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(54) **DISPLAY DEVICE AND HEAD-UP DISPLAY**

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(57) **ABSTRACT**

A display device includes: a display panel that includes a display area that displays an image on a front surface and a peripheral area located outside the display area, and that projects light incident on a back surface from the display area as display light that represents the image; a heat sink disposed to face the back surface of the display panel; a light-transmitting member held between the display panel and the heat sink; and a temperature sensor disposed in the peripheral area of the display panel to detect a temperature of the display panel. When viewed in a direction perpendicular to the front surface of the display panel, the temperature sensor does not overlap with at least one of the heat sink or the light-transmitting member.

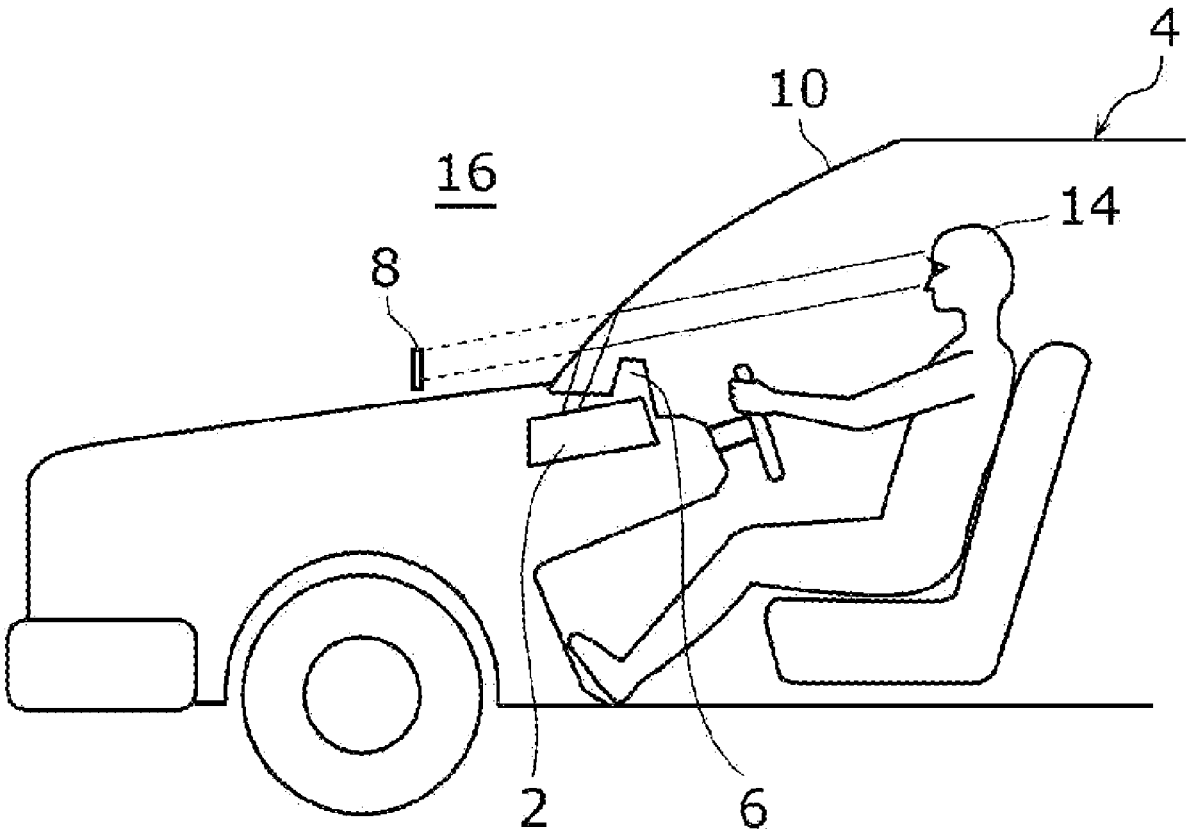


FIG. 1

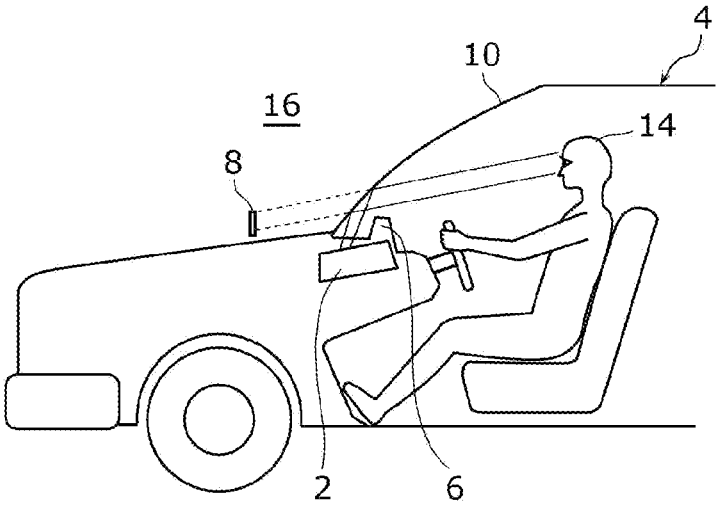


FIG. 2

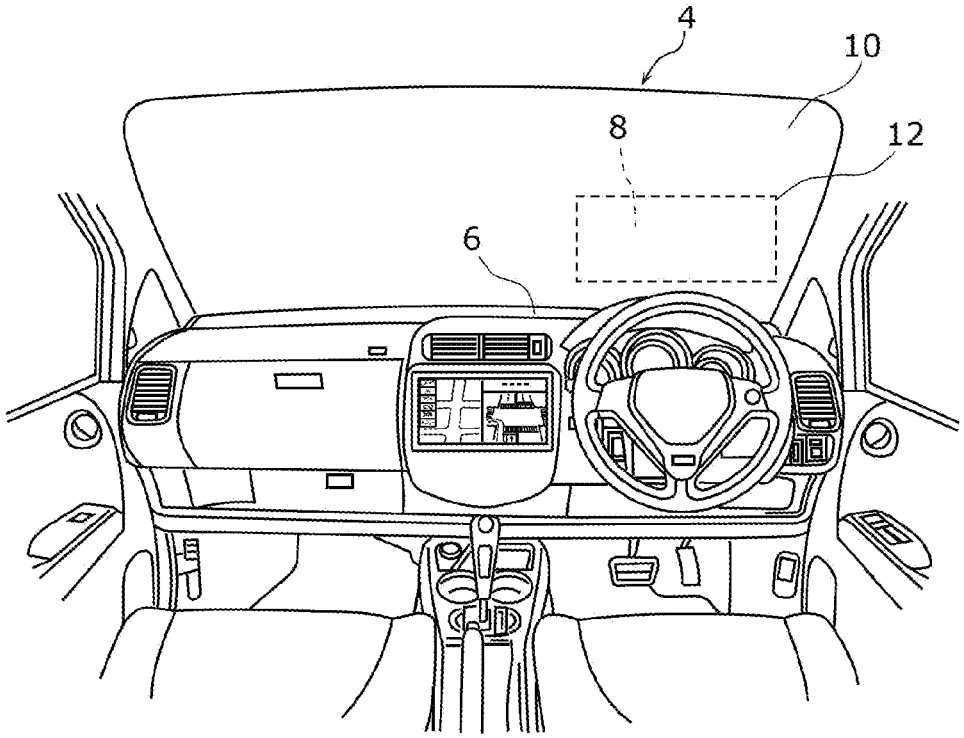


FIG. 3

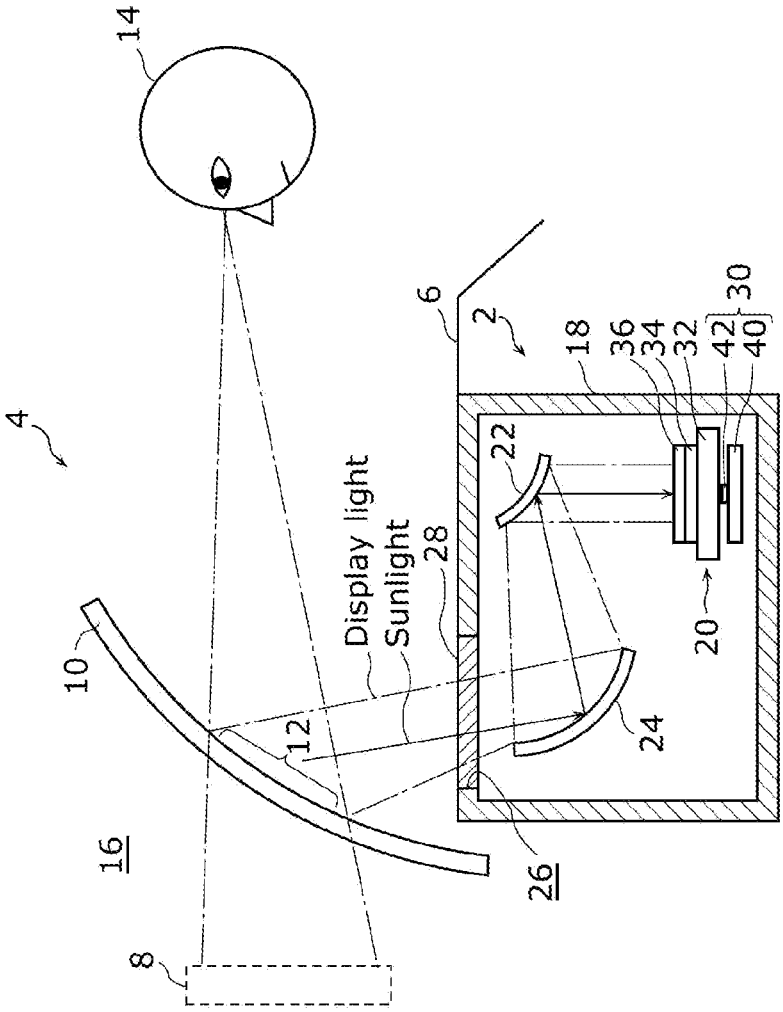

14
6
2
18
36
34
32
42
40
30
4
22
Display light
Sunlight
28
10
20
12
24
16
26
8

FIG. 4

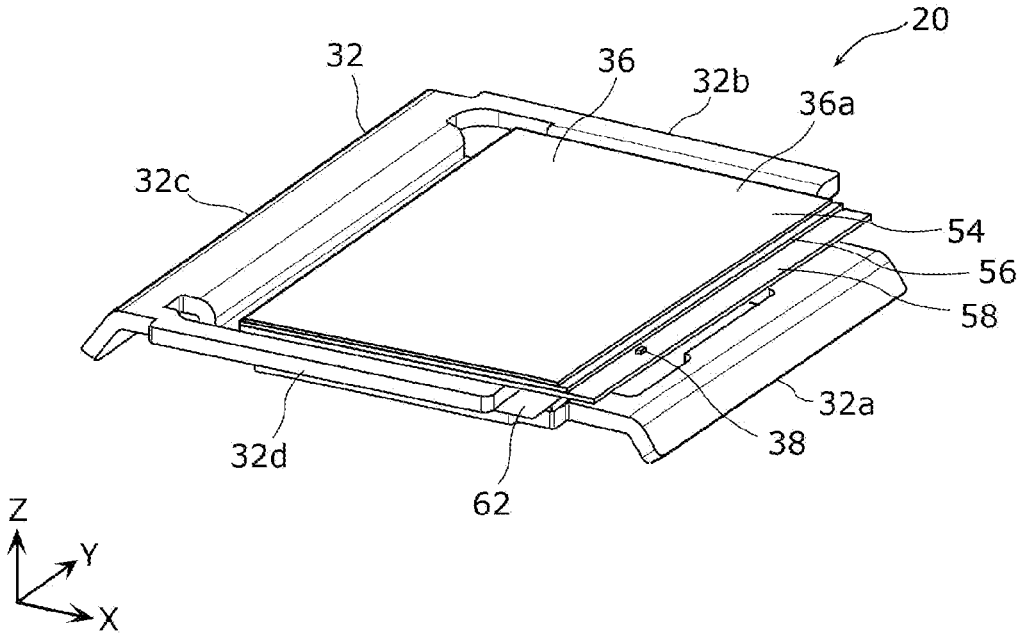


FIG. 5

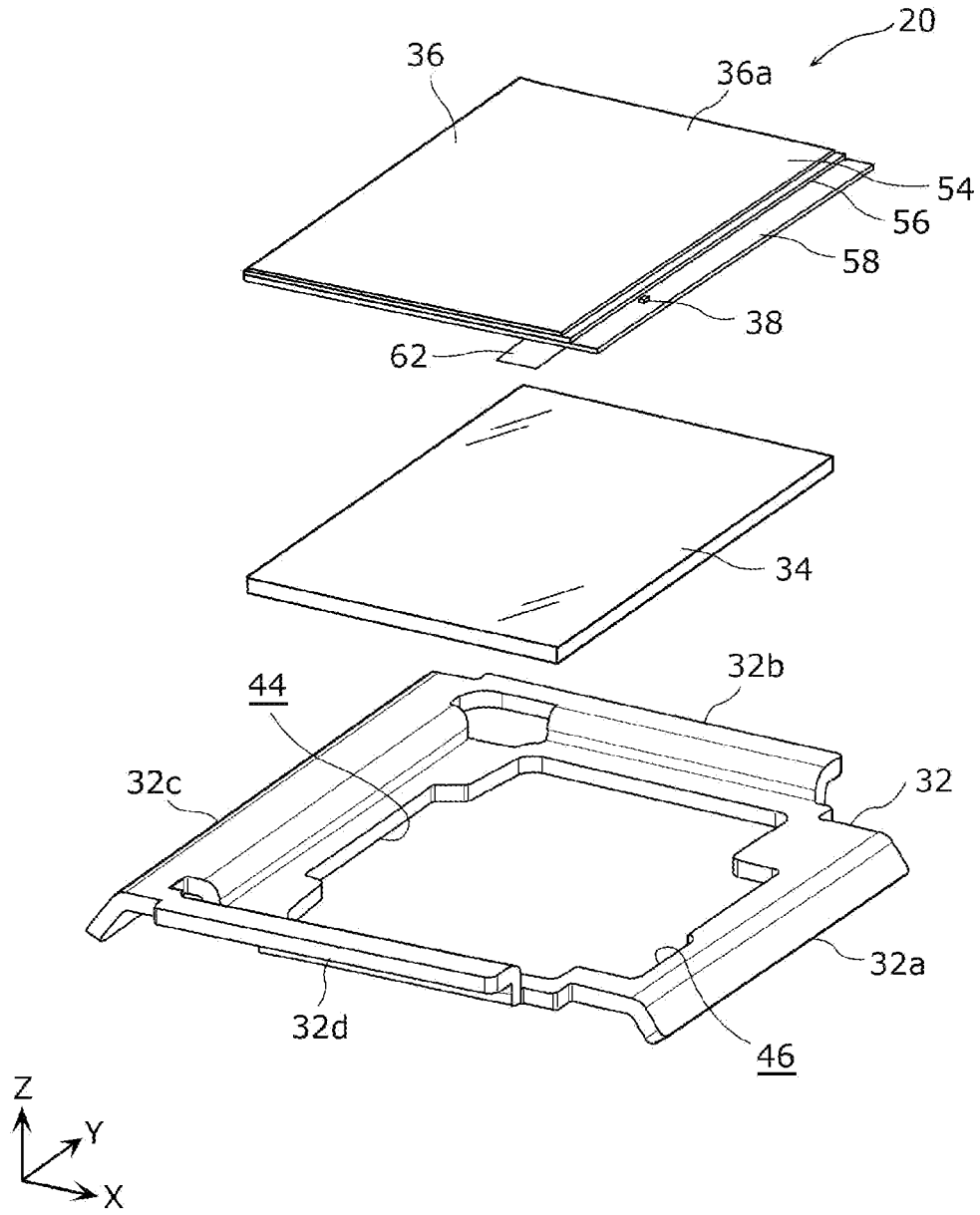


FIG. 6

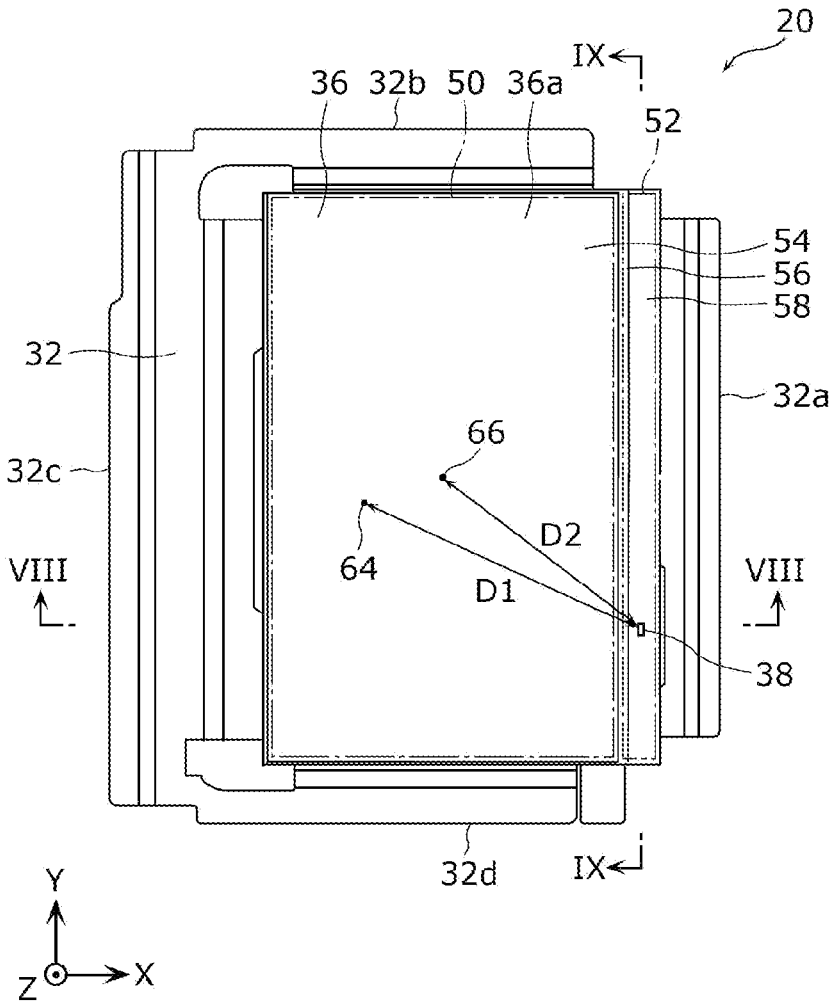

20
IX
36
32b
50
36a
52
54
56
58
32
32a
66
32c
D2
64
D1
VIII
VIII
38
32d
IX
Y
Z
X

FIG. 7

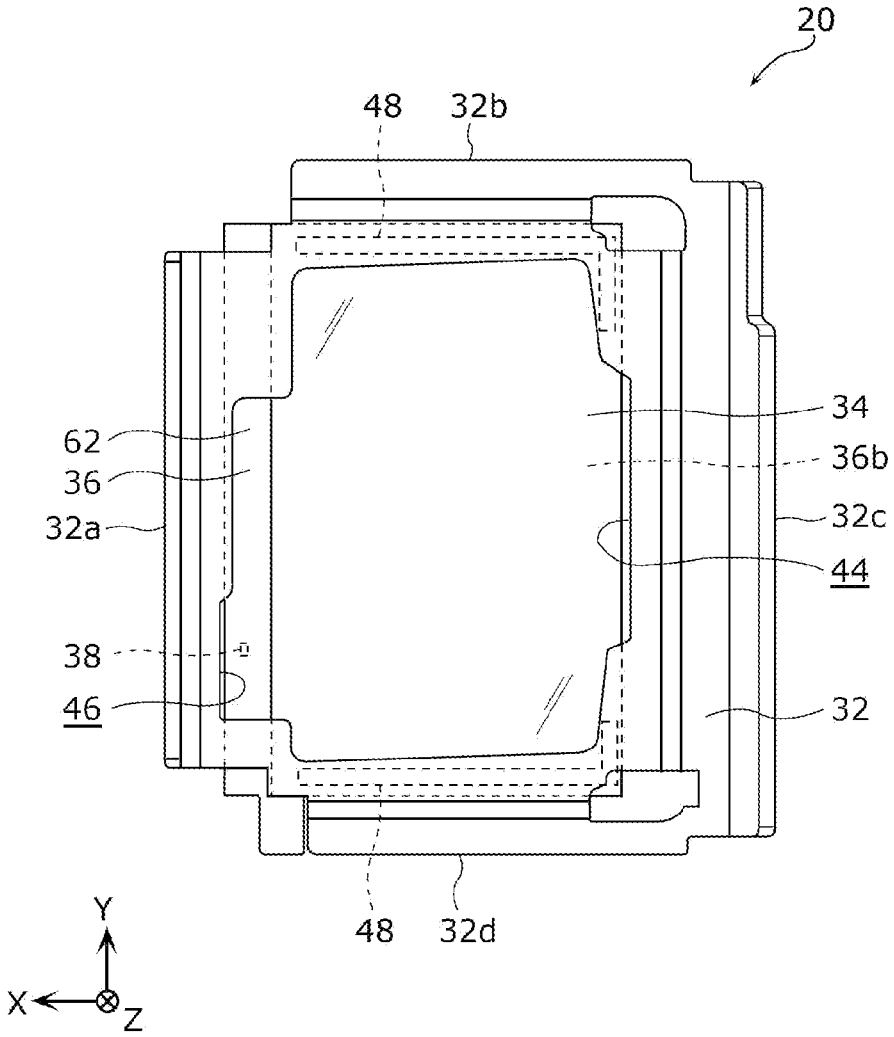


FIG. 8

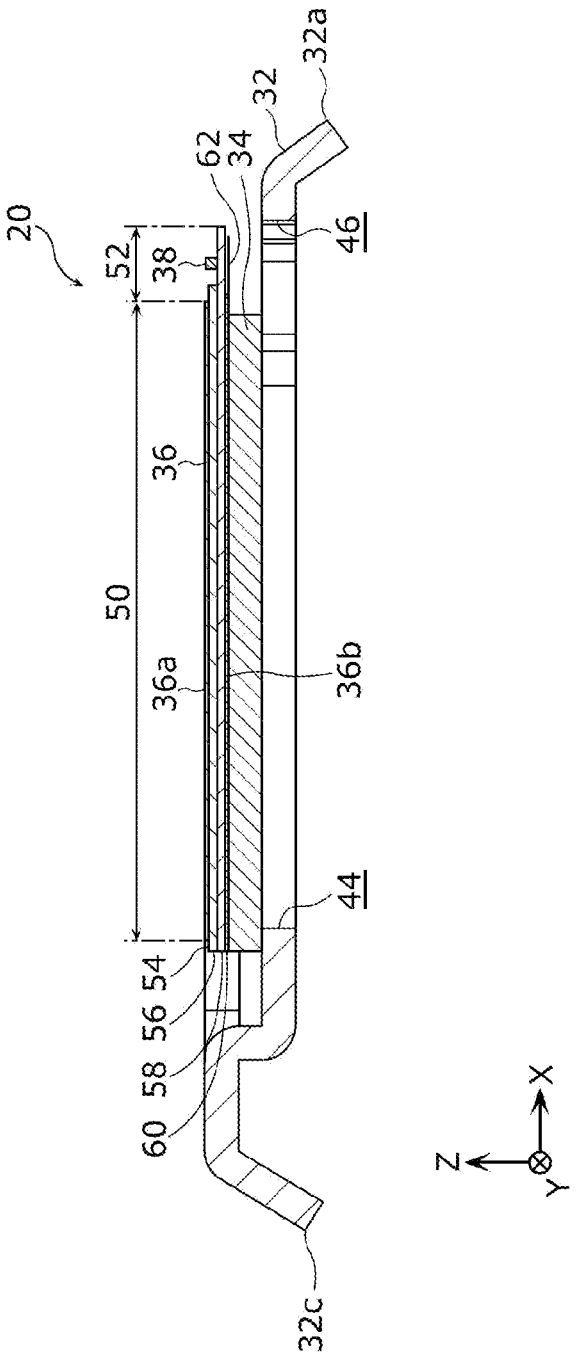


FIG. 9

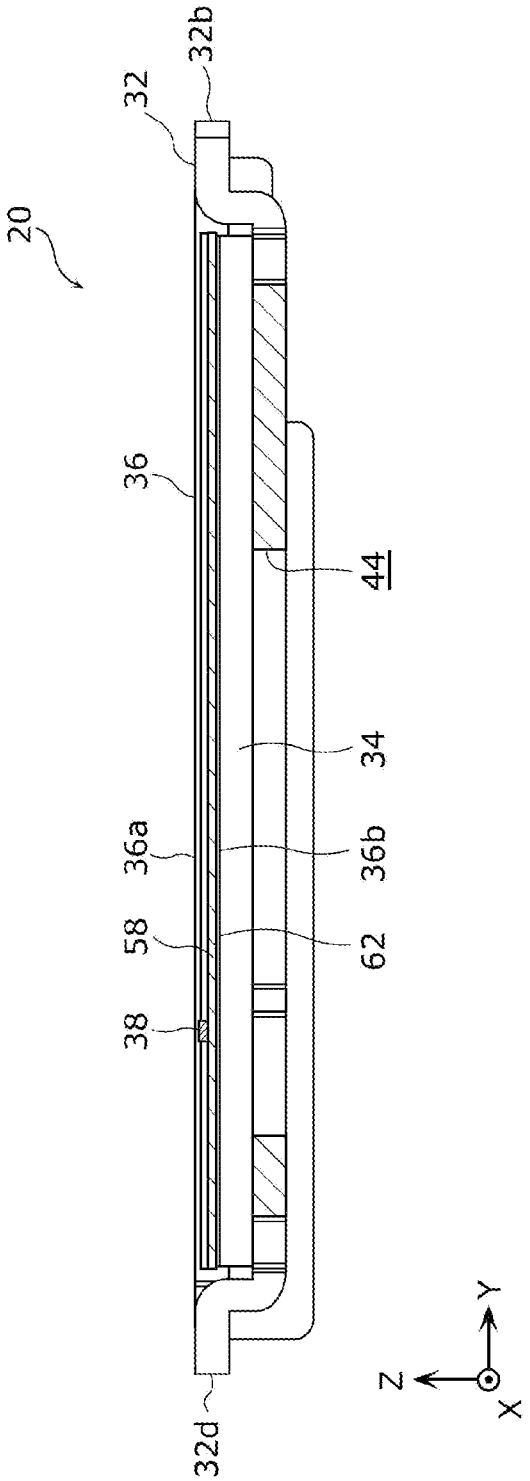
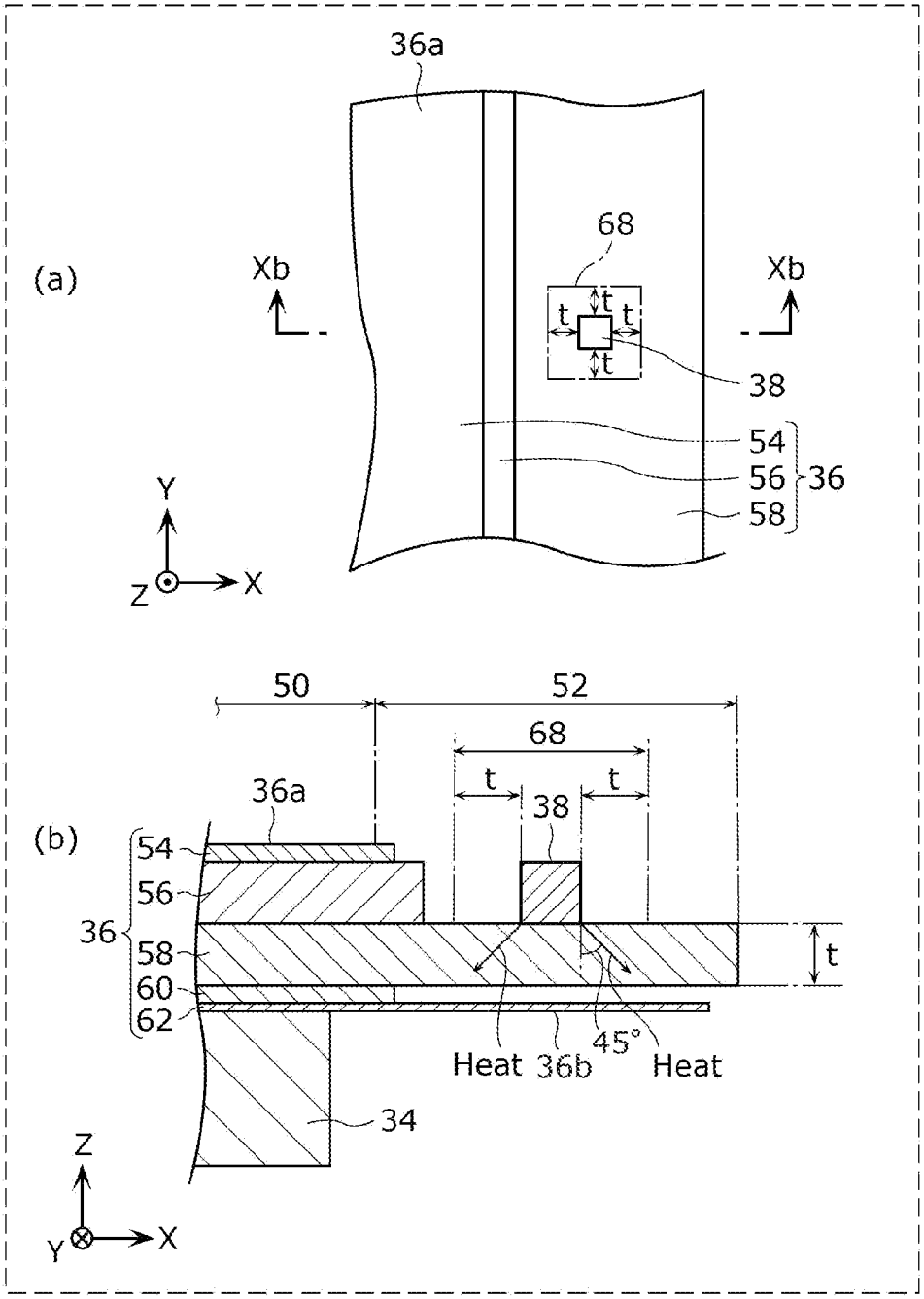


FIG. 10


(a)
36a
68
Xb
Xb
t
t
t
t
38
54
56
58
36
Y
Z
X
(b)
50
52
68
t
t
38
36a
54
56
36
58
60
62
t
Heat
36b
45°
Heat
34
Z
Y
X

DISPLAY DEVICE AND HEAD-UP DISPLAY

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application is based on and claims priority of Japanese Patent Application No. 2023-025324 filed on Feb. 21, 2023.

FIELD

[0002] The present disclosure relates to a display device and a head-up display.

BACKGROUND

[0003] A head-up display (HUD) mounted on a vehicle is known. In this head-up display, by light from the backlight entering the back surface of the display panel and exiting from the display area on the front surface of the display panel, and the light from the display area being reflected by a mirror and projected onto the vehicle's windshield (front glass), a virtual image of the image displayed in the display area of the display panel is displayed superimposed on the scenery in front of the vehicle on the windshield of the vehicle.

[0004] In the head-up display mentioned above, when sunlight enters the vehicle interior from the outside of the vehicle through the windshield, is reflected by the mirror mentioned above, and is focused on the display area of the display panel, the display panel becomes hot and has a risk of damage. In order to avoid such an issue, a technique has been proposed in which by bringing the back surface of the display panel into contact with a heat sink through a light-transmitting member made of glass, the heat generated by the display panel due to sunlight is conducted to a heat sink through the light-transmitting member and heat is dissipated (for example, see Patent Literature (PTL) 1).

[0005] Furthermore, a technique related to a so-called fail-safe function has been proposed in which a temperature sensor is placed in the peripheral area outside of the display area in the front surface of the display panel, and when the temperature of the display panel detected by the temperature sensor exceeds a threshold value, the display panel is activated by displacing the mirror described above.

CITATION LIST

Patent Literature

[0006] PTL 1: Japanese Unexamined Patent Application Publication No. 2016-31457

SUMMARY

[0007] The conventional head-up display mentioned above can be improved upon.

[0008] In view of this, the present disclosure provides a display device and a head-up display capable of improving upon the above related art.

[0009] A display device according to one aspect of the present disclosure is a display device for use in a head-up display, the display device including: a display panel that includes a display area that displays an image on a front surface and a peripheral area located outside the display area, and that projects light incident on a back surface from the display area as display light that represents the image; a heat sink disposed to face the back surface of the display panel; a light-transmitting member held between the display panel and the heat sink; and a temperature sensor disposed in the peripheral area of the display panel to detect a temperature of the display panel, wherein when viewed in a direction perpendicular to the front surface of the display panel, the temperature sensor does not overlap with at least one of the heat sink or the light-transmitting member.

[0010] It should be noted that these comprehensive or specific aspects may be realized by a system, a method, an integrated circuit, a computer program, or a computer-readable recording medium such as a compact disc-read only memory (CD-ROM), and may be also realized in any combination of systems, methods, integrated circuits, computer programs, and recording media.

[0011] The display device and the like according to one aspect of the present disclosure is capable of improving upon the above related art.

BRIEF DESCRIPTION OF DRAWINGS

[0012] These and other advantages and features of the present disclosure will become apparent from the following description thereof taken in conjunction with the accompanying drawings that illustrate a specific embodiment of the present disclosure.

[0013] FIG. **1** is a diagram showing a vehicle equipped with a head-up display according to an embodiment.

[0014] FIG. **2** is a diagram showing an area of the windshield where a HUD image is displayed by the head-up display according to the embodiment.

[0015] FIG. **3** is a schematic diagram showing a configuration of the head-up display according to the embodiment.

[0016] FIG. **4** is a perspective view showing a display device according to the embodiment.

[0017] FIG. **5** is an exploded perspective view showing the display device according to the embodiment.

[0018] FIG. **6** is a plan view showing the display device according to the embodiment.

[0019] FIG. **7** is a bottom view of the display device according to the embodiment.

[0020] FIG. **8** is a cross-sectional view of the display device according to the embodiment taken along line VIII-VIII in FIG. **6**.

[0021] FIG. **9** is a cross-sectional view of the display device according to the embodiment taken along line IX-IX in FIG. **6**.

[0022] FIG. **10** is an enlarged view of a temperature sensor of the display device according to the embodiment.

DESCRIPTION OF EMBODIMENT

(Underlying Knowledge Forming Basis of the Present Disclosure)

[0023] The present inventors have found that the following issue occur with the technology described in the "Background" section.

[0024] In the conventional head-up display mentioned above, an opening is formed in the heat sink corresponding to the display area of the display panel, and light from the backlight enters the back surface of the display panel through the opening in the heat sink. For that reason, in the display panel, heat is more easily dissipated by the heat sink

in the peripheral area where the temperature sensor is disposed than at the center of the display area.

[0025] However, with such a configuration, the difference between the temperature at the center of the display area of the display panel and the temperature detected by the temperature sensor becomes large, which creates the issue that the fail-safe function may not be executed correctly.

[0026] In order to solve such problem, a display device according to a first aspect of the present disclosure is a display device for use in a head-up display, the display device including: a display panel that includes a display area that displays an image on a front surface and a peripheral area located outside the display area, and that projects light incident on a back surface from the display area as display light that represents the image; a heat sink disposed to face the back surface of the display panel; a light-transmitting member held between the display panel and the heat sink; and a temperature sensor disposed in the peripheral area of the display panel to detect a temperature of the display panel, wherein when viewed in a direction perpendicular to the front surface of the display panel, the temperature sensor does not overlap with at least one of the heat sink or the light-transmitting member.

[0027] According to this aspect, when viewed in a direction perpendicular to the front surface of the display panel, the temperature sensor does not overlap with at least one of the heat sink or the light-transmitting member. This makes it difficult for the heat from the temperature sensor to be dissipated by the heat sink, so the difference between the temperature at the center of the display area of the display panel and the temperature detected by the temperature sensor can be suppressed to a small value. As a result, it is possible to accurately estimate the temperature at the center of the display area of the display panel based on the temperature detected by the temperature sensor, and for example, it is possible to correctly perform a fail-safe function and the like.

[0028] For example, the display device according to Aspect 2 may be configured so that in Aspect 1, the display panel includes a plurality of optical members stacked, and when viewed in the direction perpendicular to the front surface of the display panel, a predetermined area including the temperature sensor is an area expanded outward from an outermost shape of the temperature sensor by more than or equal to a thickness of one or more optical members of the plurality of optical members, and is disposed at a position where the temperature sensor does not overlap with at least one of the heat sink or the light-transmitting member.

[0029] According to this aspect, when the optical member of the display panel is formed of an isotropic material, the heat of the temperature sensor spreads inside the optical member in a diagonal direction with respect to the vertical line. Even in such a case, it is possible to more effectively suppress the heat from the temperature sensor from being conducted to the heat sink via the light-transmitting member.

[0030] For example, the display device according to Aspect 3 may be configured so that in Aspect 1 or Aspect 2, when viewed in the direction perpendicular to the front surface of the display panel, the peripheral area of the display panel protrudes outward beyond an outer peripheral part of the light-transmitting member.

[0031] According to this aspect, the temperature sensor can be placed at a position where the temperature sensor does not overlap with the light-transmitting member when viewed in a direction perpendicular to the front surface of the display panel.

[0032] For example, the display device according to Aspect 4 may be configured so that in any one of Aspects 1 to 3, when a highest temperature region where a temperature is highest due to condensation of sunlight from an outside is present on the front surface of the display panel, a distance between a highest temperature region and the temperature sensor is longer than a distance between a center of the display area and the temperature sensor.

[0033] According to this aspect, in such a case that the distance between the highest temperature region and the temperature sensor is longer than the distance between the center of the display area and the temperature sensor, when designing the display device, it is necessary to use the difference between the temperature in the highest temperature region and the temperature detected by the sensor. Even in such a case, by employing the heat sink configuration mentioned above, the difference between the temperature in the highest temperature region and the temperature detected by the temperature sensor can be suppressed to a smaller value.

[0034] For example, the display device according to Aspect 5 may be configured so that in any one of Aspects 1 to 3, the display device further includes a light source that emits light onto the back surface of the display panel, and when a highest temperature region where a temperature is highest due to emission of the light from the light source onto the back surface of the display panel is present on the front surface of the display panel, a distance between a highest temperature region and the temperature sensor is longer than a distance between a center of the display area and the temperature sensor.

[0035] According to this aspect, in such a case that the distance between the highest temperature region and the temperature sensor is longer than the distance between the center of the display area and the temperature sensor, when designing the display device, it is necessary to use the difference between the temperature in the highest temperature region and the temperature detected by the sensor. Even in such a case, by employing the heat sink configuration mentioned above, the difference between the temperature in the highest temperature region and the temperature detected by the temperature sensor can be suppressed to a smaller value.

[0036] For example, the display device according to Aspect 6 may be configured so that in any one of Aspects 1 to 5, the heat sink is in a frame shape including four sides, and among the four sides of the heat sink, a thickness of one side corresponding to the position of the temperature sensor is thinner than a thickness of each of other three sides.

[0037] According to this aspect, it is possible to more effectively make it difficult to dissipate heat from the temperature sensor.

[0038] For example, the display device according to Aspect 7 may be configured so that in any one of Aspects 1 to 5, the heat sink is in a frame shape including four sides, and among the four sides of the heat sink, a thermal conductivity of one side corresponding to the position of the temperature sensor is lower than a thermal conductivity of each of other three sides.

[0039] According to this aspect, it is possible to more effectively make it difficult to dissipate heat from the temperature sensor.

[0040] For example, the display device according to Aspect 8 may be configured so that in any one of Aspects 1 to 5, the heat sink is in a frame shape including four sides, and among the four sides of the heat sink, one side corresponding to the position of the temperature sensor is not anodized, and each of other three sides is anodized.

[0041] According to this aspect, it is possible to more effectively make it difficult to radiate heat from the temperature sensor.

[0042] For example, the display device according to Aspect 9 may be configured so that in any one of Aspects 1 to 8, the display device further includes a heat dissipation sheet held between the heat sink and the light-transmitting member.

[0043] According to this aspect, the heat conducted from the display panel to the light-transmitting member can be efficiently conducted to the heat sink via the heat dissipation sheet.

[0044] For example, the display device according to Aspect 10 may be configured so that in Aspect 9, the heat sink is in a frame shape including four sides, and the heat dissipation sheet is held between the light-transmitting member and each of three sides other than one side corresponding to the position of the temperature sensor among the four sides of the heat sink.

[0045] According to this aspect, it is possible to more effectively make it difficult to dissipate heat from the temperature sensor.

[0046] For example, the display device according to Aspect 11 may be configured so that in any one of Aspects 1 to 10, the thermal conductivity of the light-transmitting member is 3 W/mK or less.

[0047] According to this aspect, the heat conduction efficiency by the light-transmitting member can be more effectively increased.

[0048] For example, the display device according to Aspect 12 may be configured so that in any one of Aspects 1 to 11, the temperature sensor is a thermistor.

[0049] According to this aspect, the temperature sensor can be downsized.

[0050] In addition, a head-up display according to Aspect 13 of the present disclosure includes the display device according to any one of Aspects 1 to 12; and a mirror that reflects the display light projected from the display device toward a display medium.

[0051] According to this aspect, as described above, the difference between the temperature at the center of the display area of the display panel and the temperature detected by the temperature sensor can be kept small.

[0052] Hereinafter, embodiments will be specifically described with reference to the drawings.

[0053] It should be noted that all embodiments described below show comprehensive or specific examples. The numerical values, shapes, materials, components, arrangement positions and connection forms of the components, steps, order of steps, and the like shown in the following embodiments are examples, and do not limit the present disclosure. In addition, among the components in the following embodiments, components that are not described in the independent claims indicating the broadest concept will be described as optional components.

EMBODIMENT

1. Configuration of Head-Up Display

[0054] First, the configuration of head-up display **2** according to an embodiment will be described with reference to FIG. **1** to FIG. **3**. FIG. **1** is a diagram showing vehicle **4** equipped with head-up display **2** according to the embodiment. FIG. **2** is a diagram showing area **12** of windshield **10** where HUD image **8** is displayed by head-up display **2** according to the embodiment. FIG. **3** is a schematic diagram showing the configuration of head-up display **2** according to the embodiment.

[0055] As shown in FIG. **1**, head-up display **2** according to the embodiment is disposed inside dashboard **6** of vehicle **4** such as an automobile. As shown in FIG. **1** to FIG. **3**, in head-up display **2**, by projecting the display light for displaying HUD image **8**, which is a virtual image, toward the lower side of windshield **10** (an example of a display medium) of vehicle **4** near the driver's seat, for example, the display light is reflected toward driver **14** by area **12** of windshield **10**. Accordingly, driver **14** can see HUD image **8**, which is a virtual image, superimposed on the scenery in front of windshield **10** in area **12** of windshield **10**. That is, for driver **14**, HUD image **8** appears as if it were displayed in space **16** in front of windshield **10**.

[0056] As shown in FIG. **3**, head-up display **2** includes main housing **18**, display device **20**, first mirror **22** (an example of a mirror), and second mirror **24** (an example of a mirror).

[0057] Main housing **18** is in a box shape, and is made of metal such as aluminum, for example. Main housing **18** is disposed inside dashboard **6** of vehicle **4**. Display device **20**, first mirror **22**, and second mirror **24** are disposed inside main housing **18**. The upper surface of main housing **18** is disposed to face windshield **10**. Opening **26** is formed in the upper surface of main housing **18**. This opening **26** is covered with plate-shaped cover member **28** made of, for example, transparent resin.

[0058] Display device **20** is a picture generation unit (PGU) that projects display light for displaying HUD image **8** toward first mirror **22**. The configuration of display device **20** will be described later.

[0059] First mirror **22** is, for example, a convex mirror, and reflects the display light from display device **20** toward second mirror **24**. Second mirror **24** is, for example, a concave mirror, and reflects the display light from first mirror **22** toward area **12** of windshield **10**. The display light from second mirror **24** is transmitted through cover member **28** and reflected by area **12** of windshield **10**, and then enters the eyes of driver **14**.

[0060] It should be noted that in the present embodiment, head-up display **2** includes two mirrors (first mirror **22** and second mirror **24**), but is not limited thereto, and may include one mirror or three or more mirrors.

2. Configuration of the Display Device

[0061] Next, the configuration of display device **20** according to the embodiment will be described with reference to FIG. **3** to FIG. **10**. FIG. **4** is a perspective view showing display device **20** according to the embodiment. FIG. **5** is an exploded perspective view showing display device **20** according to the embodiment. FIG. **6** is a plan view showing display device **20** according to the embodi-

ment. FIG. **7** is a bottom view showing display device **20** according to the embodiment. FIG. **8** is a cross-sectional view of display device **20** according to the embodiment taken along line VIII-VIII in FIG. **6**. FIG. **9** is a cross-sectional view of display device **20** according to the embodiment taken along line IX-IX in FIG. **6**. FIG. **10** is an enlarged view of temperature sensor **38** of display device **20** according to the embodiment. Specifically, (a) in FIG. **10** is an enlarged plan view showing temperature sensor **38** of display device **20** according to the embodiment, and (b) in FIG. **10** is a cross-sectional view of display panel **36** and temperature sensor **38** taken along the line Xb-Xb in (a) in FIG. **10**.

[0062] It should be noted that in FIG. **4** to FIG. **10**, the horizontal direction of display panel **36** is the X-axis direction, the vertical direction of display panel **36** is the Y-axis direction, and the thickness direction of display panel **36** is the Z-axis direction. In addition, in FIG. **4** to FIG. **10**, the positive side of the Z axis is referred to as "upper", and the negative side of the Z axis is referred to as "lower".

[0063] As shown in FIG. **3** to FIG. **9**, display device **20** includes a PGU housing (not shown), backlight **30** (an example of a light source) (see FIG. **3**), heat sink **32**, light-transmitting member **34**, display panel **36**, and temperature sensor **38**.

[0064] The PGU housing is fixed inside main housing **18** (see FIG. **3**). The PGU housing is formed in a cylindrical shape with a rectangular cross section, for example, and is mainly made of resin. Backlight **30**, heat sink **32**, light-transmitting member **34**, display panel **36**, and temperature sensor **38** are disposed inside the PGU housing.

[0065] As shown in FIG. **3**, backlight **30** is disposed to face opening **44** (described later) of heat sink **32**. Backlight **30** includes substrate **40** and light emitting diode (LED) **42** mounted on substrate **40**. It should be noted that for convenience of explanation, illustration of backlight **30** is omitted in FIG. **4** to FIG. **9**.

[0066] Heat sink **32** is for dissipating heat generated by display panel **36**, and is made of a metal with high heat dissipation properties, such as aluminum. As shown in FIG. **3**, heat sink **32** is disposed to face backlight **30**. In addition, as shown in FIG. **8** and FIG. **9**, heat sink **32** is disposed to face back surface **36***b* of display panel **36**. As shown in FIG. **5** to FIG. **7**, heat sink **32** is formed in a substantially rectangular frame shape including four sides **32***a*, **32***b*, **32***c*, and **32***d*, for example, when viewed from the XY plane (that is, viewed in a direction perpendicular to front surface **36***a* of display panel **36**). A pair of sides **32***a* and **32***c* face with each other, and a pair of sides **32***b* and **32***d* face with each other.

[0067] As shown in FIG. **5** and FIG. **7**, opening **44** is formed in heat sink **32** in correspondence with display area **50** (described later) of display panel **36**. A part of the lower surface of light-transmitting member **34** (the surface on the side of heat sink **32**) is exposed through opening **44** of heat sink **32**, so the light from LED **42** of backlight **30** enters back surface **36***b* of display panel **36** through opening **44** of heat sink **32** and light-transmitting member **34**. In addition, recess **46** that protrudes radially outward from opening **44** is formed in a region of the peripheral edge of opening **44** that corresponds to the position of temperature sensor **38**.

[0068] Light-transmitting member **34** is made of a material having light-transmitting properties, such as transparent glass, and is formed in a rectangular plate shape when viewed from the XY plane. Light-transmitting member **34** is a member for conducting heat generated in display panel **36** to heat sink **32**, and is held between back surface **36***b* of display panel **36** and the periphery of opening **44** in the upper surface of heat sink **32** (the side of light-transmitting member **34**) as shown in FIG. **7** and FIG. **8**. That is, the upper surface of light-transmitting member **34** (the surface on the side of display panel **36**) is in contact with back surface **36***b* of display panel **36** in a thermally conductive manner, and the lower surface of light-transmitting member **34** is in contact with the periphery of opening **44** on the upper surface of heat sink **32** in a thermally conductive manner. The thermal conductivity of light-transmitting member **34** is preferably 3 W/mK or less.

[0069] As shown in FIG. **8**, the size of light-transmitting member **34** in the lateral direction (X-axis direction) is smaller than the size of display panel **36** in the lateral direction. In addition, as shown in FIG. **9**, the size of light-transmitting member **34** in the longitudinal direction (Y-axis direction) is substantially the same as the size of display panel **36** in the longitudinal direction. It should be noted that light-transmitting member **34** does not necessarily have to be transparent with a transmittance of 100%, and may be transparent with a transmittance lower than 100% (for example, transparent with a transmittance of about 80 to 90%).

[0070] It should be noted that as shown in FIG. **7**, heat dissipation sheet **48** is interposed between the lower surface of light-transmitting member **34** and the periphery of opening **44** on the upper surface of heat sink **32**. Specifically, heat dissipation sheet **48** is held between the region of the periphery of opening **44** on the upper surface of heat sink **32**, which corresponds to each of three sides **32***b*, **32***c*, and **32***d* of heat sink **32**, and lower surface of light-transmitting member **34**. Accordingly, a region of the periphery of opening **44** on the upper surface of heat sink **32** that corresponds to one side **32***a* of heat sink **32** directly contacts the lower surface of light-transmitting member **34**. In addition, a region of the periphery of opening **44** on the upper surface of heat sink **32** that corresponds to each of three sides **32***b*, **32***c*, and **32***d* of heat sink **32** contact the lower surface of light-transmitting member **34** via heat dissipation sheet **48**. Heat dissipation sheet **48** is a heat conductive member having relatively high thermal conductivity, and is mainly a silicone resin-based sheet.

[0071] Display panel **36** is, for example, a liquid crystal display (LCD), and is formed in a rectangular plate shape when viewed from the XY plane. Back surface **36***b* of display panel **36** is disposed to face the upper surface of light-transmitting member **34**, and is in contact with the upper surface of light-transmitting member **34** in a thermally conductive manner.

[0072] As shown in FIG. **6** and FIG. **8**, display area **50** for displaying an image is formed on front surface **36***a* (the surface opposite to back surface **36***b*) of display panel **36**. Display area **50** includes a rectangular outer shape in an XY plane view, and the size of display area **50** is smaller than the entire size of front surface **36***a* of display panel **36**. Peripheral area **52** is formed outward from display area **50** on front surface **36***a* of display panel **36**, which does not contribute to image display (that is, through which light entering back surface **36***b* of display panel **36** does not pass). In peripheral area **52**, wiring patterns, electrodes, and the like (not shown) are formed. In the present embodiment, peripheral area **52** is

disposed along one side **32***a* of heat sink **32**. It should be noted that peripheral area **52** may be formed in a frame shape so as to surround the entire periphery of display area **50**.

[0073] Here, the specific configuration of display panel **36** will be described with reference to (b) in FIG. **10**. As shown in (b) in FIG. **10**, display panel **36** is configured by stacking, for example, first polarizing plate **54**, first glass plate **56**, second glass plate **58**, second polarizing plate **60**, and diffusion plate **62** (an example of a plurality of optical members) in this order. Diffusion plate **62** is disposed on the side of light-transmitting member **34**, and first polarizing plate **54** is disposed on the side opposite to light-transmitting member **34**. One end of second glass plate **58** in the lateral direction (X-axis direction) protrudes laterally (on the plus side of the X-axis) from one ends of first polarizing plate **54**, first glass plate **56**, and second polarizing plate **60** in their respective lateral directions. That is, one end of second glass plate **58** in the lateral direction protrudes further to the side than the one end of light-transmitting member **34** in the lateral direction. It should be noted that the upper surface at one end in the lateral direction of second glass plate **58** that protrudes laterally defines peripheral area **52** mentioned above. Accordingly, peripheral area **52** comes to protrude outward from the outer peripheral portion of light-transmitting member **34**.

[0074] The light entering back surface **36***b* of display panel **36** passes through display panel **36** and exits from display area **50**. That is, display panel **36** projects the light that has passed through display area **50** as display light representing the image displayed on display area **50**.

[0075] Temperature sensor **38** is a sensor for detecting the temperature of display panel **36**, and includes, for example, a thermistor. As shown in (a) in FIG. **10**, temperature sensor **38** is formed, for example, in a rectangular shape including four sides when viewed from the XY plane. As shown in FIG. **6** to FIG. **8**, temperature sensor **38** is disposed on the upper surface of second glass plate **58** at one end in the lateral direction, which is disposed in peripheral area **52** of display panel **36** and expands outward from the outer periphery of light-transmitting member **34**. Specifically, when viewed in a direction perpendicular to front surface **36***a* of display panel **36**, temperature sensor **38** is disposed at a position where temperature sensor **38** does not overlap with both heat sink **32** and light-transmitting member **34**.

[0076] That is, both heat sink **32** and light-transmitting member **34** are not present directly below temperature sensor **38** when viewed in a direction perpendicular to front surface **36***a* of display panel **36**. This is because, as mentioned above, recess **46** is formed in a region of the periphery of opening **44** of heat sink **32** that corresponds to the position of temperature sensor **38**, and peripheral area **52** of display panel **36** corresponding to the position of temperature sensor **38** protrudes outward from the outer periphery of light-transmitting member **34**.

3. Effects

[0077] As shown in FIG. **3**, during the day, sunlight enters the vehicle interior from the outside of vehicle **4** through windshield **10**. The sunlight that has entered the vehicle interior enters the interior of main housing **18** through cover member **28** of head-up display **2**, is reflected by second mirror **24** and first mirror **22**, respectively, and enters front surface **36***a* of display panel **36** of display device **20**. Accordingly, sunlight is concentrated on front surface **36***a* of display panel **36** of display device **20**, and heat due to the sunlight is generated in display panel **36**.

[0078] In addition, by the light from backlight **30** being emitted onto back surface **36***b* of display panel **36**, heat due to the light from backlight **30** is generated in display panel **36**.

[0079] Heat generated in display panel **36** due to sunlight and/or light from backlight **30** is conducted to heat sink **32** via light-transmitting member **34** and dissipated into the atmosphere while diffusing inside heat sink **32**.

[0080] At this time, as mentioned above, temperature sensor **38** is disposed at a position where temperature sensor **38** does not overlap with both heat sink **32** and light-transmitting member **34** when viewed in a direction perpendicular to front surface **36***a* of display panel **36**. As a result, the heat from temperature sensor **38** is difficult to be conducted to heat sink **32** via light-transmitting member **34**, and the difference between the temperature at the center of display area **50** of display panel **36** and the temperature detected by temperature sensor **38** becomes smaller (for example, about 15 to 30° C.).

[0081] Incidentally, head-up display **2** includes a controller (not shown) that executes a fail-safe function to thermally protect display panel **36** based on the temperature detected by temperature sensor **38**. The controller estimates a temperature higher than the temperature detected by temperature sensor **38** by a predetermined temperature (for example, 25° C.) as the temperature at the center of display area **50** of display panel **36**. Then, when the estimated temperature at the center of display area **50** exceeds a threshold value (for example, 103° C.), the controller controls, for example, the displacement of at least one of first mirror **22** or second mirror **24** and the reduction of the luminous intensity of LED **42** of backlight **30** as a fail-safe function.

[0082] Although not shown, in the conventional head-up display described in the background section, the temperature sensor overlaps with both the heat sink and the light-transmitting member when viewed in the direction perpendicular to the front surface of the display panel. As a result, the heat from the temperature sensor is easily conducted to the heat sink through the light-transmitting member, and the difference between the temperature at the center of the display area of the display panel and the temperature detected by the temperature sensor becomes large (for example, about 50 to 60° C.). However, when the temperature difference increases in this way, the frequency of occurrence of the fail-safe function increases, and the problem that HUD image **8** (virtual image) is dark for driver **14** or HUD image **8** is not displayed is likely to occur.

[0083] On the other hand, in the configuration of head-up display **2** according to the embodiment, as mentioned above, the heat of temperature sensor **38** is difficult to be conducted to heat sink **32** via light-transmitting member **34**, and the difference between the temperature at the center of display area **50** of display panel **36** and the temperature detected by temperature sensor **38** becomes smaller. As a result, such an effect is obtained that the temperature at the center of display area **50** of display panel **36** can be estimated with high accuracy, and the fail-safe function is correctly executed.

[0084] It should be noted that as shown in FIG. **6**, sunlight from the outside is concentrated on front surface **36***a* of display panel **36** (or light from backlight **30** is emitted on

back surface **36***b* of display panel **36**), and there may be highest temperature region **64** where the temperature is the highest. In such a case, distance D**1** between highest temperature region **64** and temperature sensor **38** is preferably longer than distance D**2** between center **66** of display area **50** and temperature sensor **38** for the following reason. Normally, center **66** of display area **50** has the highest temperature, so when designing display device **20**, the difference between the temperature at center **66** and the temperature detected by temperature sensor **38** is used. On the other hand, in such a case that distance D**1** between highest temperature region **64** and temperature sensor **38** is longer than distance D**2** between center **66** and temperature sensor **38**, when designing display device **20**, it is necessary to use the difference between the temperature in highest temperature region **64** and the temperature detected by temperature sensor **38**, rather than the difference between the temperature at center **66** and the temperature detected by temperature sensor **38**. In such a case, by employing the configuration of heat sink **32** according to the embodiment, the difference between the temperature in highest temperature region **64** and the temperature detected by temperature sensor **38** can be suppressed to a smaller value.

[0085] In addition, as shown in (a) and (b) in FIG. **10**, when viewed in a direction perpendicular to front surface **36***a* of display panel **36**, predetermined area **68** including temperature sensor **38** is preferably disposed at a position where predetermined area **68** does not overlap with both of heat sink **32** and light-transmitting member **34**. Here, predetermined area **68** is an area expanded outward from the four sides (outermost shape) of temperature sensor **38** by more than or equal to thickness t (size in the Z-axis direction) of second glass plate **58**, respectively, when viewed in a direction perpendicular to front surface **36***a* of display panel **36**. If second glass plate **58** is formed of isotropic material, the heat from temperature sensor **38** will spread inside second glass plate **58** at an angle of about 45° to the vertical line (Z axis direction). At this time, when viewed in a direction perpendicular to front surface **36***a* of display panel **36**, predetermined area **68**, that is, the area where the heat from temperature sensor **38** spreads, is disposed at a position where predetermined area **68** does not overlap with both heat sink **32** and light-transmitting member **34**. Accordingly, it is possible to more effectively suppress heat from temperature sensor **38** from being conducted to heat sink **32** via light-transmitting member **34**.

(Other Variations)

[0086] Although the display device according to one or more aspects has been described above based on the above embodiment, the present disclosure is not limited to the above embodiment. Forms obtained by applying various modifications to the above embodiment conceived by a person skilled in the art or forms realized by combining the components in different embodiments without departing from the spirit of the present disclosure are also included in the scope of one or more aspects.

[0087] For example, in the above embodiment, the display light from display device **20** is reflected by area **12** of windshield **10**, but the present invention is not limited thereto, and the display light from display device **20** may be reflected by a combiner (an example of a display medium).

[0088] In addition, in the above embodiment, temperature sensor **38** is disposed at a position where temperature sensor **38** does not overlap with both heat sink **32** and light-transmitting member **34**, but the present invention is not limited thereto. It may be disposed at a position where temperature sensor **38** does not overlap with either one.

[0089] In addition, in the above embodiment, heat sink **32** is in a frame shape, but among four sides **32***a*, **32***b*, **32***c*, and **32***d* of heat sink **32**, the thickness of one side **32***a* corresponding to the position of temperature sensor **38** may be thinner than the thickness of each of other three sides **32***b*, **32***c*, and **32***d*. Accordingly, it is possible to more effectively make it difficult to dissipate heat from temperature sensor **38**.

[0090] Alternatively, among four sides **32***a*, **32***b*, **32***c*, and **32***d* of heat sink **32**, the thermal conductivity of one side **32***a* corresponding to the position of temperature sensor **38** may be set lower than the thermal conductivity of each of other three sides **32***b*, **32***c*, and **32***d*. Also, by such a configuration, it is possible to more effectively make it difficult to dissipate heat of temperature sensor **38**.

[0091] Alternatively, among four sides **32***a*, **32***b*, **32***c*, and **32***d* of heat sink **32**, one side **32***a* corresponding to the position of temperature sensor **38** may not be anodized, and each of other three sides **32***b*, **32***c*, and **32***d* may be anodized. Also, by such a configuration, it is possible to more effectively make it difficult to dissipate heat of temperature sensor **38**.

[0092] While various embodiments have been described herein above, it is to be appreciated that various changes in form and detail may be made without departing from the spirit and scope of the present disclosure as presently or hereafter claimed.

Further Information about Technical Background to this Application

[0093] The disclosure of the following patent application including specification, drawings, and claims are incorporated herein by reference in their entirety: Japanese Patent Application No. 2023-025324 filed on Feb. 21, 2023.

INDUSTRIAL APPLICABILITY

[0094] The display device according to the present disclosure is applicable to, for example, a PGU installed in a head-up display for a vehicle, and the like.

1. A display device for use in a head-up display, the display device comprising:

a display panel that includes a display area that displays an image on a front surface and a peripheral area located outside the display area, and that projects light incident on a back surface from the display area as display light that represents the image;

a heat sink disposed to face the back surface of the display panel;

a light-transmitting member held between the display panel and the heat sink; and

a temperature sensor disposed in the peripheral area of the display panel to detect a temperature of the display panel,

wherein when viewed in a direction perpendicular to the front surface of the display panel, the temperature sensor does not overlap with at least one of the heat sink or the light-transmitting member.

2. The display device according to claim 1,
wherein the display panel includes a plurality of optical members stacked, and
when viewed in the direction perpendicular to the front surface of the display panel, a predetermined area including the temperature sensor is an area expanded outward from an outermost shape of the temperature sensor by more than or equal to a thickness of one or more optical members of the plurality of optical members, and is disposed at a position where the predetermined area does not overlap with at least one of the heat sink or the light-transmitting member.

3. The display device according to claim 1,
when viewed in the direction perpendicular to the front surface of the display panel, the peripheral area of the display panel protrudes outward beyond an outer peripheral part of the light-transmitting member.

4. The display device according to claim 1,
when a highest temperature region where a temperature is highest due to condensation of sunlight from an outside is present on the front surface of the display panel, a distance between the highest temperature region and the temperature sensor is longer than a distance between a center of the display area and the temperature sensor.

5. The display device according to claim 1, further comprising:
a light source that emits light onto the back surface of the display panel,
wherein when a highest temperature region where a temperature is highest due to emission of the light from the light source onto the back surface of the display panel is present on the front surface of the display panel, a distance between the highest temperature region and the temperature sensor is longer than a distance between a center of the display area and the temperature sensor.

6. The display device according to claim 1,
wherein the heat sink is in a frame shape including four sides, and
among the four sides of the heat sink, a thickness of one side corresponding to a position of the temperature sensor is thinner than a thickness of each of other three sides.

7. The display device according to claim 1,
wherein the heat sink is in a frame shape including four sides, and
among the four sides of the heat sink, a thermal conductivity of one side corresponding to a position of the temperature sensor is lower than a thermal conductivity of each of other three sides.

8. The display device according to claim 1,
wherein the heat sink is in a frame shape including four sides, and
among the four sides of the heat sink, one side corresponding to a position of the temperature sensor is not anodized, and each of other three sides is anodized.

9. The display device according to claim 1, further comprising:
a heat dissipation sheet held between the heat sink and the light-transmitting member.

10. The display device according to claim 9,
wherein the heat sink is in a frame shape including four sides, and
the heat dissipation sheet is held between the light-transmitting member and each of three sides other than one side corresponding to the position of the temperature sensor among the four sides of the heat sink.

11. The display device according to claim 1,
wherein a thermal conductivity of the light-transmitting member is 3 W/mK or less.

12. The display device according to claim 1,
wherein the temperature sensor is a thermistor.

13. A head-up display comprising:
the display device according to claim 1; and
a mirror that reflects the display light projected from the display device toward a display medium.

* * * * *