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Display device

Abstract

Undulation on a front surface of a display panel is reduced. A display device includes a pulling member provided to back surface of a display panel, and pulling a second portion in a second state in which the display panel is unfolded.

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Background/Summary

TECHNICAL FIELD
(1) The disclosure relates to a display device.
BACKGROUND ART
(2) There are known foldable display devices. Patent Document 1 discloses a foldable display device including a flexible display. In folding the display device, the display panel is folded into a tear-drop shape.
(3) Note that when the display panel is folded into a tear-drop shape, a first portion of the display panel corresponding to the folding portion and the vicinity of the folding portion is bent so that a front surface of the display panel faces inwards, and a second portion of the display panel extending from the first portion is bent so that the front surface of the display panel faces backwards (that is, the back surface of the display faces inwards). Note that the front surface of the display panel corresponds to a display surface.
CITATION LIST
Patent Literature
(4) [Patent Document 1] United States Patent Application Publication No. 2015/0378397
SUMMARY
Technical Problem
(5) When the display panel is folded into a tear-drop shape, the second portion of the display panel might have a distortion swelling on the front surface of the display panel. As a result, the front surface of the display panel might suffer undulation.
Solution to Problem
(6) A display device according to an aspect of the disclosure includes: a display panel that is flexible and has a front surface and a back surface, the display panel having: a first portion bent so that the front surface faces inwards in a first state in which the display panel is folded; and a second portion positioned outside the first portion while the first portion is positioned in a center; and a pulling member provided to the back surface of the display panel, and pulling the second portion in a second state in which the display panel is unfolded.
Advantageous Effects of Disclosure
(7) An aspect of the disclosure can reduce undulation on a front face of a display panel.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a perspective view of a casing unit according to a first embodiment of the disclosure.
(2) FIG. **2** is an exploded perspective view of the casing unit according to the first embodiment of the disclosure.
(3) FIG. **3** is a plan view of the casing unit in FIG. **1** with no lifter.
(4) FIG. **4** illustrates a mechanism of how a surface of a display panel undulates in a foldable display device.
(5) FIG. **5** illustrates a plan view, and a cross-sectional view taken along line A-A, of the display device according to the first embodiment of the disclosure.
(6) FIG. **6** is an enlarged cross-sectional view mainly illustrating a pulling member and a magnet moving member of the display device according to the first embodiment of the disclosure.
(7) FIG. **7** illustrates cross-sectional views showing an operation mechanism of the pulling member and the magnet moving member in the first half of an operation for shifting the display device according to the first embodiment of the disclosure from a first state to a second state.

(8) FIG. **8** illustrates cross-sectional views showing an operation mechanism of the pulling member and the magnet moving member in the second half of the operation for shifting the display device according to the first embodiment of the disclosure from the first state to the second state.
(9) FIG. **9** is a cross-sectional view of a modification of the display device according to the first embodiment of the disclosure. FIG. **9** corresponds to FIG. **6**.
(10) FIG. **10** illustrates a plan view, a cross-sectional view taken along line B-B, and another cross-sectional view taken along line B-B, all of which show specific examples of the display panel and a ferromagnetic material.
(11) FIG. **11** is a plan view of a specific example of a ferromagnetic material having a living hinge.
(12) FIG. **12** illustrates cross-sectional views of a schematic configuration of a display device according to a second embodiment of the disclosure. FIG. **12** shows transition from a first state to a second state.

DESCRIPTION OF EMBODIMENTS

(13) Embodiments of the disclosure will be described below. For convenience in description, like reference signs designate members having identical functions throughout the description. These members might not be elaborated upon repeatedly.

First Embodiment

(14) FIG. **1** is a perspective view of a casing unit **111** according to a first embodiment of the disclosure. FIG. **2** is an exploded perspective view of the casing unit **111** according to the first embodiment of the disclosure. FIG. **3** is a plan view of the casing unit **111** in FIG. **1** with neither a lifter **6***a* nor a lifter **6***b*.
(15) The casing unit **111** includes: a hinge member **1**; a first casing **2***a*; a second casing **2***b*; magnet systems **3***a* and **3***b*; and display panel attaching members **4***a* and **4***b*.
(16) The casing unit **111** includes: the hinge member **1**; and the first casing **2***a* and the second casing **2***b* sandwiching the hinge member **1** and connected together with the hinge member **1**. The first casing **2***a* houses the magnet system **3***a* and the display panel attaching member **4***a* in the stated order from toward the hinge member **1**. The second casing **2***b* houses the magnet system **3***b* and the display panel attaching member **4***b* in the stated order from toward the hinge member **1**.
(17) The magnet system **3***a* has: a magnet **5***a*; the lifter **6***a*; and a magnet holder **7***a*. The magnet system **3***b* has: a magnet **5***b*; the lifter **6***b*; and a magnet holder **7***b*. The magnet **5***a* and the magnet **5***b* are respectively housed in the magnet holder **7***a* and the magnet holder **7***b*. The magnet systems **3***a* and **3***b* will be described later in more detail.
(18) The display panel attaching members **4***a* and **4***b* are bases to which a display panel **8** to be described later is secured.
(19) Using the hinge member **1** as a folding portion, the casing unit **111** is foldable in a manner that an upper surface of the display panel attaching member **4***a* and an upper surface of the display panel attaching member **4***b* face each other.
(20) FIG. **3** shows that the magnet **5***a* is provided across the first casing **2***a* in a direction substantially parallel with the upper surface of the display panel attaching member **4***a* and substantially perpendicular (a horizontal direction in the drawing) to a direction in which the hinge member **1** and the first casing **2***a* are arranged. Likewise, FIG. **3** shows that the magnet **5***b* is provided across the second casing **2***b* in a direction substantially parallel with the upper surface of the display panel attaching member **4***b* and substantially perpendicular (a horizontal direction in the drawing) to a direction in which the hinge member **1** and the first casing **2***b* are arranged.
(21) FIG. **4** illustrates a mechanism of how a front surface **8***a* of the display panel **8** undulates in a display device **100** that is foldable. For simplicity of illustration, FIG. **4**, and furthermore, FIGS. **7**, **8**, and **12** to be shown later, include drawings of the display device along with drawings of the display panel **8** included in the display device.
(22) The display device **100** includes: the hinge member **1**; the first casing **2***a*; the second casing **2***b*; the display panel attaching members **4***a* and **4***b*; and the display panel **8**.

(23) The display panel **8** has the front surface **8***a* and a back surface **8***b*. Note that the front surface **8***a* is a display surface of the display panel **8**, and the back surface **8***b* is a back side of the display surface. The display panel **8** is flexible. The display panel **8** has: a first portion **8***c*; and second portions **8***da* and **8***db*. The display panel **8** has the two second portions **8***da* and **8***db* sandwich the first portion **8***c*. Each of the second portions **8***da* and **8***db* is positioned outside the first portion **8***c* while the first portion **8***c* is positioned in the center.
(24) The display panel **8** is disposed from above the first casing **2***a* through above the hinge member **1** to above the second casing **2***b*. The first portion **8***c* is positioned above the hinge member **1**. The second portion **8***da* (one of the two second portions) is positioned above the first casing **2***a*. The second portion **8***db* (an other one of the two second portions) is positioned above the second casing **2***b*. The back surface **8***b* and a securing position **8***ga* (further outside the second portion **8***da* while the first portion **8***c* is positioned in the center) are secured to the upper surface of the display panel attaching member **4***a*. The back surface **8***b* and a securing position **8***gb* (further outside the second portion **8***db* while the first portion **8***c* is positioned in the center) are secured to the upper surface of the display panel attaching member **4***b*. The display panel **8** can be secured to the display panel attaching members **4***a* and **4***b* with either an adhesive, or a double-sided tape.
(25) FIG. **4** shows a first state in which the display panel **8** is folded and a second state in which the display panel **8** is unfolded. Moreover, FIG. **4** shows a case where the display panel **8** is folded into a tear-drop shape. Here, in the first state, the first portion **8***c* is bent so that the front surface **8***a* faces inwards, while each of the second portions **8***da* and **8***db* is bent so that the back surface **8***b* faces inwards.
(26) Typically, the display device **100** is often stored in the first state. When the display device **100** is in the first state for a long time, and, after that, the display device **100** shifts from the first state to the second state, the first portion **8***c* forms a distortion **8***e* dipping on the front surface **8***a*, the second portion **8***da* develops a distortion **8***fa* swelling on the front surface **8***a*, and the second portion **8***db* forms a distortion **8***fb* swelling on the front surface **8***a*. Hence, in the second state, the distortions **8***e*, **8***fa* and **8***fb* cause undulation of the front surface **8***a*.
(27) Note that the display panel **8** may be folded into, for example, a U-shape. In this case, in the first state, each of the second portions **8***da* and **8***db* is bent so that the back surface **8***b* does not face inwards. Here, in the first state, each of the second portions **8***da* and **8***db* does not have to be bent so that the back surface **8***b* face inwards. In the first state, even if each of the second portions **8***da* and **8***db* is bent so that the back surface **8***b* does not bent inwards, the distortions **8***fa* and **8***fb* could form.
(28) FIG. **5** illustrates a plan view, and a cross-sectional view taken along line A-A, of a display device **101** according to the first embodiment of the disclosure. FIG. **6** is an enlarged cross-sectional view mainly illustrating pulling members **10***a* and **10***b*, and magnet moving members **11***a* and **11***b*, of the display device **101** according to the first embodiment of the disclosure. The display device **101** includes: a casing unit **111**; and the display panel **8**.
(29) The display panel **8** is disposed from above the first casing **2***a* through above the hinge member **1** to above the second casing **2***b*. The first portion **8***c* is positioned above the hinge member **1**. The second portion **8***da* is positioned above the first casing **2***a*. The second portion **8***db* is positioned above the second casing **2***b*. The back surface **8***b* and the securing position **8***ga* are secured to the upper surface of the display panel attaching member **4***a*, and the back surface **8***b* and the securing position **8***gb* are secured to the upper surface of the display panel attaching member **4***b*. The display panel **8** can be secured to the display panel attaching members **4***a* and **4***b* with either an adhesive, or a double-sided tape.
(30) The back surface **8***b* and the second portion **8***da*, and the back surface **8***b* and the second portion **8***db*, are provided with a ferromagnetic material **9**. The ferromagnetic material **9** is secured to the entire back surface **8***b*. A combination of the ferromagnetic material **9** and the magnet **5***a* is the pulling member **10***a*, and a combination of the ferromagnetic material **9** and the magnet **5***b* is

the pulling member **10***b*.
(31) The ferromagnetic material **9** is made of, for example, a metal such as SUS430. The ferromagnetic material **9** is, for example, a plate-like member. When the ferromagnetic material **9** is a plate-like member, the ferromagnetic material **9** has a thickness of: preferably 0.03 mm or less if a living hinge is not provided; and preferably 0.5 mm or less if a living hinge is provided. The living hinge will be described later.
(32) Note that, in the plan view of the display device **101** illustrated in FIG. **5**, the outline of the display panel **8** is drawn by broken lines in order to avoid hiding most of the casing unit **111** behind the display panel **8**.
(33) The magnets **5***a* and **5***b* are provided to the back surface **8***b*. More specifically, the magnets **5***a* and **5***b* are provided across the ferromagnetic material **9** from the back surface **8***b*. The magnets **5***a* and **5***b* are provided to face the ferromagnetic material **9**. Each of the magnets **5***a* and **5***b* is such a permanent magnet as a neodymium magnet.
(34) The lifters **6***a* and **6***b* are attached to the hinge member **1**. Each of the lifters **6***a* and **6***b* may be any given component unless the component does not block magnetic force. Each of the lifters **6***a* and **6***b* is made of, for example, a non-magnetic material. A combination of the lifter **6***a* and the magnet holder **7***a* is the magnet moving member **11***a*, and a combination of the lifter **6***b* and the magnet holder **7***b* is the magnet moving member **11***b*.
(35) The first casing **2***a* and the second casing **2***b* are respectively provided with a link groove **12***a* and a link groove **12***b*. The lifter **6***a* and the lifter **6***b* are respectively provided with a link groove **13***a* and a link groove **13***b*.
(36) The lifter **6***a* and the lifter **6***b* are respectively fit into the link groove **12***a* and the link groove **12***b* at one end. The lifters **6***a* and **6***b* are rotatably connected to the hinge member **1** at an other end. The lifter **6***a* is movable in such a manner that the one end of the lifter **6***a* slides inside the link groove **12***a* with respect to the hinge member **1**. The lifter **6***b* is movable in such a manner that the one end of the lifter **6***b* slides inside the link groove **12***b* with respect to the hinge member **1**.
(37) The magnet holder **7***a* and the magnet holder **7***b* are respectively fit into the link groove **13***a* and the link groove **13***b* at one end. The magnet holders **7***a* and **7***b* are rotatably connected to the hinge member **1** at an other end. The magnet holder **7***a* is movable in such a manner that the one end of the magnet holder **7***a* slides inside the link groove **13***a* with respect to the hinge member **1**. The magnet holder **7***b* is movable in such a manner that the one end of the magnet holder **7***b* slides inside the link groove **13***b* with respect to the hinge member **1**.
(38) FIG. **7** illustrates cross-sectional views showing an operation mechanism of the pulling members **10***a* and **10***b*, and of the magnet moving members **11***a* and **11***b*, in the first half of an operation for shifting the display device **101** according to the first embodiment of the disclosure from the first state to the second state. FIG. **8** illustrates cross-sectional views showing an operation mechanism of the pulling members **10***a* and **10***b*, and of the magnet moving members **11***a* and **11***b*, in the second half of the operation for shifting the display device **101** according to the first embodiment of the disclosure from the first state to the second state. FIGS. **7** and **8** show a case where the display panel **8** is folded into a tear-drop shape. Note that, as described above with reference to FIG. **4**, in the first state, each of the second portions **8***da* and **8***db* does not have to be bent so that the back surface **8***b* faces inwards.
(39) In the first state, the casing unit **111** of the display device **101** is folded so that the upper surface of the display panel attaching member **4***a* and the upper surface of the display panel attaching member **4***b* face each other using the hinge member **1** as a folding portion. At this time, the magnets **5***a* and **5***b* are away from the ferromagnetic material **9**. Thus, the magnets **5***a* and **5***b* either cease to attract the ferromagnetic material **9** or hardly attract the ferromagnetic material **9**. As a result, in the first state, the display panel **8** hardly receives force (load) caused by the presence of the pulling members **10***a* and **10***b* and the magnet moving members **11***a* and **11***b*. Hence, the display panel **8** bends naturally.

(40) When transition starts from the first state to the second state, the lifters **6***a* and **6***b* and the magnet holders **7***a* and **7***b* start to move with respect to the hinge member **1** as described above. Thus, the magnet moving member **11***a* brings the magnet **5***a* closer to the ferromagnetic material **9**, and the magnet moving member **11***b* brings the magnet **5***b* closer to the ferromagnetic material **9**.
(41) In the second state, the magnet moving member **11***a* brings the magnet **5***a* as close as possible to the ferromagnetic material **9**, and the magnet moving member **11***b* brings the magnet **5***b* as close as possible to the ferromagnetic material **9**. Hence, the magnets **5***a* and **5***b* attract the ferromagnetic material **9**. Specifically, the magnet **5***a* attracts the ferromagnetic material **9** across from the back surface **8***b* in relation to the ferromagnetic material **9** (provided with the magnet **5***a*), and the magnet **5***b* attracts the ferromagnetic material **9** across from the back surface **8***b* in relation to the ferromagnetic material **9** (provided with the magnet **5***b*).
(42) As a result, in the second state, the pulling member **10***a* provided on the back surface **8***b* pulls the second portion **8***da* with the magnet **5***a*. Thanks to the above configuration, in the second state, the pulling member **10***a* pulls the second portion **8***da* from toward the back surface **8***b*. Such a feature can prevent the distortion **8***fa* (see FIG. **4**) swelling on the front surface **8***a* in the second portion **8***da*. Hence, undulation on the front surface **8***a* can be reduced.
(43) As a result, in the second state, the pulling member **10***b* provided to the back surface **8***b* pulls the second portion **8***db* with the magnet **5***b*. Thanks to the above configuration, in the second state, the pulling member **10***b* pulls the second portion **8***db* from toward the back surface **8***b*. Such a feature can prevent the distortion **8***fb* (see FIG. **4**) swelling on the front surface **8***a* in the second portion **8***db*. Hence, undulation on the front surface **8***a* can be reduced.
(44) In the transition from the first state to the second state, the magnet **5***a* is brought closer to the ferromagnetic material **9** sequentially from a distal end **14***a* to a proximal end **15***a* in relation to the first portion **8***c*. That is, in the transition from the first state to the second state, the magnet moving member **11***a* moves the magnet **5***a*, positioned far from the first portion **8***c*, closer to the ferromagnetic material **9**. Thus, the first portion **8***c* is not pulled by the pulling member **10***a* as much as possible. Hence, load on the first portion **8***c* can be reduced.
(45) In the transition from the first state to the second state, the magnet **5***b* is brought closer to the ferromagnetic material **9** sequentially from a distal end **14***b* to a proximal end **15***b* in relation to the first portion **8***c*. That is, in the transition from the first state to the second state, the magnet moving member **11***b* moves the magnet **5***a*, positioned far from the first portion **8***c*, closer to the ferromagnetic material **9**. Thus, the first portion **8***c* is not pulled by the pulling member **10***b* as much as possible. Hence, load on the first portion **8***c* can be reduced.
(46) The display device **101** includes: the first casing **2***a* and the second casing **2***b*; the display panel attaching members **4***a* and **4***b* that secures the display panel **8**; the hinge member **1**; and the magnet moving members **11***a* and **11***b* attached to the hinge member **1**. The pulling members **10***a* and **10***b* include: the ferromagnetic material **9** to be attracted by magnetic force; and magnets (respectively the magnets **5***a* and **5***b*). One of the ferromagnetic material **9** or each magnet is provided to the back surface **8***b*; whereas, an other one of the ferromagnetic material **9** or each magnet is provided to either the magnet moving member **11***a* or the magnet moving member **11***b*.
(47) In the display device **101**, the display panel attaching member **4***a*, the magnet moving member **11***a*, the hinge member **1**, the magnet moving member **11***b*, and the display panel attaching member **4***b* are arranged in the stated order. The first portion **8***c* corresponds to the hinge member **1**, and the second portion **8***da* and the second portion **8***db* respectively correspond to the magnet moving member **11***a* and the magnet moving member **11***b*. As illustrated in FIGS. **7** and **8**, in the second state, the display panel attaching members **4***a* and **4***b*, the magnet moving members **11***a* and **11***b*, and the hinge member **1** have respective front surfaces positioned on the same plane (specifically, a plane facing the display panel **8**). As illustrated in FIGS. **7** and **8**, in the first state, according to the "tear-drop shape" representing the folding shape of the display panel **8**, a distance between the two magnet moving members **11***a* and **11***b* is longer than a distance between the two display panel

attaching members **4***a* and **4***b*.
(48) As illustrated in FIGS. **7** and **8**, the magnet moving member **11***a* and the magnet moving member **11***b* respectively have the magnet holder **7***a* and the magnet holder **7***b* for housing the magnet **5***a* and the magnet **5***b*. In the first state, according to the "tear-drop shape" and the operation mechanism of the magnet moving members **11***a* and **11***b*, a distance between the two magnet holders **7***a* and **7***b* is shorter as the magnet holders **7***a* and **7***b* are farther away from the first portion **8***c*.
(49) The pulling member **10***a* has: the ferromagnetic material **9** provided to the back surface **8***b* and the second portion **8***da*; and the magnet **5***a* provided across the ferromagnetic material **9** from the back surface **8***b* and attracting the ferromagnetic material **9**. Hence, the magnet **5***a* attracts the ferromagnetic material **9** provided to the back surface **8***b* and the second portion **8***da*, such that the ferromagnetic material **9** and the magnet **5***a* can serve as the pulling member **10***a*.
(50) The pulling member **10***b* has: the ferromagnetic material **9** provided to the back surface **8***b* and the second portion **8***db*; and the magnet **5***b* provided across the ferromagnetic material **9** from the back surface **8***b* and attracting the ferromagnetic material **9**. Hence, the magnet **5***b* attracts the ferromagnetic material **9** provided to the back surface **8***b* and the second portion **8***db*, such that the ferromagnetic material **9** and the magnet **5***b* can serve as the pulling member **10***b*.
(51) With reference to the plan view in FIG. **5** and to FIG. **6**, the ferromagnetic material **9** is provided across the second portions **8***da* and **8***db* in a direction substantially parallel with the back surface **8***b* and substantially perpendicular (in a horizontal direction DT in the plan view in FIG. **5**) to a direction (in a vertical direction DM in the plan view in FIG. **5**) in which the first portion **8***c* and the second portions **8***da* and **8***db* are arranged. Such a feature makes it possible to pull the second portions **8***da* and **8***db* in a wide range, and to sufficiently prevent formation of the distortions **8***fa* and **8***fb* (see FIG. **4**).
(52) When the steps illustrated in FIGS. **7** and **8** are carried out in the reverse order, the operation is interpreted to shift the display device **101** from the second state to the first state. In the process of transition from the first state to the second state, the magnets **5***a* and **5***b* are brought close to the ferromagnetic material **9**; whereas, in the process of transition from the second state to the first state, the magnets **5***a* and **5***b* are pulled away from the ferromagnetic material **9**.
(53) The display device **101** has the magnet moving member **11***a* that moves and pulls the magnet **5***a* away from the ferromagnetic material **9** in the transition from the second state to the first state. As a result, the pulling member **10***a* stops pulling the second portion **8***da* in the first state. Such a feature makes it possible to reduce load to be applied on the display panel **8** because of the excessive pulling by the pulling member **10***a*.
(54) The display device **101** has the magnet moving member **11***b* that moves and pulls the magnet **5***b* away from the ferromagnetic material **9** in the transition from the second state to the first state. As a result, the pulling member **10***b* stops pulling the second portion **8***db* in the first state. Such a feature makes it possible to reduce load to be applied on the display panel **8** because of the excessive pulling by the pulling member **10***b*.
(55) The display device **101** includes the casing unit **111** and the display panel **8**, and the display device including the casing is foldable.
(56) In the display device **101**, each of the two second portions **8***da* and **8***db* is provided with a pulling member (respectively the pulling member **10***a* and the pulling member **10***b*). Such a feature can prevent formation of respective distortions (respectively the distortion **8***fa* and the distortion **8***fb*) for the second portion **8***da* and the second portion **8***db*.
(57) On the other hand, if it is not necessary to pay attention to undulation caused on the surface **8***a* by the distortion **8***fa*, the pulling member **10***a* and the magnet moving member **11***a* acting on the distortion **8***fa* may be omitted. Likewise, if it is not necessary to pay attention to undulation caused on the surface **8***a* by the distortion **8***fb*, the pulling member **10***b* and the magnet moving member **11***b* acting on the distortion **8***fb* may be omitted.

(58) The display panel **8** has the two second portions **8***da* and **8***db* positioned to sandwich the first portion **8***c*. Then, the display panel **8** is secured to the display panel attaching members **4***a* and **4***b* provided to the display device **101** and each positioned outside the two respective second portions **8***da* and **8***db* while the first portion **8***c* is positioned in the center; that is, provided in the respective securing positions **8***ga* and **8***gb*.
(59) FIG. **9** is a cross-sectional view of a modification of the display device **101** according to the first embodiment of the disclosure. FIG. **9** corresponds to FIG. **6**. As illustrated in FIG. **9**, the pulling member **10***a* and the magnet moving member **11***a* may be omitted from the display device **101** (actually, the magnet **5***a*, the lifter **6***a*, and the magnet holder **7***a* may be omitted, and the ferromagnetic material **9** is left for the pulling member **10***b*).
(60) Moreover, the pulling member **10***a* in the second state may have the magnet **5***a* and the ferromagnetic material **9** brought into contact with each other. In this case, when the magnet **5***a* and the ferromagnetic material **9** are detached, the noise made at the moment could be unpleasant to the user. Hence, between the magnet **5***a* and the ferromagnetic material **9**, a sound-insulating sheet that does not block magnetic force may be provided. The sound-insulating sheet may be provided to either the magnet **5***a* or the ferromagnetic material **9**. However, the sound-insulating sheet is provided preferably to the magnet **5***a* because the feeling of the front surface **8***a* is unlikely to be lost when the user touches the display panel **8**. Such a feature of the pulling member **10***a* also applies to the pulling member **10***b*.
(61) FIG. **10** illustrates a plan view, a cross-sectional view taken along line B-B, and another cross-sectional view taken along line B-B, all of which show specific examples of the display panel **8** and the ferromagnetic material **9**. FIG. **11** is a plan view of a specific example of the ferromagnetic material **9** having a living hinge.
(62) In FIG. **10**, the cross-sectional view taken along line B-B illustrates the ferromagnetic material **9** with no living hinge. On the other hand, in FIG. **10**, the other cross-sectional view taken along the line B-B illustrates the ferromagnetic material **9** with a living hinge.
(63) To provide a living hinge to the ferromagnetic material **9** shaped into a flat plate, a portion of the ferromagnetic material **9** is removed so that the ferromagnetic material **9** increases in flexibility. When the whole bendable portion of the display panel **8** in the first state is referred to as a portion **16**, an example of the living hinge provided to the ferromagnetic material **9** is, as shown in FIG. **11**, a mesh construction provided to a portion **17** included in the ferromagnetic material **9** and overlapping with the portion **16**.
(64) When the ferromagnetic material **9** is provided with a living hinge, the user can fold the display device **101** without difficulty even if the ferromagnetic material **9** is increased in thickness.
(65) Each of the magnets **5***a* and **5***b* may be an electromagnet.

Second Embodiment

(66) FIG. **12** illustrates cross-sectional views of a schematic configuration of a display device **102** according to a second embodiment of the disclosure. FIG. **12** shows transition from the first state to the second state. For convenience in illustration, FIG. **12** partially omits illustrations of configurations with no change found between the display devices **101** and **102**.
(67) The pulling member may be a mechanism that electrically pulls the second portion **8***da* and/or the second portion **8***db* from toward the back surface **8***b*. This mechanism will be described below.
(68) The display device **101** includes the pulling members **10***a* and **10***b* and the magnet moving members **11***a* and **11***b*. Alternatively, the display device **102** includes pulling members **18***a* and **18***b*. The pulling member **18***a* is a combination of the ferromagnetic material **9** and an electromagnet **19***a*. The pulling member **18***b* is a combination of the ferromagnetic material **9** and the electromagnet **19***b*.
(69) In the first state, the electromagnets **19***a* and **19***b* are not energized. Thus, the electromagnets **19***a* and **19***b* either cease to attract the ferromagnetic material **9** or hardly attract the ferromagnetic material **9**. On the other hand, in the second state, the electromagnets **19***a* and **19***b* are energized,

and attract the ferromagnetic material **9**.
(70) That is, in the first state, the pulling member **18***a* does not pull the second portion **8***da* from toward the back surface **8***b*; whereas, in the second state, the pulling member **18***a* pulls the second portion **8***da* from toward the back surface **8***b*. In the first state, the pulling member **18***b* does not pull the second portion **8***db* from toward the back surface **8***b*; whereas, in the second state, the pulling member **18***b* pulls the second portion **8***db* from toward the back surface **8***b*. Hence, the pulling member **18***a* can achieve the same function as the function of a combination of the pulling member **10***a* and the magnet moving member **11***a*, and the pulling member **18***b* can achieve the same function as the function of a combination of the pulling member **10***b* and the magnet moving member **11***b*.
(71) The above functions can be achieved by a not-shown energization control unit that controls whether each of the electromagnets **19***a* and **19***b* is energized. For example, the energization control unit may detect an angle at which the second casing **2***b* is open with respect to the first casing **2***a*, and determine whether the display device **102** is in the first state or the second state according to the detected angle. A threshold value of the angle to distinguish between the first state and the second state may take any given value.
(72) Note that, instead of utilizing energization or non-energization of the electromagnets **19***a* and **19***b* to control whether the ferromagnetic material **9** is attracted, for example, static electricity may be utilized to control whether the ferromagnetic material **9** is attracted.

SUMMARY

(73) A display device according to a first aspect of the disclosure includes: a display panel that is flexible and has a front surface and a back surface, the display panel having: a first portion bent so that the front surface faces inwards in a first state in which the display panel is folded; and a second portion positioned outside the first portion while the first portion is positioned in a center; and a pulling member provided to the back surface of the display panel, and pulling the second portion in a second state in which the display panel is unfolded.
(74) Thanks to the above configuration, in the second state, the pulling member pulls the second portion of the display panel from toward the back surface of the display panel. Such a feature makes it possible to prevent a distortion swelling on the front surface of the display panel. Hence, undulation on the front surface of the display panel can be reduced.
(75) In a second aspect of the disclosure, as to the display device according to the first aspect, the pulling member has: a ferromagnetic material provided to the back surface and the second portion; and a magnet provided across the ferromagnetic material from the back surface, and attracting the ferromagnetic material.
(76) Thanks to the above configuration, the magnet attracts the ferromagnetic material provided to the back surface and the second portion of the display panel, such that the ferromagnetic material and the magnet can serve as the pulling member.
(77) In a third aspect of the disclosure, as to the display device according to the second aspect, the ferromagnetic material is provided across the second portion in a direction substantially parallel with the back surface and substantially perpendicular to a direction in which the first portion and the second portion are arranged.
(78) Such a configuration makes it possible to pull the second portion of the display panel in a wide range, and to sufficiently prevent formation of the distortion.
(79) In a fourth aspect of the disclosure, the display device according to the second or third aspect further includes a magnet moving member that moves and pulls the magnet away from the ferromagnetic material in transition from the second state to the first state.
(80) Thanks to the above configuration, the pulling member stops pulling the second portion in the first state. Such a feature makes it possible to reduce load to be applied on the display panel because of the excessive pulling by the pulling member.
(81) In a fifth aspect of the disclosure, as to the display device according to the fourth aspect, in

transition from the first state to the second state, the magnet moving member moves the magnet, positioned far from the first portion, closer to the ferromagnetic material.
(82) Thanks to the above configuration, the first portion of the display panel is not pulled by the pulling member as much as possible. Such a feature can reduce load on the first portion of the display panel.
(83) In a sixth aspect of the disclosure, the display device according to the first aspect further includes: a first casing and a second casing; a first display panel attaching member and a second display panel attaching member configured to secure the display panel; a hinge member; and a first magnet moving member and a second magnet moving member attached to the hinge member. The pulling member includes: a ferromagnetic material to be attracted by magnetic force; and a magnet. One of the ferromagnetic material or the magnet is provided to the back surface of the display panel, and an other one of the ferromagnetic material or the magnet is provided to either the first magnet moving member or the second magnet moving member.
(84) In a seventh aspect of the disclosure, as to the display device according to the sixth aspect, the first display panel attaching member, the first magnet moving member, the hinge member, the second magnet moving member, and the second display panel attaching member are arranged in a stated order. The first portion corresponds to the hinge member. The second portion includes two second portions each corresponding to one of the first magnet moving member and the second magnet moving member. In the second state, the first display panel attaching member, the second display panel attaching member, the first magnet moving member, the second magnet moving member, and the hinge member have respective front surfaces positioned on a same plane. In the first state, a distance between the first magnet moving member and the second magnet moving member is longer than a distance between the first display panel attaching member and the second display panel attaching member.
(85) In an eighth aspect of the disclosure, as to the display device according to the seventh aspect, the first magnet moving member and the second magnet moving member have respective magnet holders housing the magnet. In the first state, a distance between the respective magnet holders is shorter as the respective magnet holders are farther away from the first portion.
(86) In a ninth aspect of the disclosure, the display device according to any one of the sixth to eighth aspects further includes a casing unit that is foldable. The display panel has two second portions included in the second portion and sandwiching the first portion. The casing unit includes: the hinge member; and the first casing and the second casing sandwiching the hinge member. The first portion is positioned above the hinge member. One of the two second portions is positioned above the first casing. An other one of the two second portions is positioned above the second casing.
(87) The above configurations can provide a foldable display device including a casing.
(88) In a tenth aspect of the disclosure, as to the display device according to the ninth aspect, the display device includes the pulling member for each of the two second portions.
(89) The above configuration can prevent formation of the distortion in each of the two second portions of the display panel.
(90) In an eleventh aspect of the disclosure, as to the display device according to any one of the sixth to tenth aspects, the display panel has two second portions included in the second portion and positioned to sandwich the first portion. The display panel is secured to the first display panel attaching member and the second display panel attaching member provided to the display device and each positioned outside one of the two second portions while the first portion is positioned in the center.
(91) In a twelfth aspect of the disclosure, as to the display device according to any one of the second to eleventh aspects, the magnet is an electromagnet.
(92) In a thirteenth aspect of the disclosure, as to the display device according to the first aspect, the pulling member is a mechanism that electrically pulls the second portion from toward the back

surface.
(93) The above configurations provide a pulling member that electrically pulls the second portion of the display panel from toward the back surface of the display panel.
(94) In a fourteenth aspect of the disclosure, as to the display device according to any one of the first to thirteenth aspects, in the first state, the second portion is bent so that the back surface faces inwards.
(95) Such a configuration makes it possible to achieve more remarkably advantageous effects of reducing formation of the distortion and undulation on the front surface of the display panel.
(96) The disclosure shall not be limited to the embodiments described above, and can be modified in various manners within the scope of claims. The technical aspects disclosed in different embodiments are to be appropriately combined together to implement another embodiment. Such an embodiment shall be included within the technical scope of the disclosure. Moreover, the technical aspects disclosed in each embodiment may be combined to achieve a new technical feature.

Claims

1. A display device, comprising: a display panel that is flexible and has; a front surface, a back surface, a first portion bent, such that the front surface faces inwards in a first state in which the display panel is folded, and a second portion positioned outside the first portion while the first portion is positioned in a center; and a pulling member provided to the back surface of the display panel, and configured to pull the second portion in a second state in which the display panel is unfolded, wherein: the pulling member has a ferromagnetic material provided to the back surface and the second portion, and a magnet that is provided across the ferromagnetic material from the back surface, and that attracts the ferromagnetic material, the display device further comprises a magnet moving member configured to move and pull the magnet away from the ferromagnetic material when transitioning from the second state to the first state, and when transitioning from the first state to the second state, the magnet moving member moves an end of the magnet, opposite an end positioned far from the first portion, closer to the ferromagnetic material.
2. The display device according to claim 1, wherein the ferromagnetic material is provided across the second portion in a direction substantially parallel with the back surface and substantially perpendicular to a direction in which the first portion and the second portion are arranged.
3. The display device according to claim 1, further comprising: a first casing and a second casing; a first display panel attaching member and a second display panel attaching member configured to secure the display panel; a hinge member; and a first magnet moving member and a second magnet moving member attached to the hinge member, wherein the magnet is provided to either the first magnet moving member or the second magnet moving member.
4. The display device according to claim 3, wherein the first display panel attaching member, the first magnet moving member, the hinge member, the second magnet moving member, and the second display panel attaching member are arranged in the stated order, the first portion corresponds to the hinge member, the second portion includes two second portions, each corresponding to one of the first magnet moving member and the second magnet moving member, in the second state, the first display panel attaching member, the second display panel attaching member, the first magnet moving member, the second magnet moving member, and the hinge member have respective front surfaces positioned on a same plane, and in the first state, a distance between the first magnet moving member and the second magnet moving member is longer than a distance between the first display panel attaching member and the second display panel attaching member.
5. The display device according to claim 4, wherein the first magnet moving member and the second magnet moving member have respective magnet holders housing the magnet, and in the

first state, a distance between the respective magnet holders is shorter as the respective magnet holders are farther away from the first portion.

6. The display device according to claim 3, further comprising: a casing unit that is foldable, wherein the display panel has two second portions included in the second portion and sandwiching the first portion, the casing unit includes the hinge member, and the first casing and the second casing sandwiching the hinge member, the first portion is positioned above the hinge member, one of the two second portions is positioned above the first casing, and another one of the two second portions is positioned above the second casing.

7. The display device according to claim 6, wherein the pulling member includes two pulling members, each corresponding to one of the two second portions.

8. The display device according to claim 3, wherein the display panel has two second portions included in the second portion and positioned to sandwich the first portion, and the display panel is secured by the first display panel attaching member and the second display panel attaching member each of which is positioned outside one of the two second portions while the first portion is positioned in the center.

9. The display device according to claim 1, wherein the magnet is an electromagnet.

10. The display device according to claim 1, wherein the pulling member is a mechanism configured to electrically pull the second portion from the back surface.

11. The display device according to claim 1, wherein, in the first state, the second portion is bent, such that the back surface faces inwards.