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Park et al.

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(54) **DISPLAY DEVICE**

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(73) Assignee: **Samsung Display Co., Ltd.**, Yongin-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G06F 1/16 (2006.01)
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 1/1616*** (2013.01); ***G06F 1/1652*** (2013.01); ***G06F 1/1681*** (2013.01); *H04M 1/0268* (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1681; G06F 1/1616; G06F 1/1641; G06F 1/1652; G06F 1/1679;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,961,126 A * 10/1990 Suzuki G06F 1/1616 16/223
8,804,324 B2 * 8/2014 Bohn G06F 1/1616 345/1.1

(Continued)

FOREIGN PATENT DOCUMENTS

KR 10-2012-0049762 5/2012

OTHER PUBLICATIONS

Notice of Allowance dated Oct. 17, 2016 in U.S. Appl. No. 14/806,899.

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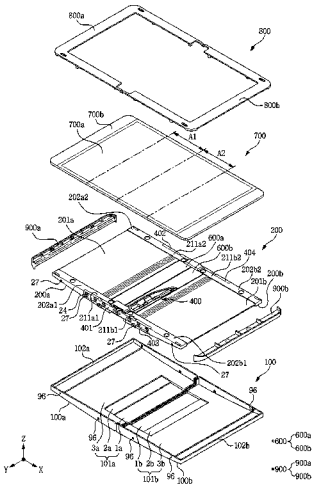
(57) **ABSTRACT**

A display device includes a bottom chassis including first and second bottom portions, a mold frame including first and second frame portions disposed in respective first and second bottom portions, a hinge portion configured to couple the first and second frame portions to each other, a flexible display panel disposed on the mold frame and the hinge portion, a first curvature adjusting portion disposed between one side of the hinge portion and the display panel and coupled to the first frame portion, a second curvature adjusting portion disposed between the opposite side of the hinge portion and the display panel and coupled to the second frame portion, a first support portion coupled to the hinge portion and configured to support the first curvature adjusting portion, and a second support portion coupled to the hinge portion and configured to support the second curvature adjusting portion.

21 Claims, 11 Drawing Sheets



(58) **Field of Classification Search**
CPC .. H04M 1/0268; H04M 1/022; H04M 1/0216; H04M 1/0247; H05K 1/028; H05K 5/0017
See application file for complete search history.

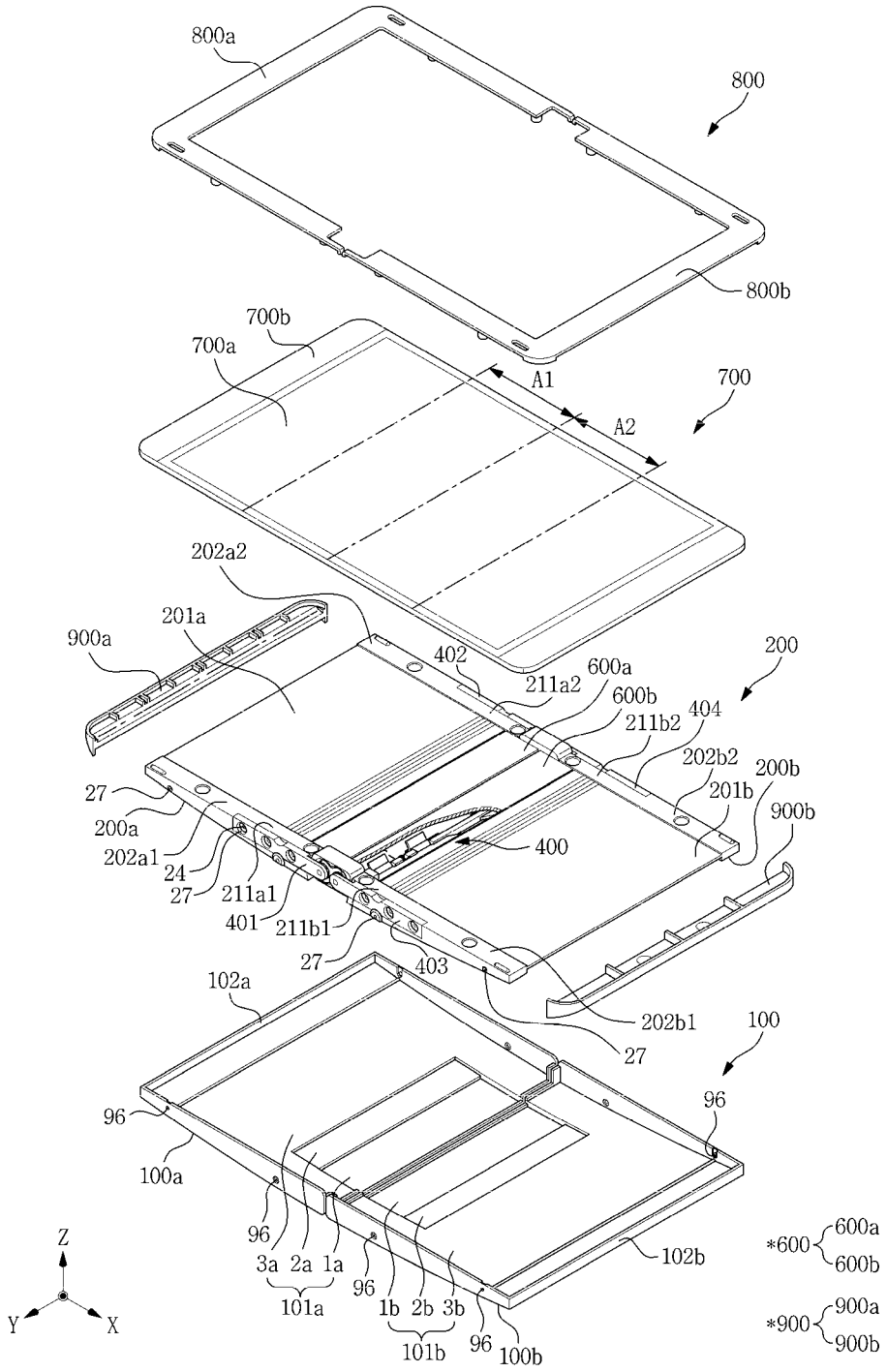
(56) **References Cited**

U.S. PATENT DOCUMENTS

9,600,035	B2 *	3/2017	Park	G06F 1/1681
2004/0036818	A1 *	2/2004	Kim	G02F 1/13336 349/58
2009/0236411	A1	9/2009	Silverbrook	
2010/0232100	A1 *	9/2010	Fukuma	F16G 13/18 361/679.01
2012/0264489	A1 *	10/2012	Choi	H04M 1/0216 455/566
2012/0307423	A1	12/2012	Bohn et al.	
2013/0021762	A1 *	1/2013	van Dijk	G06F 1/1652 361/749
2013/0037228	A1	2/2013	Verschoor et al.	
2013/0155655	A1 *	6/2013	Lee	H05K 5/03 362/97.1
2013/0342090	A1 *	12/2013	Ahn	G09F 9/33 312/258
2014/0111954	A1 *	4/2014	Lee	G06F 1/1641 361/749
2014/0126133	A1 *	5/2014	Griffin	G06F 1/1616 361/679.27
2015/0062525	A1 *	3/2015	Hirakata	G02F 1/133305 349/158
2015/0233162	A1 *	8/2015	Lee	H04M 1/02 16/223
2016/0195901	A1 *	7/2016	Kauhaniemi	G06F 1/1652 361/679.27

* cited by examiner

FIG. 1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3a
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1b
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FIG. 2

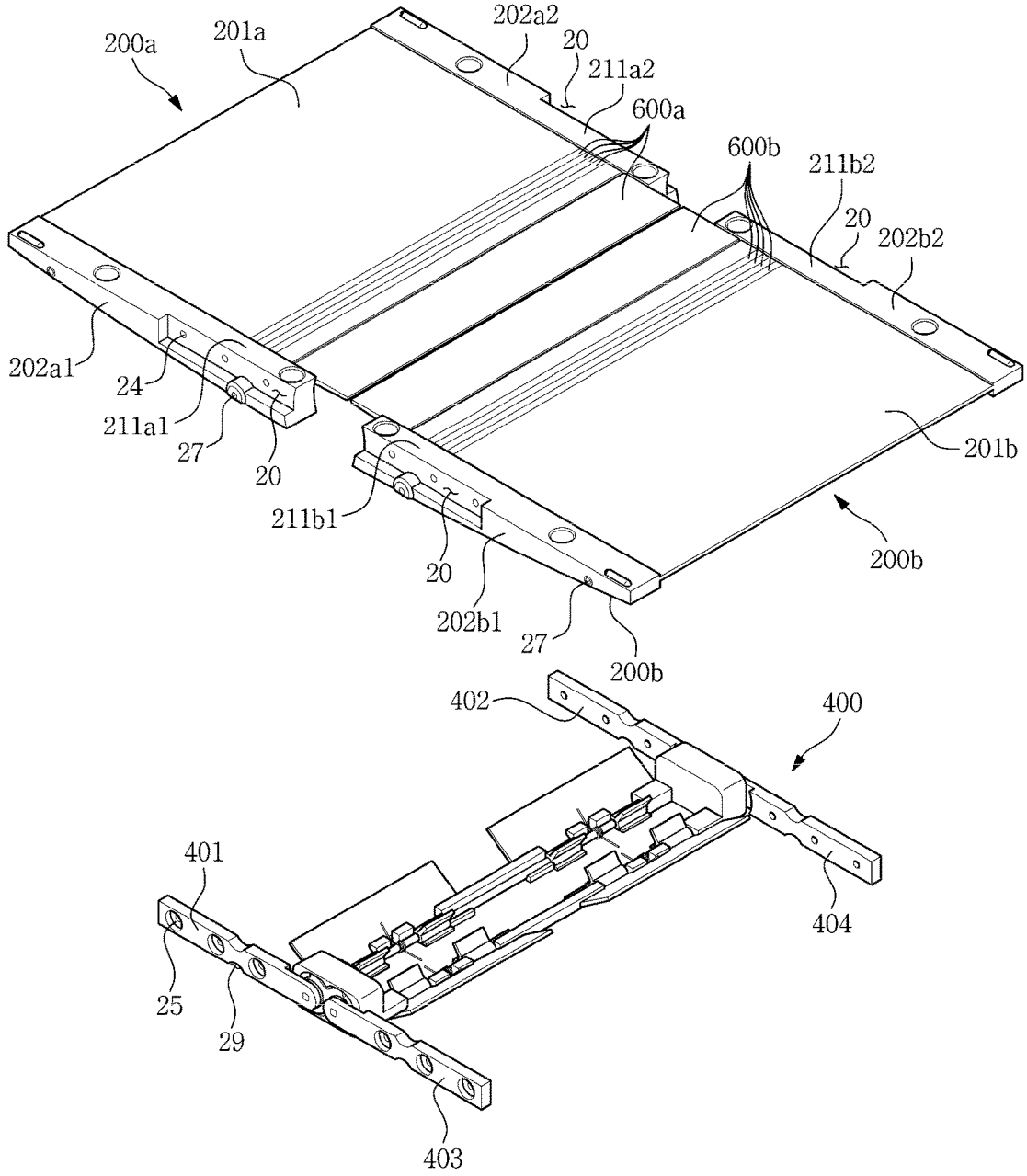
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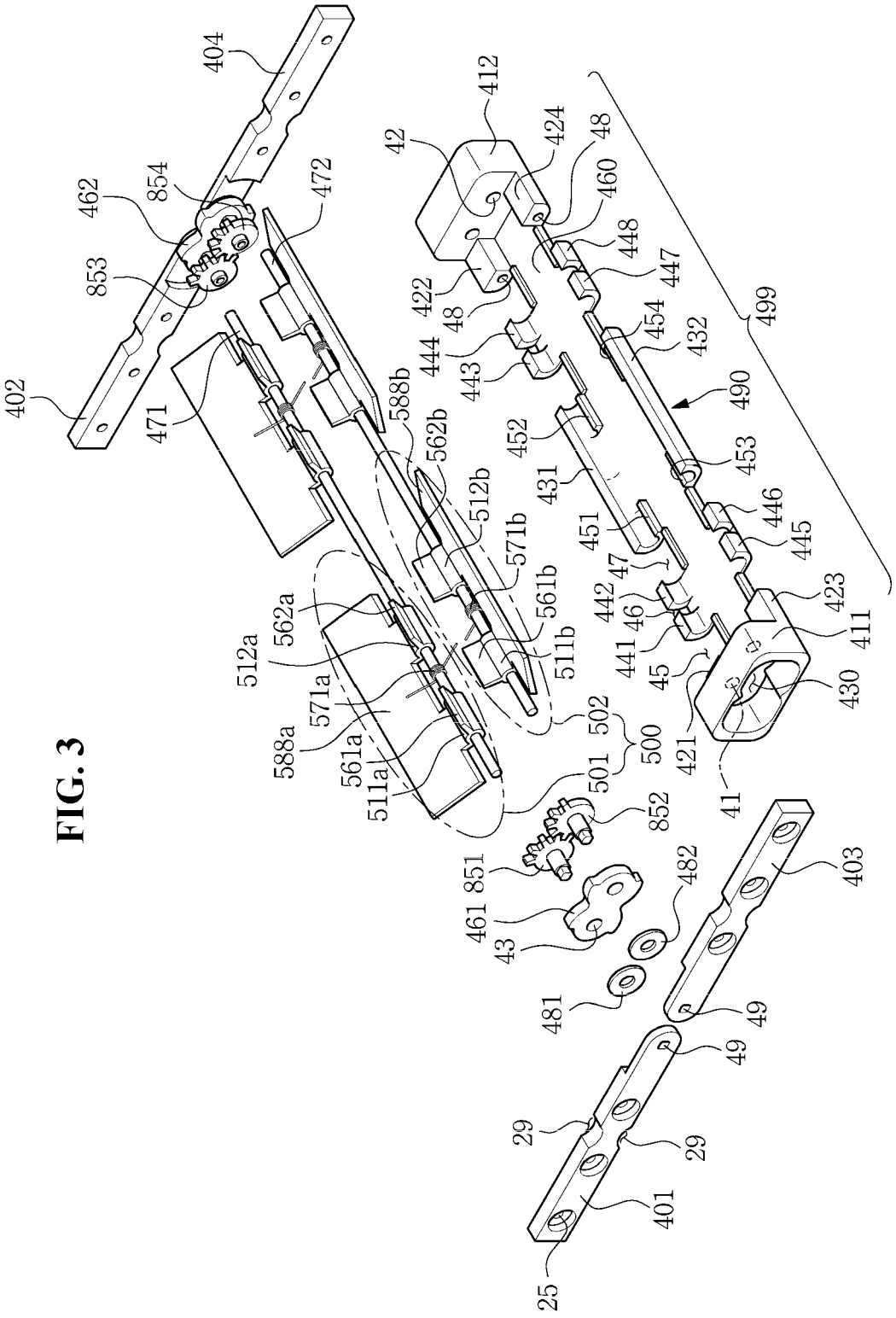
FIG. 3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852
851
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49
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401
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41

FIG. 4

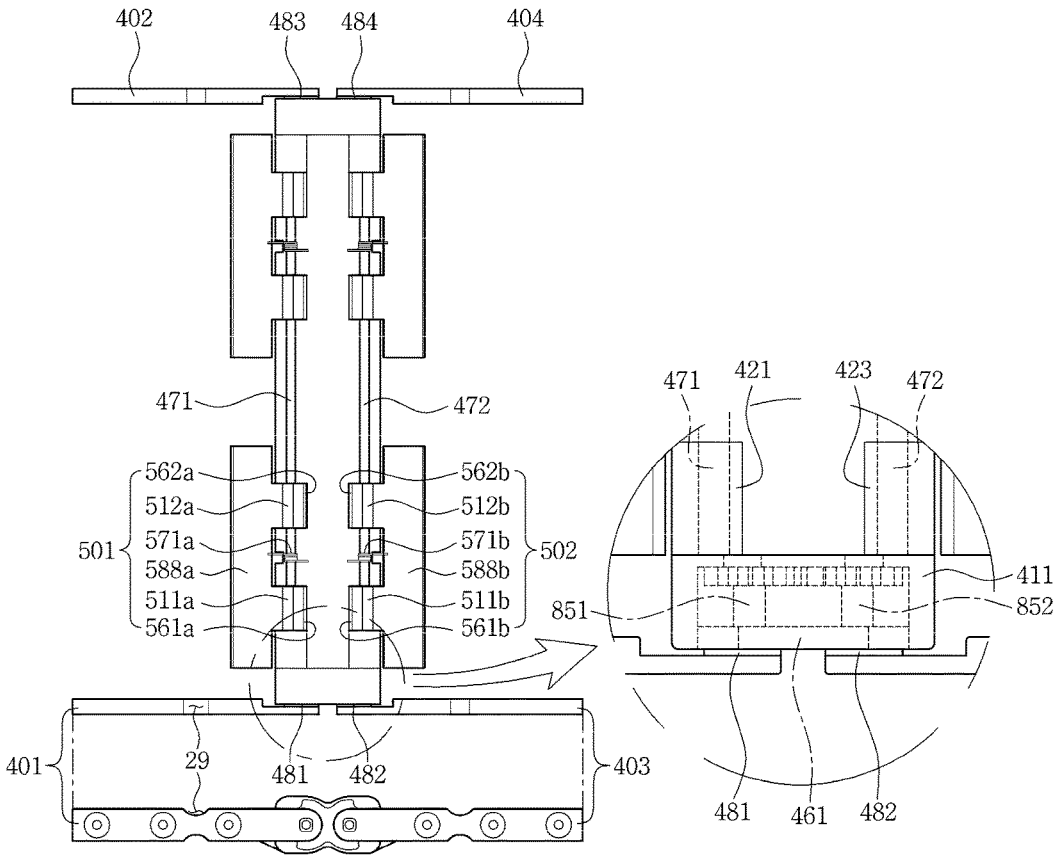
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FIG. 5

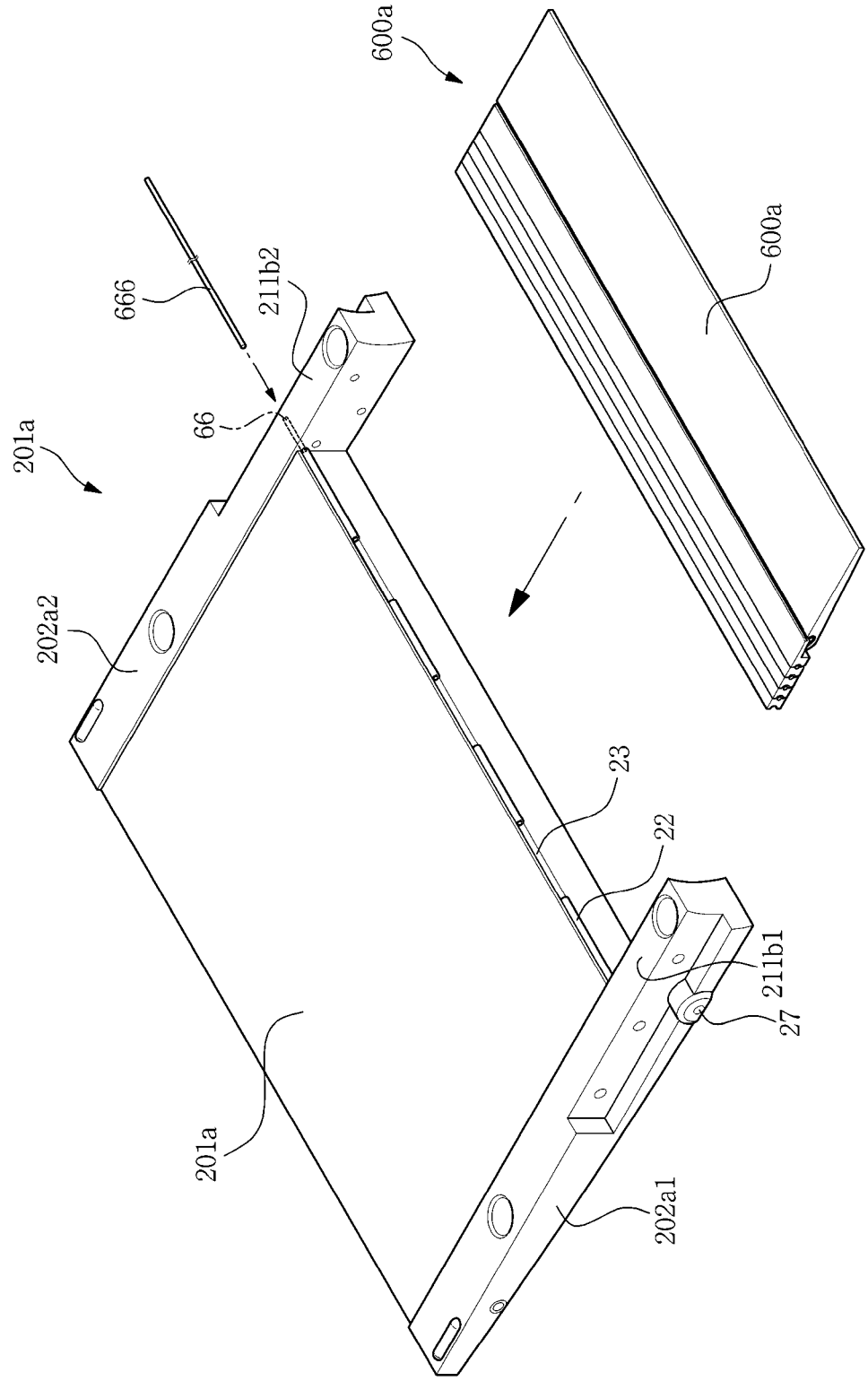

FIG. 6

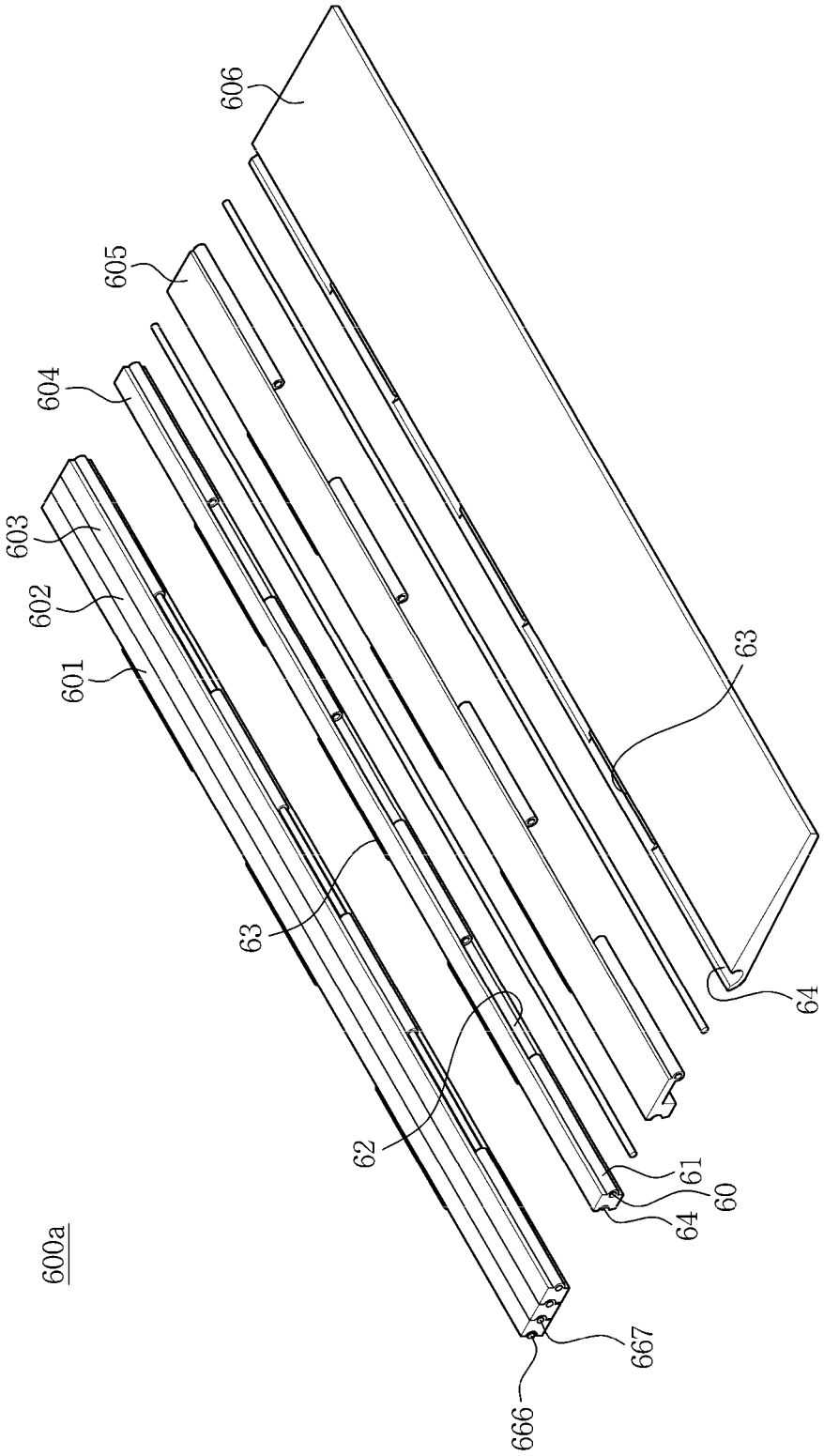

FIG. 7(a)

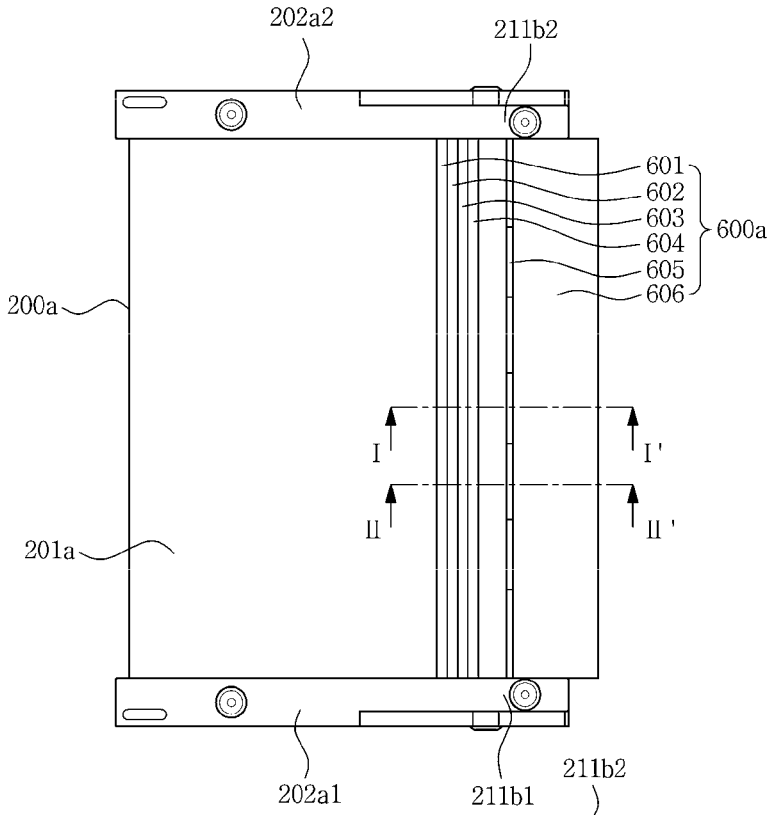

FIG. 7(b)

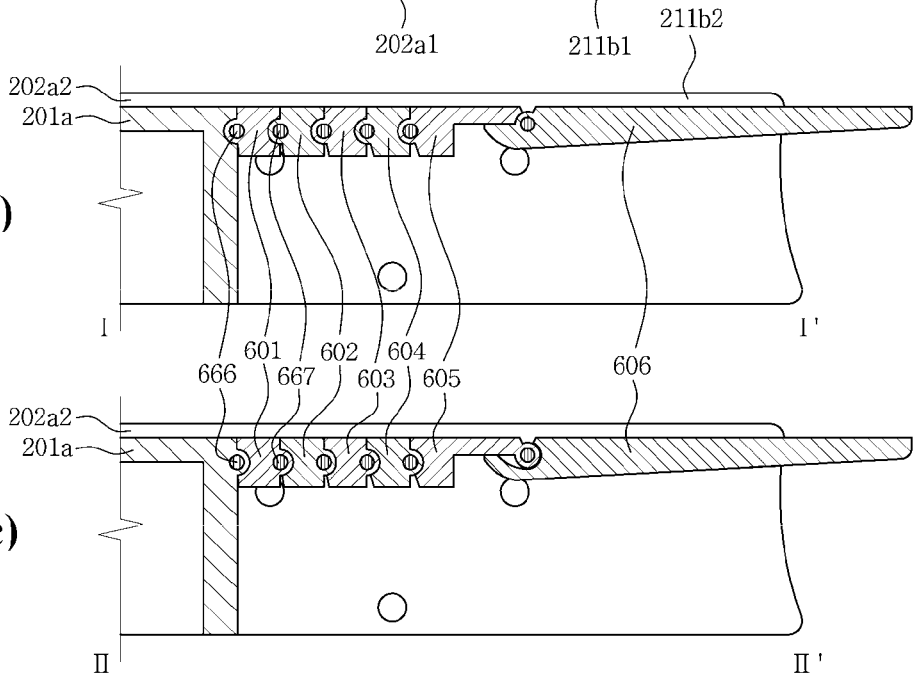

FIG. 7(c)

FIG. 8

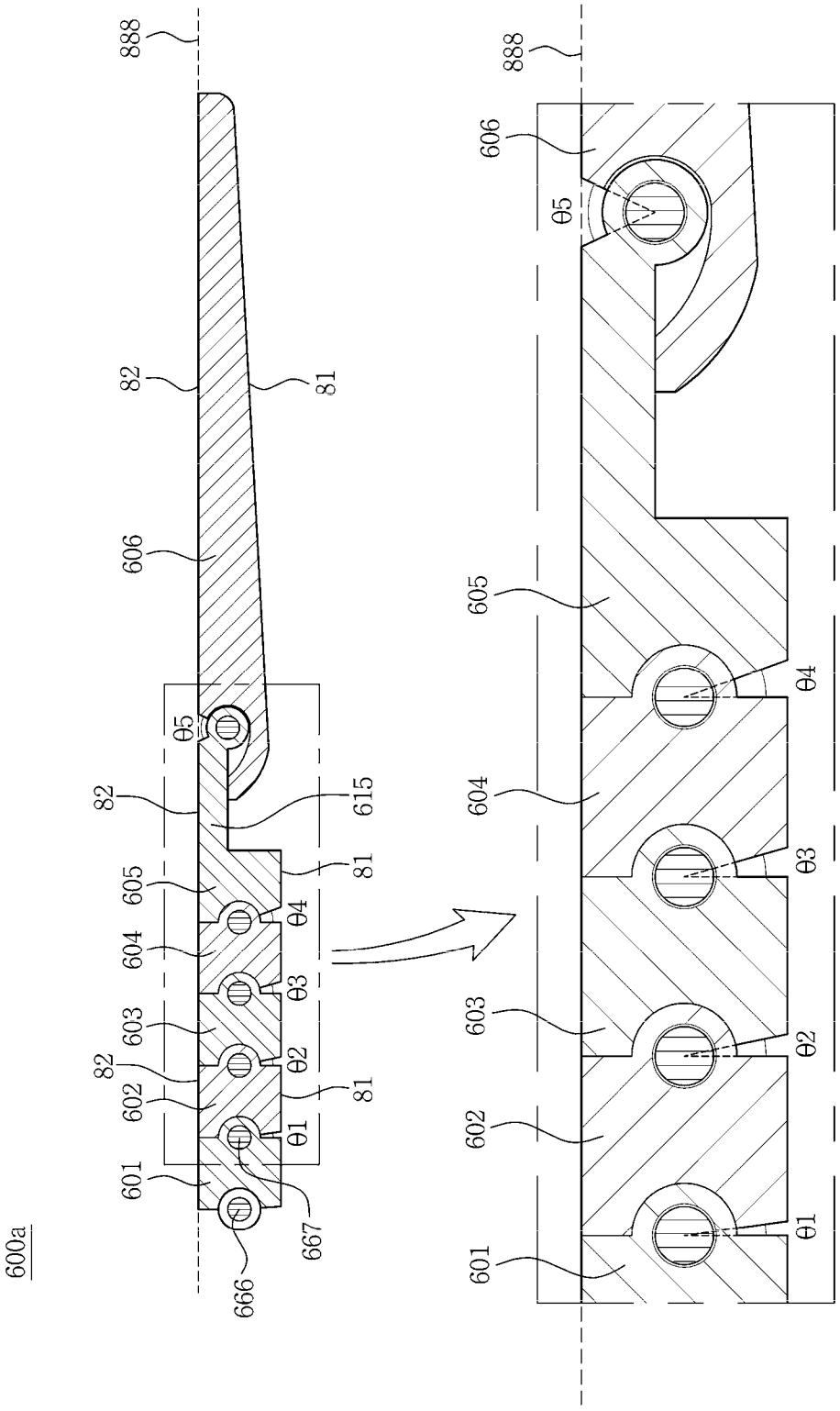

FIG. 9

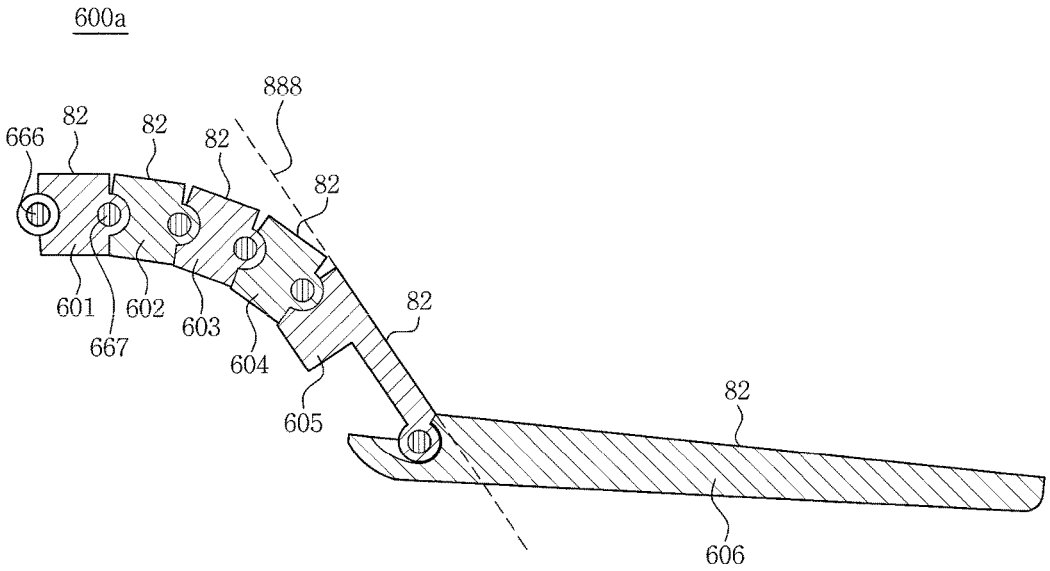

FIG. 10

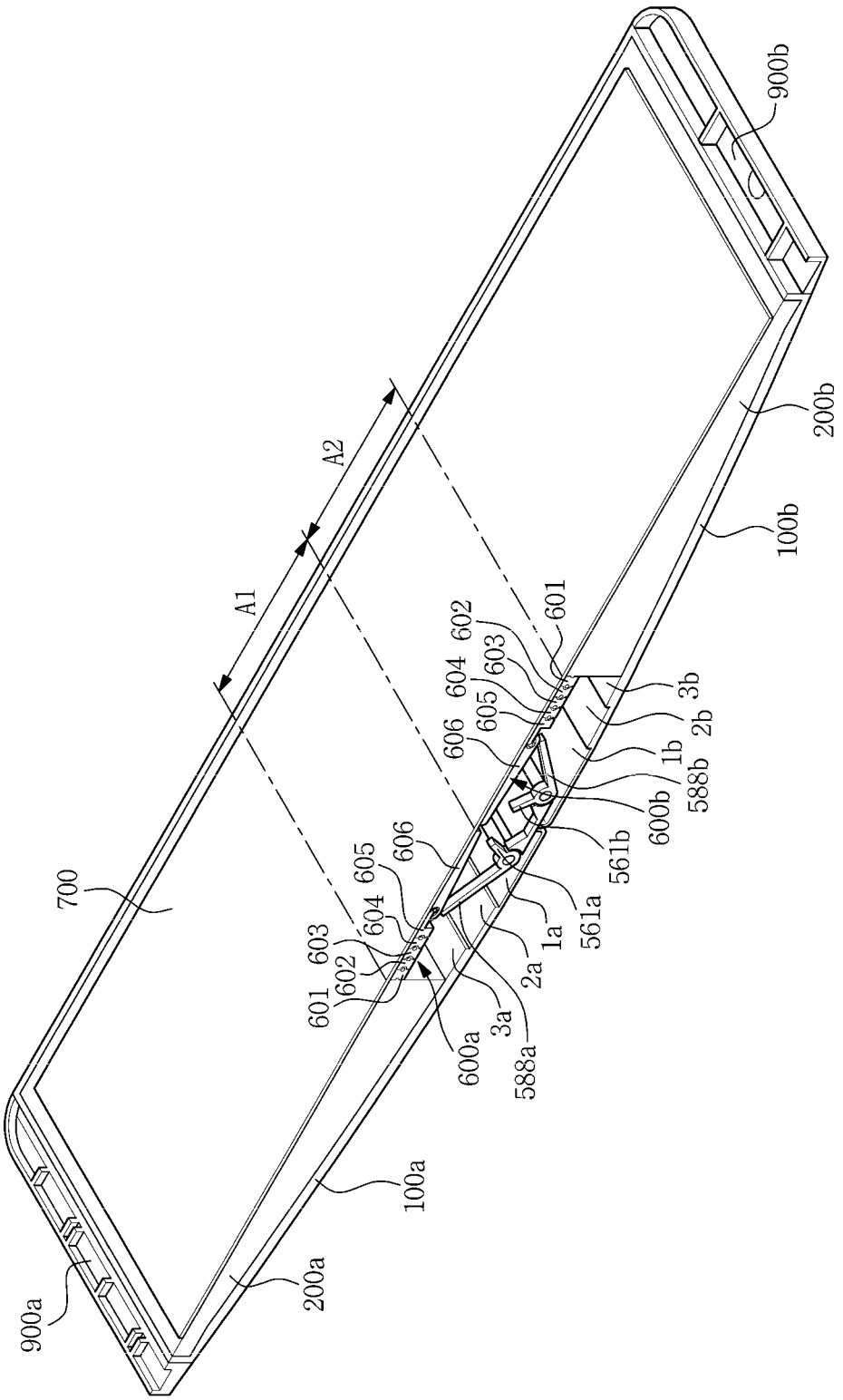
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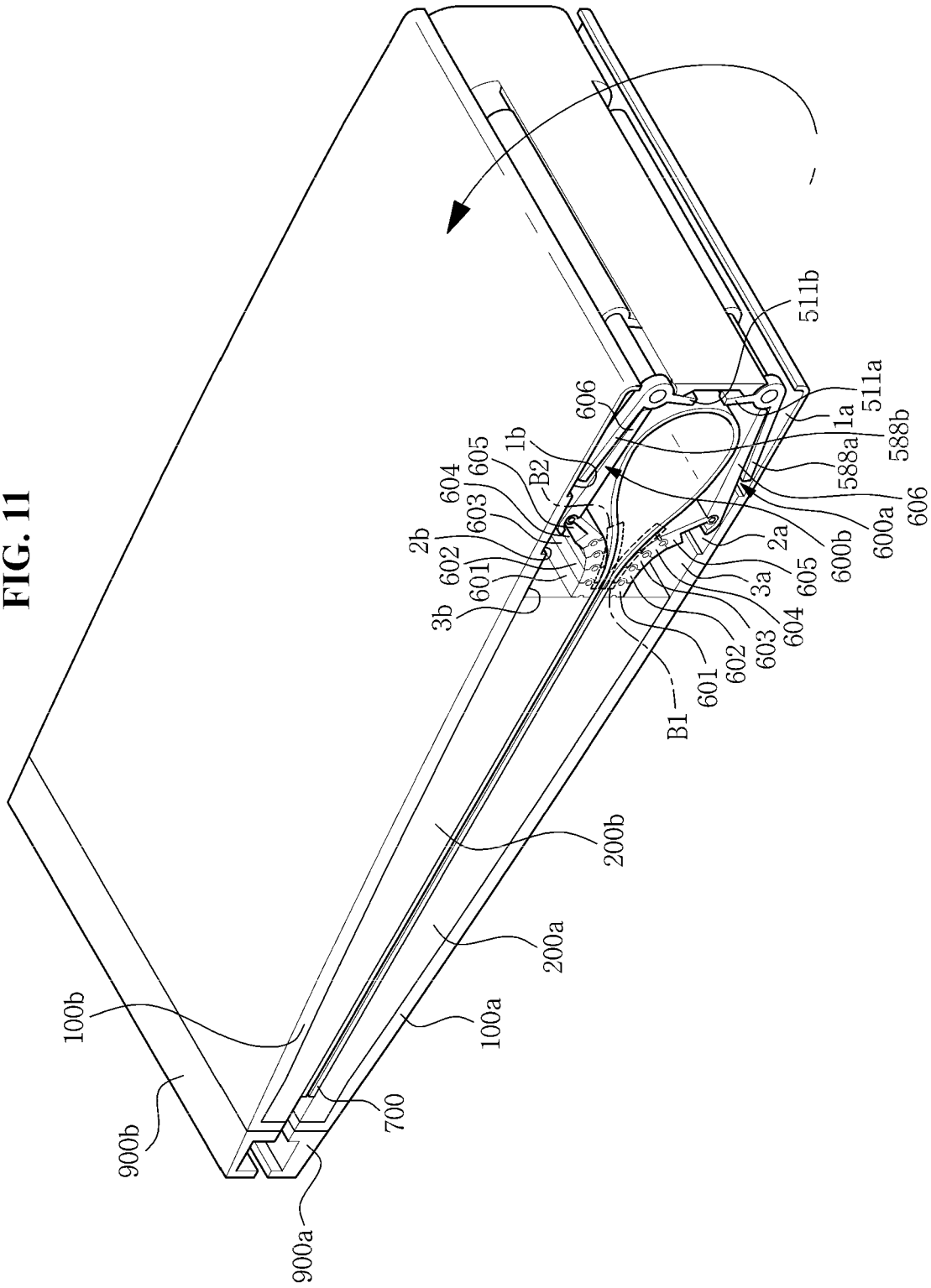
FIG. 11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B1
200b
200a
100b
100a
700
900b
900a

DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 14/806,899, filed on Jul. 23, 2015, and claims priority from and the benefit of Korean Patent Application No. 10-2014-0126961, filed on Sep. 23, 2014, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

Field

Exemplary embodiments of the invention relate to a display device including a flexible display panel, the display device configured to reduce excessive folding of a curved portion of a display panel.

Discussion of the Background

A foldable display device may include a flexible display panel that is bendable. The foldable display device may be portable and have a large screen when unfolded, and to be used in various applications such as a television, a monitor, and a mobile device, e.g., mobile phone, ultra-mobile PC, e-books, and e-newspaper.

A high stress may be applied onto a curved portion of the folded flexible display device. The high stress applied to the curved portion may damage elements near the curved portion.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the inventive concept, and, therefore, it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

SUMMARY

One or more exemplary embodiments provide a display device configured to stably control curvature of a curved portion of the display device so as to reduce or effectively prevent excessive folding of the curved portion.

Additional aspects will be set forth in the detailed description which follows, and, in part, will be apparent from the disclosure, or may be learned by practice of the inventive concept.

According to one or more exemplary embodiments, a display device includes: a bottom chassis including a first bottom portion and a second bottom portion; a mold frame including a first frame portion and a second frame portion respectively disposed in the first and second bottom portions of the bottom chassis; a hinge portion configured to couple the first and second frame portions of the mold frame to each other; a flexible display panel disposed on the mold frame and the hinge portion; a first curvature adjusting portion disposed between one side of the hinge portion and the flexible display panel, the first curvature adjusting portion coupled to the first frame portion; a second curvature adjusting portion disposed between the opposite side of the hinge portion and the display panel, the second curvature adjusting portion coupled to the second frame portion; a first support portion coupled to the hinge portion, the first support portion configured to support the first curvature adjusting portion; and a second support portion coupled to the hinge portion, the second support portion configured to support the second curvature adjusting portion.

Each of the first and second curvature adjusting portions comprises a plurality of adjustment units and a plurality of connecting shafts configured to hinge couple the plurality of adjustment units to each other.

At least two of the plurality of adjustment units have different angular rotation ranges.

An adjustment unit of the plurality of adjustment units that is substantially closer to the hinge portion has a larger angular rotation range.

At least one of the plurality of adjustment units have a upper surface and a lower surface having different lengths from each other.

An adjustment unit of the plurality of adjustment units disposed furthest from the hinge portion comprises a surface that comprises a projection and groove comprising a hole through which the connecting shaft is inserted.

Each adjustment unit of the plurality of adjustment units other than an adjustment unit of the plurality of adjustment units disposed furthest from the hinge portion comprise a surface comprising at least one first projection and at least one first groove having a first hole, alternately disposed, the connecting shaft is inserted through the first hole of the first groove and an opposite surface comprising at least one second projection and at least one second groove having a second hole, alternately disposed, the connecting shaft is inserted through the second hole of the second groove.

The second groove is disposed corresponding to the first projection and the second projection is disposed corresponding to the first groove.

The first and second grooves disposed closer from the hinge portion is smaller than the first and second grooves disposed further from the hinge portion.

Each of the plurality of adjustment units comprises a reference adjustment unit, at least one curved adjustment unit between any one of the first and second frame portions and an end portion of the reference adjustment unit and at least one straight adjustment unit hinge coupled to the opposite end portion of the reference adjustment unit.

The curved adjustment unit is configured to rotate in a range that does not intersect an imaginary reference surface extending from a surface of the reference adjustment unit; and wherein the straight adjustment unit is configured to rotate in a range that intersects (or crosses) the imaginary reference surface.

The hinge portion comprises: a shaft receiving portion and a hinge case comprising a first gear receiving portion and a second gear receiving portion disposed respectively on two sides of the shaft receiving portion; a first hinge shaft and a second hinge shaft disposed in the shaft receiving portion; a first gear and a second gear disposed in the first gear receiving portion, the first and second gears are interlocked with each other; a third gear and a fourth gear disposed in the second gear receiving portion, the third and fourth gears are interlocked with each other; a first gear cover covering a first opening formed in the first gear receiving portion, the first gear cover comprising through holes through which axes of the first and second gears are respectively disposed and exposed outwards; a second gear cover covering a second opening formed in the second gear receiving portion, the second gear cover comprising through holes through which axes of the third and fourth gears are respectively disposed and exposed outwards; a first coupling portion coupling the axis of the first gear to one side of the first frame portion; a second coupling portion coupling the axis of the third gear to the opposite side of the first frame portion; a third coupling portion coupling the axis of the second gear to one side of the second frame portion; and a

fourth coupling portion coupling the axis of the fourth gear to the opposite side of the second frame portion.

The hinge portion further comprises a washer disposed on at least one of positions between one side of the first gear cover and the first coupling portion, between the opposite side of the first gear cove and the third coupling portion, between one side of the second gear cover and the second coupling portion, and between the opposite side of the second gear cover and the fourth coupling portion.

The first gear receiving portion comprises through holes into which the axes of the first and second gears are inserted; and wherein the second gear receiving portion comprises through holes into which the axes of the third and fourth gears are inserted.

The shaft receiving portion comprises: first fixing grooves into which two ends of the first hinge shaft are respectively inserted; second fixing grooves into which two ends of the second hinge shaft are respectively inserted; at least one first support groove configured to support a central portion of the first hinge shaft; and at least one second support groove configured to support a central portion of the second hinge shaft.

The first support portion is coupled to the first hinge shaft and the second support portion is coupled to the second hinge shaft.

The first support portion comprises: at least one rotation unit rotatably coupled to the first hinge axis; at least one first support plate protruding from the rotation unit towards one side of the first curvature adjusting portion; and at least one second support plate protruding from the rotation unit towards another side of the first curvature adjusting portion.

At least one hinge spring coupled to the first hinge axis, one end of the hinge spring disposed on the first support plate and the other end of the hinge spring disposed on the shaft receiving portion.

The second support portion comprises: at least one rotation unit rotatably coupled to the second hinge axis; at least one first support plate protruding from the rotation unit towards one side of the second curvature adjusting portion; and at least one second support plate protruding from the rotation unit towards another side of the second curvature adjusting portion.

At least one hinge spring coupled to the second hinge axis, one end of the hinge spring disposed on the first support plate and the other end of the hinge spring disposed on the shaft receiving portion.

The foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the inventive concept, and are incorporated in and constitute a part of this specification, illustrate exemplary embodiments of the inventive concept, and, together with the description, serve to explain principles of the inventive concept.

FIG. **1** is a perspective view illustrating a display device according to one or more exemplary embodiments.

FIG. **2** is a perspective view illustrating a mold frame and a hinge portion illustrated in FIG. **1**, disassembled from each other, according to one or more exemplary embodiments.

FIG. **3** is an exploded perspective view illustrating the hinge portion shown in FIG. **2**, according to one or more exemplary embodiments.

FIG. **4** is a plan view and a front view illustrating the hinge portion shown in FIG. **2**, according to one or more exemplary embodiments.

FIG. **5** is an exploded perspective view illustrating a first curvature adjusting portion and first frame portion shown in FIG. **1**, separated from each other, according to one or more exemplary embodiments.

FIG. **6** is an exploded perspective view illustrating the first curvature adjusting portion shown in FIG. **5** according to one or more exemplary embodiments.

FIG. **7**(*a*) is a plan view illustrating a structure of a first frame portion and a first curvature adjusting portion coupled to each other according to one or more exemplary embodiments, and a FIGS. **7**(*b*) and **7** (*c*) are cross-sectional views respectively taken along sectional lines I-I' and II-II' of the structure of the first frame portion and the first curvature adjusting portion, according to one or more exemplary embodiments.

FIG. **8** is a cross-sectional view of a first curvature adjusting portion and an enlarged view illustrating adjustment units, according to one or more exemplary embodiments;

FIG. **9** is a cross-sectional view illustrating a first curvature adjusting portion when curved, according to one or more exemplary embodiments;

FIG. **10** is a perspective view illustrating an unfolded display device including a first curvature adjusting portion, a second curvature adjusting portion, a first support portion and a second support portion according to on roe more exemplary embodiments.

FIG. **11** is a perspective view illustrating a folded display device including a first curvature adjusting portion, a second curvature adjusting portion, a first support portion and a second support portion according to one or more exemplary embodiments.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of various exemplary embodiments. It is apparent, however, that various exemplary embodiments may be practiced without these specific details or with one or more equivalent arrangements. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring various exemplary embodiments.

In the accompanying figures, the size and relative sizes of layers, films, panels, regions, etc., may be exaggerated for clarity and descriptive purposes. Also, like reference numerals denote like elements.

When an element or layer is referred to as being "on," "connected to," or "coupled to" another element or layer, it may be directly on, connected to, or coupled to the other element or layer or intervening elements or layers may be present. When, however, an element or layer is referred to as being "directly on," "directly connected to," or "directly coupled to" another element or layer, there are no intervening elements or layers present. For the purposes of this disclosure, "at least one of X, Y, and Z" and "at least one selected from the group consisting of X, Y, and Z" may be construed as X only, Y only, Z only, or any combination of two or more of X, Y, and Z, such as, for instance, XYZ, XYY, YZ, and ZZ. Like numbers refer to like elements

throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

Although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers, and/or sections, these elements, components, regions, layers, and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer, and/or section from another element, component, region, layer, and/or section. Thus, a first element, component, region, layer, and/or section discussed below could be termed a second element, component, region, layer, and/or section without departing from the teachings of the present disclosure.

Spatially relative terms, such as "beneath," "below," "lower," "above," "upper," and the like, may be used herein for descriptive purposes, and, thereby, to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the drawings. Spatially relative terms are intended to encompass different orientations of an apparatus in use, operation, and/or manufacture in addition to the orientation depicted in the drawings. For example, if the apparatus in the drawings is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. Furthermore, the apparatus may be otherwise oriented (e.g., rotated 90 degrees or at other orientations), and, as such, the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting. As used herein, the singular forms, "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Moreover, the terms "comprises," comprising," "includes," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Various exemplary embodiments are described herein with reference to plan and/or sectional illustrations that are schematic illustrations of idealized exemplary embodiments and/or intermediate structures. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, exemplary embodiments disclosed herein should not be construed as limited to the particular illustrated shapes of regions, but are to include deviations in shapes that result from, for instance, manufacturing. For example, an implanted region illustrated as a rectangle will, typically, have rounded or curved features and/or a gradient of implant concentration at its edges rather than a binary change from implanted to non-implanted region. Likewise, a buried region formed by implantation may result in some implantation in the region between the buried region and the surface through which the implantation takes place. Thus, the regions illustrated in the drawings are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to be limiting

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure is a part. Terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense, unless expressly so defined herein.

FIG. **1** is a perspective view illustrating a display device according to one or more exemplary embodiments. FIG. **2** is a perspective view illustrating a mold frame and a hinge portion shown in FIG. **1**, disassembled from each other, according to one or more exemplary embodiments.

Referring to FIGS. **1** and **2**, a display device according to an exemplary embodiment of the invention includes a bottom chassis **100**, a mold frame **200**, a hinge portion **400**, a support portion **500** (refer to FIG. **3**), a curvature adjusting portion **600**, a flexible display panel **700**, and a top chassis **800**.

The bottom chassis **100** may include a first bottom portion **100***a* and a second bottom portion **100***b*. The first and second bottom portions **100***a* and **100***b* may be separated from each other. The first and second bottom portions **100***a* and **100***b* may be substantially symmetric to each other with respect to a Y-axis.

The first bottom portion **100***a* may include a base portion **101***a* and a plurality of side portions **102***a*. The plurality of side portions **102***a* may protrude from four respective edge portions of the base portion **101***a* by a predetermined height. Among the four side portions **102***a*, a side portion disposed corresponding to a center of the bottom chassis **100** may have the lowest height.

The lowest side portion **102***a* disposed corresponding to a center of the bottom chassis **100** may be defined as a first side portion, and a side portion disposed facing the first side portion may be defined as a second side portion. The first bottom portion **100***a* may be curved along a direction from the first side portion towards the second side portion.

The base portion **101***a* may have an inner surface including a first surface **1***a*, a second surface **2***a*, and a third surface **3***a*, each having heights different from each other. The first to third surfaces **1***a*, **2***a*, and **3***a* may have a stair shape having gradually higher height from the first side portion to the second side portion. The first surface **1***a* may have a height lower than the second surface **2***a*, and the second surface **2***a* may have a height lower than the third surface **3***a*.

The second bottom portion **100***b* may include a base portion **101***b* and a plurality of side portions **102***b*, which is similar to the first bottom portion **100***a*. The plurality of side portions **102***b* may protrude from four respective edge portions of the base portion **101***b* by a predetermined height. Among the four side portions **102***b*, a side portion disposed corresponding to a center of the bottom chassis **100** may have the lowest height.

The lowest side portion **102***b* disposed corresponding to a center of the bottom chassis **100** may be defined as a first side portion, and a side portion disposed facing the first side portion may be defined as a second side portion. The second bottom portion **100***b* may be curved along a direction from the first side portion towards the second side portion.

The base portion **101***b* may have an inner surface including a first surface **1***b*, a second surface **2***b*, and a third surface **3***b*, each having heights different from each other. The first to third surfaces **1***b*, **2***b*, and **3***b* may have a stair shape having gradually higher height from the first side portion to the second side portion. The first surface **1***b* may have a height lower than the second surface **2***b*, and the second surface **2***b* may have a height lower than the third surface **3***b*.

The mold frame **200** may include a first frame portion **200***a* and a second frame portion **200***b*. The first and second

frame portions **200***a* and **200***b* may be separated from each other. The first and second frame portions **200***a* and **200***b* may be substantially symmetric to each other with respect to the Y-axis.

The first frame portion **200***a* may have a shape corresponding to the first bottom portion **100***a*. That is, the first frame portion **200***a* may be curved along a direction from the first side portion of the first bottom portion **100***a* towards the second side portion thereof.

The first frame portion **200***a* may include a first side wall **202***a***1** and a second sidewall **202***a***2** disposed facing each other, and a stage **201***a* disposed between the first and second sidewalls **202***a***1** and **202***a***2**. The first and second sidewalls **202***a***1** and **202***a***2** may have a length longer than the stage **201***a*. In other words, portions of the first and second sidewalls **202***a***1** and **202***a***2** may protrude over an edge portion of the stage **201***a* towards the hinge portion **400**. The portions of the first and second sidewalls **202***a***1** and **202***a***2** protruding over the edge portion of the stage **201***a* may respectively be defined as first and second sidewall protrusions **211***a***1** and **211***a***2**.

The first sidewall **202***a***1** may have the same height as the second sidewall **202***a***2**. The first and second sidewalls **202***a***1** and **202***a***2** may have a height larger than the stage **201***a*.

The first frame portion **200***a* may be disposed corresponding to the first bottom portion **100***a*, which will be described below in more detail.

The first and second sidewalls **202***a***1** and **202***a***2** and the stage **201***a*, which are included in the first frame portion **200***a*, may be disposed on the third surface **3***a* of the first bottom portion **100***a*. The first sidewall protrusion **211***a***1** may be disposed on corresponding edge portions of the first surface **1***a* and the second surface **2***a*. The respective edge portions of the first and second surfaces **1***a* and **2***a* may have substantially the same height as the third surface **3***a*. The second sidewall protrusion **211***a***2** may be disposed on corresponding edge portions of the first surface **1***a* and the second surface **2***a*. The respective edge portions of the first and second surfaces **1***a* and **2***a* may have substantially the same height as the third surface **3***a*.

The first frame portion **200***a* may be affixed to the first bottom portion **100***a* using a coupling device such as a screw. Accordingly, the first and second sidewalls **202***a***1** and **202***a***2** of the first frame portion **200***a* may include grooves disposed in the projections **27**. The side portions **102***a* of the first bottom portion **100***a* may include a plurality of openings (e.g., holes) **96** disposed corresponding to the plurality of projections **27**. The coupling device may be coupled to the grooves in the plurality of projections **27** of the first frame portion **200***a* through the plurality of openings (e.g., holes) **96** of the first bottom portion **100***a*.

The second frame portion **200***b* may have a shape similar to the second bottom portion **100***b*. That is, the second frame portion **200***b* may be curved along a direction from the first side portion of the second bottom portion **100***b* towards the second side portion thereof.

The second frame portion **200***b* may include a first side wall **202***b***1** and a second sidewall **202***b***2** disposed facing each other, and a stage **201***b* disposed between the first and second sidewalls **202***b***1** and **202***b***2**. The first and second sidewalls **202***b***1** and **202***b***2** may have a length longer than the stage **201***b*. In other words, portions of the first and second sidewalls **202***b***1** and **202***b***2** may protrude over an edge portion of the stage **201***b* towards the hinge portion **400**. The portions of the first and second sidewalls **202***b***1** and **202***b***2** protruding over the edge portion of the stage **201***a* may respectively be defined as first and second sidewall protrusions **211***b***1** and **211***b***2**.

The first sidewall **202***b***1** may have the same height as the second sidewall **202***b***2**. The first and second sidewalls **202***b***1** and **202***b***2** may have a height larger than the stage **201***b*.

The second frame portion **200***b* may be disposed corresponding to the second bottom portion **100***b*, which will be described below in more detail.

The first and second sidewalls **202***b***1** and **202***b***2** and the stage **201***b*, which are included in the second frame portion **200***b*, may be disposed on the third surface **3***b* of the second bottom portion **100***b*. The first sidewall protrusion **211***b***1** may be disposed on corresponding edge portions of the first surface **1***b* and the second surface **2***b*. The respective edge portions of the first and second surfaces **1***b* and **2***b* may have substantially the same height as the third surface **3***b*. The second sidewall protrusion **211***b***2** may be disposed on corresponding edge portions of the first surface **1***b* and the second surface **2***b*. The respective edge portions of the first and second surfaces **1***b* and **2***b* may have substantially the same height as the third surface **3***b*.

The second frame portion **200***b* may be affixed to the second bottom portion **100***b* using a coupling device such as a screw. Accordingly, the first and second sidewalls **202***b***1** and **202***b***2** of the second frame portion **200***b* may include grooves disposed in the projections **27**. The side portions **102***b* of the second bottom portion **100***b* may include a plurality of openings (e.g., holes) **96** disposed corresponding to the plurality of projections **27**. The coupling device may be coupled to the grooves in the plurality of projections **27** of the second frame portion **200***b* through the plurality of openings (e.g., holes) **96** of the second bottom portion **100***b*.

Referring to FIGS. **1** and **2**, the hinge portion **400** may be disposed between the first and second frame portions **200***a* and **200***b*.

The first frame portion **200***a* may be rotatably coupled to one side of the hinge portion **400**. The first frame portion **200***a* may be coupled to a first coupling portion **401** and a second coupling portion **402** of the hinge portion **400**. For example, the first sidewall **202***a***1** may have a groove **20** in an outer side of the first sidewall **202***a***1** included in the first frame portion **200***a* and the first coupling portion **401** may be partially inserted into the groove **20**. the second sidewall **202***a***2** may have a groove **20** in an outer side of the second sidewall **202***a***2** included in the first frame portion **200***a* and the second coupling portion **402** may be partially inserted into the groove **20**.

The first and second coupling portions **401** and **402** may have a plurality of coupling holes **25** that penetrate them, respectively. The first and second sidewalls **202***a***1** and **202***a***2** of the first frame portion **200***a* may have a plurality of coupling grooves **24** respectively corresponding to the plurality of coupling holes **25**. The coupling device, such as a screw, may be inserted into the plurality of coupling grooves **24** through the coupling holes **25**, and the first coupling portion **401** may be affixed to the first sidewall **202***a***1** of the first frame portion **200***a* and the second coupling portion **402** may be affixed to the second sidewall **202***a***2** of the first frame portion **200***a*.

The second frame portion **200***b* may be rotatably coupled to another side of the hinge portion **400**. The second frame portion **200***b* may be coupled to a third coupling portion **403** and a fourth coupling portion **404** of the hinge portion **400**. For example, the first sidewall **202***b***1** may have a groove **20** in an outer side of the first sidewall **202***b***1** included in the second frame portion **200***b* and the third coupling portion **403** may be partially inserted into the groove **20**. the second

sidewall **202***b***2** may have a groove **20** in an outer side of the second sidewall **202***b***2** included in the second frame portion **200***b* and the fourth coupling portion **404** may be partially inserted into the groove **20**.

The third and fourth coupling portions **403** and **404** may have a plurality of coupling holes **25** respectively that penetrate them, respectively. The first and second sidewalls **202***b***1** and **202***b***2** of the second frame portion **200***b* may have a plurality of coupling grooves **24** respectively corresponding to the plurality of coupling holes **25**. The coupling device such as a screw may be inserted into the plurality of coupling grooves **24** through the coupling holes **25**, and the third coupling portion **403** may be affixed to the first sidewall **202***b***1** of the second frame portion **200***b* and the fourth coupling portion **404** may be affixed to the second sidewall **202***b***2** of the second frame portion **200***b*.

The hinge portion **400** will be further described with reference to FIG. **3**. FIG. **3** is an exploded perspective view illustrating the hinge portion **400** shown in FIG. **2**, according to one or more exemplary embodiments. FIG. **4** is a plan view and a front view illustrating the hinge portion **400** shown in FIG. **2**, according to one or more exemplary embodiments.

Referring to FIGS. **3** and **4**, the hinge portion **400** may include a hinge case **499**, a first hinge axis **471**, a second hinge axis **472**, a first gear **851**, a second gear **852**, a third gear **853**, a fourth gear **854**, a first gear cover **461**, a second gear cover **462**, a first washer **481**, a second washer **482**, a third washer **483**, a fourth washer **484**, a first coupling portion **401**, a second coupling portion **402**, a third coupling portion **403**, and a fourth coupling portion **404**.

The hinge case **499** may include a shaft receiving portion **490** and first and second gear receiving portions **411** and **412** respectively disposed on two opposite ends of the shaft receiving portion **490**. The hinge case **499** may include a translucent material such as plastic.

The shaft receiving portion **490** may include a bottom part **460** and a first shaft fixing part **421**, a plurality of first support parts **441**, **442**, **431**, **443**, and **444**, a plurality of first auxiliary support parts **451** and **452**, a second shaft fixing part **422**, a third shaft fixing part **423** disposed along another edge portion of the bottom part **460**, a plurality of second support parts **445**, **446**, **432**, **447**, and **448**, a plurality of second auxiliary support parts **453** and **454**, and a fourth shaft fixing part **424**, disposed along edges of the bottom part **460**.

The first and second shaft fixing parts **421** and **422** may be disposed facing each other. An insertion groove **48** having a predetermined depth may be defined in surfaces on the first and second shaft fixing parts **421** and **422** respectively facing each other.

The plurality of first support parts **441**, **442**, **431**, **443**, and **444** may include a first central support part **431** disposed on a middle between the first and second shaft fixing parts **421** and **422**, first and second side support parts **441** and **442** disposed between the first central support part **431** and the first shaft fixing part **421**, and third and fourth side support parts **443** and **444** disposed between the first central support part **431** and the second shaft fixing part **422**.

The plurality of first auxiliary support parts **451** and **452** may include a first auxiliary support part **451** disposed on one side of the first central support part **431** and a second auxiliary support part **452** disposed on the other side of the first central support part **431**.

A support groove may be defined in respective inner sides of the first central support part **431** and first, second, third, and fourth side support parts **441**, **442**, **443**, and **444**. An auxiliary support groove may be defined in respective inner sides of the first and second auxiliary support parts **451** and **452**, which face the inner side of the first central support part **431**.

An end portion of the first hinge axis **471** may be inserted into the insertion groove **48** of the first shaft fixing part **421**, and the other end portion of the first hinge axis **471** may be inserted into the insertion groove **48** of the second shaft fixing part **422**. A central portion of the first hinge axis **471** may be supported by the support groove of the first central support part **431** and the auxiliary support grooves of the two auxiliary support parts **451** and **452**. One side of the first hinge axis **471** may be supported by the support grooves of the first and second side support parts **441** and **442**, and the other side of the first hinge axis **471** may be supported by the support grooves of the third and fourth side support parts **443** and **444**.

The first shaft fixing part **421**, first and second side support parts **441** and **442**, first central support part **431**, third and fourth side support parts **443** and **444**, and second shaft fixing part **422** may be spaced apart from each other, and may have an empty space therebetween. In more detail, empty spaces may be respectively disposed between the first shaft fixing part **421** and the first side support part **441**, between the first and second side support parts **441** and **442**, between the second side support part **442** and the first central support part **431**, between the first central support part **431** and the third side support part **443**, between the third and fourth side support parts **443** and **444**, and between the fourth side support part **444** and the second shaft fixing part **422**.

The third and fourth shaft fixing parts **423** and **424** may be disposed facing each other. An insertion groove **48** having a predetermined depth may be defined in surfaces on the third and fourth shaft fixing parts **423** and **424** respectively facing each other.

The plurality of second support parts **445**, **446**, **432**, **447**, and **448** may include a second central support part **432** disposed on a middle between the third and fourth shaft fixing parts **423** and **424**, fifth and sixth side support parts **445** and **446** disposed between the second central support part **432** and the third shaft fixing part **423**, and seventh and eighth side support parts **447** and **448** disposed between the second central support part **432** and the fourth shaft fixing part **424**.

A support groove may be defined in respective inner sides of the second central support part **432** and fifth, sixth, seventh, and eighth side support parts **445**, **446**, **447**, and **448**. An auxiliary support groove may be defined in respective inner sides of the third and fourth auxiliary support parts **453** and **454**, which face the inner side of the second central support part **432**.

An end portion of the second hinge axis **472** may be inserted into the insertion groove **48** of the third shaft fixing part **423**, and the other end portion of the second hinge axis **472** may be inserted into the insertion groove **48** of the fourth shaft fixing part **424**. A central portion of the second hinge axis **472** may be supported by the support groove of the second central support part **432** and the auxiliary support grooves of the two auxiliary support parts **453** and **454**. One side of the second hinge axis **472** may be supported by the support grooves of the fifth and sixth side support parts **445** and **446**, and the other side of the second hinge axis **472** may be supported by the support grooves of the seventh and eighth side support parts **447** and **448**.

The third shaft fixing part **423**, fifth and sixth side support parts **445** and **446**, second central support part **432**, seventh

and eighth side support parts **447** and **448**, and fourth shaft fixing part **424** may be spaced apart from each other, and may have an empty space therebetween. In more detail, empty spaces may be respectively disposed between the third shaft fixing part **423** and the fifth side support part **445**, between the fifth and sixth side support parts **445** and **446**, between the sixth side support part **446** and the second central support part **432**, between the second central support part **432** and the seventh side support part **447**, between the seventh and eighth side support parts **447** and **448**, and between the eighth side support part **448** and the fourth shaft fixing part **424**.

The first gear receiving portion **411** may have a shape of a hollow case (or box). One side of the first gear receiving portion **411** may be open. The internal space of the first gear receiving portion **411** may be exposed outwards through the opening **430**. Two first through holes **41** may be defined in a surface of the first gear receiving portion **411** so as to penetrate the corresponding surface. The corresponding surface of the first gear receiving portion **411** may be disposed facing or opposing the second gear receiving portion **412**.

The first gear cover **461** may be fitted into the opening **430** of the first gear receiving portion **411** and cover the opening **430**. The first gear cover **461** may have two second through holes **43** that penetrate the first gear cover **461**. The respective second through holes **43** may be formed corresponding to the first through holes **41**.

The first gear **851** may include a coupling portion including a plurality of cogs and an axis shaft disposed in the center of the coupling portion. The coupling portion and axis shaft may be integrally formed. The plurality of cogs may be provided to a part of a circumference of the coupling portion.

The first gear **851** may be disposed within a space on one side of the first gear receiving portion **411**. The first gear **851** may be fitted into the corresponding first and second through holes **41** and **43**. For example, one end of the axis shaft included in the first gear **851** may be inserted into one of the first through holes **41** and the other end of the axis shaft of the first gear **851** may be inserted into one of the second through holes **43** corresponding to the one first through hole **41**. The other end of the axis shaft may be exposed outwards through the second through hole **43**, and the exposed portion of the other end may have a quadrangle shape.

The second gear **852** may be disposed within a space on another side of the first gear receiving portion **411**. The second gear **852** may include a coupling portion including a plurality of cogs and an axis shaft disposed in the center of the coupling portion. The coupling portion and axis shaft may be integrally formed. The plurality of cogs may be provided to a part of a circumference of the coupling portion.

The second gear **852** may be fitted into the corresponding first and second through holes **41** and **43**. For example, one end of the axis shaft included in the second gear **852** may be inserted into the other first through hole **41** and the other end of the axis shaft of the second gear **852** may be inserted into the other second through hole **43** corresponding to the other first through hole **41**. The other end of the axis shaft may be exposed outwards through the second through hole **43**, and the exposed portion of the other end may have a quadrangle shape.

The first and second gears **851** and **852** may be coupled to each other. The plurality of cogs of the first gear **851** may be interlocked with the plurality of cogs of the second gear **852**.

The second gear receiving portion **412** may have a shape of a hollow case (or box). One side of the second gear receiving portion **412** may be open. The internal space of the second gear receiving portion **412** may be exposed outwards through the opening. Two first through holes **41** may be defined in a surface of the second gear receiving portion **412** so as to penetrate the corresponding surface. The corresponding surface of the second gear receiving portion **412** may be disposed facing or opposing the first gear receiving portion **411**.

The second gear cover **462** may be fitted into the opening of the second gear receiving portion **412** and cover the opening. The second gear cover **462** may have two second through holes **43** that penetrate the second gear cover **462**. The respective second through holes **43** may be defined in places corresponding to the first through holes **41**.

The third gear **853** may include a coupling portion including a plurality of cogs and an axis shaft disposed in the center of the coupling portion. The coupling portion and axis shaft may be integrally formed. The plurality of cogs may be provided to a part of a circumference of the coupling portion.

The third gear **853** may be disposed within a space on one side of the second gear receiving portion **412**. The third gear **853** may be fitted into the corresponding first through holes **42** and second through holes. For example, one end of the axis shaft included in the third gear **853** may be inserted into one of the first through holes **42** and the other end of the axis shaft of the third gear **853** may be inserted into one of the second through holes corresponding to the one first through hole **42**. The other end of the axis shaft may be exposed outwards through the second through hole, and the exposed portion of the other end may have a quadrangle shape.

The fourth gear **854** may be disposed within a space on another side of the second gear receiving portion **412**. The fourth gear **854** may include a coupling portion including a plurality of cogs and an axis shaft disposed in the center of the coupling portion. The coupling portion and axis shaft may be integrally formed. The plurality of cogs may be provided to a part of a circumference of the coupling portion.

The fourth gear **854** may be fitted into the corresponding first through holes **42** and second through holes. For example, one end of the axis shaft included in the fourth gear **854** may be inserted into the other first through hole **42** and the other end of the axis shaft of the fourth gear **854** may be inserted into the other second through hole corresponding to the other first through hole **42**. The other end of the axis shaft may be exposed outwards through the second through hole, and the exposed portion of the other end may have a quadrangle shape.

The third and fourth gears **853** and **854** may be coupled to each other. The plurality of cogs of the third gear **853** may be interlocked with the plurality of cogs of the fourth gear **854**.

The first washer **481** may be disposed between the first gear cover **461** and the first coupling portion **401**. The first washer **481** may have a hole that penetrates a center thereof. The exposed portion of the axis shaft of the first gear **851** may be inserted through the hole of the first washer **481** and through a coupling hole **49** of the first coupling portion **401**. The other end of the axis shaft of the first gear **851** may be fitted into the coupling hole **49** of the first coupling portion **401**. The other end portion of the axis shaft of the first gear **851** and the coupling hole **49** of the first coupling portion

401 may have a quadrangular shape, and therefore, a slippage between the first gear 851 and the first coupling portion 401 may be reduced.

The second washer 482 may be disposed between the first gear cover 461 and the third coupling portion 403. The second washer 482 may have a hole that penetrates a center thereof. The exposed portion of the axis shaft of the second gear 852 may be inserted through the hole of the second washer 482 and through a coupling hole 49 of the third coupling portion 403. The other end of the axis shaft of the second gear 852 may be fitted into the coupling hole 49 of the third coupling portion 403. The other end of the axis shaft of the second gear 852 and the coupling hole 49 of the third coupling portion 403 may have a quadrangular shape, and therefore, a slippage between the second gear 852 and the third coupling portion 403 may be reduced.

The third washer 483 may be disposed between the second gear cover 462 and the second coupling portion 402. The third washer 483 may have a hole that penetrates a center thereof. The exposed portion of the axis shaft of the third gear 853 may be inserted through the hole of the third washer 483 and through a coupling hole of the second coupling portion 402. The other end of the axis shaft of the third gear 853 may be fitted into the coupling hole of the second coupling portion 402. The other end portion of the axis shaft of the third gear 853 and the coupling hole of the second coupling portion 402 may have a quadrangular shape, and therefore, a slippage between the third gear 853 and the second coupling portion 402 may be reduced.

The fourth washer 484 may be disposed between the second gear cover 462 and the fourth coupling portion 404. The fourth washer 484 may have a hole that penetrates a center thereof. The exposed portion of the axis shaft of the fourth gear 854 may be inserted through the hole of the fourth washer 484 and through a coupling hole of the fourth coupling portion 404. The other end of the axis shaft of the fourth gear 854 may be fitted into the coupling hole of the fourth coupling portion 404. The other end portion of the axis shaft of the fourth gear 854 and the coupling hole of the fourth coupling portion 404 may have a quadrangular shape, and therefore, a slippage between the fourth gear 854 and the fourth coupling portion 404 may be reduced.

The first coupling portion 401 may have a shape of a long bar. One side of the first coupling portion 401 may be rotatably coupled to the axis shaft of the first gear 851, and the other side of the first coupling portion 401 may be affixed to the first sidewall 202*a*1 of the first frame portion 200*a*. A coupling hole 49 may be defined in one side of the first coupling portion 401 so as to penetrate the first coupling portion 401 and a plurality of fastening holes 25 may be defined the other side of the first coupling portion 401 so as to penetrate the first coupling portion 401. The one side of the first coupling portion 401 may have a smaller thickness than the other side thereof. Recessed grooves 29 may be defined in two sides of a central portion of the first coupling portion 401. The projection 27 defined in the first sidewall 202*a*1 of the first frame portion 200*a* may be coupled with one groove of the recessed grooves 29.

The second coupling portion 402 may have a shape of a long bar. One side of the second coupling portion 402 may be rotatably coupled to the axis shaft of the second gear 852, and the other side of the second coupling portion 402 may be affixed to the second sidewall 202*a*2 of the first frame portion 200*a*. A coupling hole may be defined in one side of the second coupling portion 402 so as to penetrate the second coupling portion 402 and a plurality of fastening holes 25 may be defined in the other side of the second coupling portion 402 so as to penetrate the second coupling portion 402. The one side of the second coupling portion 402 may have a smaller thickness than the other side thereof. Recessed grooves may be defined in two sides of a central portion of the second coupling portion 402. The projection 27 defined in the second sidewall 202*a*2 of the first frame portion 200*a* may be coupled with one groove of the recessed grooves.

The third coupling portion 403 may have a shape of a long bar. One side of the third coupling portion 403 may be rotatably coupled to the axis shaft of the third gear 853, and the other side of the third coupling portion 403 may be affixed to the first sidewall 202*b*1 of the second frame portion 200*b*. A coupling hole may be defined in one side of the third coupling portion 403 as to penetrate the third coupling portion 403 and a plurality of fastening holes may be defined in the other side of the third coupling portion 403 as to penetrate the third coupling portion 403. The one side of the third coupling portion 403 may have a smaller thickness than the other side thereof. Recessed grooves may be defined in two sides of a central portion of the third coupling portion 403. The projection defined in the first sidewall 202*b*1 of the second frame portion 200*b* may be coupled with one groove of the recessed grooves.

The fourth coupling portion 404 may have a shape of a long bar. One side of the fourth coupling portion 404 may be rotatably coupled to the axis shaft of the fourth gear 854, and the other side of the fourth coupling portion 404 may be affixed to the second sidewall 202*b*2 of the second frame portion 200*b*. A coupling hole may be defined in one side of the fourth coupling portion 404 as to penetrate the fourth coupling portion 404 and a plurality of fastening holes may be defined in the other side of the fourth coupling portion 404 as to penetrate the fourth coupling portion 404. The one side of the fourth coupling portion 404 may have a smaller thickness than the other side thereof. Recessed grooves may be formed in two sides of a central portion of the fourth coupling portion 404. The projection defined in the second sidewall 202*b*2 of the second frame portion 200*b* may be coupled with one groove of the recessed grooves.

The first to fourth coupling portions 401, 402, 403, and 404 may respectively have two recessed grooves 29, and thus the respective first to fourth coupling portions 401, 402, 403, and 404 may be used interchangeably. For example, the first coupling portion 401 may be used in place of the third coupling portion 403, and vice versa.

As illustrated in FIGS. 3 and 4, the support portion 500 may include a first support portion 501 and a second support portion 502. The first and second support portions 501 and 502 may be separated from each other. Further, the first and second support portions 501 and 502 may be symmetric to each other with respect to the Y-axis.

The support portion 500 may include one or more first support portions 501 and one or more second support portions 502. For example, according to FIG. 3, the support portion 500 includes two first support portions 501 and two second support portions 502, but the exemplary embodiments are not limited thereto.

The first support portion 501 may be rotatably coupled to the first hinge axis 471. The first support portion 501 may include a first rotation unit 511*a*, a second rotation unit 512*a*, a first support plate 588*a*, a second support plate 561*a*, a third support plate 562*a*, and a hinge spring 571*a*. According to the exemplary embodiments, the first support portion 501 may include one of either the first and second rotation units 511*a* and 512*a*, and/or two or more of first and second rotation units 511*a* and 512*a*. The first support portion 501

may include two or more of first and second support plates **588***a* and **561***a*, and/or include two or more of the hinge spring.

The first rotation unit **511***a* may have a shape of a cylinder. The first rotation unit **511***a* may have a through hole that penetrates a central portion of the first rotation unit **511***a*. The first rotation unit **511***a* may be rotatably coupled to the first hinge axis **471** through the through hole. The first rotation unit **511***a* may be disposed in a space **45** between the first shaft fixing part **421** and the first side support part **441**.

The second rotation unit **512***a* may have a shape of a cylinder. The second rotation unit **512***a* may have a through hole that penetrates a central portion of the second rotation unit **512***a*. The second rotation unit **512***a* may be rotatably coupled to the first hinge axis **471** through the through hole. The second rotation unit **512***a* may be disposed in a space **47** between the second side support part **442** and the first central support part **431**.

The first support plate **588***a* may have a shape of a long bar. One side of the first support plate **588***a* may be coupled to one side of the first rotation unit **511***a*, and the other side of the first support plate **588***a* may be coupled to one side of the second rotation unit **512***a*. The first support plate **588***a* may protrude from the first and second rotation units **511***a* and **512***a* towards one side of the first support portion **501**.

The second support plate **561***a* may have a shape of a bar shorter than the first support plate **588***a*. The second support plate **561***a* may be coupled to another side of the first rotation unit **511***a*. The second support plate **561***a* may protrude from the first rotation unit **511***a* towards another side of the first support portion **501**. The second support plate **561***a* may have a smaller length and width than the first support plate **588***a*.

The third support plate **562***a* may have a shape of a bar shorter than the first support plate **588***a*. The third support plate **562***a* may be coupled to another side of the second rotation unit **512***a*. The third support plate **562***a* may protrude from the second rotation unit **512***a* towards another side of the first support portion **501**. The third support plate **562***a* may have a smaller length and width than the first support plate **588***a*. The third support plate **562***a* may have the same size as the second support plate **561***a*.

The first support plate **588***a* may have an angle of greater than about 45 degrees with the second support plate **561***a*. For example, the first support plate **588***a* may have an angle of about 90 degrees with the second support plate **561***a*.

The first support plate **588***a* may have an angle of greater than about 45 degrees with the third support plate **562***a*. In an exemplary embodiment, for instance, the first support plate **588***a* may have an angle of about 90 degrees with the third support plate **562***a*.

The hinge spring **571***a* may be disposed in a space **46** between the first and second side support parts **441** and **442**. The hinge spring **571***a* may be coiled around the first hinge axis **471**. One end of the hinge spring **571***a* may extend straightly and may be disposed on the bottom part **460** of the hinge case **499**, and the other end portion of the hinge spring **571***a* may extend straightly and may be disposed on the first support plate **588***a*. An angle between the first support plate **588***a* and the bottom part **460** may be maintained constant by means of the hinge spring **571***a*. When a force greater than a restoring force of the hinge spring **571***a* is applied on the first support plate **588***a*, the first support plate **588***a* may press the other end portion of the hinge spring **571***a*, and accordingly an angle between the one end portion and the other end portion of the hinge spring **571***a* may be reduced and energy may be stored in the hinge spring **571***a*.

Referring to FIG. **3**, another first support portion coupled to the first hinge axis **471** may have the same shape as the above-described first support portion **501**. The another first support portion may include a first rotation unit disposed in a space between the first central support part **431** and the third side support part **443**, a second rotation unit disposed in a space between the fourth side support part **444** and the second shaft fixing part **422**, and a hinge spring disposed in a space between the third side support part **443** and the fourth side support part **444**.

The second support portion **502** may be rotatably coupled to the second hinge axis **472**. The second support portion **502** may include a first rotation unit **511***b*, a second rotation unit **512***b*, a first support plate **588***b*, a second support plate **561***b*, a third support plate **562***b*, and a hinge spring **571***b*. According to the exemplary embodiments, the second support portion **502** may include one of either the first and second rotation units **511***b* and **512***b*, and/or two or more of first and second rotation units **511***b* and **512***b*. The second support portion **502** may include two or more of first and second support plates **588***b* and **561***b*, and/or include two or more of the hinge spring.

The first rotation unit **511***b* may have a shape of a cylinder. The first rotation unit **511***b* may have a through hole that penetrates a central portion of the first rotation unit **511***b*. The first rotation unit **511***b* may be rotatably coupled to the second hinge axis **472** through the through hole. The first rotation unit **511***b* may be disposed in a space between the third shaft fixing part **423** and the fifth side support part **445**.

The second rotation unit **512***b* may have a shape of a cylinder. The second rotation unit **512***b* may have a through hole that penetrates a central portion of the second rotation unit **512***b*. The second rotation unit **512***b* may be rotatably coupled to the second hinge axis **472** through the through hole. The second rotation unit **512***b* may be disposed in a space between the sixth side support part **446** and the second central support part **432**.

The first support plate **588***b* may have a shape of a long bar. One side of the first support plate **588***b* may be coupled to one side of the first rotation unit **511***b*, and the other side of the first support plate **588***b* may be coupled to one side of the second rotation unit **512***b*. The first support plate **588***b* may protrude from the first and second rotation units **511***b* and **512***b* towards one side of the second support portion **502**.

The second support plate **561***b* may have a shape of a bar shorter than the first support plate **588***b*. The second support plate **561***b* may be coupled to another side of the first rotation unit **511***b*. The second support plate **561***b* may protrude from the first rotation unit **511***b* towards another side of the second support portion **502**. The second support plate **561***b* may have a smaller length and width than the first support plate **588***b*.

The third support plate **562***b* may have a shape of a bar shorter than the first support plate **588***b*. The third support plate **562***b* may be coupled to another side of the second rotation unit **512***b*. The third support plate **562***b* may protrude from the second rotation unit **512***b* towards another side of the second support portion **502**. The third support plate **562***b* may have a smaller length and width than the first support plate **588***b*. The third support plate **562***b* may have the same size as the second support plate **561***b*.

The first support plate **588***b* may have an angle of greater than about 45 degrees with the second support plate **561***b*. For example, the first support plate **588***b* may have an angle of about 90 degrees with the second support plate **561***b*.

The first support plate **588***b* may have an angle of greater than about 45 degrees with the third support plate **562***b*. In an exemplary embodiment, for instance, the first support plate **588***b* may have an angle of about 90 degrees with the third support plate **562***b*.

The hinge spring **571***b* may be disposed in a space between the fifth and sixth side support parts **445** and **446**. The hinge spring **571***b* may be coiled around the second hinge axis **472**. One end of the hinge spring **571***b* may extend straightly and may be disposed on the bottom part **460** of the hinge case **499**, and the other end portion of the hinge spring **571***b* may extend straightly and may be disposed on the first support plate **588***b*. An angle between the first support plate **588***b* and the bottom part **460** may be maintained constant by means of the hinge spring **571***b*. When a force greater than a restoring force of the hinge spring **571***b* is applied on the first support plate **588***b*, the first support plate **588***b* may press the other end portion of the hinge spring **571***b*, and accordingly an angle between the one end portion and the other end portion of the hinge spring **571***b* may be reduced and energy may be stored in the hinge spring **571***b*.

Referring to FIG. **3**, another second support portion coupled to the second hinge axis **472** may have the same shape as the above-described second support portion **502**. The another second support portion may include a first rotation unit disposed in a space between the second central support part **432** and the seventh side support part **447**, a second rotation unit disposed in a space between the eighth side support part **448** and the fourth shaft fixing part **424**, and a hinge spring disposed in a space between the seventh side support part **447** and the eighth side support part **448**.

Referring back to FIG. **1**, the curvature adjusting portion **600** may include a first curvature adjusting portion **600***a* and a second curvature adjusting portion **600***b*. The first and second curvature adjusting portions **600***a* and **600***b* may be separated from each other. Further, the first and second curvature adjusting portions **600***a* and **600***b* may be disposed symmetric to each other with respect to the Y-axis.

The first curvature adjusting portion **600***a* may be configured to control a curvature of a first curved part A**1** of the flexible display panel **700**. In other words, the first curvature adjusting portion **600***a* may control a degree of curvature of the first curved part A**1** so that the first curved part A**1** may have a gentle (or low) curvature. The first curved part A**1**, as illustrated in FIG. **1**, may be defined as a part of the flexible display panel **700**, which is located between a center of the flexible display panel **700** and a first boundary portion. The first boundary portion may be a boundary between the stage **201***a* of the first frame portion **200***a* and the first curvature adjusting portion **600***a*.

The first curvature adjusting portion **600***a* may be disposed between one side of the hinge portion **400** and the flexible display panel **700**. In more detail, the first curvature adjusting portion **600***a* may be disposed between the first support portion **501** coupled to the first hinge axis **471** of the hinge portion **400** and the flexible display panel **700**. One side of the first curvature adjusting portion **600***a* may be disposed between the first and second sidewall protrusions **211***a***1** and **211***a***2** of the first frame portion **200***a*. The first curvature adjusting portion **600***a* may be hinge coupled to the stage **201***a* of the first frame portion **200***a*. A coupling structure of the first curvature adjusting portion **600***a* and the first frame portion **200***a* will be described below in more detail.

FIG. **5** is an exploded perspective view illustrating the first curvature adjusting portion **600***a* and the first frame portion **200***a* shown in FIG. **1**, separated from each other, according to one or more exemplary embodiments.

Referring to FIG. **5**, a plurality of projections **22** and a plurality of grooves **23** may be alternately disposed in a surface of the stage **201***a* of the first frame portion **200***a* facing the second frame portion **200***b*. The respective projections **22** may have a shape of a hollow cylinder. The first curvature adjusting portion **600***a* may include a plurality of projections having shape of a hollow cylinder and a plurality of grooves, disposed in one side of first curvature adjusting portion **600***a*, facing the first frame portion **200***a*. The plurality of projections **22** of the stage **201***a* of the first frame portion **200***a* may be inserted into the plurality of grooves of the first curvature adjusting portion **600***a*, and the plurality of projections of the first curvature adjusting portion **600***a* may be inserted into the plurality of grooves **23** of the stage **201***a* of the first frame portion **200***a*. The projections and grooves of the stage **201***a* of the first frame portion **200***a* may be coupled to respective projections and grooves of the first curvature adjusting portion **600***a*, by inserting a connecting shaft **666** into holes of the coupled projections so that the first curvature adjusting portion **600***a* may be hinge coupled to the first frame portion **200***a*. The connecting shaft **666** may be coupled to the stage **201***a* of the first frame portion **200***a* through a through hole **66** that penetrates the second sidewall protrusion **211***a***2**.

FIG. **6** is an exploded perspective view illustrating the first curvature adjusting portion **600***a* shown in FIG. **5** according to one or more exemplary embodiments. FIG. **7**(*a*) is a plan view illustrating a structure of the first frame portion **200***a* and the first curvature adjusting portion **600***a* coupled to each other according to one or more exemplary embodiments, and FIGS. **7**(*b*) and **7** (*c*) are cross-sectional views respectively taken along sectional lines I-I' and II-II' of the structure of the first frame portion and the first curvature adjusting portion, according to one or more exemplary embodiments. That is, FIG. **7**(*a*) is a plan view, FIG. **7**(*b*) is a cross-sectional view taken along sectional line I-I' of FIG. **7**(*a*), and FIG. **7**(*c*) is a cross-sectional view taken along sectional line II-II' of FIG. **7**(*a*).

According to FIGS. **6**, **7**(*a*), **7**(*b*), and **7**(*c*), the first curvature adjusting portion **600***a*, may include a plurality of adjustment units **601**, **602**, **603**, **604**, **605**, and **606** and a plurality of connecting shafts **667**. The plurality of adjustment units **601**, **602**, **603**, **604**, **605**, and **606** may be hinge coupled to each other by the plurality of connecting shafts **667**. FIGS. **6**, **7**(*a*), **7**(*b*), and **7**(*c*) illustrates that the first curvature adjusting portion **600***a* includes six adjustment units **601**, **602**, **603**, **604**, **605**, and **606** hinge coupled to each other, but the exemplary embodiments are not limited thereto. That is, the first curvature adjusting portion **600***a* may include a number of the adjustment unit(s) larger or smaller than the six units illustrated.

According to FIG. **6**, the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** may have a shape of a bar having a length larger than a width. The first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** may all have the same width or at least two adjustment units thereof may have different widths from each other.

At least one first projection **61** and at least one first groove **62** may be alternately formed in one lateral surface of each of the first to fifth adjustment units **601**, **602**, **603**, **604**, and **605**, and at least one second projection **63** and at least one second groove **64** may be alternately formed in another lateral surface of each of the first to fifth adjustment units **601**, **602**, **603**, **604**, and **605** opposite to the one lateral surface thereof. The at least one second groove **64** may be

formed corresponding to the at least one first projection **61**, and the at least one second projection **63** may be defined corresponding to the at least one first groove **62**.

The at least one second projection **63** and the at least one second groove **64** may be alternately defined in a surface of the sixth adjustment unit **606** disposed closest to the hinge portion **400**.

The at least one first and second projections **61** and **63** may have holes formed through central portions thereof, respectively.

The at least one first and second projections **61** and **63** may have a convex shape, and the at least one first and second grooves **62** and **64** may have a concave shape.

The first projection **61** formed on one of the adjustment units may be disposed facing the second groove **64** respectively formed on adjacent adjustment units. The first projection **61** may be inserted into the facing second groove **64**. The projections **61** and **63** may be coupled to respective grooves **62** and **64** of the adjacent adjustment units, and the connecting shaft **667** may be inserted into the holes of the projections **61** and **63**. In the way, the adjacent adjustment units may be hinge coupled to each other.

For example, the first projection **61** of the fourth adjustment unit **604** may be inserted into the second groove **64** of the fifth adjustment unit **605**, and the second projection **63** of the fourth adjustment unit **604** may be inserted into the first groove **62** of the third adjustment unit **603**. Accordingly, the projections and grooves of the third to fifth adjustment units **603**, **604**, and **605** may be coupled to each other, and the connecting shafts **667** may be inserted into the holes of the projections.

FIG. **8** is a cross-sectional view of the first curvature adjusting portion **600***a* and an enlarged view illustrating adjustment units according to one or more exemplary embodiments.

At least two of the adjustment units included in the first curvature adjusting portion **600***a* may have different angular rotation ranges. For example, an adjustment unit disposed closer to the hinge portion **400** may have a larger angular rotation range. Referring to FIG. **8**, the first adjustment unit **601** disposed farthest from the hinge portion **400** may have the smallest angular rotation range (zero (0) degrees) and the sixth adjustment unit **606** disposed closest to the hinge portion **400** may have the largest angular rotation range (θ5). The second adjustment unit **602** may have an angular rotation range (θ1) larger than the first adjustment unit **601**, the third adjustment unit **603** may have an angular rotation range (θ2) larger than the second adjustment unit **602**, the fourth adjustment unit **604** may have an angular rotation range (θ3) larger than the third adjustment unit **603**, the fifth adjustment unit **605** may have an angular rotation range (θ4) larger than the fourth adjustment unit **604**, and the sixth adjustment unit **606** may have an angular rotation range (θ5) larger than the fifth adjustment unit **605**. The angular rotation range of the first adjustment unit **601** may be substantially zero (0) degrees.

The grooves respectively included in the first to fifth adjustment units **601**, **602**, **603**, **604**, and **605** that are closer to the hinge portion **400** may be smaller. Referring to FIG. **8**, the first adjustment unit **601** may have the largest groove and the fifth adjustment unit **605** may have the smallest groove. The second adjustment unit **602** may have a groove smaller than the first adjustment unit **601**, the third adjustment unit **603** may have a groove smaller than the second adjustment unit **602**, the fourth adjustment unit **604** may have a groove smaller than the third adjustment unit **603**, the fifth adjustment unit **605** may have a groove smaller than the fourth adjustment unit **604**, and the sixth adjustment unit **606** may have a groove smaller than the fifth adjustment unit **605**. The sixth adjustment unit **606** may have a groove larger than the first adjustment unit **601**. In other words, the sixth adjustment unit **606** may have the largest groove among the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606**.

The respective first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** may include an upper surface **82** and a lower surface **81** which may have different size from each other. For example, the second adjustment unit **602** may include the lower surface **81** that is smaller than the upper surface **82** thereof. The sixth adjustment unit **606** may include the lower surface **81** that is larger than the upper surface **82** thereof.

For example, the first adjustment unit **601** may include the upper and lower surfaces **82** and **81** having substantially identical size.

The upper surfaces **82** of the first to fourth adjustment units **601**, **602**, **603**, and **604** may be substantially same size.

The lower surfaces **81** respectively included in the first to fifth adjustment units **601**, **602**, **603**, **604**, and **605** which are closer to the hinge portion **400** may be smaller. Referring to FIG. **8**, among the first to fifth adjustment unit **601**, **602**, **603**, **604**, and **605**, the first adjustment unit **601** may include the largest lower surface **81** and the fifth adjustment unit **605** may include the smallest lower surface **81**. The second adjustment unit **602** may include the lower surface **81** smaller than the first adjustment unit **601**, the third adjustment unit **603** may include the lower surface **81** smaller than the second adjustment unit **602**, the fourth adjustment unit **604** may include the lower surface **81** smaller than the third adjustment unit **603**, the fifth adjustment unit **605** may include the lower surface **81** smaller than the fourth adjustment unit **604**, and the sixth adjustment unit **606** may include the lower surface **81** smaller than the fifth adjustment unit **605**. The sixth adjustment unit **606** may include the lower surface **81** that is larger than that of the first adjustment unit **601**. In other words, the sixth adjustment unit **606** may include the largest lower surface **81** among the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606**.

Respective distances between the connecting shafts **666** and **667** may be substantially identical to each other. The respective distances between the two connecting shafts **667** connecting two sides of the fifth adjustment unit **605** may be different from the distances between other connecting shafts. That is, the distances between the connecting shafts **667** connecting the two sides of the fifth adjustment unit **605** may be larger than the distances between other connecting shafts since the fifth adjustment unit **605** includes a protrusion **615** protruding from one side of the fifth adjustment unit **605** towards the sixth adjustment unit **606**.

One adjustment unit disposed between any two adjustment units of the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** may be defined as a reference adjustment unit. For example, the fifth adjustment unit **605** may be defined as the reference adjustment unit. Accordingly, the first to fourth adjustment units **601**, **602**, **603**, and **604** between the first frame portion **200***a* and the reference adjustment unit **605** (the fifth adjustment unit **605**) may be defined as a curved adjustment unit, and the sixth adjustment unit **606** between the reference adjustment unit **605** (the fifth adjustment unit **605**) and the hinge portion **400** may be defined as a straight adjustment unit. The curved adjustment units **601**, **602**, **603**, and **604** may be hinge coupled to each other at one end portion of the reference adjustment unit

605, and the straight adjustment unit 606 may be hinge coupled at the other end portion of the reference adjustment unit 605.

An imaginary surface extending from the upper surface 82 of the reference adjustment unit 605 may be defined as a reference surface 888, and the first to fourth curved adjustment units 601, 602, 603, and 604 between the first frame portion 200*a* and the reference adjustment unit 605 may be rotated in a range that does not intersect (or cross) the reference surface 888, whereas the straight adjustment unit 606 between the reference adjustment unit 605 and the hinge portion 400 may be rotated in a range that the straight adjustment unit 606 intersects (or crosses) the reference surface 888. This will be further described below with reference to FIG. 9. Hereinafter, the first to sixth adjustment units will be used in place of the reference adjustment unit, the first to fourth curved adjustment units, and the straight adjustment unit.

FIG. 9 is a cross-sectional view illustrating the first curvature adjusting portion 600*a* when curved, according to one or more exemplary embodiments.

As illustrated in FIG. 9, the first curvature adjusting portion 600*a* may be curved along a curved surface of the flexible display panel 700, and then the first to sixth adjustment units 601, 602, 603, 604, 605, and 606 may be rotated along the curved surface. The upper surfaces 82 of the respective first to fifth adjustment units 601, 602, 603, 604, and 605 do not intersect the reference surface 888, and the upper surface 82 of the sixth adjustment unit 606 intersects the reference surface 888.

The second curvature adjusting portion 600*b* may be configured to control a curvature of the second curved part A2 of the flexible display panel 700. In other words, the second curvature adjusting portion 600*b* may control a degree of curvature of the second curved part A2 that the second curved part A2 may have a gentle (or low) curvature. The second curved part A2, as illustrated in FIG. 1, may be defined as a part of the flexible display panel 700, which is located between a center of the flexible display panel 700 and a second boundary portion. The second boundary portion may be a boundary between the stage 201*b* of the second frame portion 200*b* and the second curvature adjusting portion 600*b*.

The second curvature adjusting portion 600*b* may be disposed between one side of the hinge portion 400 and the flexible display panel 700. In more detail, the second curvature adjusting portion 600*b* may be disposed between the second support portion 502 coupled to the second hinge axis 472 of the hinge portion 400 and the flexible display panel 700. One side of the second curvature adjusting portion 600*b* may be disposed between the first and second sidewall protrusions 211*b*1 and 211*b*2 of the second frame portion 200*b*. The second curvature adjusting portion 600*b* may be hinge coupled to the stage 201*b* of the second frame portion 200*b*.

A detailed configuration of the second curvature adjusting portion 600*b* may be substantially same as the first curvature adjusting portion 600*a*, and thus, will be omitted.

Referring back to FIG. 1, the flexible display panel 700 may be disposed on the mold frame 200 and the curvature adjusting portion 600. One side of the flexible display panel 700 may be placed on the stage 201*a* of the first frame portion 200*a*, and the other side of the flexible display panel 700 may be placed on the stage 201*b* of the second frame portion 200*b*. The first curved part A1 of the flexible display panel 700 may be located on the first curvature adjusting portion 600*a* and the second curved part A2 of the flexible display panel 700 may be located on the second curvature adjusting portion 600*b*.

The flexible display panel 700 may be substantially divided into two areas; a display area 700*a* and a non-display area 700*b*. The display area 700*a* may be configured to display an image and the non-display area 700*b* may include signal lines configured to transmit image data for image display, control signals and power signals. The non-display area 700*b* may include a driver circuit board including at least one driver circuit unit configure to provide the image data, control signals and power signals.

The flexible display panel 700 may include a liquid crystal display (LCD) panel, an organic light emitting diode display (OLED) panel, a plasma display panel, an electrophoretic display panel, and the like, but exemplary embodiments are not limited thereto. The flexible display panel 700 may be any flexible display panel that is bendable and foldable.

Referring back to FIG. 1, the top chassis 800 may have an opening through which the display area 700*a* of the flexible display panel 700 and a part of the hinge portion 400 are exposed. That is, the top chassis 800 may have a quadrangular frame shape including an opening in the center of the top chassis 800. The top chassis 800 may include a first top portion 800*a* and a second top portion 800*b*. The first and second top portions 800*a* and 800*b* may be separated from each other. The first and second top portions 800*a* and 800*b* may be symmetric to each other with respect to the Y-axis.

The first top portion 800*a* may be placed on the first and second sidewalls 202*a*1 and 202*a*2 of the first frame portion 200*a* and a first side portion 900*a* of a side case 900 that will be described below. The first top portion 800*a* may be affixed to the first and second sidewalls 202*a*1 and 202*a*2 and the first side portion 900*a* using a coupling device such as a screw.

The second top portion 800*b* may be placed on the first and second sidewalls 202*b*1 and 202*b*2 of the second frame portion 200*b* and a second side portion 900*b* of the side case 900 that will be described below. The second top portion 800*b* may be affixed to the first and second sidewalls 202*b*1 and 202*b*2 and the second side portion 900*b* using the coupling device such as a screw.

Referring back to FIG. 1, the side case 900 may include the first side portion 900*a* and the second side portion 900*b*. The first and second side portions 900*a* and 900*b* may be separated from each other. The first and second side portions 900*a* and 900*b* may be symmetric to each other with respect to the Y-axis.

The first side portion 900*a* may be disposed on an edge portion of the first bottom portion 100*a*. The first side portion 900*a* may be attached to a lower surface of the first top portion 800*a*. The first side portion 900*a* may be affixed to the first top portion 800*a* using the coupling device.

The second side portion 900*b* may be disposed on an edge portion of the second bottom portion 100*b*. The second side portion 900*b* may be attached to a lower surface of the second top portion 800*b*. The second side portion 900*b* may be affixed to the second top portion 800*b* using the coupling device.

FIG. 10 is a perspective view illustrating an unfolded display device including the first curvature adjusting portion 600*a*, the second curvature adjusting portion 600*b*, the first support portion 501 and the second support portion 502 according to one or more exemplary embodiments.

According to FIG. 10, the unfolded display device may include the unfolded flexible display panel 700. The adjust-

ment units **601**, **602**, **603**, **604**, **605**, and **606** of the first curvature adjusting portion **600***a* and the adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the second curvature adjusting portion **600***b* may be aligned with respect to the reference surface **888**.

Accordingly, the respective upper surfaces of the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the first curvature adjusting portion **600***a* may be in contact with the flexible display panel **700**, and the respective upper surfaces of the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the second curvature adjusting portion **600***b* may be in contact with the flexible display panel **700**.

The first support plate **588***a* of the first support portion **501** may be configured to support one side of the sixth adjustment unit **606** included in the first curvature adjusting portion **600***a*, and the second and third support plates **561***a* and **562***a* of the first support portion **501** may be configured to support the other side of the sixth adjustment unit **606** included in the first curvature adjusting portion **600***a*.

The first support plate **588***b* of the second support portion **502** may be configured to support one side of the sixth adjustment unit **606** included in the second curvature adjusting portion **600***b*, and the second and third support plates **561***b* and **562***b* of the second support portion **502** may be configured to support the other side of the sixth adjustment unit **606** included in the second curvature adjusting portion **600***b*.

FIG. **11** is a perspective view illustrating a folded display device including the first curvature adjusting portion **600***a*, the second curvature adjusting portion **600***b*, the first support portion **501** and the second support portion **502** according to one or more exemplary embodiments.

According to FIG. **11**, the folded display device may include the folded flexible display panel **700**. Since the flexible display panel **700** is folded, the first curved part A**1** may apply pressure on the first curvature adjusting portion **600***a*. Accordingly, the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the first curvature adjusting portion **600***a* may be moved towards the first bottom portion **100***a* rotated about the respective connecting shafts **667**. Therefore, the upper surfaces **82** of the first to fifth adjustment units **601**, **602**, **603**, **604**, and **605** of the first curvature adjusting portion **600***a* may be curved. The coupling portion between the fifth and sixth adjustment units **605** and **606** of the first curvature adjusting portion **600***a* may be disposed on the second surface **2***a* of the first bottom portion **100***a*. The first support plate **588***a* included in the first support portion **501** may be rotated towards the first bottom portion **100***a*, and one side of the first support plate **588***a* may be disposed on the first surface **1***a* of the first bottom portion **100***a* by the rotation. One side of the sixth adjustment unit **606** of the first curvature adjusting portion **600***a* may be moved to a space between the first and second support plates **588***a* and **561***a*.

The first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the first curvature adjusting portion **600***a* may have a limited angular rotation range, and thus a curvature of the first curved part A**1** may be limited. An area B**1** of the first curved part A**1**, which is near the first boundary portion, may have a relatively high curvature according to the first curvature adjusting portion **600***a*. The first curvature adjusting portion **600***a* is configured to limit the curvature of the area B**1** to a predetermined value and reduce or prevent excessive folding of the area B**1** of the first curved part A**1** when the display device is folded.

Similarly, since the flexible display panel **700** is folded, the second curved part A**2** may apply pressure on the second curvature adjusting portion **600***b*. Accordingly, the first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the second curvature adjusting portion **600***b* may be moved towards the second bottom portion **100***b* rotated about the respective connecting shafts **667**. Therefore, the upper surfaces **82** of the first to fifth adjustment units **601**, **602**, **603**, **604**, and **605** of the second curvature adjusting portion **600***b* may be curved. The coupling portion between the fifth and sixth adjustment units **605** and **606** of the second curvature adjusting portion **600***b* may be disposed on the second surface **2***b* of the second bottom portion **100***b*. The first support plate **588***b* included in the second support portion **502** may be rotated towards the second bottom portion **100***b*, and one side of the first support plate **588***b* may be disposed on the first surface **1***b* of the second bottom portion **100***b* by the rotation. One side of the sixth adjustment unit **606** of the second curvature adjusting portion **600***b* may be moved to a space between the first and second support plates **588***b* and **561***b*.

The first to sixth adjustment units **601**, **602**, **603**, **604**, **605**, and **606** of the second curvature adjusting portion **600***b* may have a limited angular rotation range, and thus a curvature of the second curved part A**2** may be limited. An area B**2** of the second curved part A**2**, which is near the second boundary portion, may have a relatively high curvature according to the second curvature adjusting portion **600***b*. The second curvature adjusting portion **600***b* is configured to limit the curvature of the area B**2** to a predetermined value and reduce or prevent excessive folding of the area B**2** of the second curved part A**2** when the display device is folded.

Although certain exemplary embodiments and implementations have been described herein, other embodiments and modifications will be apparent from this description. Accordingly, the inventive concept is not limited to such embodiments, but rather to the broader scope of the presented claims and various obvious modifications and equivalent arrangements.

What is claimed is:

1. A display device comprising:

a bottom chassis comprising a first bottom portion and a second bottom portion;

a mold frame comprising a first frame portion and a second frame portion respectively disposed in the first and second bottom portions of the bottom chassis;

a hinge portion configured to couple the first and second frame portions of the mold frame to each other;

a flexible display panel disposed on the mold frame and the hinge portion;

a first curvature adjusting portion disposed between one side of the hinge portion and the flexible display panel, the first curvature adjusting portion coupled to the first frame portion; and

a second curvature adjusting portion disposed between the opposite side of the hinge portion and the flexible display panel, the second curvature adjusting portion coupled to the second frame portion,

wherein a center of the flexible display panel is not in contact with the first and the second curvature adjusting portions, and

wherein the center of the flexible display panel is disposed on a gap between the first curvature adjusting portion and the second curvature adjusting portion.

2. The display device of claim **1**, wherein each of the first and second curvature adjusting portions comprises:

a plurality of adjustment units; and

a plurality of connecting shafts configured to hinge couple the plurality of adjustment units to each other.

3. The display device of claim 2, wherein at least two of the plurality of adjustment units have different angular rotation ranges.

4. The display device of claim 3, wherein an adjustment unit of the plurality of adjustment units that is substantially closer to the hinge portion has a larger angular rotation range.

5. The display device of claim 2, wherein at least one of the plurality of adjustment units have a upper surface and a lower surface having different lengths from each other.

6. The display device of claim 2, wherein an adjustment unit of the plurality of adjustment units disposed furthest from the hinge portion comprises a surface that comprises a projection and groove comprising a hole through which the connecting shaft is inserted.

7. The display device of claim 2, wherein each adjustment unit of the plurality of adjustment units other than an adjustment unit of the plurality of adjustment units disposed furthest from the hinge portion comprise:

a surface comprising at least one first projection and at least one first groove having a first hole, alternately disposed, the connecting shaft is inserted through the first hole of the first groove; and

an opposite surface comprising at least one second projection and at least one second groove having a second hole, alternately disposed, the connecting shaft is inserted through the second hole of the second groove.

8. The display device of claim 7, wherein the second groove is disposed corresponding to the first projection and the second projection is disposed corresponding to the first groove.

9. The display device of claim 7, wherein the first and second grooves disposed closer from the hinge portion is smaller than the first and second grooves disposed further from the hinge portion.

10. The display device of claim 2, wherein each of the plurality of adjustment units comprises:

a reference adjustment unit;

at least one curved adjustment unit between any one of the first and second frame portions and an end portion of the reference adjustment unit; and

at least one straight adjustment unit hinge coupled to the opposite end portion of the reference adjustment unit.

11. The display device of claim 10, wherein the curved adjustment unit is configured to rotate in a range that does not intersect an imaginary reference surface extending from a surface of the reference adjustment unit; and

wherein the straight adjustment unit is configured to rotate in a range that intersects (or crosses) the imaginary reference surface.

12. The display device of claim 1, wherein the hinge portion comprises:

a shaft receiving portion and a hinge case comprising a first gear receiving portion and a second gear receiving portion disposed respectively on two sides of the shaft receiving portion;

a first hinge shaft and a second hinge shaft disposed in the shaft receiving portion;

a first gear and a second gear disposed in the first gear receiving portion, the first and second gears are interlocked with each other;

a third gear and a fourth gear disposed in the second gear receiving portion, the third and fourth gears are interlocked with each other;

a first gear cover covering a first opening formed in the first gear receiving portion, the first gear cover comprising through holes through which axes of the first and second gears are respectively disposed and exposed outwards;

a second gear cover covering a second opening formed in the second gear receiving portion, the second gear cover comprising through holes through which axes of the third and fourth gears are respectively disposed and exposed outwards;

a first coupling portion coupling the axis of the first gear to one side of the first frame portion;

a second coupling portion coupling the axis of the third gear to the opposite side of the first frame portion;

a third coupling portion coupling the axis of the second gear to one side of the second frame portion; and

a fourth coupling portion coupling the axis of the fourth gear to the opposite side of the second frame portion.

13. The display device of claim 12, wherein the hinge portion further comprises a washer disposed on at least one of positions between one side of the first gear cover and the first coupling portion, between the opposite side of the first gear cover and the third coupling portion, between one side of the second gear cover and the second coupling portion, and between the opposite side of the second gear cover and the fourth coupling portion.

14. The display device of claim 12, wherein the first gear receiving portion comprises through holes into which the axes of the first and second gears are inserted; and

wherein the second gear receiving portion comprises through holes into which the axes of the third and fourth gears are inserted.

15. The display device of claim 12, wherein the shaft receiving portion comprises:

first fixing grooves into which two ends of the first hinge shaft are respectively inserted;

second fixing grooves into which two ends of the second hinge shaft are respectively inserted;

at least one first support groove configured to support a central portion of the first hinge shaft; and

at least one second support groove configured to support a central portion of the second hinge shaft.

16. The display device of claim 12, further comprising:

a first support portion coupled to the hinge portion, the first support portion configured to support the first curvature adjusting portion; and

a second support portion coupled to the hinge portion, the second support portion configured to support the second curvature adjusting portion,

wherein the first support portion is coupled to the first hinge shaft and the second support portion is coupled to the second hinge shaft.

17. The display device of claim 16, wherein the first support portion comprises:

at least one rotation unit rotatably coupled to a first hinge axis;

at least one first support plate protruding from the rotation unit towards one side of the first curvature adjusting portion; and

at least one second support plate protruding from the rotation unit towards another side of the first curvature adjusting portion.

18. The display device of claim 17, further comprising at least one hinge spring coupled to the first hinge axis, one end of the hinge spring disposed on the first support plate and the other end of the hinge spring disposed on the shaft receiving portion.

19. The display device of claim 16, wherein the second support portion comprises:

at least one rotation unit rotatably coupled to a second hinge axis;

at least one first support plate protruding from the rotation unit towards one side of the second curvature adjusting portion; and

at least one second support plate protruding from the rotation unit towards another side of the second curvature adjusting portion.

20. The display device of claim **19**, further comprising at least one hinge spring coupled to the second hinge axis, one end of the hinge spring disposed on the first support plate and an other end of the hinge spring disposed on the shaft receiving portion.

21. The display device of claim **1**, wherein the first curvature adjusting portion has limited angular rotation range and is configured to limit a curvature of a first boundary portion of the flexible display panel, the first boundary portion of the flexible display panel overlapping a boundary between the first frame portion and the first curvature adjusting portion, and

wherein the second curvature adjusting portion has limited angular rotation range and is configured to limit a curvature of a second boundary portion of the flexible display panel, the second boundary portion of the flexible display panel overlapping a boundary between the second frame portion and the second curvature adjusting portion.

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