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(54) INFORMATION PRESENTATION APPARATUS

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(52) **U.S. Cl.**

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(57) **ABSTRACT**

An information presentation apparatus is provided. A light emission device (**40**) and a HCU (**100**) are mounted on a vehicle A together with a device having a driving assist function for assisting a driving operation of a driver or taking a wheel. The light emission device is arranged on an instrument panel of the vehicle (A), and displays at least one light emission spot (**51**) in a linear light emission area (**52**) arranged to extend in a width direction (WD) of the vehicle. The HCU acquires operation information about the driving assist function, and controls a light emission mode of the light emission spot in the linear light emission area based on the operation information. The HCU switches a reference position, at which the light emission spot is displayed, between a case where the driving assist function is in operation and a case where the driving assist function is not in operation.

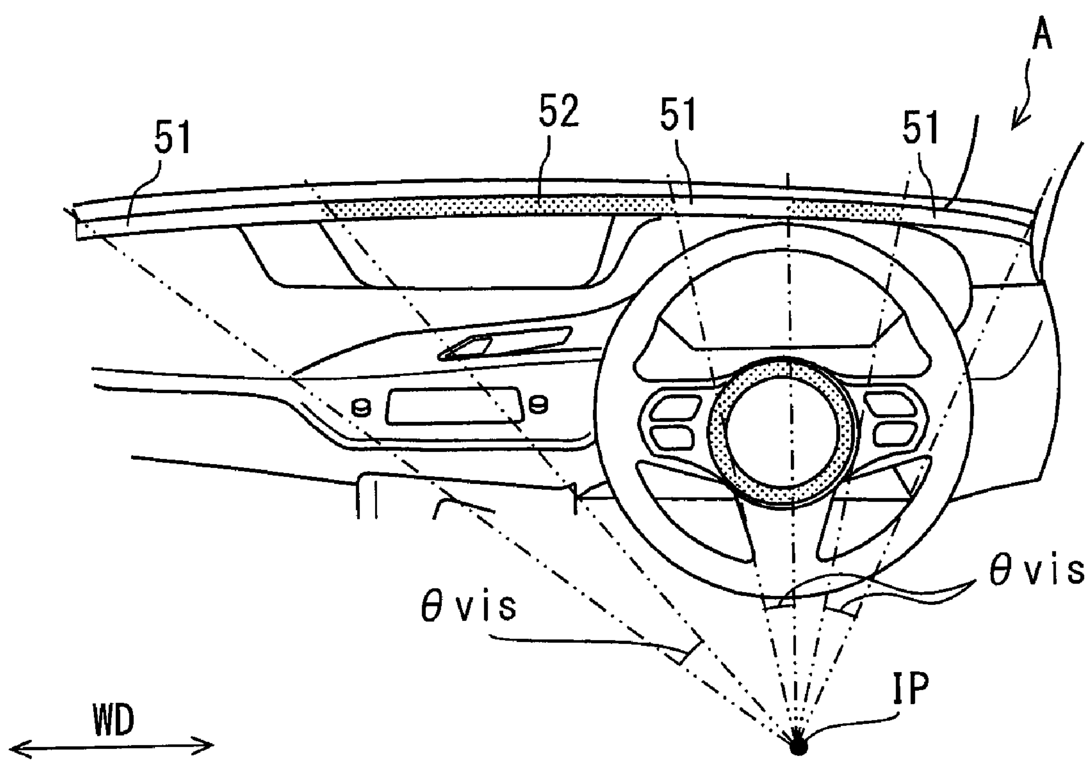


FIG. 1

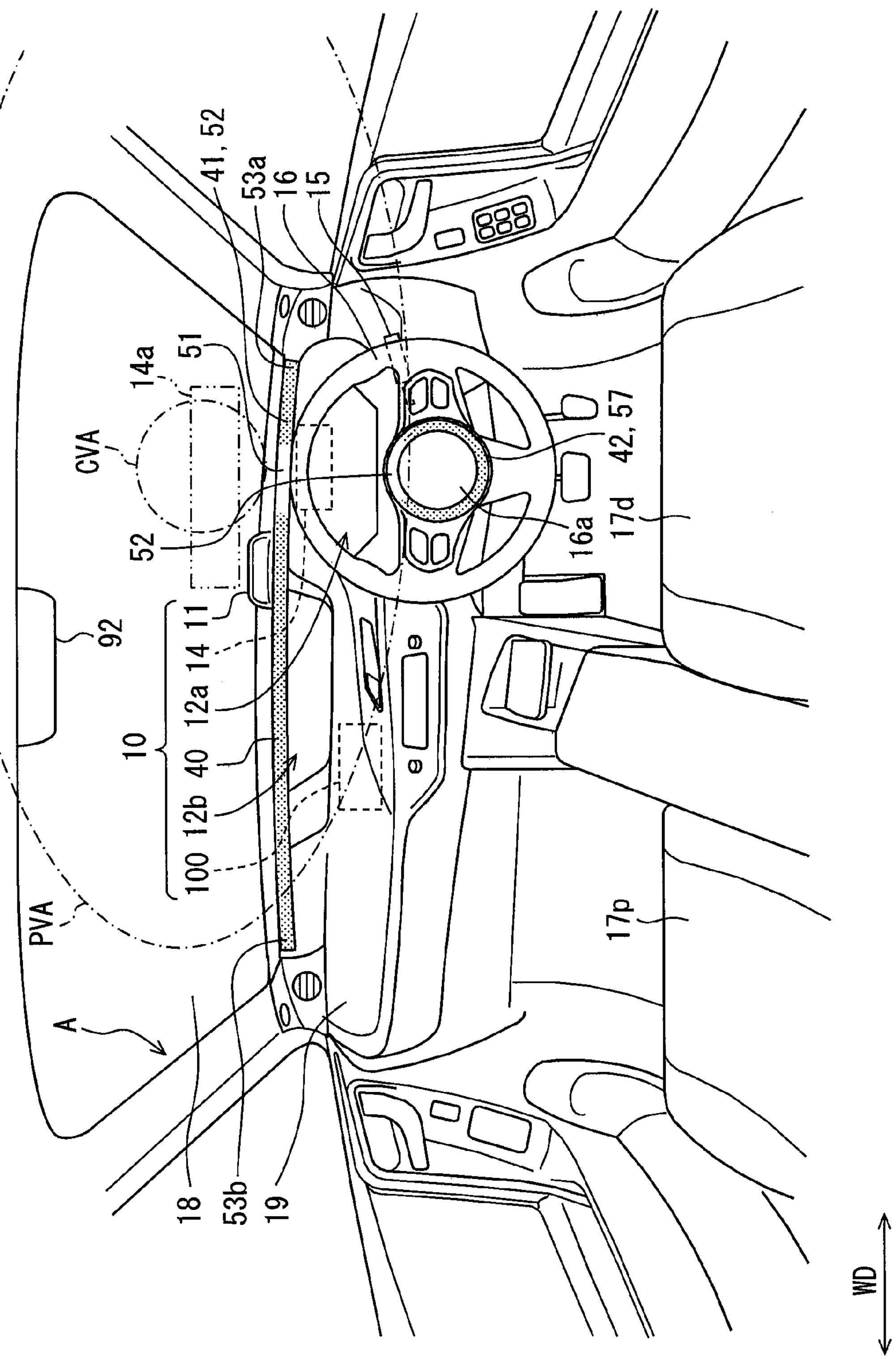

41, 52
53a
16
15
14a
51
CVA
42, 57
52
16a
17d
92
10
11
14
12a
40
12b
100
PVA
17p
A
18
53b
19
WD

FIG. 2

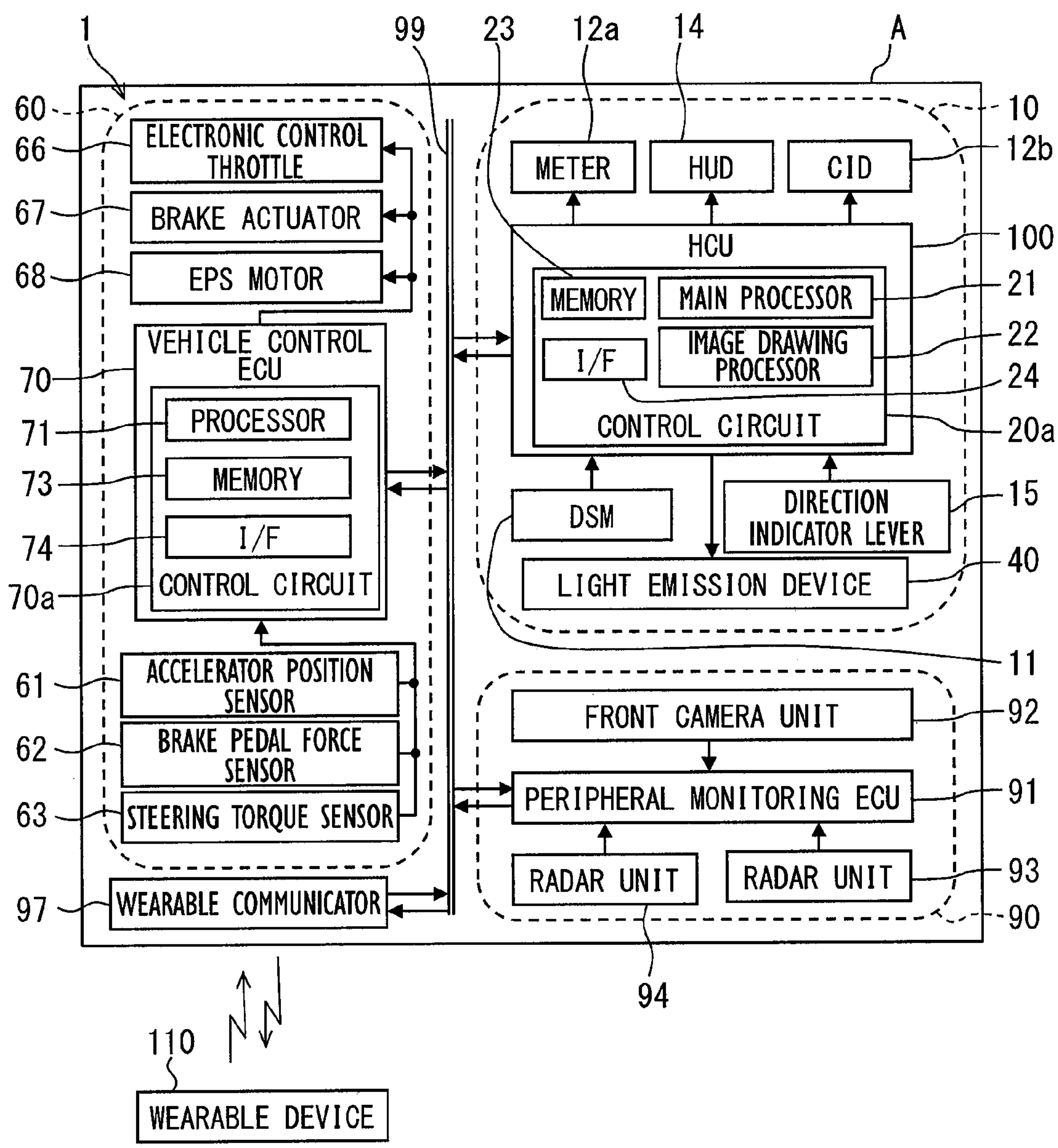

1
99
23
12a
14
A
60
10
66
ELECTRONIC CONTROL THROTTLE
METER
HUD
CID
12b
67
BRAKE ACTUATOR
HCU
100
68
EPS MOTOR
MEMORY
MAIN PROCESSOR
21
VEHICLE CONTROL ECU
I/F
IMAGE DRAWING PROCESSOR
22
24
70
CONTROL CIRCUIT
20a
71
PROCESSOR
73
MEMORY
DSM
DIRECTION INDICATOR LEVER
15
74
I/F
70a
CONTROL CIRCUIT
LIGHT EMISSION DEVICE
40
11
61
ACCELERATOR POSITION SENSOR
FRONT CAMERA UNIT
92
62
BRAKE PEDAL FORCE SENSOR
PERIPHERAL MONITORING ECU
91
63
STEERING TORQUE SENSOR
RADAR UNIT
RADAR UNIT
93
97
WEARABLE COMMUNICATOR
90
94
110
WEARABLE DEVICE

FIG. 3

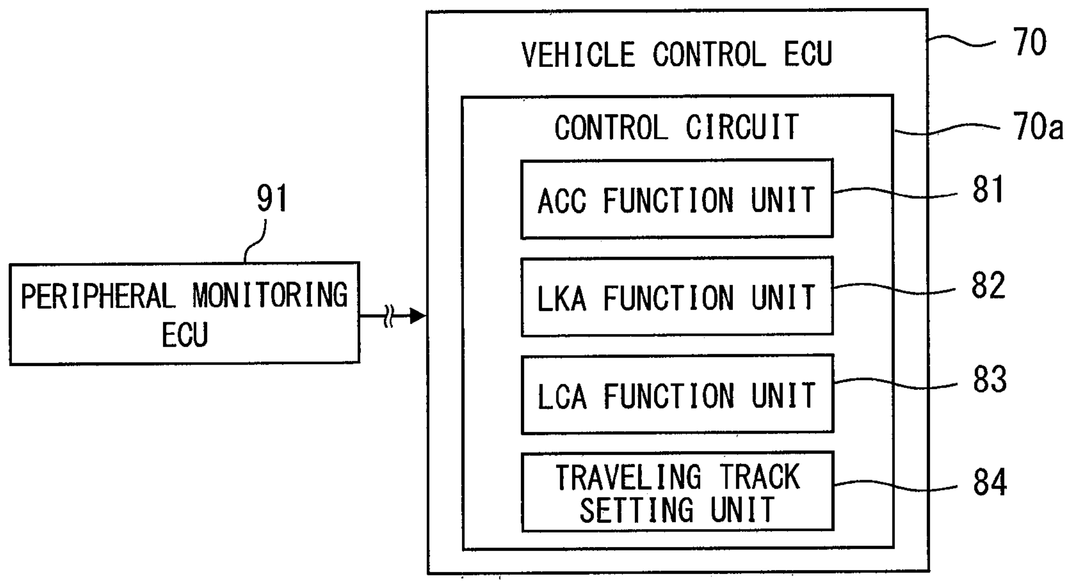
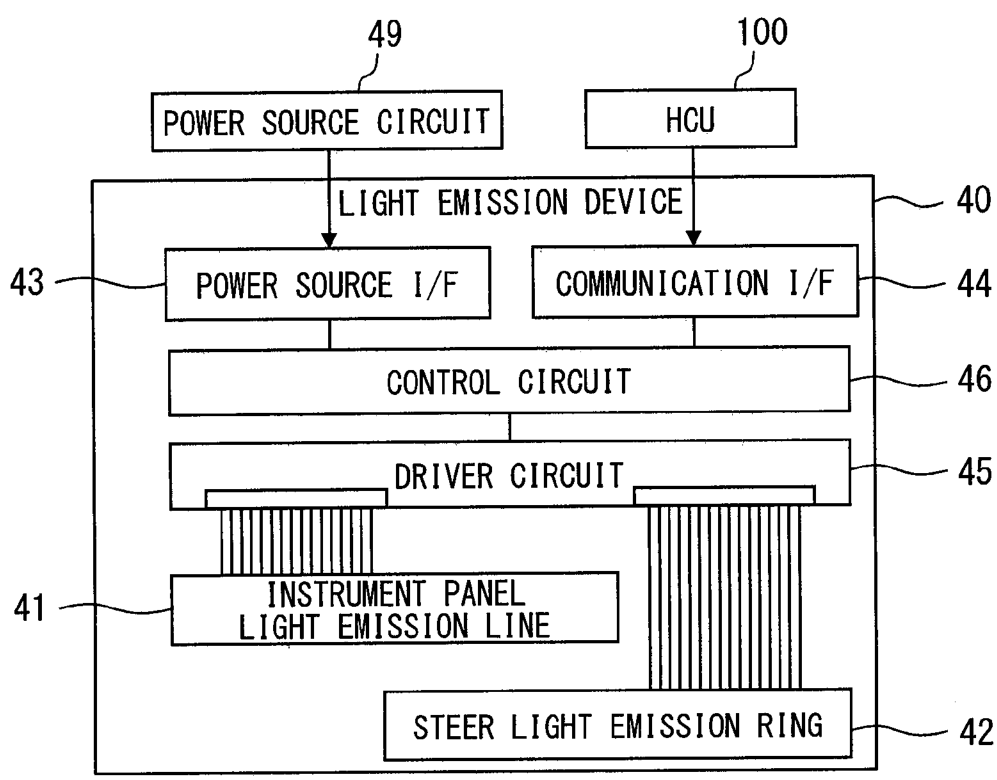
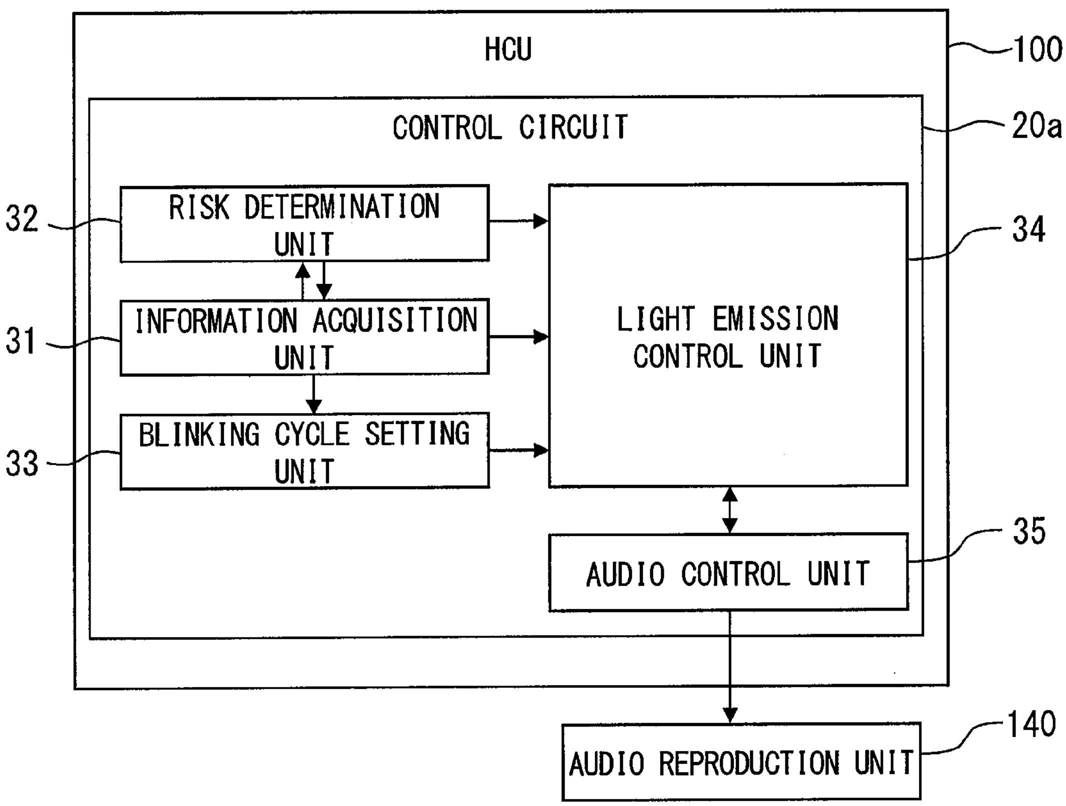

VEHICLE CONTROL ECU
70
CONTROL CIRCUIT
70a
ACC FUNCTION UNIT
81
LKA FUNCTION UNIT
82
LCA FUNCTION UNIT
83
TRAVELING TRACK SETTING UNIT
84
91
PERIPHERAL MONITORING ECU

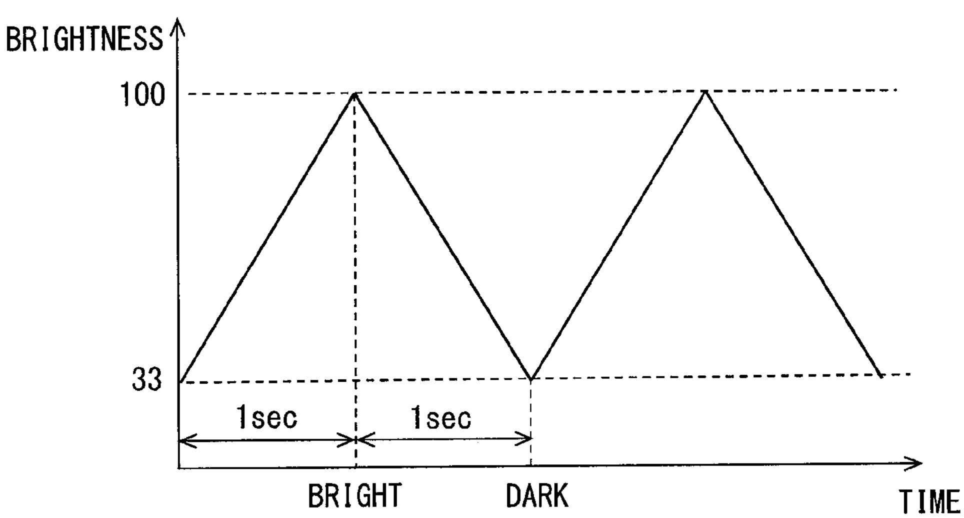
FIG. 4


49
POWER SOURCE CIRCUIT
100
HCU
LIGHT EMISSION DEVICE
40
43
POWER SOURCE I/F
COMMUNICATION I/F
44
CONTROL CIRCUIT
46
DRIVER CIRCUIT
45
41
INSTRUMENT PANEL LIGHT EMISSION LINE
STEER LIGHT EMISSION RING
42

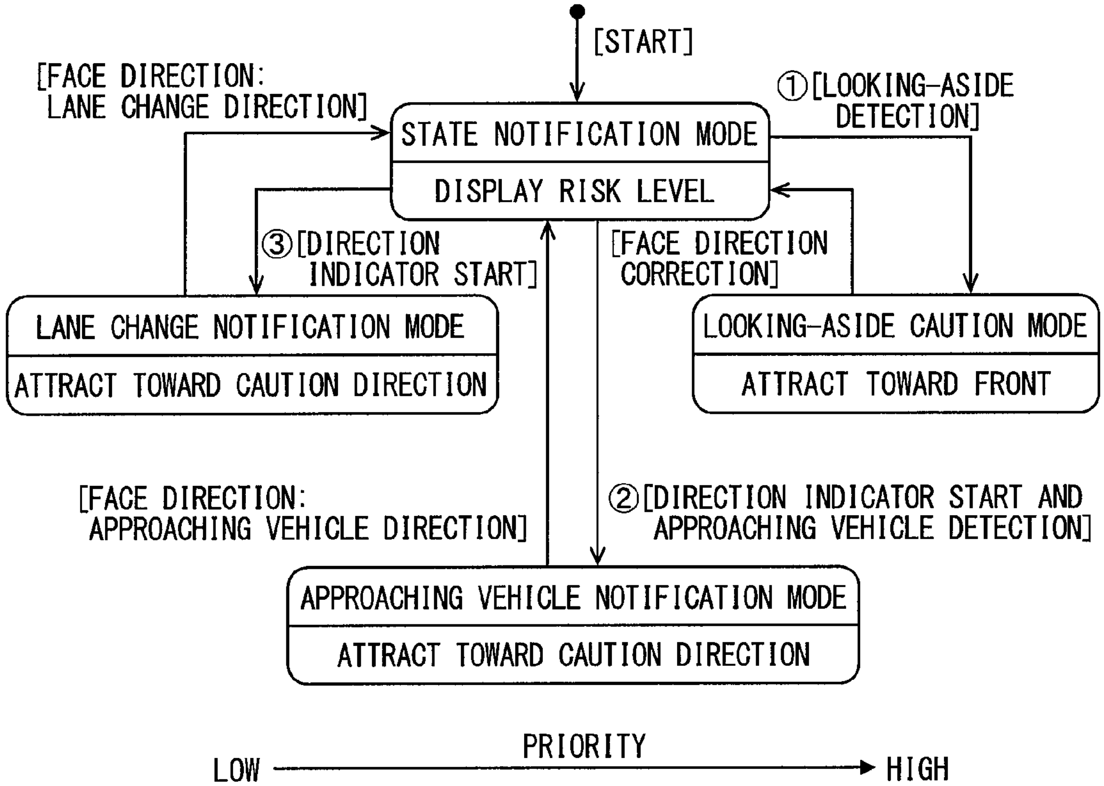
# FIG. 5


HCU
100
CONTROL CIRCUIT
20a
32
RISK DETERMINATION UNIT
31
INFORMATION ACQUISITION UNIT
33
BLINKING CYCLE SETTING UNIT
LIGHT EMISSION CONTROL UNIT
34
AUDIO CONTROL UNIT
35
AUDIO REPRODUCTION UNIT
140

# FIG. 6


BRIGHTNESS
100
33
1sec
1sec
BRIGHT
DARK
TIME

# FIG. 7


[START]
[FACE DIRECTION: LANE CHANGE DIRECTION]
STATE NOTIFICATION MODE
DISPLAY RISK LEVEL
① [LOOKING-ASIDE DETECTION]
③ [DIRECTION INDICATOR START]
[FACE DIRECTION CORRECTION]
LANE CHANGE NOTIFICATION MODE
ATTRACT TOWARD CAUTION DIRECTION
LOOKING-ASIDE CAUTION MODE
ATTRACT TOWARD FRONT
[FACE DIRECTION: APPROACHING VEHICLE DIRECTION]
② [DIRECTION INDICATOR START AND APPROACHING VEHICLE DETECTION]
APPROACHING VEHICLE NOTIFICATION MODE
ATTRACT TOWARD CAUTION DIRECTION
PRIORITY
LOW
HIGH

# FIG. 8

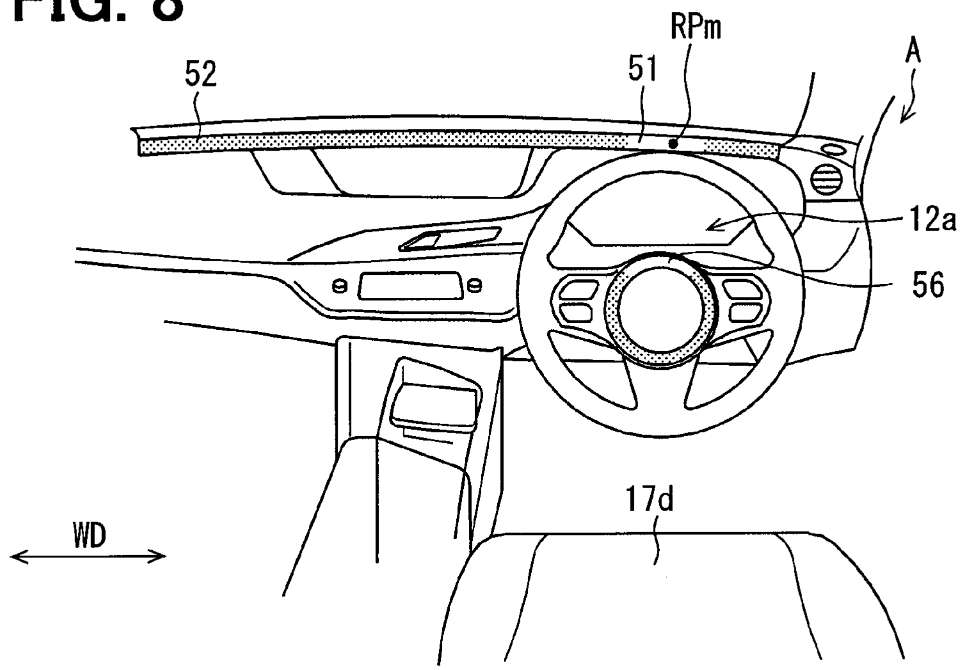

RPm
52
51
A
12a
56
17d
WD

FIG. 9

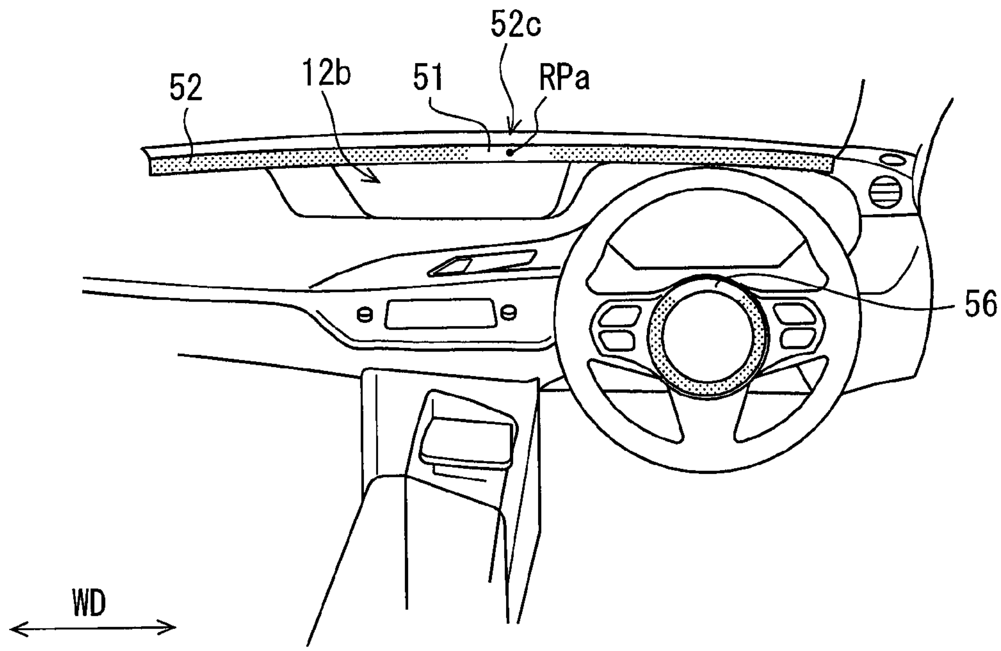
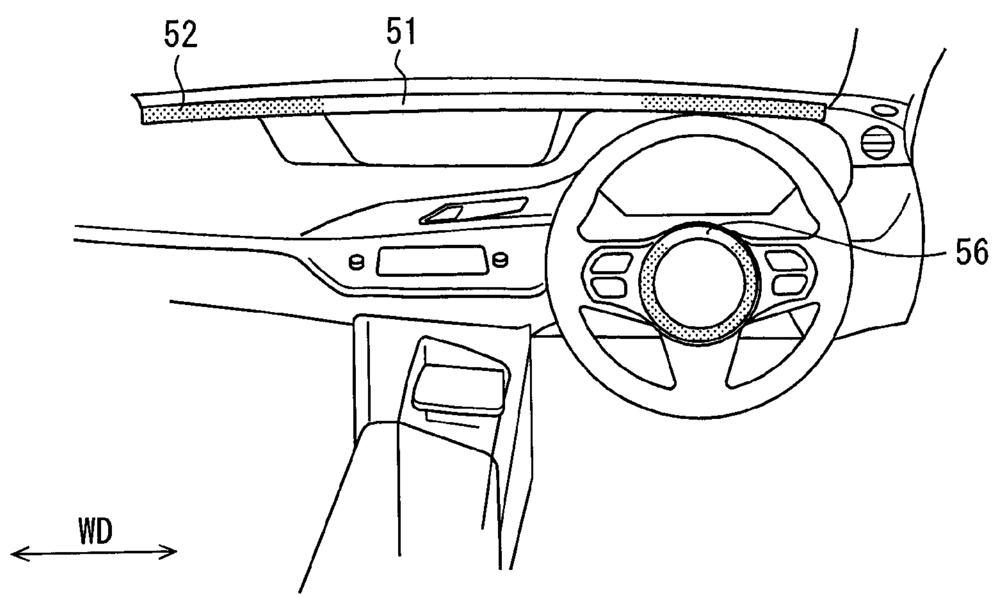
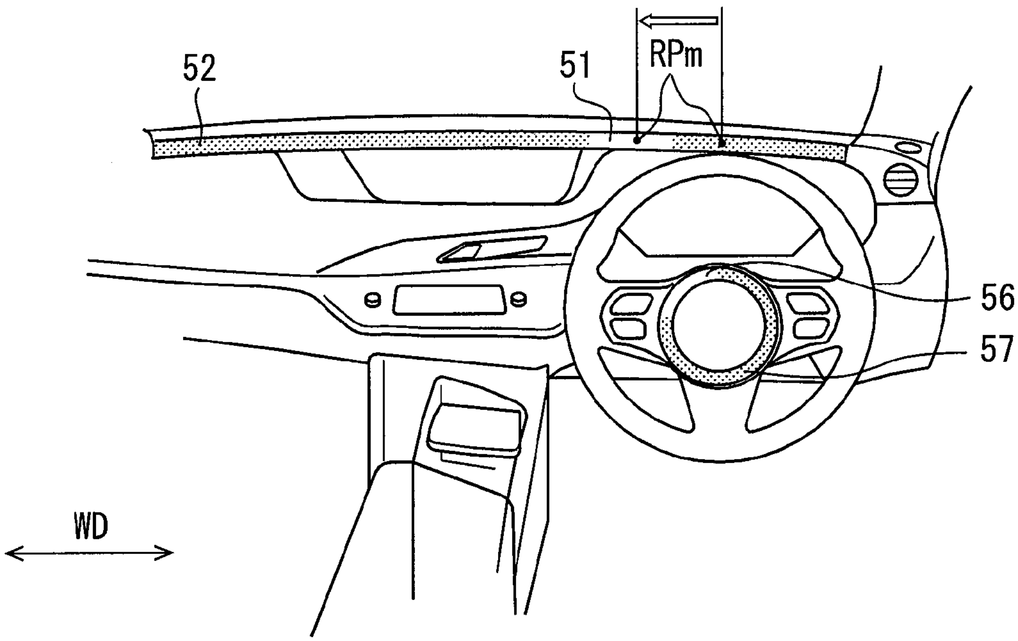


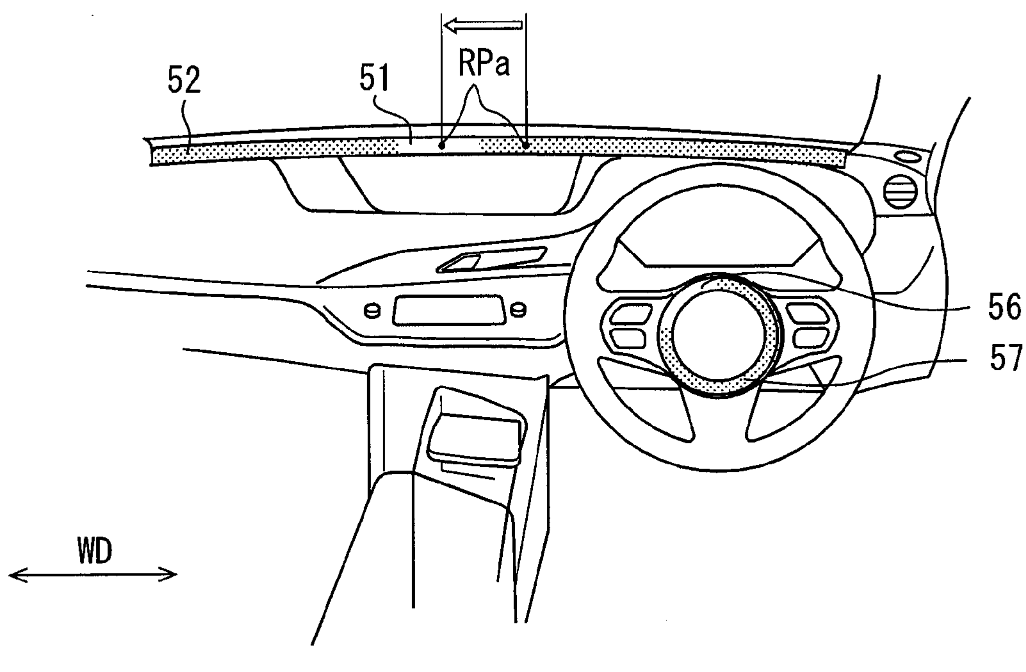

FIG. 10



# FIG. 11




# FIG. 12



# FIG. 13

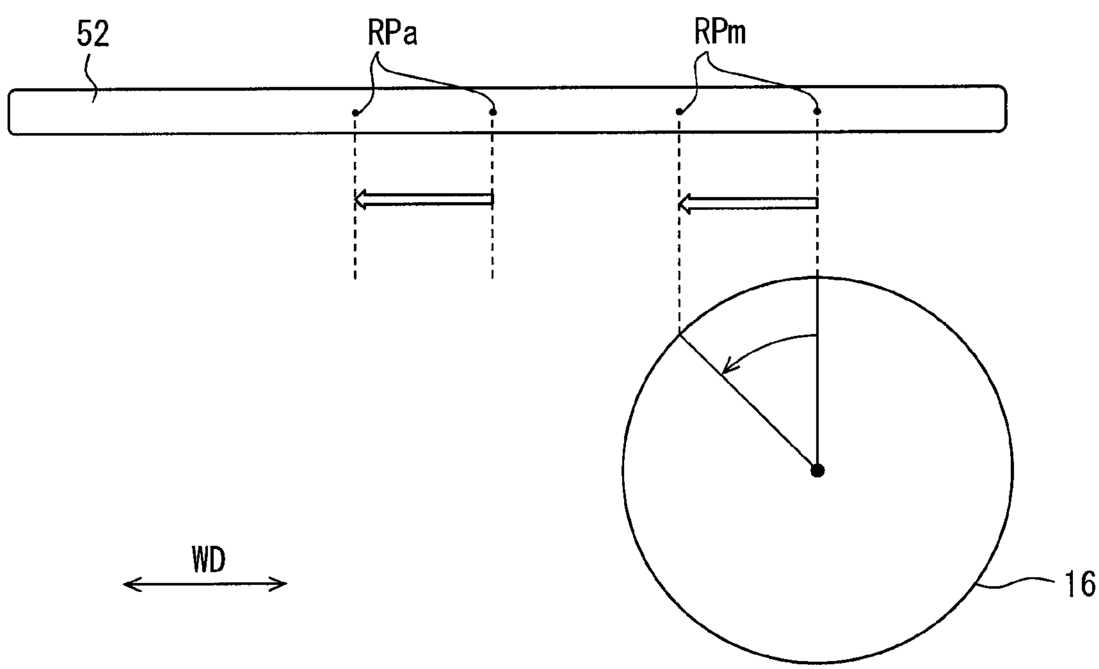


FIG. 14

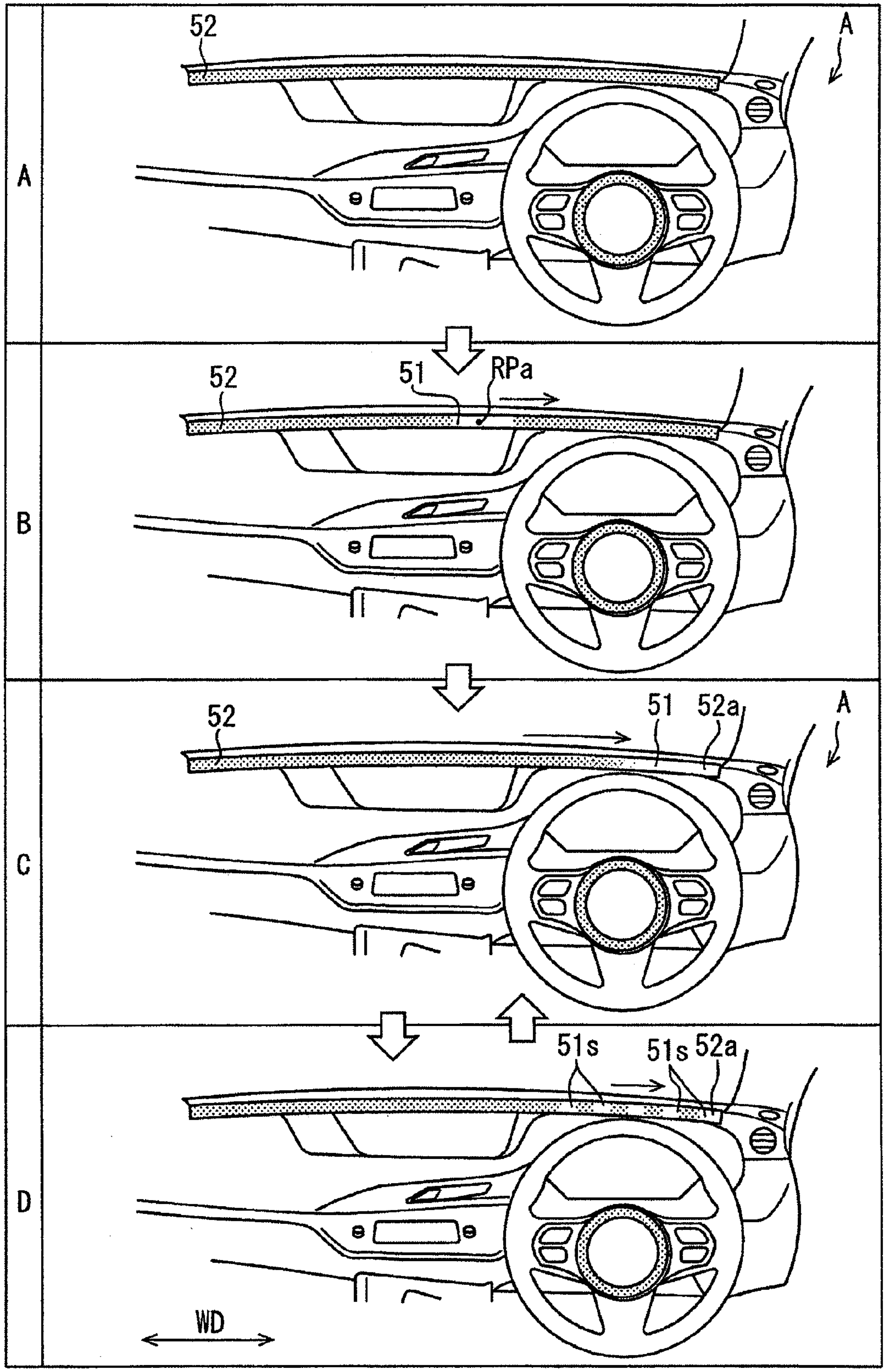


FIG. 15

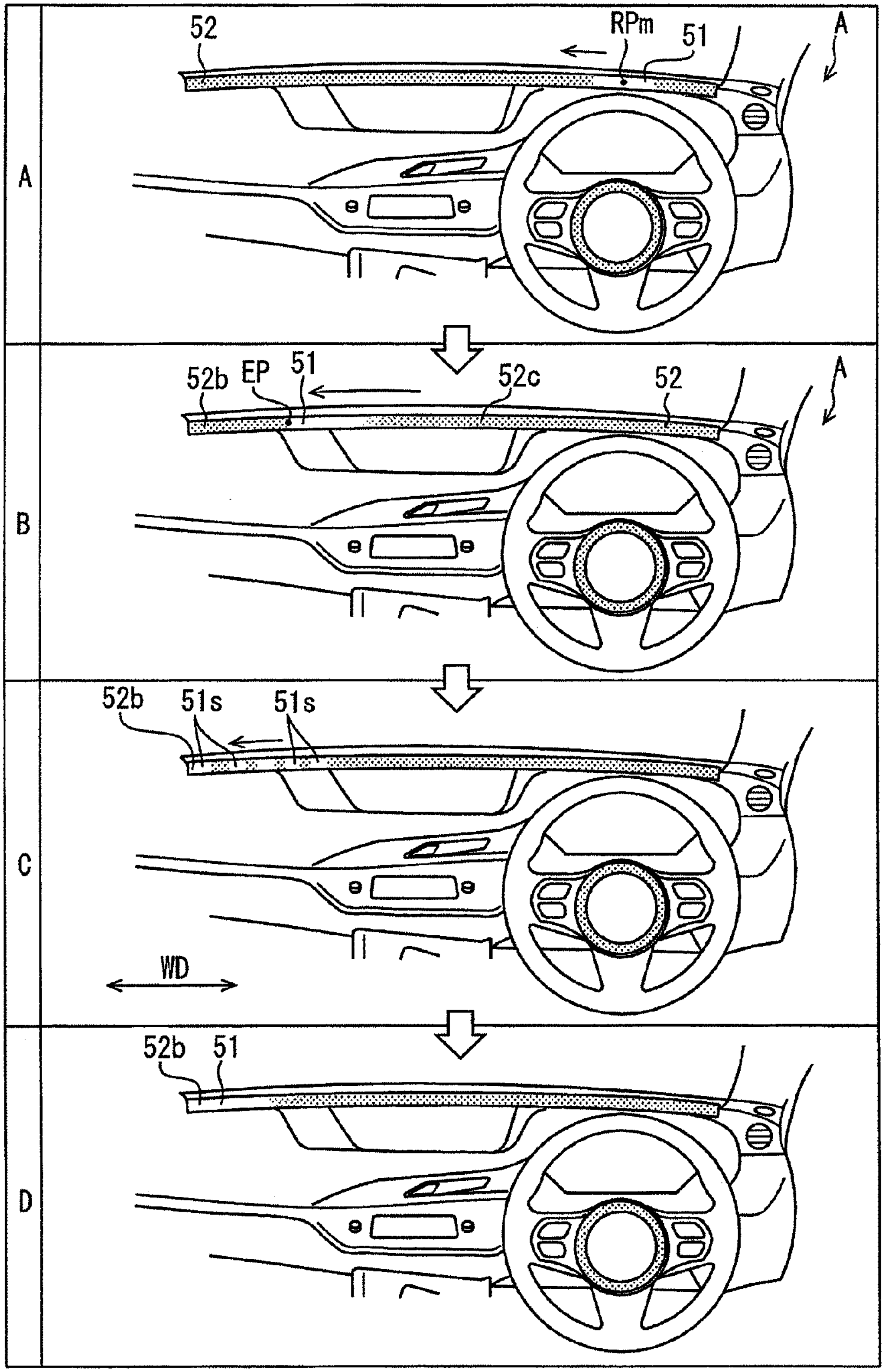


FIG. 16

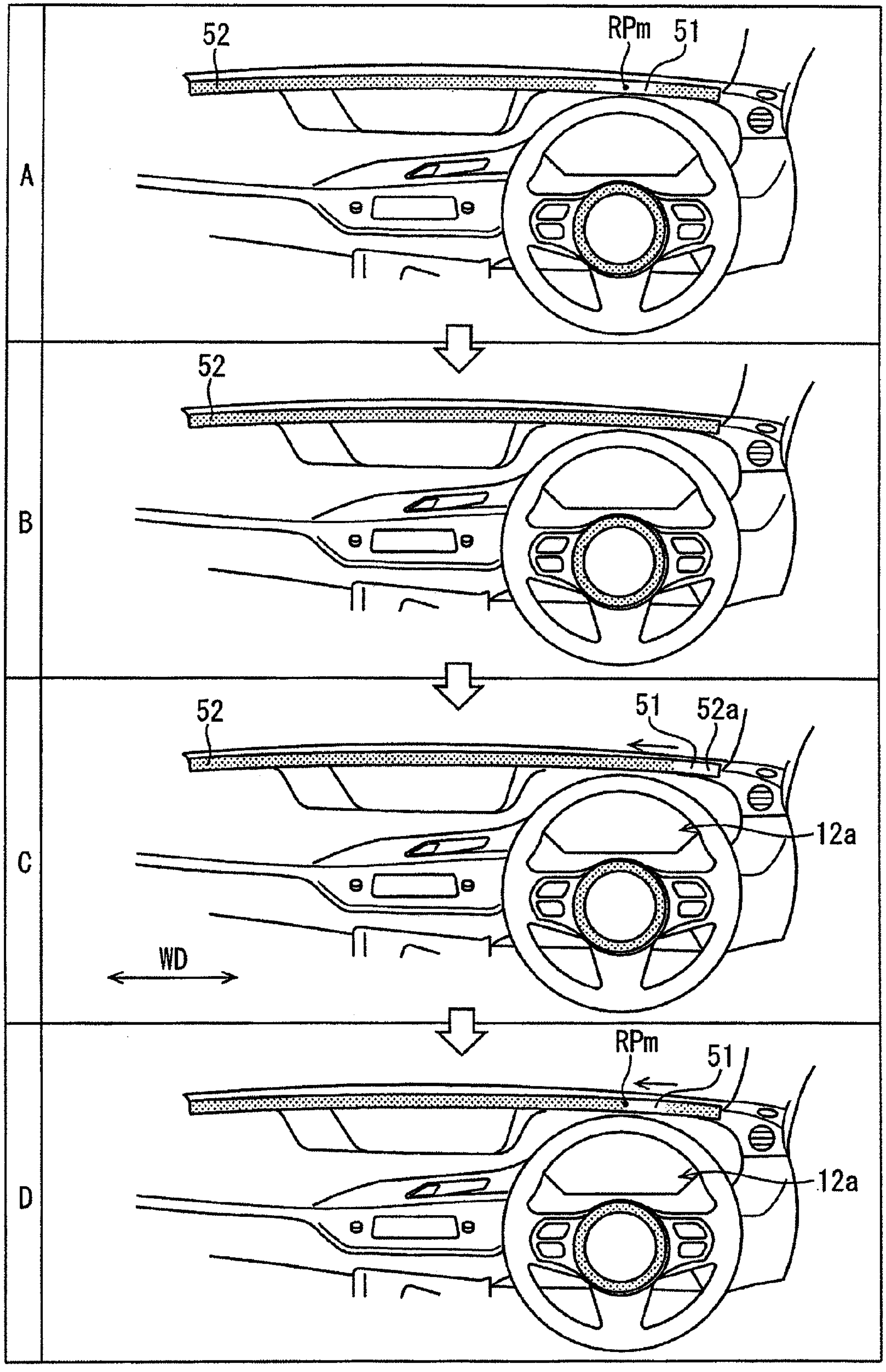


FIG. 17

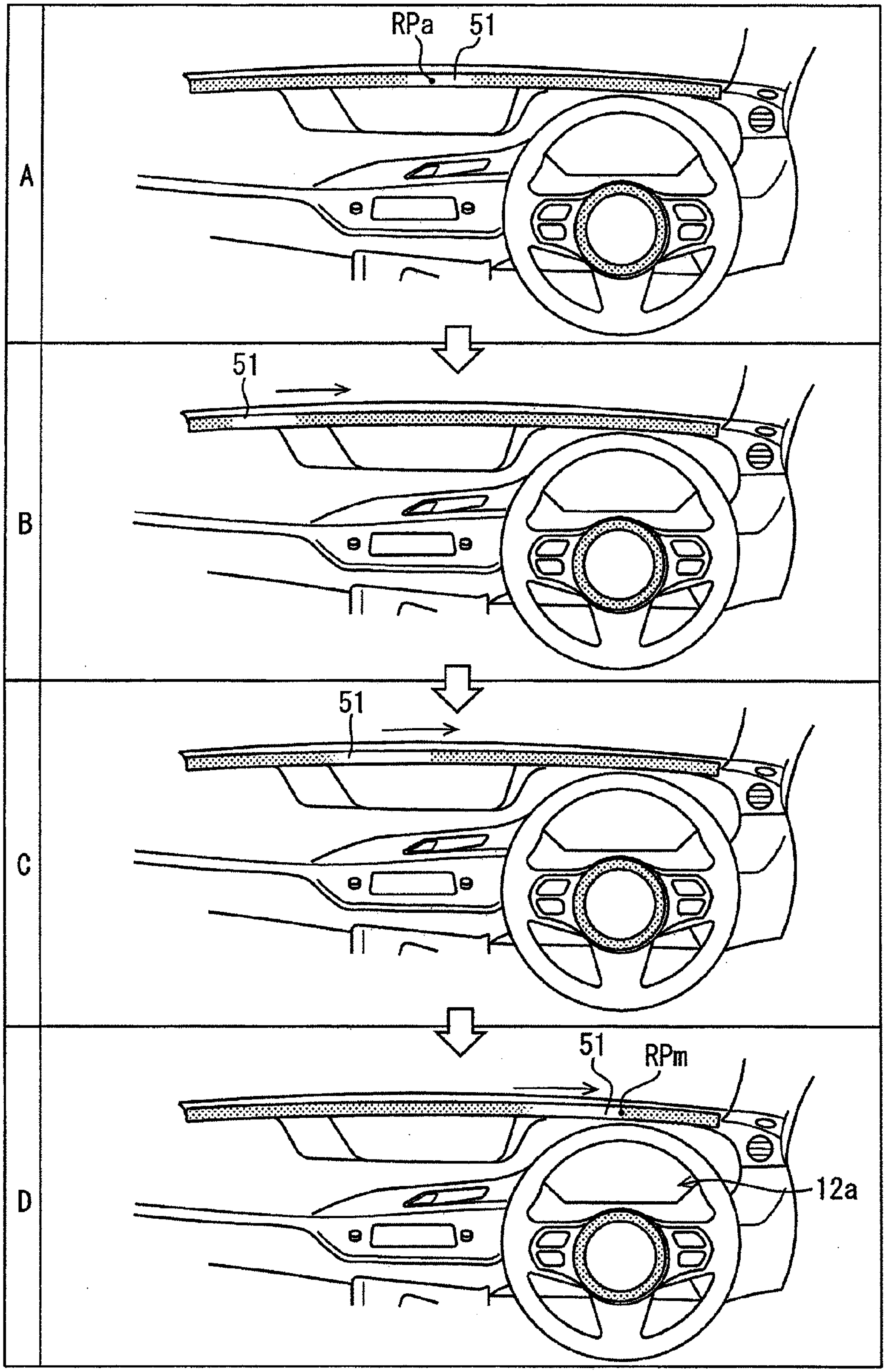


FIG. 18

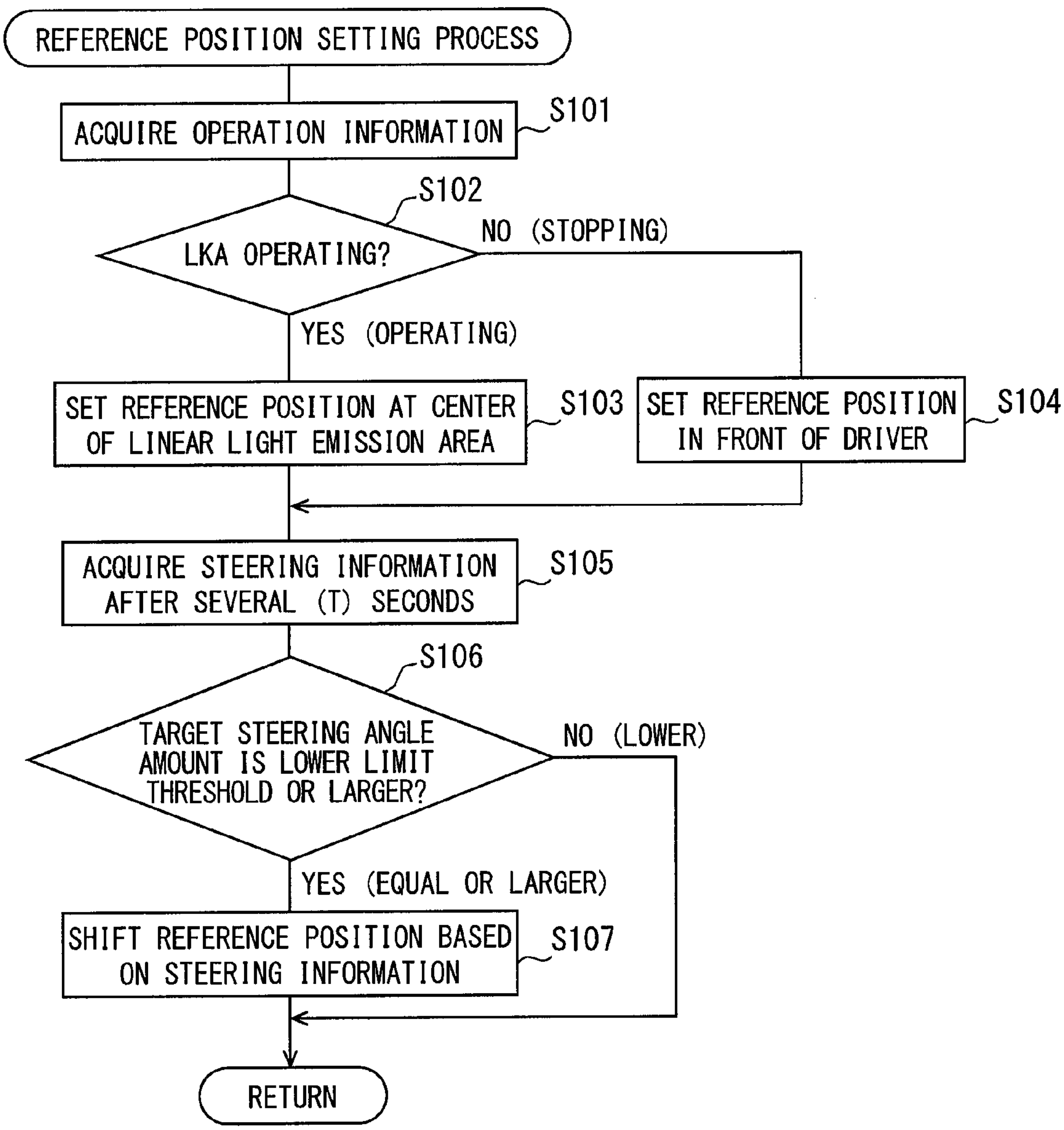

REFERENCE POSITION SETTING PROCESS
ACQUIRE OPERATION INFORMATION
S101
S102
LKA OPERATING?
NO (STOPPING)
YES (OPERATING)
SET REFERENCE POSITION AT CENTER OF LINEAR LIGHT EMISSION AREA
S103
SET REFERENCE POSITION IN FRONT OF DRIVER
S104
ACQUIRE STEERING INFORMATION AFTER SEVERAL (T) SECONDS
S105
S106
TARGET STEERING ANGLE AMOUNT IS LOWER LIMIT THRESHOLD OR LARGER?
NO (LOWER)
YES (EQUAL OR LARGER)
SHIFT REFERENCE POSITION BASED ON STEERING INFORMATION
S107
RETURN

FIG. 19

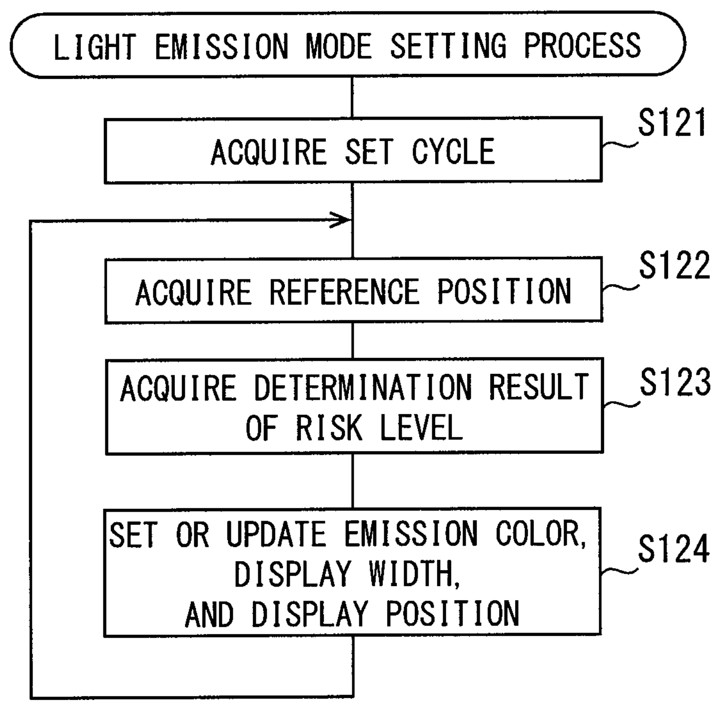
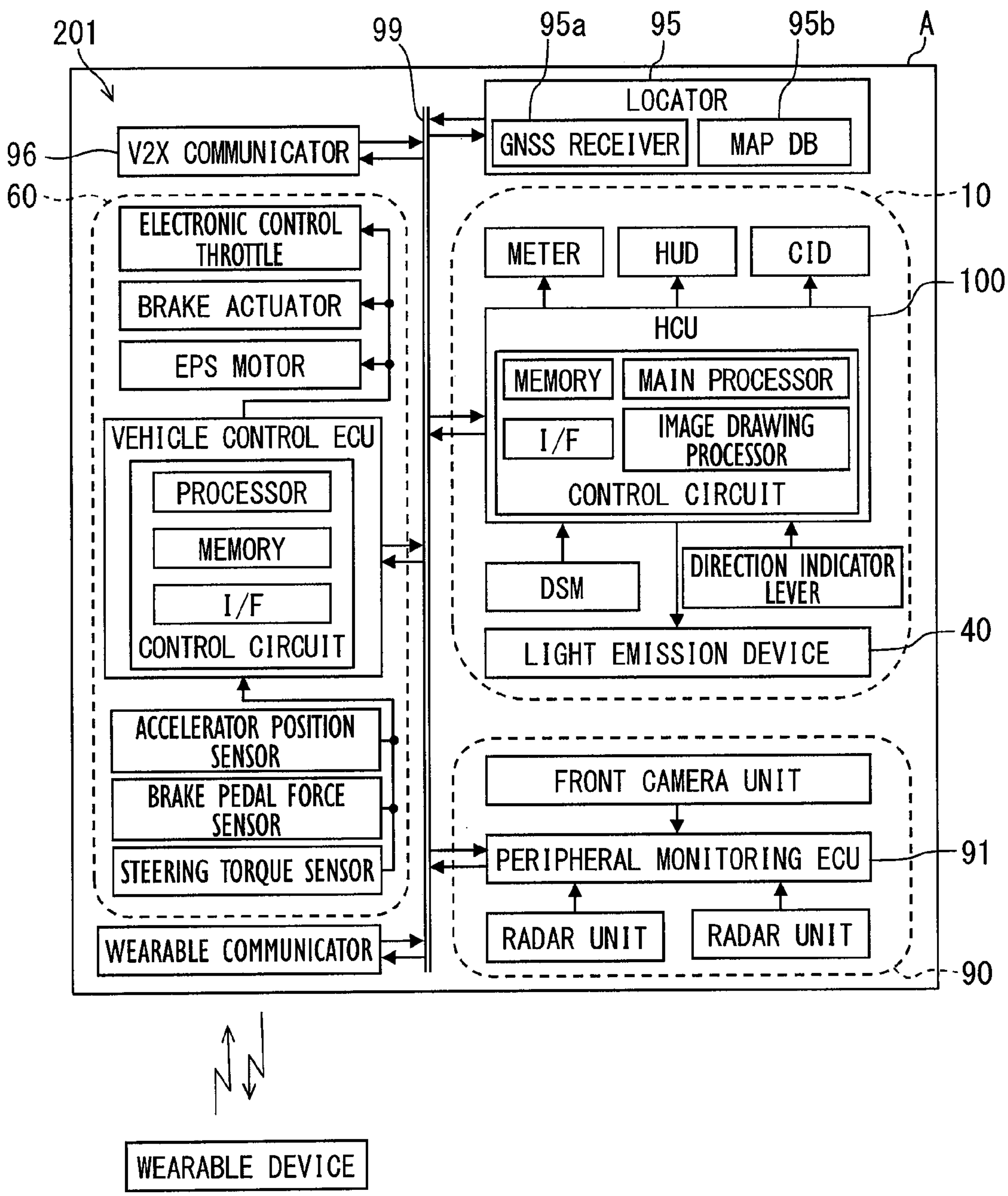

LIGHT EMISSION MODE SETTING PROCESS
ACQUIRE SET CYCLE
S121
ACQUIRE REFERENCE POSITION
S122
ACQUIRE DETERMINATION RESULT OF RISK LEVEL
S123
SET OR UPDATE EMISSION COLOR, DISPLAY WIDTH, AND DISPLAY POSITION
S124

FIG. 20



201
99
95a
95
95b
A
LOCATOR
GNSS RECEIVER
MAP DB
96
V2X COMMUNICATOR
60
10
ELECTRONIC CONTROL THROTTLE
BRAKE ACTUATOR
EPS MOTOR
METER
HUD
CID
100
HCU
MEMORY
MAIN PROCESSOR
I/F
IMAGE DRAWING PROCESSOR
CONTROL CIRCUIT
VEHICLE CONTROL ECU
PROCESSOR
MEMORY
I/F
CONTROL CIRCUIT
DSM
DIRECTION INDICATOR LEVER
LIGHT EMISSION DEVICE
40
ACCELERATOR POSITION SENSOR
BRAKE PEDAL FORCE SENSOR
STEERING TORQUE SENSOR
FRONT CAMERA UNIT
PERIPHERAL MONITORING ECU
91
RADAR UNIT
RADAR UNIT
WEARABLE COMMUNICATOR
90
WEARABLE DEVICE

FIG. 21

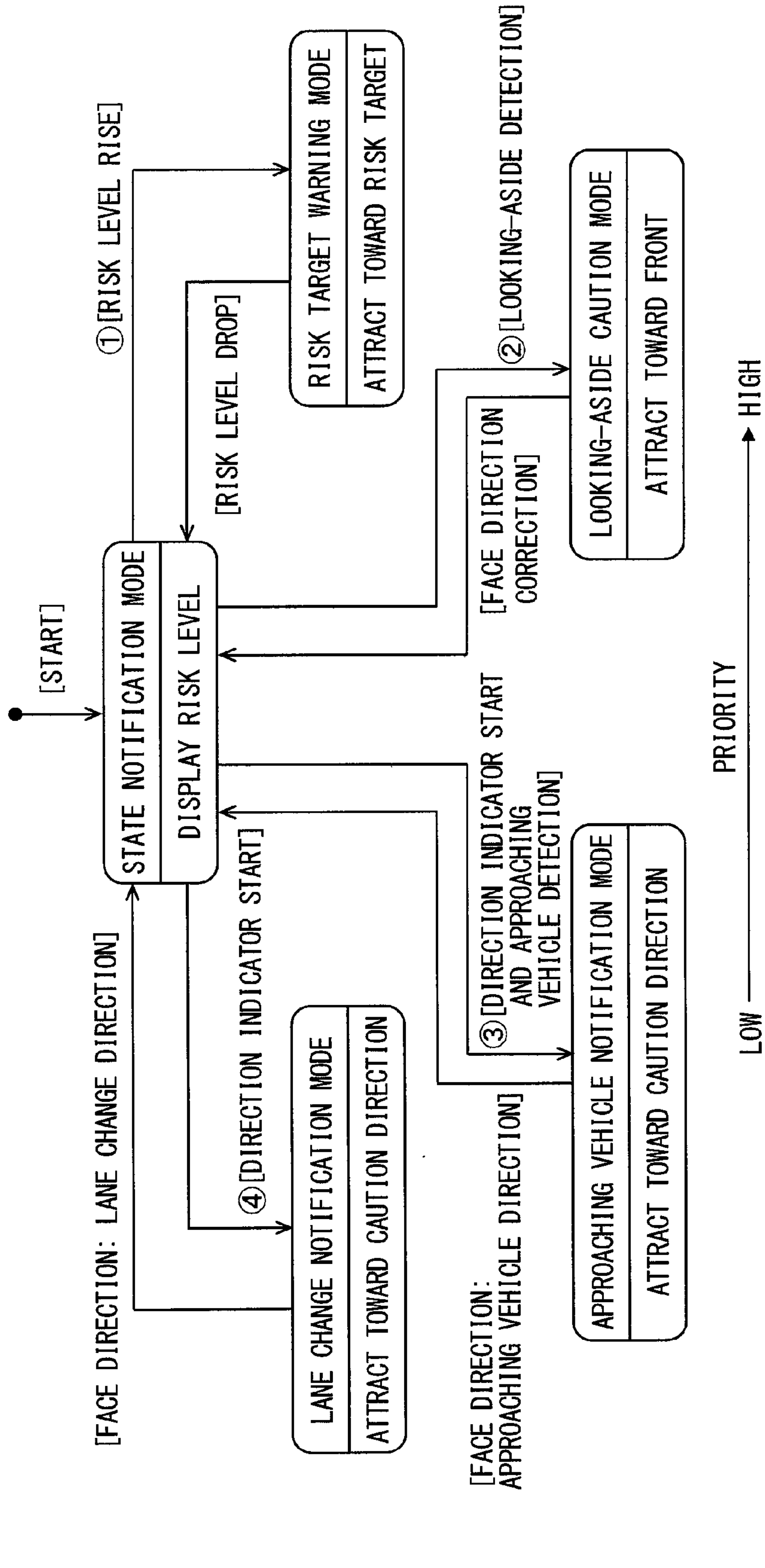

[START]
STATE NOTIFICATION MODE
DISPLAY RISK LEVEL
①[RISK LEVEL RISE]
[RISK LEVEL DROP]
RISK TARGET WARNING MODE
ATTRACT TOWARD RISK TARGET
②[LOOKING-ASIDE DETECTION]
[FACE DIRECTION CORRECTION]
LOOKING-ASIDE CAUTION MODE
ATTRACT TOWARD FRONT
③[DIRECTION INDICATOR START AND APPROACHING VEHICLE DETECTION]
[FACE DIRECTION: APPROACHING VEHICLE DIRECTION]
APPROACHING VEHICLE NOTIFICATION MODE
ATTRACT TOWARD CAUTION DIRECTION
④[DIRECTION INDICATOR START]
[FACE DIRECTION: LANE CHANGE DIRECTION]
LANE CHANGE NOTIFICATION MODE
ATTRACT TOWARD CAUTION DIRECTION
LOW
PRIORITY
HIGH

FIG. 22

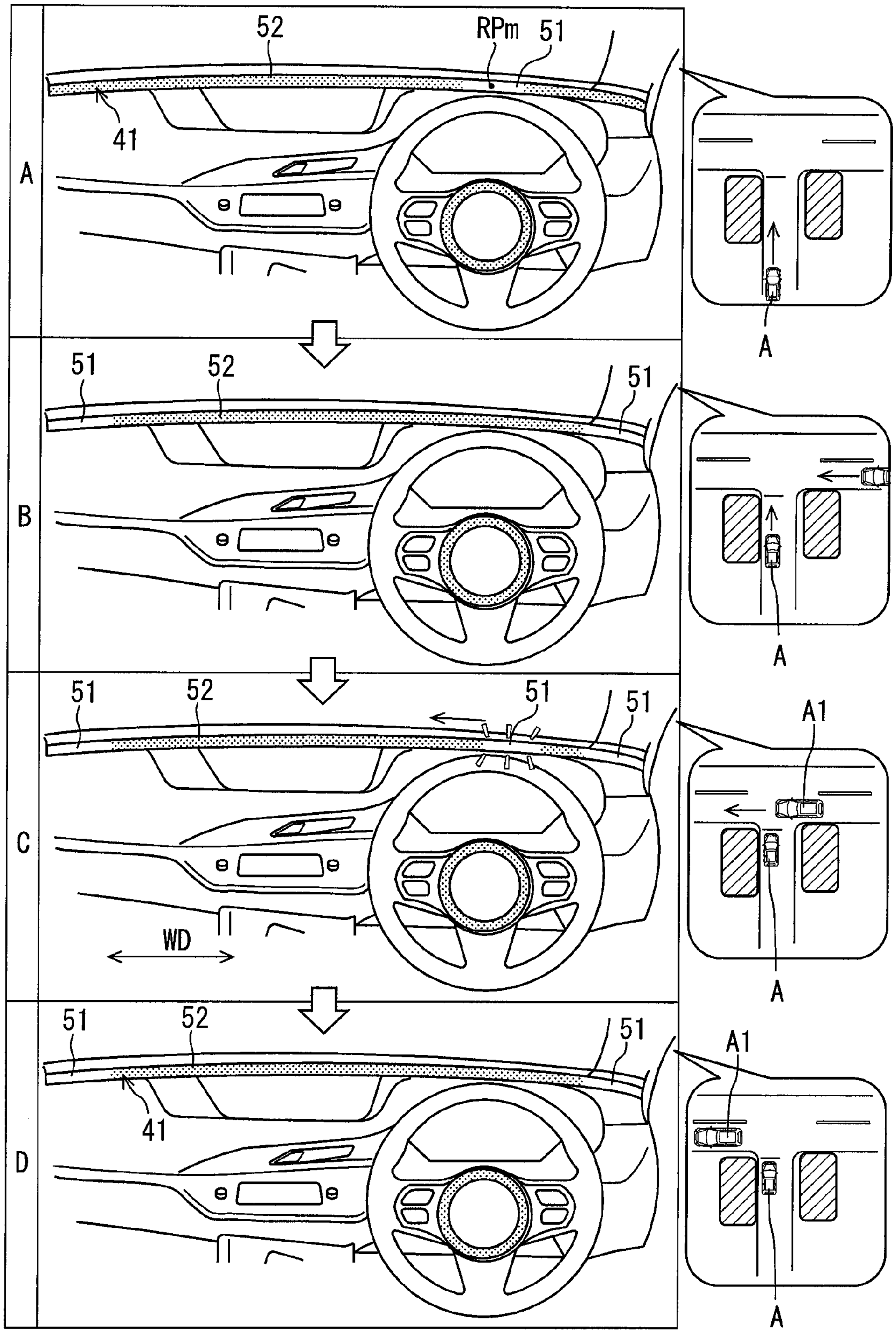


FIG. 23

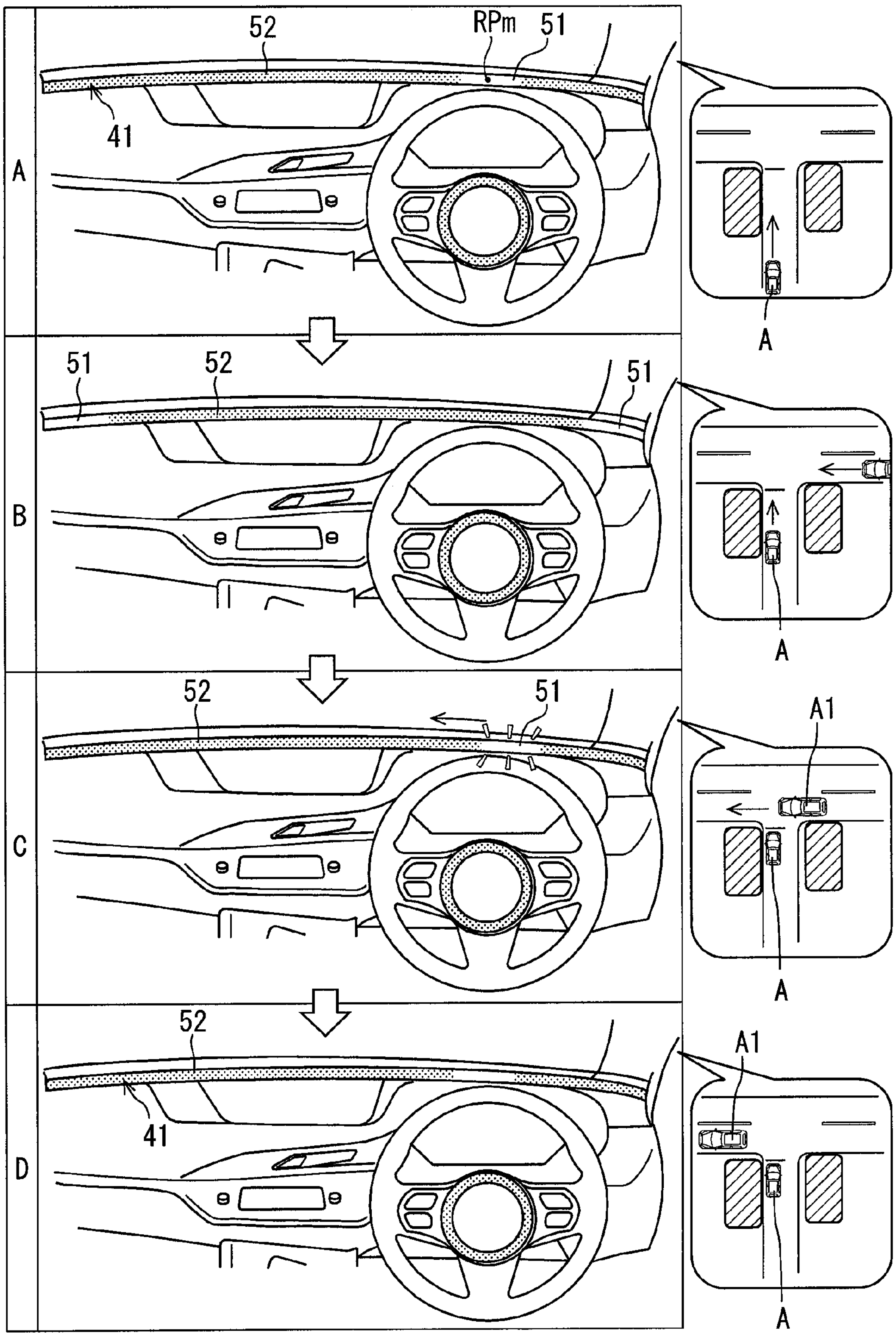


FIG. 24

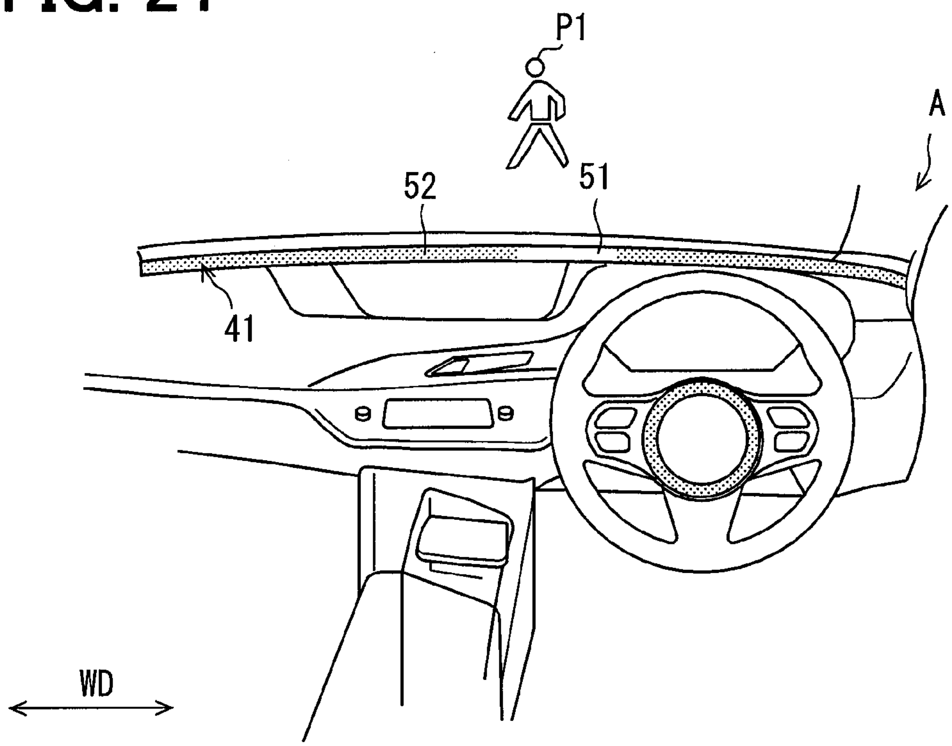



FIG. 25

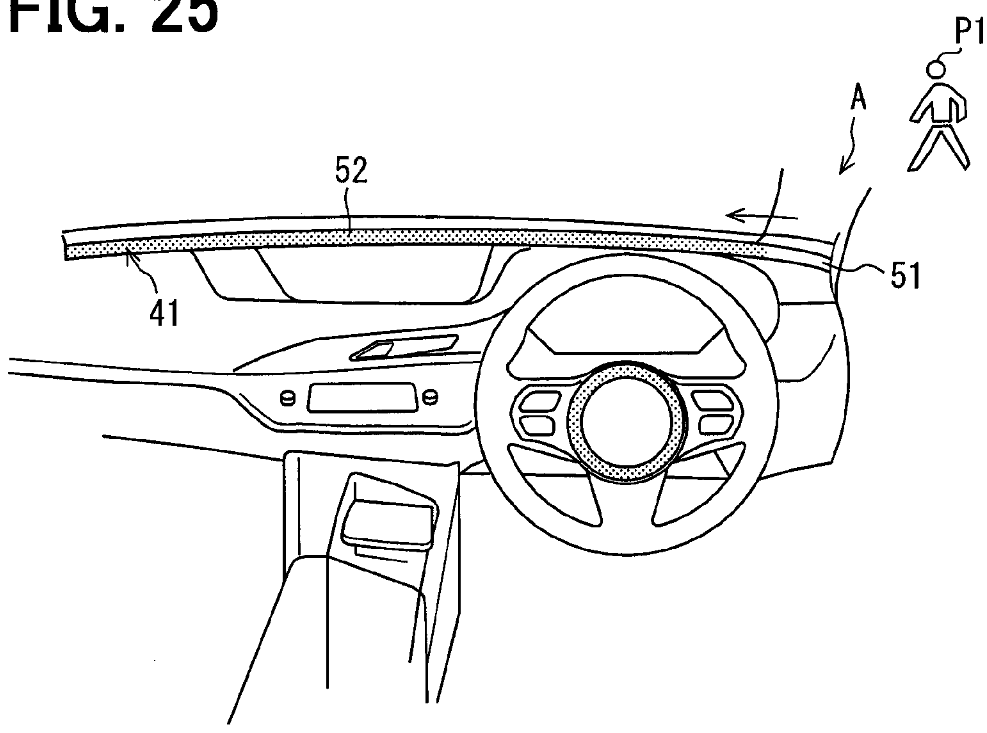


FIG. 26

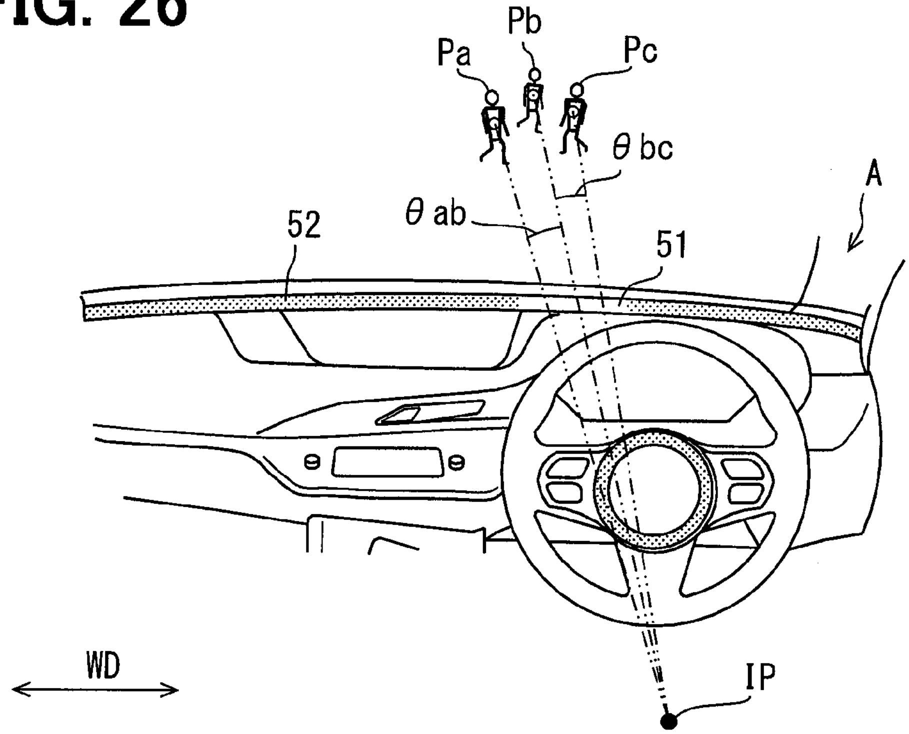



FIG. 27

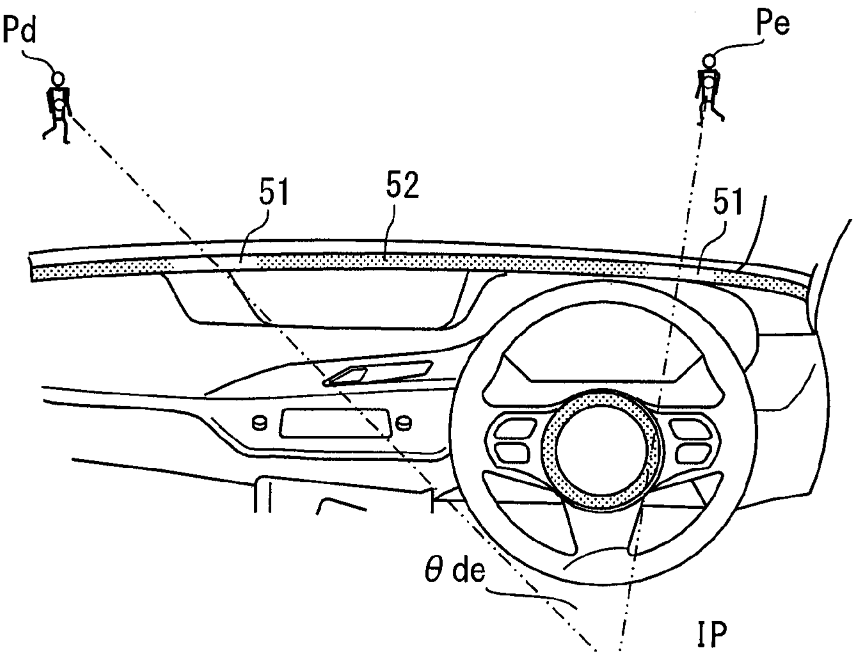
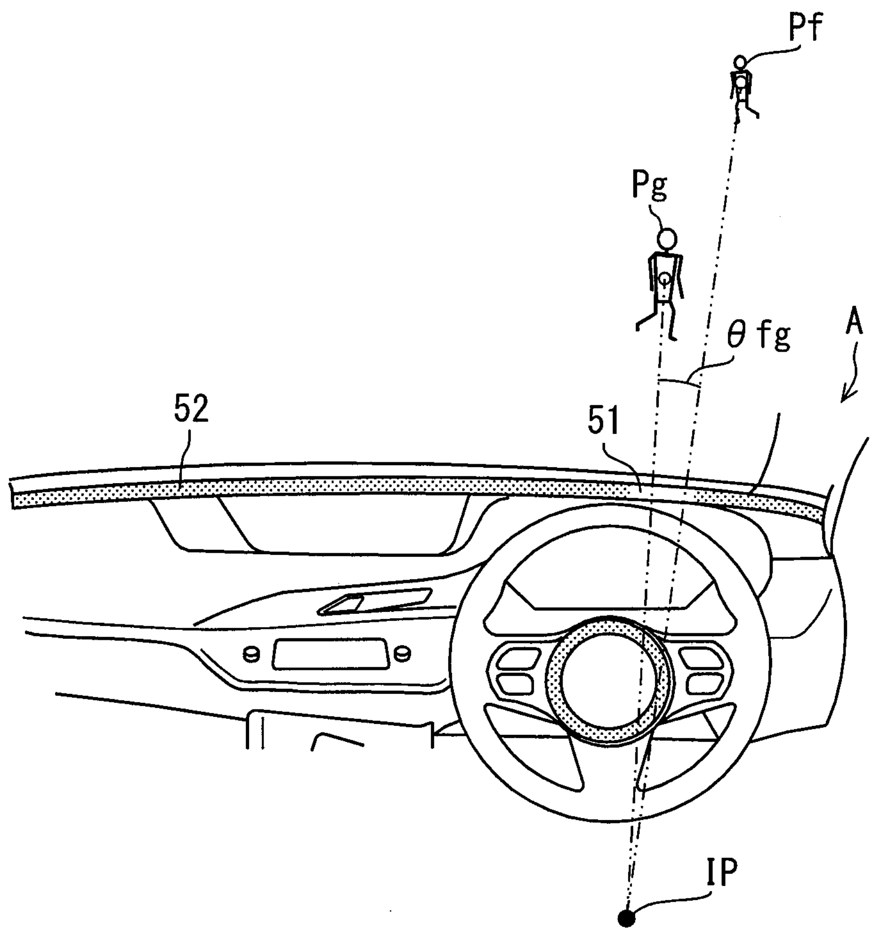
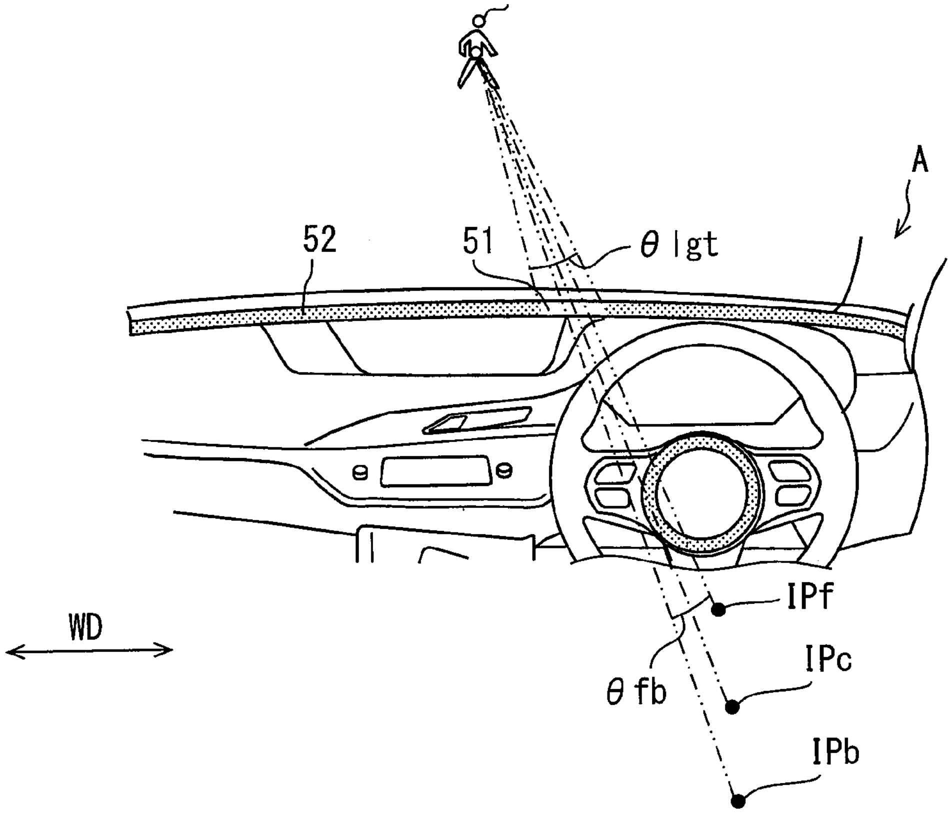


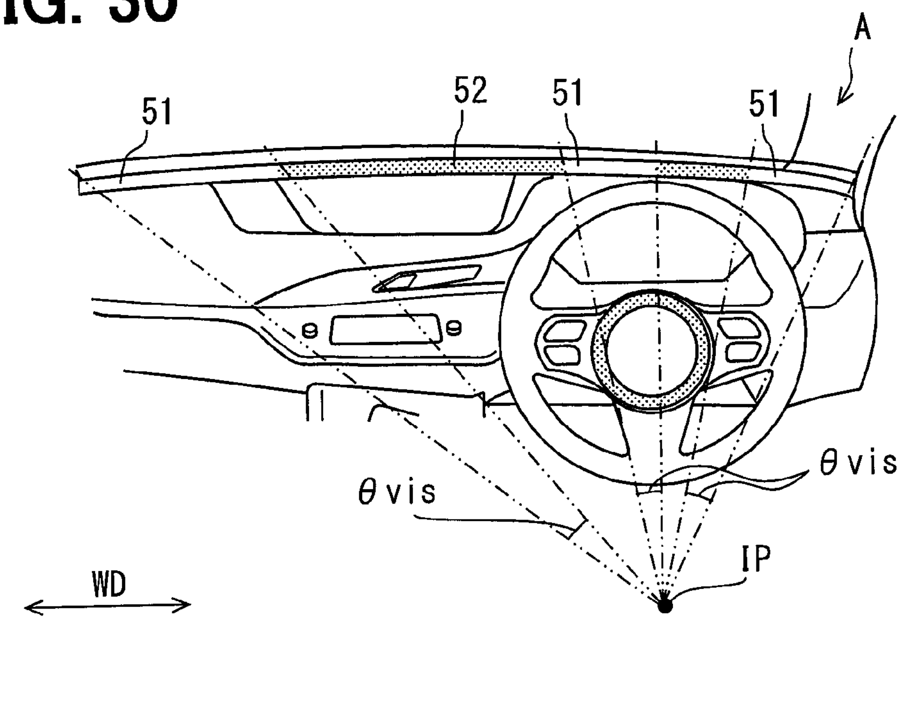
FIG. 28



# FIG. 29




# FIG. 30



# INFORMATION PRESENTATION APPARATUS

## CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is based on Japanese Patent Applications No. 2015-77088 filed on Apr. 3, 2015, and No. 2016-48660 filed on Mar. 11, 2016, the disclosures of which are incorporated herein by reference.

## TECHNICAL FIELD

**[0002]** The present disclosure relates to an information presentation apparatus which presents vehicle information to a driver.

## BACKGROUND ART

**[0003]** For example, an information presentation apparatus disclosed in Patent Literature 1 includes a light emission unit disposed on an instrument panel of a vehicle. The light emission unit is constituted by a plurality of light emitting elements aligned in a line in a width direction of the vehicle. The information presentation apparatus presents information to a driver by controlling a light emission mode of the light emission unit in accordance with acquired information.

## PRIOR ART LITERATURES

### Patent Literature

**[0004]** Patent Literature 1: JP-2014-240229-A

## SUMMARY OF INVENTION

**[0005]** In recent years, there has been provided a driving assist device on a vehicle to assist or substitute for driving operation performed by a driver. It has been demanded that an information presentation apparatus mounted on the vehicle in conjunction with the driving assist device presents information, which indicates whether assist or substitute for driving operation has been executed by the driving assist device, in a manner easily recognizable for the driver. While guidance of a visual line of the driver toward the information presentation apparatus has been disclosed in Patent Literature 1, no disclosure about presentation of information indicating the operation of the driving assist device has been given from this reference.

**[0006]** In view of the above points, it is an object of the present disclosure to provide an information presentation apparatus capable of presenting information, which indicates whether a driving assist device is in an operative state, to a driver in a manner easily recognizable for the driver.

**[0007]** According to an aspect of the present disclosure, an information presentation apparatus is mounted on a vehicle together with a driving assist device for assisting a driving operation of a driver or taking a wheel, and presents information about the vehicle to the driver. The information presentation apparatus includes: an information acquisition unit that acquires operation information about the driving assist device; a light emission display unit that is disposed on an instrument panel of the vehicle, and displays at least one light emission spot in a light emission area arranged to extend in a width direction of the vehicle; and a light emission control unit that controls a light emission mode of the light emission spot in the light emission area based on the operation information acquired by the information acquisition unit. The light emission control unit switches a reference position, at which the light emission spot is displayed, between a case where the driving assist device is in operation and a case where the driving assist device is not in operation.

**[0008]** According to the information presentation apparatus, the reference position at which the light emission spot is displayed in the operative state of the driving assist device is different from the reference position at which the light emission spot is displayed in the inoperative state of the driving assist device. This difference between the display positions of the light emission spot is securely perceivable by the driver even when the light emission area is defined in a peripheral vision range of the driver. Accordingly, the information presentation apparatus is capable of presenting information indicating whether the driving assist device is in the operative state for assisting or substituting for the driving operation in such a manner that the information is easily recognizable for the driver.

## BRIEF DESCRIPTION OF DRAWINGS

**[0009]** The above and other objects, features and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

**[0010]** FIG. **1** is a view illustrating a layout of a driver's seat and its surroundings in a self-vehicle;

**[0011]** FIG. **2** is a block diagram showing a general configuration of a vehicle onboard network according to a first embodiment;

**[0012]** FIG. **3** is a diagram showing function blocks constituted in a control circuit of a vehicle control ECU;

**[0013]** FIG. **4** is a block diagram showing a configuration of a light emission device;

**[0014]** FIG. **5** is a diagram showing function blocks constituted in a control circuit of an HCU;

**[0015]** FIG. **6** is a graph showing a transition of brightness variations repeated in a light emission spot;

**[0016]** FIG. **7** is a state transition chart showing details of transitions of light emission control modes of the light emission device;

**[0017]** FIG. **8** is a view illustrating display of light emission spots during manual driving;

**[0018]** FIG. **9** is a view illustrating display of the light emission spots during LKA operation;

**[0019]** FIG. **10** is a view illustrating the light emission spots each of which has a longer display width with a rise of a risk level;

**[0020]** FIG. **11** is a view illustrating the light emission spots whose reference positions have been shifted to show an expected traveling track of the self-vehicle during manual driving;

**[0021]** FIG. **12** is a view illustrating the light emission spots whose reference positions have been shifted to show an expected traveling track of the self-vehicle during LKA operation;

**[0022]** FIG. **13** is a view illustrating uniform shift amounts of the reference positions during LKA operation and manual driving;

**[0023]** FIG. **14** is a view illustrating a series of display for guiding a visual line of a driver toward the right during LKA operation;

**[0024]** FIG. **15** is a view illustrating a series of display for guiding the visual line of the driver toward the left during manual driving;

**[0025]** FIG. **16** is a view illustrating a series of display for guiding the visual line of the driver in a rightward looking-aside state toward the front during manual driving;

**[0026]** FIG. **17** is a view illustrating a series of display for guiding the visual line of the driver in a leftward looking-aside state toward the front during LKA operation;

**[0027]** FIG. **18** is a flowchart showing a reference position setting process;

**[0028]** FIG. **19** is a flowchart showing a light emission mode setting process;

**[0029]** FIG. **20** is a block diagram showing a general configuration of a vehicle onboard network according to a second embodiment;

**[0030]** FIG. **21** is a state transition chart showing details of transitions of light emission control modes in the second embodiment;

**[0031]** FIG. **22** is a view sequentially illustrating operations of an instrument panel light emission line in a risk target warning mode;

**[0032]** FIG. **23** is a view illustrating a modified example of FIG. **22**;

**[0033]** FIG. **24** is a view illustrating a light emission mode in a scene where a risk target is present inside front pillars;

**[0034]** FIG. **25** is a view illustrating a light emission mode in a scene where a risk target is present outside the front pillars;

**[0035]** FIG. **26** is a view illustrating a light emission mode in a scene where a plurality of risk targets are located close to each other;

**[0036]** FIG. **27** is a view illustrating a light emission mode in a scene where a plurality of risk targets are located away from each other;

**[0037]** FIG. **28** is a view illustrating a light emission mode in a scene where a plurality of risk targets are present in a particular direction at different distances from the self-vehicle;

**[0038]** FIG. **29** is a view illustrating a method for setting the length of the light emission spot; and

**[0039]** FIG. **30** is a view illustrating a method for setting the length of the light emission spot.

## EMBODIMENTS FOR CARRYING OUT INVENTION

**[0040]** A plurality of embodiments are hereinafter described with reference to the drawings. Equivalent elements in the respective embodiments are given identical reference numbers to omit some repeated description. When configurations are only partially described in the respective embodiments, the remaining parts not described may be understood from the corresponding configurations of the other embodiments already described. In addition, in combining configurations described in the plurality of embodiments, not only combinations explicitly described in the respective embodiments, but also partial combinations not explicitly described may be made as long as no problem particularly occurs. It is assumed that not explicit combinations of the configurations included in the plurality of embodiments and modified examples have been similarly disclosed in the following description.

### First Embodiment

**[0041]** As illustrated in FIGS. **1** and **2**, a human machine interface (HMI) control unit (HCU) **100** according to a first embodiment is an electronic device mounted on a self-vehicle A. The HCU **100** constitutes one of a plurality of nodes included in a vehicle onboard network **1**. The vehicle onboard network **1** is configured by an external recognition system **90**, a vehicle control system **60**, a wearable communicator **97**, an HMI system **10**, a communication bus **99** to which these components are connected, and others.

**[0042]** The external recognition system **90** includes external sensors such as a front camera unit **92** and radar units **93** and **94**, and a peripheral monitoring electronic control unit (ECU) **91**. The external recognition system **90** detects moving objects such as pedestrians, animals other than humans, bicycles, motorcycles, and other vehicles, and further detects stationary objects such as falling objects on roads, traffic signals, guard rails, curbs, road signs, road markings, mark lanes, and trees. The external recognition system **90** may include an external sensor such as a laser imaging detection and ranging (LIDAR), sound navigation and ranging (SONAR), in addition to the units **92** to **94**.

**[0043]** The front camera unit **92** is a monocular or compound-eye camera provided in the vicinity of a back mirror of the self-vehicle A, for example. The front camera unit **92** faces in a traveling direction of the self-vehicle A, and is capable of imaging a range of approximately 80 meters from the self-vehicle A at a horizontal viewing angle of approximately 45 degrees, for example. The front camera unit **92** sequentially outputs data indicating a captured image of a moving object or a stationary object to the peripheral monitoring ECU **91**.

**[0044]** The radar unit **93** is provided on a front portion of the self-vehicle A, for example. The radar unit **93** emits millimeter waves in a band of 77 GHz in the traveling direction of the self-vehicle A from a transmission antenna. The radar unit **93** receives, via a reception antenna, millimeter waves reflected on a moving object, a stationary object, or the like present in the traveling direction. The radar unit **93** scans a range of approximately 60 meters from the self-vehicle A at a horizontal scanning angle of approximately 55 degrees, for example. The radar unit **93** sequentially outputs a scanning result Indicating a reception signal to the peripheral monitoring ECU **91**.

**[0045]** The radar units **94** are provided on a left and a right part of a rear portion of the self-vehicle A, respectively, for example. Each of the radar units **94** emits near millimeter waves in a band of 24 GHz from a transmission antenna toward the rear side of the self-vehicle A. Each of the radar units **94** receives, via a reception antenna, near millimeter waves reflected on a moving object, a stationary object, and the like present on the rear side. Each of the radar units **94** scans a range of approximately 30 meters from the self-vehicle A at a horizontal scanning angle of approximately 120 degrees, for example. Each of the radar units **94** sequentially outputs a scanning result based on a reception signal to the peripheral monitoring ECU **91**.

**[0046]** The peripheral monitoring ECU **91** is mainly configured by a microcomputer including a processor and a memory. The peripheral monitoring ECU **91** is communicatively connected to the front camera unit **92**, the radar units **93** and **94**, and the communication bus **99**. The peripheral monitoring ECU **91** combines items of information acquired from the respective units **92** and **93** to detect relative positions or the like of a moving object and a stationary object present in the traveling direction (hereinafter referred to as "detection objects"). The peripheral monitoring ECU **91** further detects relative positions or the like of detection objects present on the rear side based on information acquired from the radar units **94**. The peripheral monitoring ECU **91** outputs monitoring information which includes relative position information indicating relative positions of vehicles traveling ahead and parallel around the self-vehicle A, and shape information indicating shapes of mark lanes in the traveling direction of the self-vehicle A, and others to the communication bus **99**.

**[0047]** The vehicle control system **60** includes detection sensors that detect a driving operation, such as an accelerator position sensor **61**, a brake pedal force sensor **62**, and a steering torque sensor **63**. The vehicle control system **60** further includes traveling control devices such as an electronic control throttle **66**, a brake actuator **67**, and an electric power steering (EPS) motor **68**, and Includes a vehicle control ECU **70**. The vehicle control system **60** controls traveling of the self-vehicle A, based on a driving operation by a driver, monitoring information acquired by the external recognition system **90**, and others.

**[0048]** The accelerator position sensor **61** detects a depression amount of an accelerator pedal depressed by the driver, and outputs the detected amount to the vehicle control ECU **70**. The brake pedal force sensor **62** detects a force applied to the brake pedal by the driver, and outputs the detected force to the vehicle control ECU **70**. The steering torque sensor **63** detects steering torque applied to a steering wheel (hereinafter referred to as steering) **16** by the driver, and outputs the detected steering torque to the vehicle control ECU **70**.

**[0049]** The electronic control throttle **66** controls a throttle position, based on a control signal output from the vehicle control ECU **70**. The brake actuator **67** controls a braking force generated by brake pressure in accordance with a control signal of the vehicle control ECU **70**, and applied to wheels. The EPS motor **68** controls steering force and steering retention force applied to a steering mechanism in accordance with control signals output from the vehicle control ECU **70**.

**[0050]** The vehicle control ECU **70** is constituted by one or a plurality of units selected from a power unit control ECU, a brake control ECU, an integration control ECU, and others. The vehicle control ECU **70** includes at least the integration control ECU. A control circuit **70***a* of the vehicle control ECU **70** includes a processor **71**, a rewritable nonvolatile memory **73**, an input/output interface **74** through which information is input or output, and a bus for connecting these components, for example. The vehicle control ECU **70** is connected to the sensors **61** to **63** and traveling control devices. The vehicle control ECU **70** receives detection signals output from the respective sensors **61** to **63**, and outputs control signals to the respective traveling control devices. The vehicle control ECU **70** is further connected to the communication bus **99** to communicate with the HCU **100** and the peripheral monitoring ECU **91**.

**[0051]** The vehicle control ECU **70** performs a plurality of driving assist functions for controlling a driving force, a braking force, a steering force, and the like of the self-vehicle A to assist or substitute for a driving operation performed by the driver. As shown in FIG. **3**, the vehicle control ECU **70** constitutes a plurality of function blocks (**81** to **84**) for realizing the driving assist functions under vehicle control programs stored in the memory **73** and executed by the processor **71**. The vehicle control ECU **70** is capable of outputting, to the communication bus **99**, operation information about the driving assist functions performed by the respective function blocks.

**[0052]** An adaptive cruise control (ACC) function unit **81** adjusts a driving force and a braking force, based on monitoring information acquired from the peripheral monitoring ECU **91** and indicating information about a vehicle traveling ahead to realize an ACC function for controlling a traveling speed of the self-vehicle A (see FIG. **1**). The ACC assists or substitutes for an acceleration/deceleration operation Included in a plurality of driving operations performed by the driver. The ACC function unit **81** drives the self-vehicle A at a target speed set by the driver in a state that no vehicle traveling ahead is detected. In a state that a vehicle traveling ahead is detected, however, the ACC function unit **81** controls traveling of the self-vehicle A such that the self-vehicle A follows the vehicle traveling ahead with a constant distance kept between the self-vehicle A and the vehicle traveling ahead.

**[0053]** A lane keeping assist (LKA) function unit **82** adjusts a steering force to realize a LKA function for controlling a steering angle of the steering wheel of the self-vehicle A (see FIG. **1**). The LKA assists or substitutes for steering included in a plurality of driving operations performed by the driver.

**[0054]** The LKA function unit **82** generates a steering force in a direction preventing approach toward a mark lane to maintain the self-vehicle A within a traveling lane and allow the self-vehicle A to travel along the lane.

**[0055]** A lane change assist (LCA) function unit **83** realizes an automatic lane change function for shifting the self-vehicle A (see FIG. **1**) from current traveling lane to adjacent lane. The automatic lane change is realizable during operation of the LKA, and assists or substitutes for steering by the driver similarly to the LKA. The LCA function unit **83** shifts the self-vehicle A to an adjacent lane by generating a steering force in a direction toward an adjacent lane in a state that a lane change is allowable.

**[0056]** A traveling track setting unit **84** calculates an expected traveling track of the self-vehicle A, based on shape information indicating a mark lane in the traveling direction and acquired from the peripheral monitoring ECU **91**. The traveling track setting unit **84** calculates a target steering direction and a target steering amount appropriate for the self-vehicle to travel along the expected traveling track. The LKA function unit **82** and the LCA function unit **83** control steering based on the target steering direction and the target steering amount calculated by the traveling track setting unit **84**. The traveling track setting unit **84** is capable of outputting steering information indicating the target steering direction and the target steering amount to the communication bus **99**. The traveling track setting unit **84** is capable of calculating the steering information and outputs the steering information to the communication bus **99** even in a state that the LKA function unit **82** and the LCA function unit **83** are not operating.

**[0057]** The wearable communicator **97** illustrated in FIGS. **1** and **2** is mounted on the self-vehicle A, and communicatively connected to the communication bus **99**. The wearable communicator **97** includes an antenna for realizing wireless communication. The wearable communicator **97** is capable of wirelessly communicating with a wearable device **110** present in an interior of the self-vehicle A via a wireless local area network (LAN) and Bluetooth (registered trademark), for example. The wearable device **110** is attached to a part of the body of the driver, such as the head, an ear, a wrist, a fingertip, and the neck. The wearable device **110** acquires biological information about the driver, such as a pulse rate, a heart rate, a body temperature, and blood pressure, and outputs the acquired biological information to the vehicle onboard network **1**.

**[0058]** The HMI system **10** includes operation devices such as a direction Indicator lever **15**, and a driver status monitor (DSM) **11** in addition to the HCU **100** described above. The HMI system **10** further includes a plurality of display devices such as a head-up display (HUD) **14**, a combination meter **12***a*, a center information display (CID) **12***b*, and a light emission device **40**. The HMI system **10** presents information to occupants of the self-vehicle A, such as the driver sitting on a driver's seat **17***d*.

**[0059]** The direction indicator lever **15** is provided on a column portion supporting the steering **16**. A direction indicator is operated in accordance with an operation input to the direction indicator lever **15** from the driver. The direction indicator lever **15** outputs an operation signal indicating input by the driver to the HCU **100**.

**[0060]** The DSM **11** includes a near infrared light source and a near infrared camera, and a control unit that controls these components. The DSM **11** is provided on an upper surface of an instrument panel **19** in such a position that the near infrared camera faces the driver's seat **17***d*. The DSM **11** captures, via the infrared camera, an image of the face of the driver illuminated by infrared light emitted from the near infrared light source. An image captured by the infrared camera is analyzed by the control unit. The control unit extracts the direction of the face, and the opening degrees of the eyes of the driver from the captured image, for example.

**[0061]** The DSM **11** obtains face direction information indicating a face direction of the driver, based on analysis by the control unit, and outputs the face direction information to the HCU **100**. The DSM **11** further outputs driver looking-aside information to the HCU **100** when determining that the driver is looking aside rather than front. The DSM **11** is capable of further outputting driver drowsy information to the HCU **100** when determining that the driver is in a drowsy driving state with the eyes closed.

**[0062]** The HCU **100** is connected to operation devices, the DSM **11**, and display devices, for example. The HCU **100** acquires operation signals output from the operation devices, and information output from the DSM **11**. The HCU **100** outputs control signals to the respective display devices to control display by the display devices. A control circuit **20***a* of the HCU **100** includes a main processor **21**, an image drawing processor **22**, a rewritable non-volatile memory **23**, an input/output interface **24** through which information is input and output, and a bus connecting these components.

**[0063]** The HUD device **14** acquires data from the HCU **100**, and projects light of an image of the data to a projection area **14***a* defined on a wind shield **18**. The light of the image reflected on the wind shield **18** and traveling toward the interior of the vehicle is perceived by the driver sitting on the driver's seat **17***d*. The driver views a virtual image of the image projected by the HUD device **14** as a virtual image superimposed on an external scene present ahead of the self-vehicle A.

**[0064]** The combination meter **12***a* is provided in front of the driver's seat **17***d* in the interior of the self-vehicle A. The combination meter **12***a* includes a liquid crystal display visible from the driver sitting on the driver's seat **17***d*. The combination meter **12***a* displays, on a liquid crystal display, images of speed meters and the like based on data acquired from the HCU **100**.

**[0065]** The CID **12***b* is provided at the center of the instrument panel **19** in the Interior of the self-vehicle A. The CID **12***b* includes a liquid crystal display visible from the occupant sitting on an assistant driver's seat **17***p* as well as the driver. The CID **12***b* displays a guide screen for navigation, an operation screen of an air conditioner, an operation screen of an audio device, and others on the liquid crystal display based on data acquired from the HCU **100**.

**[0066]** As illustrated in FIGS. **1** and **4**, the light emission device **40** includes an instrument panel light emission line **41**, a steer light emission ring **42**, a power source interface **43**, a communication interface **44**, a driver circuit **45**, and a control circuit **46**. The light emission device **40** displays light emission spots **51** and **56** on the instrument panel light emission line **41** and the steer light emission ring **42** to present information about the self-vehicle A to the driver.

**[0067]** The instrument panel light emission line **41** is provided on the instrument panel **19** of the self-vehicle A. The instrument panel light emission line **41** includes a linear light emission area **52**. The linear light emission area **52** is defined in such a shape as to linearly extend in a width direction WD of the self-vehicle A. The linear light emission area **52** is located above the CID **12***b*. The linear light emission area **52** has ends **53***a* and **53***b* in the width direction WD. The ends **53***a* and **53***b* are extended to bases of pillars disposed at one and the other sides of the wind shield **18**, respectively. The linear light emission area **52** is located out of a center vision range CVA of the driver sitting on the driver's seat **17***d*. On the other hand, substantially the entire linear light emission area **52** lies within a peripheral vision range PVA of the driver sitting on the driver's seat **17***d*. The linear light emission area **52** includes a plurality of light emitting elements disposed in a line in the width direction WD. The instrument panel light emission line **41** emits light from at least a part of the large number of light emitting elements to display at least the one light emission spot **51** in the linear light emission area **52**. The instrument panel light emission line **41** is capable of shifting the light emission spot **51** in the width direction WD within the linear light emission area **52**. The instrument panel light emission line **41** is further capable of changing an emission color and an emission size of the light emission spot **51**.

**[0068]** The steer light emission ring **42** is provided on the steering **16** of the self-vehicle A. The steer light emission ring **42** includes an annular light emission area **57**. The annular light emission area **57** is defined in such a shape as to annularly extend along an edge of a setter pad portion **16***a* of the steering **16**. The annular light emission area **57** is disposed below the combination meter **12***a*. A top portion of the annular light emission area **57** lies within the peripheral vision range PVA of the driver sitting on the driver's seat **17***d*. A plurality of light emitting elements are disposed in the annular light emission area **57** in a circumferential direction of the steering **16**. The steer light emission ring **42** emits light from at least a part of the large number of light emitting elements to display at least the one light emission spot **56** in the annular light emission area **57**. The steer light emission ring **42** is capable of shifting the light emission spot **56** in the circumferential direction within the annular light emission area **57**. The steer light emission ring **42** is further capable of changing an emission color and an emission size of the light emission spot **56**.

**[0069]** The power source interface **43** receives power from an in-vehicle battery or the like via a power source circuit **49**. The power source interface **43** supplies power to the components of the light emission device **40**. The instrument panel light emission line **41** and the steer light emission ring **42** display the light emission spots **51** and **56**, respectively, by using power supplied via the power source interface **43**.

**[0070]** The communication interface **44** is connected to the HCU **100**. Command signals are input from the HCU **100** to the communication interface **44** to instruct light emission modes of the instrument panel light emission line **41** and the steer light emission ring **42**.

**[0071]** The driver circuit **45** controls electric currents flowing in the respective light emitting elements provided on the instrument panel light emission line **41** and the steer light emission ring **42**. The driver circuit **45** converts power supplied from the power source interface **43** into electric currents to apply the currents to the light emitting elements designated by a control signal received from the control circuit **46**.

**[0072]** The control circuit **46** is mainly configured by a microcomputer including a processor and a memory. The control circuit **46** receives a command signal from the HCU **100** via the communication interface **44**. The control circuit **46** generates a control signal and outputs the control signal to the driver circuit **45** to allow the light emitting elements to emit light in a light emission pattern corresponding to the received command signal.

**[0073]** The control circuit **20*a*** of the HCU **100** shown in FIG. **5** constitutes a plurality of function blocks (**31** to **35**) under programs stored in the memory **23** and executed by the processors **21** and **22** to control light emission of the light emission device **40** thus configured. Details of the function blocks associated with information presentation by using the instrument panel light emission line **41** and the steer light emission ring **42** are hereinafter described with reference to FIG. **5** in conjunction with FIGS. **1** and **4**.

**[0074]** The information acquisition unit **31** acquires various types of information associated with the self-vehicle A. The information acquisition unit **31** outputs acquired information to a risk determination unit **32**, a blinking cycle setting unit **33**, and a light emission control unit **34**. The information acquisition unit **31** receives face direction information and looking-aside information from the DSM **11**, monitoring information from the peripheral monitoring ECU **91**, operation information and steering information about operations and steering of the driving assist function from the vehicle control ECU **70**, biological information from the wearable device **110**, and others. The information acquisition unit **31** further acquires event occurrence information at the time of occurrence of an event requiring attention of the driver to the left and right sides of the self-vehicle A. More specifically, the information acquisition unit **31** receives the event occurrence information Indicating that an operation of the direction indicator has been initiated by the driver or the vehicle control ECU **70** in order to perform a lane change.

**[0075]** The risk determination unit **32** determines a risk level of the self-vehicle A, based on information received from the information acquisition unit **31**. For example, the risk determination unit **32** may determine the risk level on a scale of one to five. The risk determination unit **32** determines a lowest risk level as a "normal state", and a highest risk level as a "risk level 4". The risk determination unit **32** increases the risk level with a rise of the degree of carelessness of the driver. The risk determination unit **32** outputs a determination result of the risk level to the information acquisition unit **31**.

**[0076]** The blinking cycle setting unit **33** sets a cycle for blinking the light emission spots **51** and **56** in a state notification mode described below. The blinking cycle of each of the light emission spots **51** and **56** is set to a cycle corresponding to a heart rate and a pulse rate of the driver in the normal state. The heart rate and the pulse rate may be determined based on biological information acquired by the wearable device **110**, or may be set to ordinary values determined beforehand (such as 60 per minute). In case of a heart rate set to 60 per minute, for example, the blinking cycle setting unit **33** sets the blinking cycle such that a bright state and a dark state are repeated for every one second as shown in FIG. **6**. For example, luminance in the dark state is set to approximately one third of luminance in the bright state.

**[0077]** The light emission control unit **34** shown in FIG. **5** generates a command signal in correspondence with information acquired by the information acquisition unit **31**, and outputs the command signal to the light emission device **40**. The light emission control unit **34** controls light emission of the light emission spots **51** and **56** of the instrument panel light emission line **41** and the steer light emission ring **42**. The light emission control unit **34** switches a plurality of light emission control modes of the light emission device **40**.

**[0078]** An audio control unit **35** controls an audio reproduction device **140** to give aural notification to the driver. The audio reproduction device **140** includes a speaker or the like, and reproduces a notification sound and an audio message audible by all the occupants of the self-vehicle A in the interior of the vehicle. The audio control unit **35** combines the light emission spot **51** and the audio message in cooperation with the light emission control unit **34** to securely give the driver a warning about presence of a risk.

**[0079]** The plurality of light emission control modes are hereinafter described. As shown in FIG. **7**, the plurality of light emission control modes include the state notification mode, a lane change notification mode, an approaching vehicle notification mode, and a looking-aside caution mode. The state notification mode is a light emission control mode for notifying the driver about a current risk level of the self-vehicle A. In the state notification mode, the light emission mode of the light emission spots **51** and **56** is switched in accordance with a determination result of the risk level determined by the risk determination unit **32** (see FIG. **5**).

**[0080]** Each of the lane change notification mode and the approaching vehicle notification mode is a light emission control mode for guiding the visual line of the driver in such a direction as to extend in an attention direction toward either the left side or the right side of the self-vehicle A, i.e., the side where an event requiring attention from the driver has occurred. The light emission control unit **34** (see FIG. **5**) switches the light emission control mode from the state notification mode to the lane change notification mode in response to operation of the direction indicator performed at the time of the lane change. The visual line of the driver is guided in such a direction as to extend in the attention direction toward the lane corresponding to a shift destination in accordance with light emission display in the lane change notification mode.

**[0081]** In case of detection of a vehicle traveling in parallel in the lane of destination under operation of the direction indicator performed in response to the lane change, the light emission control unit **34** (see FIG. **5**) switches the light emission control mode from the state notification mode to the approaching vehicle notification mode. The visual line of the driver is guided in such a direction as to extend in the attention direction toward the vehicle traveling in parallel in accordance with light emission display in the approaching vehicle notification mode.

**[0082]** The light emission control unit **34** (see FIG. **5**) determines whether the face of the driver has been directed toward either the left or the right corresponding to the attention direction at a predetermined angle (e.g., 45 degrees) or larger based on the face direction information. In case of determination that the direction of the face of the driver is identical to the attention direction, the light emission control mode is returned to the state notification mode from the lane change notification mode or the approaching vehicle notification mode.

**[0083]** The looking-aside caution mode is a light emission control mode for guiding the visual line of the driver looking aside toward the front. The light emission control unit **34** (see FIG. **5**) switches the state notification mode to the looking-aside caution mode, based on the looking-aside information about the driver. The visual line of the driver is guided toward the front in accordance with light emission display in the looking-aside caution mode. Thereafter, the light emission control unit **34** determines whether the face direction of the driver has been corrected, based on the face direction information. In case of determination that the face direction of the driver has been corrected, the light emission control mode is returned to the state notification mode from the looking-aside caution mode.

**[0084]** Relative priorities are established for the event notification modes, i.e., the lane change notification mode, the approaching vehicle notification mode, and the looking-aside caution mode in the plurality of light emission control modes described above. According to the first embodiment, the relative priorities are determined as the looking-aside caution mode, the approaching vehicle notification mode, and the lane change notification mode in the descending order.

**[0085]** Described hereinafter are details of the light emission mode of the instrument panel light emission line **41** in each of the light emission control modes as well as details of the light emission modes of the steer light emission ring **42**, with reference to FIGS. **8** to **17** in conjunction with FIG. **2**. In each of the linear light emission areas **52** and the annular light emission area **57** in FIGS. **8** to **17**, a dotted area indicates an area in a turned-off state, while a white area indicates an area in a turned-on state.

**[0086]** In the state notification mode, a reference position indicating the light emission spot **51** is switched between RPa and RPm in accordance with an operative state or inoperative state of the driving assist function as illustrated in FIGS. **8** and **9**. Each of the reference positions RPa and RPm indicates the center position of the light emission spot **51**. According to the first embodiment, the reference position of the light emission spot **51** is switched between RPa and RPm in accordance with an operative state or an inoperative state of LKA in the plurality of driving assist functions. The reference position RPa in the operative state of LKA is defined at a position closer to the center in the width direction WD of the self-vehicle A than the reference position RPm in the inoperative state of LKA is. Accordingly, the reference position RPm in the inoperative state of LKA is positioned above the center of the combination meter **12***a* disposed on the front of the driver's seat **17***d* (see FIG. **8**). In other words, the reference position RPm is set in front of the driver. On the other hand, the reference position RPa in the operative state of LKA is positioned above the center **52***c* of the linear light emission area **52** in the width direction WD, i.e., above the center of the CID **12***b* (see FIG. **9**).

**[0087]** The light emission spots **51** and **56** in the state notification mode change the emission color to show the current risk level of the self-vehicle A to the driver. In the normal state corresponding to the lowest risk level, the light emission spots **51** and **56** emit green light. On the other hand, in the highest risk level "4", the light emission spots **51** and **56** emit yellow light. The emission color of each of the light emission spots **51** and **56** gradually changes from green to yellow with a rise of the risk level. In addition, the display width of the light emission spot **51** in the width direction WD increases or decreases in accordance with the risk level. More specifically, the display width of the light emission spot **51** increases in the width direction WD with a rise of the risk level, and decreases in the width direction WD with a drop of the risk level as illustrated in FIG. **10**. Furthermore, the light emission spots **51** and **56** repeatedly change brightness of emission light in a cycle set by the blinking cycle setting unit **33** (see FIG. **5**).

**[0088]** As illustrated in FIGS. **11** and **12**, the light emission spots **51** and **56** are shifted in the width direction WD in accordance with an expected traveling track set by the traveling track setting unit **84** (see FIG. **3**) as an expected track after several seconds. The respective reference positions RPa and RPm of the light emission spot **51** of the linear light emission area **52** are shifted within the linear light emission area **52** by a shift amount corresponding to a target steering amount toward either the left or the right corresponding to the target steering direction after several seconds based on steering information. For example, as schematically illustrated in FIG. **13**, shift amounts of the reference positions RPa and RPm are matched with a shift amount of the outer edge of the steering **16** in the width direction WD at the time of a shift of the outer edge by the target steering amount. In addition, the shift amount of the reference position RPa in the operative state of LKA is substantially equivalent to the shift amount of the reference position RPm in the Inoperative state of LKA. Furthermore, the light emission spot **56** in the annular light emission area **57** illustrated in FIGS. **11** and **12** is similarly shifted in the circumferential direction by an angle corresponding to the target steering amount toward either the left or the right corresponding to the target steering direction after several seconds.

**[0089]** Light emission display of the instrument panel light emission line **41** in each of the lane change notification mode and the approaching vehicle notification mode is hereinafter described with reference to FIGS. **14** and **15**.

**[0090]** FIG. **14** illustrates display of the lane change notification mode for guiding the visual line of the driver toward the right corresponding to a shift destination at the time of a shift of the self-vehicle A to the right adjacent lane by utilizing an automatic lane change. In case of an absence of an approaching vehicle located in the shift destination lane and approaching the self-vehicle A, the light emission control mode is switched from the state notification mode to the lane change notification mode. The light emission spot **51** is temporarily turned off in the linear light emission area **52** in accordance with switching to the lane change notification mode (A of FIG. **14**). Thereafter, the light emission spot **51** is displayed again at the reference position RPa in an emission color corresponding to the risk level similarly to the state notification mode (B of FIG. **14**). The light emission spot **51** that has been displayed again starts shifting toward the right corresponding to the expected shift direction of the self-vehicle A in a shape leaving a trail of light backward. The light emission spot **51** reaches an end **52***a* of the linear light emission area **52** on the right side (C of FIG. **14**).

**[0091]** The light emission spot **51** having reached the end **52***a* is divided into a plurality of divisional light emission spots **51***s*. The divisional light emission spots **51***s* continuously shift toward the right while maintaining a distance therebetween (D of FIG. **14**). Thereafter, the divisional light emission spots **51***s* are stacked at the end **52***a* toward the inside in the width direction WD. As a result, the light emission spot **51** is integrally formed at the end **52***a* again (C of FIG. **14**).

**[0092]** FIG. **15** illustrates display of the lane change notification mode for guiding the visual line of the driver toward the left corresponding to a shift destination at the time of a shift of the self-vehicle A to the left adjacent lane by the driver performing a driving operation. The light emission spot **51** is temporarily turned off in accordance with switching to the lane change notification mode, and is displayed again at the reference position RPm in the emission color corresponding to the risk level (A of FIG. **15**). The light emission spot **51** that has been displayed again shifts toward the left corresponding to the expected shifting direction of the self-vehicle A to reach an end position EP (B of FIG. **15**). The end position EP is located between the center **52***c* and the left end **52***b* extended toward the assistant driver's seat **17***p* (see FIG. **1**) in the linear light emission area **52**. The end position EP is located Inside the peripheral vision range PVA (see FIG. **1**). In addition, the shift speed of the light emission spot **51** is kept substantially constant regardless of the operative or inoperative state of LKA. Furthermore, the shift speed of the light emission spot **51** toward the left is substantially equal to the shift speed of the light emission spot **51** toward the right.

**[0093]** With arrival of the light emission spot **51** at the end position EP, the plurality of divisional light emission spots **51***s* are displayed at the end **52***b* on the left side. The divisional light emission spots **51***s* continuously shift toward the left while maintaining a distance therebetween (C of FIG. **15**). Thereafter, the divisional light emission spots **51***s* are stacked at the end **52***b* toward the inside in the width direction WD. As a result, the light emission spot **51** is integrally formed at the end **52***b* again (D of FIG. **15**).

**[0094]** On the other hand, in case of presence of an approaching vehicle located in the shift destination lane and approaching the self-vehicle A, the light emission control mode is switched from the state notification mode to the approaching vehicle notification mode. In this case, the light emission spot **51** displayed again at each of the reference positions RPa and RPm (B of FIG. **14** and A of FIG. **15**) has a particular emission color regardless of the current risk level. More specifically, in the approaching vehicle notification mode, the emission color of the light emission spot **51** in the linear light emission area **52** has a color of "amber (orange)" or like colors having a stronger warning Impression than the color of the risk level "4". In addition, the display width of the light emission spot **51** that has been displayed again has a predetermined display width corresponding to the display width of the risk level "4", for example, regardless of the current risk level.

**[0095]** Light emission display of the instrument panel light emission line **41** in the looking-aside caution mode is hereinafter described with reference to FIGS. **16** and **17**.

**[0096]** FIG. **16** illustrates display for correcting the visual line of the driver looking at the right side in the inoperative state of the LKA. When the state notification mode is switched to the looking-aside caution mode, based on rightward looking-aside information acquired by the DSM **11**, the light emission spot **51** displayed at the reference position RPm is temporarily turned off in the linear light emission area **52** (A and B of FIG. **16**).

**[0097]** Thereafter, the light emission spot **51** is displayed at a portion to which the visual line of the driver has been directed (such as an end **52***a* on the right side) in the linear light emission area **52** extending in the width direction WD, based on the face direction information acquired by the DSM **11** (C of FIG. **16**). The light emission spot **51** is displayed again in the particular color such as amber similarly to the light emission spot **51** in the approaching vehicle notification mode. The light emission spot **51** that has been displayed again is shifted to the reference position RPm at the center of the combination meter **12***a*, i.e., the front of the driver.

**[0098]** FIG. **17** illustrates display for correcting the visual line of the driver looking at the left side in the operative state of the LKA. When the state notification mode is switched to the looking-aside caution mode based on leftward looking-aside information acquired by the DSM **11**, the light emission spot **51** displayed at the reference position RPa (A of FIG. **17**) is temporarily turned off. Thereafter, the light emission spot **51** emitting amber light is displayed in the direction corresponding to the visual line of the driver, based on the face direction information acquired by the DSM **11** (B of FIG. **17**). The light emission spot **51** that has been displayed again starts shifting rightward (C of FIG. **17**). The light emission spot **51** similarly shifts to the center of the combination meter **12***a* located in front of the driver even in the operative state of the LKA (D of FIG. **17**). In the looking-aside caution mode, therefore, the light emission spot **51** finally arrives at the reference position RPm regardless of the operative or inoperative state of the LKA.

**[0099]** Described hereinafter are details of processes executed by the control circuit **20***a* to realize display of the light emission spot **51** as described above, with reference to FIGS. **18** and **19** in conjunction with FIG. **5**. Initially, a reference position setting process for setting the reference positions RPa and RPm (see FIGS. **8** and **9**) of the light emission spot **51** is described with reference to a flowchart in FIG. **18**. The process shown in FIG. **18** repeatedly starts under the light emission control unit **34** of the control circuit **20***a* when the vehicle comes into a travelable state.

**[0100]** In S**101**, operation information indicating a start and an end of the LKA is acquired from the vehicle control ECU **70** (see FIG. **3**). Thereafter, the flow proceeds to S**102**. In S**102**, whether the LKA is in the operative state is determined based on the operation information acquired in S**101**. In case of determination that the LKA is in the operative state, the flow proceeds to S**103**. In S**103**, the reference position RPa is set at the center **52***c* of the linear light emission area **52** (see FIG. **9**). Thereafter, the flow proceeds to S**105**. On the other hand, in case of determination that the LKA is in the inoperative state in S**102**, the flow proceeds to S**104**. In S**104**, the reference position RPm is set in front of the driver (see FIG. **8**). Thereafter, the flow proceeds to S**105**.

**[0101]** In S**105**, steering information associated with an expected traveling track after several (t) seconds is acquired from the vehicle control ECU **70** (see FIG. **3**). Thereafter, the flow proceeds to S**106**.

**[0102]** In S**106**, whether a target steering amount included in the steering information acquired in S**105** is equal to or larger than a lower limit threshold. The lower limit threshold is set to a value corresponding to a shift of the light emission spot **51** on limited occasions of a curve and a lane change. In other words, the lower limit threshold is set to a value excluding a steering amount necessary for maintaining traveling within the lane recognizable as a straight line. In case of determination that the target steering amount is smaller than the lower limit threshold in S**106**, a series of processes end. On the other hand, in case of determination that the target steering amount is the lower limit threshold or larger in S**106**, the flow proceeds to S**107**. In S**107**, the reference position RPa or RPm set in S**103** or S**104** Is shifted to the left or the right in the width direction WD (see FIGS. **11** and **12**), based on the steering information acquired in S**105**, and then the series of processes end. The value of t is set to a value sufficient for securing a time for override, such as three seconds, after the driver recognizes the shift of the reference position RPa or RPm and determines appropriateness of the traveling direction.

**[0103]** Details of the process for setting the light emission mode of the light emission spot **51** in the state notification mode are hereinafter described. The process shown in FIG. **19** is similarly started by the light emission control unit **34** (see FIG. **5**), based on a travelable state of the vehicle.

**[0104]** In S**121**, a blinking cycle set by the blinking cycle setting unit **33** is acquired. Thereafter, the flow proceeds to S**122**. In S**122**, the latest reference position set by the reference position setting process is acquired. Thereafter, the flow proceeds to S**123**. In S**123**, a determination result of the latest risk level determined by the risk determination unit **32** is acquired. Thereafter, the process proceeds to S**124**. In S**124**, the emission color, display width, and display position of the light emission spot **51** are set or updated based on the items of information acquired in S**121** to S**123**. Thereafter, the flow returns to S**122**. Values set by repeating the processes in S**122** to S**124** are output to the light emission device **40** in FIG. **1** as command signals to realize state notification based on the light emission spot **51**.

**[0105]** According to the first embodiment described above, the light emission spot **51** is displayed at either the position RPa or the position RPm different from each other and selected in accordance with the operative state or inoperative state of the driving assist function. The difference between the display positions of the light emission spot **51** is securely perceivable by the driver even when the linear light emission area **52** is defined within the peripheral vision range PVA of the driver. Accordingly, the light emission device **40** is capable of presenting information indicating whether the driving assist function is in the operative state for assisting or substituting for a driving operation in such a manner that the information is easily recognizable for the driver.

**[0106]** In addition, according to the first embodiment, the reference position RPa of the light emission spot **51** is set at a position close to the center of the self-vehicle A in the operative state of the driving assist function. In this case, the light emission device **40** is capable of presenting, to the occupants of the self-vehicle A, the state of execution of the driving operation by the in-vehicle system. On the other hand, in the inoperative state of the driving assist function, the reference position RPm is set in front of the driver's seat **17***d*. In this case, the light emission device **40** is capable of presenting, to the occupants of the self-vehicle A, the state of execution of the driving operation by the driver.

**[0107]** Moreover, the light emission spot **51** in the first embodiment presents the risk level of the self-vehicle A to the driver as well as operation information about the driving assist function. Accordingly, the driver is capable of sensing an atmosphere showing a rise or a drop of the risk level based on information presentation of the risk level displayed by the light emission spot **51** within the peripheral vision range PVA of the driver.

**[0108]** Furthermore, according to the first embodiment, the display width of the light emission spot **51** enlarges with a rise of the risk level resulting from a careless state of the driver. The peripheral vision range PVA of the driver may become narrower as the degree of carelessness rises. In addition, the driver may become less conscious of the peripheral vision even when the peripheral vision range PVA does not change. Accordingly, the light emission device **40** allows even the driver coming into a careless state to securely recognize the light emission spot **51** provided for notification about the risk level and enlarged in the display size in accordance with a rise of the risk level.

**[0109]** The display width of the light emission spot **51** decreases with a drop of the risk level. Accordingly, the drop of the risk level is recognizable, together with reduction of disturbance to display.

**[0110]** In addition, the light emission device **40** in the first embodiment shifts the light emission spot **51** in accordance with future steering information after several seconds. In this case, the occupants including the driver of the self-vehicle A are notified about the future shift direction of the self-vehicle A by such a display. Accordingly, the light emission device **40** gives a sense of safety to the driver and the occupants by information presentation achieved by the light emission spot **51**.

**[0111]** In the mode for notifying the future shift direction by the light emission spot **51** as described above, the occupants such as the driver easily associate the light emission spot **51** with steering of the self-vehicle A. Accordingly, it is preferable that the reference position is switched between RPa and RPm based on the operation of the LKA associated with the steering function as in the first embodiment.

**[0112]** Furthermore, according to the first embodiment, the shift of the reference position RPa or RPm is suspended in the state that the target steering amount is smaller than the lower limit threshold. This configuration prevents such a situation that a slight shift of the light emission spot **51** to the left or the right bothers the driver and the occupants.

**[0113]** Furthermore, according to the first embodiment, the light emission device **40** repeatedly changes brightness of the light emission spot **51** in a blinking cycle corresponding to a heart rate of the driver in the normal state. In addition, the blinking cycle of the light emission spot **51** is maintained even at the time of a rise of the risk level. In this mode of display in the peripheral vision of the driver, the light emission device **40** considerably reduces a rise of the heart rate of the driver in comparison with reduction of a blinking cycle in accordance with a rise of the risk level. Accordingly, the light emission device **40** reduces panic and calms down the driver.

**[0114]** Furthermore, the linear light emission area **52** in the first embodiment is defined substantially within the peripheral vision range PVA of the driver. In this case, a shift of the light emission spot **51** within the linear light emission area **52** is securely visible by the driver in the peripheral vision. Accordingly, the visual line of the driver is appropriately guided in the direction of caution for the driver in accordance with a shift of the light emission spot **51** in the direction of caution.

**[0115]** It is difficult for the driver to acquire a plurality of items of information from only display located in the peripheral vision range PVA. Accordingly, the light emission spot **51** is temporarily turned off at the time of switching of the light emission control mode in the first embodiment. In this case, clear separation between state notification of the risk level and occurrence notification of events is allowed to be made. As a result, the driver more easily recognizes information presentation.

**[0116]** Furthermore, the shift speed of the light emission spot **51** is equalized in each of the lane change notification mode, the approaching vehicle notification mode, and the looking-aside caution mode in the first embodiment regardless of the operative or inoperative state of the LKA. Accordingly, quick attraction of attention is realizable by setting the shifting speed of the light emission spot **51** to the highest speed within a perceivable range by the driver.

**[0117]** Furthermore, according to the first embodiment, the end position EP is provided between the end **52***b* and the center **52***c* in the linear light emission area **52** to reduce the shift distance of the light emission spot **51** from the reference position RPm toward the left. By this reduction of the shift from the end position EP to the end **52***b*, the shift distance from the light emission spot to the left and the shift distance from the light emission spot to the right are substantially equivalent even when the reference position RPm is located away from the end **52***b* in the inoperative state of the LKA. In this case, the shift cycles of the light emission spot **51** to the left and the right are equalized. Accordingly, display for attraction of visual line gives an impression of unity.

**[0118]** Furthermore, according to the first embodiment, the visual line of the driver is guided toward a correct position through attraction of attention achieved by the light emission spot when the driver is looking aside. Accordingly, the display of the light emission spot **51** performed by the light emission device **40** not only gives notification about the risk level, but also urges the driver to take appropriate caution to contribute to lowering of the risk level.

**[0119]** Note that the instrument panel light emission line **41** corresponds to a "light emission display unit", and the linear light emission area **52** corresponds to a "light emission area" in the first embodiment. In addition, the vehicle control ECU **70** corresponds to a "driving assist device", and the HCU **100** and the light emission device **40** correspond to an "information presentation apparatus".

Second Embodiment

**[0120]** A second embodiment is a modified example of the first embodiment. A vehicle onboard network **201** in the second embodiment illustrated in FIG. **20** additionally includes a locator **95** and a V2X communicator **96**.

**[0121]** The locator **95** includes a global navigation satellite system (GNSS) receiver **95***a*, a map database **95***b*, an inertial sensor, and the like. The GNSS receiver **95***a* receives positioning signals transmitted from a plurality of artificial satellites. The locator **95** measures a position of the self-vehicle A by combining a positioning signal received via the GNSS receiver **95***a* and a measurement result obtained by the inertial sensor. The map database **95***b* includes a storage medium that stores a large number of items of map information. The locator **95** supplies position information indicating the position of the self-vehicle A, and map information indicating surroundings or traveling direction of the self-vehicle A to the vehicle control system **60** and the HMI system **10** via the communication bus **99**.

**[0122]** The V2X communicator **96** exchanges information with an in-vehicle communicator mounted on a different vehicle, and a roadside device provided on a roadside to wireless communication. The V2X communicator **96** acquires position information, which indicates positions of a different vehicle, a pedestrian, and the like difficult to be directly viewed by the driver, through road-to-vehicle communication with a roadside device provided at an intersection or other places, for example. The V2X communicator **96** sequentially outputs acquired information to the communication bus **99**.

**[0123]** Details of the plurality of light emission control modes set for the light emission control unit **34** are hereinafter described with reference to FIG. **21** in conjunction with FIGS. **20** and **5**.

**[0124]** A risk target warning mode is included in the plurality of light emission control modes of the light emission control unit **34**. The relative priority of the risk target warning mode is set higher than those of the looking-aside caution mode, the approaching vehicle notification mode, and the lane change notification mode. In the risk target warning mode, the visual line of the driver is guided toward a risk target located around or in the traveling direction of the self-vehicle A and requiring caution of the driver.

**[0125]** The information acquisition unit **31** acquires necessary information for switching to the risk target warning mode. For example, the information acquisition unit **31** is capable of acquiring map information in the traveling direction from the locator **95**. The information acquisition unit **31** is further capable of acquiring position information indicating positions of a different vehicle, a pedestrian, and the like present around the self-vehicle A from the peripheral monitoring ECU **91** and the V2X communicator **96**.

**[0126]** The risk determination unit **32** calculates, as a risk level associated with the self-vehicle A, an outside risk level around and in the traveling direction of the self-vehicle A based on various types of information collected by the information acquisition unit **31**, separately from determination of a risk level based on the degree of carelessness of the driver inside the vehicle. The risk determination unit **32** is capable of calculating a risk level of each of a stationary risk factor produced by a road structure such as a blind Intersection, and a dynamic risk factor such as a moving object approaching the self-vehicle A, for example. The risk determination unit **32** is further capable of calculating each risk level of a plurality of risk factors in case of presence of the plurality of risk factors around or in the traveling direction of the self-vehicle A.

**[0127]** The risk determination unit **32** determines presence of a risk target when a calculated risk level is higher than a first threshold. The risk determination unit **32** also determines disappearance of a risk target when a calculated risk level is lower than a second threshold. The first threshold is set higher than the second threshold in the risk level.

**[0128]** According to the second embodiment, a determination result of a risk level determined by the risk determination unit **32** is received by the light emission control unit **34**. More specifically, occurrence information indicating occurrence of a risk target and generated by the risk determination unit **32** is received by the light emission control unit **34**, and handled as a trigger for a process which switches the light emission control mode from the state notification mode to the risk target warning mode. In addition, disappearance information indicating disappearance of a risk target and generated by the risk determination unit **32** is received by the light emission control unit **34**, and may be handled as a trigger for a process which returns the light emission control mode from the risk target warning mode to the state notification mode.

**[0129]** The light emission control unit **34** acquires position information indicating a relative position of a risk target from the information acquisition unit **31**. The light emission control unit **34** displays the light emission spot **51** at a portion of the linear light emission area **52** in a direction toward the risk target as viewed from the driver in the risk target warning mode. The light emission control unit **34** shifts the position of the light emission spot **51** in the linear light emission area **52** based on position information such that the position of the light emission spot **51** follows a relative positional change of the risk target with respect to the self-vehicle A. The light emission control unit **34** further changes the mode of the light emission spot **51**, such as the emission color and the emission size, in accordance with the risk level of the risk target. In addition, in case of determination by the risk determination unit **32** that a plurality of risk targets are present, the light emission control unit **34** displays the light emission spots **51** for warnings each of which indicates the corresponding one of the plurality of risk targets (see FIG. **22**).

**[0130]** Moreover, in case of determination that the plurality of risk targets are present, the light emission control unit **34** may select the highest risk target corresponding to the highest risk level in the plurality of risk targets, and display the light emission spot **51** for a warning about the presence of the highest risk target (see FIG. **23**). In this case, the light emission spot **51** displayed in the linear light emission area **52** indicates the direction of the highest risk target as viewed from the driver. Furthermore, in case of determination that a plurality of highest risk targets are present, the light emission control unit **34** displays the plurality of light emission spots **51** for warnings each of which indicates the corresponding highest risk target.

**[0131]** Details of light emission display in the risk target warning mode realized by the configuration described above are hereinafter described with reference to FIGS. **22** and **23**. Respective scenes illustrated in FIGS. **22** and **23** show the self-vehicle A in the inoperative state of the driving assist function, and arriving at a blind intersection as a result of a driving operation by the driver.

**[0132]** While the self-vehicle A is traveling under the driving operation by the driver, the lighting light emission spot **51** is displayed at the reference position RPm located in front of the driver in the linear light emission area **52** (see A of FIG. **22** and A of FIG. **23**). The stationary risk level based on the map information rises as the self-vehicle A approaches the blind intersection. In this case, the light emission control mode is switched from the state notification mode to the risk target warning mode. With the approach of the self-vehicle A to the blind intersection where objects blocking the field of vision of the driver are present on the left and right sides of an expected stop position of the self-vehicle A, the light emission spots **51** are displayed at both ends of the linear light emission area **52** to warn the driver about blindness on the left and right sides (see B of FIG. **22** and B of FIG. **23**). The state notification mode switches to the risk target warning mode several seconds (about 3 to 5 seconds) before arrival of the self-vehicle A at the expected stop position. The light emission spots **51** are displayed in an emission color of green, for example, to notify the driver about a substantially middle risk level.

**[0133]** when position information about a different vehicle **A1** entering the intersection is acquired based on information output from the external recognition system **90** or the V2X communicator **96** (see FIG. **20**), the light emission spot **51** that gives a warning about the presence of the different vehicle **A1** is further displayed in the linear light emission area **52** (see C of FIG. **22**). In this case, a dynamic risk level calculated for the risk target of the different vehicle **A1** is higher than the risk level for the risk target of the blind intersection. Accordingly, the light emission spot **51** for the warning about the presence of the different vehicle **A1** is displayed in an emission color of red, for example, to clearly notify the driver about the high level of the risk.

**[0134]** In addition, according to the modified example described above, a combined risk level of the presence of the different vehicle **A1** and the blind intersection is higher than the stationary risk level of the presence of the blind intersection in case of acquisition of the position information about the different vehicle **A1** entering the intersection. Accordingly, the left and right light emission spots **51** turned on to attract attention from the driver are turned off, while the light emission spot **51** for the warning about the different vehicle **A1** corresponding to the highest risk target is turned on (see C of FIG. **23**).

**[0135]** The light emission spot **51** for the warning about the presence of the different vehicle **A1** as a risk target may be shifted in the linear light emission area **52** in accordance with a shift of the different vehicle **A1**. More specifically, the light emission spot **51** shifts from the vicinity of the base of the front pillar located on the right side of the driver toward the left side of the driver in case of a shift of the different vehicle **A1** from the right to the left during traveling in front of the self-vehicle A (see C of FIG. **22** and C of FIG. **23**).

**[0136]** The light emission spot **51** for the warning about the presence of the different vehicle A**1** is turned off based on disappearance information about the risk target of the different vehicle A**1** having passed through the front of the self-vehicle A. Accordingly, the instrument panel light emission line **41** returns to the state of light emission display of the pair of light emission spots **51** for attracting attention to the blind intersection (see D of FIG. **22**). In addition, according to the modified example, the light emission control mode is returned to the state notification mode in response to cancellation of the risk target warning mode (see D of FIG. **23**).

**[0137]** In the scenes described above, a warning about multiple risks associated with the different vehicle A**1** is given by the light emission spots **51**. For example, the light emission spots are always turned on with approach to an intersection or the like in case of only issue of notification about a stationary risk. This notification causes habituation for the driver, and induces distrust by the driver considering, "no car will come even in a lighting condition again", for example. On the other hand, only notification about a dynamic risk may induce overconfidence by the driver. More specifically, the driver may make an incorrect determination, considering, "no car will come in a not-lighting condition", during no detection of a risk target. It is desirable to issue a warning about combined two types of risks of both a stationary risk and a dynamic risk to avoid such distrust and overconfidence.

**[0138]** The risk target warning mode described above switches between different modes for issuing a warning about a risk target in accordance with a relative position of a risk target with respect to the self-vehicle A as illustrated in FIGS. **24** and **25**.

**[0139]** A scene illustrated in FIG. **24** shows a pedestrian P**1** corresponding to a risk target and visible on a front scene viewed by the driver between the pair of front pillars above the linear light emission area **52** extending in the width direction WD. The instrument panel light emission line **41** displays the light emission spot **51** in a range located below the pedestrian P**1** in the linear light emission area **52** as viewed from the driver. As a result, the light emission spot **51** displays the direction of the risk target as viewed from the driver.

**[0140]** In this case, the risk level of the pedestrian P**1** rises as the pedestrian P**1** approaches the self-vehicle A. Accordingly, the emission color of the light emission spot **51** sequentially changes in the order of yellow, amber, and red in accordance with approach of the pedestrian P**1**. In this case, the warning about the risk target is issued only by the light emission spot **51** in a state that the pedestrian P**1** is visually recognizable through the wind shield **18** (see FIG. **1**). In other words, a warning about the risk target by using an audio reproduction device such as a speaker is not issued.

**[0141]** A scene illustrated in FIG. **25** shows the pedestrian P**1** visible on the front scene viewed by the driver at a position away from the portion above the linear light emission area **52**. In the state that the pedestrian P**1** is visible outside the pair of front pillars as in this example, the driver does not easily notice the presence of the pedestrian P**1**. Accordingly, the instrument panel light emission line **41** displays an animation for sliding the light emission spot **51** from the one end of the linear light emission area **52** on the side close to the pedestrian P**1** toward the center of the linear light emission area **52**. The light emission spot **51** may be displayed in such a mode as to slide into the linear light emission area **52** while flashing. The driver is capable of noticing animation displayed in the linear light emission area **52** within the peripheral vision range PVA (see FIG. **1**). Accordingly, the visual line of the driver is guided by the instrument panel light emission line **41** toward the outside of the front pillars in accordance with movement of the light emission spot **51**.

**[0142]** Moreover, in the state that the direction of the risk target viewed by the driver is located outside the range of extension of the linear light emission area **52**, such as a case that the pedestrian P**1** is visible outside the front pillars, a warning sound and a warning message are reproduced from a speaker or the like to issue a warning about the risk target. For example, a voice message for warning the driver about the presence of the risk target is reproduced by the audio reproduction device **140** under control by the audio control unit **35**. Accordingly, the instrument panel light emission line **41** securely attracts the visual line of the driver toward the outside of the front pillars as well through both a visual stimulus and an audio stimulus for the warning about the risk target.

**[0143]** Hereinafter described with reference to FIGS. **26** to **28** is a light emission mode of the light emission spots **51** in case of simultaneous presence of a plurality of pedestrians Pa to Pe as risk targets in the risk target warning mode.

**[0144]** A scene illustrated in FIG. **26** shows the plurality of pedestrians Pa to Pc all determined as risk targets and located at positions close to each other as viewed from the driver. The light emission spot **51** is enlarged in the width direction WD sufficiently for containing the plurality of pedestrians Pa to Pc located close to each other. The light emission spot **51** is displayed in an emission color corresponding to the risk level of each of the pedestrians Pa to Pc.

**[0145]** More specifically, an eye point IP of the driver is defined beforehand in the interior of the self-vehicle A. The eye point IP indicates specific coordinates in a space assumed to contain the positions of the eyes of the driver sitting on the driver's seat **17***d* (see FIG. **1**). Moreover, relative coordinates of the pedestrians Pa to Pc with respect to the self-vehicle A are acquired based on position information obtained by the external recognition system **90** (see FIG. **20**) or the like. The light emission control unit **34** (see FIG. **5**) determines the size of the light emission spot **51** based on the coordinates of the eye point IP, the coordinates of the respective pedestrians Pa to Pc, and coordinates indicating a setting range of the linear light emission area **52**.

**[0146]** Initially, virtual lines connecting the eye point IP and each of the pedestrians Pa to Pc are defined. The virtual lines are defined substantially in parallel with the road surface on which the self-vehicle A travels. Angles, each of which is formed by a set of adjoining virtual lines included in the foregoing virtual lines, correspond to two direction differences θab and θbc of the risk targets as viewed from the eye point IP. When each of the direction differences θab and θbc is smaller than a threshold angle θth, the risk targets are merged into one target. In this case, a warning about the merged target is given from the one light emission spot **51**.

**[0147]** Both the ends of the light emission spot **51** in the width direction WD cross the two virtual lines located on the outermost sides, and extend to the outside of the two virtual lines as viewed in the plan view of the virtual lines and the eye point IP from above. In addition, assuming that centers of gravity of the respective pedestrians Pa to Pc are defined, virtual lines extending from the eye point IP toward coordinates of the centers of gravity virtually cross the center point of the light emission spot **51**. Accordingly, by enlargement of the size of the light emission spot **51** in the width direction WD in this manner, the one light emission spot **51** achieves a collective warning about the plurality of pedestrians Pa to Pc on the front scene viewed by the driver.

**[0148]** A scene illustrated in FIG. **27** shows the two pedestrians Pd and Pe both determined as risk targets and located at positions away from each other as viewed from the driver. In a state that a direction difference θde formed by two virtual lines connecting the eye point IP and the respective pedestrians Pd and Pe is larger than the threshold angle θth, the two light emission spots **51** are displayed in the linear light emission area **52** as respective cautions or warnings about the presence of the pedestrian Pd and the pedestrian Pe. The display positions of the light emission spots **51** are determined with reference to a pseudo intersection at which the linear light emission area **52** virtually cross the virtual lines in the plan view of the virtual lines and the eye point IP from above.

**[0149]** A scene illustrated in FIG. **28** shows two pedestrians Pf and Pg both determined as risk targets, and located substantially in an identical direction as viewed from the driver but at considerably different distances from the self-vehicle A. A direction difference θfg formed by two virtual lines connecting the eye point IP and each of the pedestrians Pf and Pg is smaller than the threshold angle θth, wherefore the one light emission spot **51** for a collective warning about these risk targets is displayed in the linear light emission area **52**. The emission color of the light emission spot **51** in this scene is determined based on the higher one of the calculated risk levels of the two risk targets. More specifically, the risk level of the one pedestrian Pg closer to the self-vehicle A in the two pedestrians Pf and Pg is selected. In this case, the light emission spot **51** in the emission color corresponding to the selected risk level is displayed in the linear light emission area **52**.

**[0150]** A method for changing the length of the light emission spot **51** in the width direction WD in accordance with a relative position of a risk target is hereinafter described with reference to FIG. **29**.

**[0151]** The length of the light emission spot **51** is adjusted by the light emission control unit **34** (see FIG. **5**) in accordance with a direction of a risk target with respect to the traveling direction of the self-vehicle A, and a distance from the self-vehicle A to the risk target. More specifically, the size of the light emission spot **51** is determined such that the light emission spot **51** indicates the direction of the pedestrian P**1** corresponding to the highest risk target as viewed from the driver even after a shift of the eye point IP of the driver toward the front or rear of the self-vehicle A as a result of a slide of the driver's seat **17***d*. In this case, not only the position of the light emission spot **51**, but also the length of the light emission spot **51** are changed such that the light emission spot **51** lights below the risk target on the front scene viewed by the driver even after a change of the position of the driver's seat **17***d* (see FIG. **1**) in the front-rear direction of the self-vehicle A.

**[0152]** This point is further detailed. The eye point IP described above corresponds to an eye point IPc assumed as a position of the eyes of the driver in a state that the driver's seat **17***d* (see FIG. **1**) is located at the center of a slide range, for example. In addition to the eye point IPc, assumable beforehand are an eye point IPf in a state that the driver's seat **17***d* is located at a foremost position in the slide range, and an eye point IPb in a state that the driver's seat **17***d* is located at a rearmost position in the slide range.

**[0153]** Virtual lines substantially parallel with the road surface on which the self-vehicle A travels are definable between the pedestrian P**1** corresponding to the risk target, and the respective eye points IPf and IPb at the foremost position and the rearmost position. A direction difference θfb formed by the two virtual lines with the pedestrian P**1** located at the center of the difference Indicates an amount of deviation of a visual recognition direction produced by the difference between the eye points IPf and IPb.

**[0154]** On the other hand, virtual lines substantially parallel with the road surface on which the self-vehicle A travels are similarly definable between the pedestrian P**1** and both ends of the light emission spot **51**. On the assumption that an angle formed by the two virtual lines with the pedestrian P**1** located at the center of the angle is a lighting angle θlgt of the light emission spot **51**, the lighting angle θlgt is set to a value larger than the direction difference θfb. In such a setting that the eye point IP of the driver is located within the range of the lighting angle θlgt, the light emission spot **51** is visible below the pedestrian P**1** on the front scene of the driver. Note that the center of the light emission spot **51** in the width direction WD is determined at a virtual intersection between the linear light emission area **52** and the virtual line extending from the eye point IPc to the pedestrian P**1**.

**[0155]** According to the setting method described above, the light emission control unit **34** (see FIG. **5**) increases the calculated direction difference θfb and the lighting angle θlgt to enlarge the light emission spot **51** in the width direction WD in accordance with approach of the risk target toward the self-vehicle A. This adjustment of the length of the light emission spot **51** allows the light emission spot **51** to light below the risk target to notify the driver about the direction of the risk target.

**[0156]** A method for changing the length of the light emission spot **51** in the width direction WD in accordance with the display position of the light emission spot **51** is hereinafter described with reference to FIG. **30**.

**[0157]** The length of the light emission spot **51** increases in the width direction WD as the display position of the light emission spot **51** moves away from the driver. More specifically, on the assumption that sizes and relative positions of risk targets with respect to the self-vehicle A are substantially the same, the length of the light emission spot **51** decreases to the minimum in front of the driver, and gradually increases with a shift from the front along the linear light emission area **52**. More specifically, angles θvis formed by virtual lines connecting the eye point IP and both ends of each of the light emission spots **51** displayed at respective positions in the linear light emission area **52** (hereinafter, each of the angles is referred to as "viewing angle") are substantially uniform. Each of the viewing angles θvis is set to approximately 10°, for example.

**[0158]** According to the setting method described above, the light emission control unit **34** (see FIG. **5**) enlarges the light emission spot **51** in the width direction WD by increasing the number of lighting light emitting elements in accordance with a shift of the display position of the light emission spot **51** from the front of the driver. This adjustment of the length of the light emission spot **51** allows the driver to securely notice the light emission spot **51** even when the lighting light emission spot **51** is displayed on the assistant driver's seat side located at a long distance from the driver.

**[0159]** According to the second embodiment described above, advantageous effects similar to those of the first embodiment are offered. In this case, information Indicating whether the driving assist function is in the operative state is presented to the driver in a manner easily recognizable for the driver. Moreover, in the risk target warning mode of the second embodiment, the driver is notified about the direction of the presence of a risk target based on the light emission spot **51**. Accordingly, the instrument panel light emission line **41** is capable of securely attracting attention from the driver toward a risk target requiring attention from the driver. Furthermore, the light emission spot **51** in the second embodiment is shiftable toward the left and the right while following a risk target. Accordingly, the instrument panel light emission line **41** is capable of continuously attracting the visual line of the driver toward a risk target at a high risk level.

## Other Embodiments

**[0160]** Exemplary embodiments are not limited to the plurality of embodiments specifically described herein. The technical spirits of the present disclosure are applicable to various other embodiments and combinations.

**[0161]** According to the embodiments described herein, the light emission spot is temporarily turned off before switching from the state notification mode to the other light emission control modes. However, an instrument panel light emission line in a first modified example may superimpose, on a main light emission, a sub light emission spot in an emission color different from the color of a main light emission spot that performs notification about the state while displaying the main light emission spot at the reference position. In this case, the instrument panel light emission line shifts the sub light emission spot to the left or the right to guide the visual line of the driver. Moreover, the types of the light emission control modes set for the light emission device may be varied as appropriate. Furthermore, the priorities of the respective light emission control modes may be varied as appropriate.

**[0162]** Each of the reference positions RPa and RPm in the respective embodiments indicates the center position of the light emission spot **51** in a state that the self-vehicle A travels straight in the state notification mode. However, each of the reference positions may be located at any position in the light emission spot as long as the reference position defines the position of the light emission spot. For example, each of the reference positions may be disposed at the right end or the left end. Furthermore, each of the reference positions may be manually adjusted by the driver.

**[0163]** The light emission spot **51** in each of the embodiments changes both the emission color and the display width in accordance with the risk level. However, the emission color associated with the risk level is not limited to the range of colors from green to red as described in the respective embodiments. Moreover, the light emission spot may change only either the emission color or the display width in accordance with the risk level. Furthermore, it is difficult to greatly enlarge the light emission spot toward the right during manual driving without operation of the LKA. Accordingly, the light emission spot may have a shape asymmetrically enlarged in the left-right direction, i.e., a shape more greatly enlarged toward the left of the reference position than toward the right of the reference position.

**[0164]** According to the embodiments described above, the light emission spot **51** in the linear light emission area **52** and the light emission spot **56** in the annular light emission area **57** have the same emission color. However, the light emission spots may respectively have different emission colors for light emission. In addition, brightness of the light emission spots may be synchronously changed. On the other hand, brightness of the light emission spots may be repeatedly changed in different cycles. Furthermore, while synchronous information presentation by the instrument panel light emission line **41** and the steer light emission ring **42** is realized in the embodiments, only the instrument panel light emission line **41** may be used to present operation information about the driving assist device to the occupants without use of the steer light emission ring **42**.

**[0165]** According to the embodiments, the light emission spot **56** in the annular light emission area **57** is turned off so as not to disturb attraction of attention from the driver by the light emission spot **51** in the linear light emission area **52**. However, the light emission spot on the steering may be turned on even during the light emission control mode for attracting attention of the driver.

**[0166]** The instrument panel light emission line **41** in the embodiments forms the linear light emission area **52** extending in the horizontal direction above the combination meter **12***a* and the CID **12***b*. However, the shape and position of the "light emission area" may be varied as appropriate. For example, the ends of the linear light emission area are not required to reach the bases of the respective pillars as long as the linear light emission area extends to cross the respective centers of the combination meter and the CID. Moreover, the linear light emission area may be formed below the combination meter and the CID, for example. Furthermore, the instrument panel light emission line may be a "light emission display unit" which shows a light emission spot visible for the driver, and formed as a virtual image of emission light projected on the lower edge of the wind shield and reflected on the lower edge. According to this configuration, the "light emission area" is defined at the lower edge of the wind shield. In addition, the instrument panel light emission line may be constituted by a plurality of linear light emission areas formed on the instrument panel.

**[0167]** Furthermore, the number and layout of many light emitting elements configuring the instrument panel light emission line **41** may be varied as necessary. In addition, the instrument panel light emission line for displaying the shiftable light emission spot may be realized by a self-emitting panel such as a band-shaped organic electroluminescence (EL) in place of the configuration of light emitting diodes.

**[0168]** According to the embodiments, the "inoperative state of driving assist device" corresponds to the operative state of the LKA, while the "operative state of driving assist device" corresponds to the stopping state of the LKA. Accordingly, the reference position is switched based on whether the LKA is operating. However, the driving assist function used as a trigger for switching the reference position is not limited to the LKA described above. The reference position may be switched based on the operation and stop of various types of functions capable of functioning as the "driving assist device".

**[0169]** For example, the reference position may be switched in response to automatic lane change, automatic passing, or the like under the operative state of the LKA. Furthermore, the reference position may be switched based on the operation of the ACC. Alternatively, the reference position may be switched in response to an operation of completely automatic driving constantly performing all controls by the automatic driving system mounted on the vehicle.

**[0170]** According to the embodiments, the shift speeds of the light emission spot to the left and the right are equalized. However, the shift speeds of the light emission spot may be varied as appropriate. In a state that the shift speed of the light emission spot is excessively high, the corresponding light emission spot is visually recognized as only linear light emission in the peripheral view of the driver. Accordingly, the shift of the light emission spot is not perceivable. It is therefore preferable that the shift speed of the light emission spot is set to the maximum speed in the speed range recognizable by the driver as movement of the spot to realize attraction of attention.

**[0171]** Furthermore, in the light emission control modes for notification about an event, the shift speed of the light emission spot to the right may be different from the shift speed of the light emission spot to the left. In addition, the shift speed of the light emission spot during operation of the driving assist function may be different from the shift speed of the light emission spot during non-operation of the driving assist function. Moreover, the light emission spot flowing from the reference position RPm toward the left during manual operation may continuously shift to the end **52***b* without ending the shift at the end position EP.

**[0172]** The light emission spot in the embodiments cyclically repeats blinking to change brightness in the state notification mode. The light emission spot may be turned off in the darkest state during the blinking operation. Furthermore, brightness of the light emission spot may be changed by varying a tone (brightness) of the emission color in addition to variations of luminance, or in place of variations of luminance. Alternatively, the light emission spot may be a display which cyclically repeats expansion and contraction in the width direction WD.

**[0173]** The light emission spot according to the embodiments presents information about the operation state of the driving assist function, the risk level, and the like to the driver. However, the information presented by the light emission spot is not limited to these items of information. For example, the instrument panel light emission line may light the light emission spot for attraction of attention in case of occurrence of abnormality of the self-vehicle A. In this case, indicators are displayed on the combination meter, the HUD device, and the like as well as attraction of attention by the light emission spot. The emission color of the light emission spot is equalized with the display color of the indicators, such as blue, red, and other colors easily noticeable by the driver.

**[0174]** The light emission device is provided on a right-handle vehicle according to the embodiments. However, needless to say, modes for a light emission device mounted on a left-handle vehicle are also regarded as embodiments.

**[0175]** In the looking-aside notification mode of the embodiments, the visual line of the driver is guided toward the front by the light emission spot shifting to the center of the combination meter regardless of whether the driving assist function (device) is operating. However, the visual line of the driver may be guided to the reference position RPa at the center of the CID during operation of the driving assist device. As described above, the destination position for attraction of attention for correcting the looking-aside state may be varied in accordance with the operation of the driving assist function similarly to the reference position. In addition, the destination position may be disposed substantially at the same position as the reference position. Furthermore, the destination position in the looking-aside notification mode may be disposed in a direction to which the visual line of the driver is desired to be directed.

**[0176]** In the risk target warning mode according to the second embodiment, the length of the light emission spot **51** is changed by the plurality of adjusting methods. However, use of these adjusting methods may be omitted as necessary. Furthermore, in case of presence of a large number of risk targets requiring warnings, for example, the light emission spot need not follow the risk targets.

**[0177]** According to the first embodiment, the internal risk level is determined based on the degree of carelessness of the driver. However, the determination method of the internal risk level may be changed as necessary. For example, the risk determination unit may determine the risk level of the driver, based on the degree of sleepiness of the driver, a staggering behavior of the self-vehicle A, information about other vehicles traveling around the self-vehicle A, and the like.

**[0178]** According to the embodiments, the functions performed by the respective processors **21** and **22** of the control circuit **20***a* may be performed by hardware and software different from the processors **21** and **22**, or a combination of these hardware and software. For example, in case of a vehicle onboard network from which the HCU **100** is removed, a part or all of processes such as a reference position setting process and a light emission mode setting process may be executed by a control circuit of a light emission device, a control circuit of a vehicle control ECU, or others.

**1**.-**23**. (canceled)

**24**. An information presentation apparatus that is mounted on a vehicle together with a driving assist device for assisting a driving operation of a driver or taking a wheel, and presents information about the vehicle to the driver, the information presentation apparatus comprising:

an information acquisition unit that acquires operation information about the driving assist device;

a light emission display unit that is disposed on an instrument panel of the vehicle, and displays at least one light emission spot in a light emission area arranged to extend in a width direction of the vehicle;

a light emission control unit that controls a light emission mode of the light emission spot in the light emission area based on the operation information acquired by the information acquisition unit; and

a risk determination unit that determines whether a risk target, to which the driver should pay attention, is disposed around the vehicle or in a traveling direction of the vehicle, wherein:

the light emission control unit switches a reference position, at which the light emission spot is displayed, between a case where the driving assist device is in operation and a case where the driving assist device is not in operation;

when the risk target is disposed, the light emission control unit displays the light emission spot in the light emission area to indicate a direction to which the risk target is disposed as viewed from the driver; and

the light emission control unit sets a size of the light emission spot to indicate the direction of the risk target as viewed from the driver when an eye point of the driver shifts frontward or rearward with respect to the vehicle.

**25**. The information presentation apparatus according to claim **24**, wherein:

the light emission control unit enlarges the light emission spot as a display position of the light emission spot shifts away from the driver.

**26**. An information presentation apparatus that is mounted on a vehicle together with a driving assist device for assisting a driving operation of a driver or taking a wheel, and presents information about the vehicle to the driver, the information presentation apparatus comprising:

an information acquisition unit that acquires operation information about the driving assist device;

a light emission display unit that is disposed on an instrument panel of the vehicle, and displays at least one light emission spot in a light emission area arranged to extend in a width direction of the vehicle; and

a light emission control unit that controls a light emission mode of the light emission spot in the light emission area based on the operation information acquired by the information acquisition unit, wherein:

the light emission control unit switches a reference position, at which the light emission spot is displayed, between a case where the driving assist device is in operation and a case where the driving assist device is not in operation; and

the light emission control unit enlarges the light emission spot as a display position of the light emission spot shifts away from the driver.

**27**. The information presentation apparatus according to claim **26**, further comprising:

a risk determination unit that determines whether a risk target, to which the driver should pay attention, is disposed around the vehicle or in a traveling direction of the vehicle, wherein:

when the risk target is disposed, the light emission control unit displays the light emission spot in the light emission area to indicate a direction to which the risk target is disposed as viewed from the driver.

**28**. The information presentation apparatus according to claim **27**, wherein:

the light emission control unit shifts a position of the light emission spot in the light emission area to follow a relative positional change of the risk target with respect to the vehicle.

**29**. The information presentation apparatus according to claim **27**, wherein:

when a plurality of risk targets are disposed in a predetermined range, the light emission control unit shows the driver a direction, in which the plurality of risk targets are collectively disposed, by enlarging the light emission spot in a width direction of the vehicle and by displaying the light emission spot in the light emission area.

**30**. The information presentation apparatus according to claim **27**, wherein:

the risk determination unit calculates a risk level of each risk target detected around the vehicle or in the traveling direction of the vehicle; and

when the risk determination unit determines that a plurality of risk targets are disposed, the light emission control unit selects one of the plurality of risk targets having a highest risk level as a highest risk target, and displays the light emission spot in the light emission area to indicate a direction to which the highest risk target is disposed as viewed from the driver.

**31**. The information presentation apparatus according to claim **27**, further comprising:

an audio control unit that warns the driver about a presence of the risk target by outputting a sound from an audio reproduction device when the direction, to which the risk target is disposed as viewed from the driver, is out of an extension range of the light emission area.

**32**. The information presentation apparatus according to claim **26**, wherein:

the light emission control unit sets the reference position in a case where the driving assist device is in operation to be closer to a center of the vehicle in the width direction than the reference position in a case where the driving assist device is not in operation.

**33**. The information presentation apparatus according to claim **26**, wherein:

the light emission control unit sets the reference position in a case where the driving assist device is not in operation to be in front of a driver's seat (**17***d*) on which the driver sits down.

**34**. The information presentation apparatus according to claim **26**, wherein:

the information acquisition unit further acquires a determination result indicative of a risk level of the vehicle; and

the light emission control unit changes an emission color of the light emission spot in accordance with the risk level.

**35**. The information presentation apparatus according to claim **26**, wherein:

the information acquisition unit further acquires a determination result indicative of a risk level of the vehicle; and

the light emission control unit changes a size of the light emission spot in accordance with the risk level.

**36**. The information presentation apparatus according to claim **35**, wherein:

the information acquisition unit further acquires a determination result of the risk level based on a careless state of the driver; and

the light emission control unit enlarges and displays the light emission spot as the risk level increases.

**37**. The information presentation apparatus according to claim **35**, wherein:

the information acquisition unit further acquires a determination result of the risk level based on a careless state of the driver; and

the light emission control unit reduces and displays the light emission spot as the risk level decreases.

**38**. The information presentation apparatus according to claim **26**, wherein:

the driving assist device has at least a steering function for assisting a steering operation of the driver or taking a steering operation among a plurality of driving operations performed by the driver; and

the light emission control unit changes the reference position based on whether the steering function of the driving assist device is in operation.

**39**. The information presentation apparatus according to claim **26**, wherein:

the information acquisition unit further acquires steering information indicative of a target steering direction in which an expected traveling track of the vehicle is realized; and

the light emission control unit shifts the reference position of the light emission spot in a direction corresponding to the target steering direction.

**40**. The information presentation apparatus according to claim **39**, wherein:

the information acquisition unit further acquires a target steering amount to the target steering direction as the steering information; and

the light emission control unit suspends to shift the reference position when the target steering amount is smaller than a lower limit threshold.

**41**. The information presentation apparatus according to claim **26**, wherein:

the light emission control unit repeatedly changes a brightness of the light emission spot in a cycle corresponding to a heart rate or a pulse rate of the driver in a normal state.

**42**. The information presentation apparatus according to claim **26**, wherein:

the information acquisition unit further acquires occurrence information of an event, to which the driver should pay attention in a right side or a left side of the vehicle; and

the light emission control unit shifts the light emission spot from the reference position toward the direction of the right side or the left side, to which the driver should pay attention, based on the occurrence information of the event.

**43**. The information presentation apparatus according to claim **42**, wherein:

the light emission control unit temporarily turns off the light emission spot before starting to shift the light emission spot.

**44**. The information presentation apparatus according to claim **42**, wherein:

the light emission control unit shifts the light emission spot substantially at a same speed in both a case where the driving assist device is in operation and a case where the driving assist device is not in operation.

**45**. The information presentation apparatus according to claim **42**, wherein:

the light emission control unit finish shifting the light emission spot at a position closer to the reference position than an end of the light emission area that extends toward an assistant driver's seat of the vehicle.

**46**. The information presentation apparatus according to claim **26**, wherein:

the information acquisition unit further acquires inattentive driving information indicating that the driver looks aside; and

based on the inattentive driving information, the light emission control unit shifts the light emission spot from a right side or a left side, to which the driver looks aside, toward a front of a driver's seat on which the driver sits down.

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