

Specification

DISPLAY DEVICE

Technological Field

[1]

The present invention pertains to a display device, and more particularly, to a display device that senses touch inputs using an infrared ray method.

Background Technology

[2]

Generally, a display device equipped with a touch screen panel (TSP) is an input device that recognizes the location of the push or touch on the screen of the display's display surface with a finger or pen and communicates this information to the system, and the technology has spread widely thanks to the distribution of smartphones.

[3]

A touch screen panel is composed of a display, a touch sensing unit, a controller IC (integrated circuit), driver software, and so on. The touch sensing unit is composed of the upper panel and lower panel (film or glass) on which transparent electrode (indium tin oxide, ITO) is attached, and plays the role of sensing the location of the occurrence of signals caused by changes in electric capacity and sending this information to the controller IC.

[4]

The controller IC plays the role of converting the analog signals transmitted from the touch sensing unit to digital signals to change to coordinates to be displayed on the screen, and the driver software is the program that receives the digital signals entering the controller IC to embody the touch sensing unit according to each operating system.

[5]

Such touch screen panels may be classified into the resistive overlay method, capacitive method, ultrasonic method, optical method using light such as infrared ray method, and so on.

[6]

On the other hand, the infrared ray method touch screen panel is a method that utilizes the infrared ray's characteristic of being intercepted when touching an obstacle by using the infrared ray's straightness. Under the infrared ray TSP method, multiple light-emitting diodes (LEDs) that emit the infrared ray and multiple photo diodes that correspond to each of these emitting diodes face each other around the panel to form a matrix. When a finger (or any narrow and long object such as a stick, pencil, or brush, hereinafter to be referred to as an object of certain shape) touches the screen to intercept light, output at the intercepted area decreases, and the coordinate of this area is

obtained to determine the input location of the touch.

[7]

In this case, a finger or any object of certain shape may be used as input device. Such a touch screen panel is excellent in terms of light penetration rate, durability, and applicability to large screens, and thus this type of touch screen panels is applied to ATM's, kiosks, and so on.

[8]

In the case of the conventional display device applied with such an infrared ray touch screen panel, multiple light-emitting diodes and photo diodes are placed to face each other around the display in order for the light emitted by multiple light- emitting diodes to flow into the corresponding photo diodes.

[9]

During the process in which the light emitted by such light-emitting diodes flow into the photo diodes across the touch area at the front of the display, loss of light occurs due to the distance between the light-emitting diodes and photo diodes.

[10]

Especially, as shown by the conventional display device (1) illustrated in Figure 1, the light (A) that travels across the touch area (T) at the front of the display (2) may diffuse while traveling to the light-receiving guide unit (5) across the touch area (T) from the light-emitting guide unit (4).

[11]

Therefore, in the case of the normal bunch light (A1) that travels toward the center of the incident surface of the light- receiving guide unit (5) from the center of the exit surface of the light-emitting guide unit (4), it is possible to travel normally from the light-emitting guide unit (4) to the light-receiving guide unit (5).

[12]

However, in the case of the downward light (A2) that is projected downward from the exit surface of the light-emitting guide unit (4) is reflected toward the front of the display (2) from a flat cover glass (3) placed on the front surface of the display (2), resulting in loss of light.

[13]

Additionally, the upward light (A3) that tilts toward from the exit surface of the light-emitting guide unit (4) is projected to the outside at the front for the display device (1) resulting in loss of light.

[14]

Additionally, if the distance between the light-emitting unit and the light-receiving unit increases due to the increase in the size of the display, the loss of light that passes through the touch area (T) may increase.

[15]

Due to such loss of light, device malfunctions may occur as a result of the decrease in accuracy of touch recognition through the touch screen panel, and in the event that the output of the light-emitting diode is increased in order to compensate for the loss of light, the lifespan of the light-emitting diode is reduced.

[16]

In Figure 1, part 6 (not described) is a light-emitting diode, part 7 is a photo diode, part 8 is a printed circuit board (PCB), and part 9 is a rear cover.

Details of the invention

Technical Problem

[17]

The purpose of the present invention is to provide a display device with improved touch recognition performance.

Means to Solve the Problem

[18]

The present invention to achieve the above purpose provides a display equipped with a display surface and a cover glass attached to the display surface, and includes a touch sensing unit that senses touch inputs by intercepting the light that passes through the touch area at the front of the display surface, wherein the cover glass provides a concavely curved display device in order to guide the light that passes through the touch area.

[19]

Additionally, the light that passes through the touch area may travel in the first and second orthogonal directions, and the front surface of the cover glass may be curved along at least one of the first and second directions.

[20]

Additionally, the front surface of the cover glass may include at least one of spherical surface and non-spherical surface.

[21]

Additionally, the front surface of the cover glass may include an atypical curved surface.

[22]

Additionally, the front surface of the cover glass may include multiple curved surfaces.

[23]

Additionally, the rear surface of the cover glass may be curved along at least one of the first and second directions.

[24]

Furthermore, the touch sensing unit may include a light-emitting unit that is placed at the display's edge to emit light across the touch area, and a light-receiving unit that is placed to face the light-emitting unit to sense the light emitted from the light-emitting unit.

[25]

Additionally, the light-emitting unit may include at least one light-emitting diode and a light-emitting guide unit that guides the light emitted by at least one of the light-emitting diodes to send the light to the touch area, and the light-receiving unit may include at least one photo diode and a light-receiving guide unit that guides the incident light to at least one photo diode.

[26]

Additionally, the end area to which the light from the light-emitting guide unit is sent may include a lens unit.

[27]

Additionally, the end area that is located near the exit surface of the light-emitting guide unit may include a reflection unit that is tilted at a certain angle relative to the display surface.

[28]

Furthermore, the first distance between the exit surface of the light-emitting guide unit and the incident surface of the light-receiving guide unit, the second distance between the center of the incident surface and the light-receiving center, which is the center of the light that enters the incident surface, and the curvature radius of the front surface of the cover glass may be set to satisfy

$$0 \leq \frac{\text{the second distance}}{\text{the first distance}} \times \text{the curvature radius} \leq 600.$$

[29]

Additionally, in order to achieve the above purpose, the present invention may provide a display equipped with a display surface and include a touch sensing unit that senses touch inputs by intercepting the light that passes through the touch area at the front of the display surface, wherein a light-emitting unit, a light-receiving unit that is placed to face the light-emitting unit to sense the light emitted by the light-emitting unit, and a concavely curved cover glass to guide the light that heads toward the light-receiving unit from the light-emitting unit may be included.

[30]

Furthermore, the light that passes through the touch area may travel in the first and second orthogonal directions, and the front surface of the cover glass may be curved in at least one of the first and second directions.

[31]

Additionally, in order to achieve the above purpose, the present invention may provide a display device that includes a display equipped with a display surface and a touch sensing unit that is equipped with a cover glass attached to the display surface, and that senses touch inputs when the

light that passes through the touch area at the front of the display surface is intercepted, wherein the first distance between the exit surface of the light-emitting unit and the incident surface of the light-receiving unit of the touch sensing unit, and the second distance between the center of the incident surface and the light-receiving center, which is the center of the light that enters the incident surface, and the curvature radius of the front surface of the cover glass satisfy $0 \leq \frac{\text{the second distance}}{\text{the first distance}} \times \text{the curvature radius} \leq 600$.

Brief Description of the Drawings

[32]

Figure 1 is a cross-sectional drawing that roughly illustrates the structure of a display device equipped with a touch sensing unit in accordance with the conventional technology.

[33]

Figure 2 is a perspective-view drawing that roughly illustrates a display device in accordance with an embodiment of the present invention.

[34]

Figure 3 is a cross-sectional drawing that roughly illustrates the structure of the display device illustrated in Figure 2.

[35]

Figure 4 is a cross-sectional drawing that illustrates the optical route of the display device illustrated in Figure 3.

[36]

Figure 5 illustrates a graph and a table that illustrate the optical efficiency of the touch sensing unit in accordance with an embodiment of the present invention.

[37]

Figure 6 is a partial cross-sectional drawing that illustrates a modification example of the light-emitting guide unit illustrated in Figure 3.

[38]

Figure 7 is a cross-sectional drawing that roughly illustrates the display device in accordance with another embodiment of the present invention.

Specific details to embody the present invention

[39]

Below, embodiments of the present invention will be described in detail by referring to the attached drawings. The present invention will be described by referring to those embodiments with which it will be most appropriate to understand the technological characteristics of the present invention. However, the technological characteristics of the present invention are not restricted by the embodiments to be described. Rather, these embodiments will be presented in order to illustrate

that it is possible to implement the present invention according to the embodiments to be described below.

[40]

Therefore, the present invention can be implemented by making various modifications within the technological scope of the present invention based on the embodiments to be described below, and these modified embodiments may be considered to be within the technological scope of the present invention. Additionally, regarding the part numbers indicated on the attached drawings to help with understanding the embodiments to be described below, related units among the units that operate identically in each embodiment were indicated with the same numbers or with the same numbers with extension numerals.

[41]

The display device in accordance with an embodiment of the present invention described below is a device equipped with an infrared ray touch screen panel and is an electronic device. Additionally, the device may be a display device that senses touch inputs when another type of light or electronic waves such as ultrasonic waves pass through the touch area at the front of the display surface of the display and the device senses the interception location by the user's touch input.

[42]

Figure 2 is a perspective-view drawing that roughly illustrates the display device (10) in accordance with an embodiment of the present invention, and Figure 3 is a cross-sectional drawing that roughly illustrates the structure of the display device (10) illustrated in Figure 2.

[43]

Below, Figure 2 and Figure 3 will be referenced, and the structure of the display device (10) will be described.

[44]

As illustrated in Figure 2 and Figure 3, the display device (10) includes a display (100), a touch sensing unit (200), a printed circuit board (300), and a rear cover (400).

[45]

The display (100) includes a display surface that displays the screen toward the front direction (z-axis).

[46]

The display (100) is in the shape of a flat rectangle, and the front surface may be flat, and the display (100) may include a backlight unit (not illustrated), a reflective sheet (not illustrated), an optical sheet (not illustrated), a liquid crystal panel (not illustrated), and so on.

[47]

Besides, the display may be modified into various shapes such as an ellipse, a circle, and so on,

and in such a case the touch sensing unit, the printed circuit board, and the rear cover may be modified in accordance with the shape of the display.

[48]

Since the display (100) is identical or similar to the widely used conventional technology, detailed description of the display will be omitted here.

[49]

The touch sensing unit (200) includes a cover glass (210), a light-emitting unit (220), and a light-receiving unit (230).

[50]

The touch sensing unit (200) in accordance with an embodiment of the present invention is an infrared ray touch sensing unit (200) that determines the coordinates of the touch input by obtaining the coordinates of the applicable location by sensing the interception of the flow of light such as infrared ray, which travels across the touch area (T) at the front of the display surface of the display (100), by a touch input.

[51]

Additionally, the touch sensing unit (200) in accordance with an embodiment of the present invention is able to sense touches by using invisible light or electric waves such as ultrasonic waves besides the infrared light.

[52]

The cover glass (210) is attached to the display surface of the display (100) and covers the display surface of the display (100).

[53]

The cover glass (210) is composed of a translucent material such as glass so that the screen displayed on the display surface of the display (100) may be displayed forward through the cover glass (210).

[54]

Furthermore, the cover glass (210) is concavely curved in order to guide the light that passes through the touch area (T), and the front surface (211) of the cover glass (210) is concavely curved. The specific structure of the cover glass (210) will be described in detail next.

[55]

The light-emitting unit (220) may be placed at the display (100)'s edge, and the light emitted from the light-emitting unit (220) may enter the light-receiving unit (230) placed at a location where it faces the light-emitting unit (220) across the touch area (T).

[56]

The light-emitting unit (220) may include multiple light-emitting diodes (221), and the light-

receiving unit (230) may include multiple photo diodes (231) corresponding to the multiple light-emitting diodes (221).

[57]

The light-emitting diode (221) may include a light-emitting diode (LED) or laser diode (LD), and so on, and the photo diode (231) may include an optical sensor, and so on.

[58]

The light-emitting unit (220) and the light-receiving unit (230) may be placed along the display (100)'s edge, to wrap the display (100)'s edge, and it is preferable to place the light-emitting unit (220) and the light-receiving unit (230) to face each other in order for the light emitted from the light-emitting unit (220) to be sensed through the light-receiving unit (230).

[59]

Additionally, multiple light-emitting diodes (221) may be placed along the display (100)'s edge, and multiple photo diodes (231) may be placed along the edge of the display (100) that faces the multiple light-emitting diodes (221).

[60]

For example, as illustrated in Figure 2, the display (100) may include edges at the top, bottom, left, and right, and the light-emitting unit (220) may be placed at the top and left edges of the display (100) to emit light across the entire touch area (T) from the top and left edges of the display (100).

[61]

Additionally, the light-receiving unit (230) may be placed at the bottom and right edges of the display (100) that faces the light-emitting unit (220) in order to sense the light emitted from the light-emitting unit (220) and that passes through the touch area (T).

[62]

Namely, the light-emitting unit (220) placed at the left edge of the display (100) may project light to the first direction (Ax) along the x-axis, and the light-emitting unit (220) placed at the top edge of the display (100) may project light to the second direction (Ay) along the y-axis.

[63]

The first direction (Ax) and the second direction (Ay) may be orthogonal to each other, and the light that travels along the first direction (Ax) and the second direction (Ay) may pass through covering the entire touch area (T) at the front of the display.

[64]

As illustrated in Figure 2, when the user's touch is input on the touch area (T), the input touch point (TP) simultaneously intercepts the light emitted from the light-emitting unit (220) at the left edge of the display (100) and moving in the first direction (Ax) and the light emitted from light-emitting unit (220) at the top edge of the display (100) and moving in the second direction (Ay).

[65]

Through this process, the light-receiving unit (230) at the location corresponding to the touch point (TP) doesn't sense light or the amount of light sensed decreases. As a result, the controlling unit (not illustrated) is able to determine the touch input coordinates by obtaining the coordinates of the touch point (TP) through the location of the applicable light-receiving unit (230).

[66]

As described previously, the light-emitting unit (220) may include multiple light-emitting diodes (221), and additionally, may further include a light-emitting guide unit (222) that guides the light emitted by the light-emitting diode (221) to send the light to the touch area (T).

[67]

Additionally, the light-receiving unit (230) may include multiple photo diodes (231), and may further include a light-receiving guide unit (232) that guides the incident light that passed through the touch area (T) to the photo diode (231).

[68]

As illustrated in Figure 3, at the rear side opposite to the front side where the display (100)'s display is placed it is possible to place a printed circuit board (300) containing a light-emitting diode (221) and a photo diode (231), and a rear cover (400) may be attached to the rear of the display (100), the rear of the touch sensing unit (200), and the rear of the printed circuit board (300).

[69]

The printed circuit board (300) may control the light-emitting diode (221) and the photo diode (231) through the controlling unit by allowing electricity and electric signals in the light-emitting diode (221) and the photo diode (231). Furthermore, various components that configure the display device (10) besides the light-emitting diode (221) and the photo diode (231) may be installed on the printed circuit board (300).

[70]

The light emitted from the light-emitting diode (221) placed on the rear of the display (100) may be projected in the direction across the touch area (T) through the light-emitting guide unit (222) that wraps the side of the display (100), namely in the first direction (Ax) and the second direction (Ay).

[71]

Furthermore, the light that travels across the touch area (T) through the light-emitting guide unit (222) may enter the photo diode (231) placed at the rear of the display (100) through the light-receiving guide unit (232) placed at the location that faces the light-emitting guide unit (222) and wraps the side of the display (100).

[72]

As described, with the display device (10) in accordance with an embodiment of the present invention it is possible to place the light-emitting diode (221) and the photo diode (231) at the back rather than at the side of the display (100) to guide the light emitted from the light-emitting diode (221) through a separate light-emitting guide unit (222) and a separate light-receiving guide unit (232) to guide the emitted light to the touch area (T) and the photo diode (231), in order to reduce the thickness of the bezel of the display device (10).

[73]

Furthermore, the light-emitting guide unit (222) and the light-receiving guide unit (232) may form the exterior of the display device (10) by wrapping the side of the display (100). Additionally, as illustrated in Figure 2, the light-emitting guide unit (222) and the light-receiving guide unit (232) may form the entire exterior of the display device (10) by being attached to the rear cover (400).

[74]

As described, it is possible to reduce the thickness of the bezel of the display device (10) by configuring the light-emitting guide unit (222) and the light-receiving guide unit (232) to form the exterior of the display device (10) along with the rear cover (400).

[75]

Furthermore, the light-emitting guide unit (222) and the light-receiving guide unit (232) that wrap the side of the display (100) may be configured as a single body in the shape of a closed loop that wraps the outside of the display (100).

[76]

Additionally, the light-emitting diode and the photo diode may be placed directly at the display's side, and the light-emitting diode may pass through the touch area directly to emit the light toward the photo diode, so that a more simplified display device structure with the omission of a separate light-emitting guide unit and a separate light-receiving guide unit may be possible.

[77]

The light that enters one end of the light-emitting guide unit (222) and one end of the light-receiving guide unit (232) may be emitted outside through the opposite end after passing through the inside.

[78]

The light-emitting guide unit (222) may be placed at the top and right edges of the display (100), and the light-receiving guide unit (232) placed opposite the light-emitting guide unit (222) may be placed at the bottom and right edges of the display (100).

[79]

More specifically, the exit surface (2221) of the light-emitting guide unit (222) may be placed at the top and left edges of the display (100), and the incident surface (2321) of the light-receiving

guide unit (232) may be placed at the bottom and right edges of the display (100).

[80]

Through this, the light may be projected in the first and second directions (A_x , A_y) through the exit surface (2221) of the light-emitting guide unit (222), and the light projected in the first and second directions (A_x , A_y) may enter the incident surface (2321) of the light-receiving guide unit (232) through the touch area (T).

[81]

Additionally, the location of the light-emitting guide unit and the location of the light-receiving guide unit may be modified in various ways according to the direction of the light that travels across the touch area (T).

[82]

As illustrated in Figure 3, the light-emitting guide unit (222) and the light-receiving guide unit (232) through which the light travels along the inside may be in the shape of multiple curvatures in accordance with the shape of the display device (10) and in accordance with the placement of the light-emitting diode (221), placement of the light-receiving diode (231), and placement of the touch area (T). The curvature may function as reflecting unit that modifies the movement direction of the light that travels across the inside of the light-emitting guide unit (222) and inside of the light-receiving guide unit (232).

[83]

The light emitted from the light-emitting diode (221) placed at the rear of the display (100) flows into one end of the light-emitting guide unit (222) to be reflected on the multiple curvatures inside the light-emitting guide unit (222) to change the route, and is emitted to the touch area (T) through the exit surface (2221) of the other end of the light-emitting guide unit (222).

[84]

Afterwards, the light emitted through the exit surface (2221) of the light-emitting guide unit (222) enters the incident surface (2321) of the light-receiving guide unit (232) after passing through the touch area (T).

[85]

The light that enters the incident surface (2321) of the light-receiving guide unit (232) passes through the inside of the light-receiving guide unit (232), and is reflected on the multiple curvatures inside the light-receiving guide unit (232), and ultimately enters the light-receiving diode (231) placed at the rear of the display (100).

[86]

As illustrated in Figure 3, in order for the light exiting from the exit surface (2221) of the light-emitting guide unit (222) to travel to the incident surface (2321) of the light-receiving guide unit

(232) across the touch area (T) formed at the front of the cover glass (210), the exit surface (2221) of the light-emitting guide unit (222) and the incident surface (2321) of the light-receiving guide unit (232) must be configured to protrude forward more than the cover glass (210).

[87]

Therefore, a touch area (T) may be formed between the exit surface (2221) of the light-emitting guide unit (222), the incident surface (2321) of the light-receiving guide unit (232) and the front surface (211) of the cover glass (210).

[88]

Figure 4 is a cross-sectional drawing that illustrates the optical route of the display device (10) illustrated in Figure 3.

[89]

Below, the process in which the light that passes through the touch area (T) through the cover glass (210) is guided will be described by referring to Figure 4.

[90]

As described previously, the front surface (211) of the cover glass (210) that covers the display surface of the display (100) is concavely curved toward the rear of the display surface, and may be curved in at least one direction out of the first direction and second direction (A_x , A_y) in which the light travels.

[91]

For example, as illustrated in Figure 2 to Figure 4, the front surface (211) of the cover glass (210) may be concavely curved along the first direction (A_x).

[92]

In Figure 2 to Figure 4, the light that travels to the touch area (T) along the first direction (A_x) and the front surface (211) of the cover glass (210) concavely curved along the first direction (A_x) were illustrated for convenience. However, the front surface of the cover glass may be curved concavely along various directions in accordance with the movement direction of the light.

[93]

For example, the front surface (211) of the cover glass (210) may be concavely curved along the second direction (A_y) that is orthogonal to the first direction (A_x), and may be concavely curved along both the first direction and the second direction (A_x , A_y).

[94]

Furthermore, the front surface (211) of the cover glass (210) may include a spherical surface or non-spherical surface, and may include multiple curved surfaces that include both spherical and non-spherical surfaces. Additionally, the front surface (211) of the cover glass (210) may include an atypical curved surface.

[95]

Through this, loss of the light that passes through the touch area (T) and travels to the light-receiving guide unit (232) can be prevented by setting multiple reflecting angles of the cover glass (210).

[96]

As described, the concavely curved front surface (211) of the cover glass (210) may be modified in various shapes in accordance with the movement direction of the light that passes through the touch area (T) and may be in various shapes to guide the light that passes through the touch area (T) to the light-receiving guide unit (232).

[97]

Additionally, it is preferable for the concavely curved front surface (211) of the cover glass (210) to be curved to the extent that the screen displayed through the display unit of the display (100) is not distorted.

[98]

As illustrated in Figure 4, the light (A) emitted from the light-emitting diode (221) enters one end of the light-emitting guide unit (222) and arrives at the incident surface (2221) of the light-emitting guide unit (222) through refraction, after which the light is emitted to the touch area (T) formed at the front of the front surface (211) of the cover glass (210) through the incident surface (2221) of the light-emitting guide unit (222).

[99]

The light (A) emitted through the exit surface (2221) of the light-emitting guide unit (222) may expand to the normal bunch light (A1) heading toward the center of the incident surface (2321) of the light-receiving guide unit (232) in the direction parallel to the display surface of the display (100), the downward light (A2) that is projected downward toward the front surface (211) of the cover glass (210) from the exit surface (2221) of the light-emitting guide unit (222), and the upward light (not illustrated) that is projected upward from the exit surface (2221) of the light-emitting guide unit (222).

[100]

The downward light (A2) may travel to the incident surface (2321) of the light-receiving guide unit (232) by being guided by being reflected along the front surface (211) of the cover glass (210) concavely curved along the first direction (Ax).

[101]

The light guided through the front surface (211) of the cover glass (210) will be described in detail below.

[102]

As the downward light (A2) emitted by the exit surface (2221) of the light-emitting guide unit (222) is reflected along the concavely curved front surface (211) of the cover glass (210), the downward light (A2) is reflected toward the outside of the front of the display surface of the display (100) at the front surface of the cover glass, so that loss of light may be prevented.

[103]

Through this process, it is possible to improve accuracy of touch recognition through the touch sensing unit (200).

[104]

As described previously, it is possible for the front surface (211) of the cover glass (210) to be concavely curved along at least one direction out of the first direction (Ax) and second direction (Ay), and it is possible to modify the shape of the cover glass in various ways in order to guide the light that passes through the touch area (T) after being projected from the exit surface (2221) of the light-emitting guide unit (222) to the incident surface (2321) of the light-receiving guide unit (232).

[105]

More specifically, the front surface (211) of the cover glass (210) may be curved at the predetermined curve radius (R), and the front surface (211) of the cover glass (210) may be curved at various curve radiuses (R) by including multiple curved surfaces or atypical curved surfaces.

[106]

The route of the light that passes through the touch area (T) in order to sense the touch input in accordance with the shape and size of the display (100) may be modified in various ways as well, and it is possible to configure a cover glass with the highest level of optical efficiency by changing the shapes of curved surfaces including the curvature of the concavely curved front surface of the cover glass in various ways in accordance with the optical route.

[107]

Figure 5 illustrates a graph and a table that illustrate the optical efficiency of the touch sensing unit in accordance with an embodiment of the present invention.

[108]

Below, the structure in which the optical efficiency of the light that is guided through the front surface (211) of the cover glass (210) may be increased based on the data illustrated in Figure 5 by referring to the relationship of the curvature radius (R) of the front surface (211) of the cover glass (210), the first distance (L) between the exit surface (2221) of the light-emitting guide unit (222) and the incident surface (2321) of the light-receiving guide unit (232), and the second distance (D) between the center (C1) of the incident surface (2321) of the light-receiving guide unit (232) and the light-receiving center (C2), which is the center of the light that enters the incident surface

(2321) illustrated in Figure 4.

[109]

The light-receiving center (C2), which refers to the center of the light that enters the incident surface (2321) of the light-receiving guide unit (232), may be the location at which strength of the light that flows into the incident surface (2321) is the highest, and the center (C1) of the incident surface (2321) and the light-receiving center (C2), which is the location where the strength of the light that flows into the incident surface (2321) is the highest, may be moved by a certain distance. It is preferable for the second distance (D) to be vertical distance between the center (C1) of the incident surface (2321) and the light-receiving center (C2).

[110]

Figure 5 (a) illustrates a graph and a table that illustrate the optical efficiency measured in accordance with the changes in the curvature radius (R) of the front surface (211) of the cover glass (210) by setting the optical efficiency at 1.0, which is the level when the front surface of the cover glass (210) is flat with the first distance (L) set at 250mm.

[111]

Figure 5 (b) illustrates a graph and a table that illustrate the optical efficiency measured in accordance with the changes in the curvature radius (R) of the front surface (211) of the cover glass (210) by setting the optical efficiency at 1.0, which is the level when the front surface of the cover glass (210) is flat with the first distance (L) set at 150mm.

[112]

In Figure 5 (a), it can be confirmed that optical efficiency is the highest when the curvature radius (R) of the front surface (211) of the cover glass (210) is around 6,000mm, and in Figure 5 (b) it can be confirmed that optical efficiency is the highest when the curvature radius (R) of the front surface (211) of the cover glass (210) is around 3,000mm.

[113]

Furthermore, when the curvature radius (R) increases to certain size, optical efficiency through the structure of the front surface (211) of the cover glass (210) shows no difference with a flat cover glass, and when the second distance (D) increases to certain level, there is a limit at which the curvature radius (R) of the front surface (211) of the cover glass (210) becomes very small in order to acquire optical efficiency or the first distance (L) must be very small.

[114]

Therefore, based on the results of the data analysis illustrated in Figure 5, it is preferable for the curvature radius (R) of the front surface (211) of the cover glass (210), the first distance (L) between the exit surface (2221) of the light-emitting guide unit (222) and the incident surface (2321) of the light-receiving guide unit (232), and the second distance (D) between the center (C1)

of the incident surface (2321) of the light-receiving guide unit (232) and the light-receiving center (C2), which is the center of the light that enters the incident surface (2321) to satisfy the following conditional formula:

[115]

[Conditional formula]

[116]

$$0 \leq \frac{\text{the second distance}}{\text{the first distance}} \times \text{the curvature radius} \leq 600$$

[117]

The above conditional formula was derived through the test data illustrated in Figure 5, and this means that when the front surface (211) of the cover glass (210) is in the shape of a concave curve, optical efficiency improves compared to the conventional flat front surface of the cover glass.

[118]

Specifically, in accordance with the above conditional formula and in accordance with the graph and the table illustrated in Figure 5, if the value of “Second distance (D)/First distance (L) × Curvature radius (R)” is 600 or less, optical efficiency is measured higher than 1.0, which is the level of optical efficiency if the front surface of the cover glass is flat, and if the number exceeds 600 optical efficiency is lower than 1.0, which is the optical efficiency level when the front surface of the cover glass is flat.

[119]

Figure 6 is a partial cross-sectional drawing that illustrates a modification example of the light-emitting guide unit illustrated in Figure 3.

[120]

Figure 6 (a) to Figure 6 (c) magnifies the structure of the end area that is near the exit surface from which the light of the light-emitting guide unit is emitted.

[121]

When we refer to Figure 6 (a), we can see that the end area near the exit surface (2221a) of the light-emitting guide unit (222a) may include a reflection unit (2222a) that is tilted at the first angle (Θ1) relative to the flat surface that is parallel to the display surface of the display (100).

[122]

By adjusting the first angle (Θ1) of the reflection unit (2222a), it is possible to modify the angle of the light (Aa) that is projected in the touch area (T) from the exit surface (2221a) of the light-emitting guide unit (222a).

[123]

In Figure 6 (a), the reflection unit (2222a)’s angle was modified to the first angle (Θ1), which is less than the initial angle (Θ0) at the light-emitting guide unit (222) illustrated in Figure 3.

However, it is possible to modify the first angle (Θ_1) to be larger than the initial angle (Θ_0).

[124]

By adjusting the first angle (θ_1) of the reflection unit (2222a), it is possible to tilt the angle of the light (Aa) projected on the exit surface (2221a) to head toward the front surface (211) of the cover glass (210), and through this it is possible to increase the amount of light headed toward the incident surface (2321) of the light-receiving guide unit (232) by adjusting the angle of reflection at the front surface (211) of the cover glass (210).

[125]

When we refer to Figure 6 (b) and Figure 6 (c), we can see that the end area near the exit surfaces (2221b, 2221c) of the light-emitting guide units (222b, 222c) may include lens units (2222b, 2222c) that adjust the amount of light emitted from the exit surfaces (2221b, 2221c).

[126]

As illustrated in Figure 6 (b), the lens unit (2222b) may include a convex mirror or concave lens, and through this it is possible to adjust the angle of the light (Ab) projected toward the front surface (211) of the cover glass (210), or expand the amount of light (Ab) to increase the amount of the normal bunch light or downward light that is guided through the front surface (211) of the cover glass (210) emitted from the exit surface (2221b) of the light-emitting guide unit (222b).

[127]

Furthermore, as illustrated in Figure 6 (c), the lens unit (2222c) may include a concave mirror or convex lens, and it is possible to emit light (Ac) gathered from the exit surface (2221c) by gathering light from the inside of the light-emitting guide unit (222c).

[128]

As described above, it is possible to further reduce loss of light by projecting gathered light (Ac) on the touch area (T).

[129]

Figure 7 is a cross-sectional drawing that roughly illustrates the display device (10') in accordance with another embodiment of the present invention.

[130]

Since the display device (10') illustrated in Figure 7 is almost identical to the display device (10') illustrated in Figure 3 in terms of most components, description of duplicated areas will be omitted.

[131]

As illustrated in Figure 7, since the front surface (211') of the cover glass (210') of the display device (10') is curved concavely, the rear surface (212') of the cover glass (210') is also concavely curved.

[132]

For example, the rear surface (212') of the cover glass (210') may be curved along any one direction out of the first and second directions (A_x , A_y).

[133]

The cover glass (210') is composed of a translucent material, and the light emitted from the exit surface (2221) of the light-emitting guide unit (222) is able to enter the incident surface (2321) of the light-receiving guide unit (232) by moving along the inside of the cover glass (210').

[134]

Therefore, since the rear surface of the cover glass (210') is concavely curved along the direction of movement of the light that travels to the touch area (T), it is possible to guide the light that passes through the inside of the cover glass (210') to the incident surface (2321) of the light-receiving guide unit (232).

[135]

For this purpose, it is preferable for the front surface (211') and rear surface (212') of the cover glass (210') to be curved surfaces with the identical shape, and it is also preferable for the curvature radii (R') to be identical.

[136]

Furthermore, as illustrated in Figure 7, by curving the display surface of the display (100) as well, it is possible to display through the display surface a screen with improved visibility and immersion, and it is possible to configure the front surface (211') and rear surface (212') of the cover glass (210') and the display surface of the display (100) in the shape of a curve with the identical curvature radius (R').

[137]

Through this, it is possible to improve accuracy of touch inputs through the touch sensing unit (200) at the same time improving visibility and immersion of the screen displayed through the display (100).

[138]

Various embodiments of the present invention were individually described above. However, it is not necessary for each embodiment to be embodied independently. In other words, it is possible to combine configurations and operations of different embodiments.

[139]

Additionally, preferable embodiments of the present invention were illustrated and described above. However, the present invention is not limited to the embodiments described above, and the present invention can be embodied in various ways by any person with ordinary level of knowledge in the field in which the present invention belongs without deviating from the gist of the present invention claimed in the scope of claims section, and these modified embodiments must not be

understood to be outside the technological ideas or forecasts of the present invention.

Claims

[Claim 1]

A display device that includes a display equipped with a display surface and a cover glass that is attached to the display surface, and a touch sensing unit that senses touch inputs by intercepting the light that passes through the touch area at the front of the display surface, wherein the cover glass is concavely curved in order to guide the light that passes through the touch area.

[Claim 2]

The display device of Claim 1, wherein the light that passes through the touch area travels in the first and second orthogonal directions, and wherein a front surface of the curved glass is curved in at least one direction out of the first and second directions.

[Claim 3]

The display device of Claim 2, wherein the front surface of the cover glass includes at least one of a spherical surface and a non-spherical surface.

[Claim 4]

The display device of Claim 2, wherein the front surface of the cover glass includes an atypical curved surface.

[Claim 5]

The display device of Claim 2, wherein the front surface of the cover glass includes multiple curved surfaces.

[Claim 6]

The display device of Claim 2, wherein a rear surface of the cover glass is curved in at least one direction out of the first and second directions.

[Claim 7]

The display device of Claim 2, wherein the touch sensing unit includes a light-emitting unit that is placed on the edge of the display to emit light across the touch area, and a light-receiving unit that is placed to face the light-emitting unit to sense the light emitted by the light-emitting unit.

[Claim 8]

The display device of Claim 7, wherein the light-emitting unit includes at least one light-emitting diode and a light-emitting guide unit that guides the light emitted by at least one of the light-emitting diodes to project the light to the touch area, wherein the light-receiving unit includes at least one photo diode and a light-receiving guide unit that guides the incident light to at least one of the photo diodes.

[Claim 9]

The display device of Claim 8, wherein one end to which the light-emitting guide unit's light is projected includes a lens unit.

[Claim 10]

The display device of Claim 8, wherein the one end that is near the exit surface of the light-emitting guide unit includes a reflection unit that is tilted at a certain angle relative to the display surface.

[Claim 11]

The display device of Claim 8, wherein the first distance between the exit surface of the light-emitting guide unit and the incident surface of the light-receiving guide unit, the second distance between the center of the incident surface and the light-receiving center, which is the center of the light that enters the incident surface, and the curvature radius of the front surface of the cover glass are set to satisfy the formula:

$$0 \leq \frac{\text{the second distance}}{\text{the first distance}} \times \text{the curvature radius} \leq 600 \quad .$$

.

[Claim 12]

A display device that includes a display equipped with a display surface and a touch sensing unit that senses touch inputs by intercepting the light that passes through the touch area at the front of the display surface, wherein the touch sensing unit includes a light-emitting unit that emits light, a light-receiving unit that is placed to face the light-emitting unit to sense the light emitted from the light-emitting unit, and a cover glass concavely curved to guide the light that heads toward the light-receiving unit from the light-emitting unit.

[Claim 13]

The display device of Claim 12, wherein the light that passes through the touch area travels to the first and second orthogonal directions, and wherein the front surface of the cover glass is curved in at least one direction out of the first and second directions.

[Claim 14]

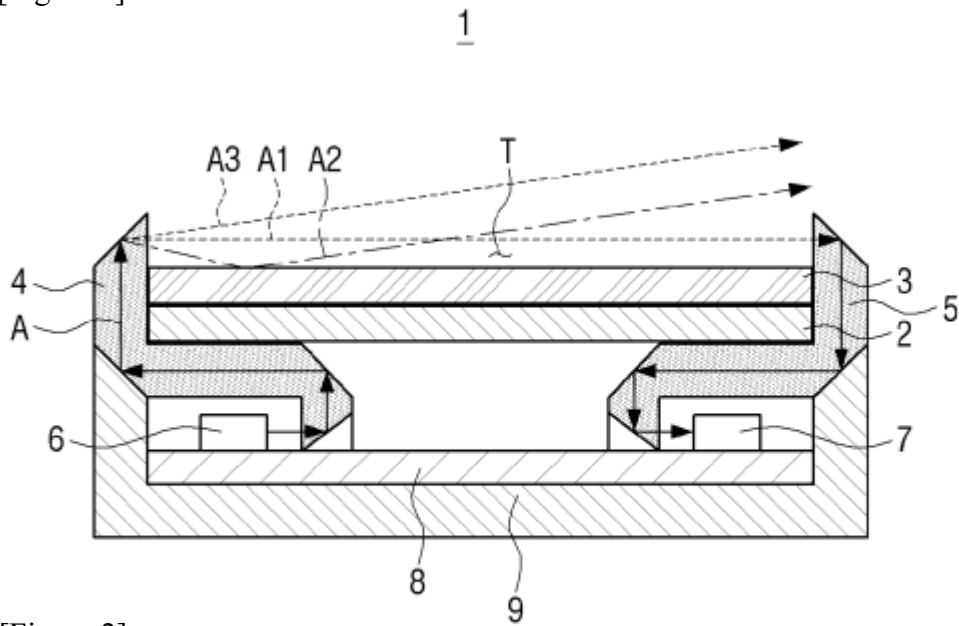
A display device that includes a display equipped with a display surface and a touch sensing unit that has a cover glass attached to the display surface, and that senses touch inputs when the light that passes through the touch area at the front of the display surface is intercepted, wherein the first distance between the exit surface of the light-emitting unit and the incident surface of the light-receiving unit of the touch sensing unit, and the second distance between the center of the incident surface and the light-receiving center, which is the center of the light that enters the incident surface, and the curvature radius of the front surface of the cover glass satisfy $0 \leq \frac{\text{the second distance}}{\text{the first distance}} \times \text{the curvature radius} \leq 600$.

Abstract

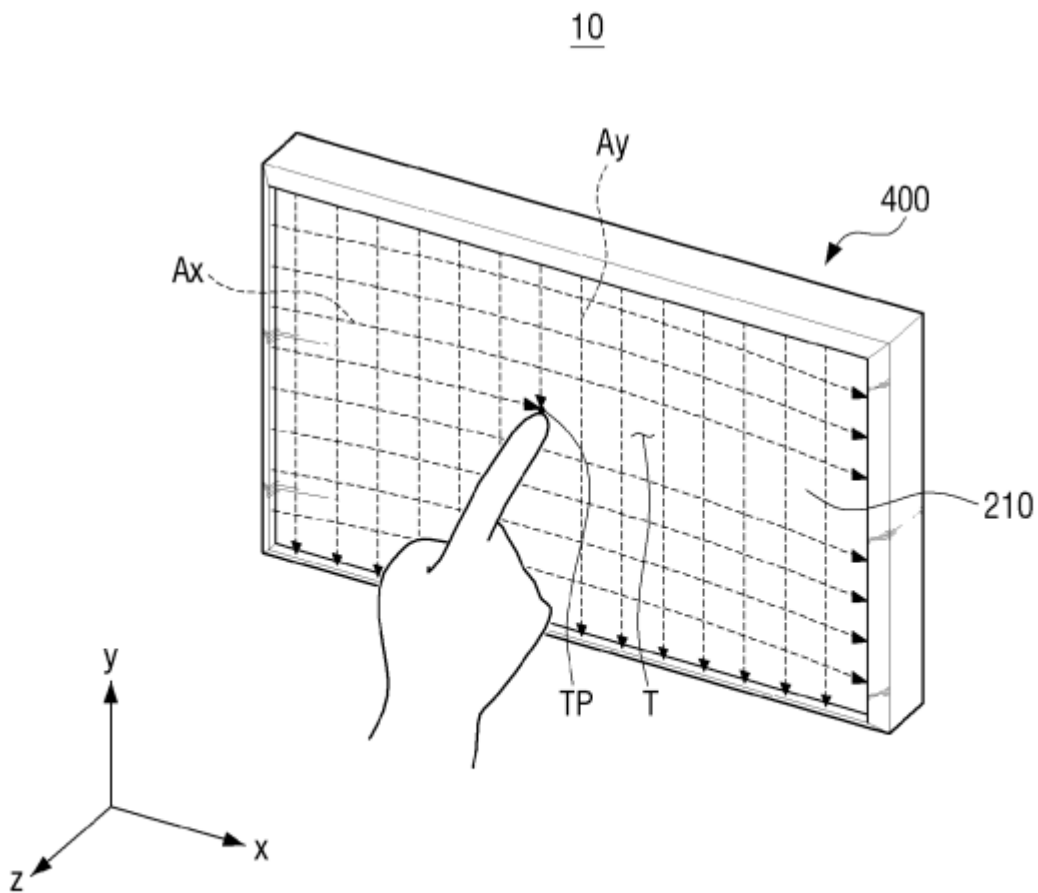
A display device is disclosed, the display device including: a display; a touch screen panel attached to the display that senses touch inputs by intercepting the light that passes through a touch area on the display, wherein the touch screen panel includes a cover unit that covers the display and the cover unit includes at least one curved surface formed in order to guide light that passes through the touch area. The display device in accordance with the present invention is able to reduce the amount of loss of light that passes through the touch area by the light being guided along the curved cover unit from the light-emitting unit to the light-receiving unit.

Drawings

[Figure 1]

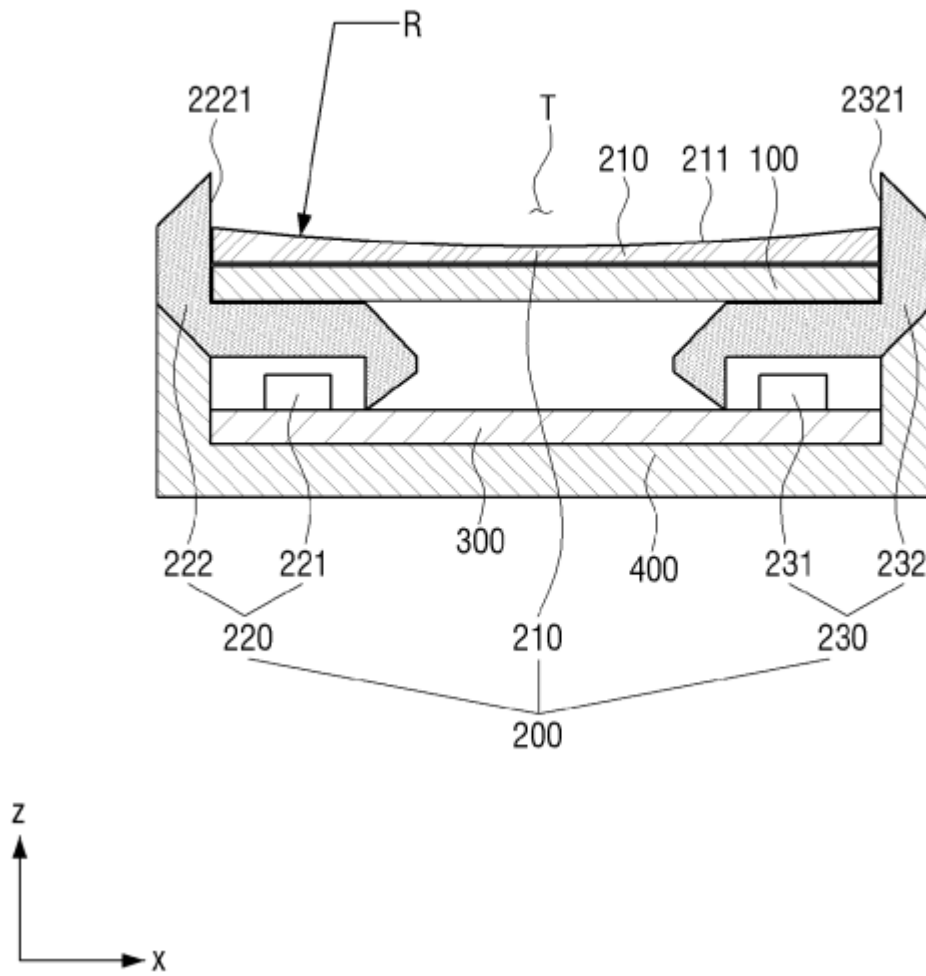


[Figure 2]



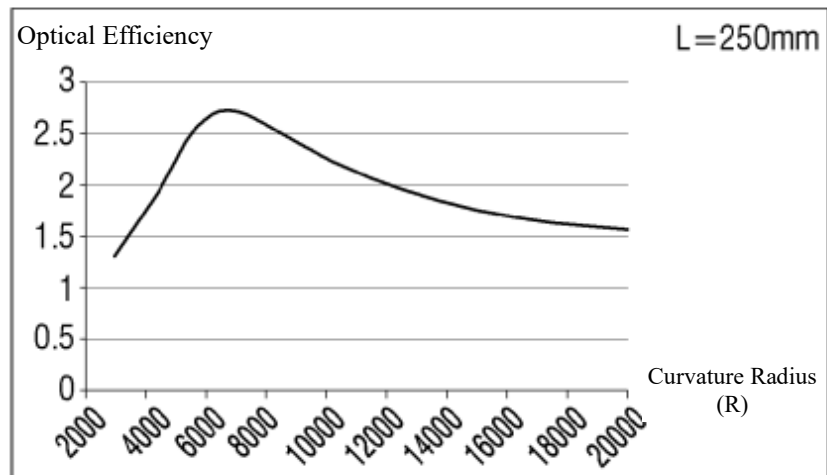
[Figure 3]

10



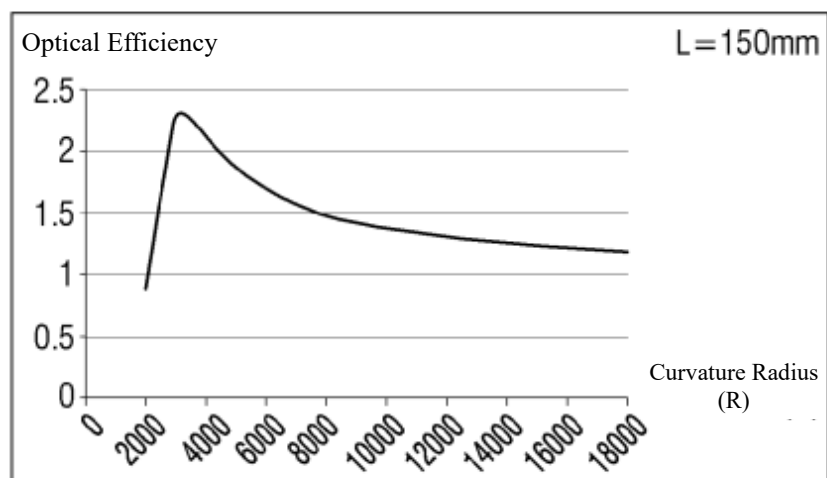
[Figure 5]

(a)



Curvature Radius (R) (mm)	Flat	3000	4000	6000	8000	10000	12000	14000	16000	18000	20000
Optical Efficiency	1.0	1.32	1.74	2.66	2.57	2.25	2.01	1.84	1.72	1.63	1.56

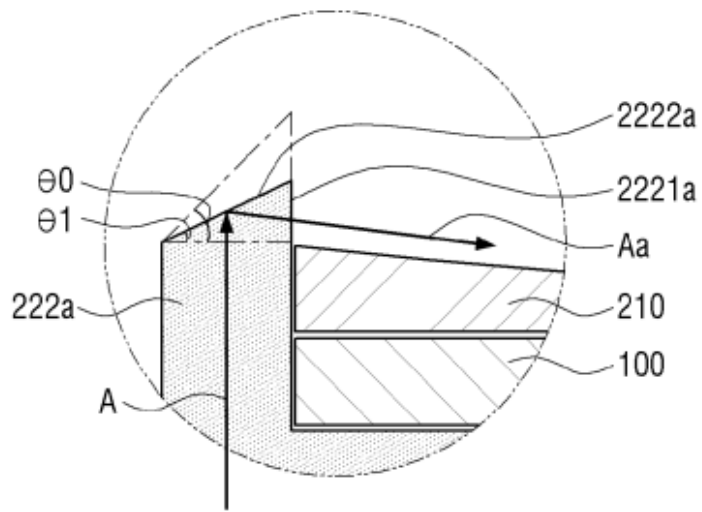
(b)



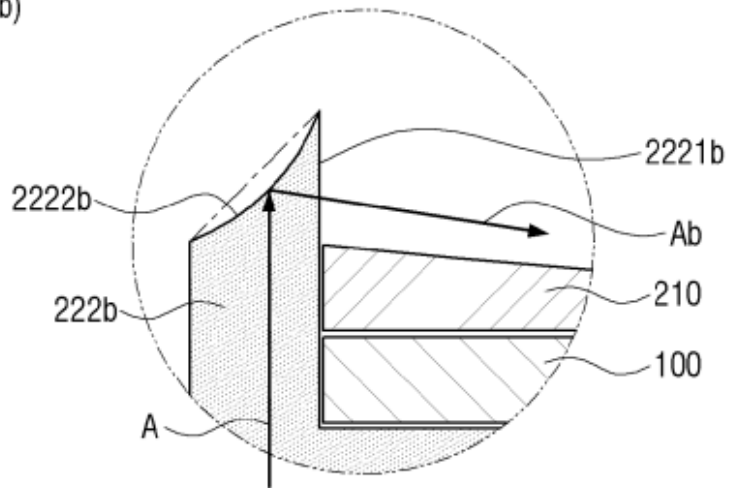
Curvature Radius (R) (mm)	Flat	2000	3000	4000	6000	8000	10000	12000	14000	16000	18000
Optical Efficiency	1.0	0.90	2.28	2.12	1.72	1.51	1.40	1.33	1.28	1.24	1.21

[Figure 6]

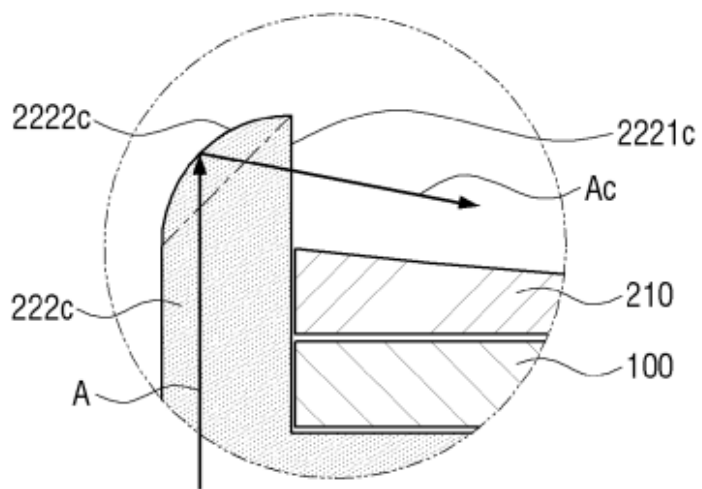
(a)



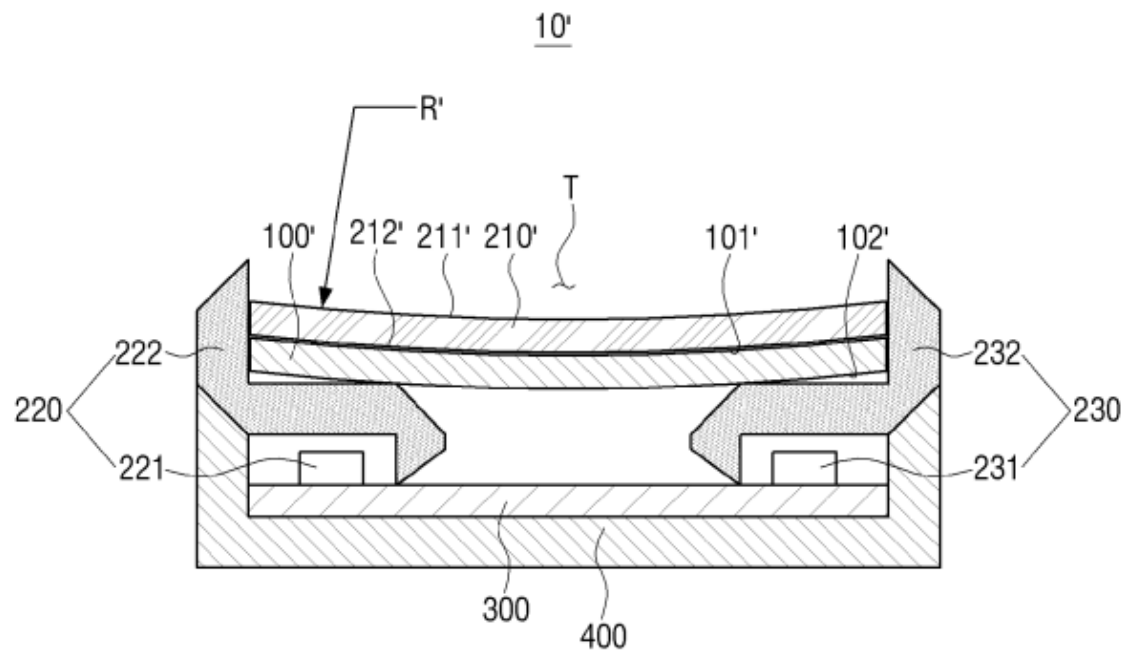
(b)



(c)



[Figure 7]





DECLARATION OF TRANSLATOR

I, Seongweon Park, hereby declare as follows:

1. I personally prepared the attached translation from Korean into English of the patent that is entitled “Han – W02018066761-PAMPH-20180412-0250” in English (also attached).
2. The attached translation is, to the best of my knowledge, a true, full and accurate translation of the attached Japanese document.
3. I am competent to perform this translation, because I have one and a half years of experience as a professional Korean-to-English patent translator.
4. I declare under the penalty of perjury under the laws of the United States that the foregoing is true and correct; and further declare that I am aware that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 1001 of Title 18 of the United States Code.

Dated: October 6, 2023

TRANSLATOR SIGNATURE