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Choi et al.

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(54) **SOUND GENERATING APPARATUS**

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(73) Assignee: **LG DISPLAY CO., LTD.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 27 days.

This patent is subject to a terminal disclaimer.

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(30) **Foreign Application Priority Data**

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CPC ***H04R 1/323*** (2013.01); ***G02F 1/1333*** (2013.01); ***G06F 1/1605*** (2013.01); ***H04R 1/025*** (2013.01);
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(58) **Field of Classification Search**
CPC H04R 1/323; H04R 1/025; H04R 7/045; H04R 9/02; H04R 1/028; H04R 5/02;
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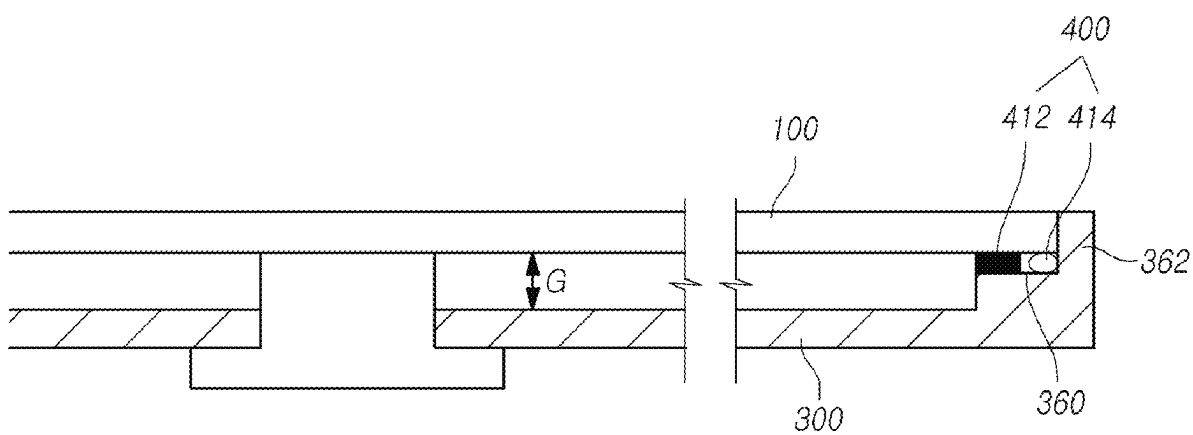
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

A panel vibration type sound generating display device is disclosed. The display device includes a display panel for displaying an image; a sound generating actuator connected to the display panel and configured to vibrate the display panel to generate sound; a support structure spaced apart from the display panel with an air gap between the support structure and the display panel; and a baffle part disposed between the support structure and the display panel to surround the air gap.

16 Claims, 34 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/696,847, filed on Nov. 26, 2019, now Pat. No. 11,019,425, which is a continuation of application No. 15/987,267, filed on May 23, 2018, now Pat. No. 10,555,073, which is a continuation of application No. 15/374,566, filed on Dec. 9, 2016, now Pat. No. 10,009,683.

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

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(58) **Field of Classification Search**

CPC G02F 1/1333; G02F 1/133308; G06F 1/1605; H01L 51/5253; G02B 6/0011

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See application file for complete search history.

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FIG. 1

RELATED ART

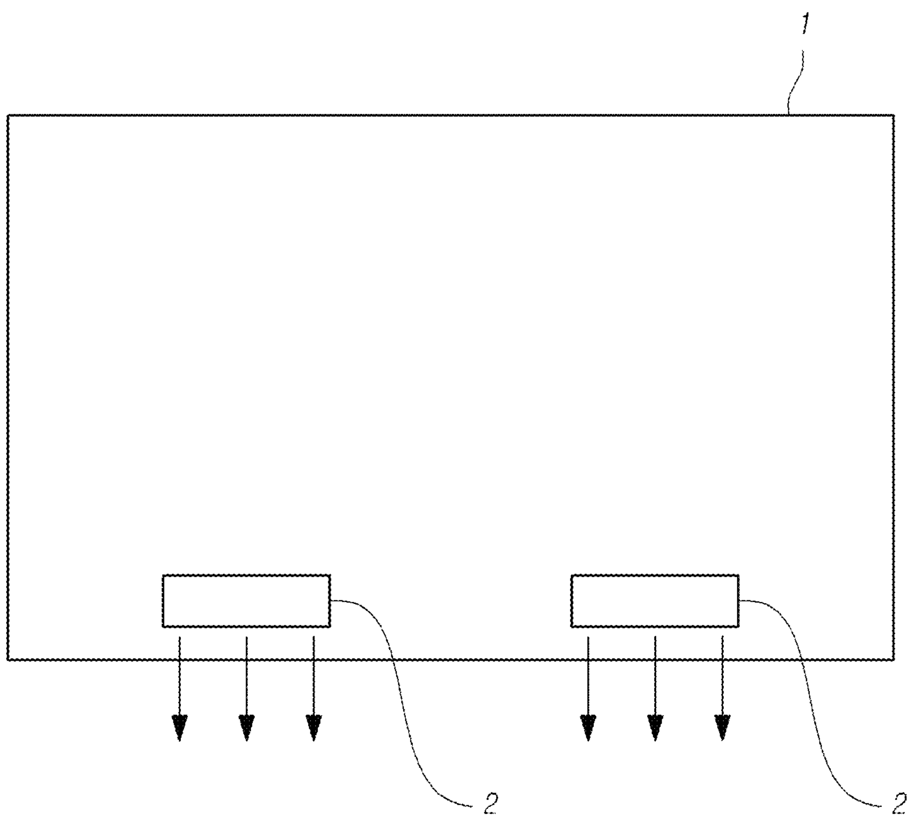


FIG.2A

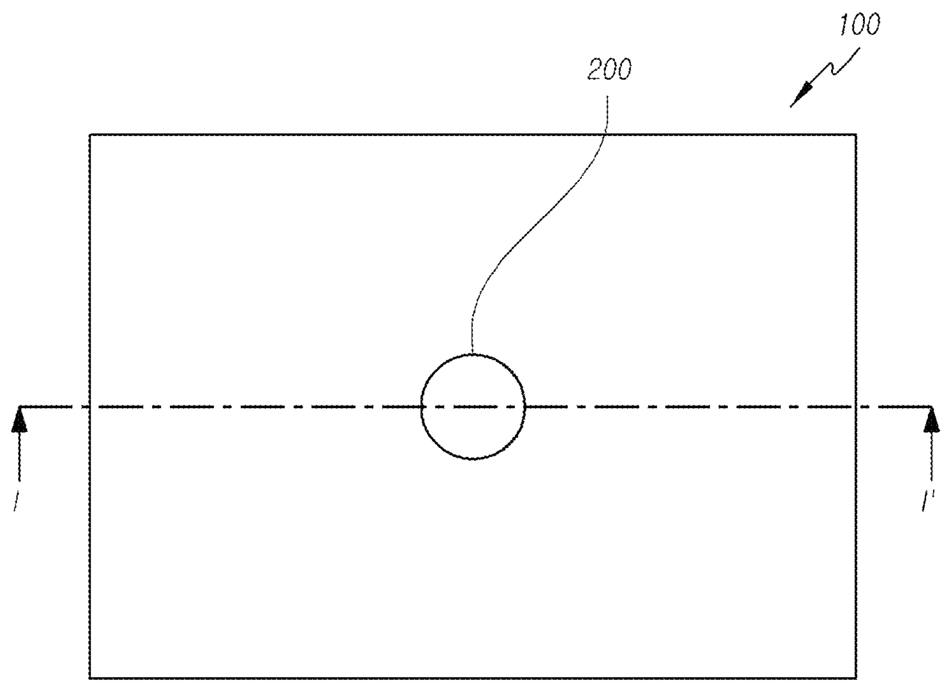


FIG.2B

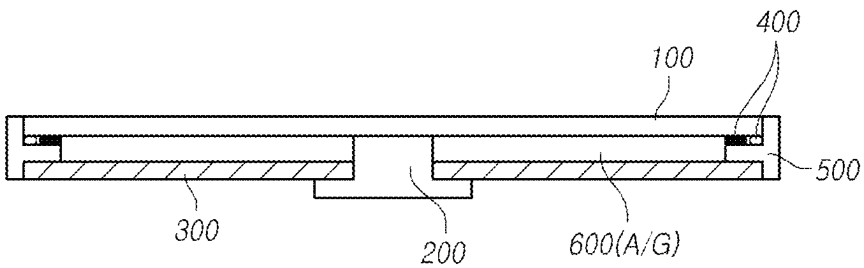


FIG.3A

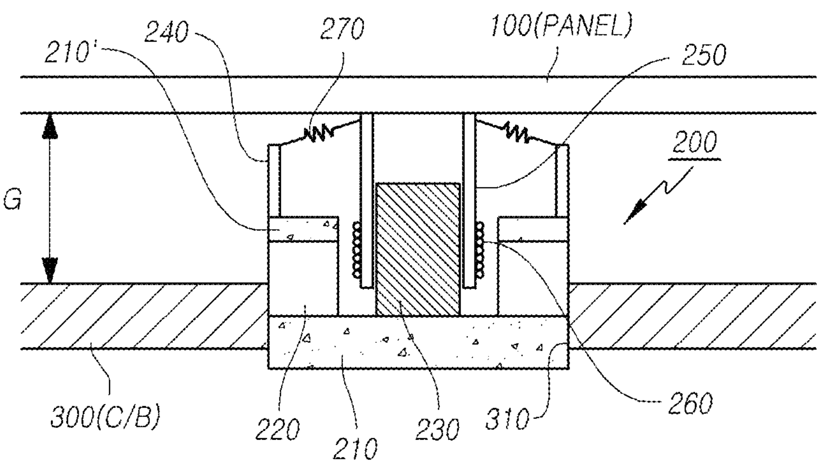


FIG.3B

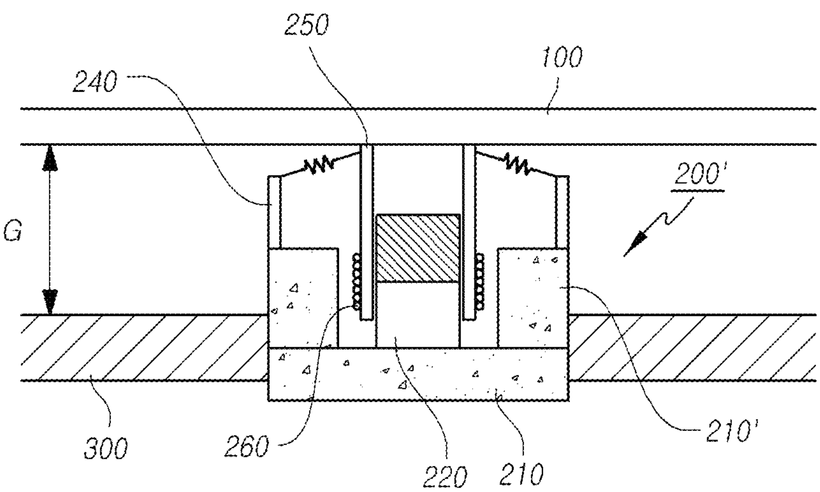


FIG.4A

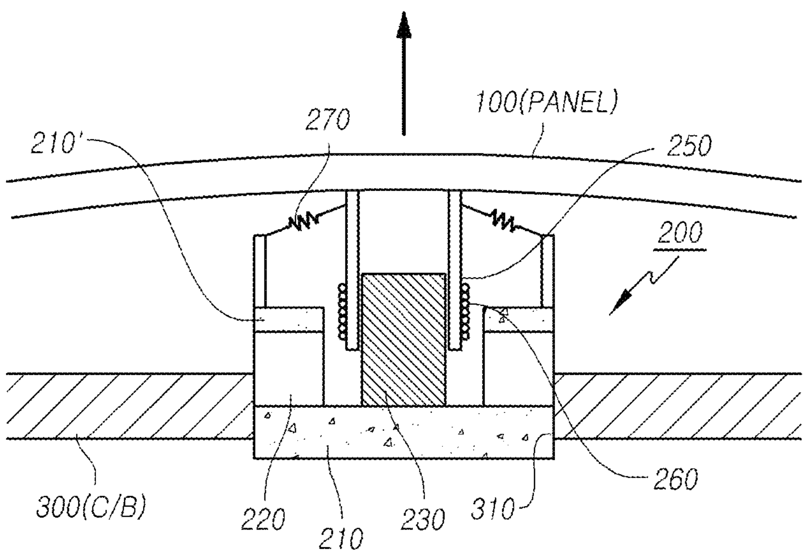


FIG.4B

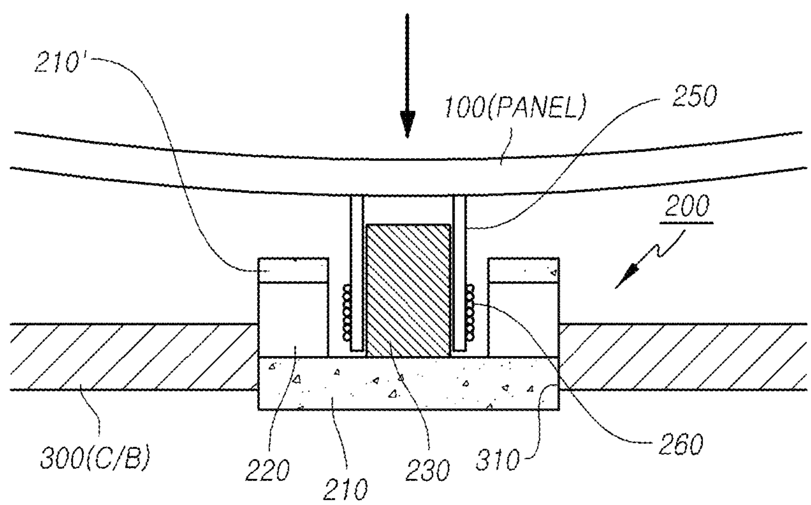


FIG.5A

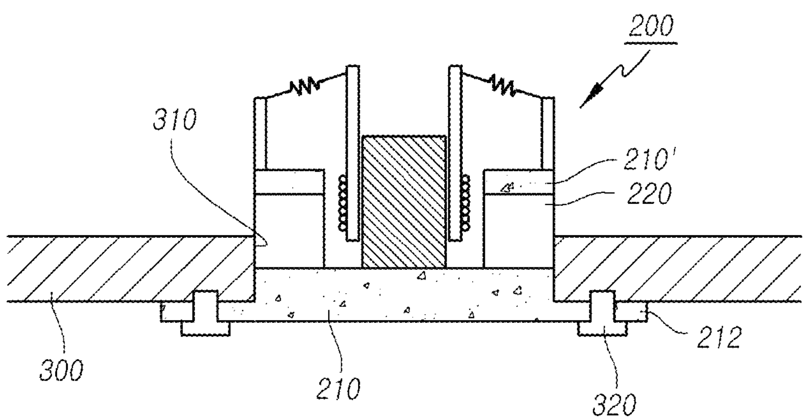


FIG.5B

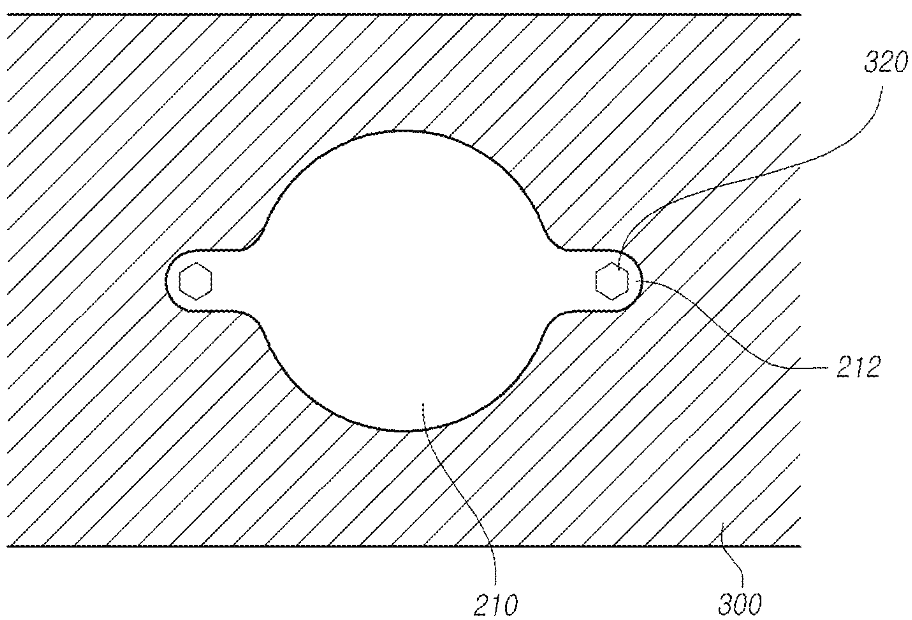


FIG.6A

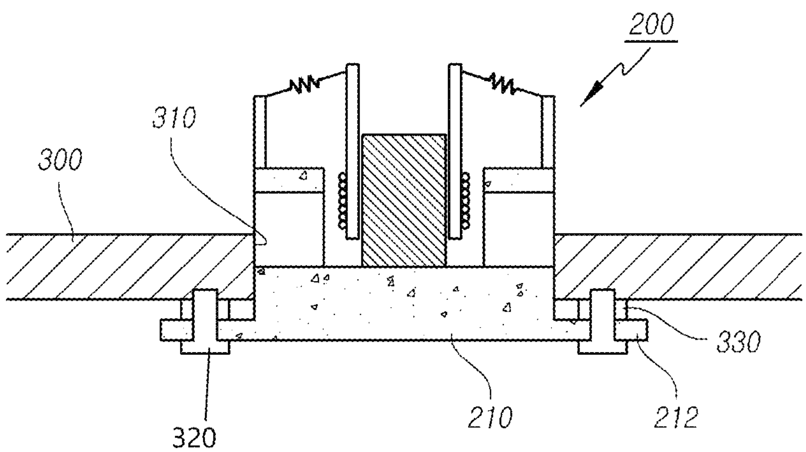


FIG.6B

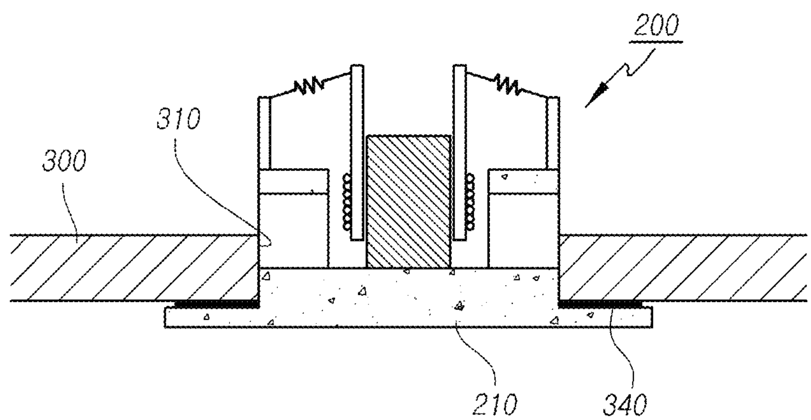


FIG. 7A

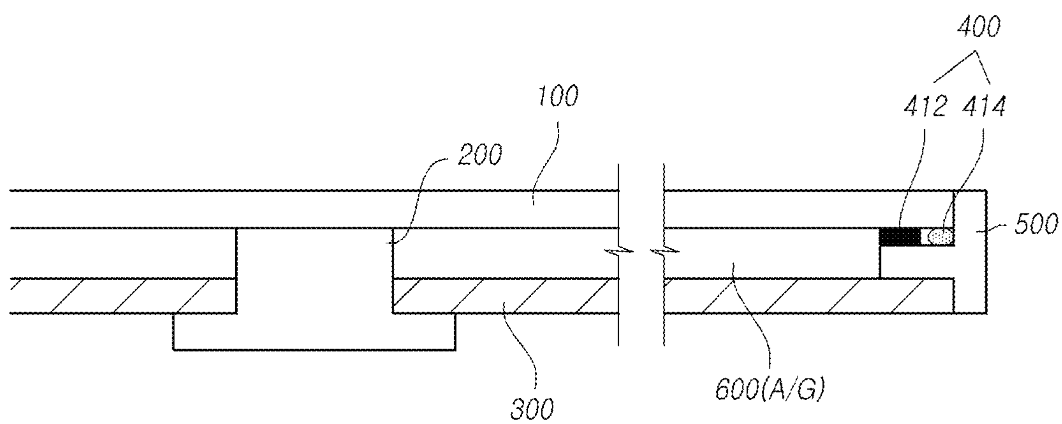


FIG. 7B

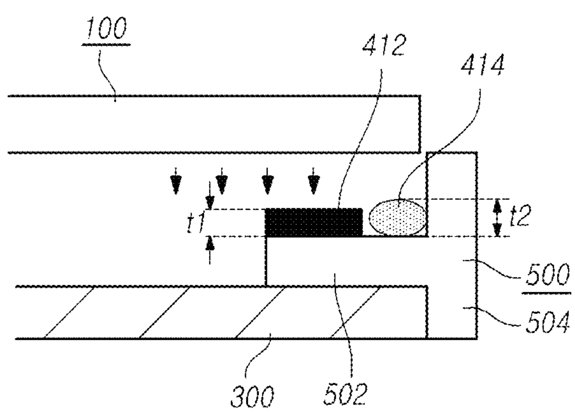


FIG. 7C

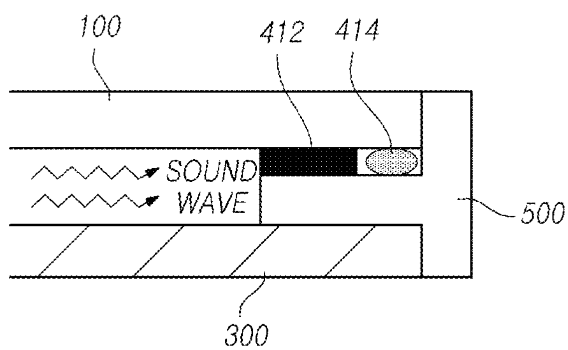


FIG.8

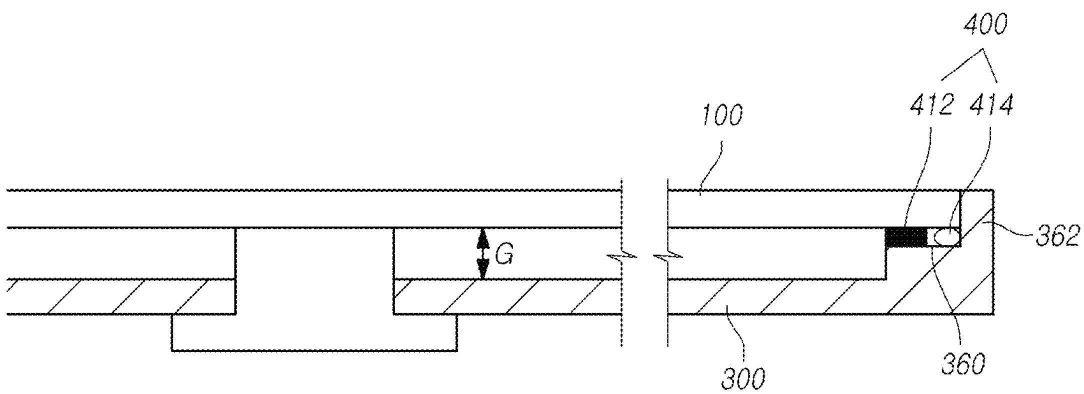


FIG.9A

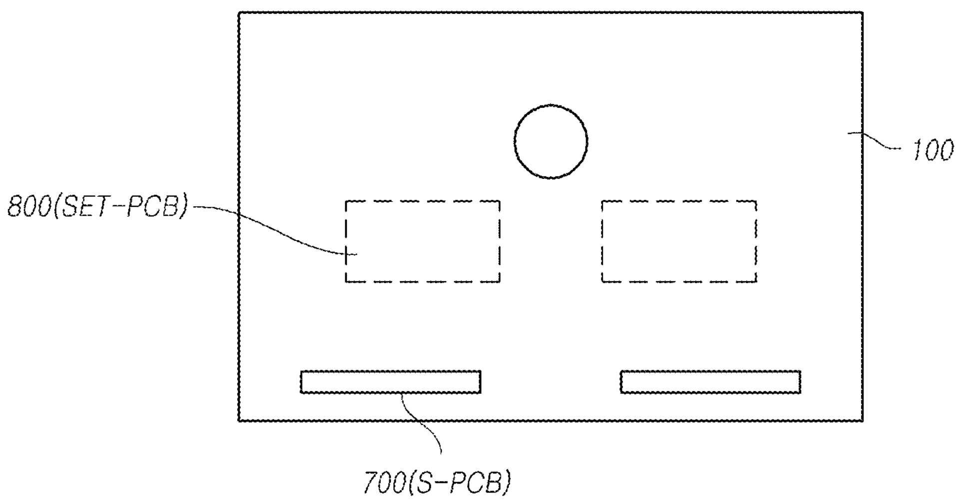


FIG.9B

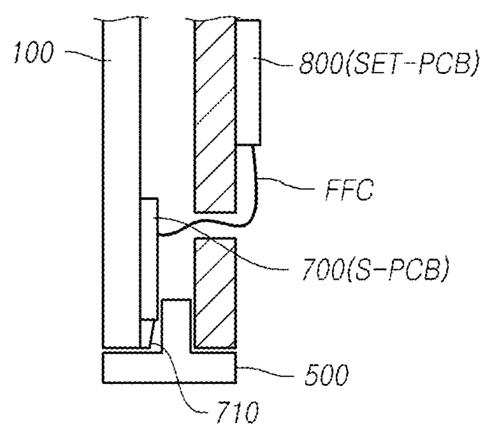


FIG. 10A

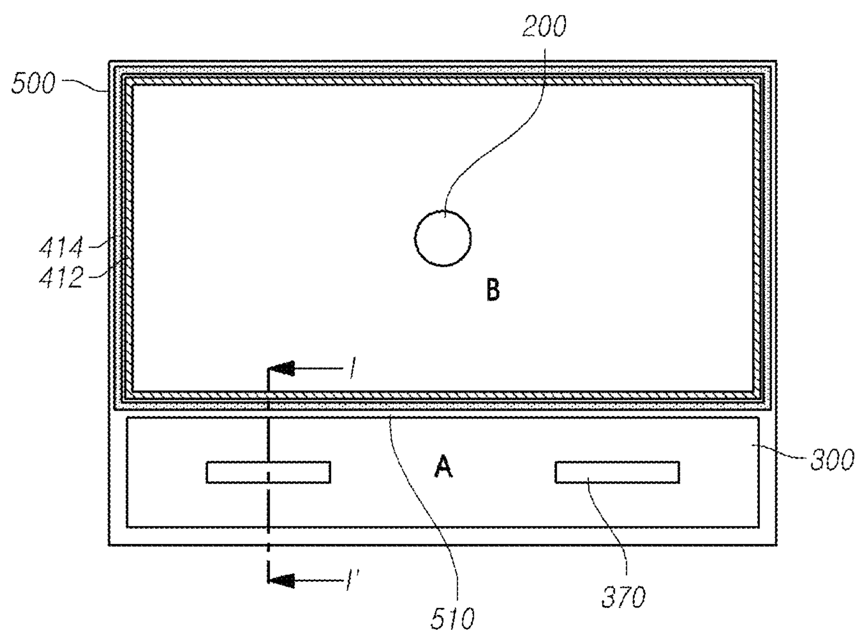


FIG. 10B

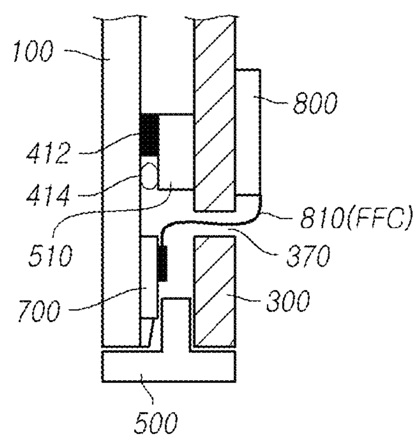


FIG. 11A

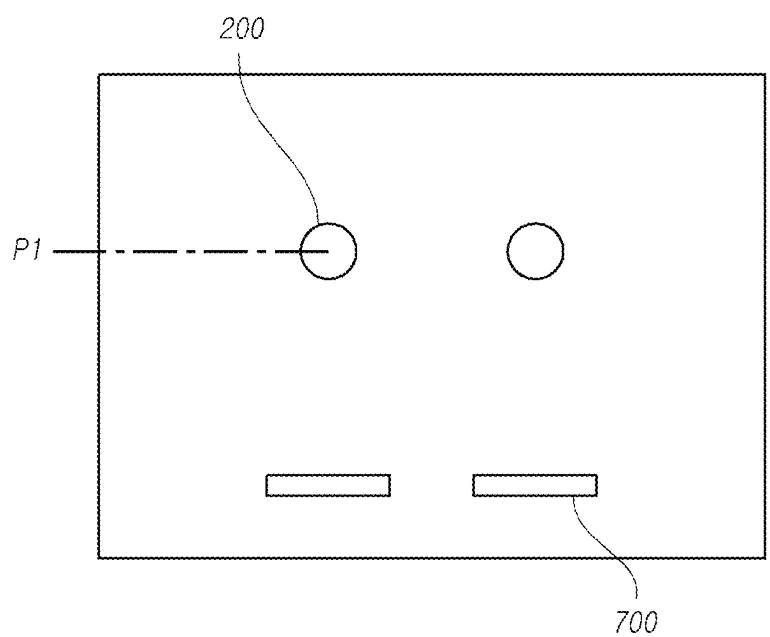


FIG.11B

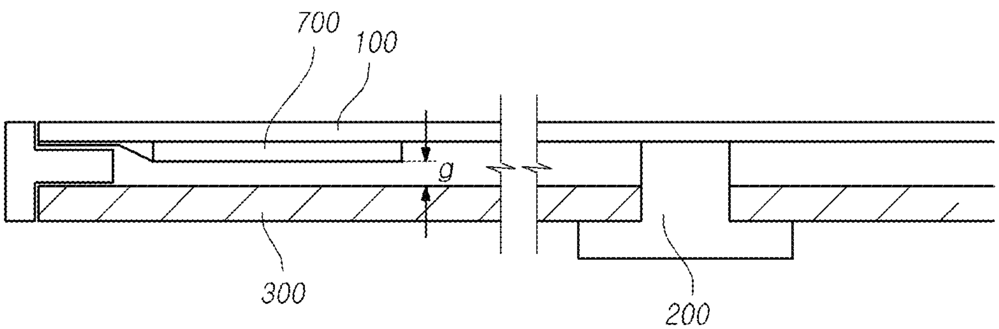


FIG. 12A

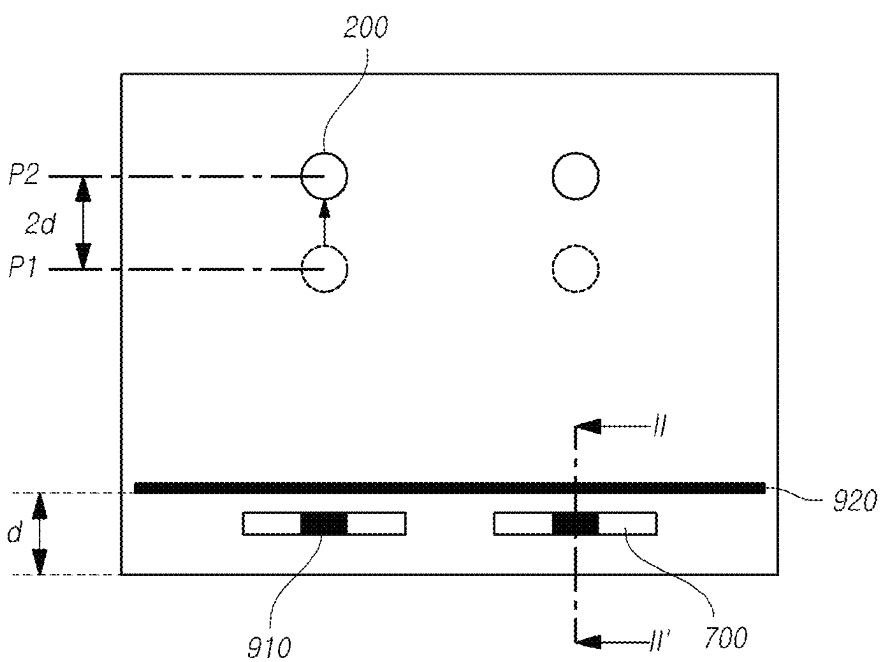


FIG. 12B

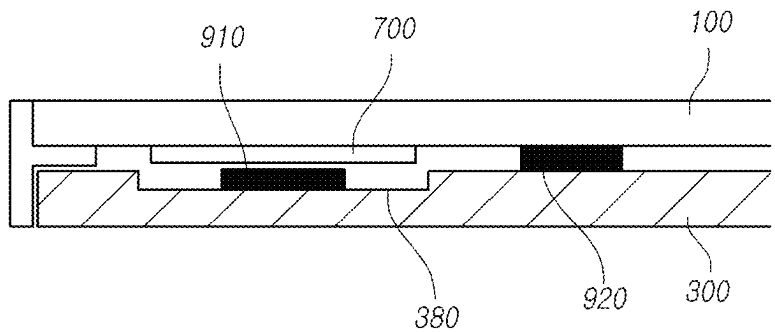


FIG. 13

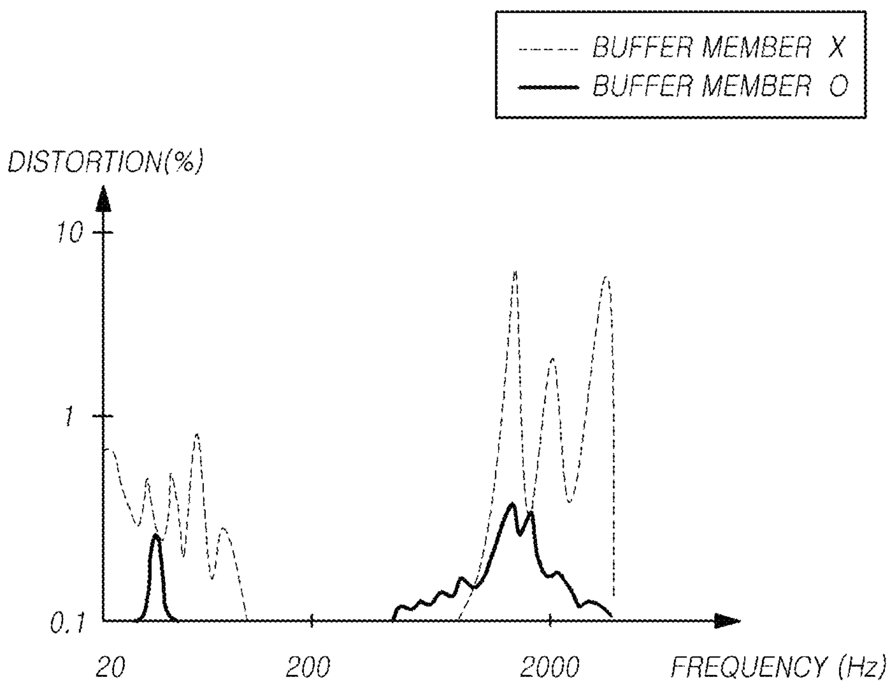

BUFFER MEMBER X
BUFFER MEMBER O
DISTORTION(%)
10
1
0.1
20
200
2000
FREQUENCY (Hz)

FIG. 14

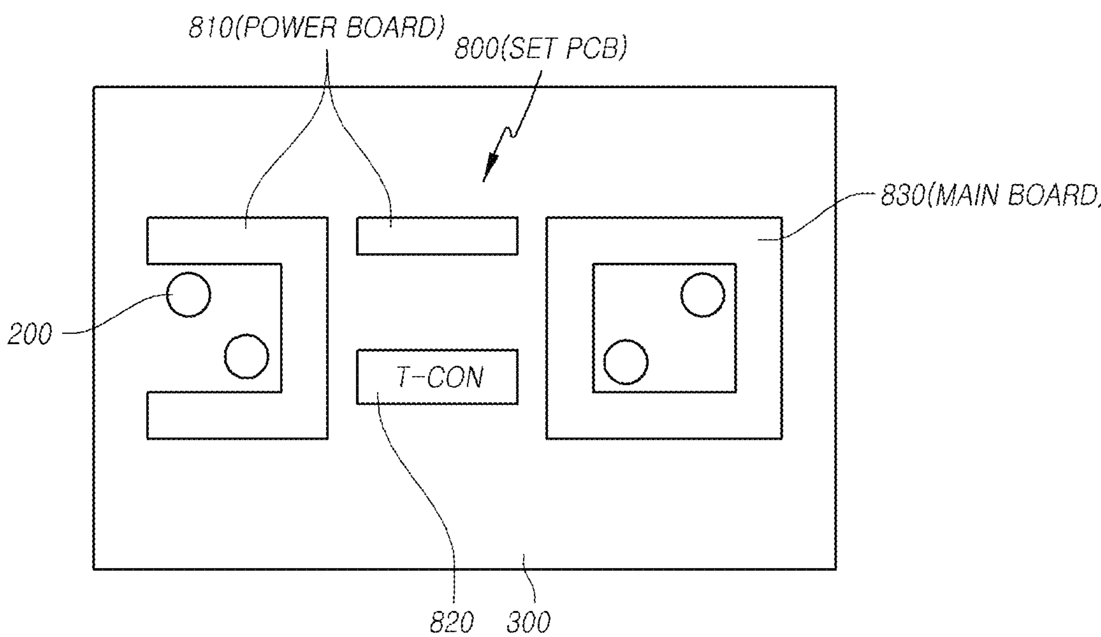


FIG. 15A

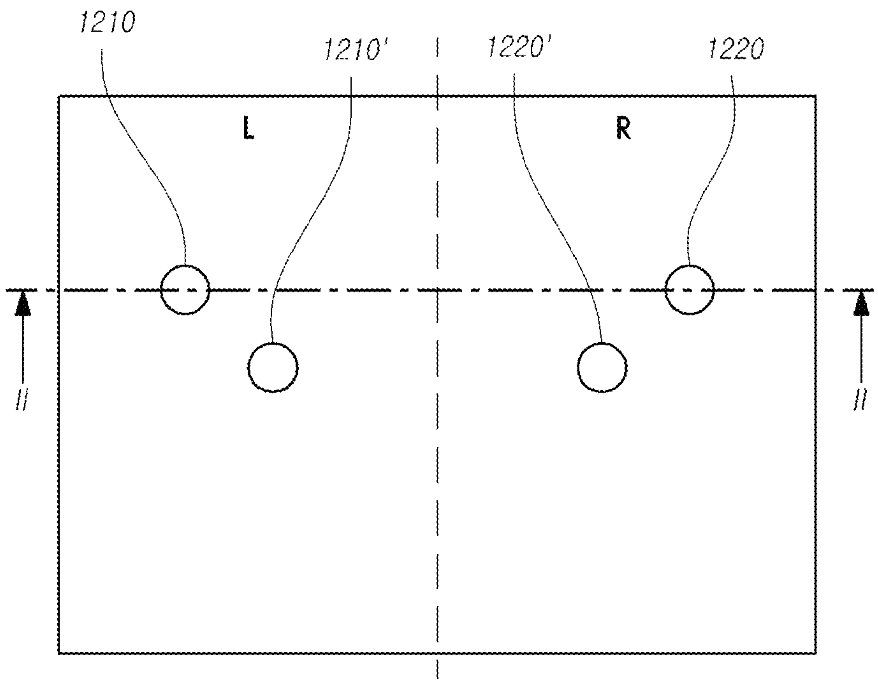


FIG. 15B

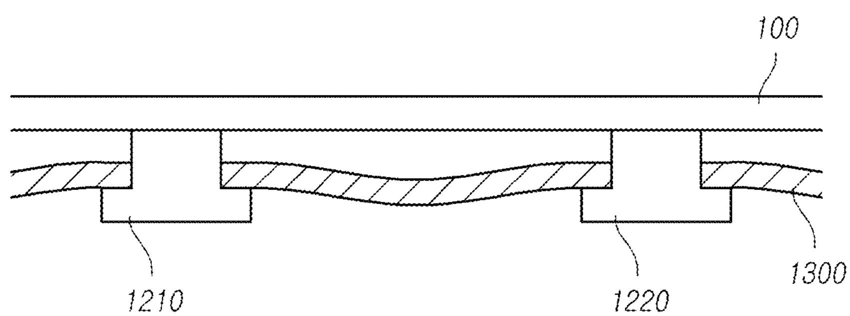


FIG. 16A

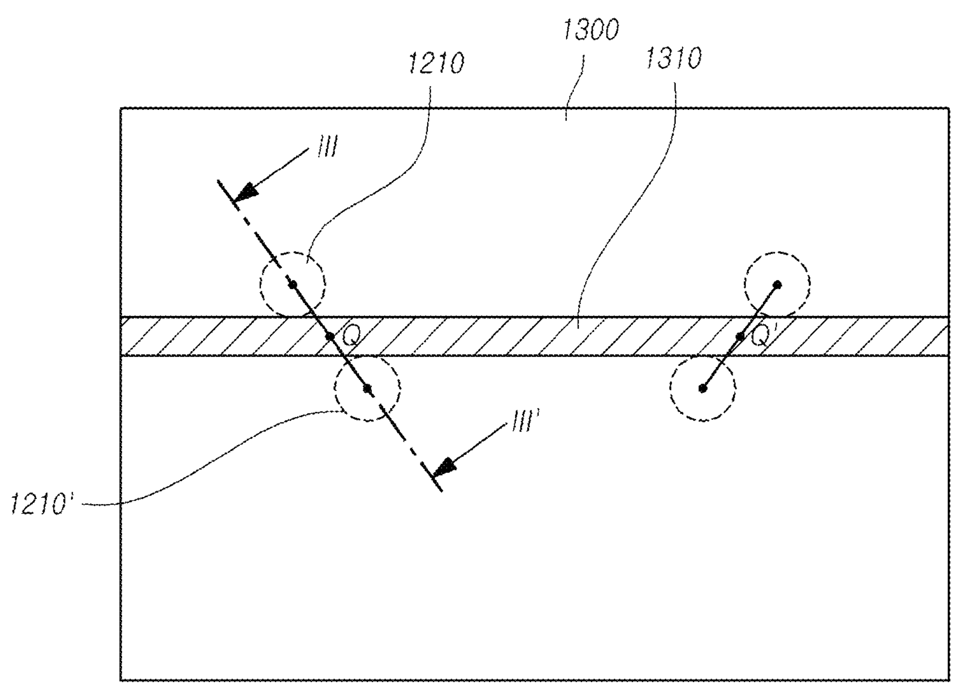


FIG. 16B

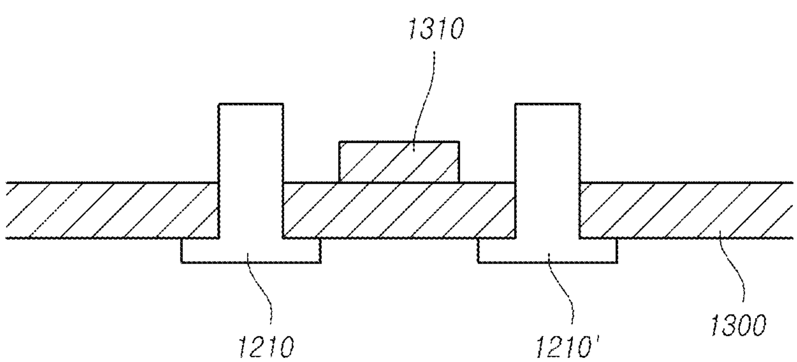


FIG.17A

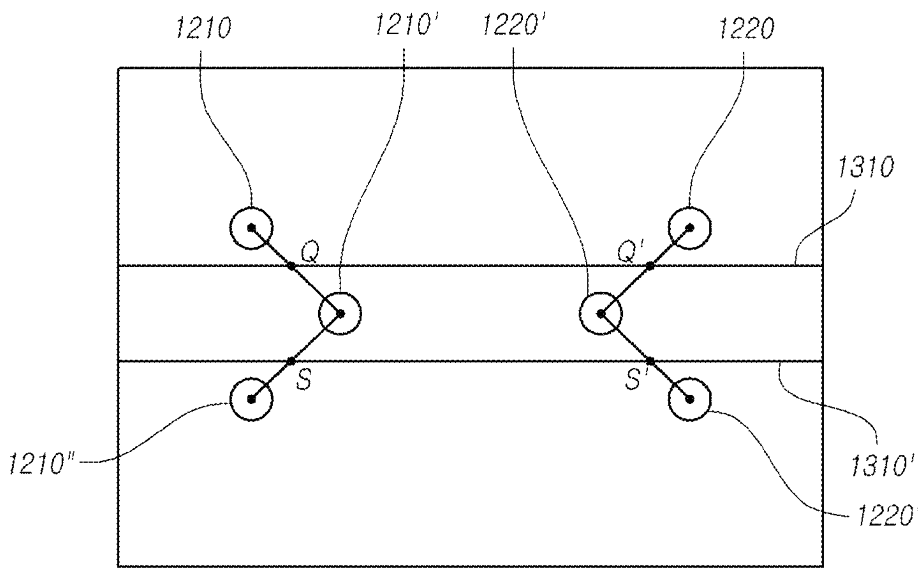


FIG. 17B

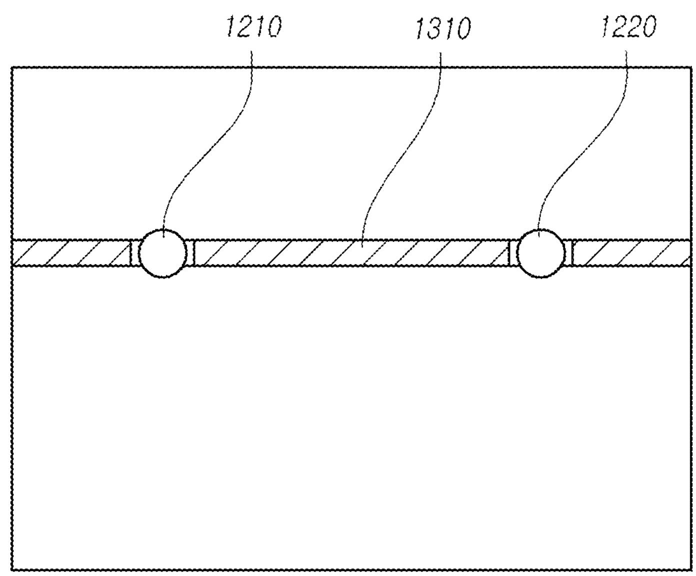


FIG. 18A

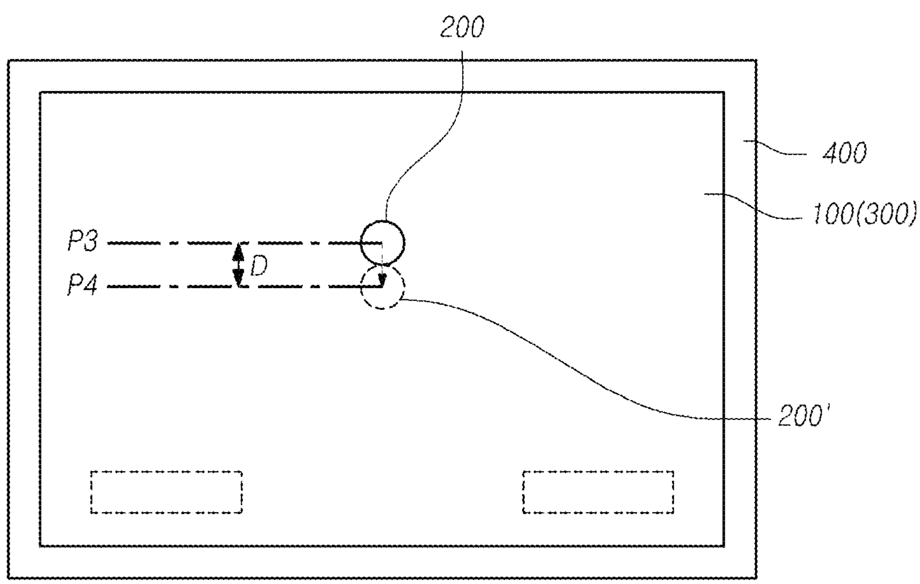


FIG. 18B

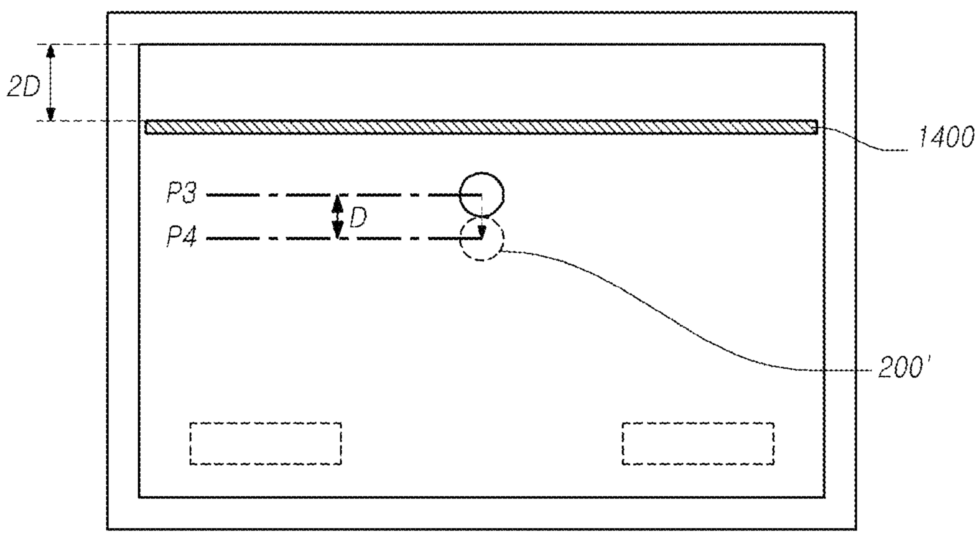
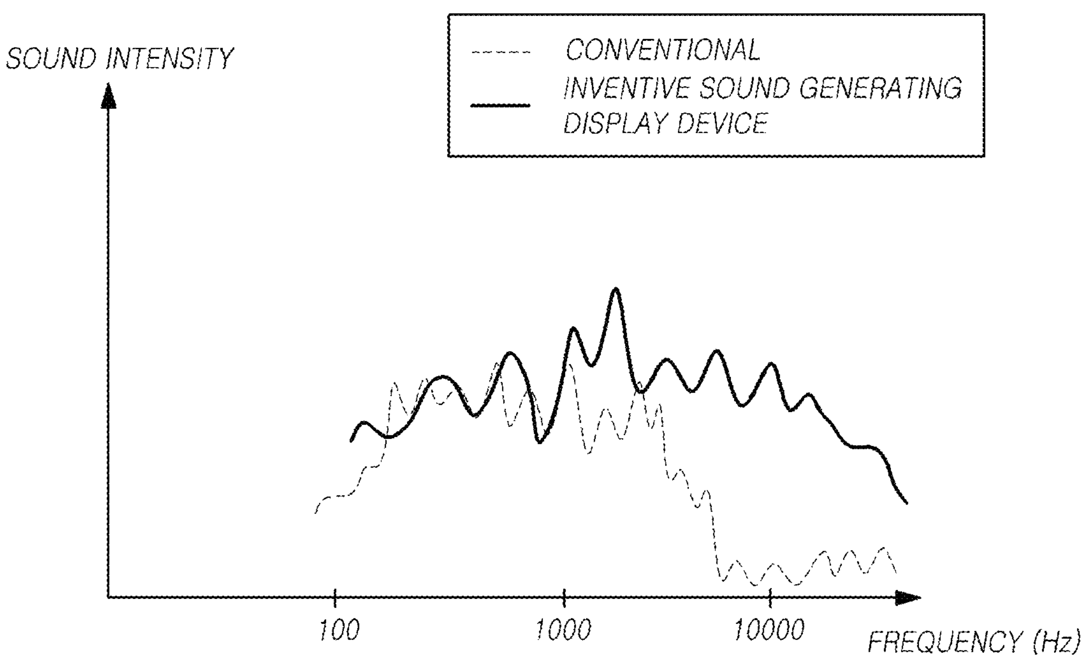


FIG. 19


CONVENTIONAL
INVENTIVE SOUND GENERATING DISPLAY DEVICE
SOUND INTENSITY
100
1000
10000
FREQUENCY (Hz)

SOUND GENERATING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of co-pending U.S. patent application Ser. No. 17/228,674, filed Apr. 12, 2021, which is a continuation of U.S. patent application Ser. No. 16/696,847, filed Nov. 26, 2019, now U.S. Pat. No. 11,019,425, issued May 25, 2021, which is a continuation of U.S. patent application Ser. No. 15/987,267, filed May 23, 2018, now U.S. Pat. No. 10,555,073, issued Feb. 4, 2020, which is a continuation of U.S. patent application Ser. No. 15/374,566, filed Dec. 9, 2016, now U.S. Pat. No. 10,009,683, issued Jun. 26, 2018, which claims priority from Korean Patent Application No. 10-2016-0037118, filed on Mar. 28, 2016. Each of the above prior U.S. and Korean Patent Applications is hereby incorporated by reference for all purposes as if fully set forth herein.

1. FIELD OF THE INVENTION

The present disclosure relates to a display device and, more specifically, to a display device for generating sound by directly vibrating a display panel thereof.

2. DESCRIPTION OF THE PRIOR ART

With the development of various portable electronic devices, such as mobile communication terminals and notebook computers, there has been an increase in the requirement for a flat panel display device applicable thereto.

The flat panel display devices being researched include a Liquid Crystal Display Device, a Plasma Display Panel, a Field Emission Display Device, a Light Emitting Diode Display Device, and an Organic Light Emitting Diode Display Device.

Among these display devices, the Liquid Crystal Display (LCD) device includes: an array substrate including a thin film transistor; an upper substrate including a color filter and/or a black matrix; and a liquid crystal material layer formed therebetween, wherein an alignment state of the liquid crystal layer is controlled according to an electric field applied between opposite electrodes of a pixel area, and thereby the transmittance of light is adjusted to display an image.

In a display panel of such a liquid crystal display device, an Active Area (AA) configured to provide an image to a user and a Non-active Area (NA), which is a peripheral area of the Active Area (AA), are defined. The display panel is usually manufactured by attaching a first substrate, which is an array substrate having a thin film transistor formed therein to define a pixel area, and a second substrate, which is an upper substrate having a black matrix and/or color filter layer formed thereon, to each other.

The array substrate or first substrate, on which a thin film transistor is formed, includes a plurality of gate lines GS extending in a first direction and a plurality of data lines DL extending in a second direction perpendicular to the first direction, and one pixel area P is defined by each gate line and each data line. One or more thin film transistors are formed in one pixel area P, and gate and source electrodes of each thin film transistor may be connected to a gate line and a data line, respectively.

Among these display devices, the liquid crystal display device does not have its own light-emitting element and thus needs a separate light source. Therefore, the liquid crystal

display device has a back-light unit having a light source, such as an LED, which is arranged at the rear surface thereof and irradiates a light toward a front surface of the liquid crystal panel thereof, thereby at last implementing a recognizable image.

Meanwhile, an Organic Light Emitting Diode (OLED) display device, which has recently been in the spotlight as a display device has a fast response rate, a high light emitting efficiency, a high luminance and a wide viewing angle compared to other conventional devices, because an OLED emits light by itself, i.e., an additional backlight unit is not required.

In the organic light emitting diode display device, sub-pixels including organic light emitting diodes are arranged in a matrix form, and the brightness of the sub-pixels selected by a scan signal is controlled according to a gray scale of the data. Further, the organic light emitting diode display device, which is an emissive element, consumes a smaller amount of power and has a high response speed, a high light emitting efficiency, a high luminance, and a wide viewing angle.

Meanwhile, the above-described display device may be included in a set apparatus or finished produce, such as a television (TV), a computer monitor, or an advertising panel.

Such a display device or set apparatus includes a sound output device, such as a speaker, for generating and outputting sound relating to an image.

Conventionally, a company that manufactures a display device, such as a liquid crystal display device or an organic light emitting diode display device, manufactures only a display panel or display device, while another company that manufactures a sound output device assembles the sound output device, such as a speaker, with the manufactured display device, so as to finally complete a set apparatus capable of outputting both an image and sound.

FIG. **1** is a schematic plan view of a speaker included in a conventional display device.

As shown in FIG. **1**, the conventional display device **1** includes a speaker **2** disposed at a rear or lower part of a display panel thereof.

In this structure, the sound generated by the speaker **2** does not progress toward a viewer, who is viewing an image from the front side of the display device **1**, but progresses toward the rear side or the underside of the display panel. Therefore, the sound may disturb the viewer's immersive experience.

Further, when the sound generated from the speaker **2** progresses toward the rear side or underside of the display panel, the sound quality may be degraded due to an interference with sound reflected by a wall or floor.

Also, the sound generated by a speaker included in conventional display devices is not oriented toward a viewer of the display device and may thus undergo diffraction, which decreases sound localization. Moreover, in configuring a set apparatus, such as a TV, a speaker may occupy a predetermined space, which imposes a restriction on the design and spatial arrangement of the set apparatus.

Therefore, there has been an increasing interested in the development of technology which can improve the quality of sound output from a display device and prevent the viewer's immersive experience from being disturbed.

SUMMARY OF THE INVENTION

The present disclosure has been made to overcome the above-mentioned problems of the prior art and, in one aspect, provide a panel vibration type sound generating display device, which can generate sound by directly vibrating a display panel of the display device.

In another aspect, the present disclosure provides a display device including a panel vibration type sound generating apparatus, which has a predetermined air gap formed between a display panel and a sound generating actuator and an actuator support hole formed in a support structure of the display device, so that the display device has a reduced thickness while having an excellent sound generation performance. The support structure may also be termed a support member or support part.

In another aspect, the present disclosure provides a display device having a sound generation baffle part formed therein, which includes an adhesive member attached between the upper surface of the support structure and the lower surface of the display panel and a sealing part disposed outside the adhesive member, so that the display device can minimize sound leakage and improve a sound output characteristic. The adhesive member may be a double-sided tape.

In another aspect, the present disclosure provides a display device, which includes one or more buffer members arranged between the inner surface of the support structure and the rear surface of the display panel adjacent to a source printed circuit board (PCB) or between the support structure disposed at the rear surface of the display panel and the source PCB to fix/support the sound generating actuator, to prevent interference and noise between the support structure and a Source PCB (S-PCB) for driving the display panel.

The panel vibration type sound generating display device may further comprise a set PCB, which is disposed at an outer rear surface of the cover bottom and includes a control circuit configured to control the entire display device, wherein a cable passing hole through which a connection cable for electrically connecting the source PCB and the set PCB is to pass is disposed at an area of the cover bottom corresponding to the first area.

In another aspect, the present disclosure provides a display device in which a sound generating actuator is placed at a first position of a support structure of the display device and a set PCB of a set apparatus is placed at a second position, which is different from the first position, so as to avoid interference between the sound generating actuator and the set PCB, and improve the sound characteristic.

In still another aspect, the present disclosure provides a display device, which has a reinforcement member arranged inside the support structure of the display device when two or more sound generating actuators are used, so that the display device can prevent deformation of the support structure due to different vibration characteristics of the two or more sound generating actuators or prevent sound distortion by the vibration of the support structure.

In view of the above aspects, a display device of the present embodiment includes: a display panel configured to display an image; and a sound generating actuator connected to a surface of the display panel configured to vibrate the display panel to generate sound. The surface may be an inner surface, for example.

The display device may further include a support structure, such as a cover bottom, configured to cover and support at least a rear surface of the display panel, wherein the sound generating actuator is inserted in and fixed to a support hole formed at the cover bottom to be fixed to the support structure.

The support structure of the panel vibration type sound generating display device may comprise: a cover bottom supporting the rear side of the display panel, a source PCB for driving the display panel is disposed on a rear surface of one side of the display panel, and a first buffer member spaced from the source PCB by a predetermined distance is placed on an inner surface of the cover bottom corresponding to the source PCB.

The sound generating actuator may further include: a plate inserted in the support hole; a magnet disposed on the plate; a center pole disposed at a center of the plate; a bobbin disposed to surround the center pole and be in contact with the display panel; and a coil wound around the bobbin. The plate may be a lower plate, for example.

The lower plate configuring the sound generating actuator may further include an extension part extending outward, and the extension part may be fixed to the lower surface of the cover bottom through a bolt, a PEM™ nut, or an adhesive member.

The extension part and the cover bottom of the panel vibration type sound generating display device, may be fixedly coupled to each other by one of a bolt fastened through a through-hole provided through the extension part to a screw hole disposed at the cover bottom and an adhesive member disposed between the extension part and the cover bottom.

The panel vibration type sound generating display device may further comprise a baffle part disposed between the support structure and the lower surface of the display panel to define an air gap, which is a space in which the display panel can be vibrated by the sound generating actuator.

An air gap is formed between the display panel and the support member, and the display device may further include a baffle part including an adhesive member and a sealing part arranged between the lower surface of the display panel and the upper surface of the support member at an edge of the air gap.

The baffle part of the panel vibration type sound generating display device may comprise an adhesive member disposed at an edge of the air gap and attached to the lower surface of the display panel and the upper surface of the support structure, and a sealing part disposed outside the adhesive member.

The sealing part of the panel vibration type sound generating display device may have a thickness larger than the thickness of the adhesive member.

The support member includes a cover bottom supporting a rear side of the display panel and a middle cabinet supporting the edge of the display panel. The middle cabinet may include an area division member configured to separate a first area including a source PCB and a second area including a sound generating actuator.

The support structure of the panel vibration type sound generating display device may comprise a cover bottom, which supports a rear side of the display panel, and a middle cabinet, which has a shape of a frame, coupled to the cover bottom to support a side surface of the display panel, and stably holds the edge of the display panel, the middle cabinet comprising an area division member configured to separate a first area including a source PCB for driving the display panel and a second area including the sound generating actuator.

The baffle part of the panel vibration type sound generating display device may comprise an adhesive member attached to three sides of the middle cabinet corresponding to the second area, an upper surface of the area division member, and the lower surface of the display panel, and a sealing part disposed outside the adhesive member.

A recessed part is formed on an upper surface of the cover bottom opposite to the source PCB placed on a rear surface of the display panel, and a first buffer member spaced a predetermined distance from the lower surface of the display panel may be disposed on the recessed part. The recessed part may be concave, for example.

The cover bottom may have a second buffer member disposed thereon, which is in contact with the lower surface of the display panel and the upper surfaces of the cover bottom while separating a first area covering the source PCB and a second area covering the sound generating actuator.

The sound generating actuator may include two or more actuators, which are symmetrically arranged and have different vibration characteristics, and the cover bottom may further have a reinforcement member disposed thereon, which passes through adjacent positions of the two or more actuators.

An embodiment of the present disclosure as described above provides a display device including a panel vibration type sound generating display device, which generates sound by directly vibrating a display panel, thereby making it unnecessary to install a separate speaker to the display device or a set apparatus including the display device.

Further, since the progressing direction of the sound coincides with the image output direction in the display device, the display device or the set apparatus can improve sound localization or sound output characteristics, the mechanism of the set apparatus can be easily designed, and can have a reduced thickness thereof.

A concave part of the panel vibration type sound generating display device may be disposed on the inner surface of the cover bottom corresponding to the source PCB and the first buffer member may be disposed on an upper surface of the concave part.

The cover bottom of the panel vibration type sound generating display device may have a second buffer member disposed thereon, which is in contact with the lower surface of the display panel and the upper surfaces of the cover bottom while separating a first area covering the source PCB and a second area covering the sound generating actuator.

The support structure of the panel vibration type sound generating display device may comprise a cover bottom supporting the rear side of the display panel. The display device may further comprise a set PCB, which is disposed at an outer rear surface of the cover bottom and includes a control circuit configured to control the entire display device, and a first position in which the sound generating actuator is disposed and a second position in which one or more boards configuring the set PCB are arranged do not overlap each other.

The support structure of the panel vibration type sound generating display device may comprise a cover bottom supporting the rear side of the display panel, the sound generating actuator may comprise two or more actuators, which are symmetrically arranged and have different vibration characteristics, the cover bottom may have a reinforcement member disposed thereon, which passes through adjacent positions of the two or more actuators.

The two or more actuators of the panel vibration type sound generating display device may comprise two left sound generating actuators and two right sound generating actuators, and the reinforcement member may be disposed to pass through a middle point of a segment connecting the two left sound generating actuators and a middle point of a segment connecting the two right sound generating actuators.

The panel vibration type sound generating display device may further comprise a sound compensation member, which is lengthily disposed at a position spaced a certain distance apart from an edge of the display panel opposite to a moving direction of the sound generating actuator when the sound generating actuator moves to a destination position spaced a predetermined distance apart from an initial position.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic plan view of a speaker included in a conventional display device;

FIGS. **2**A and **2**B are schematic views of a panel vibration type sound generating apparatus according to an embodiment of the present disclosure wherein FIG. **2**A is a plan view and FIG. **2**B is a sectional view;

FIGS. **3**A and **3**B are sectional views of two types of sound generating actuators used according to embodiments of the present disclosure;

FIGS. **4**A and **4**B illustrate a state in which a sound generating actuator according to an embodiment of the present disclosure vibrates a display panel to generate sound;

FIGS. **5**A and **5**B illustrate an example of a coupling state between a sound generating actuator according to an embodiment of the present disclosure and a cover bottom, which is a supporting structure of a display device;

FIGS. **6**A and **6**B illustrate other embodiments of a coupling state between a sound generating actuator and a cover bottom;

FIGS. **7**A to **7**C illustrate an example of a baffle part formed between a display panel and a middle cabinet, which is one of the structures for supporting the display panel to form a sound transferring air gap between the display panel, which serves as a vibrating plate, and a cover bottom;

FIG. **8** illustrates a structure of a baffle part according to another embodiment in which the adhesive member and the sealing part are placed directly on a cover bottom;

FIGS. **9**A and **9**B illustrate a locational relation between a source PCB for driving a display panel and a set PCB for driving a set apparatus, which are arranged at the rear surface of a display device;

FIGS. **10**A and **10**B illustrate an embodiment which further includes an area division member additionally formed on a middle cabinet, and a cable passing hole through which a connection cable (FFC) formed on a cover bottom passes;

FIGS. **11**A and **11**B are schematic views showing the relative arrangement of the cover bottom and the source PCB for driving the display panel;

FIGS. **12**A and **12**B illustrate an embodiment including a buffer member capable of preventing interference and noise between the source PCB and the cover bottom illustrated in FIGS. **11**A and **11**B;

FIG. **13** is a graph illustrating a noise reduction effect when the buffer members of the embodiment illustrated in FIGS. **12**A and **12**B are used;

FIG. **14** illustrates a relative arrangement between a sound generating actuator and a set PCB in a display device according to an embodiment of the present disclosure;

FIGS. **15**A and **15**B illustrate a display device including two or more actuators symmetrically arranged therein, and a distortion of a cover bottom due to a difference of vibration quantity in the display device;

FIGS. **16**A and **16**B illustrate a structure which has a reinforcement member disposed inside a cover bottom in order to prevent generation of sound distortion by twisting or vibration of the cover bottom;

FIGS. **17**A and **17**B illustrate specific arrangements of reinforcement members on a cover bottom;

FIGS. **18**A and **18**B illustrate an embodiment, which further includes a sound compensation member in order to maintain the sound output characteristics when the sound generating actuator has been vertically moved; and

FIG. **19** is a graph illustrating a sound output characteristic when a panel vibration type sound generating apparatus according to the present embodiment is used, in comparison with a conventional speaker.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Hereinafter, embodiments of the present disclosure will be described with reference to the accompanying drawings. In assigning reference numerals to elements in the drawings, the same elements will be designated by the same reference numerals as far as possible although they are illustrated in different drawings. Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

In addition, terms, such as first, second, A, B, (a), (b) or the like may be used herein in describing elements of the present invention. Each of these terminologies is not used to define an essence, order or sequence of a corresponding component but used merely to distinguish the corresponding component from other component(s). In the case that it is described that a certain element "is connected to", "is coupled to", or "is connected with" another element, it should be understood that not only can the certain element be directly connected or coupled to the another element, but an additional element may also be "interposed" between the elements or the elements may be connected or coupled to each other through an additional element.

FIGS. **2**A and **2**B are schematic views of a panel vibration type sound generating apparatus according to an embodiment of the present disclosure, wherein FIG. **2**A is a plan view and FIG. **2**B is a sectional view.

As shown in FIGS. **2**A and **2**B, a display device according to this embodiment includes a display panel **100** configured to display an image, and a sound generating actuator **200** which is attached to a surface of the display panel and vibrates the display panel to generate sound.

The sound generating actuator **200**, which is described below in more detail with reference FIGS. **4**A and **4**B, includes a magnet, a plate supporting the magnet, a center pole protruding from a central area of the plate, and a bobbin disposed to surround the center pole and having a coil wound thereon, to which an electric current for generating sound is applied, wherein a distal end of the bobbin is attached to one surface of the display panel.

As shown in FIG. **2**B, the display device may include a support structure configured to support one or more of the rear surface or a side surface of the display panel, and the plate of the sound generating actuator may be fixed to the support structure.

The support structure includes a cover bottom **300** disposed at the rear surface of the display panel, and may further include a middle cabinet **500** which is coupled to the cover bottom while surrounding the side surface of the display panel and receives and supports one side edge of the display panel.

The cover bottom configuring the support structure may be a plate-shaped member made of metal or plastic extending over the entire rear surface of the display device.

The cover bottom **300** in the present disclosure is not limited to the term thereof but may be used as other expressions, such as a plate bottom, a back cover, a base frame, a metal frame, a metal chassis, a chassis base, or m-chassis, and has a concept including all types of frames or plate-shaped structures, each of which may be arranged on the rear base part of the display device as a support for the display panel.

In the present specification, the term "display device" not only describes a display device, such as an OLED module or a Liquid Crystal Module (LCM) including a display panel and a driving unit for driving the display panel, but this term also includes a set electronic apparatus or a set apparatus, such as a notebook computer, a television, a computer monitor, or a mobile electronic device such as a smartphone or an electronic pad, which are finished products including such an LCM or OLED module.

For clarity, an LCM or OLED module configured by a display panel and a driving unit thereof may be expressed as a "display device", and an electronic apparatus, as a finished product, including such an LCM or OLED module may be expressed as a "set apparatus". For example, the display device may include an LCD or OLED display panel and a source PCB, which is a control unit for driving the display panel, and the set apparatus may further include a set PCB, which is a set control unit electrically connected to the source PCB to control the entire set apparatus.

The display panel **100** used in the present embodiment includes all types of display panels including a liquid crystal display panel, an Organic Light Emitting Diode (OLED) display panel, and a Plasma Display Panel (PDP) and is not limited to a specific display panel, as long as the display panel is directly vibrated by the sound generating actuator **200** to generate sound wave.

When the display panel is a liquid crystal display panel, the display panel may include: a plurality of gate lines; a plurality of data lines; pixels defined at intersecting areas between the gate lines and data lines; an array substrate including a thin-film transistor, which is a switching device configured to adjust a light transmission degree at each pixel; an upper substrate including a color filter and/or a black matrix; and a liquid crystal material layer formed therebetween.

When the display panel is an OLED display panel, the display panel may include: a plurality of gate lines; a plurality of data lines; pixels defined at intersecting areas between the gate lines and data lines; an array substrate including a thin-film transistor, which is a switching device configured to selectively apply a voltage to each pixel; an OLED layer disposed on the array substrate; and a sealing substrate or an encapsulation substrate disposed on the array substrate to cover the OLED layer. The sealing substrate protects the thin film transistor and the OLED layer from external impact and prevents moisture from permeating the OLED layer.

Although there is no limitation in the type of the display device used in a display device according to this embodiment, it may be preferred that the display panel is an OLED display panel by the reasons described below.

Specifically, a liquid crystal display panel has many laminated layers and requires an indirect light source type back-light having a separate light source disposed therein. Therefore, when the liquid crystal display panel is directly vibrated by the sound generating actuator **200**, the directivity of the liquid crystal material may be shaken and thus cause distortion of an image.

In contrast, since the OLED device of the OLED display panel is an emissive element, the OLED display panel does not require a separate light source and has one panel in which multiple layers including a polarization layer, a glass layer, and an encapsulation layer are integrated. Therefore, even when the OLED display panel is directly vibrated by the sound generating actuator **200**, the vibration has nearly no influence on the light emitting property of the organic light emitting layer and thus causes no image distortion. Therefore, in an embodiment of the present disclosure, an OLED display panel is preferably used.

The display panel used in a display device according to an embodiment of the present disclosure has a general structure, so a more specific description thereof will be omitted.

The display device according to an embodiment of the present disclosure may further include a baffle part **400** configured to form an air gap, which is a space disposed between the display panel and a support structure, i.e., the cover bottom **300** or the middle cabinet **500**, to transfer the generated sound wave.

That is, by coupling the display panel to the cover bottom at an edge of the air gap and sealing the same, the air gap may be defined as an area sealed in all directions, and such a sealed air gap may be expressed as a baffle structure.

Referring to FIGS. **7**A to **7**C, the baffle part **400** may include an adhesive part **412** disposed at an edge of the cover bottom or middle cabinet and is attached to the lower surface of the display panel, and a sealing part **414** disposed outside the adhesive part to reinforce the sealing of the air gap **600**.

The adhesive part **412** may be configured by a double sided tape. It is preferred that the height of the sealing part **414** is higher than the height of the adhesive part **412** as described below in more detail with reference to FIGS. **7**A to **7**C.

FIGS. **3**A and **3**B are sectional views of two types of sound generating actuators used according to embodiments of the present disclosure.

A sound generating actuator **200** used in these embodiments may include a magnet **220**, which is a permanent magnet, plates **210** and **210'** configured to support the magnet, a center pole **230** protruding from a central area of the plate **210**, a bobbin **250** disposed to surround the center pole **230**, and a coil **260** wound around the bobbin, wherein an electric current for generating sound is applied to the coil **260**.

The sound generating actuator used in the present embodiment may include both a first structure in which the magnet is disposed outside the coil and a second structure in which the magnet is disposed inside the coil.

FIG. **3**A illustrates the first structure having the magnet disposed outside the coil, which may be called a dynamic type or an external magnet type.

In the sound generating actuator of the first structure, the lower plate **210** is fixed to a support hole **310** formed at the cover bottom **300** and the magnet **220**, which is a permanent magnet having an annular shape, and is disposed on the lower plate and surrounding the center pole **230**.

The upper plate **210'** is disposed on the magnet **220**, and an external frame **240** protruding from the upper plate is disposed outside the upper plate.

The center pole **230** protrudes from the central area of the lower plate **210** and the bobbin **250** surrounds the center pole **230**.

The coil **260** is wound around a lower portion of the bobbin **250**, and the electric current for generating sound is applied to the coil.

A damper **270** may be disposed between an upper part of the bobbin and the external frame **240**.

The lower plate **210** and the upper plate **210'** fix the sound generating actuator **200** to the cover bottom **300** while supporting the magnet **220**, the lower plate **210** has a cylindrical shape as shown in FIG. **3**A, the magnet **220** having a ring shape is disposed on the lower plate **210**, and the upper plate **210'** is disposed on the magnet.

As the lower plate **210** and the upper plate **210'** are coupled to the cover bottom **300**, the magnet **220** disposed between the lower plate **210** and the upper plate **210'** can be fixedly supported.

The plate may be formed of a material having a magnetic property, such as ferrite Fe. The plate is not limited to the term thereof and may be expressed by another term, such as a yoke.

The center pole **230** and the lower plate **210** may be integrally formed.

The bobbin **250** is a cylindrical structure formed by paper or aluminum sheet, and the coil **260** is wound around a predetermined lower area of the bobbin. A combination of the bobbin and the coil may be referred to as a voice coil.

When the electric current is applied to the coil, a magnetic field is formed around the coil. Then, due to an external magnetic field formed by the magnet **220**, the entire bobbin moves upward while being guided by the center pole according to Fleming's Law.

Meanwhile, since the distal end of the bobbin **250** is attached to the rear surface of the display panel **100**, the bobbin vibrates the display panel based on the application or non-application of the electric current, and such vibrations generate sound waves.

The magnet **220** may be a sintered magnet, such a barium ferrite, or may be a cast magnet made from an alloy of ferric oxide (Fe2O3), barium carbonate (BaCO3), strontium ferrite having an improved magnetic component, aluminum (Al), nickel (Ni), and cobalt (Co), without being limited thereto.

A damper **270** is disposed between an upper part of the bobbin **250** and the external frame **240**, and the damper **270** has a wrinkle structure and thus contracts or expands to adjust the up-down vibration of the bobbin according to the up-down movement of the bobbin. That is, since the damper **270** is connected to the bobbin **250** and to the external frame **240**, the up-down vibration of the bobbin is restricted by the restoring force of the damper **270**. Specifically, when the bobbin **250** vibrates upward beyond a predetermined height or downward beyond a predetermined level, the restoring force of the damper **270** can return the bobbin to its original position.

The damper may be expressed by another term, such as an edge.

FIG. **3**B illustrates the second structure having the magnet disposed inside the coil, which may be expressed as a micro type or an internal magnet type.

In the sound generating actuator of the second structure, the lower plate **210** is fixed to a support hole **310** formed at the cover bottom **300**, the magnet **220** is disposed at a central area of the lower plate, and the center pole extends upward from the top of the magnet.

The upper plate **210'** protrudes from a peripheral part of the lower plate **210**, and the external frame **240** is disposed on the edge of the upper plate **210'**.

The bobbin **250** is disposed to surround the magnet **220** and the center pole **230**, and the coil **260** is wound around the bobbin.

The damper **270** is disposed between the external frame **240** and the bobbin.

The sound generating actuator of the second structure shown in FIG. **3**B has a smaller leakage of magnetic flux than that of the first structure shown in FIG. **3**A and thus, the corresponding display device can have a smaller size. However, the sound generating actuator of the second structure may undergo reduction of magnetic flux due to a large current input and is difficult to manufacture.

In these embodiments, both the actuators of the first structure and the second structure may be used, and the following description discusses the first structure as a representative for convenience of description.

The sound generating actuator used in a display device according to an embodiment of the present disclosure is not limited to the type illustrated in FIGS. **3**A and **3**B, and includes other types of actuators as long as the actuators can vibrate a display panel up and down to generate sound in response to application of the electric current.

FIGS. **4**A and **4**B illustrate a state in which a sound generating actuator according to an embodiment of the present disclosure vibrates a display panel to generate sound.

FIG. **4**A illustrates a state in which the electric current has been applied, wherein the center pole connected to the lower surface of the magnet serves as the N pole and the upper plate connected to the upper surfaces of the magnet serves as the S pole to establish an external magnetic field between coils.

In this state, if an electric current for generating sound is applied to a coil, an applied magnetic field is generated around the coil. The applied magnetic field generates, together with the external magnetic field, a force of moving the bobbin upward.

By the force, the bobbin moves upward and the display panel coupled to the distal end of the bobbin moves upward, as shown in FIG. **4**A.

In this state, if the application of the electric current is interrupted or the electric current is applied in the opposite direction, a force of moving the bobbin downward is generated in the same principle, and the display panel thus moves downward.

In this way, according to the direction and magnitude of the electric current applied to the coil, the display panel vibrates up and down to generate sound wave.

FIGS. **5**A and **5**B illustrate an example of a coupling state between a sound generating actuator according to an embodiment of the present disclosure and a cover bottom, which is a supporting structure of a display device.

FIGS. **6**A and **6**B illustrate other embodiments of a coupling state between a sound generating actuator and a cover bottom.

The sound generating actuator **200** according to an embodiment of the present disclosure may be inserted through and supported by a support hole formed on a cover bottom or back cover, which is a support structure of a display device. FIGS. **5**A to **6**B illustrate various support structures.

In the support structure of FIG. **5**, a support hole **310** is formed through the cover bottom **300**, and at least one among the lower plate **210** of the sound generating actuator **200**, the magnet **220**, and the upper plate **210'** is inserted and received in the support hole.

An extension part **212** extending outward from the lower plate is additionally formed on the lower surface of the lower plate **210**, and the extension part **212** is fixed to the lower surface of the cover bottom **310** to allow the sound generating actuator **200** to be mounted to the cover bottom.

In this way, when the sound generating actuator **200** is inserted in and fixed to the support hole formed through the cover bottom, the distance between the display panel and the cover bottom can be reduced to thereby reduce the thickness of the display device.

In other words, although an air gap in which the display panel can vibrate should be arranged between the display panel and the cover bottom, the sound generating actuator inserted in/fixed to the support hole of the cover bottom can minimize the air gap due to the reduced height of the sound generating actuator disposed between the rear surface of the display panel and the inner surface of the cover bottom.

In the structure illustrated in FIGS. **5**A and **5**B, a screw hole is formed on the rear surface of the cover bottom, and a bolt **320** or a screw is fastened through the screw hole formed through the extension part **212** of the lower plate to the screw hole of the cover bottom to fix the sound generating actuator to the cover bottom.

Meanwhile, in the structure illustrated in FIG. **6**A, which is not a simple screw-coupling structure, a PEM™ nut **330** or self-clinching nut is placed to secure a predetermined distance between the cover bottom **300** and the extension part **212** of the lower plate, and the actuator is then fixed by the bolt **320**.

Use of the PEM nut **330** or self-clinching nut as shown in FIG. **6**A can secure a predetermined space between the sound generating actuator and the cover bottom, thereby minimizing the transfer of the vibrations from the actuator to the cover bottom.

In the structure shown in FIG. **6**B, an adhesive member, such as a double-sided tape, is disposed between the cover bottom and the extension part **212** of the lower plate of the actuator to attach and fix them to each other.

When the adhesive member as shown in FIG. **6**B has a properly adjusted elasticity and thickness, the adhesive member can function as a kind of damper to minimize the transfer of the vibrations from the actuator to the cover bottom.

The structures as shown in FIGS. **5**A to **6**B in which the sound generating actuator **200** attached to the display panel to directly vibrate the display panel is inserted in and fixed to a support hole formed through the cover bottom can reduced the thickness of the display device in comparison with the structure in which the actuator is completely received in the display device.

FIGS. **7**A to **7**C illustrate an example of a baffle part formed between a display panel and a middle cabinet, which is one of structures for supporting the display panel, in order to form an air gap between the display panel, which serves as a vibrating plate, and a cover bottom.

As shown in FIG. **7**A, the panel vibration type sound generating apparatus according to this embodiment secures an air gap **600**, which is a space allowing the panel to be vibrated by the sound generating apparatus **200**, between the display panel **100** and a support structure (cover bottom **300**).

Further, one side of the display panel is coupled to the support structure of the display panel to generate sound waves during the vibration of the display panel. Especially, the generated sound should not leak to the outside through a side, etc. of the display device.

To this end, the display device according to this embodiment has a baffle part **400** formed between the lower surface of the display panel and the support structure.

Specifically, it is preferred that a predetermined section (that is, air gap) is defined around the sound generating actuator, a baffle part is disposed between the upper surface of the cover bottom or middle cabinet and the lower surface of the display panel at an edge of the section, and the baffle part **400** includes an adhesive member **412**, such as a double-sided tape, attached between the lower surface of the display panel and the upper surface of the support structure of the display device, and a sealing part **414** disposed outside the adhesive member.

The section in which the baffle part is formed may be the entire display panel area defined by four outer sides of the display panel. However, the section is not limited to such a definition and may be defined by an area excluding the area in which a source PCB is disposed, as described below.

When two or more sound generating actuators are arranged to implement stereo or three-dimensional sound, two or more sections may be separately arranged to form the baffle part.

As shown in FIGS. **7**A to **7**C, the support structure of the display device may include a middle cabinet **500**, which is coupled to the cover bottom and is configured to allow a part of the display panel to be stably placed thereon, in addition to the cover bottom **300** covering the entire rear surface of the display panel.

The middle cabinet **500** is a frame-shaped member formed along the outer periphery of the display panel, and includes a horizontal support part **502** on which a part of the display panel is stably placed, and a vertical support part **504** bent perpendicularly in opposite directions from the horizontal support part to cover the side surface of the cover bottom and the side surface of the display panel. Therefore, the middle cabinet may have a shape of a letter "T" in general.

The middle cabinet **500** configures an external ornamental part of the side surface of the display device or set apparatus, and may not be used or integrally formed with the cover bottom in some cases.

According to the embodiment of FIG. **7**A, the adhesive member **412** configuring the baffle part **400** is a double-sided tape disposed between the upper surface of the horizontal support part of the middle cabinet **500** and the display panel and fixes the lower surfaces of the display panel to the middle cabinet.

The sealing part **414** configuring the baffle part is placed outside of the adhesive member and preferably has a thickness or height larger than the thickness or height of the adhesive member.

The sealing part **414** may be made from a material having a large elasticity, such as rubber, and has a thickness t**2** larger than the thickness t**1** of the adhesive member **412** as illustrated in FIG. **7**B.

That is, as illustrated in FIG. **7**B, one adhesive surface of the adhesive member **412**, which is a double-sided tape having a thickness t**1**, is attached to the inner part of the upper surface of the horizontal support part **502** of the middle cabinet **500**, and the sealing part **414** made of an elastic material having a thickness larger than t**1** is disposed outside the adhesive member.

In this state, the display panel **100** is attached to the other adhesive surface of the adhesive member **412**. Then, the display panel is attached to the middle cabinet while pressing, to a certain degree, the sealing part **414** having the larger thickness. (FIG. **7**C)

As a result, the sealing of the air gap around the sound generating actuator is further enhanced.

The structure illustrated in FIG. **7**C, in which the display panel **100** and the cover bottom **300** are coupled to each other while forming the air gap **600** to be as wide as the thickness of the adhesive member **412** and the horizontal support part **502** of the middle cabinet, can secure a vibration space in which the display panel can generate sound, and can prevent the internally generated sound waves from leaking to the outside along the side surface of the display device.

The baffle part **400** disposed at an edge of the air gap, which has a double structure of the adhesive member **412** and the sealing part **414** while allowing the sealing part to have a larger thickness, can further enhance the sealing of the air gap and prevent leakage of the sound.

It should be construed that the middle cabinet **500** used in the present specification may be replaced by another term, such as a guide panel, a plastic chassis, a p-chassis, a support main, a main support, or a mold frame, and includes all types of members, which are structures having a shape of a four-sided frame and having a sectional shape including multiple bent portions and are connected to the cover bottom to be used to support the display panel and the baffle part.

The middle cabinet **500** may be made of synthetic resin, such as a polycarbonate, by injection molding, without being limited thereto.

FIG. **8** illustrates a structure of a baffle part according to another embodiment in which the adhesive member and the sealing part are placed directly on a cover bottom.

Although a middle cabinet is used to support the cover bottom and the display panel in the embodiment described above, the middle cabinet may not be always required.

The embodiment illustrated in FIG. **8** shows a structure in which the cover bottom **300** supports one side of the display panel while forming an external appearance of the side surface of the display device without a middle cabinet.

The structure illustrated in FIG. **8** includes a cover bottom **300** in which a step portion **360** protrudes upward from a base surface at one side of the cover bottom **300** and a side surface supporting part **362** vertically extends from the outside of the step portion **360**.

A part of the edge of the display panel **100** is stably placed on and attached to the step portion **360** of the cover bottom **300**, the side surface support part **362** of the cover bottom surrounds and protects the side surface of the display panel **100**, and the cover bottom resultantly forms an external ornamental part of the entire side and rear surfaces of the display device.

In this structure, in order to configure the baffle part **400** for generation of sound, the adhesive member **412** in the form of a double-sided tape is disposed inside the step portion **360** of the cover bottom and the sealing part **414** having a thickness larger than that of the adhesive member is disposed outside the adhesive member.

In this state, the display panel **100** is placed on the step portion **360** of the cover bottom and is attached to one adhesive surface of the adhesive member **412**, so that the display panel is coupled to the cover bottom. Then, the sealing part **414** is compressed to secure and enhance the sealing of the air gap for transfer of sound.

The embodiment of FIG. **8** has a simple structure without a middle support structure like the middle cabinet and includes the baffle part **400**, which is disposed at an edge of the air gap and has a double structure of the adhesive member **412** and the sealing part **414** while allowing the sealing part to have a larger thickness. Therefore, the embodiment of FIG. **8** can secure a vibration space in which the display panel can generate sound, and can prevent the internally generated sound waves from leaking to the outside along the side surface of the display device.

The thickness of the air gap, that is, the distance G between the display panel and the cover bottom, may have a value of about 1.0 to 3.0 mm in an embodiment of the present disclosure. However, the thickness is not limited to the range and may have a value in a range different according to the degree of vibration of the display panel, etc.

However, in order to reduce the thickness of the display device, it is preferable to minimize the thickness G of the air gap in consideration of the quantity of vibration of the display panel by the sound generating actuator, the range of sound to be output, and the quantity of output. In an embodiment of the present disclosure, an optimum thickness of the air gap G is about 2.0 mm.

FIGS. **9**A and **9**B illustrate a locational relation between a source PCB for driving a display panel and a set PCB for driving a set apparatus, which are arranged at the rear surface of a display device.

As shown in FIGS. **9**A and **9**B, the display device includes a source PCB, which is a circuit board including a Source Driver Integrated Circuit (S-DIC) for driving a display panel to drive data lines formed on the display panel and is referred to as simply "S-PCB".

The display device or a set apparatus including the same is connected to the S-PCB and may further include a Control Printed Circuit Board (C-PCB) having control parts and various electric devices mounted thereon to generally control the display device or set apparatus.

Specifically, an OLED display device, to which the present embodiment is applicable, may include: an OLED display panel **100** including a plurality of data lines DL, a plurality of gate lines, and a plurality of sub-pixel SP arranged thereon; a data driver configured to drive the plurality of data lines DL; a gate driver configured to drive the plurality of gate lines GL; and a controller configured to control the data driver and the gate driver.

The controller supplies various control signals to the data driver and the gate driver to control the data driver and the gate driver, starts scanning according to a timing implemented in each frame, converts image data input from the outside into a data signal format used in the data driver and outputs a converted image data, and properly controls the driving of the data driver according the scanning.

The controller may be a timing controller used in a general display technology or may be a control apparatus including a timing controller to further perform another control function.

The data driver supplies a data voltage to the plurality of data lines DL to drive the data lines DL. Herein, the data driver is also referred to as a "source driver".

The data driver may include at least one Source Driver Integrated Circuit (S-DIC) to drive the plurality of data lines.

The gate driver sequentially supplies a scan signal to the plurality of gate lines GL to sequentially drive the gate lines GL. The gate driver is also referred to as a "scan driver" and may include at least one Gate Driver Integrated Circuit (G-DIC).

Each Source Driver Integrated Circuit (S-DIC) may be connected to a bonding pad of an OLED display panel either by a Tape Automated Bonding (TAB) method or a Chip On Glass (COG) method or directly. In some cases, S-DICs may be integrated and arranged in an OLED panel. Further, each S-DIC may be packaged on a film connected to an OLED display panel by a Chip On Film (COF) method.

That is, a display device, to which the present embodiment is applicable, may include: at least one Source Printed Circuit Board (S-PCB) necessary for circuit connection of at least one Source Driver Integrated Circuit (S-DIC); and a Control Printed Circuit Board (C-PCB) or set PCB configured to mount control parts for controlling the entire display device and various electric devices thereon.

Here, at least one S-DIC may be mounted on or a Chip-On Film (COF) having at least one S-DIC mounted thereof may be connected to the at least one source PCB.

The C-PCB or set PCB **800** may include a controller configured to control operations of the data driver and the gate driver, and a Power Management IC (PMIC) configured to supply various voltages or currents to the display panel, the data driver, and the gate driver or control the various voltages or currents to be supplied.

The source PCB is usually located at one side among the upper side and the lower side of a display panel. However, according to the driving scheme or panel design scheme, the source PCB may be arranged on both the upper side and the lower side.

That is, as shown in FIGS. **9**A and **9**B, the source PCB **700** is connected to the display panel **100** and the COF **710** and is disposed on a lower rear surface of the display panel.

The C-PCB or set PCB **800** may be disposed at the outer rear side of the cover bottom **300** and connected through a flexible cable to the source PCB **700** located inside the cover bottom.

In the structure shown in FIGS. **9**A and **9**B, it is difficult to configure a baffle part as described above with reference to FIGS. **7**A to **7**C, at the lower side of the display panel having the sound generating actuator **200** mounted thereon.

In other words, since the source PCB **700** and the chip-on film **710** connected thereto are arranged in the vicinity of the lower side of the display panel, it is difficult to arrange the baffle part **400** including the adhesive member **412** and the sealing part **414**, and the sealing of the air gap may be degraded even when the baffle part is arranged.

Further, the generated sound may leak backward through a cable passing hole, which is formed through a part at the lower side of the cover bottom to enable a flexible cable for connection between the source PCB **700** disposed inside the cover bottom and the set PCB **800** disposed outside the cover bottom to pass therethrough.

Therefore, in order to apply a sound generating apparatus of the present embodiment to a display device having the structure as shown in FIGS. **9**A and **9**B, it is necessary to solve the problems of degradation in the sealing of the baffle part and the sound leakage. In this respect, an embodiment, as shown in FIGS. **10**A and **10**B, is presented.

The embodiment illustrated in FIGS. **10**A and **10**B has a structure, which further includes an area division member **510** configured to partition the middle cabinet into two or more areas and has a baffle part formed on the area division member, in order to solve the problems of the structure described above with reference to FIGS. **9**A and **9**B. This embodiment also includes a cable passing hole through which a connection cable (FFC) formed on a cover bottom passes.

The area division member **510** divides the entire area of the middle cabinet surrounding the entire display panel into a first area A in which the source PCB is included and a second area B in which the source PCB is not included, wherein the sound generating actuator **200** is disposed in a part of the second area B.

The area division member may be manufactured in the form of a bar having a thickness corresponding to the horizontal support part of the middle cabinet to be attached to the middle cabinet **500** through welding, etc. However, the present disclosure is not limited thereto and the entire middle cabinet including the area division member **510** may be integrally manufactured as one unit.

As shown in FIG. **10**A, an area division member **510** is lengthily disposed in the horizontal direction of the display device, and an adhesive member **412** and a sealing part **414** are arranged on the upper side of the area division member **510** and three sides of the middle cabinet corresponding to the second area B.

FIG. **10**B is a sectional view taken along line I-I' of FIG. **10**A, in which the adhesive member **412** and the sealing part **414** are arranged on the upper side of the area division member **510** to seal the second area B as an air gap.

In a part of the lower area of the cover bottom **300**, specifically, among the areas divided by the area division member **510**, a cable passing hole **370**, through which a connection cable **810** connecting the source PCB **700** and the set PCB **800** is to pass, is formed in the first area A, which includes the source PCB.

The structure as shown in FIGS. **10**A and **10**B in which only the second area B, which does not include a source PCB is formed as a sound generating area can minimize the degradation of the sealing of the sound generating area by interference of the source PCB.

Further, the cable passing hole **370** disposed in the first area A including the source PCB can prevent sound leakage through the cable passing hole.

FIGS. **11**A and **11**B are schematic views showing the relative arrangement of the cover bottom and the source PCB for driving the display panel.

As shown in FIG. **11**A, a source PCB **700** including an S-DIC or data driver is connected to the display panel through a chip-on film, etc., and is disposed at one side (lower side) of the display panel.

As shown in FIG. **11**B, a gap g is formed between the source PCB and the cover bottom in the area in which the source PCB is disposed, and is smaller than a gap between the source PCB and the cover bottom in the other area.

Therefore, when the sound generating actuator **200** according to the present embodiment is arranged and vibrates the display panel, the source PCB, which integrally vibrates the display panel, may collide with the cover bottom in the area in which the source PCB is placed.

The collision between the source PCB and the cover bottom may generate noise and may even damage the source PCB.

Further, even without direct collision between the source PCB and the cover bottom, strong vibrations of the display panel at the time of sound generation may have an influence on the performance of the source PCB when the vibration is continuously transferred to the source PCB.

In order to solve this problem, arranging a buffer member for protecting the source PCB between the source PCB and the cover bottom or between the display panel and the cover bottom is proposed.

FIGS. **12**A and **12**B illustrate an embodiment including a buffer member capable of preventing interference and noise between the source PCB and the cover bottom illustrated in FIGS. **11**A and **11**B.

In the embodiment of FIGS. **12**A and **12**B, a source PCB **700** including a circuit element for driving the display panel is disposed at the rear surface of the display panel, a recessed part **380** is formed in an area of the cover bottom, which faces the source PCB, and a first buffer member **910** having a predetermined elasticity is placed on the upper surface of the concave part **380**. The recessed part **380** may be concave, for example.

Further, a second buffer member **920** extending along a length of one direction may be additionally disposed on the cover bottom.

Specifically, as shown in FIG. **12**A, the display panel may be divided into a first area A covering the source PCB and a second area B covering the sound generating actuator, and the second buffer member **920** is preferably disposed as being extended along a length of the first area A and second area B to separate the first area A and the second area B from each other.

Of course, although not illustrated, the baffle part **400** including the adhesive member **412** and the sealing part **414** described above with reference to FIGS. **7**A to **8** may be disposed on all of the four sides of the display panel in the embodiment of FIGS. **12**A and **12**B.

The first buffer member **910** and the second buffer member **920** may be configured by a one-sided tape or double-sided tape. However, the present disclosure is not limited thereto, and the buffer member may include all types of members formed of rubber, plastic, paper, or other materials, which have a predetermined elasticity.

It is preferred that the first buffer member **910** is disposed on the concave part **380** of the cover bottom while the upper surface of the first buffer member **910** is spaced a predetermined distance apart from the source PCB and the second buffer member **920** has one surface in contact with the cover bottom and the other surface in contact with the lower surface of the display panel.

Of course, the first buffer member **910** may be placed on a part of the upper surface of the cover bottom, which faces the source PCB.

As shown in FIG. **12**B, the concave part **380** formed at the cover bottom area corresponding to the source PCB increases the gap between the source PCB and the cover bottom to reduce the possibility that the source PCB may collide with the cover bottom even when the display panel vibrates to generate sound.

Moreover, the first buffer member **910** disposed on the concave part **380** of the cover bottom can buffer a large vibration of the display panel even when the source PCB moves toward the concave part of the cover bottom due to the larger vibrations, so as to reduce the generation of noise due to interference between the source PCB and the cover bottom and reduce the possibility of damage to the source PCB.

Further, when the display panel vibrates in the second area B, which is the sound generation area, the second buffer member **920** can prevent the vibration from being transferred to the source PCB **700** disposed on the rear surface of the display panel to some degree, and thus can minimize the degradation of performance of the source PCB due to continuous vibration of the display panel.

The location of the sound generating actuator may be changed according to the arrangement of the second buffer member **920**.

That is, as shown in FIG. **12**A, when the second buffer member **920** is spaced a distance d apart from the lower side of the display panel, the sound generating actuator **200** may be moved by about 2d from the initial position P**1** and is then installed at position P**2**.

Changes in the sound output characteristics according to the installation of the second buffer member can be minimized by moving the sound generating actuator by about twice that of the space d between the second buffer member **920** and one side of the display panel.

FIG. **13** is a graph illustrating a noise reduction effect in the case of using the buffer members of the embodiment illustrated in FIGS. **12**A and **12**B.

As a result of actual experiments, it has been confirmed that, when the first buffer member **910** and the second buffer member **920** described above with reference to FIGS. **12**A and **12**B are not used, unnecessary excessive noise was generated in a low sound range of several dozens of Hz and in a sound range of 1000 Hz or higher, as noted from the dotted line of FIG. **13**.

In contrast, as noted from the solid line of FIG. **13**, the noise is largely reduced in the corresponding bands when the buffer members of FIGS. **12**A and **12**B are used.

FIG. **14** illustrates a relative arrangement between a sound generating actuator and a set PCB in a display device according to an embodiment of the present disclosure.

In general, a display device or a set apparatus including the display device includes not only a source PCB including a control circuit (data driver IC, etc.) for driving a touch function or a data line of a display panel, but also a set PCB connected to the source PCB to control the display device or the entire set apparatus and supply power thereto.

As described above with reference to FIGS. **10**A and **10**B, the source PCB is attached to the rear surface of the display panel and the set PCB is attached to the outer side of the rear surface support structure of the display device, such as a cover bottom or a back cover.

The embodiment of FIG. **14** provides a display device in which a sound generating actuator is placed at a first position of a support structure of the display device and a set PCB of a set apparatus is placed at a second position different from the first positions, so as to avoid interference between the sound generating actuator and the set PCB.

As illustrated in FIG. **14**, the set PCB **800** placed on the rear surface of the cover bottom may include a power board **810** configured to supply power to the display panel, a timing controller **820** configured to generate a timing pulse or a timing signal for driving a gate line or data line, and a main board **830** including a control circuit for controlling the entire display device or set apparatus.

Boards **810**, **820**, and **830** of the set PCB **800** are attached to the rear surface of the cover bottom **300**, and the sound generating actuator **200** is fixedly inserted in a support hole formed through the cover bottom as described above.

Therefore, it is preferable to place the sound generating actuator **200** (first position) and the set PCB (second position) at different positions, as shown in FIG. **14**, to avoid interference therebetween.

Even when the sound generating actuator **200** is fixed within the cover bottom, if the positions of the sound generating actuator and the set PCB overlap, the vibration of the sound generating actuator may be continuously transferred to the circuit elements of the set PCB to have a bad influence on the performance of the set PCB.

Therefore, the arrangement of the sound generating actuator **200** (first position) and the set PCB (second position) at different positions as shown in FIG. **14** facilitates the arrangement design of elements and can minimize the degradation of the performance of the set PCB.

FIGS. **15**A and **15**B illustrate a display device including two or more actuators symmetrically arranged therein, and a distortion of a cover bottom due to a difference of vibration quantity in the display device.

According to the embodiment shown in FIGS. **15**A and **15**B, a plurality of sound generating actuators may be symmetrically arranged at left and right portions or upper and lower portions of the display panel to output different sounds at the areas.

For example, as shown in FIG. **15**A, in order to implement stereo sound, one or two left sound generating actuators **1210** and **1210'** are arranged at the left side of the display panel, one or two right sound generating actuators **1220** and **1220'** are arranged at the right side of the display panel, and the left and right actuators may be differently vibrated.

As shown in FIG. **15**B, which is a sectional view taken along line II-II' of FIG. **15**A, when the different vibrations of the left and right actuators **1210** and **1220** are continuously repeated, the vibration difference between the left side and right side of the cover bottom **1300** is continuously accumulated.

Since the cover bottom is usually manufactured to have as thin a thickness as possible, the accumulation of the vibration difference between the left side and right side of the cover bottom may cause the cover bottom to be curved or deformed. That is, as shown in FIG. **15**B, the cover bottom **1300** may be twisted or deformed. Further, even when the cover bottom **1300** is not deformed, the vibration difference of the cover bottom due to the vibration difference between the left and right actuators may cause distortion of the generated sound.

In order to solve this problem, a structure as shown in FIGS. **16**A and **16**B, which has a reinforcement member disposed inside a support structure of a display device while using two or more sound generating actuators is proposed.

This structure prevents the generation of sound distortion by twisting or vibration of the cover bottom.

In the embodiment illustrated in FIGS. **16**A and **16**B, at least one reinforcement member **1310** may be disposed inside or outside of the cover bottom in order to prevent deformation of the cover bottom or sound distortion by the unbalanced vibration of the cover bottom in the case of using multiple sound generating actuators having different vibration characteristics as described with reference to FIGS. **15**A and **15**B.

The reinforcement member **1310** may be formed to have a shape of a long bar passing through a portion adjacent to multiple sound generating actuators and are preferably arranged at particular positions to optimize the reinforcement characteristics.

As shown in FIG. **16**A, when two left sound generating actuators **1210** and **1210'** and two right sound generating actuators **1220** and **1220'** are arranged, the reinforcement member **1310** may be disposed to extend through a middle point Q between the two left sound generating actuators **1210** and **1210'** and a middle point Q' between the two right sound generating actuators **1220** and **1220'**.

This arrangement can optimize the reinforcement performance of the reinforcement member **1310** even when the two left and right sound generating actuators have different vibration characteristics.

The reinforcement member **1310** may be manufactured in the form of a separate metal bar and is then attached to the inner surface of the cover bottom as shown in FIG. **16**B, to which the present disclosure is not limited.

For example, the cover bottom may be manufactured through injection molding, and may have a reinforcement member **1310** integrally formed by protruding a part of the inner surface of the cover bottom.

The reinforcement member **1310** is not inevitably disposed on the inner surface of the cover bottom, but may be disposed on the outer surface of the cover bottom. However, in consideration of an external appearance and the thickness of the display device, it is preferred that the reinforcement member is disposed on the inner surface of the cover bottom **1300**.

FIGS. **17**A and **17**B illustrate specific arrangements of reinforcement members on a cover bottom.

FIG. **17**A illustrates a structure in which three sound generating actuators are arranged at each of the left side and right side thereof and two reinforcement members **1310** and **1310'** are arranged, wherein a first reinforcement member **1310** is disposed to extend through middle points Q-Q' of segments, each of which connects to two upper actuators among the three left or right sound generating actuators, and a second reinforcement member **1310'** is disposed to extend through middle points S-S' of segments, each of which connects to two lower actuators among the three left or right sound generating actuators.

FIG. **17**B illustrates a structure in which only one left actuator and only one right actuator are arranged and the reinforcement member **1310** is disposed to extend through centers of the left and right actuators **1210** and **1210'**. In this structure, two divided reinforcement members may be formed in consideration of the arrangement structure of the actuators inserted in and supported by the cover bottom.

The symmetric arrangement of two or more sound generating actuators having different vibration characteristics as described above can prevent deformation (twisting) of the cover bottom due to the different vibration characteristics of the sound generating actuators or sound distortion by the vibration of the cover bottom.

FIGS. **18**A and **18**B illustrate an embodiment, which further includes a sound compensation member in order to maintain the sound output characteristics when the sound generating actuator has been vertically moved by a reason of design.

FIG. **18**A illustrates a state in which a sound generating actuator **200** is disposed at an initial position P**3** having an optimal sound output characteristic.

However, the sound generating actuator may have to be moved by a predetermined distance D from the initial position P**3** in order to maintain a lower thickness of the upper end portion or by reasons relating to design or arrangement of parts.

In this case, only a simple movement of the sound generating actuator changes the relative position with respect to the baffle part **400** and may thus degrade the sound output characteristics.

Therefore, in such a case, if the sound generating actuator is moved to a destination position P**4** spaced a movement distance D apart from the initial position P**3**, a lengthy sound compensation member **1400** is preferably placed at a position spaced 2D apart from an edge (side) opposite to the moving direction.

That is, as shown in FIG. **18**B, when the sound generating actuator is moved downward to a position P**4** spaced apart by D from the initial position P**3** by a reason relating to design, a sound compensation member **1400** extending along the length of the horizontal direction is placed at a position spaced apart by 2D from the upper edge of the display panel. The arrangement of a sound compensation member at a position corresponding to twice that of the moving distance D of the sound generating actuator enables the moved actuator to be located in the middle of the changed air gap by the sound compensation member, thereby minimizing the change in the sound generation characteristics according to the movement of the actuator.

The sound compensation member **1400** may be implemented by a double-sided tape disposed between the cover bottom and the display panel.

As described above, when it is necessary to change the position of a sound generating actuator, a sound compensation member may be placed at a position proportional to the moving distance, to maintain the relative position of the actuator in the entire air gap, thereby preventing the sound characteristics from changing according to the movement of the actuator.

FIG. **19** is a graph illustrating a sound output characteristic in the case of using a panel vibration type sound generating apparatus according to an embodiment of the present disclosure, in comparison with a conventional speaker.

As a result of an actual experiment, a rapid sound intensity reduction (sound pressure reduction) as illustrated by a dotted line in FIG. **19** was observed in the middle/high sound range of 4000 Hz or higher when a speaker disposed at the rear surface or the lower end as shown in FIG. **1** separately from the display panel.

In contrast, as illustrated by a solid line in FIG. **19**, the structure according to this embodiment, in which a sound generating actuator is fixed to a support structure to directly vibrate the display panel, can reduce the sound pressure in the middle/high sound range, and especially can greatly improve the sound output characteristic in the high sound range.

As a result, use of the present embodiment can provide rich sound output in all sound ranges.

According to the present embodiment as described above, one or more sound generating actuators are fixed to a support structure to directly vibrate the display panel. Therefore, the progressing direction of the sound coincides with the image output direction to enhance the sound localization and improve the sound output characteristics in a wide sound range.

Further, since a display device or a set apparatus does not require a separate speaker, the mechanism of the set apparatus can be easily designed and the thickness of the display device or set apparatus can be reduced.

Especially, a predetermined air gap is formed between the display panel and the sound generating actuator and the sound generating actuator is inserted in and fixed to a support hole formed at a support structure of the display device. Therefore, the display device has an excellent sound generation performance while having a reduced thickness.

Further, a baffle part, which includes an adhesive member (double-sided tape) attached between the upper surface of the support structure and the lower surface of the display panel and a sealing part disposed outside the adhesive member, can minimize sound leakage and improve the sound generating performance.

Further, the arrangement of one or more buffer members between a source PCB of the display panel and the support structure disposed at the rear surface of the display panel to fix/support the sound generating actuator or between the inner surface of the support structure and the rear surface of the display panel adjacent to the source PCB can prevent generation of interference and noise between the support structure of the display device and a source PCB (S-PCB) for driving the display panel.

Also, the arrangement of a reinforcement member on the support structure of the display device when two or more sound generating actuators are used can prevent deformation of the support structure due to different vibrations of the two or more sound generating actuators.

The above description and the accompanying drawings provide an example of the technical idea of the present invention for illustrative purposes only. Those having ordinary knowledge in the technical field, to which the present invention pertains, will appreciate that various modifications and changes in form, such as combination, separation, substitution, and change of a configuration, are possible without departing from the essential features of the present invention. Therefore, the embodiments disclosed in the present invention are intended to illustrate the scope of the technical idea of the present invention, and the scope of the present invention is not limited by the embodiment. The scope of the present invention shall be construed on the basis of the accompanying claims in such a manner that all of the technical ideas included within the scope equivalent to the claims belong to the present invention.

What is claimed is:

1. An apparatus, comprising:

a vibrating plate;

at least one sound generating actuator disposed at a rear of the vibrating plate and configured to vibrate the vibrating plate to generate sound;

a support structure on a rear surface of the vibrating plate;

a printed circuit at the rear of the vibrating plate; and

an area division member at a rear portion of the vibrating plate, the area division member dividing an area at the rear portion of the vibrating plate into a first area including the printed circuit and a second area including the at least one sound generating actuator.

2. The apparatus of claim **1**, further comprising a baffle part disposed between the support structure and the vibrating plate to form an air gap between the support structure and the vibrating plate.

3. The apparatus of claim **2**, wherein the baffle part is disposed at a periphery of the second area between the support structure and the vibrating plate to surround the air gap in the second area.

4. The apparatus of claim **2**, wherein the vibrating plate is configured to generate sound waves in the air gap when vibrated by the at least two sound generating actuators, and

wherein the baffle part surrounds the air gap to reduce leakage of the sound waves out of the air gap.

5. The apparatus of claim **2**, wherein the baffle part comprises at least one of an adhesive member and a sealing part disposed outside of the adhesive member.

6. The apparatus of claim **1**,

wherein the at least one sound generating actuator includes at least two sound generating actuators, and

wherein the apparatus further comprises a reinforcement member extending between a sound generating actuator and another sound generating actuator among the at least two sound generating actuators.

7. The apparatus of claim **6**, wherein the reinforcement member is disposed apart from the sound generating actuator and the other sound generating actuator.

8. The apparatus of claim **1**, wherein the support structure comprises:

a cover bottom covering the rear portion of the vibrating plate; and

a middle cabinet supporting a periphery of the vibrating plate.

9. The apparatus of claim **1**, wherein the support structure comprises:

a recessed part disposed in an inner surface of the support structure, the recessed part being disposed opposite the printed circuit; and

a first buffer member in the recessed part between the support structure and the printed circuit.

10. The apparatus of claim **1**,

wherein the at least one sound generating actuator includes at least two sound generating actuators respectively disposed at different areas of the vibrating plate and respectively configured to vibrate the different areas of the vibrating plate to generate sound, and

wherein each of the at least two sound generating actuators is configured to vibrate the vibrating plate to generate sound projecting in a direction coinciding with an image output direction of the vibrating plate to localize the output sound.

11. The apparatus of claim **10**, further comprising a baffle part at a rear portion of the vibrating plate separating one of the different areas from another of the different areas.

12. The apparatus of claim **10**, wherein the at least two sound generating actuators are configured to generate a stereo sound.

13. The apparatus of claim **10**, wherein the at least two sound generating actuators are symmetrically arranged.

14. The apparatus of claim **10**, wherein the at least two sound generating actuators are configured to generate different vibrations from one another to generate different sounds in the different areas of the vibrating plate.

15. The apparatus of claim **1**, wherein the thickness of the air gap is from about 1.0 mm to 3.0 mm.

16. The apparatus of claim **1**, further comprising a sound compensation member.

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