower base from a trapezoid shape whose lower base is longer than an upper base.

9. The head-up display apparatus for the vehicle of claim **1**, wherein the output position of the image in the left/right direction is varied without an orientation with respect to a horizontal direction being varied.

10. The head-up display apparatus for the vehicle of claim **1**, wherein the shape of the image is substantially symmetric with respect to the center thereof in the left/right direction.

11. (canceled)

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