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Bendable display device

Abstract

A bendable display device includes a display module; and a bending system on a rear surface of the display module and configured to change the display module between a flat mode and a bended mode, wherein the bending system includes a fixed plate, a rotating plate, and first and second horizontal bars, wherein the rotating plate has a pinion portion, and wherein the first and second horizontal bars have first and second rack portions engaged with the pinion portion at one ends thereof, respectively.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

(1) The present application claims the priority of Korean Patent Application No. 10-2022-0085524 filed on Jul. 12, 2022, which is hereby incorporated by reference in its entirety.

BACKGROUND

Technical Field

(2) The present disclosure relates to a display device, and more particularly, to a bendable display device capable of switching between a flat mode and a bended mode.

Description of the Related Art

(3) An electroluminescent display device is one of flat panel display devices. It has a wide viewing angle as compared with a liquid crystal display device because it is self-luminous. It is also thin, light weight, and low in power consumption because a backlight unit is not necessary. In addition, an electroluminescent display device may be driven by low voltages of direct current (DC) and has a fast response time. An electroluminescent display device is also resistant to external impacts and may be used in a wide range of temperatures because its components are solids. An electroluminescent display device may also be manufactured at low cost.

(4) Recently, a bendable display device, which can be freely bended and unfolded by forming components of the electroluminescent display device on a flexible substrate, has been highly

demanded.
(5) The bendable display device can switch between a flat mode and a bended or curved mode according to the user's needs. Here, depending on the switching method, the bendable display device can be divided into a grip method in which force is applied by directly holding a display module with a hand and a non-grip method in which force is applied using a lever or the like.
BRIEF SUMMARY
(6) Accordingly, embodiments of the present disclosure are directed to a bendable display device that substantially obviates one or more of the problems due to the limitations and disadvantages of the related art.
(7) The inventors have realized that the gripping and non-gripping bendable display devices have different structures. Further this is inconvenient because the user can change the mode of the bendable display device by only one technique.
(8) In addition, the gripping bendable display device has problems that there is a high possibility of damage to a display panel, a uniform curvature implementation is lowered, and a flat surface implementation is reduced. On the other hand, the non-gripping bendable display device has problems that convenience for a curvature implementation is reduced and a display module shakes when switching to a flat mode. The inventors provide herein solutions to these problems they have identified.
(9) More specifically, an object of the present disclosure is to provide a bendable display device capable of selectively applying a grip method and a non-grip method.
(10) The features and aspects of the present disclosure are not limited to those described above. Additional features and advantages of the disclosure will be set forth in the description which follows, and in part will be apparent to those skilled in the art from the description or may be learned by practice of the disclosure. These and other advantages of the disclosure may be realized and attained by the structure particularly pointed out in, or derivable from, the written description, claims hereof, and the appended drawings.
(11) To achieve these and other advantages of the present disclosure and in accordance with the purpose of the disclosure, as embodied and broadly described herein, a bendable display device includes a display module; and a bending system on a rear surface of the display module and configured to change the display module between a flat mode and a bended mode, wherein the bending system includes a fixed plate, a rotating plate, and first and second horizontal bars, wherein the rotating plate has a pinion portion, and wherein the first and second horizontal bars have first and second rack portions engaged with the pinion portion at one ends thereof, respectively.
(12) It is to be understood that both the foregoing general description and the following detailed description are explanatory and by way of examples and are intended to provide further explanation of the disclosure as claimed without limiting its scope.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS
(1) The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description serve to explain the principles of the disclosure. In the drawings:
(2) FIG. **1** is a view schematically illustrating a bendable display device in a flat mode according to an example embodiment of the present disclosure from the front side;
(3) FIG. **2** is a view schematically illustrating a bendable display device in a bended mode according to an example embodiment of the present disclosure from the front side;

(4) FIG. **3** is a view schematically illustrating a bendable display device according to an example embodiment of the present disclosure from the rear side;
(5) FIG. **4** is an exploded perspective view schematically illustrating a bendable display device according to an example embodiment of the present disclosure from the rear side;
(6) FIG. **5** is a schematic cross-sectional view of a display panel of a bendable display device according to an example embodiment of the present disclosure;
(7) FIG. **6** is a view schematically illustrating a bending system of a bendable display device according to an example embodiment of the present disclosure;
(8) FIG. **7** is a schematically enlarged view of the area A**1** of FIG. **6**;
(9) FIG. **8** is a schematic cross-sectional view taken along the line I-I′ of FIG. **7**;
(10) FIG. **9** is an exploded perspective view schematically illustrating a part of a bending system of a bendable display device according to an example embodiment of the present disclosure from the front side;
(11) FIG. **10** is an exploded perspective view schematically illustrating a part of a bending system of a bendable display device according to an example embodiment of the present disclosure from the rear side;
(12) FIG. **11** is a view schematically illustrating a bendable display device in a flat mode according to an example embodiment of the present disclosure;
(13) FIG. **12** is a schematic cross-sectional view taken along the line II-IP of FIG. **11**;
(14) FIG. **13** is a view schematically illustrating a bendable display device in a bended mode according to an example embodiment of the present disclosure;
(15) FIG. **14** is a schematic cross-sectional view taken along the line III-III′ of FIG. **13**;
(16) FIG. **15** is a graph schematically showing amplitude due to shaking of a display module of a bendable display device according to an example embodiment of the present disclosure in a flat mode and a bended mode;
(17) FIG. **16** is a graph schematically showing torque applied to a display module of a bendable display device according to an example embodiment of the present disclosure in a flat mode and a bended mode;
(18) FIGS. **17**A and **17**B are views schematically illustrating the mode switching of a bendable display device according to an example embodiment of the present disclosure using a grip method; and
(19) FIGS. **18**A and **18**B are views schematically illustrating the mode switching of a bendable display device according to an example embodiment of the present disclosure using a non-grip method.

DETAILED DESCRIPTION

(20) Advantages and features of the present disclosure and methods for achieving them will be made clear from embodiments described in detail below with reference to the accompanying drawings. The present disclosure can, however, be implemented in many different forms and should not be construed as being limited to the embodiments set forth herein, and the embodiments are provided such that this disclosure will be thorough and complete and will fully convey the scope of the present disclosure to those skilled in the art to which the present disclosure pertains.
(21) Shapes, sizes, ratios, angles, numbers, and the like disclosed in the drawings for describing the embodiments of the present disclosure are illustrative, and thus the present disclosure is not limited to the illustrated matters. The same reference numerals refer to the same components throughout this disclosure. Further, in the following description of the present disclosure, when a detailed description of a known related art is determined to unnecessarily obscure the gist of the present disclosure, the detailed description thereof will be omitted herein. When terms such as “including,” “having,” “consisting of,” and the like mentioned in this disclosure are used, other parts can be added unless the term “only” is used herein. When a component is expressed as being singular, being plural is included unless otherwise specified.

(22) In analyzing a component, an error range is interpreted as being included even when there is no explicit description.
(23) In describing a positional relationship, for example, when a positional relationship of two parts is described as being "on," "above," "below," "next to," or the like, unless "immediately" or "directly" is not used, one or more other parts can be located between the two parts.
(24) In describing a temporal relationship, for example, when a temporal predecessor relationship is described as being "after," "subsequent," "next to," "prior to," or the like, unless "immediately" or "directly" is not used, cases that are not continuous can also be included.
(25) Although the terms first, second, and the like are used to describe various components, these components are not substantially limited by these terms. These terms are used only to distinguish one component from another component. Therefore, a first component described below can substantially be a second component within the technical spirit of the present disclosure.
(26) Features of various embodiments of the present disclosure can be partially or entirely united or combined with each other, technically various interlocking and driving are possible, and each of the embodiments can be independently implemented with respect to each other or implemented together in a related relationship.
(27) Reference will now be made in detail to embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings.
(28) FIG. **1** is a view schematically illustrating a bendable display device in a flat mode according to an example embodiment of the present disclosure from the front side. FIG. **2** is a view schematically illustrating the bendable display device in a bended mode according to an example embodiment of the present disclosure from the front side.
(29) In FIG. **1** and FIG. **2**, the bendable display device **1000** according to an example embodiment of the present disclosure may be used in a flat mode or a bended mode depending on the user's purpose or convenience.
(30) Specifically, as shown in FIG. **1**, the bendable display device **1000** can be used in the flat mode while playing a game, watching a movie, or in an office area. Then, to enhance a sense of reality and immersion, as shown in FIG. **2**, the bendable display device **1000** can be switched and used in the bended mode. In this case, for example, the bendable display device **1000** in the bended mode can have the highest sense of reality and immersion at a curvature of up to 800R (an arc with a radius of 800 mm).
(31) The bendable display device **1000** according to an example embodiment of the present disclosure may include a bending system for switching between the flat mode and the bended mode. The bendable display device **1000** according to an example embodiment of the present disclosure having a bending system will be described with reference to FIGS. **3** to **5**.
(32) FIG. **3** is a view schematically illustrating a bendable display device according to an example embodiment of the present disclosure from the rear side, and FIG. **4** is an exploded perspective view schematically illustrating the bendable display device according to an example embodiment of the present disclosure from the rear side. FIGS. **3** and **4** show the bendable display device in the flat mode. In addition, FIG. **5** is a schematic cross-sectional view of a display panel of the bendable display device according to an example embodiment of the present disclosure and shows one pixel region.
(33) In FIG. **3** and FIG. **4**, the bendable display device **1000** according to an example embodiment of the present disclosure may include a display module **100**, a bending system **200**, and a holding system **300**.
(34) The display module **100** may include a display panel **110** displaying an image. In addition, although not shown in the figures, the display module **100** may further include a cover unit supporting and protecting the display panel **110**. For example, the cover unit may include a middle cabinet and a back cover.
(35) The display panel **110** may be an electroluminescent display device including a light-emitting

diode and a thin film transistor.
(36) Specifically, referring to FIG. **5**, a shield pattern **121** of a conductive material, such as metal, may be formed on a substrate **111**. The substrate **111** may be formed of a material having flexibility and may be a glass substrate or a plastic substrate. For example, polyimide may be used as the plastic substrate, but the embodiments of the present disclosure are not limited thereto.
(37) The shield pattern **121** may be formed of at least one of aluminum (Al), copper (Cu), molybdenum (Mo), titanium (Ti), chromium (Cr), nickel (Ni), tungsten (W), and an alloy thereof and may have a single-layer or multiple-layer structure. For example, the shield pattern **121** may have a double-layer structure including a lower layer of molybdenum titanium (MoTi) and an upper layer of copper (Cu), and the upper layer may have a larger thickness than the lower layer.
(38) A buffer layer **112** of an insulating material may be formed on the shield pattern **121**. The buffer layer **112** may be disposed substantially on an entire surface of the substrate **111**. The buffer layer **112** may be formed of an inorganic material, such as silicon oxide (SiO.sub.2) or silicon nitride (SiN.sub.x), and may include a single layer or multiple layers.
(39) A semiconductor layer **122** may be formed on the buffer layer **112** and be patterned. The semiconductor layer **122** may be disposed to overlap the shield pattern **121**. The semiconductor layer **122** may be formed of an oxide semiconductor material. In this case, the shield pattern **121** may block light incident on the semiconductor layer **122** and may help prevent the semiconductor layer **122** from deteriorating due to such incident light.
(40) Alternatively, the semiconductor layer **122** may be formed of polycrystalline silicon, and both ends of the semiconductor layer **122** may be doped with impurities. In this case, the shield pattern **121** may be omitted.
(41) A gate insulation layer **113** of an insulating material may formed on the semiconductor layer **122** substantially over the entire surface of the substrate **111**. The gate insulation layer **113** may be formed of an inorganic insulating material, such as silicon oxide (SiO.sub.2) or silicon nitride (SiN.sub.x). If the semiconductor layer **122** is made of an oxide semiconductor material, the gate insulation layer **113** may be formed of silicon oxide (SiO.sub.2) Alternatively, if the semiconductor layer **122** is made of polycrystalline silicon, the gate insulation layer **113** may be formed of silicon oxide (SiO.sub.2) or silicon nitride (SiN.sub.x).
(42) A gate electrode **123** of a conductive material, such as metal, may be formed on the gate insulation layer **113** corresponding to the center of the semiconductor layer **122**. The gate electrode **123** may be formed of at least one of aluminum (Al), copper (Cu), molybdenum (Mo), titanium (Ti), chromium (Cr), nickel (Ni), tungsten (W), and an alloy thereof and may have a single-layer or multiple-layer structure. For example, the gate electrode **123** may have a double-layer structure including a lower layer of molybdenum titanium (MoTi) and an upper layer of copper (Cu), and the upper layer may have a larger thickness than the lower layer.
(43) In addition, although not shown in the figure, a gate line may be further formed on the gate insulation layer **113** through the same process as the gate electrode **123**. The gate line may extend in a first direction and may be connected to the gate electrode **123**.
(44) In an example embodiment of the present disclosure, the gate insulation layer **113** may be formed substantially over the entire surface of the substrate **111**. However, alternatively, the gate insulation layer **113** may be patterned to have the same shape as the gate electrode **123**.
(45) An interlayer insulation layer **114** made of an insulating material may be formed on the gate electrode **123** substantially over the entire surface of the substrate **111**. The interlayer insulation layer **114** may be formed of an inorganic insulating material, such as silicon oxide (SiO.sub.2) or silicon nitride (SiN.sub.x). Alternatively, the interlayer insulation layer **114** may be formed of an organic insulating material, such as photo acryl or benzocyclobutene.
(46) The interlayer insulation layer **114** may have first and second contact holes **113***a* and **113***b* respectively exposing a top surface of the semiconductor layer **122** near both ends. The first and second contact holes **113***a* and **113***b* may be disposed respectively at both sides of the gate

electrode **123** and may be spaced apart from the gate electrode **123**. The first and second contact holes **113***a* and **113***b* may also be formed in the gate insulation layer **113**. Alternatively, if the gate insulation layer **113** is patterned to have the same shape as the gate electrode **123**, the first and second contact holes **113***a* and **113***b* may be formed only in the interlayer insulation layer **114**.

(47) Source and drain electrodes **124** and **125** of a conductive material, such as metal, may be formed on the interlayer insulation layer **114**. The source and drain electrodes **124** and **125** may be formed of at least one of aluminum (Al), copper (Cu), molybdenum (Mo), titanium (Ti), chromium (Cr), nickel (Ni), tungsten (W), and an alloy thereof and may have a single-layer or multiple-layer structure. For example, the source and drain electrodes **124** and **125** may have a double-layer structure including a lower layer of molybdenum titanium (MoTi) and an upper layer of copper (Cu), and the upper layer may have a larger thickness than the lower layer. Alternatively, the source and drain electrodes **124** and **125** may have a triple-layer structure.

(48) In addition, although not shown in the figure, a data line and a power supply line may be further formed on the interlayer insulation layer **114** and may be formed through the same process as the source and drain electrodes **124** and **125**.

(49) The source and drain electrodes **124** and **125** may be spaced apart from each other with the gate electrode **123** positioned therebetween and may be in contact with both ends of the semiconductor layer **122** through the first and second contact holes **113***a* and **113***b*, respectively.

(50) Although not shown in the figure, the data line may extend in a second direction and cross the gate line, thereby defining a pixel region. The power supply line for supplying a high potential voltage may be spaced apart from the data line.

(51) The semiconductor layer **122**, the gate electrode **123**, and the source and drain electrodes **124** and **125** may form a thin film transistor T. The thin film transistor T may have a coplanar structure in which the gate electrode **123** and the source and drain electrodes **124** and **125** are located at the same side with respect to the semiconductor layer **122**.

(52) Alternatively, the thin film transistor T may have an inverted staggered structure in which the gate electrode and the source and drain electrodes are located at different sides with respect to the semiconductor layer. That is, the gate electrode may be disposed under the semiconductor layer, and the source and drain electrodes may be disposed over the semiconductor layer. The semiconductor layer may be formed of oxide semiconductor or amorphous silicon.

(53) Meanwhile, one or more thin film transistors having substantially the same structure as the thin film transistor T can be further formed on the substrate **111**.

(54) A passivation layer **115** of an insulating material may be formed on the source and drain electrodes **124** and **125** substantially over the entire surface of the substrate **111**. The passivation layer **115** may be formed of an inorganic insulating material, such as silicon oxide (SiO_2) or silicon nitride (SiN_x).

(55) A planarization layer **116** of an insulating material may be formed on the passivation layer **115** substantially over the entire surface of the substrate **111**. The planarization layer **116** may be formed of an organic insulating material, such as photo acryl or benzocyclobutene. The planarization layer **116** may have a flat top surface.

(56) The planarization layer **116** and the passivation layer **115** may have a drain contact hole **116***a* exposing the drain electrode **125**. The drain contact hole **116***a* may be spaced apart from the second contact hole **113***b*. Alternatively, the drain contact hole **116***a* may be disposed right over the second contact hole **113***b*.

(57) A first electrode **132** may formed on the planarization layer **116** and may be formed of a conductive material having relatively high work function. The first electrode **132** may be disposed in the pixel region and be in contact with the drain electrode **125** through the drain contact hole **116***a*. For example, the first electrode **132** may be formed of a transparent conductive material, such as indium tin oxide (ITO) or indium zinc oxide (IZO), but is not limited thereto.

(58) The electroluminescent display panel according to an example embodiment of the present

disclosure may be a top emission type in which a light-emitting diode is configured to output light toward a direction away from the substrate **111**. Accordingly, the first electrode **132** may further include a reflective electrode or a reflective layer, formed of a metal material having a relatively high reflectance, below the transparent conductive material. For example, the reflective electrode or reflective layer may be formed of an aluminum-palladium-copper (APC) alloy, silver (Ag), or aluminum (Al). The first electrode **132** may have a triple-layer structure of ITO/APC/ITO, ITO/Ag/ITO or ITO/Al/ITO, but is not limited thereto.

(59) A bank **117** of an insulating material may be formed on the first electrode **132**. The bank **117** may overlap and cover lateral edges of the first electrode **132** and may expose a central portion of the first electrode **132**.

(60) At least a top surface of the bank **117** may be hydrophobic, and a side surface of the bank **117** may be hydrophobic or hydrophilic. The bank **117** may be formed of an organic insulating material having a hydrophobic property. Alternatively, the bank **117** may be formed of an organic insulating material having a hydrophilic property and may be subjected to a hydrophobic treatment.

(61) In an example embodiment of the present disclosure, the bank **117** may have a single structure including a single bank. However, the bank **117** may have a dual structure. That is, the bank **117** may have a dual structure including a hydrophilic bank of a lower portion and a hydrophobic bank of an upper portion.

(62) Next, a light-emitting layer **134** may be formed on the first electrode **132** exposed through the bank **117**.

(63) Although not shown in the figure, the light-emitting layer **134** may include a first charge auxiliary layer, a light-emitting material layer, and a second charge auxiliary layer sequentially disposed over the first electrode **132**. The light-emitting material layer may be formed of any one of red, green, and blue luminescent materials, but is not limited thereto. The luminescent material may be an organic luminescent material, such as a phosphorescent compound or a fluorescent compound, or may be an inorganic luminescent material, such as a quantum dot.

(64) The first charge auxiliary layer may be a hole auxiliary layer, and the hole auxiliary layer may include at least one of a hole injecting layer (HIL) and a hole transporting layer (HTL). In addition, the second charge auxiliary layer may be an electron auxiliary layer, and the electron auxiliary layer may include at least one of an electron injecting layer (EIL) and an electron transporting layer (ETL). However, the present disclosure is not limited thereto.

(65) The light-emitting layer **134** may be formed through a solution process or an evaporation process. If the light-emitting layer **134** is formed through the solution process, a height of the light-emitting layer **134** in the region adjacent to the bank **117** may rise higher closer to the bank **117**.

(66) A second electrode **136** of a conductive material having relatively low work function may be formed on the light-emitting layer **134** substantially over the entire surface of the substrate **111**. The second electrode **136** may be formed of aluminum (Al), magnesium (Mg), silver (Ag), or an alloy thereof. The second electrode **136** may have a relatively small thickness such that light from the light-emitting layer **134** may be transmitted therethrough. Alternatively, the second electrode **136** may be formed of a transparent conductive material, such as indium-gallium-oxide (IGO), but is not limited thereto.

(67) The first electrode **132**, the light-emitting layer **134**, and the second electrode **136** may constitute a light-emitting diode De. The first electrode **132** may serve as an anode, and the second electrode **136** may serve as a cathode, but the present disclosure is not limited thereto.

(68) As described above, the electroluminescent display panel according to an example embodiment of the present disclosure may be a top emission type display panel in which light from the light-emitting layer **134** of the light-emitting diode De is output toward a direction away from the substrate **111**, that is, output to the outside through the second electrode **136**. The top emission type display panel may have a wider emission area than a bottom emission type display panel of the same size, to thereby improve luminance and reduce power consumption.

(69) In addition, although not shown in the figure, an encapsulation layer may be formed on the second electrode **136** substantially over the entire surface of the substrate **111** to block moisture or oxygen introduced from the outside, thereby protecting the light-emitting diode De.
(70) Referring to FIG. **3** and FIG. **4** again, a plurality of first bending guide pins **162** and a plurality of second bending guide pins **164** may be provided on a rear surface of the display module **100**. Specifically, the first and second bending guide pins **162** and **164** may be disposed on a central portion of the display module **100** along a vertical direction, that is, a Z direction and may be spaced apart from each other along a horizontal direction, that is, an X direction. The first bending guide pins **162** may be disposed on the left side with respect to the center of the display module **100** along the X direction in the context of the figure, and the second bending guide pins **164** disposed on the right side. In each of the first and second bending guide pins **162** and **164**, a pair of bending guide pins **162** or **164** spaced apart along the Z direction may be spaced apart from another pair at regular intervals along the X direction. Although it is illustrated that four first and second bending guide pins **162** and **164** are provided, respectively, but the present disclosure is not limited thereto. The number and arrangement of the first and second bending guide pins **162** and **164** may vary.
(71) The first and second bending guide pins **162** and **164** may be engaged with first and second bending guide slots **232***b* and **234***b* of first and second horizontal bars **232** and **234**, respectively, and may move horizontally along the X direction within the first and second bending guide slots **232***b* and **234***b*, respectively.
(72) Next, the bending system **200** may be provided on the rear surface of the display module **100**. The display module **100** may switch between the flat mode and the bended mode by operation of the bending system **200**. In the bended mode, the display module **100** has the curvature along the X direction.
(73) The bending system **200** may include a fixed plate **210**, a rotating plate **220**, and the first and second horizontal bars **232** and **234** sequentially disposed along a Y direction from the rear surface of the display module **100**. In addition, the bending system **200** may further include first and second vertical bars **242** and **244** between the display module **100** and the first and second horizontal bars **232** and **234** and further include a tension member **250**, a compression member **260**, and a locking member **270** between the fixed plate **210** and the rotation plate **220**.
(74) The fixed plate **210**, which is a bracket that connects the display module **100** and the holding system **300**, may have a front surface fixed to the display module **100** and may include at least one nut socket **212** and at least one fixed protrusion **214** on its rear surface. In addition, the fixed plate **210** may further include at least one fixed hole **216**.
(75) The nut socket **212** may be combined with a nut hole **332** of a holder portion **330** of the holding system **300** by a screw. The fixed protrusion **214** may be connected to one end of the tension member **250**. The fixed hole **216** may correspond to the compression member **260** and the locking member **270**.
(76) The rotating plate **220** may be disposed on the rear surface of the fixed plate **210**. The rotating plate **220**, which is a housing, may rotate with respect to the fixed plate **210**. A pinion portion **222** may be provided on a rear surface of the rotating plate **220**.
(77) Meanwhile, a lever **280** may be connected to one side of the rotating plate **220**. The lever **280** may rotate together with the rotating plate **220**.
(78) The first and second horizontal bars **232** and **234** may be disposed on the rear surface of the rotating plate **220**. The first and second horizontal bars **232** and **234**, which are curvature making bars, may extend along the X direction and cross a center of the rear surface of the display module **100** in the Z direction. The first and second horizontal bars **232** and **234** may be disposed on left and right sides of the center of the rear surface of the display module **100** in the X direction, respectively.
(79) The first and second horizontal bars **232** and **234** may have first and second rack portions **232***a*

and **234***a* at respective ends facing each other. The first and second rack portions **232***a* and **234***a* may be engaged with the pinion portion **222** to change a rectilinear motion into a rotational motion or a rotational motion into a rectilinear motion.
(80) In addition, the first and second horizontal bars **232** and **234** may have a plurality of first and second bending guide slots **232***b* and **234***b*, respectively. Each of the first and second bending guide slots **232***b* and **234***b* may extend in the X direction. The first and second bending guide slots **232***b* and **234***b* may correspond to the first and second bending guide pins **162** and **164** of the display module **100**, respectively.
(81) Next, the first and second vertical bars **242** and **244** may be rigid bars and extend in the Z direction. Inner sides of the first and second vertical bars **242** and **244** may be fixed to left and right edges of the display module **100**, respectively, and outer sides of the first and second vertical bars **242** and **244** may be fixed to other ends of the first and second horizontal bars **232** and **234**, respectively. The first and second vertical bars **242** and **244** may be used to implement the curvature of upper and lower ends of the display module **100**.
(82) Next, the tension member **250**, the compression member **260**, and the locking member **270** may be provided substantially between the fixed plate **210** and the rotating plate **220**.
(83) The tension member **250** may be fixed to the fixed plate **210** and the rotating plate **220**, and the tension of the tension member **250** may change due to the rotational motion of the rotating plate **220**.
(84) The compression member **260** and the locking member **270** may be disposed in a rotating depression provided on a front surface of the rotating plate **220** and may correspond to the fixed hole **216** of the fixed plate **210**.
(85) Next, the holding system **300** may be provided on a rear surface of the bending system **200**. The holding system **300** may include a base portion **310**, a stand portion **320**, and the holder portion **330**.
(86) The base portion **310** is to support the components of the bendable display device **1000**. The base portion **310** may be separated into two parts having a certain angle therebetween in the context of the figure, but is not limited thereto. Alternatively, the base portion **310** may be formed in a polygonal, circular, or elliptical plate shape.
(87) The stand portion **320** may extend in the Z direction and may have a lower end fixed to the base portion **310** and an upper end fixed to the holder portion **330**. The stand portion **320** may be configured to adjust a height of the display module **100** by changing the position of the holder portion **330** along the Z direction.
(88) The holder portion **330** may have a substantially rectangular shape. The holder portion **330** may be fixed to an inner side of the stand portion **320**, which faces the display modules **100**, and may be combined with the fixed plate **210**. The holder portion **330** may have the nut hole **332** at each corner corresponding to the nut socket **212** of the fixed plate **210**. A screw may be united to the nut hole **332** of the holder portion **330** and the nut socket **212** of the fixed plate **210**, so that the holder portion **330** can be combined with the fixed plate **210**.
(89) The configuration of the bending system of the bendable display device according to an example embodiment of the present disclosure will be described in detail with reference to FIGS. **6** to **10**.
(90) FIG. **6** is a view schematically illustrating the bending system of the bendable display device according to an example embodiment of the present disclosure, FIG. **7** is an enlarged view of the area A**1** of FIG. **6**, and FIG. **8** is a cross-sectional view taken along the line I-I′ of FIG. **7**. In addition, FIG. **9** and FIG. **10** are views illustrating a part of the bending system of the bendable display device according to an example embodiment of the present disclosure. FIG. **9** is an exploded perspective view from the front side, and FIG. **10** is an exploded perspective view from the rear side. Here, FIGS. **6** to **10** show the bending system in the flat mode and will be described based on a direction viewed from the rear side.

(91) In FIGS. **6** to **10**, the bending system **200** according to an example embodiment of the present disclosure may include the fixed plate **210**, the rotating plate **220**, and the first and second horizontal bars **232** and **234**. In addition, the bending system **200** according to an example embodiment of the present disclosure may further include the tension member **250**, the compression member **260**, and the locking member **270**, and may further include the first and second vertical bars **242** and **244**.
(92) The fixed plate **210** may have a substantially rectangular shape, and four corners may be rounded. The fixed plate **210** may include the plurality of nut sockets **212** and one fixed protrusion **214** on the rear surface, which faces the rotating plate **220**. In addition, the fixed plate **210** may further include the plurality of fixed holes **216**.
(93) The plurality of nut sockets **212** may extend and protrude toward the Y direction from the rear surface of the fixed plate **210**. One nut socket **212** may be provided to correspond to each corner of the fixed plate **210**. The nut sockets **212** may have a screw thread on an inner surface for fastening with the screw.
(94) The fixed protrusion **214** may extend and protrude in the Y direction from the rear surface of the fixed plate **210** and may have a lower height than the nut sockets **212**. The fixed protrusion **214** may be provided on the left side of the rear surface of the fixed plate **210** in the context of the figure and may be disposed substantially between the nut sockets **212** respectively corresponding to the upper and lower left corners of the fixed plate **210**. However, the present disclosure is not limited thereto, and the fixed protrusion **214** may vary.
(95) The plurality of fixed holes **216** may be disposed in the center of the fixed plate **210** substantially along the X direction and may be arranged in a downward convex circular arc shape. Here, a size of the plurality of fixed holes **216** may increase as the distance from the fixed protrusion **214** increase. Accordingly, the size of the plurality of fixed holes **216** may increase from left to right, that is, in a counterclockwise direction in the context of the figure. In other words, the diameter of the plurality of fixed holes **216** may increase in the counterclockwise direction. The plurality of fixed holes **216** may vary the intensity of the force required for the mode switching, thereby improving user convenience.
(96) However, the present disclosure is not limited thereto, and the plurality of fixed holes **216** may have the same size, that is, the same diameter.
(97) The rotating plate **220** on the rear surface of the fixed plate **210** may have a substantially circle shape and may rotate on the XZ plane with respect to the fixed plate **210**. The rotating plate **220** may have the pinion portion **222** on the rear surface, which is a surface facing the first and second horizontal bars **232** and **234** and have a rotating protrusion **224** and a rotating depression **226** on the front surface, which is a surface facing the fixed plate **210**. In addition, the rotating plate **220** may have a rotating hole **228** at the center.
(98) The rotating plate **220** may include a first plate portion **220***a* and a second plate portion **220***b*. The second plate portion **220***b* may be disposed on a front surface of the first plate portion **220***a*, and the pinion portion **222** may be disposed on a rear surface of the first plate portion **220***a*. The first plate portion **220***a* may have a larger size than the second plate portion **220***b*, so that edges of the front surface of the first plate portion **220***a* may be exposed.
(99) Further, the first plate portion **220***a* may have an extension part **220***c* at one side. The extension part **220***c* may extend from the first plate portion **220***a* on the XZ plane.
(100) The rotating protrusion **224** may be disposed on a front surface of the extension part **220***c*. The rotating protrusion **224** may be spaced apart from the second plate portion **220***b* and may extend and protrude toward a −Y direction from the front surface of the extension part **220***c*.
(101) Meanwhile, the lever **280** may be connected to the extension part **220***c* of the first plate portion **220***a*. However, the present disclosure is not limited thereto, and the position of the lever **280** may vary. The lever **280** may be a component for applying force and may rotate together with the rotating plate **220**.

(102) The rotating depression **226** may be provided in the second plate portion **220***b*. The rotating depression **226** may extend into the first plate portion **220***a*. The rotating depression **226** may be disposed between the rotating protrusion **224** and the rotating hole **228**. However, the present disclosure is not limited thereto, and the position of the rotating depression **226** may vary.
(103) The rotating hole **228** may be provided in the first and second plate portions **220***a* and **220***b* and the pinion portion **222**. In this case, the size of the rotating hole **228** may decrease from the second plate portion **220***b* to the pinion portion **222**. Accordingly, the diameter of the rotating hole **228** in the second plate portion **220***b* may be larger than the diameter of the rotating hole **228** in the pinion portion **222**. However, the present disclosure is not limited thereto. Although not shown, a shaft, which serves as a rotation axis of the rotational motion of the rotating plate **220**, may be provided in the rotating hole **228**.
(104) The first and second horizontal bars **232** and **234** on the rear surface of the rotating plate **220** may extend along the X direction and may be disposed substantially on left and right sides of the pinion portion **222**, respectively. The first and second horizontal bars **232** and **234** may have the first and second rack portions **232***a* and **234***a* at the respective ends facing each other. The first and second rack portions **232***a* and **234***a* may extend substantially along the X direction and be spaced apart from each other along the Z direction. Each of the first and second rack portions **232***a* and **234***a* may have a plurality of teeth to be engaged with the pinion portion **222**, and the pinion portion **222** may be disposed between the first and second rack portions **232***a* and **234***a* along the Z direction. In this case, the plurality of teeth may be provided in one side surfaces of the first and second rack portions **232***a* and **234***a* facing the pinion portion **222**, and other side surfaces of the first and second rack portions **232***a* and **234***a* may be flat.
(105) The pinion portion **222** and the first and second rack portions **232***a* and **234***a* may be engaged with each other to change a rectilinear motion into a rotational motion or a rotational motion into a rectilinear motion. Here, the pinion portion **222** may rotate in a clockwise direction or counterclockwise direction, and the first and second rack portions **232***a* and **234***a* may move linearly along the X direction.
(106) For example, when the pinion portion **222** rotates in the clockwise direction, each of the first and second rack portions **232***a* and **234***a* moves horizontally in a direction toward the pinion portion **222**. That is, the first rack portion **232***a* moves in the X direction, and the second rack portion **234***a* moves in a −X direction. On the other hand, when the pinion portion **222** rotates in the counterclockwise direction, each of the first and second rack portions **232***a* and **234***a* moves horizontally in a direction away from the pinion portion **222**. That is, the first rack portion **232***a* moves in the −X direction, and the second rack portion **234***a* moves in the X direction.
(107) Or, when each of the first and second rack portions **232***a* and **234***a* moves horizontally in the direction toward the pinion portion **222**, the pinion portion **222** rotates in the clockwise direction. On the other hand, when each of the first and second rack portions **232***a* and **234***a* moves horizontally in the direction away from the pinion portion **222**, the pinion portion **222** rotates in the counterclockwise direction.
(108) Accordingly, by applying a force to one of the pinion portion **222** and the first and second rack portions **232***a* and **234***a* to move it, the rest may be moved.
(109) In addition, the first and second horizontal bars **232** and **234** may further include first and second guide portions **232***c* and **234***c* at the respective ends facing each other. The first and second guide portions **232***c* and **234***c* may be spaced apart from the first and second rack portions **232***a* and **234***a* along the Z direction, respectively, and may have a substantially U-like shape together with the first and second rack portions **232***a* and **234***a*. Namely, each of the respective ends of the first and second horizontal bars **232** and **234** facing each other may have a U-like shape.
(110) Here, the first and second rack portions **232***a* and **234***a* may be disposed between the first and second guide portions **232***c* and **234***c*, and the pinion portion **222** may be disposed between the first and second rack portions **232***a* and **234***a*. Accordingly, the first rack portion **232***a* may be disposed

between the pinion portion **222** and the second guide portion **234***c*, and the second rack portion **234***a* may be disposed between the pinion portion **222** and the first guide portion **232***c*.
(111) The first and second guide portions **232***c* and **234***c* may guide movement of the first and second rack portions **232***a* and **234***a* in the X direction and prevent the first and second rack portions **232***a* and **234***a* from moving in the Z direction.
(112) Here, side surfaces of the first rack portion **232***a* and the second guide portion **234***c* facing each other may be substantially parallel to the X direction, and side surfaces of the second rack portion **234***a* and the first guide portion **232***c* facing each other may be substantially parallel to the X direction. The side surfaces of the first rack portion **232***a* and the second guide portion **234***c* and the side surfaces of the second rack portion **234***a* and the first guide portion **232***c* may be spaced apart from each other with a gap greater than 0 and equal to or less than 1 mm, preferably, greater than 0 and equal to or less than 0.1 mm, for precise control by minimizing component spacing. However, the present disclosure is not limited thereto. Alternatively, the side surfaces of the first rack portion **232***a* and the second guide portion **234***c* may be in contact with each other, and the side surfaces of the second rack portion **234***a* and the first guide portion **232***c* may be in contact with each other.
(113) Meanwhile, as stated above, the first and second horizontal bars **232** and **234** may have the plurality of first and second bending guide slots **232***b* and **234***b*, respectively.
(114) Next, the tension member **250** may be provided substantially between the fixed plate **210** and the rotating plate **220**. The tension member **250** may be combined with the rotating plate **220** and may have a first end fixed to the fixed plate **210** and a second end fixed to the rotating plate **220**. Specifically, the tension member **250** may surround a side surface of the second plate portion **220***b* of the rotating plate **220** and may have first and second loops **252** and **254** at the first and second ends, respectively. In this case, the first loop **252** may be fixed to the fixed protrusion **214** of the fixed plate **210**, and the second loop **254** may be fixed to the rotating protrusion **224** of the rotating plate **220**.
(115) In the figure, the tension member **250** may have no tension, and the distance between the first and second loops **252** and **254** may be the maximum. However, in the flat mode and the curve mode, the tension member **250** may have tension, and in this case, the distance between the first and second loops **252** and **254** may be smaller than shown.
(116) The tension member **250** may improve shaking of the display module **100** of FIG. **3** in the flat mode to secure rigidity. Specifically, in the display module **100** of FIG. **3** in the flat mode, internal stress may be removed, and shaking may occur. However, in the present disclosure, the tension member **250** may be provided, so that the tension of the tension member **250** in the flat mode can be maximized and the tension member **250** in the bended mode may have a specific level of tension. Here, the tension of the tension member **250** in the flat mode may be greater than the tension of the tension member **250** in the bended mode. Accordingly, by always applying stress to the display module **100** of FIG. **3**, vibration of the display module **100** of FIG. **3** can be prevented or minimized.
(117) In addition, when switching from the flat mode to the bended mode, the tension member **250** may reduce the linear tension and support the torque to facilitate the mode switching. For example, the tension member **250** may be a torsion spring. However, the present disclosure is not limited thereto.
(118) Alternatively, the tension member **250** can be applied as long as it has a configuration capable of applying tension. For example, the tension member **250** may be implemented by at least two compression springs. In this case, one ends of the compression springs may be fixed to the rotating plate **220**, and other ends of the compression springs may be fixed to the first and second horizontal bars **232** and **234**, respectively. The tension may be changed by the rotational motion of the rotating plate **220** and the rectilinear motion of the first and second horizontal bars **232** and **234**.
(119) Next, the compression member **260** and the locking member **270** may be provided

substantially between the fixed plate **210** and the rotating plate **220**. The compression member **260** and the locking member **270** may be disposed in the rotating depression **226**.

(120) The compression member **260** and the locking member **270** may correspond to the fixed holes **216** of the fixed plate **210**. Accordingly, the rotating depression **226** of the rotating plate **220** may correspond to the fixed holes **216** of the fixed plate **210**.

(121) In this case, the locking member **270** may be disposed between the compression member **260** and the fixed plate **210**, and part of the locking portion **270** may be disposed in one of the fixed holes **216**. The compression member **260** may apply a force to the locking member **270** toward the fixed plate **210**, so that the locking member **270** can maintain a stopped position in one fixed hole **216**. Accordingly, the locking member **270** may be seated in one fixed hole **216** until an additional force is applied, thereby stopping the mode switching and maintain the seated state.

(122) The compression member **260** may have a compression force that can withstand a reaction force at a curvature of up to 800R.

(123) Here, the size of the fixed holes **216** may be smaller than the size of the locking member **270**. Specifically, the diameter of the largest fixed hole **216** may be smaller than the diameter of the locking member **270**. The sizes of the fixed holes **216** and the locking member **270** may be configured to withstand a reaction force in the bended mode and may be configured to withstand the reaction force at a curvature of up to 800R.

(124) For example, the compression member **260** may be a compression spring. In addition, the locking member **270** may be a spherical object, that is, a ball. However, the present disclosure is not limited thereto.

(125) The fixed holes **216**, the rotating depression **226**, the compression member **260**, and the locking member **270** may constitute a stopper structure that can stop the mode switching of the display module **100** of FIG. **3** step by step, that is, change the curvature of the display module **100** of FIG. **3** step by step. In this case, the curvature of the display module **100** of FIG. **3** can be precisely controlled according to the number and interval of the fixed holes **216**.

(126) Implementation of the flat mode and the bended mode of the bendable display device by the bending system **200** will be described in detail with reference to FIGS. **11** to **14**.

(127) FIG. **11** is a view schematically illustrating a bendable display device in a flat mode according to an example embodiment of the present disclosure, FIG. **12** is a cross-sectional view taken along the line II-IP of FIG. **11**, FIG. **13** is a view schematically illustrating a bendable display device in a bended mode according to an example embodiment of the present disclosure, and FIG. **14** is a cross-sectional view taken along the line III-III′ of FIG. **13**.

(128) First, as shown in FIGS. **11** and **12**, in the flat mode, a distance between one ends of the first and second horizontal bars **232** and **234** facing each other may be minimized, and a distance between the first and second loops **252** and **254** of the tension member **250** may be short. In this case, the extension part **220***c* of the rotating plate **220** and the lever **280** may be disposed substantially on the left side of the rear surface of the display module **100**. Accordingly, the first and second horizontal bars **232** and **234** may be parallel to the XZ plane, and the display module **100** may also be parallel to the XZ plane to thereby be in a flat state.

(129) Next, by rotating the lever **280** and the rotating plate **220** in the counterclockwise direction, as shown in FIGS. **13** and **14**, the extension part **220***c* of the rotating plate **220** and the lever **280** may be disposed substantially on the right side of the rear surface of the display module **100**. Accordingly, the pinion portion **222** of the rotating plate **220** may also rotate in the counterclockwise direction, and each of the first and second rack portions **232***a* and **234***a* may move horizontally in a direction away from the pinion portion **222**. Therefore, the distance between the one ends of the first and second horizontal bars **232** and **234** facing each other may be maximized, and the distance between the first and second loops **252** and **254** of the tension member **250** may be increased.

(130) Here, since the other ends of the first and second horizontal bars **232** and **234** are fixed to left

and right edges of the display module **100**, respectively, the compression force may be applied to the left and right edges of the display module **100** by the stroke S induced by the movement of the first and second rack portions **232***a* and **234***a*, and the left and right edges of the display module **100** may be bent in the −Y direction, so that the display module **100** can be in the bended state.
(131) At this time, the locking member **270** of FIG. **8** is locked into one fixed hole **216** of FIG. **8** with a force capable of overcoming the reaction force, so that the display module **100** can maintain the bended state.
(132) On the other hand, when switching the bended mode of FIGS. **13** and **14** into the flat mode of FIGS. **11** and **12**, the components of the bendable display device according to an example embodiment of the present disclosure may move in an opposite direction to the above-mentioned direction.
(133) Here, it is described that the first and second horizontal bars **232** and **234** linearly move by the rotational movement of the pinion portion **222**, but the present disclosure is not limited thereto. Alternatively, the pinion portion **222** may be rotated by the linear movement of the first and second horizontal bars **232** and **234**.
(134) Meanwhile, as stated above, in the bendable display device according to an example embodiment of the present disclosure, by the tension member **250**, the shaking of the display module **100** in the flat mode can be prevented or minimized, and the mode switching can be facilitated. This will be described with reference to FIGS. **15** and **16**.
(135) FIG. **15** is a graph schematically showing amplitude due to shaking of a display module of a bendable display device according to an example embodiment of the present disclosure in a flat mode and a bended mode, and FIG. **16** is a graph schematically showing torque applied to a display module of a bendable display device according to an example embodiment of the present disclosure in a flat mode and a bended mode. A comparative example is shown together. Here, the solid line corresponds to the example embodiment, and the dashed line corresponds to the comparative example.
(136) As shown in FIG. **15**, in the example embodiment of the present disclosure, by maximizing the tension of the tension member **250** in the flat mode, stress may be always applied to the display module **100**, so that the shaking of the display module **100** can be minimized in the flat mode. Accordingly, compared to the comparative example, the amplitude due to the shaking can be significantly reduced.
(137) Additionally, in the example embodiment of the present disclosure, the tension member **250** may have a specific level of tension in the bended mode, and the linear tension may be decreased in the process of switching from the flat mode into the bended mode, thereby supporting the torque when changing the mode. Accordingly, as shown in FIG. **16**, compared to the comparative example, the torque required in the flat mode and the bended mode may be reduced, and it is possible to switch between the flat mode and the bended mode with a smaller force, so that it is easy to switch the mode.
(138) The bendable display device according to an example embodiment of the present disclosure can switch the modes using both the grip method and the non-grip method. These will be described in detail with reference to FIGS. **17**A and **17**B and FIGS. **18**A and **18**B.
(139) FIGS. **17**A and **17**B are views schematically illustrating the mode switching of a bendable display device according to an example embodiment of the present disclosure using a grip method. FIG. **17**A shows a bendable display device in a flat mode, and FIG. **17**B shows a bendable display device in a bended mode.
(140) As shown in FIG. **17**A, by holding the right upper end of the display module **100** in the flat mode with a hand and applying a force in a front direction which the front surface of the display module **100** faces, the second rack portion **234***a* of the second horizontal bar **234** may move horizontally toward the right edge of the display module **100**, and the pinion portion **222** may rotate in the counterclockwise direction due to the horizontal movement of the second rack portion **234***a*.

Accordingly, the first rack portion **232***a* of the first horizontal bar **232** may move horizontally toward the left edge of the display module **100**.
(141) Therefore, as shown in FIG. **17**B, the one ends of the first and second horizontal bars **232** and **234** facing each other may move away from the pinion portion **222**, and the display module **100** may be in the bended mode. In this case, by the rotation of the pinion portion **222**, the lever **280** connected to the rotating plate **220** may also be rotated in the counterclockwise direction, and the lever **280**, which is disposed on the left side of the rear surface of the display module **100** in the flat mode, may be disposed on the right side of the rear surface of the display module **100**.
(142) On the other hand, when switching from the bended mode to the flat mode, the force may be applied to the display module **100** of FIG. **17**B in the bended mode in a rear direction which the rear surface of the display module **100** faces, the display module **100** may be in the flat mode of FIG. **17**A. Each component of the bendable display device **1000** according to an example embodiment of the present disclosure may move in an opposite direction to the above-mentioned direction.
(143) In FIGS. **17**A and **17**B, the right upper end of the display module **100** may be held with a hand and the force may be applied. However, the present disclosure is not limited thereto. Alternatively, the left upper end of the display module **100** may be held with a hand and the force may be applied, the left and right upper ends of the display module **100** may be held with hands and the force may be applied, or the centers of the left and right edges of the display module **100** may be held with hands and the force may be applied.
(144) FIGS. **18**A and **18**B are views schematically illustrating the mode switching of a bendable display device according to an example embodiment of the present disclosure using a non-grip method. FIG. **18**A shows a bendable display device in a flat mode, and FIG. **18**B shows a bendable display device in a bended mode.
(145) As shown in FIG. **18**A, by holding the lever **280** disposed on the left side of the rear surface of the display module **100** in the flat mode with a hand and applying a force to the right, the lever **280** may be rotated in the counterclockwise direction. Accordingly, the rotating plate **220** connected to the lever **280** may rotate in the counterclockwise direction, and the pinion portion **222** of the rotating plate **220** may also rotate. In this case, the first and second rack portions **232***a* and **234***a* engaged with the pinion portion **222** may move horizontally toward the left and right edges of the display module **100**, respectively.
(146) Therefore, as shown in FIG. **18**B, the one ends of the first and second horizontal bars **232** and **234** facing each other may move away from the pinion portion **222**, and the display module **100** may be in the bended mode. In this case, the lever **280** may be disposed on the right side of the rear surface of the display module **100**.
(147) On the other hand, when switching from the bended mode to the flat mode, by holding the lever **280** of FIG. **18**B with a hand and applying a force to the left side, the lever **280** may be rotated in the clockwise direction. Accordingly, each component of the bendable display device **1000** according to an example embodiment of the present disclosure may move in an opposite direction to the above-mentioned direction, and the display module **100** may be in the flat mode of FIG. **18**A.
(148) As described above, in the bendable display device **1000** according to an example embodiment of the present disclosure, the bending system **200** including the first and second rack portions **232***a* and **234***a* and the pinion portion **222** may be provided, so that it is possible to selectively apply the grip method and the non-grip method when switching the modes.
(149) In the bendable display device according to the present disclosure, by applying a bending system including two rack portions and one pinion portion, the grip method and the non-grip method can be selectively applied when switching the modes of the display module, thereby increasing the convenience. Accordingly, problems in each of the grip method and the non-grip method can be improved.

(150) In addition, by applying a tension member, the shaking of the display module in the flat mode can be improved, and the mode switching can be facilitated.
(151) Further, by providing the stopper structure, it is possible to maintain the flat state and the bended state of the display module, and the curvature can be adjusted step by step.
(152) It will be apparent to those skilled in the art that various modifications and variations can be made in the display device of the present disclosure without departing from the technical idea or scope of the disclosure. Thus, it is intended that embodiments of the present disclosure cover the modifications and variations of the disclosure provided they come within the scope of the appended claims and their equivalents.
(153) The various embodiments described above can be combined to provide further embodiments. All of the U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet are incorporated herein by reference, in their entirety. Aspects of the embodiments can be modified, if necessary to employ concepts of the various patents, applications and publications to provide yet further embodiments.
(154) These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

Claims

1. A bendable display device, comprising: a display module; and a bending system on a rear surface of the display module and configured to change the display module between a flat mode and a bended mode, wherein the bending system includes a fixed plate, a rotating plate, and first and second horizontal bars, wherein the rotating plate has a pinion portion, and wherein the first and second horizontal bars have first and second rack portions engaged with the pinion portion at one ends thereof, respectively; wherein the bending system further includes a tension member connected to the fixed plate and the rotating plate, wherein a tension of the tension member in the flat mode is greater than a tension of the tension member in the bended mode; wherein the fixed plate includes a fixed protrusion connected to a first end of the tension member, and wherein the rotating plate includes a rotating protrusion connected to a second end of the tension member; and wherein a distance between the first and second ends of the tension member in the flat mode is shorter than a distance between the first and second ends of the tension member in the bended mode.
2. The bendable display device of claim 1, wherein the tension member is a torsion spring.
3. The bendable display device of claim 1, wherein the bending system further includes a compression member and a locking member, wherein the fixed plate includes at least one fixed hole, and the rotating plate has a rotating depression, and wherein the compression member and the locking member are disposed in the rotating depression, and part of the locking member is disposed in the at least one fixed hole.
4. The bendable display device of claim 3, wherein the fixed plate includes a plurality of fixed holes, and wherein sizes of the plurality of fixed holes are smaller than a size of the locking member.
5. The bendable display device of claim 3, wherein the compression member is a compression spring, and the locking member is a spherical object.
6. The bendable display device of claim 1, wherein the bending system further includes a lever connected to the rotating plate.
7. The bendable display device of claim 1, wherein the bending system further includes first and

second vertical bars, and wherein inner sides of the first and second vertical bars are fixed to left and right edges of the display module, respectively, and outer sides of the first and second vertical bars are fixed to other ends of the first and second horizontal bars, respectively.

8. The bendable display device of claim 1, wherein the first and second horizontal bars further include first and second guide portions at the one ends, respectively, and wherein the first rack portion is disposed between the pinion portion and the second guide portion, and the second rack portion is disposed between the pinion portion and the first guide portion.

9. The bendable display device of claim 8, wherein each of the one ends of the first and second horizontal bars has a U-like shape.

10. The bendable display device of claim 1, further comprising: a holding system provided on a rear surface of the bending system by being combined with the fixed plate, and configured to support the bendable display device and to adjust a height of the display module.

11. The bendable display device of claim 1, wherein the first and second horizontal bars are linearly moved in opposite directions by rotation of the pinion portion; and wherein the pinion portion is rotated by linear movement of the first and second horizontal bars in opposite directions.